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THE JUST INTONATION GUITAR WORKS OF LOU HARRISON, JAMES TENNEY, AND LARRY POLANSKY

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Abstract

Compositions in alternative tuning systems constitute a significant repertoire in twentieth-century U.S. music. A closely-related group of composers further specialized in just intonation—a particular kind of tuning system that utilizes whole-number relationships between pitches, resulting in a near infinite variety of interval sizes. Composers writing in just intonation often had to design their own instruments (or adapt traditional ones) for the performance of the precise ratios they required; somewhat surprisingly, a substantial number of their works employ the guitar, an instrument most often associated with equal temperaments. The purpose of this dissertation is to document and analyze the range of musical results achieved by a selection of closely-related U.S. composers who brought the guitar from one intonational context to the other.

This study is based on archival research; organology; musical and tuning analysis; and oral histories. After establishing the relevant historical and critical precedents in the Introduction, the dissertation develops as a series of case studies. Chapter One analyses the genesis and legacy of a uniquely-tuned resophonic guitar, devised by Lou Harrison (1917–2003) for the composition of his last completed

piece, *Scenes from Nek Chand*. After Harrison's death, more than a dozen additional composers were inspired to write for this organologically puzzling, yet beautifully resonant instrument. Chapter Two focuses on the guitar music of composer and theorist James Tenney (1934–2006), who created works of staggering harmonic complexity without the requirement for custom-made or refretted instruments. Chapter Three traces the influence of both approaches in the numerous guitar works of composer, performer, and theorist Larry Polansky (b. 1954), who was a student, colleague, and lifelong friend of both Harrison and Tenney. Finally, the concluding chapter assesses the current status of intonation experiments involving the guitar, documenting a scene that transcends the confines of the U.S. avant-garde into the domain of popular musics around the world.

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This dissertation is dedicated to the memory of Prof. Fredric Lieberman, whose work and teachings on analysis, organology, and discourse profoundly influenced my musical thinking and approach.

Introduction

"Just Intonation is the best intonation"
—Lou Harrison[1]

"Tuning is another form of government"
—John Cage[2]

Overview

Compositions in alternative tuning systems constitute a significant repertoire in twentieth-century U.S. music. A closely-related group of composers further specialized in *just intonation*—a particular kind of tuning system that utilizes whole-number relationships between pitches. The *Harvard Dictionary of Music and Musicians* defines a just intonation system as "any tuning that incorporates five or more acoustically pure types of interval within the octave."[3] From a more technical standpoint, any tuning in which pitches are expressed by whole-number ratios qualifies as a just intonation tuning. The earliest surviving musical-theoretical treatises from Greece, India, and China include intonation and tuning concern; through their long history, these matters also invite cross-disciplinary ties into psychoacoustics, cognition, perception, cultural conventions, aesthetics, and philosophy.

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[1] Lou Harrison, *Music Primer* (New York: Peters, 1971), 4.

[2] Mark Gresham, "John Cage" (1991 interview) in *Choral Conversations* (San Carlos, CA: Thomas House, 1997). Reprinted in Richard Kostelanetz, *Conversing with Cage* (New York, Routledge, 2003),102

[3] "Just Intonation," *The Harvard Dictionary of Music*, Don Randel, ed., (Cambridge: Harvard University Press, 2003), 440.

American composer, theorist, and instrument builder Harry Partch (1901–1974) was among the first and most influential composers to use a just tuning in the twentieth century. He thought of his musical system, which he called Monophony, as the continuation of Greek and Renaissance aesthetic ideals, uniting prosody, music, and dance into a singular "corporeal" expression, in opposition to the "abstractions" of Romantic European concert music.[4] To realize his vision, Partch adapted existing musical instruments and created new ones, producing an imaginative collection of percussion and string instruments. Both his music and his book *Genesis of a Music* were seminal influences on younger composers such as Lou Harrison (1917-2003) and Ben Johnston (b. 1926). Other notable composers working in just and alternative intonations include Terry Riley, LaMonte Young, James Tenney, Larry Polansky, Pauline Oliveros, Rhys Chatham, Glenn Branca, Kyle Gann, and many more.

Traditionally, guitars are fretted in twelve-tone equal temperament (hereafter 12TET). Since some just intervals cannot be well approximated in equal temperament, performing just intonation music on the guitar requires a different approach to the instrument—either retuning the open strings, re-fretting the fingerboard, or a combination of the two. The difficulties inherent in the process lie in the assumption that, for most practical purposes, only two of the following three features can coexist: The sounding of pure, rational intervals; the possibility of

[4] Partch introduces and defines these terms in Harry Partch, *Genesis of a Music* (New York: Da Capo, 1947), 9.

modulation; and a manageable number of notes per octave.[5] Nevertheless, there have been attempts, dating back to the Renaissance and Baroque eras, to realize a range of other temperaments and tunings on fretted instruments. Theorist Juan Bermudo (1510–65) and composer Luis Milán (c. 1500–61) advocated the use of a range of positions for some of the Spanish vihuela's tied frets to create irregular meantone tunings that would feature "better" thirds on some strings at the expense of others.[6] Two hundred years later, an article presented to the Royal Society of London by Thomas Salmon in 1705 suggested placing independent fretlets under the individual strings of a viol in order to replicate the pure ratios of justly tuned intervals; the author even recommended the use of a different fingerboard for each key, describing how "they are taken out and put in upon the Neck of the Viol, with as much ease, as you pull out and thrust in the Drawer of a Table."[7] The "Enharmonic Guitar" designed by Thomas Perronet Thompson in 1829 as a training aid for his daughter, is another example of alternative tuning solutions for fretted strings: It featured a myriad of

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[5] In Polansky, Daniel Rockmore, et. al., "A Mathematical Model for Optimal Tuning Systems," *PNM* (2009): 71, the authors offer "five constraints" for the definition of tuning systems: Pitch Set, Repeat Factor, Intervals, Hierarchy, and Key. These constraints are a product of musical and cultural aesthetics developed over long periods of time; experimental tuning systems alter one or more of these constraints from their accepted norms, leading in turn to more or less "practical" solutions.

[6] See Antonio Corona-Alcalde, "'You Will Raise a Little Your 4th Fret': An Equivocal Instruction by Luis Milan?" *The Galpin Society Journal* 44 (1991): 2–45; Wolfgang Freis, "Perfecting the Perfect Instrument: Fray Juan Bermudo on the Tuning and Temperament of the 'Vihuela de Mano,'" *Early Music* 23/3 (1995): 421–35.

[7] Thomas Salmon, "The Theory of Musick reduced to Arithmetical and Geometrical Proportions," *Philosophical Transactions of the Royal Society of London* 24/302 (1705), second figure. Salmon's presentation is discussed in Leta Miller and Albert Cohen, *Music in the Royal Society of London, 1660–1806* (Detroit: Detroit Studies in Music Bibliography, 1987), 17, 66–67, 207; and Lindley, *Lutes, Viols, and Temperament*, 68–69.

independently placed frets that could be switched around to allow for the performance of pure triads in all keys. Thompson's guitar, however inventive, was far from practical. The frets were inserted into slots and not secured to the fingerboard in any way: Were the instrument to be turned upside down, the frets would simply fall out.[8]

In the twentieth century composers like Partch, Harrison, Tenney, Polansky, and others have created an impressive body of work in just intonation for guitar, multiple guitars, and guitar with other instruments. Some of these works call for *ad hoc*, custom made instruments, utilizing a variety of historical and novel approaches, whereas others employ inventive, non-permanent adaptations of standard guitars.

The use of guitars in this context is not haphazard. Guitars are common instruments, and both the steel-string acoustic and electric varieties are iconic elements of U.S. popular music. Harry Partch's works that include guitar, such as *Barstow* and *U.S. Highball* (1941/1968 and 1943/1955), follow a period the composer spent as a transient in California and the Southwest during the height of the Depression. A portable and common instrument like the guitar was the perfect choice for accompanying lyrics compiled from graffiti and late-night boxcar conversations among Partch and his fellow travelers—especially considering its connotations as a vernacular instrument. On the other hand, the existing just intonation compositions for guitar belong squarely in the contemporary concert repertoire, and they offer a unique combination of musical, theoretical, and cultural elements for criticism.

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[8] Lindley, ibid., 68–69.

Limits and Scope

The purpose of this study is to identify, chronicle, and analyze a portion of the U.S. repertoire of music in just intonation for guitar. Particular attention will be given to the approaches taken by composers and instrument builders to adapt existing instruments or to create new ones. The discussion will also investigate the aesthetic and philosophical implications of these approaches, especially with regard to the difficulty—if not outright impossibility—of having any kind of fretted, stringed instrument be accurately "in tune."

The main body of this dissertation consists of three case studies focused on Lou Harrison, James Tenney, and Larry Polansky. The reason for the selection of these composers lies in their historical importance, the volume of their production for guitar, and in the fact that they represent three generations of U.S. experimental composers. Also under consideration is a more heterogeneous group of contemporary composers, who have written more than a dozen new pieces for a specific just intonation resophonic guitar devised by Harrison in 2002.

Finally, this study hopes to contextualize the relationship of the just intonation repertoire for guitars with both the experimental music repertoire and the general classical guitar literature. Up to the beginning of the twentieth century, the vast majority of works in the classical guitar repertoire had been composed by guitarists, and it was largely through the commisioning and editing work of performers such as Andrés Segovia (1893-1987), Julian Bream (b. 1933), and John Williams (b. 1941)

that the repertoire expanded to include works by composers who did not play the instrument themselves.[9] Harrison's *Scenes from Nek Chand* (2002) is an elaborate example of the composer-performer collaboration paradigm, as the commission for a new guitar piece also yielded a uniquely retuned instrument, which in turn prompted sixteen additional compositions by fourteen composers. Conversely, Polansky offers new insights into the figure of the composer-performer, as his involvement with the guitar delves deeper into technical realms, employing extended techniques and novel tuning solutions to transcend the assumed limitations of the instrument.

There is much music fitting the criteria of the present inquiry that nonetheless has been excluded from it; most notably, the guitar music of Harry Partch. Although it represents an essential and undeniable precedent for the material under consideration, Partch's works for and with guitars make up a body of music that is perhaps too great to fit within the practical limits of this study. The list of compositions that include adapted guitars is sizeable: *Barstow*, *The Letter*, and *U.S. Highball* from *The Wayward* (1941–43, several subsequent revisions); seven pieces from *Eleven Intrusions* (1949–50, no. 3, 4, 5, 8, 9, 10, and 11); *Ring Around the Moon* (1949–1950); *Oedipus* (1950/1952–54/1967); *Even Wild Horses* (1952); *Revelations at the Courthouse Park* (1960); *And on the Seventh Day Petals Fell in Petaluma* (1963–66); and *Delusion of the Fury* (1965–66). In addition, in order to offer a substantial contribution to existing Partch scholarship, the project have to include a detailed

[9] For a review of this historical phenomenon see Stephen Goss, "The Guitar and the Musical Canon," *The Journal of the European Guitar Teachers' Association* (July 2000): 7–8.

organological analysis, including a study of the surviving instruments; a musical and technical review of the guitar writing in Partch's scores, especially with regard to his use of notation and tablature; and a survey of existing historical and modern recordings. The resulting monograph-length discussion would upset the balance (and realistically, the feasibility) of the present dissertation. As such, I chose to focus on the approaches taken by Partch's musical heirs, and deferred the exploration of Partch's own guitar works to a future date.

There are also numerous examples of instruments modified to play in temperaments other than 12TET—such as, for example, the 19TET guitars necessary to perform the music of composers Ivor Darreg (born Kenneth Vincent Gerard O'Hara, 1917–1994), and Easley Blackwood Jr. (b. 1933), or the numerous works calling for quarter-tone guitars.[10] As these are examples of a different compositional aesthetic (one not always concerned with the ratios of the harmonic series), they will not be included in my discussion.

Literature Review

The existing literature related to just intonation in U.S. music falls into three broad categories: reviews of historical tuning systems; theoretical essays, often written by composers working in this genre; and historical, biographical, and

[10] See, for example, the guitar works of Mexican composer Julian Carrillo (1875–1965), *Invocation* (1998, for ensemble) by Ezra Sims (b.1928), and *Renvoi/Shards* (2008, for quarter-tone guitar and quarter-tone vibraphone) by Brian Ferneyhough (b. 1943).

analytical writings on experimental and mainstream concert music. A further subset of literature consists of the several journals and newsletters that were published primarily in California from the 1970s to the early 1990s by composers, instrument builders, and theorists working with just intonation and other tuning systems. Especially relevant to this discourse is the *Xenharmonic Bulletin* (1963–1992), in which Ivor Darreg discusses several guitar fretting patterns, as well as the musical and aesthetic properties they entail; and *Xenharmonikon* (1974–1998), which contains theoretical and instrument-building essays by Harrison, Polansky, Ervin Wilson, and John Chalmers. Other publications such as *Interval* (1978–1987), *Experimental Musical Instruments* (1985–1999), and *1/1* (1986–2007), the official journal of the Just Intonation Network, provide additional context for the alternative tuning community in which all of the composers subject to this study, to one degree or another, were involved. A text related specifically to this musical scene is David Doty's *Just Intonation Primer*, which was originally published by the JI Network in 1993, and is now available directly from the composer's website. The *Primer* provides a terse overview of contemporary tuning theory, including models for analysis and a comprehensive reference of technical terms, and represents an invaluable resource for those approaching this complex subject.[11]

Although historical tuning surveys, such as J. Murray Barbour's *Tuning and Temperament*, usually stop short of the twentieth century, they still provide context

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[11] David Doty, *The Just Intonation Primer: an Introduction to the Theory and Practice of Just Intonation*. (San Francisco, CA: Just Intonation Network, 1993).

with their discussion of technical and theoretical approaches to the many problems of tuning. Barbour's evaluation of just intonation is quite critical, because he approaches tuning from the point of view of common practice musical and harmonic standards. Furthermore, he compares just tunings in terms of their deviation from the model of twelve-tone equal temperament—an approach that, however practical, confirms the author's theoretical bias.[12] Barbour's failure to appreciate just tunings from an aesthetic or experimental point of view is even more apparent in his 1950 review of Harry Partch's *Genesis of a Music*, in which he lambasts the composer's system for losing "all power of transpositions" and having modulation take on "a different meaning."[13] It goes without saying that the point of Partch's musical and compositional endeavors may have been lost on the older, more conservative critic.

Lindley's *Lutes, Viols, and Temperaments* also stops short of investigating the past century. Nevertheless, Lindley chronicles the theoretical, organological, and practical implementation of just, meantone, and tempered tunings on fretted stringed instruments from the Renaissance to the nineteenth century—including accounts of some of the organological oddities mentioned previosuly.[14]

Another relevant historical and theoretical tuning survey is found in John Chalmers's *Divisions of the Tetrachord.* Chalmers, an active member of the California

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[12] J. Murray Barbour, *Tuning and Temperament: A Historical Survey* (New York: Da Capo, 1972).

[13] J. Murray Barbour, "Review," *The Musical Quarterly* 36.1 (1950), 131–135.

[14] Mark Lindley, *Lutes, Viols, and Temperaments* (Cambridge: Cambridge University Press, 1984)

just intonation scene in the 1970s and 1980s, and currently an astrobiologist at the University of California, San Diego, reviews the historical approaches from Greeks and Near Eastern sources to the question of the division of the perfect fourth into smaller ratios. Chalmers catalogues all possible divisions using the 81:80 syntonic comma as a practical limit. The project, which took several years to complete, was inspired by Chalmers's work with Harrison (who had envisioned a "Great Book of Modes" for his projected "Modal Room"), and saw the involvement of Polansky (who oversaw publication through Frog Peak) and of composer Carter Scholz (who edited the text and designed the figures). As such, *Divisions of the Tetrachord* is a perfect example of—and testament to—the kind of enthusiastic and meticulous approaches taken by the members of the California tuning community.[15]

A much earlier work, Hermann von Helmholtz's *On the Sensations of Tones as a Psychological Basis for the Theory of Music* (first English edition published in 1875) is a foundational text of modern acoustics and musical perception, as well as their impact on music theory. Helmholtz was an advocate of five-limit just intonation due to its acoustical purity, and argued that both singers and violinists would naturally lean towards natural intervals, rather than tempered ones. [16] In addition to his rigorous methodology, his discussion of acoustical phenomena such as overtones, combination tones, and difference tones proved a fundamental influence for subsequent

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[15] John Chalmers, *Division of the Tetrachord*, (Hanover: Frog Peak Music, 1993).

[16] Hermann von Helmholtz, *On the Sensations of Tone*, (Mineola: Dover, 1958), 316–330.

acoustically-minded writers and composers, such as Henry Cowell and Harry Partch.

Cowell's *New Musical Resources* is among the first and most extensive theoretical texts by a twentieth-century composer to deal with issues of intonation. Cowell based much of his discourse on the ratios of the harmonic series, suggesting their application not only to the tuning of pitches, but also to the organization of rhythm, tempo, meter, and dynamic levels. For instance, Cowell applied the 3:2 ratio of the perfect fifth to rhythmic proportions in some of his works; he also designed the Rhythmicon, an instrument capable of reproducing complex polyrhythms according to the ratios of the overtone series, and realized in 1932 by musical inventor Lev Termen.[17] Most crucially, echoes of various aspects of Cowell's theories can be found throughout the works of Harrison, Tenney, and Polansky, as will be noted in the relevant chapters.

Partch's monograph *Genesis of a Music* is structured as a (somewhat opinionated) historical review of tuning practices, a theoretical/aesthetic manifesto, and a descriptive account of his instruments and some of his compositions. The discussion of the three guitars Partch adapted to play in his Monophonic system represents one of the few written discussion of the instruments; however, Partch's description lacks measurements and details of construction.[18] Literature on Partch, such as Bob Gilmore's recent monograph, does not discuss these guitars

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[17] Henry Cowell, *New Musical Resources* (New York: Knopf, 1930).

[18] For a discussion of his guitars, see Harry Partch, *Genesis of a Music.*, 203–207

extensively;[19] even Richard Kassel's critical edition of the 1968 version of *Barstow* does not treat the guitar featured in the composition in more than a passing manner.[20] Among other notable studies of Partch, Bradford Blackburn's recent dissertation analyzes the modulatory possibilities inherent in the Monophonic system, as well as the relationship between Partch's concept of Corporeality and the kinesthetic elements of performing on his array of custom-made instruments. Part of Blackburn's project included the recreation of some of Partch's instruments, including the Adapted Guitar II; unfortunately, there are no organological details other than a few pictures.[21]

Throughout his career, Ben Johnston has articulated his compositional philosophy in a series of essays, recently reissued in the collection *Maximum Clarity*. Johnston's contribution to the field of just intonation includes both the practical application of theoretically infinite tuning matrices (what the composer calls "extended just intonation"), and the development of a generalized notational system, which utilizes novel accidentals derived from the successive partials of the overtone series to indicate pitches factored by higher, more complex ratios. One drawback of Johnston's notation is that it assumes the tuning of a 5-limit just intonation scale on C

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[19] Bob Gilmore, *Harry Partch: A Biography* (New Haven: Yale University Press, 1998).

[20] Richard Kassel, *Harry Partch: Barstow—Eight Hitchhiker Inscriptions from a Highway Railing at Barstow, California [1968 Version]*, Music of the United States of America, 9 (Madison: AR Editions, 2000).

[21] Bradford Blackburn, *Tonal Modulation with Just Intonation; Corporeality and Musical Gesture: In the Music of Harry Partch*, Dissertation (D.M.A.), University of Illinois at Urbana-Champaign, 2006.

as its point of departure, requiring the use of more complex accidentals when the music is based on a different or distant fundamental (such as an equal-tempered pitch).[22]

Among other writings by composers, Lou Harrison's *Music Primer* concerns itself mostly with pedagogical matters.[23] Of the scholarly texts addressing Harrison's life and works, Leta Miller and Fredric Lieberman's two monographs discuss his involvement with just intonation and instrument building in depth. In the introduction to *Lou Harrison* the authors also discuss *Scenes from Nek Chand* (the piece for which the just intonation resophonic guitar was created), albeit without going into great organological detail.[24] Heidi Von Gunden's earlier publication on the music of Harrison does not explore the composer's use of tunings in a particularly detailed fashion, nor does she linger on Harrison's involvement with guitars and other fretted instruments beyond passing references.[25]

Until recently, one of the few monograph-length analyses of James Tenney's works was *The Early Music of James Tenney*, written by Larry Polansky for the publication series *Soundings.* Polansky discusses Tenney's output up to the early

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[22] Ben Johnston and Bob Gilmore, "*Maximum Clarity*" *and other Writings on Music* (Urbana, IL: University of Illinois Press, 2006).

[23] Lou Harrison, *Music Primer* (New York: Peters, 1971).

[24] Leta Miller and Fredric Lieberman, *Lou Harrison: Composing a World* (New York: Oxford University Press, 1998), and Miller and Lieberman, *Lou Harrison* (Chicago: University of Illinois Press, 2006).

[25] Heidi Von Gunden, *The Music of Lou Harrison* (Metuchen, N.J.: Scarecrow Press, 1995).

1980s, laying the foundation for any subsequent analysis.[26] He also addresses Tenney's theoretical work, providing a valuable commentary on both *META+Hodos* (in which Tenney suggests an *gestalt* approach to the analysis of modern music) and *A History of "Consonance and Dissonance,"* Tenney's survey of changing harmonic theories from antiquity to the common practice period.[27] Tenney's theoretical writings constitute a fundamental theoretical framework for the analysis of his own and other contemporary music. Particularly relevant to this study is the definition of "harmonic space" that can be found in Tenney's paper "John Cage and the Theory of Harmony."[28] This latter article, first published in 1983, is included in the 2008 issue of the *Contemporary Music Review*, edited by Robert Hasegawa and dedicated to recent scholarship on Tenney; it includes articles examining his late works as well as the ramifications of his harmonic and stochastic theories.[29] Another relevant study of the formal and compositional aspects of Tenney's works is composer Brian Belet's dissertation, which includes a detailed analysis of *Changes* (1985), one of Tenney's

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[26] Larry Polansky, "The Early Music of James Tenney," in *Soundings 13: The Music of James Tenney* (Santa Fe: Soundings Press, 1983).

[27] James Tenney, *META+HODOS: A Phenomenology of 20th Century Musical Materials and an Approach to the Study of Form* (Oakland: Frog Peak Music, 1986); and James Tenney, *A History of 'Consonance and Dissonance'* (New York: Excelsior, 1988).

[28] James Tenney, "John Cage and the Theory of Harmony," in *Soundings 13: The Music of James Tenney*, Peter Garland, ed. (Santa Fe, Soundings Press, 1983).

[29] Robert Hasegawa, ed., "The Music of James Tenney," *Contemporary Music Review*, 27.1 (2008); includes writings on Tenney by Robert Wannamaker, Michael Winter, Marc Sabat, and others.

most ambitious and harmonically complex scores.[30]

Larry Polansky's guitar works have so far attracted the attention of performers more than scholars.[31] In 2010 New World Records released a retrospective recording of his compositions for guitar, which are performed regularly in Europe as well as in the United States.[32] In addition to having composed hundreds of pieces, Polansky has also produced a wealth of theoretical and critical texts.[33] As Polansky's guitar music reflects his multiple interests—from intonation to algorithmic composition, from Shaker melodies to impressive displays of virtuosity—an in-depth study that relates it to the U.S. just intonation tradition is warranted, and will address a significant gap in the existing scholarship.

Methodology and Theoretical Framework

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[30] Brian Belet, *An Examination of the Theories and Compositions of James Tenney, 1982-1985*. Ph.D. Dissertation, University of Michigan, 1991.

[31] One of the few exceptions is the section dedicated to Polansky in Kyle Gann's *American Music in the Twentieth Century* (New York: Schirmer, 1997), 375–380. Gann, a composer himself and an advocate of just intonation, also gives attention to Harrison and Tenney in earlier sections of the book, but (unsurprisingly) does not dwell on their compositions for guitar.

[32] Larry Polansky, ZWERM, et. al., *The World's Longest Melody* (New York: New World Records, 2011).

[33] Several of these texts, and most of his compositions, are freely available on the composer's website: http://eamusic.dartmouth.edu/~larry/

This study is constructed on the basis of archival research; musical analysis of scores and recordings; an organological analysis of the instruments modified or adapted to play in just intonation; and oral histories.

Given that there is not one "just intonation," but rather an infinite variety of tunings employing just ratios, the theoretical and tuning systems employed by each composer must be clearly defined. Harry Partch was one of few composers to adopt a single, overarching tuning system—the closed forty-three note scale detailed in *Genesis of a Music*; in contrast, Harrison's, Tenney's, and Polansky's approaches varied throughout their careers. In general terms, Harrison's output for guitar falls in what he would call his "Strict Style" category, that is to say compositions employing a single mode with a limited (and often small) number of pitches, tuned in just ratios and without cognates. By comparison, in the works that Lou Harrison composed in his "Free Style," any particular note could vary in tuning, as pitches are determined solely by the ratios between adjacent notes (either melodically or harmonically). Tenney's and Polansky's approaches changed similarly throughout the years, and they tended to incorporate a higher degree of complexity in their harmonic and tuning endeavors. Although comparative analysis is not one of the purposes of the present study, the theoretical works of Johnston, Doty, and the "Extended Helmholtz-Ellis JI Pitch Notation" system developed by Marc Sabat and Wolfgang Von Schweinitz will provide a common set of tools for the analysis of the entire repertoire under

scrutiny.[34]

The Helmholtz-Ellis notation system takes an approach similar to Johnston's; however, it departs from a chain of consecutive Pythagorean fifths/fourths, as opposed to defining every accidental in relation to C=1:1. A set of special accidentals indicate the distance in cents between a higher-prime interval and a melodically "nearby" interval, which is calculated using lower prime factors. For example, a downward arrow turns the conventional accidental specifying a 3-limit Pythagorean third (81:64) into its 5-limit just major third (5:4) counterpart, or 21.5¢; a small numeral seven indicates the difference between the harmonic minor seventh (7:4) and the Pythagorean minor seventh (16:9), or 27.3¢. The result is a precise and unequivocal notation system that greatly benefits the analysis and performance of complex just intonation pieces; this study will adopt the Helmholtz-Ellis accidentals (with the addition of cents deviation when additional clarity is needed) throughout.

Archival Sources

The principal archival sources include: the Lou Harrison Archives, Special Collections, McHenry Library, University of California, Santa Cruz; the James Tenney Fonds, Clara Thomas Archives, York University, Toronto; the estate of James Tenney, Los Angeles, CA; and the private archive of Larry Polansky, Hanover, NH.

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[34] The notation is introduced and explained in a document published on the Plainsound music collective website: Marc Sabat and Wolfgang Schweinitz, "The Extended Helmholtz-Ellis JI Pitch Notation," Plainsound Music Edition Website, http://www.marcsabat.com/pdfs/notation.pdf

Overview of Dissertation Chapters

Chapter One focuses on the unique resophonic guitar adapted to an eleven-limit just scale for the composition and performance of Lou Harrison's last finished piece, *Scenes from Nek Chand* (2002). This instrument, which immediately reminds the listener of various U.S. popular musics, such as Hawai'ian, Country, and Blues, has since sparked the interest of several other composers—including Polansky, Scholz, Terry Riley, and Ron Nagorcka—who went on to produce close to twenty additional pieces for this strange and fascinating guitar. The chapter traces Harrison's inspiration for the piece, outlines the history of resophonic guitars since their invention in the late 1920s, and documents the composer's own involvement with guitars throughout his career. A detailed analysis of the theoretical and practical implications of the guitar's modified tuning, as well as a musical analysis of the composition itself, constitutes the central part of this discussion. Finally, a selection of other pieces for the just resophonic guitar concludes the chapter by offering a sample of Harrison's lasting influence and the performance legacy of the instrument he created.

Chapter Two is dedicated to the guitar music of James Tenney and provides an example of an alternative solution to adapting guitars to perform in just intonation. None of the pieces discussed in this chapter requires a custom-made instrument or any kind of permanent modification to a standard-issue guitar. After a brief biographical and stylistical overview, Tenney's music will be analyzed in terms of its

theoretical and practical tuning approaches: *Harmonium II* (1976, 2005), *Septet* (1981), *Water on the Mountain…Fire in Heaven* (1985), and *Spectrum 4* (1995). All of these pieces reflect Tenney's continuing interest in the harmonic series, fitting in a coherent context with earlier pieces such as *Quintex* (1972) and *Spectral Canon for Conlon Nancarrow* (1974). Tenney's writing for guitar defies conventional practices, yet remains idiomatic and accessible. Most notably, this chapter includes works that employ higher-division equal temperments to approximate just ratios, and discusses the techincal and aesthetic ramifications of this choice.

Larry Polansky's approach to just tunings on the guitar is perhaps the most sophisticated of this group, due in part to his own familiarity with the instrument as a performer and improviser. Chapter Three will analyze his large output for guitar in just intonation, highlighting connections to the works of Tenney and Harrison, as well as the unique preoccupations of Polansky's poetics. The guitar pieces under consideration include both traditional and adapted guitars: *The Schneider Variations* (1995); *for jim, ben, and lou* (1995); *ii-v-i* (1997); *ivtoo* (2000); *toovviivfor* (2002); Four Voice Canon #17 (2002); *Yitgadal* (2003–04); *freeHorn* (2004); *Songs and Toods* (2005); *10 Strings, 9 Events* (2011); and *9 Events* (quartet version, 2011).

The final chapter will consider some additional examples from the U.S. just intonation guitar scene, such as the employment of a guitar with independently moveable frets in Ben Johnston's *The Tavern* (1998–2008), and the harmonic series compositions for electric guitar orchestra of Rhys Chatham (b. 1952) and Glenn

Branca (b. 1948). In addition, it will also discuss some instances of the cross-pollination of just tunings from experimental to broader, popular music contexts. These and other recent developments will attest to the breadth, depth, and vitality of the just intonation repertoire for guitar, providing a fitting conclusion for this study—the kind of history that should be considered a continuing work in progress.

Chapter One
Reminiscence, Reflections, and Resonance: The Just Intonation Resophonic Guitar and Lou Harrison's *Scenes from Nek Chand.*

> While mother played an afternoon of Mah Jong with friends, we children listened to records or the radio. We heard a lot of Hawaiian music and I can remember the sliding and waving guitar tones over a gap of almost eighty years. The wonderful sculpture and architecture of Nek Chand, near Chandigarh, set me to composing three small pieces in admiration.
>
> —Lou Harrison[1]

On a fall morning in 2001, guitarist David Tanenbaum and luthier Kenny Hill drove to Lou Harrison's house in Aptos, California in a station wagon full of guitars. Tanenbaum had received word from Charles Amirkhanian, director of the Other Minds festival of contemporary and avant-garde music in San Francisco, that Harrison had accepted a commission for a new guitar piece—on some conditions. The composer was not interested in writing for the classical guitar, an instrument that he found lacking in power and sustain, and favored the use of just tunings over equal temperament.

Tanenbaum's "audition" began with his own most prized, French-made

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[1] Lou Harrison, introductory notes to the MS score of *Scenes to Nek Chand*. The MS is housed in the Lou Harrison Archive, Special Collections, McHenry Library, University of California, Santa Cruz (hereafter: UCSC McHenry). The full text of this note, including the original dedications, can be accessed through the Other Minds archives, www.archive.org/details/OM8HarrisonScenesfromNikChand (sic).

classical guitar: "First I tried a Friederich for him, and then Kenny and I loaded a station wagon with lots of types of guitars—steel, twelve-string, Dobro—and Lou always said no."[2] Hill then thought of Dave Scully, a Santa Cruz street musician who performed on an old metal-body tricone resonator guitar. Hill and Tanenbaum located the busker, borrowed his guitar for an afternoon in exchange for lunch money, and brought it back to Harrison, who instantly and enthusiastically approved of the sound. Tricone resonators, which were especially popular in the 1920s and 30s, use three wafer-thin spun aluminum cones, which are connected to the strings through a T-shaped bridge and resonate sympathetically to increase volume and projection; the individual cones can sometimes vibrate slightly out of phase with one another, producing a characteristic wavering vibrato effect.

Having found an acceptable instrument, Harrison composed a piece in just intonation, inspired not only by the unique tone of the tricone resonator, which reminded him of Hawaiian music he heard on the radio as a child, but also by the imaginative work of Nek Chand (b. 1924), a self-taught sculptor and architect from India and the creator of the Rock Garden of Chandigarh. Around the time of the Other Minds commission, Harrison encountered a retrospective feature on Nek Chand in a book dedicated to outsider art, and found the visuals, as well as the artist's story, particularly moving.[3] In 1965, while working as a roads inspector for Chandigarh's

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[2] David Tanenbaum, personal communication with the author, 7 February 2010.

[3] Lou Harrison, interview with John Schneider, 2002. The book Harrison refers to is likely John Maizels, *Raw Creation: Outsider Art and Beyond* (London: Phaidon Press, 1996), 215–25.

Public Works Department, Nek Chand began developing a series of interlinked courtyards in a greenbelt area, incorporating sculptures made of found objects and recycled materials. Local authorities discovered this unsanctioned development in 1972; yielding to public pressure, they spared the garden from demolition and granted the artist a permanent workforce for expansion and upkeep in 1976.[4] As I will explain, these two seemingly disparate inspirational sources—the resophonic guitar used in Hawaiian music and the art of the Indian Nek Chand—in fact share a common historical link, the kind of cross-cultural connection that fascinated Harrison throughout his life.

Scenes from Nek Chand was commissioned with funds from Los Angeles new music patron Betty Freeman. It bears a dedication to Charles Amirkhanian, his wife Carol Law, and guitarist David Tanenbaum, who presented the premiere on 7 March 2002 at the eighth annual Other Minds festival in San Francisco. The work was recorded soon after, not only by Tanenbaum, but also by John Schneider, a guitarist who has specialized in microtonal and just intonation music, and who contributed to the difficult process of creating a just intonation fingerboard for the tricone resonator. Both his recording and Tanenbaum's were released within days of each other in June

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[4] The story as understood by Harrison can be found in Maizels, *Raw Creation*, 215 and 220. Iain Jackson offers a more critical account in "Politicised Territory: Nek Chand's Rock Garden in Chandigarh," *Global Built Environment Review* 2/2 (2002): 51–58. It should be noted that Nek Chand's work has taken on environmental and political dimensions. This is due both to Chand's use of recycled—but also misappropriated—materials, and to the development of the Rock Garden in spite of stringent urban planning, which had been devised by French Architect Le Corbusier to showcase the city of Chandigarh as the utopian symbol of a modernized and westernized India. More (and contrasting) information on the Nek Chand Foundation can be found at www.nekchand.com and www.nekchand.info.

2003.[5] As Harrison's last completed piece, *Scenes from Nek Chand* combines his lifelong interests in alternative tunings, instrument-building, and cross-cultural pollination. Perhaps most surprisingly, Harrison's visionary (if impractical) instrument choice would be validated by the many composers who have been writing for the just intonation resophonic guitar since the piece's premiere, thus contributing to an alternative guitar repertoire for the new millennium.

Fretting Matters: Lou Harrison and the Guitar

Harrison's experiments with different tuning systems on the guitar date to 1952, when he sent a one-page manuscript piece, *Serenado por Gitaro*, to composer Frank Wigglesworth. In an accompanying letter, Harrison suggested that the guitar could be tuned diatonically if an instrument with moveable frets were available.[6] He might have been thinking of lutes, however; in 1952 guitars with moveable frets would not have been easy to find (and gut-fretted lutes would have been in similarly short supply). Harrison had been obsessed with just intonation ever since he read Harry Partch's *Genesis of a Music* in 1949, and this letter shows that the possibility of

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[5] Lou Harrison, Harry Partch, et al., *Just Guitars,* John Schneider, guitar (Bridge 9132); Lou Harrison, *Serenado.* David Tanenbaum, guitar (New Albion 123); both recordings are in just intonation. There is also a more recent recording by Giacomo Fiore (GFCD 2011).

[6] Harrison's proposed scale is Ptolemy's "Intense Diatonic," also known as the 5-limit just major scale. In harmonic and tuning parlance, limits describe the highest prime factor allowed in the computation of the intervals of a musical scale or tuning sequence. Thus a 5-limit scale only contains intervals derived from the octave (prime factor 2), the perfect fifth (3) and the just major third (5).

pure intervals on the guitar was already on his mind.[7]

In 1977 Harrison met Tom Stone, the inventor of a system of interchangeable fingerboards for guitars and other fretted instruments called Switchboards. The design allowed the player to secure a number of different fingerboards to a specially made neck, thus enabling the use of a variety of tuning systems on the same instrument—not unlike what the English mathematician Thomas Salmon had advocated nearly three centuries earlier in a paper presentated to the Royal Society of London.[8] Fascinated with the idea, Harrison arranged to have such a guitar made to assist in the composition of five suites for the instrument, each in a different tuning. The first of these planned works, the *Serenade for Guitar and Optional Percussion*, was completed in 1978. The tuning is based on a 5-limit octatonic scale that contains only two sizes of whole and half steps.[9] Unfortunately, Stone never delivered the promised guitar, leading Harrison to incorporate the early sketches of a second suite into what is now the *String Quartet Set* (1979).[10] Both *Serenado* and the *Serenade* can be performed in equal temperament, and they constitute the foundation of Harrison's

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[7] Lou Harrison, letter to Frank Wigglesworth (Lou Harrison Music Manuscripts, MS 132, ser. 1, UCSC McHenry).

[8] Thomas Stone, *Fretted Musical Instrument with Detachable Fingerboards for Providing Multiple Tonal Scales* (U.S. Patent 4,132,143, filed January 6, 1977 and issued January 2, 1979). Salmon's fretting system for viols is discussed in the introduction, as well as in Leta Miller and Albert Cohen, *Music in the Royal Society of London, 1660–1806* (Detroit: Detroit Studies in Music Bibliography, 1987).

[9] For a discussion of the tuning of the *Serenade* see Bill Alves, "The Tuning of Lou Harrison's *Serenade for Guitar and Optional Percussion*," http://www.billalves.com/porgitaro/serenadetuning.html.

[10] Lou Harrison, interview with John Schneider. Joshua Tree, CA, 2002. (UCSC McHenry).

repertoire for guitar. In addition, guitarists such as Tanenbaum and Schneider have since labored tirelessly (with the composer's blessing) to adapt Harrison's pieces for other plucked strings for performance, and many of his harp and harpsichord pieces have now become popular as guitar transcriptions. More recently, Schneider completed a series of "suites" in different modes by grouping pieces according to their tunings; by using removable fingerboards, the suites can be performed as a set, as Harrison originally intended.[11]

Rather than employing removable fingerboards, the guitar for *Nek Chand* requires a fixed and highly idiosyncratic fretboard to accommodate Harrison's tuning scheme, which is based on pure ratios of the sixth through eleventh harmonics. In addition to performers Tanenbaum and Schneider, the conversion of the instrument involved collaboration with a number of other figures. The details of the tuning calculations were worked out by Bill Slye (1970–2010), a young guitarist/composer from the University of California, Santa Cruz who had been studying informally with Harrison in Aptos. Slye worked with Bill Alves, a Southern California composer and codirector (with Schneider) of the microtuning festival MicroFest. Slye also recruited Don Young, CEO of National Reso-Phonic Guitars of San Luis Obispo, California, to help with the production of the custom instruments. By May 2002 National Reso-Phonic had built five just intonation tricones, two of which were intended as "loaners" to be circulated among guitarists and composers to stimulate further pieces

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[11] Lou Harrison, *Por Gitaro,* John Schneider, guitar, Mode Records 195, 2008.

for the instrument. Currently four of these guitars are owned by Schneider, Tanenbaum, guitarist Elliot Simpson (The Hague), and composer Garry Eister (Santa Maria, California). The fifth instrument is currently on loan to guitarist/composer Alex Wand (b. 1986).[12]

Harrison's choice of a specialty guitar should not come as a surprise. He had written works for found, foraged, or newly constructed instruments since the 1930s, and had learned that performers (often his friends) were willing to indulge him.[13] For Harrison, the quality of the sound itself was paramount, and he would sooner build a new instrument than make do with one that could not deliver his ideal sound; he also vociferously eschewed amplification, always opting to resolve matters of volume and balance by means of instrumentation and orchestration. For example, in his *Concerto for Pipa with String Orchestra* (1997), Harrison chose the Chinese lute for its ability to be heard over the orchestral ensemble, thinning out the accompaniment in the quieter passages.[14]

In the case of the classical guitar, Harrison had pointed to its short sustain and overall lack of power as the main drawbacks of an instrument for which he otherwise felt an affinity.[15] The tricone resonator addressed all of these issues, offering a louder,

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[12] As we will see in the concluding portion of this chapter, the number of "unofficial" copies of resonator guitars retrofitted with this particular fretting pattern is continuing to grow.

[13] See Miller and Lieberman, *Composing a World: Lou Harrison, Musical Wayfarer*, 127 ff.

[14] Leta Miller, personal communication with the author, 17 February 2010.

[15] David Tanenbaum, personal communication with the author, 7 February 2010. Also Lou Harrison, interview with John Schneider, Mode 195.

richer, and more sustaining timbre produced in an entirely acoustic way. From an extra-musical point of view, the instrument also mirrors the piece's inspiration; through the filter of Harrison's imagination, the resophonic guitar has been thought anew, repurposed from its previous context like the recycled sculptures of Chand's fantastical gardens.

Part One: Reminiscence—Tracing the History of Harrison's Inspirations

In his inscription to the score of *Nek Chand*, Harrison refers to the music of the Hawaiian Craze of the 1920s and 1930s as an inspiration; the sound of those "sliding and waving guitar tones" was the sound of the tricone resonator-equipped steel guitar. "Steel guitars" are referred to as such not because of the material from which they are built, but because of the manner in which they are played. Instead of fretting individual strings with the left hand, the strings are stopped by a metal rod typically called a "steel," which is made of polished steel, brass, ceramic, or glass. Because the strings are tuned to various triadic configurations, the rod can be used to slide single-note lines as well as chords. This method of playing, which originates in late nineteenth-century Hawaiian practices, features the guitar held flat in the lap for better access. Because the sliding hand approaches the fingerboard from above, rather than reaching around the neck as with the traditional playing position, Hawaiian makers began to modify the typical Spanish design around the turn of the century. Necks were hollowed out and built using a square, rather than D-shaped, section,

increasing structural strength and resonance, and steel strings supplanted gut and silk.[16]

Some of these design elements, popularized in the early decades of the twentieth century by notable guitarmakers such as Chris Knutsen and Oscar Weissenborn, are apparent in the work of John Dopyera, a Slovak immigrant with a penchant for innovation, as attested by the patents he filed for improved neck-setting methods for violins, and mechanical optimization of banjo heads.[17] In 1924 Dopyera was approached by George Beauchamp, a vaudeville guitar player who was looking for a louder, better projecting guitar. Dopyera had already been considering various resonating devices, and through Beauchamp's prodding he finally designed the tricone resonator in 1926, receiving patents in 1928, 1929, and 1930. Dopyera's original design was a metal-bodied instrument with a square neck meant exclusively for slide playing.[18] Round-neck, Spanish-style tricone guitars followed by the end of

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[16] Hugh Davies, "Hawaiian Guitar" *Grove Music Online*, ed. Deane Root, www.grovemusic.com. Although square-necked guitars are most common for playing with a steel, any guitar can be converted to this style by raising the strings at the nut, so that they would still clear the frets under the weight of the rod.

[17] On Knutsen's designs, such as the "symphony" or harp-guitar with its hollow soundboard extension, and his influence on other luthiers see George T. Noe and Daniel L. Most, *Chris J. Knutsen: From Harp Guitars to the New Hawaiian Family: History and Development of the Hawaiian Steel Guitar* (Everett, WA: Noe Enterprises, 1999), 12–15 and 102–6; and Gregg Miner, *The Knutsen Archives*, www.harpguitars.net/knutsen/knutsen_home.htm.

[18] See U.S. patents 1762617, www.google.com/patents/US1762617; 1741453, www.google.com/patents/US1741453; and D76382, www.google.com/patents/USD76382.

1928.[19]

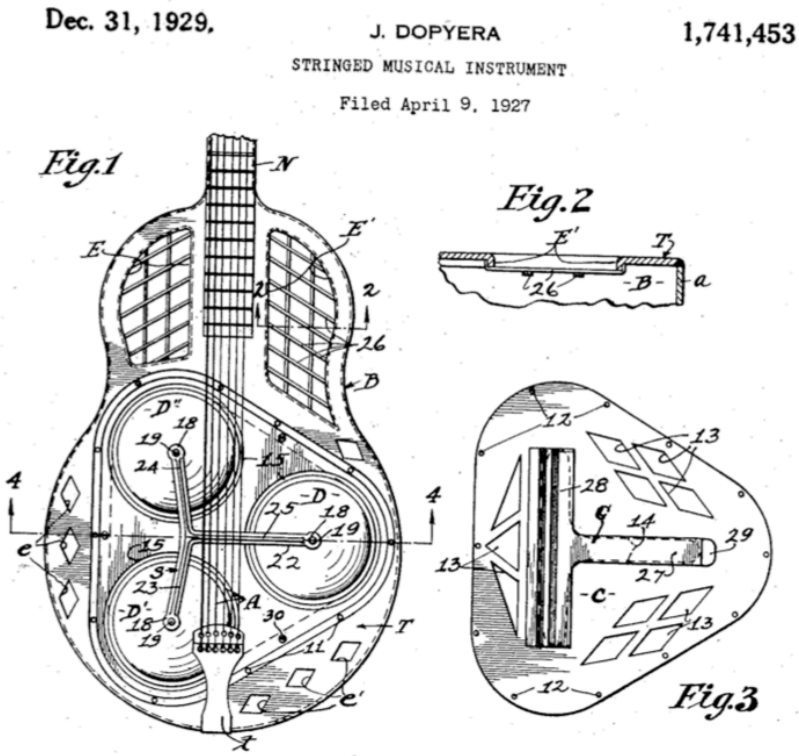

Figure 1.1 Illustration from one of John Dopyera's patents for the tricone resophonic guitar.

The collaboration between Dopyera and Beauchamp led to the birth of the National Resonator Instruments company in 1927; however, the entrance of the United States into the Second World War effectively halted production and led to the dissolution of the company.[20] Nationals from the 1930s became extremely rare,

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[19] Bob Brozman, John Dopyera, et al., *The History & Artistry of National Resonator Instruments* (Fullerton, CA: Centerstream Publishing, 1993), 27–29. Brozman presents extensive documentation concerning the company's genesis, the birth of Dopyera's Dobro Company, and the successive invention of the single-cone resonator.

[20] Brozman, *National Resonator Instruments,* 43.

sought after by collectors and performers alike beginning with the folk revival of the late 1950s and early 1960s. In more recent years, new instruments have been re-created according to the original specifications by National Reso-Phonic Instruments of San Luis Obispo, California—the company that would eventually bring to life the uniquely tuned Lou Harrison tricones.

Among the many musicians using National guitars, Sol Hoopii (1902–53) is generally credited as the first Hawaiian player to adopt a tricone resonator; he was given a guitar by National as early as 1926, and was featured extensively in the company's catalogs. Through his activity in Hollywood and in the recording studio, Hoopii established a permanent link between Island music and the sound of a resonator. He provided the soundtrack for popular Hawaiian-themed movies such as *Bird of Paradise* (1932), *Waikiki Wedding* (1937), and the cartoon feature *Betty's Bamboo Isle* (1937), and recorded dozens of traditional Hawaiian numbers for Columbia and Brunswick.[21] Other influential players such as the Tau Moe Family, Sam Ku West, Jim and Bob of "The Genial Hawaiians," and David Kane also performed on National tricones.[22] The soundscape they created pervaded the country.[23] Radio programs of Hawaiian music date to 1923, and many stations held

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[21] Ibid., 115–16.

[22] Ibid., 121–34.

[23] This popularity of Hawaiian guitars in the 1920s and beyond represents the efforts of a second generation of performers. Most Hawaiian musicians consider Joseph Kekuku (1874–1932) the founder of the style that grew to be so popular in the following decades; an alternative interpretation suggested by Mantle Hood will be explored later. For several versions of the Kekuku story, see Lorene Ruymar, *The Hawaiian Steel Guitar and its Great Hawaiian Musicians* (Anaheim Hills, CA: Centerstream Publishing, 1996), 2–11.

weekly shows dedicated to the style, such as the popular *Hawaii Calls* (1935–75); the music had in television debut in October 1939 when the Honolulu Serenaders appeared on a broadcast by the Farnsworth Television and Radio Corporation.[24] Musicians in other genres, such as Western swing bands in the Texas-Louisiana-Oklahoma region, and bluesmen in the Mississippi Delta also adopted resonator instruments.[25] Tricone resonator guitars are still employed in popular genres today, from Hawaiian and country to fingerstyle guitar and blues. Thanks to Harrison's determination, they have also found an unexpected niche in the classical guitar repertoire.

The Tuning of *Nek Chand*'s Guitar

The exploration of just tuning systems constitutes one of the main features of Lou Harrison's mature style. The composer, who preferred pure intervals to the otherwise predictable and limited palette of intervals available in equal temperament, developed what had been a youthful interest into enthusiastic endorsement and, ultimately, complete philosophical advocacy. This process can be seen as a quest for freedom; to Harrison, the identical intervals of equal temperament were ultimately colorless next to the microtonal gradations provided by a system of pure harmonic ratios. He incorporated intonational considerations into his music in a remarkably organic way,

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[24] Ruymar, *Hawaiian Steel Guitar*, 46–56.

[25] Although the Hawaiian recordings of the 1920s reputedly influenced early Western swing steel guitar players, the link between "bottleneck" slide blues and Island music is still a matter for speculation. Ibid., 49–51.

as shown by the number of instruments he designed and crafted to produce his required tones; stylistically, he often employed homophonic textures to allow tuning and temperamental nuances to be heard clearly.

The turning point of Harrison's harmonic journey came in 1949, two years after suffering a severe nervous breakdown while living in New York City—a crisis stemming from the combination of a demanding yet unrewarding professional schedule, difficult romantic relationships, and a general aversion to the chaotic and noisy metropolitan life. Succored by John Cage and supported by Charles Ives, Frank Wigglesworth, and Virgil Thomson, among other friends, Harrison embarked on a lifelong path to recovery after nine months of clinical stay. Part of his therapy included a biographical reconstruction; the composer interpreted this prescription in a larger musical sense, retracing the harmonic and tuning theories found in Early Modern and Medieval European treatises to the works of ancient Greek and Hindu theorists.[26] While immersed in this research, Harrison received a copy of Harry Partch's *Genesis of a Music* from Virgil Thomson, who accompanied the gift with a sibylline invitation to make "what he could" out of it.[27] Partch's theorization of a new monodic language, based on a forty-three division octave in pure mathematical ratios, served as a catalyst for the recovering composer to break free from the constraints of

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[26] Miller and Lieberman, *Composing a World,* 111.

[27] Ibid., 44.

both equal temperament and the twelve-tone explorations of his student days.[28]

After his return to California in 1953, just intonation grew into an outright obsession for Harrison, who incorporated it in most of his works and progressively charged it with political and philosophical implications.[29] In an early example, the *Strict Songs* for eight baritones and chamber orchestra (1955), the composer specified the ratios for tuning the pentatonic modes employed in each of the four movements; piano and harp are required to retune, whereas strings, trombones, and voices can match these pitches. The limited pitch collection of pentatonic and hexatonic modes allow for uncompromised just tunings, and Harrison explored them extensively; in 1961 he spent his time aboard a freighter to Japan devising forty-three pentatonic computations in a variety of tunings.[30] Harrison completed the move from accompanied voices to solo keyboard in just intonation with *Cinna* (1957), a tack-piano or harpsichord piece which required a complete overhaul of the instrument's tuning. The piece features eleven sizes of seconds and thirds, and five kinds of fourths, all of which are used to great expressive effect.[31]

In 1967 Harrison met William Colvig, an electrician with a passion for

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[28] For a concise presentation of Partch's theoretical and aesthetic construction, see Richard Kassell, *Harry Partch: Barstow–Eight Hitchhiker Inscriptions from a Highway Railing at Barstow, California [1968 Version]*, Music in the United States of America, 9 (Madison, WI: A-R Editions, 2000), xxvi–xxxvi.

[29] See, for instance, the discussion of *Pacifika Rondo* in Miller and Lieberman, *Lou Harrison* (2006), 103.

[30] Lou Harrison, *Music Primer* (New York: Peters, 1971), 110–17.

[31] Leta Miller, ed., *Lou Harrison: Selected Keyboard and Chamber Music, 1937–1994*, Music in the United States of America, 8 (Madison, WI: A-R Editions, 1998), xlii–xliv.

acoustics; the two men would become lifelong partners. Through their combined efforts, the composer's commitment to alternative intonation systems found a new outlet in instrument building.[32] Starting with simple harps and psalteries, the couple graduated to building and tuning complex ensembles such as the "American Gamelan," an eclectic collection of resonating metallophones tuned to a just D major scale spanning more than five octaves that they later affectionately nicknamed Old Granddad. In the following years, Harrison and Colvig would build gamelans for San Jose State University and Mills College, which they tuned in accordance to acceptable Javanese standards, but featuring pure, non-beating interval ratios.[33]

In light of Harrison's penchant for instrument building and alternative tunings, it should come as no surprise that he decided to cast his *Scenes from Nek Chand* in just intonation, or that he modified the standard arrangement of a guitar's tuning to meet his sonic requirements. As we have seen, Harrison was particularly interested in modes containing only five or six pitches. In an interview with John Schneider, he mused that he had spent most of his life coming up with "new" modes, when he found that a six-note scale occurred naturally in the harmonic series encompassing overtones six through eleven. Because intervals become progressively smaller as one ascends further in the series, this collection is the only contiguous six-note mode

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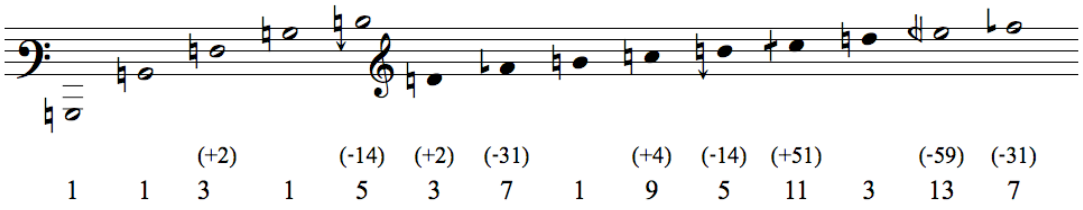
[32] Miller and Lieberman, *Composing a World*, 53–54.

[33] Ibid., 164–65. Beating refers to the periodical fluctuations in volume caused by the interference between mistuned frequencies.

within an octave.[34] For *Scenes from Nek Chand*, Harrison based his scale on a low G, resulting in the mode D–F–G–A–B–C ♯–D. As noted by composer and theorist David Doty, this tuning can also be characterized as otonal, Harry Partch's term for a collection of pitches derived from the overtone series (in this case, harmonics 1, 3, 5, 7, 9, and 11).[35] Example 1.1 shows the overtone series on G with the notes used in *Nek Chand* indicated, along with their variance in cents (¢) from equal temperament.



Example 1.1 Harmonic series on G up to the 13th harmonic, with the *Nek Chand* mode indicated.

The tuning falls within the so-called eleven-limit, meaning that the eleventh harmonic is the highest prime number factor necessary to derive the tuning's intervals. Comparing sizes in cents (see Table 1.1), the subminor third D–F (~267¢) and the neutral seventh D–C ♯ (~1049¢) stand out as the intervals furthest removed from their equal-tempered counterparts of 300 and 1100¢. The C ♯ in question is indeed a close approximation of the quarter tone between C and C ♯ in equal temperament, and Harrison exploits its poignancy at salient points in the piece, as will

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[34] Lou Harrison, interview with John Schneider, 2002.

[35] David Doty, *National Reso-phonic Just Intonation Guitar Chord Atlas*, 2006, www.dbdoty.com/ChordAtlas.pdf. For Partch's definition, see Harry Partch, *Genesis of a Music* (New York, Da Capo Press: 1947), 160.

be highlighted later.

Intervals for *Scenes from Nek Chand*

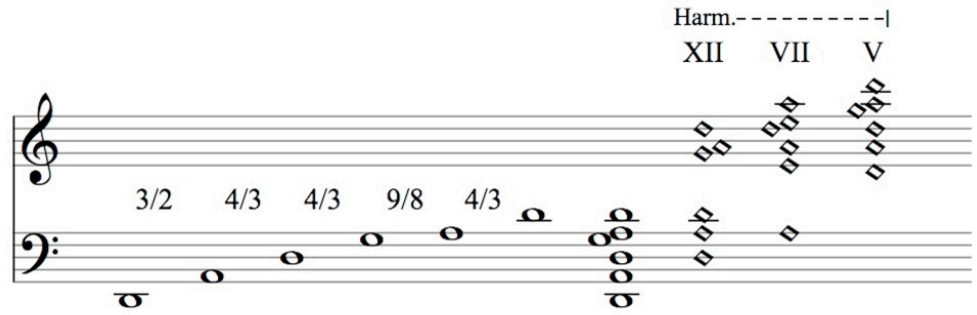
		F	G	A	B	C♯	D
Ratios	D	7:6	4:3	3:2	5:3	11:6	2:1
	F	1:1	8:7	9:7	10:7	11:7	12:7
	G	7:4	1:1	9:8	5:4	11:8	3:2
	A	14:9	16:9	1:1	10:9	11:9	4:3
	B	7:5	8:5	9:5	1:1	11:10	6:5
	C♯	14:11	16:11	18:11	20:11	1:1	12:11
Cents	D	266.87	498.04	701.96	884.36	1049.36	1200
	F	0	231.17	435.08	617.49	782.49	933.13
	G	968.83	0	203.91	386.31	551.32	701.96
	A	764.92	996.09	0	182.40	347.41	498.04
	B	582.51	813.69	1017.60	0	165	315.64
	C♯	417.51	648.68	852.59	1035	0	150.64
		F	G	A	B	C♯	D

Table 1.1 Interval inventory for *Scenes from Nek Chand*

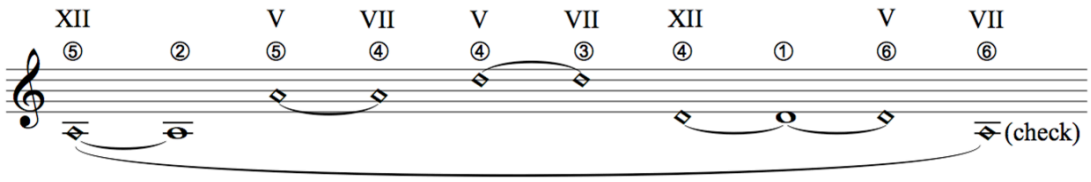
Such a collection of notes requires an extensive modification of the guitar's tuning and positioning of frets. For *Nek Chand*, Harrison specified that the strings be tuned to D–A–D–G–A–D, low to high, a configuration that appears frequently in fingerstyle acoustic and Celtic guitar playing, but is foreign to most classical settings; it is likely that Harrison was introduced to the so-called DADGAD tuning by his pupil Bill Slye, who was a guitarist as well as a student of intonation systems.[36] In the

[36] Slye's senior project includes practical consideration for tuning guitars in just intonation, as well as compositions for justly tuned guitars and other instruments. William Slye, *Just Intonation Realization.* Senior Thesis, BA in Music, University of California, Santa Cruz, 2000.

DADGAD tuning, the shared harmonics between the strings, detailed in Example 1.2, maximize sympathetic resonance, resulting in a glowing sound when paired with the tricone's rich timbre and long sustain. These overlapping harmonics can also serve as a reference for tuning, as in the sequence notated in Example 1.3. Such a tuning offers a great practical advantage for the performer, as G–D and D–A are the two pure fifths in the mode of *Nek Chand*. Moreover, reducing the number of open pitches simplifies the calculations for the new just-intoned fretboard. These benefits, however, come with the disadvantage that the guitarist must learn a new set of fingerings.



Example 1.2 Open strings and harmonics of a guitar in DADGAD tuning.



Example 1.3 Sample tuning sequence using harmonics and open strings.

Retuning the open strings was by far the simpler part of the process, as the guitar also needed an entirely new fretboard that would produce the required just intervals. Because there was not enough time for the construction of an appropriate instrument, Tanenbaum gave the world premiere of *Scenes from Nek Chand* in equal temperament, with the exception of the first movement, which features a slide throughout and could thus be performed in its intended form. After this first performance, Harrison and Slye enlisted the help of Schneider, a champion of music for guitar in alternative tunings, to help realize a tricone guitar in just intonation. Their work ultimately led to the formulation of a just tuning for the entire twelve pitches of the chromatic scale, and the resulting guitar inspired the composition of sixteen new works by other composers.

Part Two: Reflections—An Analysis of the Musical and Programmatic Elements of *Scenes from Nek Chand*

Harrison cast his *Scenes from Nek Chand* in three movements (slow–fast–fast), giving each section a title that would evoke elements from the sculptor's gardens in Chandigarh: "The Leaning Lady," "The Rock Garden," and "The Sinuous Arcade with Swings in the Arches." Performances of the work average around ten minutes, with the opening slow movement taking about half the duration of the piece. Although the music remains confined to the same six-note mode from beginning to end, the movements differ in terms of texture, structure, and affect to provide variety and balance.[37]

"The Leaning Lady" requires the guitarist to use a slide for the majority of the movement; the combination of the slide with the metal-bodied resonator recreates the signature sound of Hawaiian music that Harrison refers to in his program note for the piece. The main motive's dual descending voices also serves as a representation of the eponymous slanting statue from Chandigarh;[38] the use of the slide, which Harrison encouraged to be "as sensuous" as one likes, gives the music a plaintive and meditative feel.[39] Structurally, the movement resembles an abbreviated rondo (A–B–A'–C–A''–B'–A''') with a short coda; the downwards motive recurs in alternation

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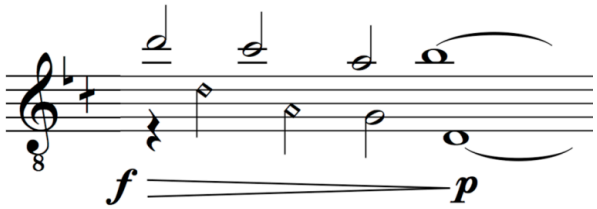
[37] Lou Harrison, *Scenes from Nek Chand* (Lebanon, NH: Frog Peak Music, 2005). The printed edition of the score is a clean copy of the latest manuscript version, with the inclusion of performance and tuning notes by John Schneider.

[38] For a picture of the *Leaning Lady* see Maizels, *Raw Creation*, 219.

[39] Lou Harrison, interview with John Schneider, 2002.

with episodes that feature a melody played against interrupted drones—Harrison's personal interpretation of the *jhala* of classical Indian music.[40]



Example 1.4 Opening motive from "The Leaning Lady"

The piece's most idiosyncratic pitches, the "out-of-tune" F and C ♯, appear in this movement in different guises; Harrison uses the F mostly as a passing tone, often sliding it down to D in a vocal gesture, whereas he gives the C ♯ more space, often letting it ring before resolving it. The resolution itself may occur in either direction, taking advantage of the almost equal distance from B or D (165 and 150¢, respectively). As shown in Examples 1.5 and 1.6, both pitches sometimes appear in the same passage to build tension; the latter half of the phrase employs only sweeter-sounding intervals (such as the pure minor third B–D), thus offering a satisfying resolution. Harrison uses a similar device in the movement's coda, where the dissonant pitches become progressively scarcer until they disappear completely.

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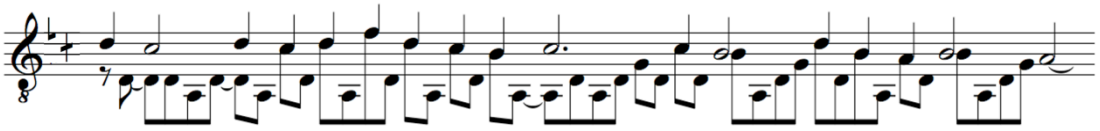
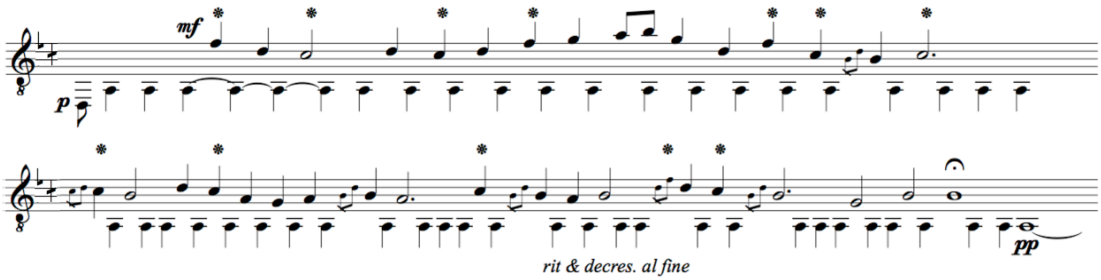
[40] The Jhala is a quick section at the end of a *Raga*'s fixed composition that often features a melodic pattern played against an interrupted drone. Harrison was particularly attracted to this texture, which he called "India's answer to the Alberti Bass;" he wrote several pieces that makes allusion to the technique, such as *Avalokiteshvara* (1964), the *Suite for Violin and American Gamelan* (1974), and the eponymous *Jahla in the Form of a Ductia to Pleasure Leopold Stokowski on his Ninetieth Birthday* (1972). See Miller and Lieberman, *Lou Harrison*, 55.



Example 1.5 *Jhala*-like passage featuring the alternation of "far" and more consonant intervals in "The Leaning Lady."



Example 1.6 Fading of more pungent intervals in "The Leaning Lady"

The gliding melody of Harrison's "The Leaning Lady" is not the first example of a musical thread connecting India to Hawaii. In an article on the relationship between Hawaiian steel guitar playing and its music, Mantle Hood reports the description of an 1884 performance by a man named Davion, an alleged stowaway traveler from India, who rested the guitar in his lap and played it with a rod held in the fretting hand. Hood notes the resemblance to the playing technique of the *gottuvadyam,* a type of Indian *veena* whose name literally means "sliding rod instrument," which belongs to a tradition that could date back as far as 200 B.C.[41] He

[41] Mantle Hood, "Musical Ornamentation as History: The Hawaiian Steel Guitar," *Yearbook for Traditional Music* 15 (1983): 145. Hood also suggests that Joseph Kekuku, the assumed father of Hawaiian guitar playing, could have witnessed or heard of this performance, and then went on to popularize the technique in a new musical context on the Islands and beyond.

supports this hypothesis by alluding to a certain "untalkable" affinity between vocal and instrumental styles found in both Hawaiian and Indian musical idioms, with the voice and guitar imitating one another through range, color, and articulation. Drawing from recorded performances of Hawaiian music, Hood also highlights examples of parallel passages in falsetto (voice) and harmonics (guitar), the similar use of glides up to and down from the main note, and the careful employment of non-vibrato, straight tones as ornaments.[42]

The second movement of Harrison's suite, *The Rock Garden*, features a much brisker tempo, and its boisterous single-note lines offer a radical departure from the placid atmosphere of the opening; the straightforward formal plan, a ternary structure with a brief coda, suits the exuberance of the music. Because of the scalar nature of the main theme (see Example 1.7) and the quick tempo, the undecimal C ♯ goes almost unnoticed until the end of the first part, when it is highlighted by an insistent repeated-note passage. In the contrasting middle section, Harrison employs the fullest chords of the entire piece, a stack of fourths obtained from three open strings of the guitar, alternating with single-note passages in a call-and-response that culminates in a playful syncopated episode (see Example 1.8). Although there are no explicit programmatic references, *The Rock Garden* seems to convey Harrison's excitement for Nek Chand's creation in the jungle of Chandigarh.

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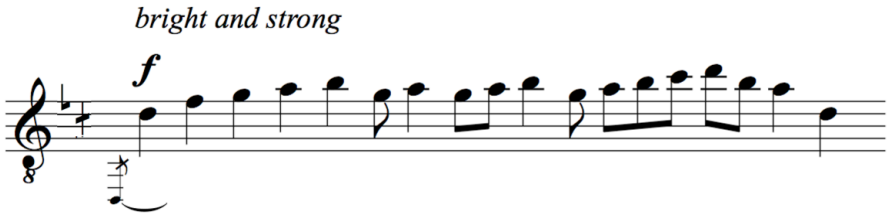
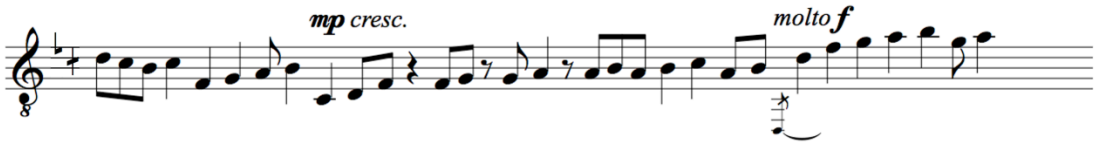
[42] Hood, "Musical Ornamentation as History," 146.



Example 1.7 Opening motive of "The Rock Garden."



Example 1.8 Syncopated retransition in "The Rock Garden."

Clearer extra-musical connotations return in the piece's last movement, inspired by the architectural detail of Chand's garden that struck Harrison's imagination most vividly. In conversation with John Schneider, Harrison conveyed his amazement at some of the pictures he had seen of the arcade:

> A stream goes through the property and he's built an arcade, literally, following the shore. It's very big, and there are sizable arches made of bags of piled up concrete, but they are real arches. The arcade is two-sided, that is to say there are arches, and a roof with banisters so you can promenade on the top. In every arch there is an iron-chained swing for two people. It's just beautiful.[43]

The music, in 3/4 for the first time in the piece, is marked "amiably swinging"; as instructed by Harrison, the guitarist is advised to incorporate a relaxed pushing-and-

[43] Harrison, interview with John Schneider, 2002.

pulling into the phrasing to convey such an affect.[44] The texture recalls the implied polyphony and *style brisé* typical of seventeenth-century French lute music found in the works of Ennemond Gaultier and René Mesangeau, and then reprised by the school of *clavecinistes*. This peculiar textural approach represents perhaps another influence form Harrison's youth coming to the fore in the piece, as the composer was particularly interested in Baroque music in his formative years.[45]

Harrison chose to write this final movement as an estampie, a medieval dance that he had employed in about a dozen other works, including the *String Quartet Set*, the *Grand Duo* (1987), the *Concerto for Pipa and String Orchestra*, and the Harpsichord Sonata (1999).[46] Traditionally, estampies feature repeating verselets followed by a short refrain with alternating "open" or "closed" endings; in this case, Harrison crafted a novel form, using two refrains of similar music, albeit with the melodic incipit of the second transposed down a third, which are then repeated without changes, yielding the scheme AxAy, BxBy, CxCy, DxDy, ExEy, CxCy, FxFy. The last notes of each refrain, however, are modified to lead seamlessly into the next

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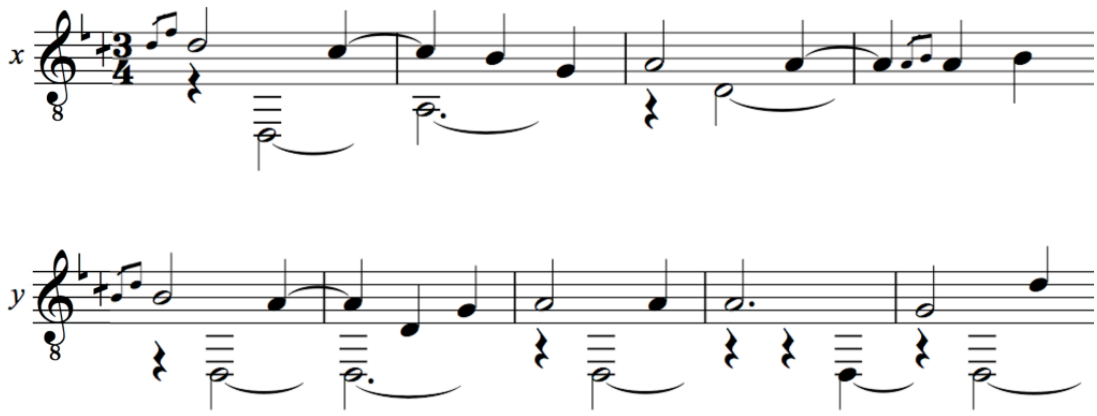
[44] Harrison, interview with John Schneider, 2002; also David Tanenbaum, personal communication with the author, 7 February 2010.

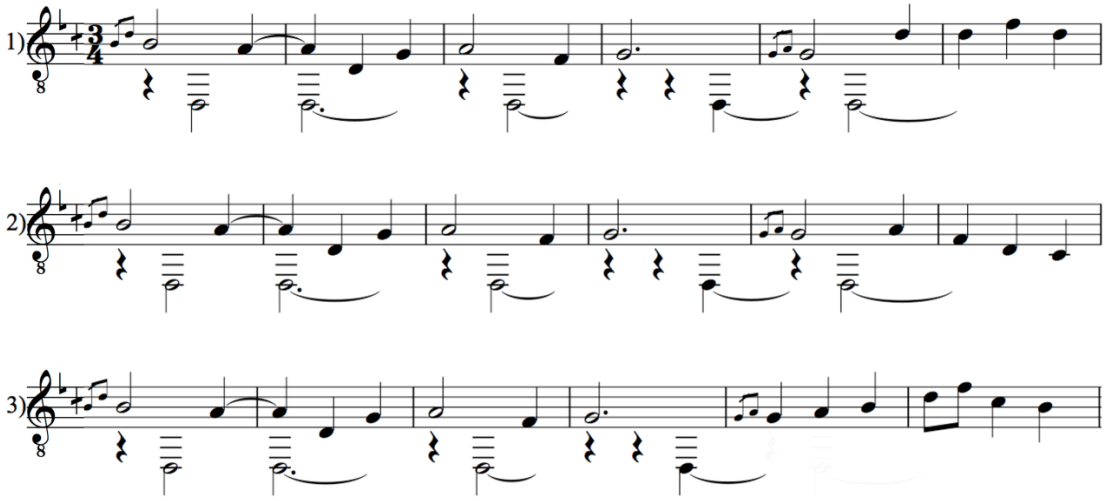
[45] Harrison studied harpsichord and recorder while at San Francisco State University (1935–36), and began the composition of a set of six sonatas for the keyboard instrument (1934–43), which were modeled on the works of Domenico Scarlatti. He continued to be interested in baroque music throughout his life, and often made explicit reference to Baroque styles and forms, as with the rondeaux movements of the *Varied Trio* of 1987. See Miller, ed., *Selected Keyboard Works*, l–li. Towards the end of his life, he returned to the harpsichord to compose a second Sonata in 1999.

[46] For a detailed analysis of the estampie from the Harpsichord Sonata, see Miller and Lieberman, *Lou Harrison* (2006), 84, 90–91. Miller also discusses the estampie from the *Grand Duo* in Miller, ed., *Selected Keyboard and Chamber Music*, lii–liii.

verse.



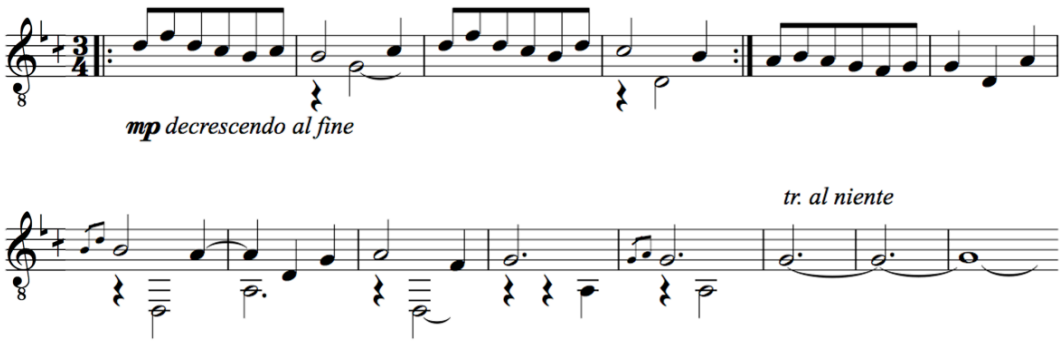
Example 1.9 Refrain *x* and *y* in "The Sinuous Arcade with Swings in the Arches"



Example 1.10 Variance in last measure of refrain *y* to lead seamlessly into following verselet.

The sections have varying lengths, with the repeat always longer due to an extra measure in the y refrains. Section F, the longest at 29 (14+15) measures, shows

a remarkable use of the 11-limit C ♯, which is placed against first a G and then a D (yielding an 11:8 tritone and 11:6 seventh) in a poignant farewell gesture. Not unlike "*The Leaning Lady*," this heightening of dissonance gives way to more consonant intervals, until the final *dissolvenza* of an unaccompanied trill on G.



Example 1.11 Final gesture of "The Sinuous Arcade with Swings in the Arches."

For the performer, *Nek Chand* poses a number of technical challenges that are not immediately apparent when looking at the score. The fretboard overhaul necessary to obtain the desired pure ratios requires the guitarist to learn to navigate a complex network of fretlets, as simply relying on muscle memory will not always provide the necessary accuracy. The performer must also learn a new set of fingerings for the DADGAD tuning, which shifts notes on the first, second, and sixth string two frets higher. Finally, the slide, required in the first movement, is unfamiliar to most classical guitarists; careful practice is needed in order to produce a full and convincing tone.

Performers must also decide how to approach the piece in terms of their picking hands. Bare fingernails (the classical guitarist's weapon of choice) are not only doomed by the tricone's steel strings, but also might prove too light to fully coax the instrument's tone and resonance—a matter of extreme importance for Harrison's aesthetics. The textures of the piece are sparse enough to allow for the use of a pick, if the performer has the required technical facility; alternatively, metal fingerpicks can be worn in the manner of folk and blues resonator players (as suggested by Schneider in his notes to the published score) thus allowing for the application of conventional right hand technique. The guitarist must become comfortable with all of these foreign elements (guitar, fingerboard, tuning, plucking technique) to give the kind of effortless performance that conveys the music's sense of serenity, tranquility, and awe.

Part Three: Resonance—The Legacy of *Nek Chand*

Dedicatee David Tanenbaum initially tried to dissuade Harrison from writing for such an unusual guitar, arguing that a more traditional instrument would interest guitarists all over the world.

Harrison was steadfast, reportedly telling Tanenbaum that even a single performance in the Bay Area would be enough, but agreed to add a note to the score characterizing the just tuning as "only the preferred one," thereby allowing for performances in equal temperament. What neither had foreseen was that the specially crafted guitar would elicit considerable attention from a diverse range of composers in the years following the premiere of *Nek Chand.* These new compositions utilize the full twelve-note tuning, devised in the spring of 2002 by Slye and Alves.[47]

The evolution of the tuning is shown most clearly by the use of lattice diagrams, which in this case feature a ratio of 3:2 (pure fifths) on the horizontal axis, 5:4 (pure major thirds) on the vertical axis, and 7:4 (harmonic seventh) on the z-axis. To adapt the tuning's four prime factors to a three dimensional model, the 11:8 ratio was drawn "down and left."[48] Comparing lattices for the original tuning and Alves's first proposal (Figure 1.2), one can see how the new G ♯, B ♭, C, E ♭, E, and F ♯ were chosen to extend each of the four dimensions in a balanced and practical way. Along

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[47] Unfortunately, Bill Slye's untimely death in January 2010 prevented the author from interviewing him. The information presented in this section is compiled from accounts by Bill Alves, John Schneider, David Tanenbaum, and Charles Hanson.

[48] For a more in-depth discussion of tuning lattices and diagrams, see David Doty, *Just Intonation Primer* (San Francisco: The Just Intonation Network, 1993).

with a total of eight pure fifths (C–G, G–D, D–A, E–B, B–F ♯, C ♯–G ♯, E ♭–B ♭, B ♭–F), the number of pure major triads grew from one (G–B–D) to three (adding D–F ♯–A and C–E–G)—two features that increased the number of available tonal centers and, consequently, the possibilities for modulation, broadening the appeal to other composers. (Note that because the major thirds are given on the vertical axis and the perfect fifths on the horizontal ones, pure major triads are formed by lines at right angles.)[49]

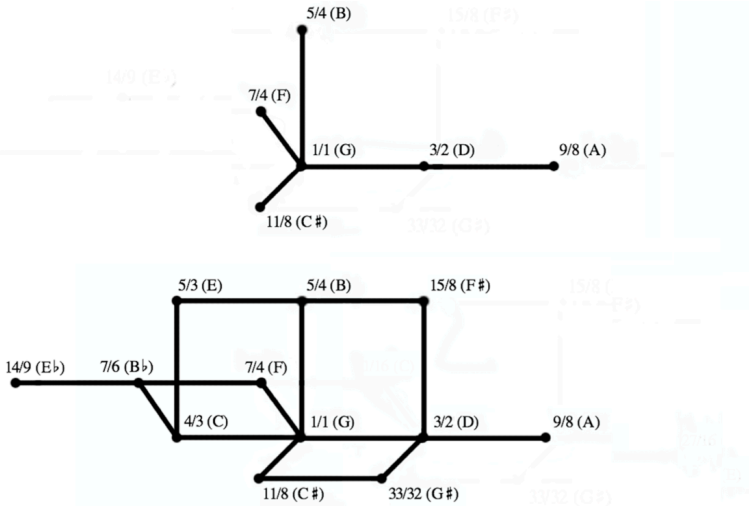

Figure 1.2 Lattice diagrams for the *Nek Chand* mode (above), and Bill Alves's first 12-note tuning proposal (below).

As an alternative, Alves conjured a scale made up exclusively of harmonics 16–32 of G, which would have resulted in an instrument of lush resonances but limited modulatory possibilities. The surviving correspondence between Alves and Slye shows that the latter was interested in modal variety and "blue" notes—those

[49] Bill Alves, interview with the author, Santa Cruz, CA, 25 April 2010.

derived from the seventh harmonic and thus strikingly foreign to equal-tempered ears —more so than in expanding the tonal range of the instrument. Once given the two proposals, Slye tinkered with the possibilities, eventually incorporating the harmonic C (21/16) and E (27/16) into the framework of Alves's first tuning. The resulting hybrid allows for an assortment of modal flavors, while providing two viable tonal centers on G and D.

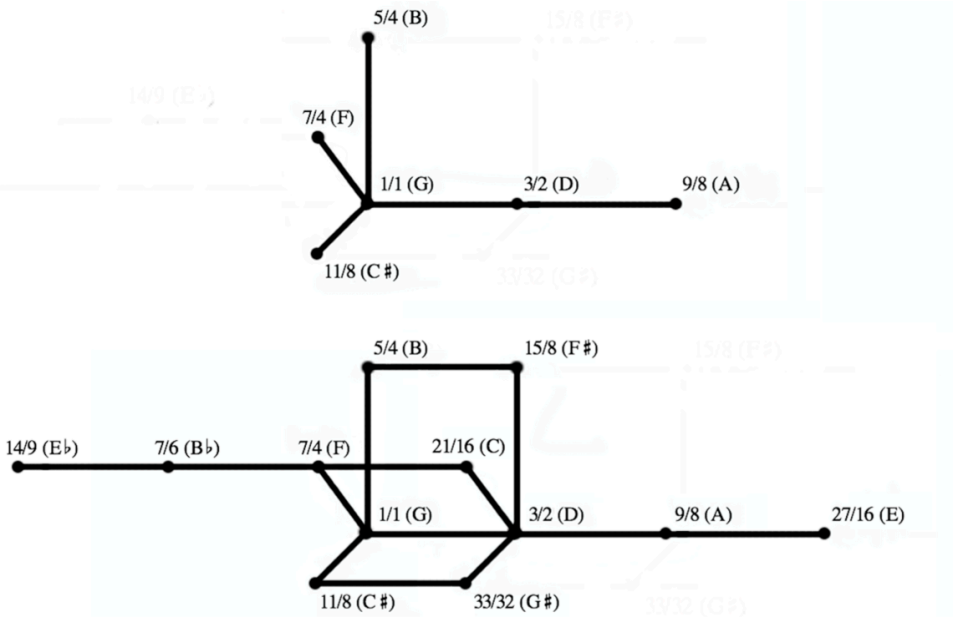

Figure 1.3 Slye's final tuning scheme for *Scenes from Nek Chand.*

As shown in Figure 1.3, the original six-note structure of *Nek Chand* was effectively duplicated in the process, being transposed by a ratio of 3:2 from G to D (one "step" to the right in the lattice). This structural shift results from the fact that the higher harmonics of G coincide with harmonics 6–11 of D—in more technical terms, the complete tuning now contains otonal hexads on G and D: G–D–B–F–A–C ♯ and

D–A–F ♯–C–E–G ♯, respectively. The remaining two notes (B♭ and E♭) reflect Alves's original instruction to keep the tuning within the eleven-limit rather than expanding it to higher orders of harmonics, as they were derived by extending the lattice down from F along the 3-axis. Table 1.2 juxtaposes the pitches and ratios for each tuning; a transposition of the final tuning to D highlights the recurrence of the *Nek Chand* mode, which now encompasses the scale A–C–D–E–F ♯–G ♯–A.

Tuning Comparison for the Just Intonation Resophonic Guitar

Alves Proposal 1	Alves Proposal 2	Final Tuning G=1:1	Final Tuning D=1:1
G (1:1)	G (1:1)	G (1:1)	G (4:3)
G ♯ (33:32)	G ♯ (17:16)	G ♯ (33:32)	G ♯ (11:8)
A (9:8)	A (9:8)	A (9:8)	A (3:2)
B♭ (7:6)	B♭ (19:16)	B♭ (7:6)	B♭ (14:9)
B (5:4)	B (5:4)	B (5:4)	B (5:3)
C (4:3)	*C (21:16)*	C (21:16)	C (7:4)
C ♯ (11:8)	C ♯ (11:8)	C ♯ (11:8)	C ♯ (11:6)
D (3:2)	D (3:2)	D (3:2)	D (1:1)
E♭ (14:9)	D ♯ (13:8)	E♭ (14:9)	E♭ (28:27)
E (5:3)	*E (27:16)*	E (27:16)	E (9:8)
F (7:4)	F (7:4)	F (7:4)	F (7:6)
F ♯ (15:8)	F ♯ (15:8)	F ♯ (15:8)	F ♯ (5:4)

Table 1.2 Side-by-side comparison of proposed and final tunings.

With the theoretical calculations in place, the last step required was to translate the tuning into practice, taking into consideration the physical attributes of strings as they are fretted (and thus stretched) and played—an endeavor in which Slye had some previous experience, having designed and inlaid two just-intoned guitar fingerboards, as well as a marimba keyboard, for his Senior Project at the University

of California, Santa Cruz. According to National Reso-phonic CEO Don Young, who assisted Slye with the project, it took them the better part of a day to trace the prototype fingerboard with a movable fret and a strobe tuner; the resulting distances were then programmed into the company's computer-controlled fretboard routers, which in turn cut the slots into which the many fretlets were glued.[50] This newly tuned fretboard, characterized by a fractured, almost cubist, look, appeared on the five just-tuned tricones issued in spring of 2002; the just intonation premiere of *Scenes from Nek Chand* was immediately given by Schneider on 25 May in Los Angeles, for a concert dedicated to American just tunings as part of Microfest 2002.[51]

Figure 1.4 Bill Slye with the first prototype of the refretted tricone resophonic guitar.

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[50] Don Young, telephone interview with the author, 28 May 2010.

[51] The MicroFest Program Archives can be accessed at www.microfest.org/2002/may25.htm

A Rapidly Growing New Repertoire

At the time of this writing, fourteen additional composers have written or arranged works for the just intonation tricone, including pieces with voice, keyboard, and even an ensemble of four Nationals (Table 1.3). Their ranks span three generations, from Terry Riley (b. 1935) to 31-year-old Iranian Sahba Aminikia; furthermore, the instrument has attracted composers who had not previously written for solo guitar, such as David Doty and Ron Nagorcka. The majority of these newly composed pieces were brought to life through the independent commissioning efforts of Schneider and Tanenbaum, who have, in fact, created an alternative twenty-first century guitar repertoire.

One of the first composers to respond to the justly tuned resonator was Riley, who had been fascinated with the instrument since hearing Tanenbaum play *Scenes from Nek Chand*; in March 2003, the composer was arrested for assembling without a permit in Nevada City, California, where he had joined a demonstration against the U.S. invasion of Iraq. After spending one night in jail, the composer was found guilty and offered three choices by the judge: he could spend more time behind bars, pay a fine, or do some kind of community service. Riley chose the last option, suggesting he could write a piece of music as penance. That work, *Quando Cosas Malas Caen del Cielo*, depicts the events leading to Riley's arrest, the night in jail, and the mounting feelings of horror caused by the first bombings of Baghdad over the course

Table 1.3 List of known pieces for the refretted resophonic guitar as of May 2013.

Composer	Title	Year	Movements
Lou Harrison (1917-2003)	*Scenes from Nek Chand*	2002	3
Harrison	*Suite for National Steel*	1952/1991	5
Terry Riley (b. 1935)	*Quando Cosas Malas Caen Del Cielo*	2003	4
David Doty (b. 1950)	*Suite for National Steel*	2003-2005	4
Dusan Bogdanovic (b. 1955)	*Village Music*	2004	2
Garry Eister (b. 1952)	*Arirang and Sanjo*	2004	3
Elias Tanenbaum (1924-2008)	*Bushwacked*	2004	1
Larry Polansky (b. 1954)	*Songs and Toods*	2005	5
Sasha Bogdanowitsch (b. 1971)	*New Piece*	2005	1
Ron Nagorcka (b. 1948)	*Just Dance*	2005	1
Nagorcka	*About 7*	2005/2012	1
Carter Scholz (b. 1953)	*Almost Square*	2005	1
John Schneider (b. 1950)	*Tombo por Lou*	2006	4
Peter Yates (b. 1953)	*Quips*	2007	5
Eister	*The Prisoner*	2008	1
Riley	*Moonshine Sonata*	2008	2
Andrew York (b. 1958)	*Just Music*	2008	6
Eister	*Sleep*	2009	6
Sahba Aminikia (b. 1981)	*Suite for Just Intonation Steel Guitar*	2009	3
Matthew Grasso (b.1972)	*Three Spirits*	2010	3
Alex Wand (b .1986) and Brendan Byrnes (b.1980)	*The Plains of Jars*	2012	1
Wand	*A Process in the Weather of the Heart*	2012	5
Polansky	*freeHorn*	2004-2012	1
Eister	*Whom Follows Who?*	2012	1

of four movements.[52]

Riley imaginatively employs the instrument's tuning to trace a descent from boisterous optimism to darkness and violence. The opening "National Broadstreet March" is written largely in D mixolydian, a mode that features a pure major third and sixth, perfect fourth and fifth, and a sweet minor seventh from the tonic; the tuning's more biting intervals, such as E-flat and B-flat, appear sparingly and mostly as coloristic appoggiaturas. "La Melodia Que Se Sienta Solo," the second movement, features both a slide and a seven-note mode in overt homage to Harrison's "Leaning Lady;" together with the third movement, in which the tonal palette is further reduced to a mere five pitches, they offer textural contrast while increasing tension before the explosive finale. In the last movement, a brooding passacaglia, Riley employs the entire twelve-note gamut, with the dissonant intervals sounding especially strident and poignant by means of contrast. Because of its convincing and powerful musical rhetoric, the seventeen-minute *Quando Cosas Malas Caen Del Cielo* represents one of the most exciting new works for guitar of any kind in recent years.

Riley's creative use of tuning as an overarching aesthetic element is one of many that composers have taken in response to the musical restrictions of the instrument. In his *Three Spirits* (2010), guitarist-composer Matthew Grasso (b. 1972) introduces the available musical material gradually, setting the first movement in five-

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[52] Riley utilizes idiosyncratic spellings for many of the titles of his movements and compositions. See Beth Levy, Program Notes to *Things Fall from the Sky*. San Francisco Contemporary Music Players (San Francisco, 23 February 2009); also David Tanenbaum, personal communication with the author, 7 February 2010, and Gyan Riley, personal communication with the author, 17 March 2010.

limit just intonation, the second in seven-limit, and the third in eleven-limit; the resulting sonic tapestry increases in color as well as complexity, reflecting the natural progression of the harmonic series.[53]

Some of the composer attracted to the re-fretted resophonic guitar come from an extensive background of working with tuning systems. James Tenney had one of the loaner instruments for a few months, but, even though he was fascinated by its timbre and tuning, he did not write anything for it.[54] Larry Polansky, on the other hand, received a loaned guitar in the summer of 2005 and proceeded to write *Songs and Toods*, a collection of five pieces that meticulously explore the harmonic possibilities of the instrument. Polansky's work with the just intonation tricone will be discussed in the chapter dedicated to his music; additionally, Polansky's enthusiasm for the guitar prompted his Tasmanian colleague and friend Ron Nagorcka (b. 1948) to write two pieces of his own.

Nagorcka's compositional style melds elements as diverse as just intonation, field recording, and virtuoso didjeridoo playing. In 2005 he wrote *Just Dance* and *About 7* for the just intonation tricone. Both pieces were written mainly with the help of an electronic keyboard tuned to match the guitar, since the composer did not have access to a refretted instrument. Although Nagorcka checked the resulting fingerings on a conventional guitar, the pieces are not particularly idiomatic and, as a result,

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[53] *Three Spirits* was premiered by the author of this dissertation at the Davis Art Center (Davis, CA), on July 7, 2012.

[54] John Schneider, personal communication with the author, 10 August 2010.

suffered delayed premieres. *Just Dance*, a solo in rondo form and about six minutes in length, was eventually edited for performance premiered by the author of this dissertation on 29 March, 2012 at the experimental art and music space the wulf. in downtown Los Angeles. *Just Dance* is harmonically adventurous: It starts off on a "far" harmony built on A♭ (an 11–limit interval), explores tonalities closer to the tuning's fundamental such as G and D, but keeps returning (almost mischieviously) to its strange, original root. *About 7* goes even further: The strings are retuned to a just intonation version of standard tuning (E–A–D–G–B–D, low to high), yielding an array of microtonal variances for each pitch class. The music highlights these cognates through two polyphonic lines that snake microtonally through adjacent pitches, resulting in a piece that was virtually impossible to play. After the premiere of *Just Dance*, Nagorcka reworked *About 7* as a duet for two refretted just intonation tricones; the piece was finally premiered at Microfest on April 13, 2013 by guitarist Travis Andrews and the author.

Perhaps the strongest indication of the sustaining interest around the justly tuned tricone is represented by Sahba Aminikia's composition *Suite for Steel Guitar,* written nearly a decade after *Scenes from Nek Chand* by a composer two generations younger than Harrison. Aminikia heard one of the five National prototypes when he was a student at the San Francisco Conservatory, and reported that its smaller intervals resembled the *maqmat* of classical Persian music. In the fast middle section of the *Suite*, Aminikia uses odd-meter strumming patterns in combination with the

tuning to evoke the Setar, a kind of plucked lute related to the Tar and Tanbur.[55] The *Suite*, which was commissioned by and dedicated to Elliot Simpson, was completed in October 2009 and recorded in April 2010. In the intervening years other young composers, such as Alex Wand and Brian Baumbusch (b. 1987), have contributed to the still-growing repertoire of the refretted resophonic guitar.[56]

The Quest for Pure Intervals: A Fool's Errand?

In addition to its theoretical and aesthetic allure, the instrument of *Scenes from Nek Chand* epitomizes the challenging nature of applying tuning systems to fretted instruments. While borrowing Tanenbaum's guitar in preparation for a commission in 2010, Matthew Grasso was troubled by some intervals—including octaves and fifths—that did not sound as pure as they were supposed to.[57] He noticed discrepancies in the placement of several frets; for example, consider the position of the first fret for the first and sixth string—which are both tuned to D—in Figure 1.4. Measurements by luthier Scott Richter (Fairfax, CA) confirmed that roughly a fifth of the notes in the first twelve frets varied from pure tuning by as much as 6¢. Although these discrepancies are negligible when intervals are played melodically (as in most of *Nek Chand*), and can be remedied through sensitive finger placement and pressure, they

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[55] Sahba Aminikia, personal communication with the author, 28 August 2010.

[56] At the time of writing, Baumbusch was completing a duet for two refretted tricones, as well as a piece for two refretted guitars and retuned harp.

[57] Matthew Grasso, personal communication with the author, 30 August 2010.

become more apparent when a composition features consonant harmonies more overtly.[58] Richter suggests that the empirical way in which the frets were originally placed could have led to these idiosyncrasies, especially considering the variability of a given string's stretching under different fretting pressures. The design of a tricone bridge further complicates the picture, as the aluminum construction is not fixed on the instrument, and can easily be moved in and out of position during performance or transport. In the end, Richter laid out an alternative fretboard template by calculating fret positions from the mathematical ratios of the tuning, and subsequently applying compensation at both the nut and saddle (the breaking points that define the actual vibrating length of open and fretted strings). The resulting fingerboard has the added benefit of a cleaner look, as fretlets under those strings tuned to the same pitch class now fall on a straight line. After Richter's example, at least two other resophonic guitars have been retrofitted to play in just intonation: One by composer/guitarist Brian Baumbusch, and another by Belgian guitarist Tom Pauwels of the Ictus contemporary music ensemble.[59]

Even though the just intonation resophonic guitar seems especially unforgiving in its tuning needs, the predominantly homophonic and melodic bias in

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[58] Scott Richter, personal communication with the author, 3 September 2010. The luthier found notes above the twelfth fret to be more problematic, given that an error in placement yields twice the discrepancy as in the lower octave.

[59] Baumbusch performed *Scenes from Nek Chand* and *Jahla* (with the William Winant percussion group) on the just intonation guitar on the Mills Music Now/Music for People and Thingamajigs joint concert on 12 October 2012. Pauwels performed the European premieres of two Polansky pieces on 29 November 2012 as part of a John Cage centennial celebration in Luxembourg: http://www.rainydays.lu/2012/.

the instrument's repertoire also helps obscuring its faults, meaning that although imperfectly tuned intervals might be apparent under close scrutiny, they may well go unnoticed in a live performance situation.

Conclusion

The choice of any tuning system necessitates some degree of compromise—whether in terms of practicality, modulatory capabilities, or the purity of intonation. With the justly tuned resophonic guitar one must also contend with the inherent spectral inharmonicity of plucked metal strings as well as fretting complications such as those encountered by Slye and Richter. Whatever the difficulties of achieving the intervals envisioned by Harrison and Slye, *Scenes from Nek Chand* stands as a groundbreaking work that stimulated a new way of thinking about an old subject. Aside from the theoretical and aesthetic implications, the tuning in combination with the aluminum cones within the guitar's body creates an amazing resonance, almost giving the impression that the guitar is amplified. In a way, Harrison's original reluctance to write for the conventional classical guitar is vindicated by the sonic triumph that emanates from the justly tuned tricone; single-note lines excite a shimmering harmonic shadow thanks to the guitar's sensitivity to sympathetic resonance, whereas pure triads and extended harmonies, such as the eleven-limit otonalities built on G or D, glow with an intensity and richness completely foreign to our tempered musical world.

The just intonation resophonic guitar fits within the context of experimental instrument making in twentieth-century U.S. music, standing alongside the Rhythmicon (the electronic rhythm machine that Henry Cowell commissioned from Lev Termen), Harry Partch's original orchestra of percussion and string instruments, the Megalyra family of instruments of Ivor Darreg, and Paul Dresher's long-scale hurdy-gurdys. More so than any of these examples, Harrison's guitar has been remarkably successful in inspiring other composers, endowing the new instrument with a growing and diverse repertoire. In an age of staggering electro-acoustical and digital resources, this entirely acoustic instrument proves that the old topic of intonation still has much to offer. Like the Indian sculptor that inspired *Scenes from Nek Chand*, Harrison refashioned something old into something vibrant, beautiful, and full of life.

Chapter Two
(re)Fret Not! James Tenney's Music for Guitars

In contrast to the examples of instruments adapted for just intonation encountered in the previous pages, much of the guitar music of James Tenney (1934–2006) explores just tunings and extended harmonic constructs without the need for steam gun and fretting hammer. Tenney's pieces for guitar perfectly illustrate broader theoretical and aesthetic trends that occupied the composer's entire career, and reveal a practical-minded approach to instrumental writing. Furthermore, his tuning solutions establish an important precedent for a following generation of composers, led by Larry Polansky, who would further expand the repertoire of extended just intonation music for guitar without calling for adapted or modified instruments.

The pieces under consideration are: *Harmonium II* (1976, rev. 2005), for two guitars; *Septet* (1981) for six electric guitars and electric bass; *Water on the mountain…Fire in heaven* (1985), for six electric guitars; and *Spectrum 4* (1995), for violin, alto recorder, piano, bass clarinet, trombone, vibraphone, guitar, and string bass. Tunings for these pieces are markedly different. *Septet* and *Spectrum 4* are in just intonation, which is realized on the guitar utilizing two different methods; *Water on the mountain…Fire in heaven* approximates just intonation by means of a 72-tone equal tempered system, obtained by tuning each of the six guitars a sixth of a semitone apart; finally, the most recent version of *Harmonium II* utilizes a hybrid

tuning, with each of the two guitars in equal temperament, but pitched approximately 30¢ away from one another.[1]

The common—and crucial—element in these pieces is Tenney's approach to the guitar as an instrument that, albeit tempered, is easy to retune. Through extensive retuning of the open strings and a careful specification of fretted and harmonic fingerings, the performance of precisely-tuned pitches and intervals becomes no more difficult than conventional playing, thus circumventing the requirements asked of performers of flexible-tuning instruments (such as strings and brass, for instance). Such simple adaptations allow Tenney to employ the guitar in harmonic contexts of unprecedented complexity. After identifying the theoretical and aesthetic framework common to Tenney's works for guitars, the following pages will present a detailed analysis of each piece to highlight the elegance and efficiency of the composer's musical language.

James Tenney: A Theoretical Digest

Throughout his life, James Tenney was equally active as a composer and theorist: Starting in 1959 he wrote and published dozens of essays on formal analysis, algorithmic composition, harmony and intonation, musical perception and

[1] There is one additional Tenney piece featuring guitar: *Sneezles (An Encore),* (1986, rev1995). For Soprano, alto recorder/flute, clarinet, tenor-bass trombone, electric guitar, violin, double bass, vibraphone. This four-page song does not focus on tuning and is therefore extraneous to our discussion.

psychoacoustics, and more.[2] Some of these texts have had a difficult history in terms of availability: Tenney's most influential work, the Gestalt psychology-based analytical manual *Meta+Hodos*, was circulated among fellow composers and students in typewritten form for more than twenty-five years until its publication by Frog Peak Music in 1986.[3] Despite this spotty availability, Tenney's theoretical texts have been influential and inspirational to younger generations of composers—some of whom have been students of Tenney's, such as Polansky, Robert Wannamaker, Marc Sabat, Douglas Wadle, Michael Winter, and many more. Most importantly, Tenney's theories and concepts as expressed in his writings provide a fundamental interpretive basis for the analysis of his compositions, especially considering that, with few exceptions, he rarely described the workings of his pieces in detail.[4]

Tenney's recurring theoretical subjects—form, harmony, perception—arise from key periods of his life—his performance beginnings as a solo pianist and a champion of the music of Ives and Ruggles, among others; his experiences as a founding member of the Tone Roads collective, and as a performer in the ensembles of Steve Reich, Philip Glass, and especially Harry Partch, who introduced Tenney to

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[2] A collection of these works, entitled *From Scratch*, is currently being prepared for publication for University of Illinois Press by Polansky, Wannamaker, Winter, and Lauren Pratt.

[3] James Tenney, *META+HODOS and META Meta+Hodos* (Hanover: Frog Peak Music, 1986). Originally published (in an extremely limited run) by the Inter-American Institute for Music Research, Tulane University, New Orleans, 1964.

[4] James Tenney, "About Diapason" (1996), long circulated among students and colleagues of Tenney, it will be included in *From Scratch*; and James Tenney, "About Changes: Sixty Four Studies for Six Harps," *Perspectives of New Music* 25, no. 1/2 (1987), 64-87.

rational tunings during his graduate studies at the University of Illinois; and his research tenure at the Bell Telephone Laboratories in New York, 1961–64.[5]

Tenney's emphasis on perception predates the kind of systematic approaches that have since become popular, and led him to compose some of the first (and perhaps still foremost) examples of spectralist compositions in North America.[6] From a theoretical standpoint, it also informs his formal-analytical (*Meta+Hodos*), historical (*A History of "Consonance" and "Dissonance"*), and harmonic writings.[7] Crucial to many of Tenney's harmonic constructions is the concept of "tolerance range," that is to say the narrow range within which two pitches (or two intervals) can be assumed to be equivalent. There can be several kinds of tolerance range, such as the more or less objective 5¢ range within which the human ear cannot easily distinguish melodic intervals, and wider ranges that depend on the interaction of acoustical factors (spectral complexity, transients), cultural conventions, musical context, and so forth.[8] For Tenney, the tolerance range does not only allow for a degree of intonational flexibility, but also serves to trace a practical limit—one based on psychoacoustics—for the development of his harmonic theories.

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[5] For a biographical sketch, see Brian Belet, *An Examination of the Theories and Compositions of James Tenney, 1982-1985* (1990), 2–4.

[6] Robert Wannamaker, "The Spectral Music of James Tenney," *Contemporary Music Review* 27, no.1 (2008), 91–94. Wannamaker includes the *Septet* among those pieces of Tenney that show commonalities with the spectralist repertoire.

[7] James Tenney, *A History of "Consonance" and "Dissonance"* (New York: Excelsior, 1988).

[8] One example is the equal-tempered major third, which is widely accepted in 12TET contexts as a viable substitute of the natural major third, despite being 14¢ sharp.

Tenney invokes the tolerance range with exactly such a function in the second part of "John Cage and the Theory of Harmony," the text that perhaps comes closest to a harmonic and aesthetic manifesto for his music:

> Since our perception of pitch intervals involves some degree of approximation, these frequency ratios must be understood to represent pitches within a certain tolerance range — i.e., a range of relative frequencies within which some slight mistuning is possible without altering the harmonic identity of an interval. […] Whether all such intervals among a given set of pitches are in fact distinguishable depends, of course, on the tolerance range, and it is this which prevents an unlimited proliferation of "dimensions" in harmonic space. That is, at some level of scale-complexity, intervals whose frequency ratios involve a higher-order prime factor will be indistinguishable from similar intervals characterized by simpler frequency ratios, and the prime factors in these simpler ratios will define the dimensionality of harmonic space in the most general sense.[9]

In the rest of the article Tenney adapts Cage's definition of a sound-space, in which any possible sonic event can be denoted by the values of five determinants —"frequency or pitch, amplitude or loudness, overtone structure or timbre, duration, and morphology (how the sound begins, goes on, and dies away)"[10]—to his own definition of harmonic *space*, that is to say a multi-dimensional continuum of pitch, defined by a variable number of axes corresponding to the prime factors of intonation theory.[11] For instance, Figure 2.1 illustrates a three-dimensional harmonic space (with axes for primes 2, 3, and 5); alternatively, a simpler two-dimensional model could

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[9] James Tenney, "John Cage and the Theory of Harmony*,"* 22–23.

[10] John Cage, "Experimental Music," in *Silence: Lectures and Writings* (Middleton: Wesleyan, 1961), 9.

[11] In this light, Tenney's concept of harmonic space is an extension (and in some ways a refinement) of the lattice tuning systems developed by Ben Johnston.

also define the same harmonic space by "collapsing" the axis of the octave (i.e. that of the first prime) on itself.[12]

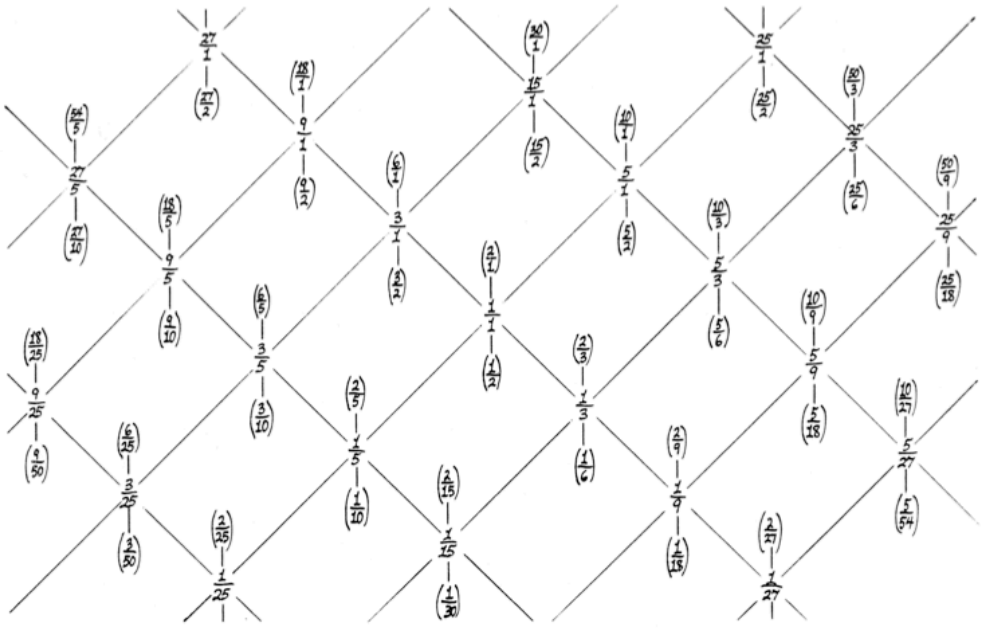

Figure 2.1 example of (2,3,5) harmonic space (Tenney's own illustration).

The impetus for this definition was the need for a harmonic theory that is descriptive (or "aesthetically neutral"), general, and especially quantitative (i.e. objectively measurable)—as opposed to many historical harmonic theories, which tended to be prescriptive, specialized, and anything but measurable.[13] This concept of harmonic space plays a fundamental role in much of Tenney's music from the 1980s

[12] Tenney, "John Cage and the Theory of Harmony", 21ff.

[13] Tenney, ibid., 3–4.

and onward, acting as the backdrop on which complex harmonic itineraries develop. Given an *n*-dimensional harmonic space, any pitch that falls within the prime limit defined by the space can be localized through a set of coordinates. Movements in the space happen along the axes, and can thus be measured with a sort of weighted "city block" metric (meaning that distance on higher-prime axes is weighed more heavily than the same number of steps along a lower-prime axis; i.e. one step along the 3-axis weighs less, and is therefore considered less distant, than one step along the 7-axis). Tenney's formula for measuring harmonic distance (HD), which he and others have used extensively as both a compositional and analytical tool, is predicated on the concept of harmonic space.[14] Other compositional and theoretical constructs, such as the "Crystal Growth" algorithm detailed in a 1998 article, similarly rely on the previously-established concepts of harmonic distance and harmonic space to form a complex and coherent theoretical body.[15]

Another relevant concept for our discussion comes from the early 1980s, when Tenney returned to algorithmic composition after a hiatus of several years. One procedure models the "dissonant counterpoint" of early twentieth century U.S. music. First described in Henry Cowell's notebooks from 1915, dissonant counterpoint was developed further by Cowell and Charles Seeger in the 1920s and 30s, and employed

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[14] The HD formula measures the shortest distance between any two points in an n-dimensional harmonic space by the formula: HD(a:b) = log(ab); in other words, it computes the complexity of the prime factors involved in the definition of any interval. See Tenney, ibid., 24; and John Chalmers, *Divisions of the Tetrachord*, 60.

[15] The crystal growth algorithm is explained at length in Tenney, "On Crystal Growth in Harmonic Space," *Contemporary Music Review* 27, no.1 (2008), 47–56.

by them as well as several of their contemporaries, including Johanna Beyer, Ruth Crawford Seeger, Lou Harrison, and—crucially for Tenney—Carl Ruggles.[16] Tenney's algorithm, in fact, evolved from an earlier statistical study of the melodic style of Carl Ruggles, in which the younger composer mapped the statistical recurrence of pitches in his predecessor's work over a period of several years.[17] The transformation of these analytical findings into a compositional tool, which had been foreshadowed in Tenney's Bell Labs papers, matured in the 1980s to become his favored method of producing randomness and ensuring variability, whether in terms of pitch succession, instrumentation, register, or other parameters.[18] Tenney used this "dissonant counterpoint" algorithm in the composition of works such as the *Spectrum* series, *Seegersongs,* and the late string quartet *Arbor Vitae*, but he also used it as a sort of "random number generator" in most pieces since the 1980s, including *Changes* and *Water on the mountain…Fire in heaven*.[19]

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[16] "Dissonant Counterpoint," as a set of principles, avoids the repetition of pitches and reverses the common-practice treatments reserved for consonant (octave, major/minor thirds/sixths, perfect fourths/fifths) and dissonant (seconds/sevenths, tritones) intervals. For a history of the method, see John Spilker, "The Origins of 'Dissonant Counterpoint': Henry Cowell's Unpublished Notebook," *Journal of the Society for American Music* 5 (2011), 481–533.

[17] Tenney, "Chronological Development of Carl Ruggles' Melodic Style," *Perspectives of New Music* 16 no.1 (1977), 36–69. Also Polansky, *The Early Music of James Tenney,* 253–255.

[18] Larry Polansky, Alex Barnett, and Michael Winter, "A Few More Words About James Tenney: Dissonant Counterpoint and Statistical Feedback," *Journal of Mathematics and Music*, 5.2, 2011, 63–82.

[19] Polansky, Barnett, and Winter, "Dissonant Counterpoint," 20. Also Michael Winter, "On James Tenney's *Arbor Vitae* for String Quartet," *Contemporary Music Review* 27 no.1 (2008), 131–150.

The common aesthetic trend that unifies these theoretical preoccupations is an interest in the phenomenology of sound, which in turn stems from an "experimental" attitude in the broader, more scientific meaning of the term. As a composer, Tenney was uninterested in musical representations of narrative, drama, or subjectivity; what interested him was the exploration of sonic phenomena, the sounding out of physical and acoustical concepts, the investigation and trial of musical processes. Tenney's recurring compositional challenge lies in solving the problem at hand in as elegant and concise way possible, much like the way mathematicians would approach the solution of a historic equation. Although his music articulates itself in time, much of it exists outside of it—the works as they exist in scores and recordings being simply excerpted from processes that can be thought of as having no real end. In that guise, his work is ultimately a reference to the physics of sound as it happens and is perceived in the world around us: Reaching infinitely upwards like each successive order of the harmonic series.[20] His invitation to the audience is simply to listen, to come along on his acoustic explorations, and to marvel.

The Guitar Pieces of James Tenney: Tuning Overview

Tenney's four pieces for guitar—*Harmonium II* (1976/2008), *Septet* (1981), *Water on the mountain… Fire in heaven* (1985), and *Spectrum 4* (1995)—span the mature years

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[20] Donnacha Dennehy, "Interview with James Tenney," *Contemporary Music Revie* 27.1, 2008, 79–89. Tenney reffered to the harmonic series as "the only thing given to us by nature…except sound itself."

of his compositional career, and reflect both his renewed interest in the harmonic series as structural material (*Harmonium II*, *Septet*) and the return to algorithmic compositional methods. Throughout these works, Tenney uses extensive retuning of the open guitar strings to produce a range of harmonically tuned pitches. In *Spectrum 4*, following the example of the string quintet *Spectra for Harry Partch* (1972), Tenney tunes each string to a different partial of the piece's fundamental. Each string is either sounded open, or can be used to produce a higher, compound ratio via harmonics. For example, tuning a string to the 7th partial of a given fundamental, and subsequently touching (not fretting) the string at the 5th node would result in the 35th partial of the fundamental. This method has the benefit of not requiring any familiarity with just ratios on the performer's part—once tuned, the instrument can be played as if reading a tablature. Conversely, in the *Septet* Tenney detunes one or two strings for each guitar by an amount corresponding to the *cent deviation* (from 12TET) of a given partial. The actual partials are then performed by stopping the strings at the appropriate places on the equal-tempered fingerboard. For instance, the C# needed to sound a 5:4 third above the fundamental A is played at the second fret on the second string, which was previously detuned by the necessary 14¢. Finally, *Water on the mountain… Fire in heaven* uses the most radical departure from conventional tuning. The six guitars are tuned one-sixth of a semitone (~16.67¢) apart from each other, and treated together as a meta-instrument in 72TET. This tuning system provides a close approximation of many important eleven-limit intervals,

without being wedded to any particular fundamental. Tenney had already experimented with equal temperaments in the 1970s, most notably with *Glissande* (1972), a piece for strings and tape delay in 84TET, which foreshadowed his highly adaptive approach to intonation systems.[21]

[21] An important precedent for the use of higher-order equal temperaments as an approximation of harmonic ratios is the work of Ezra Sims (b. 1928), who has been writing almost excluisvely using a quasi-just scale derived from 72TET since the 1940s. On his tuning approach, see Ezra Sims, "Long Enough to Reach the Ground, or How Long Should a Man's Legs Be?" *Perspectives of New Music* 32, no.1 (1994), 208–213. Other notable examples include the music of Ivor Darreg, Easley Blackwood Jr. (b. 1933), and Wendy Carlos (b. 1939).

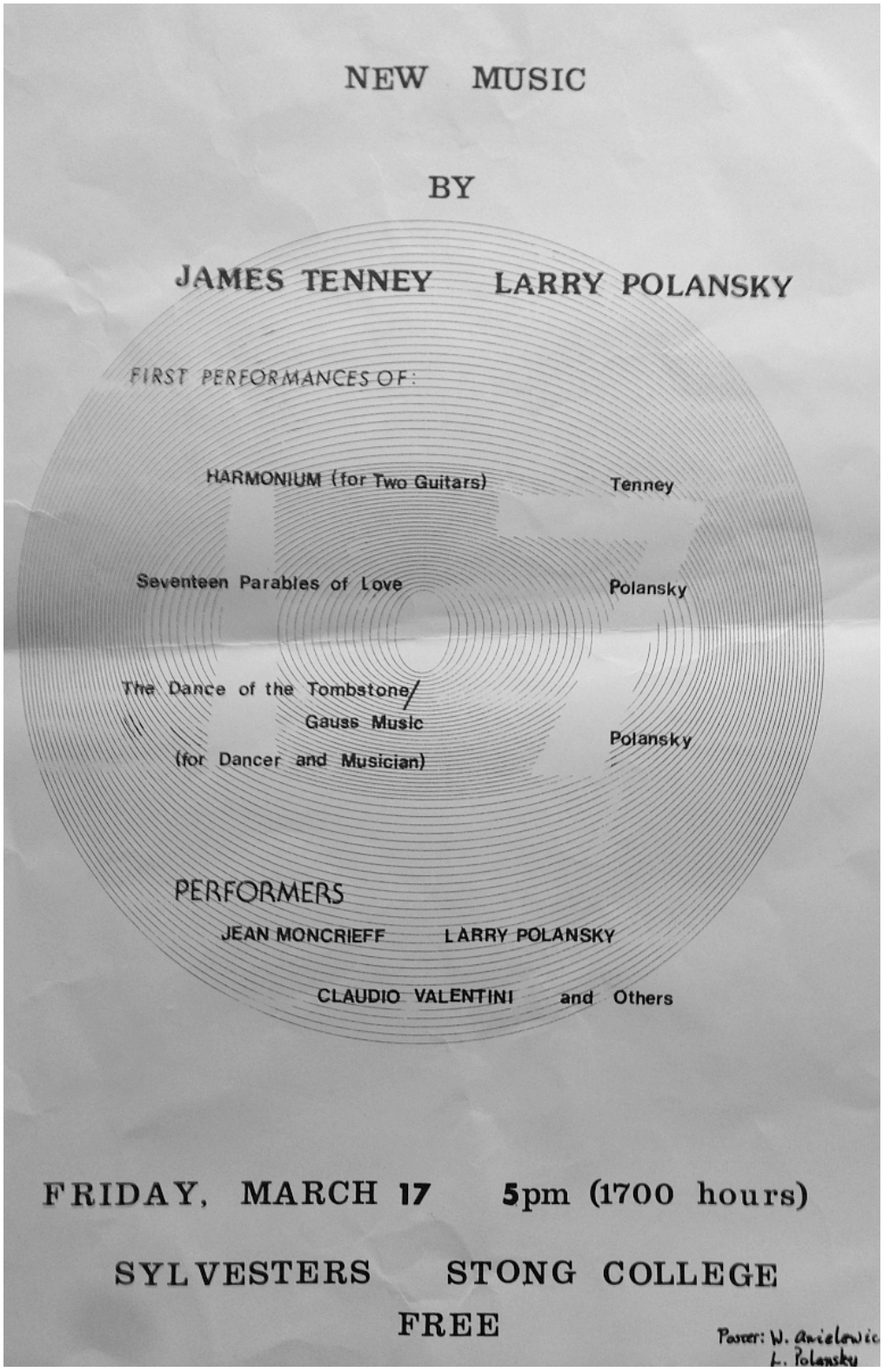
Part One: Harmonium II

Tenney's first guitar piece, *Harmonium II* was written in 1976 as the second installment in a series of seven pieces that explore the harmonic series through sequences of modulating chords. Foreshadowing his future approach to writing for the instrument, Tenney scored *Harmonium II* for two guitars that play in hocket throughout and effectively merge into a single "meta-instrument." The original version was written in equal temperament, and premiered by Larry Polansky and Claudio Valentini at a concert in Toronto on 17 March, 1978. After a couple of additional performances (including an arrangement for guitar and harp, given by Polansky and Claudia Scaletti at the University of Illinois, Urbana-Champaign on 13 December, 1979), an unconvinced Tenney withdrew the piece, reworking its harmonic material into a version for three harps tuned ~14¢ apart, which became *Harmonium III*.[22]

Almost three decades later, however, Tenney revisited the shelved composition and gave curator and guitarist John Schneider the score for a new version, which was performed at Microfest 2003 in Los Angeles by guitarists Eric Benzant-Feldra and Michael Kubirka. For this revision, Tenney introduced a tuning approach similar to the one he had used in *Harmonium III*, pitching one of the guitars

[22] James Tenney, letter to Larry Polansky (undated, 1981). Tenney Fonds, Clara Thomas Archives, York University, Toronto (hereafter: Tenney Fonds).

Figure 2.2 Poster for the premiere of *Harmonium II*


NEW MUSIC
BY
JAMES TENNEY LARRY POLANSKY
FIRST PERFORMANCES OF:
HARMONIUM (for Two Guitars) Tenney
Seventeen Parables of Love Polansky
The Dance of the Tombstone/
Gauss Music
(for Dancer and Musician) Polansky
PERFORMERS
JEAN MONCRIEFF LARRY POLANSKY
CLAUDIO VALENTINI and Others
FRIDAY, MARCH 17 5pm (1700 hours)
SYLVESTERS STONG COLLEGE
FREE
Poster: W. Anielewicz
L. Polansky

approximately 30¢ lower than the other.[23] Such a tuning, which allows for better-tuned harmonic sevenths, also provides a "higher resolution" for the short-distance modulations between adjacent chromatic pitches that characterize the work.

Throughout the piece, the distribution of pitches between the two guitars appears to be strictly regimented. Most obviously, pitches corresponding to the lower primes 1, 3, and 5 appear in Guitar II (which is tuned normally), whereas higher primes (7, 11, and 17) are played by Guitar I and therefore sound ~31¢ flat. This use of tempered tuning is exemplary of Tenney's utilitarian approach to intonation: In addition to providing a much better-tuned seventh harmonic, and overall closer approximations of higher ratios than 12TET (harmonics 7, 11, and 17 are mistuned by ±0, +18, and -26, as opposed to +31, +49, and -5, respectively), the tuning also creates a finer microtonal fabric—and one in which the pithces are less immediately familiar—for the piece's short-distance modulations.[24]

Over the course of this short piece (approximately four minutes in performance), Tenney takes the listener across twelve tonal centers, running "clockwise" along the circle of fourths from B to G♭. In the first half of the piece the

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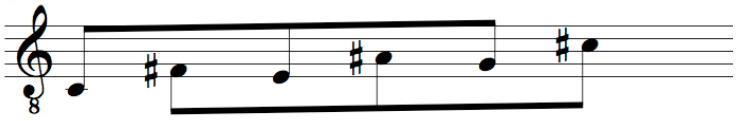
[23] The score is published by Smith Publications (2008). In a review of the Microfest performance for the LA Times, Josef Woodward mistakenly refers to the guitars being tuned a quartertone apart. "Microtonal Guitarists Open Ears," *Los Angeles Times*, 29 April, 2003, http://articles.latimes.com/2003/apr/29/entertainment/et-woodard29

[24] Another example of Tenney's pragmatic approach to tuning and temperament is discussed by Belet in the context of the 1972 piece *Glissande*, in which Tenney opted for the use of seventh-tone divisions (versus sixth-tones) after evaluating the suitability of each system for the aesthetic and compositional purposes of that particular piece. Belet, *An Examination of the Theories and Compositions of James Tenney*, 45.

chords are built progressively, as higher primes are introduced one at a time, increasing the overall number of notes each chord includes. For example, the opening B triad (B_{HP5}, three notes) is followed by an E_{HP7} (four notes), an A_{HP11} (five notes), and an incomplete D_{HP17} (six notes, as the 13th is omitted).[25] This sonority is both a subset of the octatonic mode made up of the first eight odd primes of the overtone series—a chord that Tenney had explored extensively in works such as *Clang*, *Chorales for Orchestra*, and many others—and a "harmonic series version" of the so-called *Petrushka* chord (two major triads a tritone apart), which Tenney would have known especially well from its appearance in the "Emerson" movement of Ives's *Concord Sonata*.[26]



Example 2.1 HP17 aggregate in *Harmonium II*

The process with which Tenney moves from one chord to the next is a gradual substitution of "close-by" harmonic pitches. For instance, the D ♯ (B^5) changes not to

[25] For the analysis of aggregates in *Harmonium II* and *Septet* I am defining "A_{HPn}" as a chord built of primes up to *n* over the fundamental (i.e. A_{H17} contains 2, 3, 5, 7, 11, 13, and 17). Similarly, A_{Hn} indicates a chord built of harmonics up to *n* (i.e. A_{H17} contains 2, 3, 5, 7, 9, 11, 13, 15, 17)

[26] Geoffrey Block, *Ives, Concord Sonata: Piano Sonata No. 2 ("Concord, Mass., 1840-1860"),* (Cambridge: Cambridge University Press, 1996), 56, discusses the possible borrowing of the sonority from Stravinsky on Ives's part. Tenney, as we have seen, had performed the *Concord* as a recitalist.

E, but to the flat D of Guitar I (approximating E^{7}); the intervening D natural played by Guitar II in measures 13–16, makes the transition smoother by splitting the distance between the two pitches.[27] Similarly, the F ♯ (B^{3} or E^{9}) creeps up past G (E^{19}) to G ♯ (E^{5}), again making use of the 1/6th tone pitches available on the way (see Example 2.2). As more primes are introduced, the rhythmic patterns become denser, growing in speed to the quintuplets that introduce the HP17 chords of the second half of the piece.

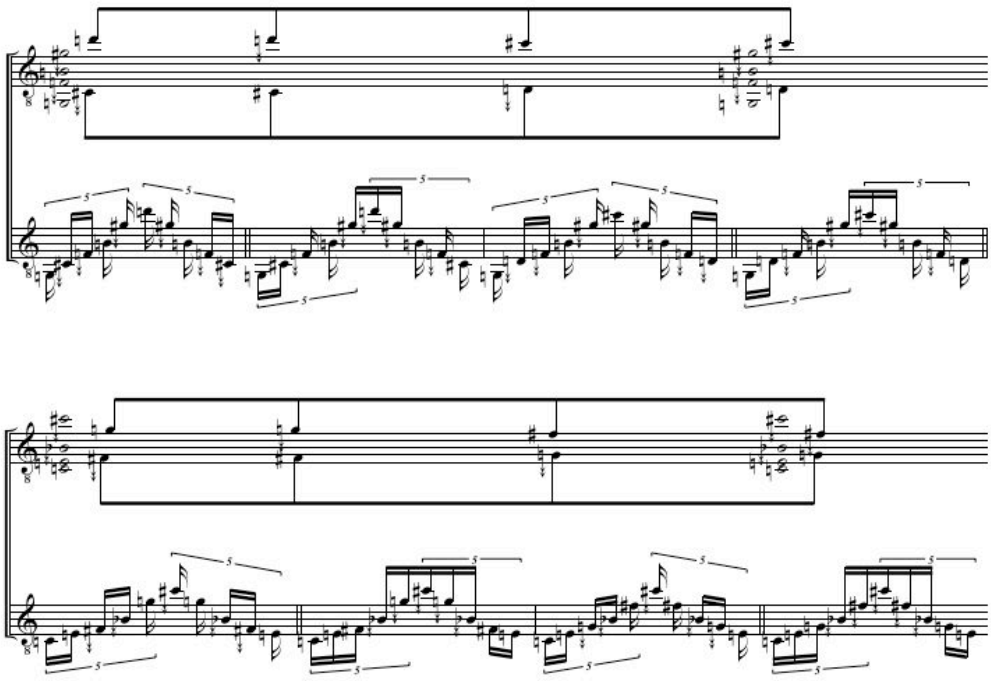
The latter part of the piece consists of a series of eight direct—rather than gradual—modulations from D_{HP17} to $G♭_{HP17}$, with the roots moving by a perfect fourth as established previously. Initially, pitches change to their nearest neighbor, which is often found in the other guitar. Subsequently primes 3 and 11 exchange places in the chord spacing via a microtonal "switch" to rearrange the new chord (see Example 2.3). As this process recurs, a progressive rearrangement of the chord

[27] Because of this hybrid tuning context, and for the sake of clarity, I am borrowing the double-arrowhead accidental from the Helmholtz-Ellis just intonation notation to indicate pitches one-sixth of a tone flat in the examples.

Example 2.2 Opening of *Harmonium II*, highlighting the microtonal "creeping" of pitches from one guitar to the other.

Guitar I (stems up)

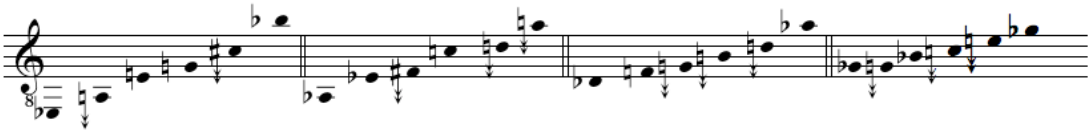
Guitar II (stems down)



Example 2.3 Rearrangement of primes 3 and 11 in different chord voicings in *Harmonium II.*

voicings, ultimately preparing the spelling of the final G♭[HP17]chord. As in other pieces by Tenney, the overall trajectory of the piece is determined by its material in an almost deterministic way; the compositional challenge lies in describing such a trajectory in as economical a way as possible—meaning to find the quickest and smoothest way to travel across all of the tonalities of the piece. The last sonority is presented in an interspersed, closed voicing, with the two major triads played in strict hocket between the two voices. The smaller span of this final arpeggio (a mere augmented sixth, compared to the two-octave-plus range of the previous ones) is in

part a result of the instrumentation. The D♭ root of the next-to-last chord has to be raised an octave to fall within the range of the guitars; as the final G♭ is also approached "from below," the resulting chord is the first to feature intervals smaller than a third, creating a novel sonority.



Example 2.4 Contraction of voicing in the final measures of *Harmonium II*.

Harmonium II foreshadows several of Tenney's theoretical and aesthetic developments—most importantly, the approximation of harmonic series relationships in an equal tempered context. Beneath an apparent simplicity lies a piece of considerable musical challenges: The two guitarists must act as one, blending their timbres and carefully staggering their attacks to maintain the illusion of a single instrumental voice. Perhaps because of this combination of an innocent façade and a more difficult substance, *Harmonium II* still counts few performances beyond its recent revival. In its new, widely-available incarnation, however, the piece offers performers and listeners the opportunity to explore a different kind of harmonic motion, preparing them for more ambitious tonal explorations to come.[28]

[28] Whereas the earliest version of *Harmonium II* was circulated only in mansucript form, the Smith Publication edition is in print and readily available. A recent performance by two USC graduate students, Albert Diaz and Adam Pettit, is available on YouTube: http://www.youtube.com/watch?v=iOP4Q6GEM48.

Part Two: Septet

Not unlike *Harmonium II*, Tenney wrote his *Septet* as a modulation study—although in this case the entire work encompasses a single harmonic change. Due to its coherent and concise organization, it is in some ways the simplest of the composer's works for guitar, despite an ebullient and microscopically detailed surface appearance. Writing for six electric guitars and electric bass, Tenney distributes the musical material among the members of the ensemble in a way that makes complex polyrhythmic and harmonic relations possible—thus recreating textures reminiscent of *Spectral CANON for CONLON Nancarrow*, without resorting to mechanical or technological aids. The composer first announced the piece in a 1982 letter to Larry Polansky, who was then at the Mills Center for Contemporary Music.[29] Eventually Polansky organized a group of guitarists for the premiere, which took place at the Mills Contemporary Ensemble concert on 8 May, 1985, along with additional performances in San Francisco, Berkeley, Santa Cruz, and Marin County.[30] A recording of one of the San Francisco performances, a benefit event for the Just Intonation Network, was released in 1986 by Tellus (an audio cassette magazine that ran from 1983 to 1993) as part of an issue dedicated to new works in just intonation.[31] In addition, a studio recording dating from around the time of the premiere appeared

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[29] James Tenney, letter to Larry Polansky (18 February 1982), Tenney Fonds.

[30] Larry Polansky, letter to James Tenney (undated, July 1985), Tenney Fonds.

[31] Polansky, letter to Tenney, undated (1985–86). Tenney Fonds. A "cassettography" on the Tellus Wikipedia page lists the Just Intonation Network release as #14.

on the companion CD to issue number 7 of the *Leonardo Music Journa*l; new music specialist Seth Josel also recorded the piece for his album *Go Guitars.*[32] More recently, the *Septet* figures in the repertory of electric guitar ensembles such as DITHER.[33]

Formally the piece can be divided in five sections, the first three consisting entirely of materials derived from the harmonic series on A (up to the 11th partial), and the remaining two shifting to a series based on E. Strictly speaking, however, the entire piece derives from the first harmonic series, as all successive harmonics of E are related to the lower pitch by whole-number ratios. The shift occurs at measure 160, roughly three-fourths of the way through the 218-measure long piece—a relationship underscored by the accompanying tempo modulation from quarter note= 60 to 90 (= 3:2).

In addition to these macroscopic considerations, harmonic ratios also govern microscopic rhythmic elements. Generally speaking, pitches appear in rhythmic patterns that reflect the harmonic numbers of the pitches themselves; each player is responsible for a single ratio (and its octaves) at a time. As one example, in measure 25, Guitar 6 takes over Guitar 5's 7:8 rhythmic pattern on a repeated low A, then changes its pitch to the harmonic seventh (31¢ flatter than a tempered minor seventh)

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[32] "Cocks Crow, Dogs Bark: New Compositional Intentions," *Leonardo Music Journal* 7, 1997; and James Tenney, Lois V Vierk, and Phill Niblock, Seth Josel, *Go Guitars,* (O.O Discs 36, 1998).

[33] A performance at Brooklyn's Invisible Dog, with Polansky conducting an ensemble featuring DITHER plus additional musicians Nick Didkovsky, Dan Josephson, and Devin Maxwell is available on YouTube: <http://www.youtube.com/watch?v=m-oN7El5VM8>

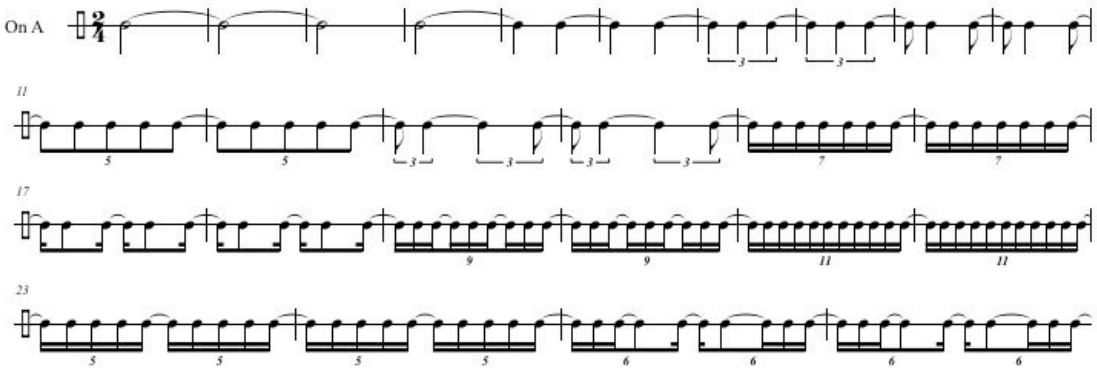
in measure 59.

In order to perform these pitches accurately, each guitarist must retune some of the strings by the appropriate cent deviation to accurately sound the assigned partial. For instance, Guitar 2 tunes the top two strings fourteen cents flat, and is responsible for the 5th and 10th partials throughout the piece. The player can fret these strings to produce pure major thirds and tenths.[34] In a similar vein, Guitars 3 and 6, responsible for the 11th and 7th harmonics, tune their top strings 49¢ and 31¢ flat, respectively. Guitars 1, 4, and 5 are assigned intervals derived from the 2nd and 3rd, and thus do not need to retune (deviations of 2–4¢ falling squarely within the tolerance range, especially in the context of fretted strings).

Harmonic relationships are one of two principles governing the unfolding of the piece. The other element at play in the *Septet* is canonic in nature, in the loose term of a "musical rule." For example, the opening section is a unison canon; the attacks across the parts combine to produce rhythmic ratios that reflect those of the harmonic series. In sections II–V, the "rule" is that the order of introduction (or removal) of successive partials follows harmonic series order. As a result, section II, which begins with all instruments sounding unison A2 in superparticular rhythmic subdivisions (Example 2.5), progressively grows into a sort of "Rhythmicana," a musical form explored by Henry Cowell in which partials are played in rhythmic

[34] The tuning as indicated in the score makes the octave C#s in measure 83 and following impractical, if not impossible. Tuning the third string down fourteen cents as well would enable the guitarist to play those measures comfortably without compromising other notes.

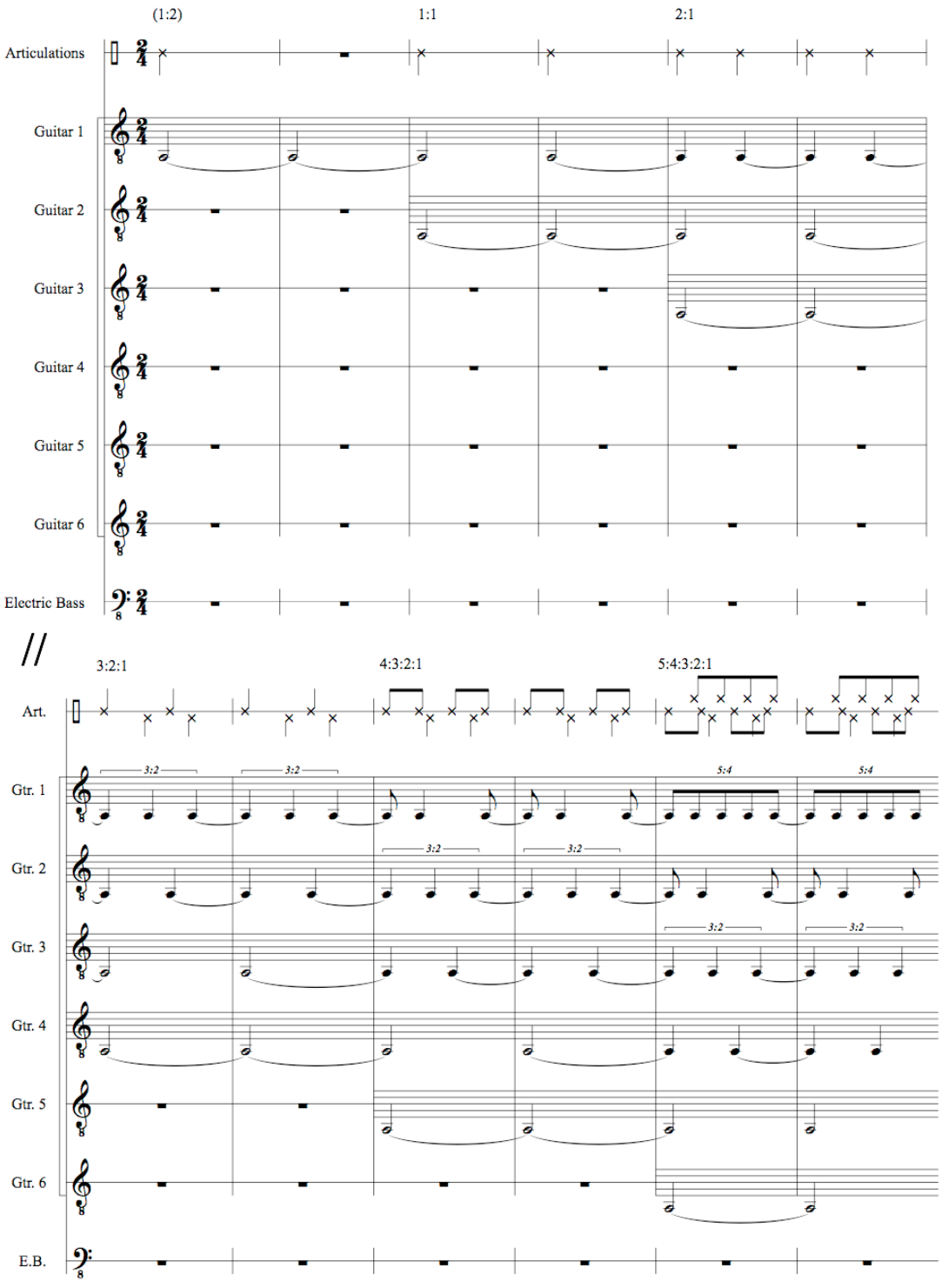
values that reflect their harmonic number (e.g. the 3rd harmonic is played as a triplet, the 5th as a quintuplet, and so forth—as detailed in Example 2.6).[35] At the juncture between sections II and III the seven voices form the chord A_{H11}—an otonal hexad in Partch's parlance, and an aggregate that appears frequently in Tenney's works (Example 2.7).

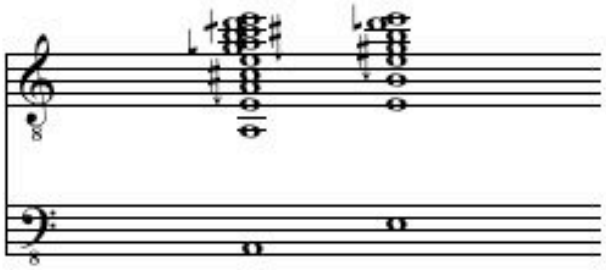


Example 2.5 Rhythmic structure of the opening unison canon in *Septet*.

[35] See for example Cowell's *Rhythmicana* (1931, for Rhythmicon and orchestra) and *Quartet Euphometric* (1915–1917).

Example 2.6 Superparticular ratios of effective note articulations in *Septet*.

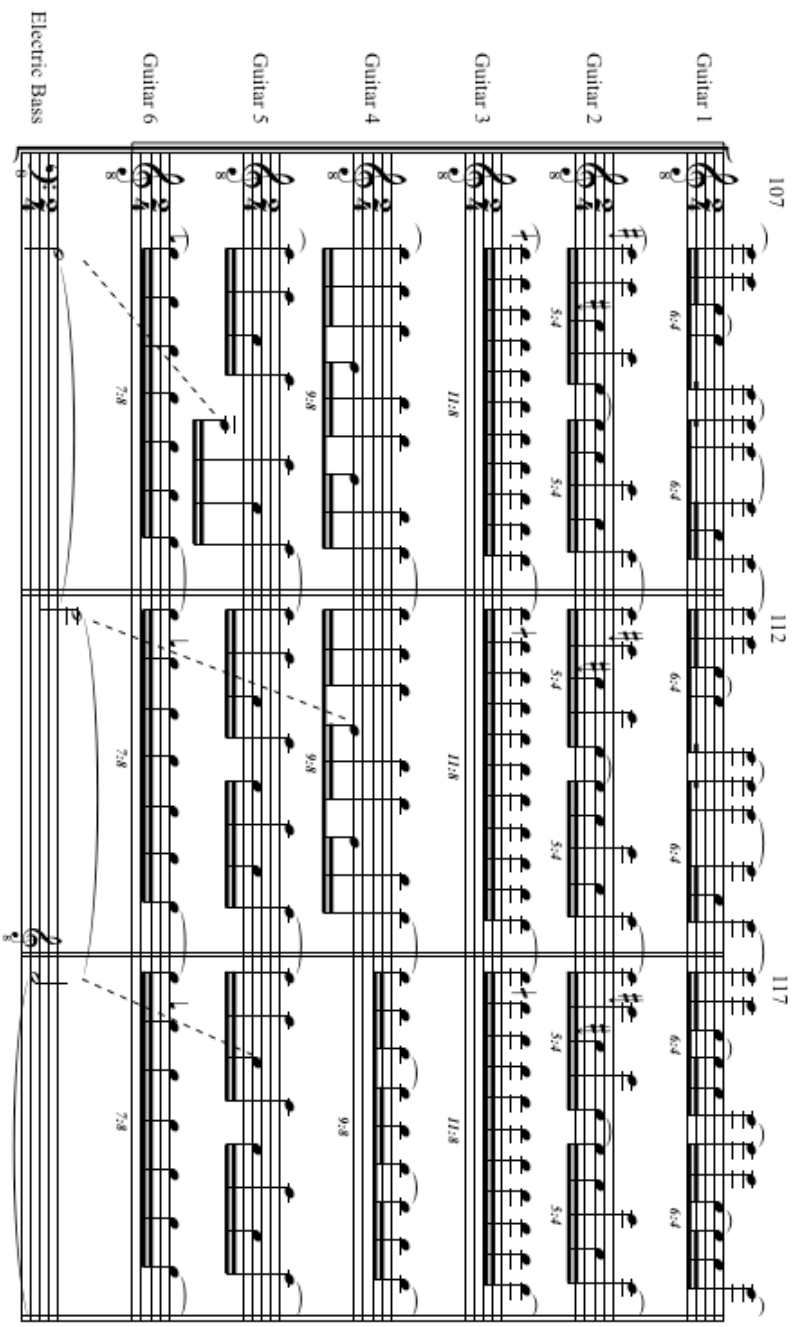

(1:2)
1:1
2:1
Articulations
Guitar 1
Guitar 2
Guitar 3
Guitar 4
Guitar 5
Guitar 6
Electric Bass
//
3:2:1
4:3:2:1
5:4:3:2:1
Art.
Gtr. 1
Gtr. 2
Gtr. 3
Gtr. 4
Gtr. 5
Gtr. 6
E.B.
3:2
5:4

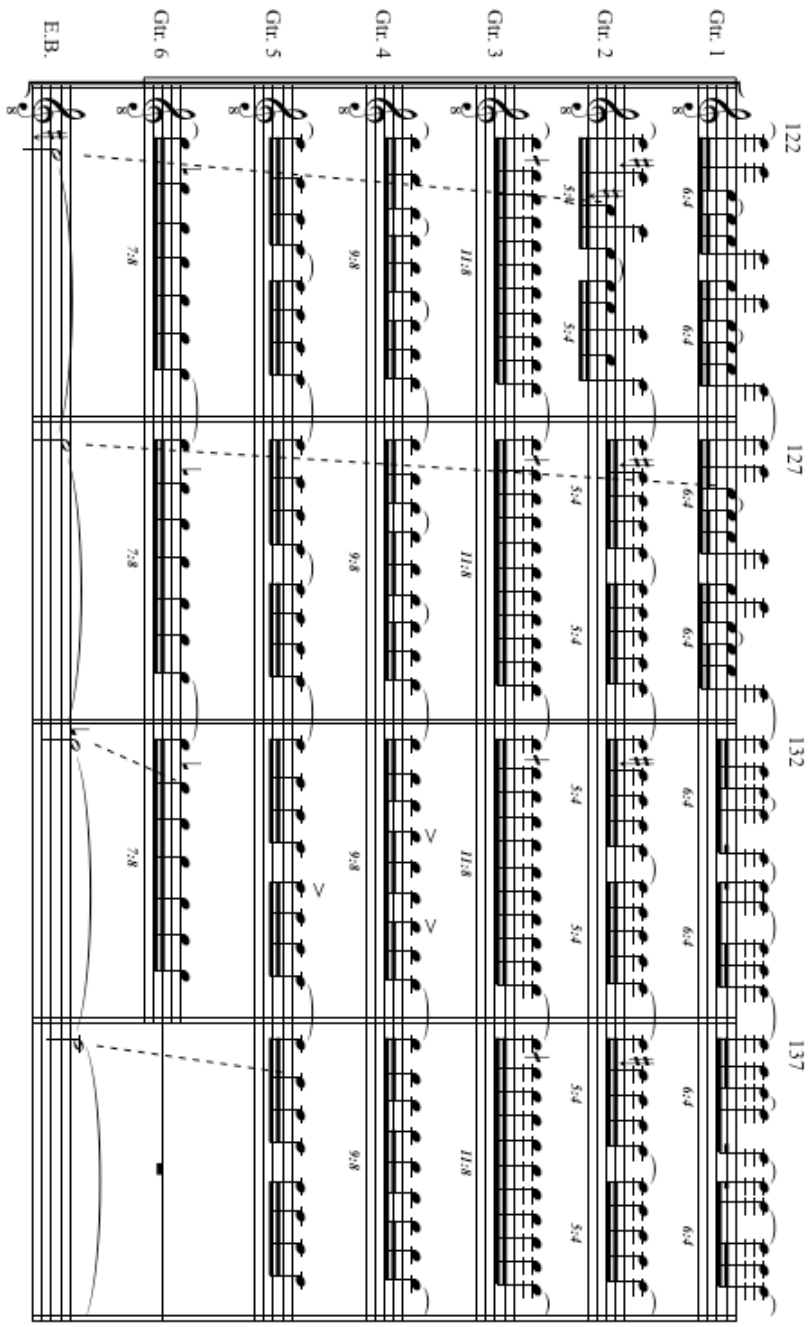


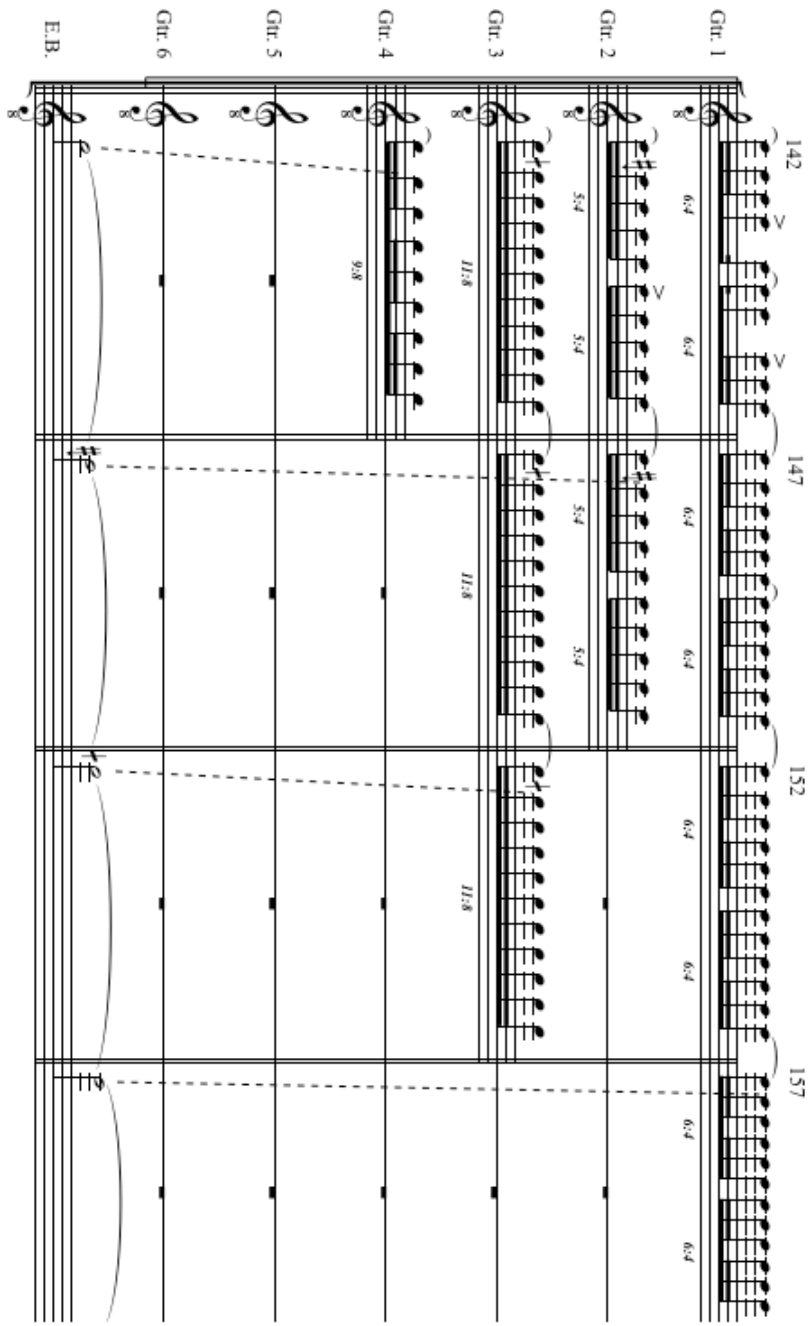
Example 2.7 A_{H11} and E_{H7} aggregates in *Septet*.

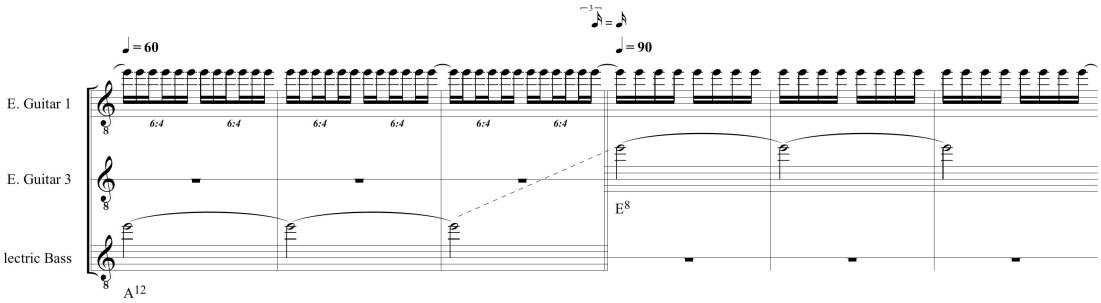
Sections III and IV contain the process with which Tenney shifts tonality from A to E. This process occurs both horizontally and vertically: in measure 107 the Bass begins playing successive harmonics from the A series on the downbeat of each repeated group. As these harmonics sound, the guitar part with the corresponding pitch drops it from the texture. For example, after the Bass plays A^2, the same pitch disappears from Guitar 5's pattern in measure 112; similarly, Guitar 3 drops the lower of its two Es (A^3) in measure 117. As a result, the chord vanishes from the bottom up, as if passed through a slow-motion sweeping filter (Example 2.8a). By measure 157, only the high E (A^{12}) of Guitar 1 is left; a rhythmic modulation preserves the pulse across the overall tempo change (by a ratio of 3:2), and the bass passes its last pitch to Guitar 3, which begins a descent along the "new" harmonic series of E (A^{12} being of course the same pitch as E^8). (Example 2.8b)

Example 2.8a Harmonic simplification leading to modulation, *Septet*.


107
112
117
Guitar 1
Guitar 2
Guitar 3
Guitar 4
Guitar 5
Guitar 6
Electric Bass
6:4
5:4
11:8
9:8
7:8


122
127
132
137
Gtr. 1
Gtr. 2
Gtr. 3
Gtr. 4
Gtr. 5
Gtr. 6
E.B.
6:4
5:4
11:8
9:8
7:8

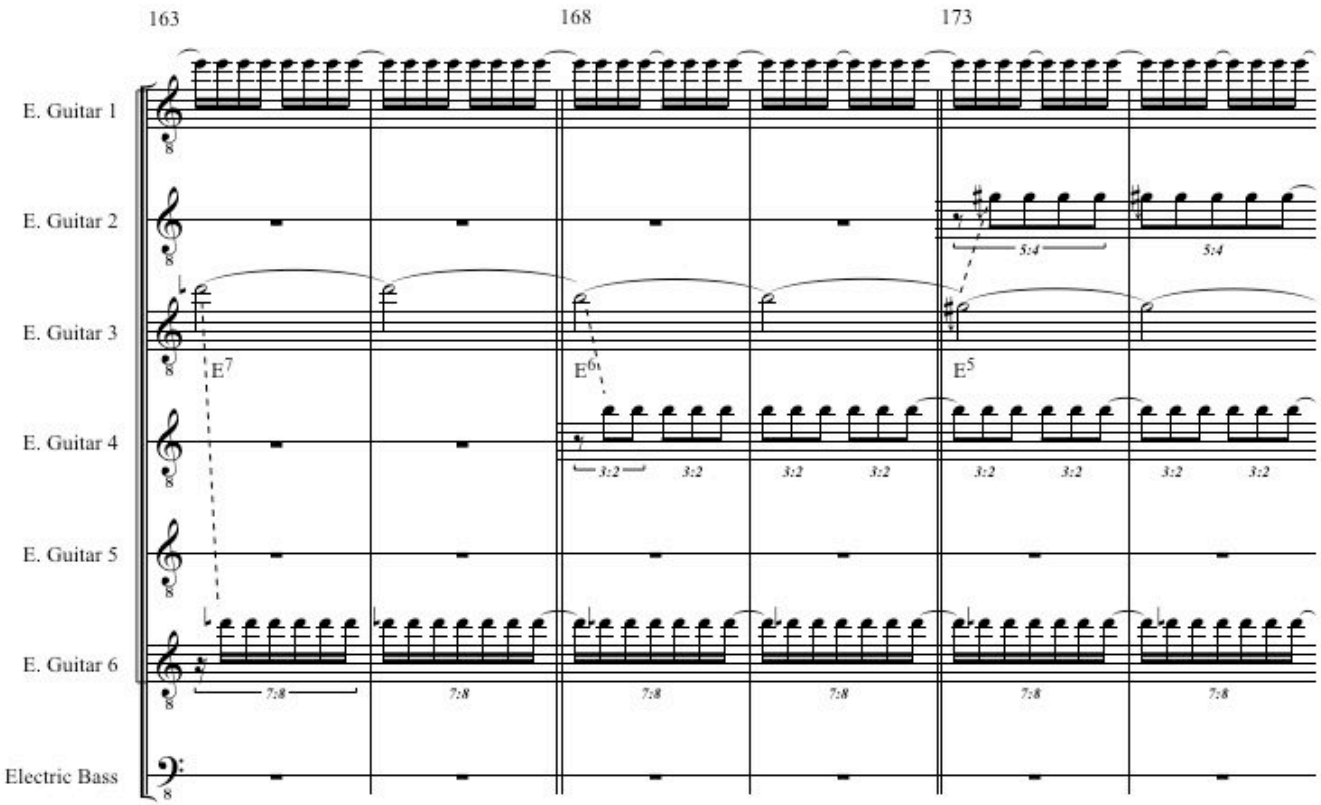

142
147
152
157
Gtr. 1
Gtr. 2
Gtr. 3
Gtr. 4
Gtr. 5
Gtr. 6
E.B.
6:4
5:4
11:8
9:8



Example 2.8b Modulation "pivot" detail, *Septet*.

In section IV, this process is reversed. As Guitar 3 sounds harmonics seven to one of E, the pitches are picked up by the respective player and sounded in the appropriate rhythmic pattern (Example 2.9). Tenney allows the completed E_{H7} chord to resonate for measures 193–198, and then embarks in a final filtering procedure, with higher partials disappearing from the texture in favor of unison low Es, until the piece's end in measure 218. Ostensibly, this process could be repeated—or reversed—with a return to A. In a sense, the musical piece acts as a model of the lower octaves of the harmonic series "exploded" over the additional dimension of time, and as such could be interpreted as having no real beginning or end. In this light, it is a clear realization of the theoretical framework Tenney had stipulated in *"John Cage and the Theory of Harmony,"* while also referencing the scalar and harmonic constructions outlined by Cowell half a century before.

Example 2.9 “Sounding out” of E_{H7} sonority in section IV, *Septet*.


163
168
173
E. Guitar 1
E. Guitar 2
E. Guitar 3
E. Guitar 4
E. Guitar 5
E. Guitar 6
Electric Bass
E7
E6\
E5
5:4
3:2
7:8

In addition to its deliberate musical treatment of spectral and harmonic phenomena, a critical innovative element in Tenney's *Septet* is the choice to limit each player to a small set of intervals, each available on a specific string. Were the piece to require more extensive fretted passages from its players, its (un)compromised tuning would of course make performance difficult, if not impossible. By restricting the pitch material required of each player, Tenney can still choose from a palette of harmonic pitches without the need for expensive refretting or more advanced and difficult techniques (such as playing precisely-tuned pitches with a slide, or by bending a lower tone). After checking the initial tuning for accuracy, each player is free to play the guitar as usual, without further adjustments. Again, this kind of pragmatic approach appears throughout Tenney's works—most notably in *Spectra for Harry Partch* and, in similar guises, in his later works for guitar. In the case of the *Septet*, the instrumental forces are used in a somewhat inefficient way, with only a handful of pitches produced *per guitar*; however, this less than optimal allocation of musical resources can be explained through the complexity of the rhythmic patterns present in the piece. Although in theory (and with some additional retuning) it would be possible for each player to be responsible for two partials instead of one, the resulting polyrhythms within each part would render the piece difficult to the very limits of practicality. Conversely, part of the beauty of the *Septet* lies in the pedagogical aspect: rather than requiring the musicians to be intonation experts, Tenney offers them the opportunity to become familiar with the sounds and rhythms

of harmonic ratios. Considering the wide availability of guitars and guitarists nowadays, gathering and rehearsing an ensemble is feasible for many music departments and professional groups. The progression of intonation and harmonic frontiers was after all a concern close to Tenney's heart. In an interview with composer Donnacha Dennehy, Tenney speaks of the role of accessible, yet precise intonational notation in a pedagogical, "quasi-evolutionary" sense:

> I'm also counting on a kind of an evolutionary process involving hearing, people learning to do this more and more. I think there's a performing practice situation with people that have worked with me on a piece that has these kinds of requirements. They're going to end up ten years later being teachers or conductors or performers, and it will spread. It will take time, you know, before it really becomes commonplace in the culture. But that's all right, because it's going to happen. I really believe it's going to happen.[36]

[36] Dennehy, "Interview with James Tenney," 80. The continuing vitality of tuning experimentation (especially at institutions formerly associated with Tenney, such at U.C. Santa Cruz and the California Institute for the Arts), and the way with which once-deemed-impossible pieces have become more frequently heard, seem to indicate that Tenney's conviction might be happening after all.

Part Three: Water on the mountain…Fire in heaven

Composed in 1985 for six guitars in a microtonal, "quasi-just" tuning, *Water on the mountain…Fire in heaven* (*Water…Fire* hereafter) is among Tenney's most harmonically complex pieces. It shares algorithmic inception, tuning, and harmonic language with *Changes*, a set of sixty-four studies for six harps from the same year; as a matter of fact, the computer output for *Water…Fire* even bears the subtitle "Study 65." Despite this relationship, *Water…Fire* and *Changes* differ in significant ways. From a historical standpoint, the first was transcribed into notation soon after the completion of the algorithm, and premiered in a concert at York University in October 1985 under the direction of conductor James McKay.[37] A decade later, new music specialist Seth Josel released a studio recording of the piece on his CRI album *Long Distance*.[38] By contrast, only the first sixteen studies of *Changes* have been prepared for performance. Composers Michael Winter and Casey Anderson are currently completing a transcription of the remainder of the piece; as a consequence, no commercial recording exists to date.[39] Another difference is structural: Although *Changes* is a much larger work as a whole, the program for *Water…Fire* specifies a longer duration for the single movement. Each of the studies for *Changes* lasts

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[37] A tape recording of the first performance (or of a separate studio session) is held by the York University archive, and was recently digitized upon a request from the author. Tenney Fonds, 1998-038/032.

[38] Sidney Corbett, James Tenney, Martin Bresnick, Eric Lyon, and Aaron Jay Kernis; Seth Josel, Guitars, *Long Distance* (New York, NY: CRI, 1996).

[39] The transcriptions are held in the Tenney Fonds. The first sixteen studies were performed by the New Music Concerts Ensemble at the Premiere Dance Theater in Toronto under the direction of Robert Aitkev on 15 December 1985.

between 1’ 20” and 2’ 40”, as opposed to the eight minutes of the guitar piece; in addition, Tenney has allowed for performances of *Water...Fire* to happen as a three-stage process, resulting in a total performance time of about twenty-five minutes.[40] Finally, and perhaps paradoxically, *Water…Fire* has not stimulated the same amount of critical interest as *Changes*.[41]

From a practical standpoint, the tuning for *Water on the mountain…Fire in heaven* is a departure from the approach Tenney had taken in the *Septet* just a few years before. Rather than employing cent-variations for only one or two strings per guitar, each instrument is pitched one-sixth of a semitone (~17¢) apart from the next to create a complete 72-tone equal tempered tuning (72TET hereafter) across the six guitars. 72TET affords the same freedom to modulate as any equal temperament, while also offering a harmonic context that closely approximates many significant intervals in 11-limit just intonation.[42] Table 2.1 shows the deviations of the main 72TET intervals used in *Water…Fire* from their just counterparts; consistently with Tenney’s terminology, the lowest note of the piece (E ~34¢ flat) equals Pc0 in the

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[40] The performance directions to *Water...Fire* and the resulting realizations of the piece will be explored in more detail in the conclusion of this section.

[41] In addition to Tenney’s own writing “About Changes” *Perspective of New Music* 25 no.1/2 (1987), 64:87, and Belet’s dissertation (93–129), consider for example Gayle Young, “The Pitch Organization of *Harmonium for James Tenney*,” *PNM* 26.2, 1988, 204–205, in which the author, when discussing Tenney’s use of the 11:9 interval, cites *Changes* but not *Water… Fire*.

[42] James Tenney, letter to Larry Polansky, undated, 1984. In a previous letter, Tenney reports conceiving the piece as another septet, with the guitars tuned one-seventh of a semitone away from each other (i.e. in 84TET).

72TET pitch-set.[43] Notice how the largest error, the one corresponding to the 27:16 Pythagorean major sixth, is just +6¢. More significantly, the 5:4 major third (+3¢) is tuned with considerable improvement from 12TET's +14¢; the harmonic seventh (7:4) and undecimal tritone (11:8) are tempered by -2¢ and -1¢, respectively.

72TET	Cents	Approx Ratio	Δ
0	0	1:1	±0
5	83	21:20	-1
7	117	16:15	+5
9	150	12:11	±0
11	183	10:9	+1
12	200	9:8	-4
14	233	8:7	-2
16	267	7:6	±0
19	317	6:5	+2
21	350	11:9	+3
23	383	5:4	-3
26	433	9:7	-2
28	467	21:16	-3
30	500	4:3	+2
33	550	11:8	-1
35	583	7:5	±0
37	617	10:7	±0
42	700	3:2	-2
46	767	14:9	+2
47	783	11:7	+1
49	817	8:5	+3
51	850	18:11	-3
53	883	5:3	-1
54	900	27:16	-6
56	933	12:7	+1
58	967	7:4	-2
60	1000	16:9	+4
61	1017	9:5	±0
62	1033	20:11	-2
63	1050	11:6	+1
65	1084	15:8	-4

Table 2.1 Main 72TET pitches used in *Water on the Mountain...Fire in Heaven*, their corresponding just ratios, and deviations in cents.

[43] For the notation of 72TET pitches I chose to borrow some accidentals from the Helmholtz-Ellis notation. In this context, each arrowhead raises/lowers the equal-tempered pitch by ±16.67 cents (rather than raising/lowering the Pythagorean interval by a syntonic comma, ~ ±21.5 cents).

The algorithmic procedures that govern both *Changes* and *Water…Fire* are explained in great detail in the article published by Tenney in *Perspectives of New Music*, and I refer the reader to the composer's own words for the most accurate account of the piece's workings.[44] Those aspects that are most valuable for this analysis, however, will be summarized in the following paragraphs.

On the simplest level, *Water…Fire* consists of a series of modulations within a two-voice "polyphonic" framework.[45] The length of the piece is specified at the onset of the algorithm as 480 seconds (exactly eight minutes). Over the course of this timespan, the algorithm modulates away from the original modal root (Pc0), following a complex set of harmonic constraints, and then returns "home." As explained by Tenney himself, the program is only successful if it manages to return to the original root within a certain window of time from the specified end of the piece; in the case of the final version of *Water…Fire* it first reaches the dominant at 429 seconds, when it initiates a cadential sequence to buy some time before reaching its goal.[46] The duration of the piece is divided hierarchically in ten segments of similar length; each segment, in turn, contains a number of clangs proportional to its duration, creating a self-similar structure akin to the "square root" organization of

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[44] James Tenney, "About Changes," 64–87.

[45] By "polyphony" Tenney indicates the presence of independent musical layers or "voices", rather than a reference to contrapuntal styles; note, for example, that either voice can contain aggregates as well as single notes.

[46] Ibid., 83, 87.

John Cage's pieces from the 1930s and 1940s.[47]

The distance between each successive modal root is calculated stochastically using values that are defined at the beginning of the algorithm, but after each successive modulation the program "tweaks" these values slightly to maximize the possibility of a successful overall trajectory.[48] These modulations happen as a sort of random walk in a tempered, three-dimensional harmonic space defined by the 3, 5, and 7 prime axes. Table 2.2 contains a list of all possible root movements, as well as their original probability as specified in the algorithm and actual recurrence in the piece.

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[47] Tenney defines a clang as "a sound or sound-configuration which is perceived as a primary musical unit or aural gestalt;" *Meta+Hodos*, 87. Not unlike motives, phrases, and periods in conventional formal analysis, clangs can be grouped hierarchically in sequences, sections, and segments; in *Water…Fire* Tenney organizes the music only in clangs and segments (forfeiting sequencences and sections) from a compositional standpoint. "About Changes," 68.

[48] Ibid., 83–84.

Mod. Ratio	72TET	# of Mod.	Freq.	Algorithmic Prob.	Δ
1:1	0	4	0.04	0.00	+0.04
16:15	7	0	0.00	0.01	-0.01
10:9	11	5	0.05	0.05	±0
9:8	12	1	0.01	0.05	-0.04
8:7	14	5	0.05	0.04	+0.01
7:6	16	5	0.05	0.04	+0.01
6:5	19	2	0.02	0.01	+0.01
5:4	23	1	0.01	0.03	-0.02
4:3	30	46	0.48	0.30	+0.18
3:2	42	1	0.01	0.10	-0.09
8:5	49	6	0.06	0.10	-0.04
5:3	53	8	0.08	0.11	-0.03
12:7	56	1	0.01	0.02	-0.01
7:4	58	1	0.01	0.02	-0.01
16:9	60	2	0.02	0.01	+0.01
9:5	61	1	0.01	0.01	±0
15:8	65	7	0.07	0.10	-0.03
Total		96	1.00	1.00	

Table 2.2 Inventory of modulation root movements in *Water...Fire.*

Whereas root movement is confined to a three-dimensional space, the intervallic construction of the modes happens in four dimensions (including the 11-axis) to provide a variety of familiar and less familiar hexads, which cover a wide range of harmonic complexity. The modes include aggregates such as Partch's otonalities, the min7/b9 chord of jazz harmonies, and an assortment of triads from common-practice Western harmony.[49] The algorithmic generation of each new mode is a product of Tenney's HD function, which the composer tuned specifically to favor closely-related pitches in harmonic space. Furthermore, the algorithm aims to

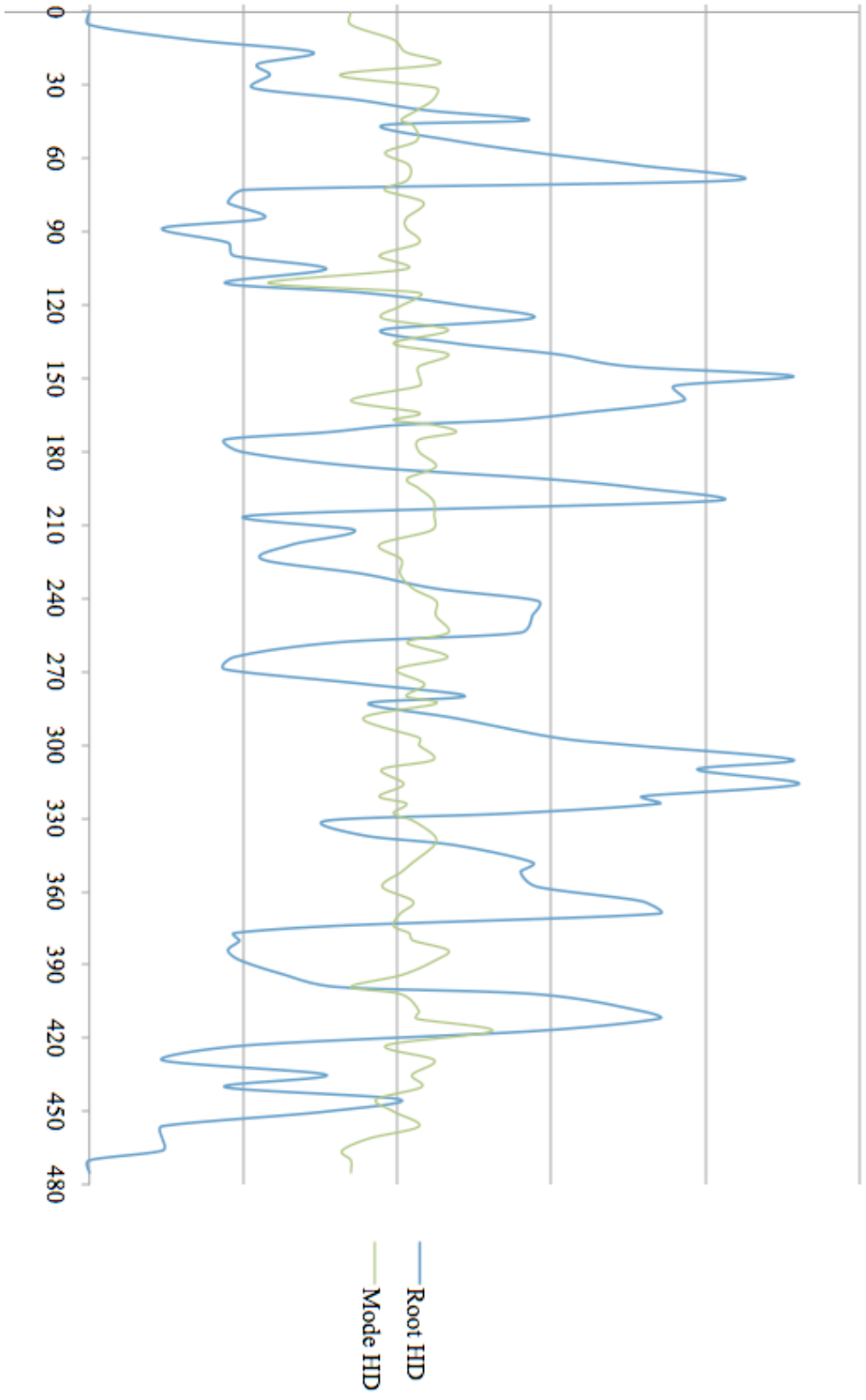
[49] Ibid., 76–81.

maintain some commonalities between adjacent modes, both in terms of pivot pitch classes (Pcs) and of internal intervallic structure.

HD values provide quantitative measurements that, plotted over time, display the overall harmonic trajectory of the piece. Figure 2.3 shows the harmonic distance of each new root from Pc0, as well as the overall harmonic complexity of the mode built upon each root. It is apparent that, whereas modal complexity stays relatively constant over the course of the piece, the roots of the modes end up travelling quite far in harmonic space. The peaks and valleys in root harmonic distance distribution correspond to the algorithm's frustrated attempts to return to Pc0 ahead of time.

The trajectory of root modulations can also be mapped graphically in harmonic space (3:5:7), representing pure fifths/fourths (3:2/4:3, or 42/30 in the 72TET-set) on the horizontal axis; pure major thirds/minor sixths (5:4/8:5, or 23/49) on the vertical axis; and harmonic sevenths/septimal seconds (7:4/8:7, or 58/14) on the z-axis. Each each arrow indicates a single root progression—elbow connectors therefore represent more distant movements.

Figure 2.3 Plotting of HD value of each new root from original tonal center, and of HD value of each new mode, over the duration of *Water on the Mountain...Fire in Heaven*.


0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
Root HD
Mode HD

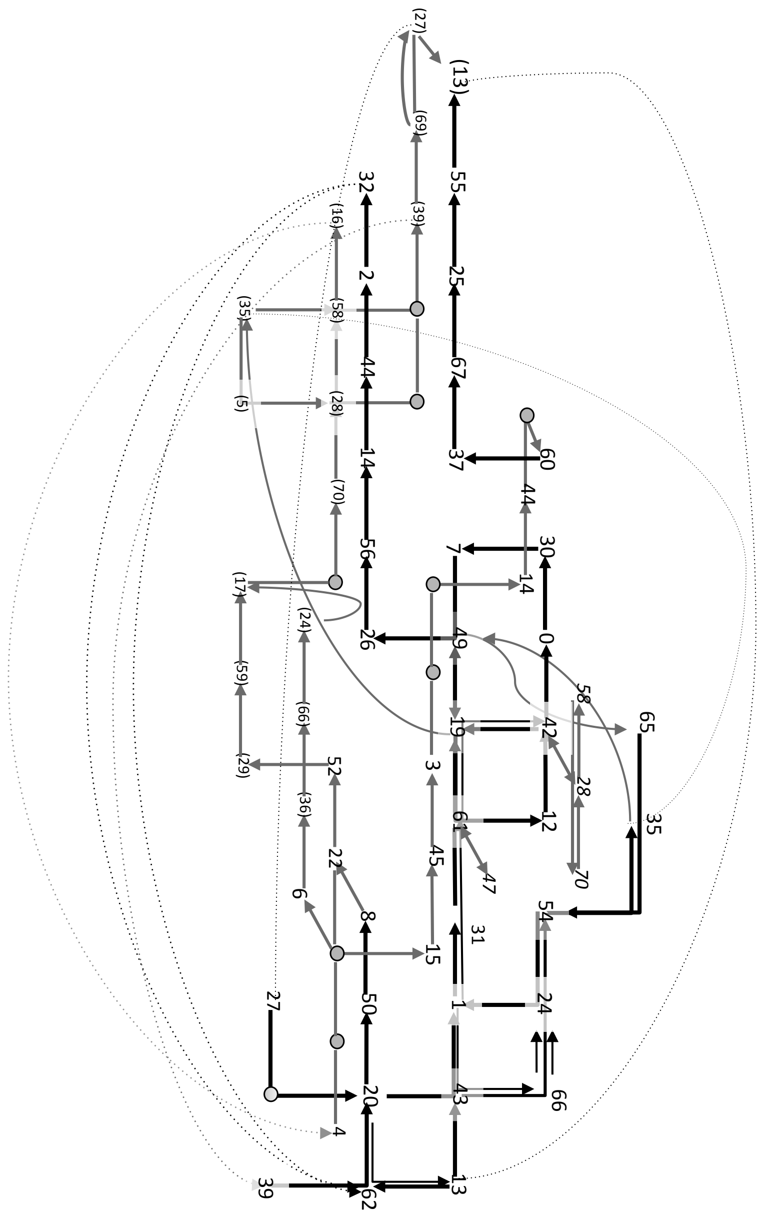
Because this is *tempered* harmonic space, there is a certain degree of recurrence; for instance, pitches on the horizontal axis (the axis of perfect fifths/ fourths) repeat after twelve steps in either direction. Furthermore, a high enough number of steps along *any* axis will result in a pitch that could also be derived from a different prime. Three moves "forward" on the septimal axis (each equal to fourteen 72TET steps), for example, will yield a pitch that is a perfect (tempered) fifth away from the original, whereas in rational tuning the pitches would be close, yet distinct:

$$14 \times 3 = 42$$

$$8{:}7 \times 8{:}7 \times 8{:}7 = 512{:}343 \neq 3{:}2 \; (1.493 \neq 1.5)$$

Because of these recurrences, this representation is only one among many possibilities—distant pitches in particular could be depicted on any of the three axes. Recursive pitches are indicated in parentheses and should be considered equivalent in terms of their harmonic distance to surrounding pitches. To allow for a more readable picture in Figure 2.4, I have limited the range movement on the 7-axis to only two "steps" (to and fro with relation to Pc0), and chosen to indicate modulations that would have transgressed this limit as a dotted connection to a point on another axis.

Figure 2.4 “Random Walk” in 72TET equivalent of (3, 5, 7) harmonic space



Even allowing for a potentially more compact rendering of the piece's harmonic trajectory, Figure 2.4 still manages to show the large number of momentary tonal centers explored over the course of the piece—each of the indicated roots surrounded by closely-grouped fifths, thirds, sevenths, ninths, and so forth, all tuned within a tolerance of ±3 cents. To create a comparable harmonic landscape in just intonation would be daunting, perhaps impossible without using electronic means.[50] Thanks to Tenney's flexible and inventive approach to temperament, however, this musical construct can be realized with six guitarists and the willingness to retune.

Choosing from the pitches available within the current mode, the algorithm composes a clang, a term, as we have seen, used by Tenney to denote a set of musical elements (whether single notes or simultaneities) that the ear is likely to perceive as belonging together. The duration of each clang is also algorithmically determined (average clang duration for the piece is about 5 seconds), and the end of a clang in either voice initiates a change of mode. As a result, the mode can change in the middle of a clang, but at any given time the algorithm can only choose from the six pitches of the mode that is currently active.[51]

The algorithm also determines the dynamic level and duration of every pitch in the piece. Pitch classes are assigned to the guitar capable of reproducing them (as

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[50] As one example, Polansky's *B'rey'sheet* (1984) achieves similar results in electronic medium.

[51] In his dissertation (102–103), Belet states that the *Changes* algorithm was designed so that two modes could be active at a given time in certain cases, resulting in a 50% likelyhood of clangs from adjacent modes actually overlapping. However, I have found no such instance in the code for *Water…Fire.*

each guitarist can only play 1/6 of the available gamut), whereas duration and loudness are determined after a parametric calculation involving the density profile for the entire piece. As with *Changes*, this profile is calculated stochastically using *I Ching* hexagrams; more precisely, three sets of digrams are used to represent temporal, pitch, and dynamic density, with two hexagrams to indicate initial and final status for each category. Any "change" in status is then rendered by a half-cosine interpolation for a smooth transition.[52] *Water on the mountain…Fire in Heaven*, as reflected by the title, utilizes hexagrams thirty-nine ("Limping," Mountain+Water) and fourteen ("Great Possessing," Heaven+Fire) to derive its parametric profile. Figure 2.5 shows how these hexagrams yield a dynamic profile that varies from quiet to loud, temporal density changing from sparse to full, and pitch range going from medium to high. On a macroscopic level, the result is an increase in activity over the course of the piece, with the ending measures sounding much busier, denser, and louder than the sparse beginning.[53]

Perhaps the most unusual and opaque element in *Water…Fire* is its notation. The score is a musical transcription of the algorithmic output—which, as we have seen, specifies the parameters for each pitch in the piece. Each guitar is notated on a double staff, one for each polyphonic layer, so that either voice articulates across the

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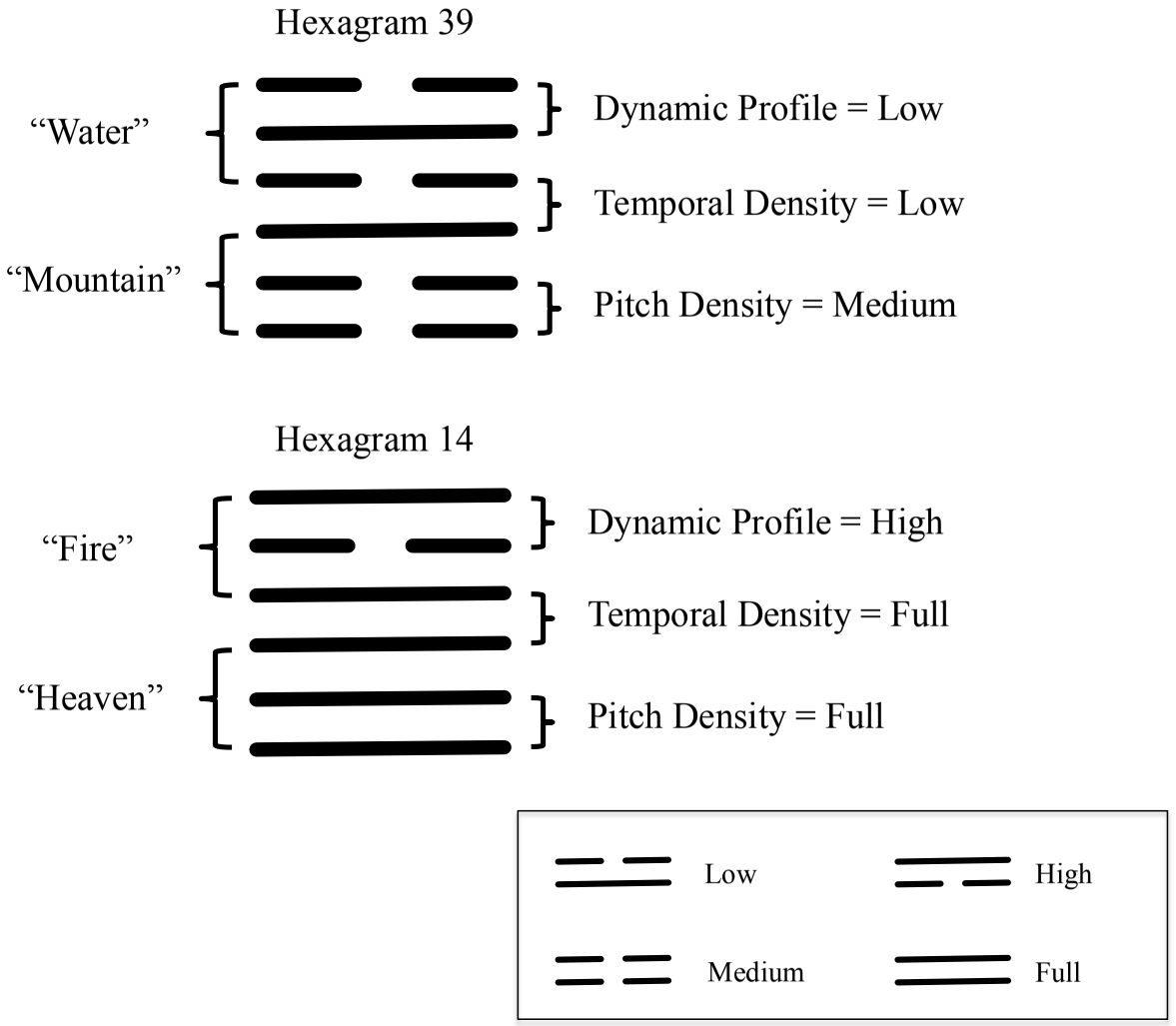
[52] Tenney, "About Changes," 66–67.

[53] Tenney's use of I Ching hexagrams, and the choice of "Changes" as the title of the sixty-four studies collection, represents an overt connection to Cage's use of the same book as a source for chance operations, as in the composition of the third part of the *Concert for prepared piano* (1950–51) and *Music of Changes* (1951)

Figure 2.5 Hexagrams and parametrical status for *Water...Fire.*


Hexagram 39
"Water"
"Mountain"
Dynamic Profile = Low
Temporal Density = Low
Pitch Density = Medium
Hexagram 14
"Fire"
"Heaven"
Dynamic Profile = High
Temporal Density = Full
Pitch Density = Full
Low
High
Medium
Full

respective six staves in a complex, score-wide hocket. Pitches are notated in 12TET without enharmonics (only sharps are used), with a master deviation in cents indicated for each guitar—not unlike the solution adopted in the *Septet*. Such a notational arrangement makes the piece easier to read and perform, but also obscures the underlying harmonic structures among pitches and voices. The performers are effectively playing from tablature, a situation common in scores that incorporate more elaborate tuning systems (as in, most notably, the works of Harry Partch). Although ostensibly anyone could calculate the relative size of intervals between the parts, such reverse engineering would remain ambiguous without consulting the original printouts. Conductor James McKay noted that the opacity of the score, with no correspondence between sounding notes and those on the page, posed considerable challenges in rehearsal and performance. Tenney responded that hearing the sounds in one's head was not important, but their precise realization in practice was.[54]

Example 2.10 shows a transcription of the first segment of the piece (mm. 1–15), indicating actual sounding pitches in both voices, as well as the changing modes with their respective ratios. The rate of modulation is high (roughly one mode per measure). Due to the nature of the algorithm and transcription, adjacent modes may sometimes overlap for the duration of a held-over note. These occurrences can sometimes "expand" the mode to include pitches from the previous one, which are expressed as more complex ratios to the new fundamental (indicated in parentheses in

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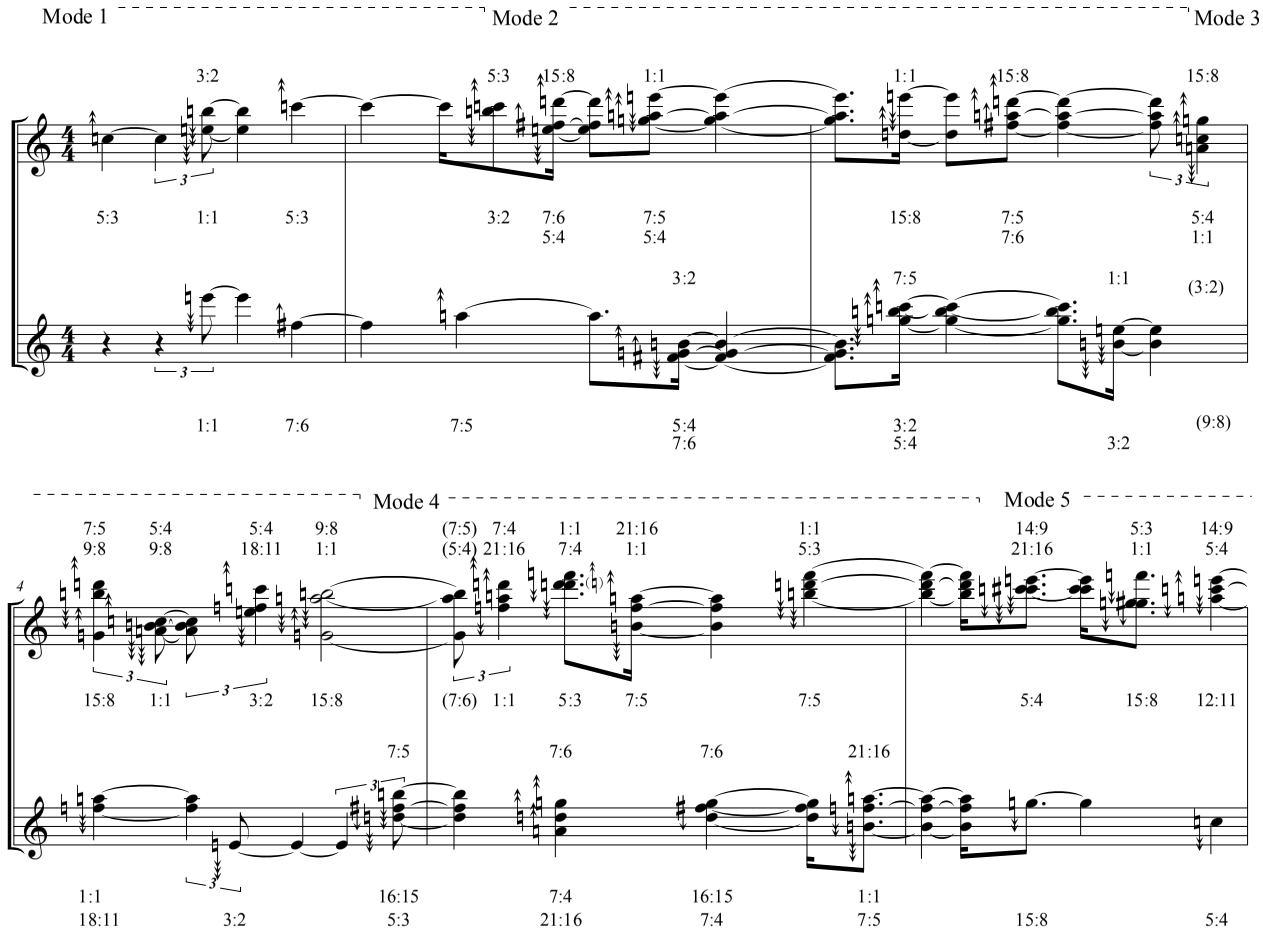
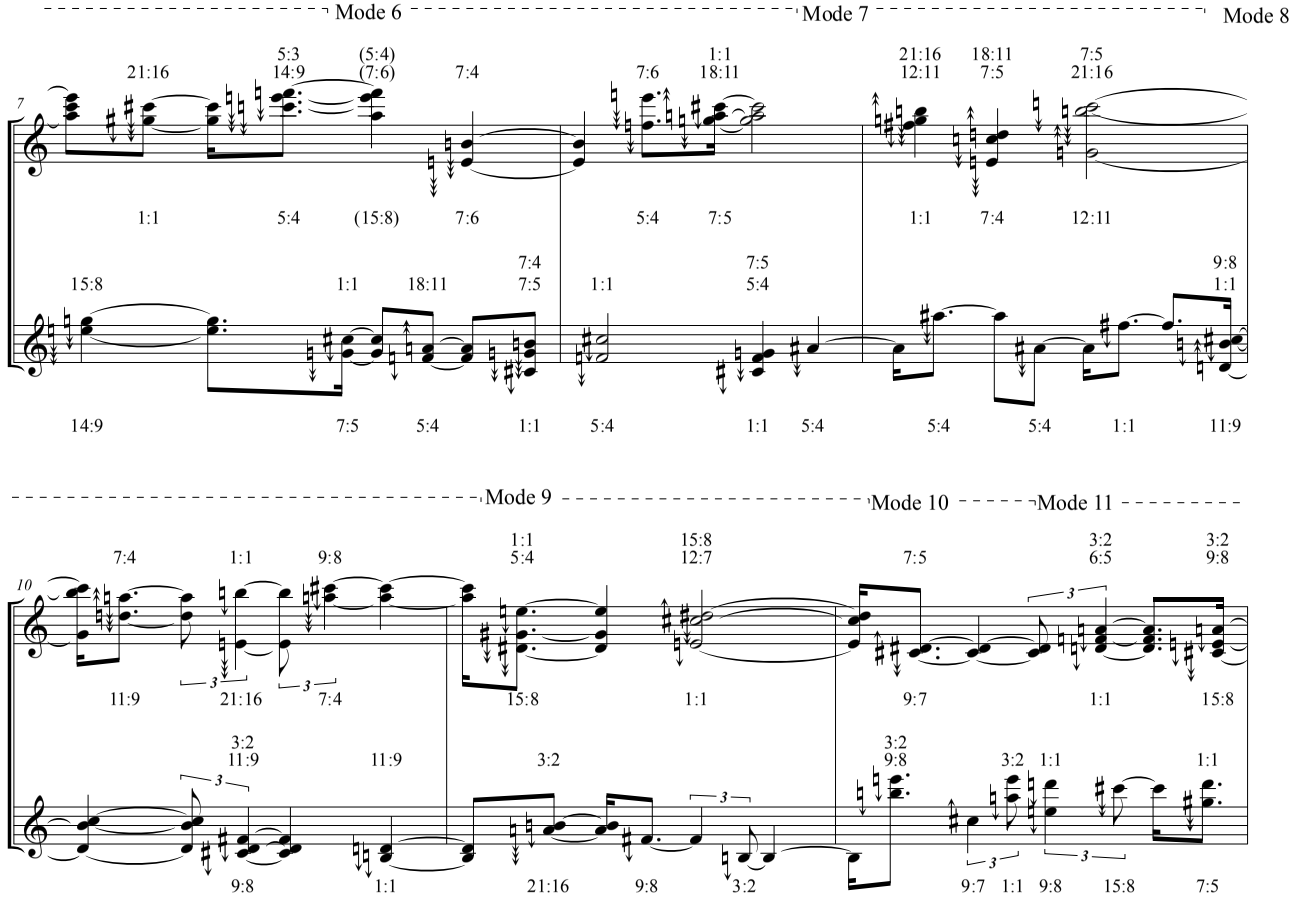
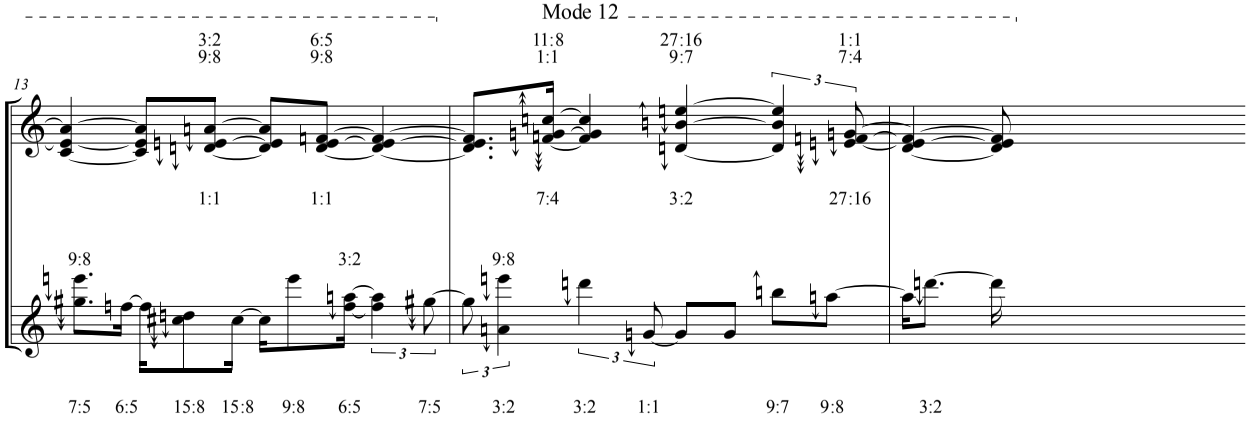
[54] James McKay, e-mail communication with the author, December 6, 2012.

Example 2.10 Opening segment of *Water...Fire*, transcribed to show sounding pitches.


Mode 1
Mode 2
Mode 3
Mode 4
Mode 5


Mode 6
Mode 7
Mode 8
7
21:16
5:3
14:9
(5:4)
(7:6)
7:4
7:6
1:1
18:11
21:16
12:11
18:11
7:5
7:5
21:16
1:1
5:4
(15:8)
7:6
5:4
7:5
1:1
7:4
12:11
15:8
1:1
18:11
7:4
7:5
1:1
7:5
5:4
9:8
1:1
14:9
7:5
5:4
1:1
5:4
1:1
5:4
5:4
5:4
1:1
11:9
Mode 9
Mode 10
Mode 11
10
7:4
1:1
9:8
1:1
5:4
15:8
12:7
7:5
3:2
6:5
3:2
9:8
11:9
21:16
7:4
15:8
1:1
9:7
1:1
15:8
3:2
11:9
11:9
3:2
3:2
9:8
3:2
1:1
1:1
9:8
1:1
21:16
9:8
3:2
9:7
1:1
9:8
15:8
7:5


Mode 12
13
3:2
9:8
6:5
9:8
11:8
1:1
27:16
9:7
1:1
7:4
1:1
1:1
7:4
3:2
27:16
9:8
3:2
9:8
7:5
6:5
15:8
15:8
9:8
6:5
7:5
3:2
3:2
1:1
9:7
9:8
3:2

Example 2.10). However, in light of the speed of the modulations and the relatively quick natural decay of the electric guitars, such overlaps are hard to hear in performance, and are indicated here only for the sake of theoretical fastidiousness.

One element that is communicated clearly by the piece's scoring is the division between the two voices. Perhaps due to the difficulty in reading across staves (and, to an extent, in fingering and holding all pitches for the indicated durations), the composer has suggested the performance of each voice individually. Both existing recordings first present each voice in isolation, as separate movements, before mixing them together to form the complete harmonic picture. As noted both in Brian Belet's analysis and in the liner notes to Josel's recording, this structural arrangement yields an added element of discovery to the work, as its full harmonic structure is revealed progressively by the superimposition of the two layers. From an aesthetic point of view, Tenney's flexibility towards realization is not surprising, as he advocated the alternative performance of his player piano pieces by turning the rolls upside-down.[55]

At both micro- and macroscopic levels, *Water on the mountain…Fire in heaven* offers an unprecedented degree of harmonic complexity. Like the *Septet*, it represents Tenney's brilliant approach to instrumentation, allowing him to redefine practicality and accessibility in the service of a broader musical palette. As a corollary

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[55] While there is no indication of such "separate voices" realization in the published score, Belet reports the existence of performance notes prescribing such a plan, as well as an alternative, shorter version (presumably without the "summed" voice section). Tenney's handwritten notes for the York Archives recording clearly indicate his preference for a particular mix-down of the recordings of the two voices, chosen as the one to be used in performances of the taped work. Belet, *An Examination of the Theories and Compositions of James Tenney.,* 118.

to *Changes*, the piece allows us to participate in a longer, continuous modulating trajectory, stretching our harmonic horizons with the use of a mere thirty-six strings.

Part Four: *Spectrum 4*

Tenney's *Spectrum Pieces*, composed between 1995 and 2001, is a series of eight chamber works for a variety of ensemble forces, ranging from three musicians and delay system in *Spectrum 7* to twenty players in *Spectrum 3*. All are algorithmically composed, and all explore (as hinted by the title) the materials of the overtone series. Furthermore, all pieces utilize F as the fundamental with the exception of *Spectrum 2*, which uses Bb. As suggested by musicologist Bob Gilmore, the *Spectrum Pieces* continue a new trend within Tenney's harmonic series works, following in the direction indicated by *In a Large, Open Space* (1993–1994). In this work of indeterminate duration and instrumentation, the gamut of available pitches encompasses the first thirty-two partials of the harmonic series on F. Given the "open" nature of the score, the order of entrance of the various pitches is left entirely to the performers, and does not necessarily follow harmonic series order, as had been the case with earlier works. The resulting sonority, full of microtonal clusters and devoid of any agogic or temporal emphasis on the fundamental, departs from that of earlier pieces—a deliberate effect, and Tenney's response to accusations of "excessive euphonia" in his previous music.[56] In the *Spectrum Pieces*, pitch entrances are strictly determinate, but the algorithm governing note order and frequency ensures variability to produce a similarly stochastic result.

Spectrum 4 is the only work in the series to include guitar. Through the

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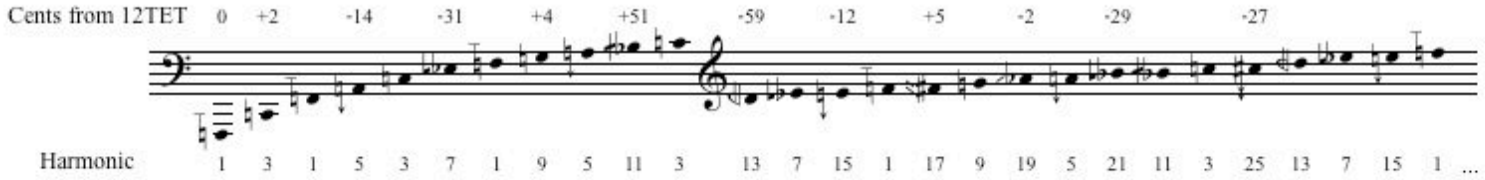
[56] Bob Gilmore, liner notes to James Tenney, The Barton Workshop, *Spectrum Pieces*, NWR 80692-2, 2009.

employment of a careful tuning scheme, the instrument is not only completely integrated in the microtonal fabric of the piece, but also expands the gamut of available pitches beyond the limits of the rest of the ensemble. As with his previous guitar pieces, Tenney demonstrates an uncanny ability to adapt the guitar to rigorous tuning contexts while preserving playability and practicality, treating it as a kind of hybrid instrument in which the tuning is fixed, yet still easy to modify.

The complete pitch set for *Spectrum 4* can be divided in three smaller sets, corresponding to three sections of the ensemble: Violin, alto recorder, piano, bass clarinet, trombone, and string bass form group one; the vibraphone group two, and the guitar group three. Group one plays from a twelve-note harmonic set built on a near-infrasonic F (21.83 Hz), detailed in example 2.11. The gamut reflects harmonic series spacing, meaning that harmonics are only available starting in the octave in which they first appear. In more technical terms, the set falls within the 19-limit and avoids cognates, thus enabling the (retuned) piano to play all available pitches.[57] Other instruments are required to match each pitch's intonation, and to minimize beats by playing without vibrato. By contrast, the vibraphone's only available pitched notes

[57] In order to avoid cognates, Tenney notates the eleventh harmonic as a 49¢ flat B, rather than a 51¢ sharp B♭. For the sake of consistency, and in accordance with the Helmholtz-Ellis notational standards, I will be referring to the same note as an undecimal B♭ (51¢ sharp).

Example 2.11 Basic gamut for *Spectrum 4*.


Cents from 12TET
0 +2 -14 -31 +4 +51 -59 -12 +5 -2 -29 -27
Harmonic
1 3 1 5 3 7 1 9 5 11 3 13 7 15 1 17 9 19 5 21 11 3 25 13 7 15 1 ...

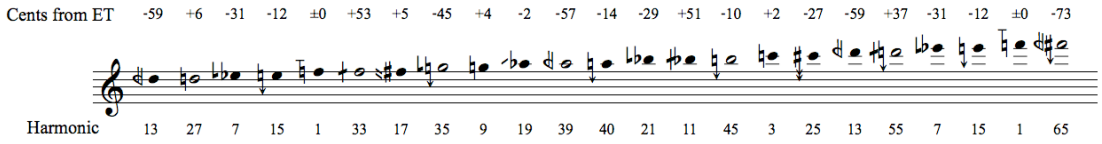
are those within ±5¢ of their just counterparts (i.e. F, F ♯, G, A ♭, and C); seven different unpitched sounds complete the percussionist's twelve note set, effectively standing in for those pitches that would be out of tune.

Open String	H2	H3	H4	H5
D (13) -59c	D (26) -59c	A (39) -57c	D (52) -59c	F ♯ (65) -73c
B♭ (11) +51c	B♭ (22) +51c	F (33) +53c	B♭ (44) +51c	D (55) +37c
G (9) +4c	G (18) +4c	D (27) +6c	G (36) +4c	B (45) -10c
E♭ (7) -31c	E♭ (14) -31c	B♭ (21) -29c	E♭ (28) -31c	G (35) -45c
A (5) -14c	A (10) -14c	E (15) -12c	A (20) -14c	C (25) -29c
C (3) +2c	C (6) +2c	G (9) +4c	C (12) +2c	E (15) -12c

Table 2.3 Guitar pitches as open strings and harmonics 2–5, *Spectrum 4*.

The guitar's collection is a subset of the master one, with the addition of harmonics 27, 33, 35, 39, 45, 55, and 65. These higher partials are produced as natural harmonics of the open strings, which are tuned to lower harmonics of the fundamental (see Table 2.3)—an approach similar to the one Tenney had used in *Spectra for Harry Partch* and in his last completed work, the string quartet *Arbor Vitae* (2006). The combined use of retuned open strings and natural harmonics allows for the production of precisely tuned pitches without the need for gauging (or even

calculating!) cent deviations from 12TET. From a textural point of view, the guitar's additional pitches populate the upper octave of the gamut with cognates, significantly increasing the spectral complexity of the entire piece without compromising its playability (Example 2.12).



Example 2.12 Upper octave of gamut in *Spectrum 4*; white noteheads indicate pitches introduced by the guitar.

Like the other pieces in the series, *Spectrum 4* employs a proportional notation in which each system corresponds to thirty seconds, white notes indicate long tones (separated by breath marks), and beamed notes represent clangs, to be played legato. The form of the piece is what Tenney called a half-swell: The music starts quietly and sparsely for the first seven minutes, then builds up in dynamics and density until the abrupt ending, which corresponds to the mid-point of the swell.[58] As in *Water on the mountain…Fire in heaven*, the form of the piece is dictated by a set of parametric limits for dynamics, textural density, and temporal density—one for the beginning of the piece, and one for the end. These limits are once again interpolated in order to

[58] Gilmore, Program Notes to *Spectrum Pieces*. Additional examples of this form can be found in *Koan*: *Having Never Written a Note for Percussion* and the three "Swell Pieces" from his *Postal Pieces* set (1965–1971). See Polansky, *The Early Music of James Tenney*, 193–203.

provide a smooth transition over time, and the resulting parameters are incorporated in the algorithm to generate musical information (such as the number of notes in a clang, their dynamic level, and register).[59] Note, however, that harmonic complexity does not take part in this process: The opening system already includes all twelve notes of the master set, with the guitar contributing higher partials (such as 27 (D) and 65 (F#), the highest partial of the entire piece). The perceived increase in complexity over the duration of the piece is rather a function of the increase in temporal density and dynamics.

As we have seen, a statistical feedback algorithm modeling dissonant counterpoint practices regulates pitch selection throughout the piece. Each of the eight parts is generated individually—i.e. by running multiple instances of the algorithm in parallel; in addition, the guitar version of the code features some modifications to accommodate the different gamut available to the instrument. The sort of enforced variability resulting from the algorithm is not a simple chance operation, as the probability for the selection of any pitch is tweaked to be much lower after the pitch itself has been chosen (a uniform probability distribution, by comparison, would make the repetition of a pitch just as likely as the selection of a different one). Nevertheless, a certain amount of repetition is still present, and can be verified at a glance by following the unpitched, numbered sound-events in the

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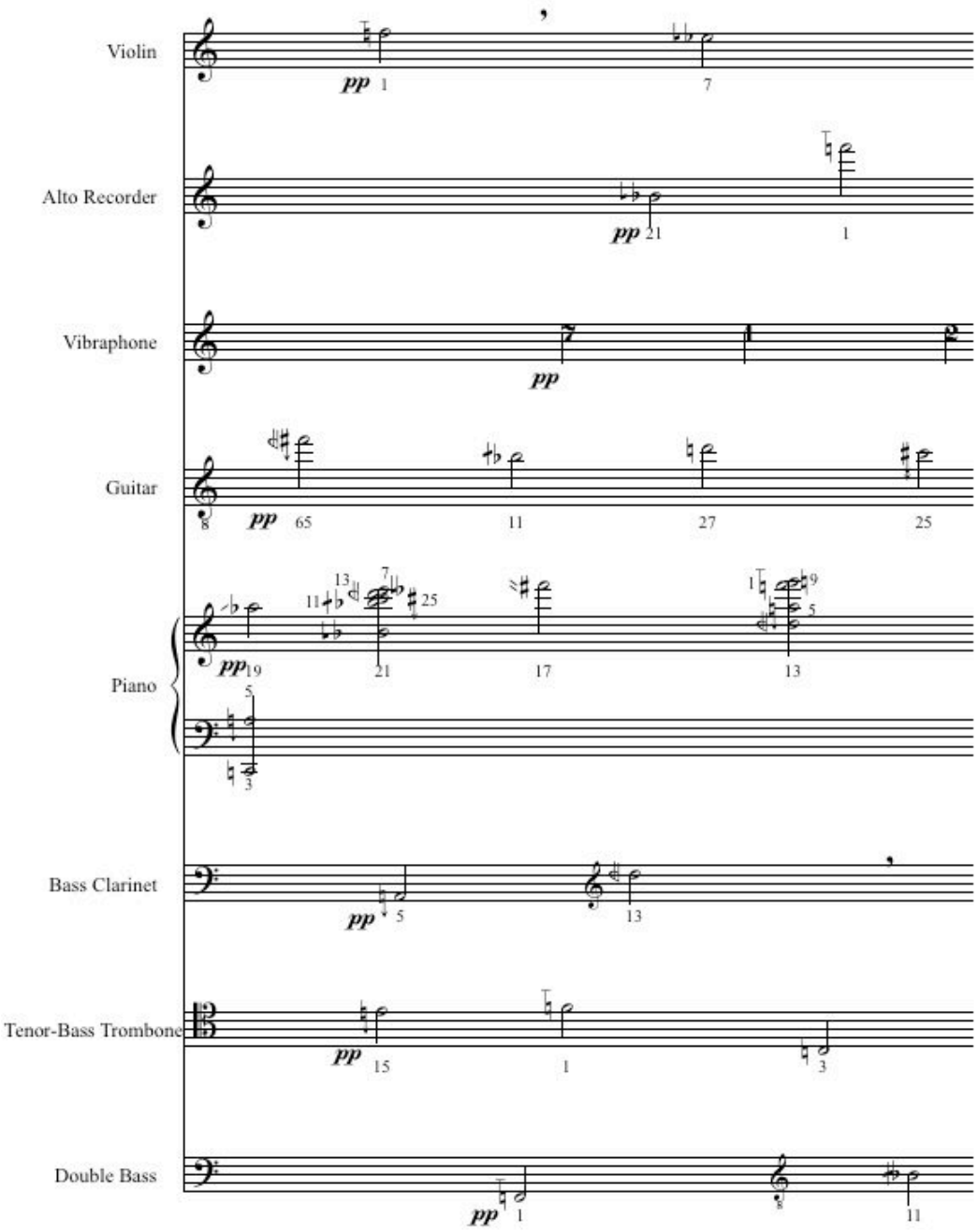
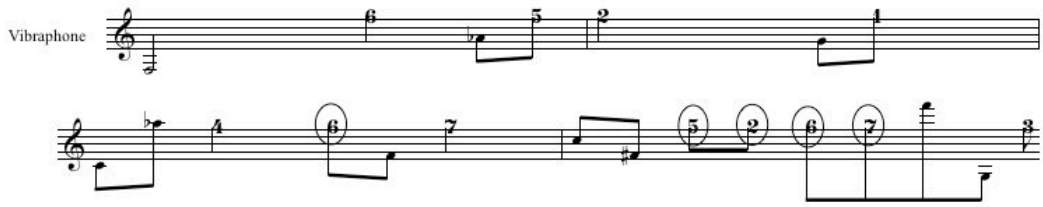
[59] The concept of parametric profiles, i.e. the plotting of a given musical parameter over time, is introduced as an analytical/perceptual model in *Meta+Hodos*, 33. It is especially telling how Tenney employed the parametric profile into a compositional tool, allowing him to control the *resulting form* of a piece from a perceptual standpoint.

Example 2.13 Opening of *Spectrum 4*.


Violin
Alto Recorder
Vibraphone
Guitar
Piano
Bass Clarinet
Tenor-Bass Trombone
Double Bass

percussion part, as indicated in eample 2.14; similar instances happen in the other parts. Although repetition *does* occur to a degree, on the broader level the resulting effect is that of ever-changing variability across the instrumental parts, with no particular emphasis on a given note or section of the gamut.



Example 2.14 Recurrence of unpitched percussion events in vibraphone part.

Because the spacing of the gamut is weighted towards the higher partials, and because each part is generated independently (meaning that lower pitches are overall less likely to occur than higher ones), the instruments capable of reproducing the lowest harmonics (string bass, trombone, bass clarinet, piano, and, to an extent, the guitar) spend most of their time in their higher registers. As such, the absence of a continuous (or even prominent) fundamental in the bass register further contributes to the hazy atmosphere of the piece, creating a very different sonority than any of the other pieces in our discussion.

Conclusion

Whether composed algorithmically or by hand, the guitar works of James Tenney form a cohesive whole that both illustrates the composer's harmonic and formal language, and serves as a guideline for approaching the instrument in extended just intonation and microtonal contexts. As we have seen, Tenney's tuning modifications successfully maintain playability and accessibility by not requiring the modification of the fretboard or employing alternative notational system. Such practicality, unfortunately, translates to a degree of opacity in his scores—a factor that may have contributed to the difficult reception and dissemination of these complex yet rewarding pieces. By composing such ambitious works for one of the world's most commonly available instruments, Tenney is pointing towards the development of a new and more refined mode of listening, and inviting us to follow him in his exploration of the ratios, rhythms, and sounds of the harmonic series.

Chapter Three
"Exploring Fertile Ideas:" The JI Guitar Music of Larry Polansky

> Larry Polansky (b. 1954) is a composer, theorist, teacher, writer, performer, programmer, editor and publisher. He lives in Hanover, New Hampshire, is co-director and co-founder of Frog Peak Music, and teaches at Dartmouth College.[1]

As is apparent from this "very short bio" found on the composer's website, Larry Polansky wears many different hats. What the paragraph does not tell us is that Polansky's output is similarly variegated: his compositions range in length and scope from a few seconds to over an hour; his activities as a performer traverse several instruments and musical genres; his championing of other composers' works includes figures from the first half of the twentieth century, such as Ruth Crawford Seeger and Johanna Beyer, to the present day. Yet there is a surprising coherence among the variety, as numerous threads run across these disparate endeavors and keep them from collapsing into an eclectic musical mess. Two of these threads—Polansky's relationship with the guitar, and his interest in rational tunings—have intertwined throughout his career to delineate one of the most impressive and extensive repertoires in the genre. Polansky's approach to tuning, as we will see, relies on the work of his three principal musical mentors—Lou Harrison, James Tenney, and Ben Johnston—to create an intonation framework that is flexible and powerful, yet remarkably accessible.

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[1] Larry Polansky, http://eamusic.dartmouth.edu/~larry/bios/veryshortbio.pdf

Perhaps because Polansky fits the role of the proverbial moving target, critical and analytical examinations of his music are scarce. He has written copiously about his own pieces, and makes his notes and analyses available through his website—resources from which this inquiry draws extensively.[2] In terms of criticism, fellow composer and musicologist Kyle Gann includes Polansky in his anthology *American Music in the Twentieth Century*, and analyzes Polansky's use of mensuration canons in the context of the New York avant-garde scene of the 1990s in a separate published article.[3] Belgian new music guitarist Toon Callier (b.1983), who premiered the complete version of Polansky's *for jim, ben, and lou* (1995) in 2009, wrote an essay on both the composer and the piece. Although not particularly analytical in nature, this writing offers an interesting insight into the perception of the composer abroad: Callier highlights Polansky's eclecticism as a fundamentally American trait, placing him not only in the context of experimental composers such as John Cage, Christian Wolff, and Tenney, but also in relation to Charles Ives.[4]

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[2] Polansky's choice to making writings, scores, and recordings freely available on his website is symptomatic of his general attitude towards publishing, imprimatur, and information flow in the digital age.

[3] Kyle Gann, "Downtown Beats for the 1990s: Rhys Chatham, Mikel Rouse, Michael Gordon, Larry Polansky, Ben Neill," *Contemporary Music Review* 10, no. 1 (January 1, 1994): 33–49. Also: Gann, *American Music in the Twentieth Century* (New York: Schrimer, 1997), 375–379.

[4] Toon Callier, "The World's Longest Melody: Who the F*** is Larry Polansky?," http://www.zwerm.be/TheWorldsLongestMelody.pdf, (no page numbers).

Larry Polansky: A Biographical Sketch

The musicological process often relies on biographical accounts for critical and interpretive context; in the case of Polansky, introducing the key elements of his life becomes an absolute necessity, as his catalogue is filled with dedications to family, friends, and colleagues, as well as with other, less direct references to his background and worldview. Most tellingly, Polansky has developed and maintained life-long friendships and working partnerships with the vast majority of the figures mentioned in the following passages.

Larry Polansky was born in New York City on October 16, 1954, the son of Arnold Joseph and Sydelle Polansky. He grew up in Valley Stream, Queens, and was raised Jewish from a cultural standpoint, if not a overly religious one. By age ten he had begun playing guitar—he remembers playing his first paid gig for a Bar Mitzvah, which took place before his own. Upon graduating from high school in 1972 he embarked on a solo trip across South America; he returned to the United States in 1973 and enrolled at the New College in Sarasota, Florida, a small, independent, experimental liberal arts school founded in 1960. Polansky's main interests were in music, mathematics, and anthropology, and the New College soon proved too small a place for him. After he had read "every book about music in the library" he decided to transfer across the country to the University of California, Santa Cruz, where he

declared a dual major in math and music composition in 1974.[5] Also arriving in Santa Cruz was James Tenney, who had been hired in a one-year position in the music department after his tenure at Bell Labs in New York City and his first teaching experience at CalArts. Gordon Mumma, who joined the UCSC music department in 1975, would prove a fundamental influence in prodding Polansky towards graduation. Furthermore, Lou Harrison, although not officially affiliated with the University, lived a few miles away in Aptos and would provide a strong influence to the younger composer. Polansky met Harrison and his partner Bill Colvig at a party at Tenney's house in 1975; soon after, Colvig taught Polansky how to tune using an oscilloscope, and Polansky purchased from the couple one of the monochords and transfer harps they had designed and built as an intonation study aid.[6]

During his first summer in California, Polansky received a grant from UCSC to attend John Chowning's digital sound synthesis workshops at Stanford's Center for Computer Research in Music (CCRMA); there he met fellow algorithmic composition enthusiast Charles Ames (b. 1955). He then followed Tenney to York Univeristy in Toronto in the fall of 1976, before returning to Santa Cruz to graduate in the spring of 1977. Polansky's prolificity as a composer is exemplified by his senior recitals, which consisted of two full-length programs dedicated to acoustic and

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[5] Quotations without footnotes in this chapter are taken from numerous personal interviews with the composer by the author.

[6] Appropriately, Polansky, Tenney, and Ezra Sims owned harmonically-numbered monochords #7, 9, and 11; some copies of the original owner's manual, written and typeset by Harrison, are still available on Frog Peak: http://www.frogpeak.org/fpartists/fpharrison.html

electronic compositions, respectively.

Upon graduation, Polansky returned to Toronto, where he did some graduate work with Tenney at York, and participated in the new music scene as a composer and a performer—premiering, as we have seen, Tenney's *Harmonium 2*, and collaborating with composers such as Michael Byron, David Rosenboom, Gayle Young, and Jon Hassell, as well as with various contemporary performers, like percussionist Willie Winant and dancer Anita Feldman.

In the fall of 1977 he moved to Urbana-Champaign to act as Ben Johnston's graduate assistant while working towards a Master's in composition at the University of Illinois. There he worked on electronic and acoustic intonation projects, transcribed Partch works such as *Seventeen Lyrics by Li Po* and *Eleven Intrusions*, taught intonation classes, and served as a copyist for Johnston's compositions. While at Illinois he also continued his activities as a performer of new music, including a series of performances of Schoenberg's *Serenade*, Op. 24 on mandolin. Upon receiving the M.A. Polansky moved back to New York, where he worked as a music copyist, performed in various experimental, jazz, and rock settings, and studied with jazz guitarist Chuck Wayne (1923–1997). In 1980 he was awarded a BMI Young Composer Award for his piece *Sh'ma—Fuging Tune in G*.

In 1981 David Rosenboom, the newly-appointed director at the Center for Contemporary Music at Mills College in Oakland, California, offered a part-time faculty and staff position to Polansky. During his time at Mills Polansky maintained a

Figure 3.1 Program for Polansky's two senior composition recitals at U.C. Santa Cruz, 1977.

MUSIC FOR TRADITIONAL INSTRUMENTS
FRIDAY, JUNE 3, 1977
8:00 P.M.

IN MEMORIAM: STEFAN WOLPE

solo trumpet
Glenn Smith

PIANO STUDY #1 (for Carl Ruggles)

Larry Tyrrell

PIANO STUDY #2 (for Melissa)

(March in D)
Ingrid Hoermann

PIANO STUDY #3 (for G. Cantor)

(Stabilite Structurelle)
Scott Moore

MOVEMENT FOR IANNIS XENAKIS

clarinet and digitally synthesized tape
Ken Durling

PIANO STUDY #4

(Et Morphogenese)
Ingrid Hoermann, Evelyn Lust,
Larry Polansky

—— INTERMISSION ——

A VERY SLOW LAMENT FOR SOLO OBOE

(WHICH HAPPENS TO BE 51 MEASURES LONG)

Ken Durling (clarinet)

MOVEMENT IN E MAJOR FOR JOHN CAGE

violin and piano
Carla Picchi, Ingrid Hoermann

PIANO STUDY #5 (for JPR)

just Fender Rhodes and synthesized drone
Larry Polansky, Paul Sparrow

SILENCE STUDY #4 (for Joe Pinzarrone)

four actors and viola
Ingrid Hoermann, Michael Schippling,
Larry Tyrell, Melissa Libby, Corky Harris

MUSIC FOR TAPE; COMPUTER MUSIC
SATURDAY, JUNE 4, 1977
8:00 P.M.

FOUR VOICE CANON #2 (for Steve Reich)

(two channel tape)
Interdata Model 3 controlled Moog
("JAKI" programs)

SASCHA"S SONG (for the peoples of Chile)

(four channel tape)
Voices:
Corky, Craig, and Sascha Harris

FOUR VOICE CANON #3 (for Melissa)

(two channel tape)
Stanford AI PDP-10
("JAKI" programs)

STOCHASTIC STUDY #1 (for Sherman Raftenberg)

STUDY #2 (for Anton Webern)

(monaural tape)

STUDY #3

(two channel tape)
Stanford AI PDP-10
("COMPOST" programs)

HOY COMIENZA UNA NUEVA ETAPA (for Sal Martirano and Dr. Salvadore Allende)

(four channel tape)
Voices: Laurie Brumell, Phil Alusson,
Joe Hannan, Vicki Kirsch, Peggy Smith

—— INTERMISSION ——

MUSIC FOR JUST INTONATION

MEDITATION AND EXULTATION INC = 256 cps (for Harry Partch)

Ken Durling (clarinet, piano)
Larry Polansky (piano, guitar)
Roger Poirier (bass)
and assorted drones

Please, no smoking, eating or drinking in the Concert Hall.
No photographing or recording of the concert allowed.

multifaceted approach to his artistic activities, as he continued working with computer music and live computer-performer interfaces, which led to the release of the HMSL language with Rosenboom and Phil Burk.[7]

In 1982 Polansky attended John Cage's seventieth birthday party, hosted by Harrison and Colvig in Aptos. There he met Jody Diamond, an ethnomusicologist and composer who was in charge of the Mills gamelan; they began dating and were married in January 1985. That same year they co-founded Frog Peak Music (A Composers' Collective), a uniquely-run publishing house, which counts over one hundred composers in its roster.[8] In addition, Polansky kept busy performing with the Mills Contemporary Music Players (presenting, as we have seen, the premiere of Tenney's *Septet* in 1985) and with the Berkeley Mandolin Ensemble and other groups; and publishing a number of articles, including a monograph-length analysis of the early music of James Tenney for Soundings Press.[9] In June 1988 Diamond and Polansky traveled to Indonesia for a year for a gamelan documentary project.

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[7] HMSL (Hierarchical Music Specification Language) is a programming language used both for composition and live performance. It is no longer in use, but has been replaced by its "evolutionary successor" JSML (Java Music Specification Language), developed by Nick Didkovsky. HSML Home, http://softsynth.com/hmsl/.

[8] On the philosophy behind Frog Peak Music: "[Frog Peak] gets a lot of people's work out into the world in a very honest, simple, sincere way, with no cosmetic nonsense and also no hype. I've been committed to that all through my life—never selling anything, never convincing anybody of anything, of really staying true to the musical idea as much as possible. [N]ow with the web, there's no reason not to put all your pieces on the web as well, and, certainly, we encourage that. [...] All of my computer music life has been devoted to making cheap, public domain available software." Frank J. Oteri, "Larry Polansky: Open Source," *New Music Box*, 16 November, 2009, < http://www.newmusicbox.org/articles/larry-polansky-open-source/>.

[9] Cited earlier: Larry Polansky, "The Early Music of James Tenney," in *Soundings 13: The Music of James Tenney* (Santa Fe: Soundings Press, 1983).

Although he jokes that his main role was to carry and operate A/V equipment, during his time in Southeast Asia Polansky drafted his largest work at the time: The instrumental tour-de-force *Lonesome Road (The Crawford Variations)*. The fact that he wrote this set of fifty-one variations for solo piano without access to the instrument exemplifies the strength and facility of Polansky's musical imagination.

In 1990 Polansky accepted a faculty position at Dartmouth College in Hanover, New Hampshire; in the same year, he helped found *Leonardo Music Journal*, of which he was editor until stepping down in 2000. At Dartmouth, Polansky has been co-director of the electronic music studio and of the graduate program in electroacoustic music, and he served as department chair from 1998 to 2003 and again from 2006 to 2007. In the 1990s and 2000s, in addition to composing close to one hundred works and authoring twenty articles, he further developed his editorial side, contributing to the re-discovery of the music of Johanna Beyer, and completing (with Judith Tick) Ruth Crawford's *The Music of American Folk Song* at the request of her estate.[10] In the summer of 2012 he accepted an offer to return to UC Santa Cruz as a professor of composition, a position he will assume in the 2013–2014 academic year.

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[10] Ruth Crawford Seeger, *The Music of American Folk Song: And Other Writings*, Larry Polansky and Judith Tick, eds., (Rochester: University of Rochester Press, 2001).

Compositional Overview

As of December 2012, Polansky's official works list amounted to more than two hundred works, in addition to dozens of rounds—a form to which he often returns for pedagogical reason, or to set funny, mundane, or scientific texts by friends, colleagues, family, and students. One element that brings coherence to Polansky's oeuvre is his predisposition to works in series—exploring one "fertile idea" in several ways, trying different approaches to the same problem, all the while trying to avoid outright repetition.[11] Some examples are the pieces derived from *Psaltery* (1979); the various sets of *toods* (Polansky's phonetic neologism for etude), each exploring a diverse range of problems and constrictions, such as the *tooaytoods*, limited to a two-second length, and the *onceatoods*, in which every note in a given instrument's gamut is sounded; the Four Voice Canons, which deal with various kind of mensural relationships; and many more. This "experimental" attitude—a word chosen carefully, and in a broad sense, acknowledging the composer's distaste for the term—represents perhaps the single defining characteristic of Polansky's artistic attitude: a what-if curiosity, a willingness to take things apart to figure out how they work, and a welcoming open-mindedness towards both predicted and unpredicted outcomes.

In addition to this unified approach, I have identified four recurring categories that are helpful in partitioning some of Polansky's principal genres and types of

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[11] Larry Polansky and Paul Doornbusch, "About Mapping: Answers to Questions of Paul Doornsbusch," <http://music.dartmouth.edu/%7Elarry/misc_writings/talks/about.mapping.html>

composition: the use of algorithmic and computer composition; the implementation of rational tunings; the preoccupation with difficulty, virtuosity, and an "all-around" sort of musicianship; and the reliance and borrowing from popular and folk genres, especially songs. These interpretive angles are not exhaustive, nor, for that matter, exclusive; several of Polansky's pieces merge some of these themes, while others do not feature any. Nevertheless, these angles offer a substantial number of analytical insights, and serve as guides for the intertextual relation of separate parts of the composer's output.

The use of algorithmic composition and the integration of various computer environments for live performance have represented for Polansky ways to integrate his mathematical training with his artistic endeavors. Through the years, his use of these resources has changed: in the 1980s he was mainly busy "home-rigging" HMSL-driven systems for live, dynamic interaction for performance; in the 1990s and 2000s he re-focused on composing scores using HMSL and its updated successor, JMSL (developed by guitarist/composer and frequent collaborator Nick Didkovsky in 1997). Whether composed "by hand" or entirely at the computer, many of his pieces rely on stochastical and statistical procedures, sometimes in conjunction with software modeling of physical instruments, to outline compositional possibilities and choose among them. Algorithms can be used, for instance, to chart the harmonic progression of a piece from consonance to more complex dissonance, according to formulas such as Euler's *Gradus Suavitatis* function, as in the case of *Yitgadal* (2004,

for mixed ensemble), *Jargon* (2005, for cello orchestra), or "85 Chords" from *Songs and Toods* (2005, for the just intonation resophonic guitar).[12] Other algorithmic practices favored by Polansky include *morphing*—the gradual transformation of musical elements via parametrical manipulations, e.g. morphing one melody into another by the progressive alteration of its motivic contour—and the time stretching of phrases (or entire compositions) according to either pre-specified or stochastic sets of parameters.

Intonation issues have interested Polansky since his student days—tuning theory being perhaps the most immediately mathematical aspect of music. The joint presence of Jim Tenney and Lou Harrison in Santa Cruz was a catalyst for Polansky's exploration of tuning, which from those early days included the question of how to approach the use of alternative intonations in a fundamentally practical way. Electronic means, of course, offer the greatest flexibility in terms of uncompromised rational tunings; the majority of Polansky's pieces in just intonation, however, incorporate acoustic instruments, and resort to playing techniques and non-permanent retuning as a way to obtain the necessary pitches. In general terms, Polansky's

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[12] Akin to Tenney's HD formula, Euler's Gradus Suavitatis ("Degree of Pleasure") function describes the complexity of an interval according to its prime factors. The result of the Euler GS function is a simple integer that can be integrated in algorithmic context to describe harmonic trajectories. Polansky on the GS function: "The Euler function is especially important, because of its simplicity, computability, and power. It yields similar results to the Tenney HD, and is defined as follows: 1) the GS of a prime number is itself; 2) the GS of a composite number is the sum of the GSs of the prime factors, minus one less than the number of factor." Larry Polansky, "Harmony Primer," 11–12, http://music.dartmouth.edu/~larry/UCSC_CLASSES_2011_2012/Music_150x/misc/tuning/harmony.primer%20revision%201_29_12.pdf

approach to tuning is more closely aligned with Tenney's than with Harrison's and Johnston's (to mention his most immediate mentors). Polansky anchors much of his work on the ratios of the harmonic series, but rather than using these ratios to construct scales, modes, and harmonies, he treats them as a more general gamut from which to draw the pitches for his compositions.[13] As his tuning aesthetics matured over the years, Polansky successfully developed a framework for modulating interrelated harmonic series—initially with the manipulation of pre-recorded tapes, as in *Psaltery*, then with the dynamic re-tuning of instruments in the course of performance, as in *for jim, ben, and lou* (1995), and finally with the integration of live electronic sound synthesis, most notably with the *freeHorn* (2004) program. Although theoretically intricate and musically sophisticated, much of Polansky's "heterophonic tuning" music, as he calls it, places very reasonable logistical and technical demands on its performers.

Although unassuming, even apologetic about his own performance abilities, Polansky is a formidable guitarist and mandolinist, who navigates with ease across musical styles as disparate as bluegrass, rock, jazz, and free improvisation. His familiarity with instrumental technique and a performer's attitude translate into a desire for pushing boundaries, both referencing a given instrument's history, albeit not necessarily its "classical" one, and transcending it. His music employs a variety of

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[13] For an alternative approach, see Ben Johnston, "Scalar Order as a Compositional Resource"
PNM 2.2, 1964, pp. 56–76 (Reprinted in *Maximum Clarity*).

extended techniques that are integrated seamlessly into the compositions rather than simply acting as gestures or clichés. Many of these techniques relate to tuning—see for instance the fiendishly difficult work *Piker* (1998), whose middle movement explores the first seventeen partials of the harmonic series—on a piccolo!; or the live retuning of a guitar's strings in pieces such as *ii-v-i* (1995) and for *jim, ben, and lou*. Another recurrent performance extension in Polansky's music lies in the frequent request for performers to double as singers. The difficulty of the sing-and-play pieces varies wildly—some are simple, whereas others are nearly impossible due to highly independent, often bitonal parts. Yet to the composer these requests are reasonable, as Polansky considers the voice the universal instrument, and believes that everyone should be encouraged to cultivate and perform with his or her voice.[14] Polansky's fondness for rounds—a more basic, but often surprisingly challenging of the musicianship test—can be interpreted in a similar vein. One drawback of Polansky's reliance on extended techniques and ultra-virtuosic writing is the delayed performance of much of his music. Pieces such as *Lonesome Road* and *for jim, ben and lou* had to wait several years for a complete premiere; other pieces are still waiting.[15]

Finally, a crucial recurring element in the music of Larry Polansky is his use

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[14] In addition to the obvious examples of self-accompaniment in the folk and pouplar repertoires, consider also the precedent set by Harry Partch in *The Wayward*, or the lute songs of the Italian Renaissance and Elizabethan England, for that matter.

[15] *Lonesome Road* was composed in 1989 and premiered (in a joint effort by three different pianists) in 1994; *for jim, ben, and lou* was composed in 1995 and premiered in 2009.

of vernacular song. This borrowing usually happens in unadulterated form, and the source melodies are not varied in the traditional sense. The material—folk songs, Shaker hymns, Hebrew and Yiddish lyrics—is drawn both from the biographical and the artistic heritage of Polansky as a contemporary U.S. composer: Many of the folk songs used, for example, are taken from Ruth Crawford's own settings and harmonizations. With their plain contours and universal affect, the popular and religious melodies and texts offer a stark contrast to the much more dense and angular music that Polansky writes; yet the integration of these disparate elements is done very gracefully, leading to seamless and often poignant results.

Overview of Pieces Under Consideration

The richness of thematic elements in Polansky's compositions, as well as his dense network of personal and artistic relationships with so many crucial figures in twentieth-century U.S. music, warrant a thorough and detailed investigation of at least a portion of Polansky's output—in this case, those compositions that deal with the problem of employing a traditionally equal-tempered instrument like the guitar in rationally-tuned contexts. The pieces writen explicitly for guitar(s) in just intonation include: *the Schneider Variations* (1994); *for jim, ben, and lou*; *ii-v-i* (1997); *ivtoo* (2000); *toovviivfor* (2002); Four Voice Canon #17 (2002); *Yitgadal* (2003–04); *Songs and Toods* (2005); *9 Events* (quartet version, 2011); and *10 Strings, 9 Events* (2011). In addition, there are other pieces that will be encountered in this discussion,

including the contrabass quartet *Movement for Lou Harrison* (1977); the quartet *Movement for Andrea Smith* (1978); the guitar solo "*...getting rid of the glue…"* (1978); and *freeHorn*, a flexible piece for any number of live players and live electronics, derived from the earlier electronic piece *Psaltery*, and representing the culmination of a sequence of works that modulate across related harmonic series.

My analyses will be articulated topically, grouping pieces together according to their tuning approach. To ensure a balance between breadth and depth, some pieces will be addressed in more detail, with ancillary points and further examples drawn from the others. The groups are defined as follows: 1) pieces using a combination of retuned open strings and harmonics ("Rue Plats" and "The World's Longest Melody" from *for jim, ben, and lou*; *ivtoo*; Four Voice Canon #17; *Yitgadal*; and the *9 Events* pieces); 2) pieces in "fluid tuning" that modulate among related harmonic series (*Psaltery,* "Preamble" from *for jim, ben and lou*; *ii-v-i*; *toovviivfor*; and *freeHorn*); and 3) pieces written for guitar that have been refretted to play in just intonation (*Schneider Variations* and *Songs and Toods*).

Part One: Music for Conventional Guitars

In a piece musingly entitled "Confessions of a Lousy Carpenter" that appeared in the first issue of *1/1: The Journal of the Just Intonation Network*, Polansky wrote:

> The history of experimentation in this area [composition in rational tunings] has been closely linked with instrument design, and for good reasons. Most western instruments, at least from the nineteenth century onward, are built to play in tempered tunings, and composers using just intonation have either had to retune and/or alter them, or build instruments of their own design. My own experience as a composer working closely for many years with rational tunings has been a bit unusual, because I am almost completely incompetent as a carpenter. In addition, I have a natural predilection and love for the instruments and musicians I grew up with and learned with. Thus, my own music has had to solve the problem of how to get the intonations I need from instruments and instrumentalists who are, for various reasons, not inclined to play them.[16]

Although this article was written relatively early in the composer's career, his works list to date reflects the principles he set forth in the text: with few exceptions, which will be addressed later, Polansky's works in just intonation for and with guitars do not require any modification to the instruments other than a creative (and impermanent) retuning of the open strings. The principles by which he adapts guitars to rational tuning contexts are quite simple, as outlined in the ensuing pages of the same article: Open strings are retuned to a partial of the piece's fundamental, and players are instructed to only play on the strings' nodes to produce compound ratios. This approach is not entirely novel: Polansky himself indicates examples from the works of Ben Johnston (especially String Quartet No. 4); Tenney's "Spectra for Harry

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[16] Larry Polansky, "Confessions of a Lousy Carpenter," *1/1* 1.1 (1985), 1.

Partch," from *Quintext*; Lou Harrison's *Elegiac Symphony,* and Harry Partch's own reliance of otonal or harmonic tunings for the adapted guitars. In the remainder of the article Polansky outlines his own compositional and notational approach for *Movement for Lou Harrison*, for bass quartet, and *Movement for Andrea Smith*, for two violins and two violas—a couple of early pieces that foreshadow the directions taken in future compositions.

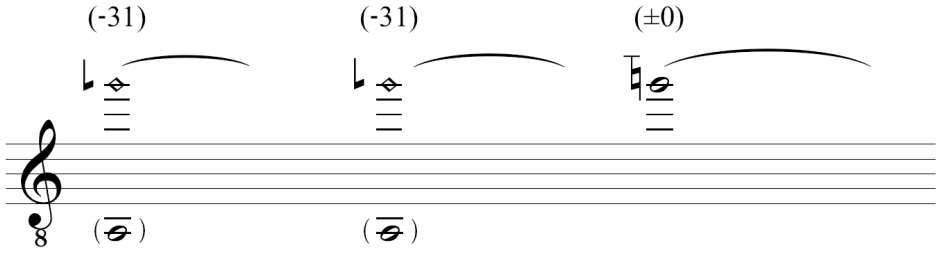
Of all of the influences acknowledged, the one exerted by Jim Tenney's approach in *Quintext* is immediately recognizable throughout Polansky's writing for guitars in just intonation. The key benefit of employing a combination of harmonic nodes and retuned open strings lies in the ease of playability, as performers do not have to learn any unusual just interval beyond those required to retune the open strings of their instruments. As we have seen in our discussion of Tenney's guitar writing for *Spectrum 4*, compound intervals well beyond the confines of those easily tuneable by ear become instantly and easily accessible through this method, with performers playing almost as if following a tablature.

The guitar tuning for a given piece depends on its fundamental, overall tuning complexity, and instrumentation; with few exceptions, Polansky detunes downwards (to avoid the likelihood of string breakage), and keeps strings within a second or a third of their standard tuning. The gamut of pitches available depends on the highest harmonic node that the guitarist is asked to touch—usually the fourth or fifth, to ensure ease of playability and consistency of volume; in some cases, as we will see,

these gamuts are further augmented by fretted notes. Stopping a string at the first, second, fifth, or seventh fret (or their octaves) provides acceptable approximations (within ±5¢) of intervals 17:16, 9:8, 4:3, and 3:2 above the unfretted pitch, respectively. The addition of fretted notes comes at the cost of increased difficulty, as the guitarist must shift along the length of the fingerboard to fret each note at the appropriate position. The recurrent use of open strings and harmonics (which can be produced by the picking hand alone by touching a node with the index finger and plucking with the thumb) somewhat mitigates this aspect—nevertheless, the instrumental approach necessary to perform Polansky's guitar music is quite different from conventional practice, and requires some adaptation on the performer's part.

for jim, ben, and lou

In the early part of his career, Polansky composed three guitar works: the solo ... *getting rid of the glue*... (1978), and the ensemble pieces *The Hensley Variations* (1984, for guitar, violin, and flute) and *The Gottlieb Variations* (1985, for guitar, harp, and cello). None of these pieces employs just tunings, although ...*getting rid of the glue*… exposes the idiosyncrasies of tuning theory by letting a 7:4 harmonic seventh ring out against its tempered counterpart (Example 3.1). Throughout the years, however, he had been incorporating the guitar in just intonation contexts as a performer in his own and fellow experimental composers' live computer-interfaced works.



Example 3.1 Harmonic/tempered pitch juxtaposition in ...*getting rid of the glue*...

In 1995 Polansky completed a three-movement work for guitar, harp, and percussion called *for jim, ben, and lou*. It is the first scored work to integrate two fundamental poles of his musical world—the guitar and rational tunings. The piece consists of three discrete movements, each dedicated to a key figure in Polansky's artistic development: the opening "Preamble" for James Tenney; the middle movement, a set of variations on the Yiddish song *Rue Plats*, for Ben Johnston; and finally "The World's Longest Melody" for Lou Harrison. In addition, each movement highlights a musical or compositional element that Polansky associated with its dedicatee—Tenney's movement is constructed entirely according to the ratios of the harmonic series, Johnston's makes use of variation form, like some of this composer's most iconic works, and Harrison's focuses on superparticular melodic ratios to create an effect hinting at gamelan.

Throughout the work, rational tuning plays fundamental structural and formal roles, while also encompassing rhythmic, melodic, and harmonic elements.

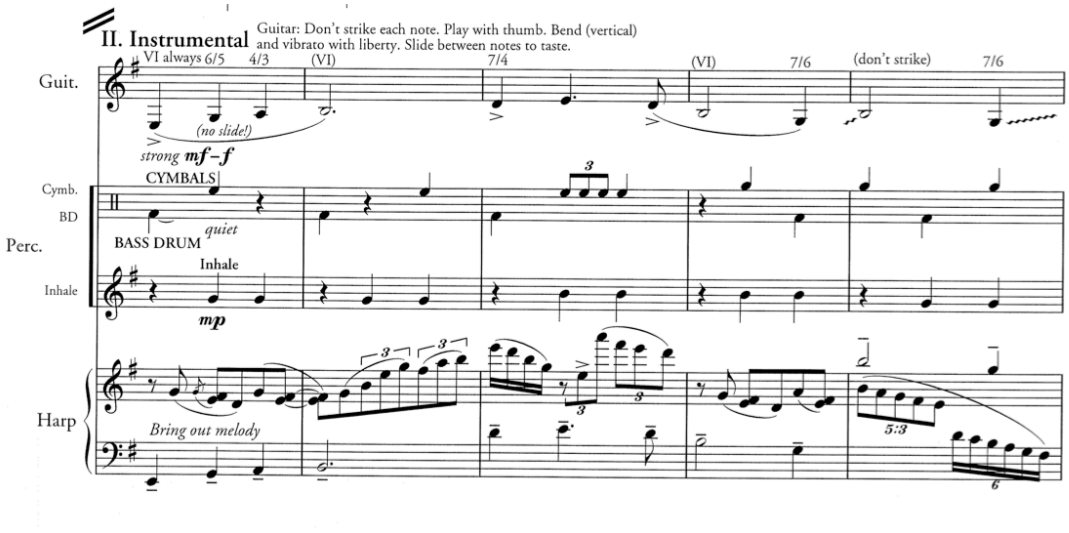
Furthermore, the tuning approaches of each movement are markedly different, both with respects to their theory and their realizations. The opening movement "Preamble" employs a realization of one of Polansky's "fluid tunings" with live acoustic instruments, and will be discussed in detail in the appropriate section. In "Rue Plats," Polansky retunes the five-octave harp to three sets of minor modes on E, but leaves the guitar tuned to equal temperament. The guitarist (who is also busy singing and making different kinds of percussion effects, including hand claps, breathing noises, and sandblock swipes) is then asked to match intervals either by using a slide or by bending a lower tone up to the desired pitch. Formally the movement articulates as a series of four sung verses, each followed by an instrumental solo. The tempo is that of a moderately-paced waltz, true to the affect of the Yiddish tune that serves at its theme.

Mayn Rue Plats ("My Resting Place") originated as a poem by the Polish immigrant Maurice Rosenfeld in the 1890s and was later set to music to become a popular song; it describes the harrowing conditions of the textile sweatshops in which many Jewish immigrants in the United States toiled around the turn of the twentieth century. The song became associated with the Triangle Factory Fire of 1911, New York City's most devastating industrial disaster to date, during which 146 female workers lost their lives.[17] The percussion battery includes milk cans, which provide

[17] There is no clear indication of when exactly Rosenfeld wrote *Mayn Rue Plats*, but he published another poem in *The Jewish Daily Forward* four days after the Triangle fire, railing against the factory owners and mourning the victims. See Leon Stein, *The Triangle Fire* (New York: Carroll & Graf, 1962), 145–146.

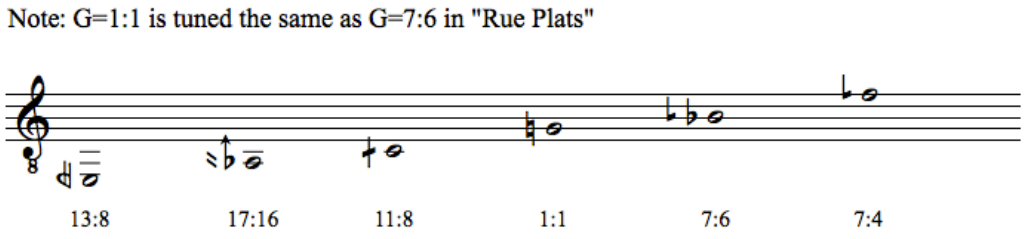
an oblique musical reference to Jewish oppression, pointing to the receptacles that were used for storing and preserving documents by the Warsaw Ghetto community on the eve of its destruction in 1943.

From an intonation standpoint the movement highlights Polansky's flexible approach to tuning: just-tuned harp and equal-tempered guitar coexist, and when their pitches clash briefly they create a shimmering effect, rather than an obnoxious detuning. When precise intonation is needed, the guitarist is asked to adjust fingerings and techniques to match the harp as possible—but the music's poignant and understated tone makes it more of an invitation than a rigid requirement, as shown in Example 3.2.



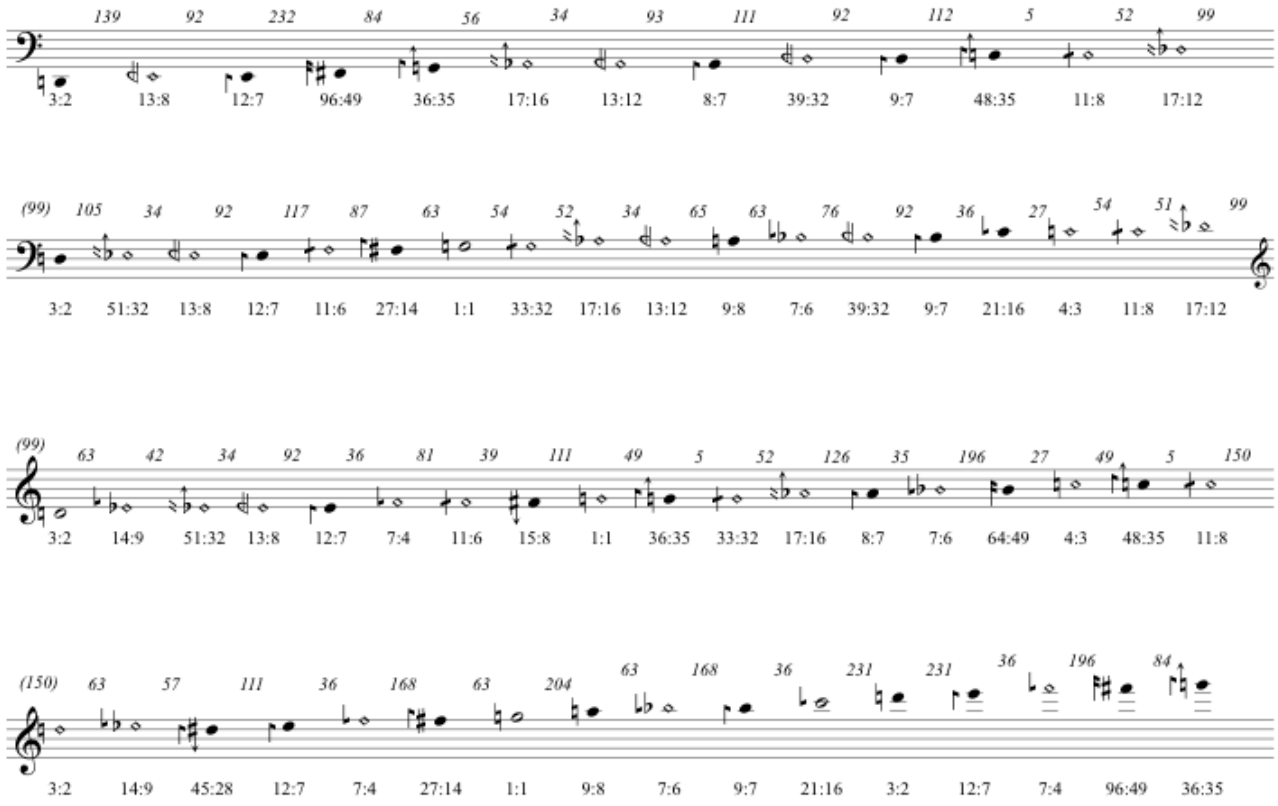
Example 3.2 Guitar solo section in "Rue Plats," with intonation left up to the performer (bending/fingering).

Tuning plays a more central role in "The World's Longest Melody," the final movement of the work. Although the harp does not retune, the fundamental of this movement is changed to the G=7:6, a sub-minor third above the tonic of "Rue Plats." The guitar also adopts a just tuning for the occasion, its open strings tuned as indicated in Example 3.3. The guitarist plays the strings open and as harmonics, but also stops them at the fifth and seventh fret—which are tempered, but virtually indistinguishable from their pure rational counterparts. Harp and guitar are effectively treated as one instrument, and the piece unfolds as a single melodic line in continuous eighth notes, played in hocket between the two instruments; the percussionist accompanies them by highlighting the different number of beats that shape the phrasing. The overall tuning for the movement is shown in Example 3.4; diamondheads indicate notes exclusive to the guitar alone; unfilled ovals represent shared pitches. Notice how the guitar introduces higher-prime intervals (11, 13, and 17) to substantially augment the complexity of the harp's original seven-note and seven-limit tuning.



Example 3.3 Guitar tuning for "The World's Longest Melody"

Example 3.4 Combined harp and guitar tuning for “The World’s Longest Melody.” Black noteheads indicate harp notes, diamondheads guitar notes, and unfilled ovals shared notes between the instruments.


139 92 232 84 56 34 93 111 92 112 5 52 99
3:2 13:8 12:7 96:49 36:35 17:16 13:12 8:7 39:32 9:7 48:35 11:8 17:12
(99) 105 34 92 117 87 63 54 52 34 65 63 76 92 36 27 54 51 99
3:2 51:32 13:8 12:7 11:6 27:14 1:1 33:32 17:16 13:12 9:8 7:6 39:32 9:7 21:16 4:3 11:8 17:12
(99) 63 42 34 92 36 81 39 111 49 5 52 126 35 196 27 49 5 150
3:2 14:9 51:32 13:8 12:7 7:4 11:6 15:8 1:1 36:35 33:32 17:16 8:7 7:6 64:49 4:3 48:35 11:8
(150) 63 57 111 36 168 63 204 63 168 36 231 231 36 196 84
3:2 14:9 45:28 12:7 7:4 27:14 1:1 9:8 7:6 9:7 21:16 3:2 12:7 7:4 96:49 36:35

"The World's Longest Melody" borrows its name from an idea of melodic generation and contour that Polansky has employed to compose several other eponymous works. Although formally introduced in the score/article "Distance Music," the composer reports being preoccupied with these concepts since the early eighties.[18] The basic premise of "The World's Longest Melody" algorithm and pieces is the specification of the probability that a stepwise melodic motion will recur in the same or opposite direction (thereby defining melodic contour). This concept can be applied to live algorithmic-aided improvisations as well as to computer-generated compositions, as is the case with the concluding movement of *for jim ben and lou*.

Section	# of Beats	# of Phrases	Avg. Beats per Phrase
1	157	52	3
2	199	30	7
3	262	24	11
4	327	26	13
5	382	33	12

Table 3.1 Beat and phrase structure for "The World's Longest Melody"

This version of "The World's Longest Melody" is subtitled "The Ever-Widening Half-Step," which is an accurate description of the piece's melodic trajectory. The music is divided into five sections that grow in length both at the micro- (number of beats in each "phrase") and macro-level, as shown in Table 3.1. In

[18] Larry Polansky, "Distance Music," *Perspectives of New Music* (25.1-2, 1987): 541–42.

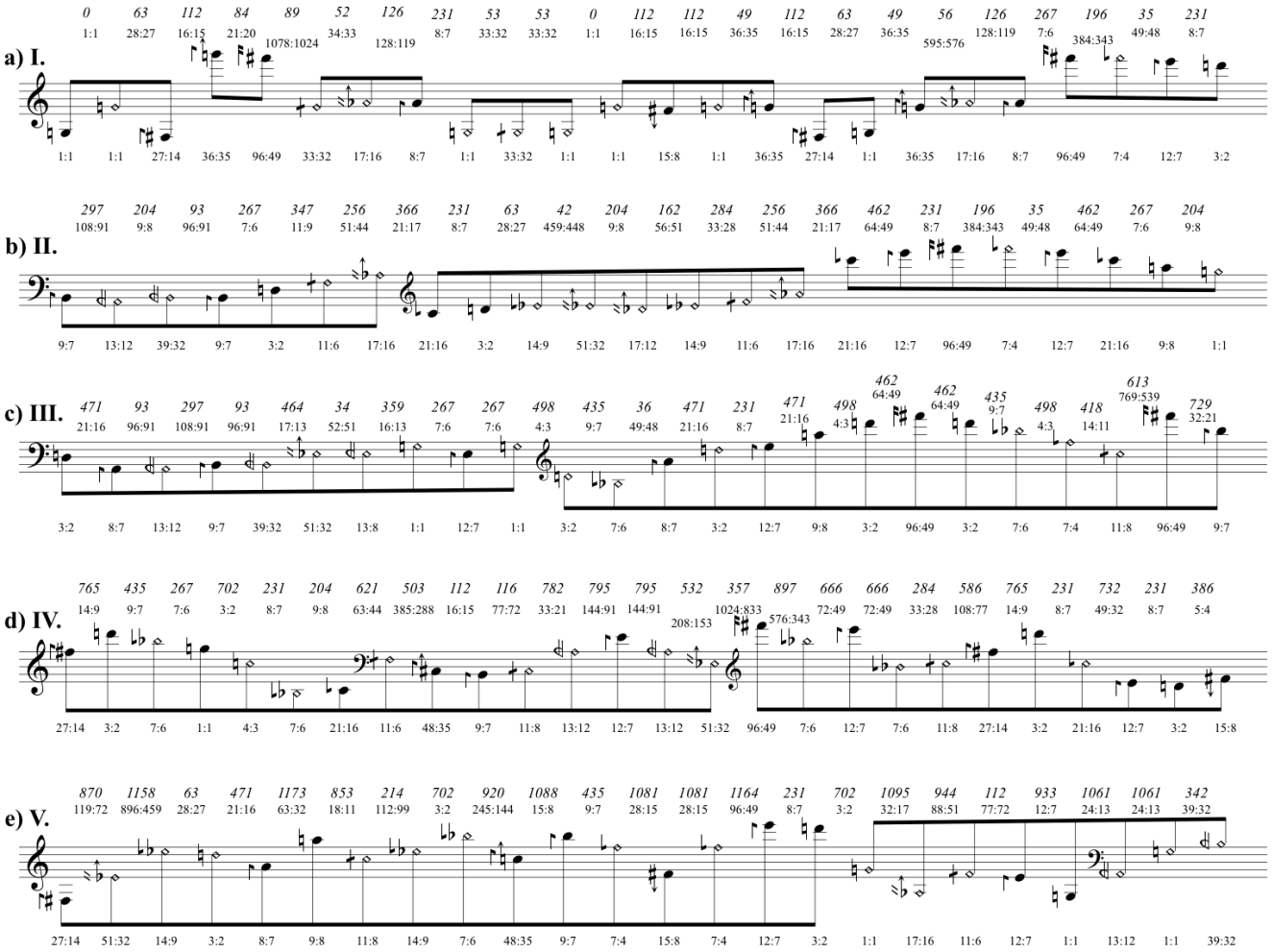
each section, the melodic movement of the hocketing line consists of "steps" that fall within a certain intervallic range. Thus in the first section adjacent pitches are unisons and small seconds away from one another; as the piece progresses, these intervals grow wider (although smaller intervals still occur in the later sections, just less frequently), culminating in major sevenths and mistuned octaves in Section 5. Example 3.5 shows excerpts from each of the piece's five sections, highlighting the intervallic content of the melodic line in both ratios and cents. Note that the algorithm is choosing the next available pitch from the totality of the gamut, resulting in octave skips where the chosen note is not available in the current octave—a quirk that yields some additional registral variety to the continuous melody.

The entirety of *for jim, ben, and lou* features a complex harmonic plan, with the three fundamentals of the movements describing a (mistuned) major triad C–E–G (1:1–5:4–35:24). In addition, the outer movements feature a similar harmonic trajectory, with each section highlighting successive triadic tones over their fundamentals; "Rue Plats" remains stable on its tonic E. The overarching structural plan of the piece and the difference in harmonic complexity among the movements is staggering—especially considering that *for jim, ben, and lou* uses conventional instruments. The price to pay for producing such a fine degree of intonational precision on a standard-issue guitar and harp, however, is an increase in difficulty, caused by the numerous extended (and sometimes altogether novel) techniques employed throughout the work. As a result, *for jim, ben, and lou* has had a

complicated performance history. The piece was originally commissioned by the Japan-America Interlink Festival for performance by John Schneider's ensemble Just Strings in 1995; however, only the second movement was premiered at the festival in Japan. The piece received its complete premiere, given by Toon Callier (guitar), Jutta Troch (harp) and Jeroen Stevens (percussion) on April 14, 2009 at the contemporary music venue Logos in Gent, Belgium.[19] The same trio went on to record the piece for Polansky's recent release "The World's Longest Melody" on New World Records in 2010.

[19] Callier, "*for jim ben and lou,"* 23.

Example 3.5 Excerpts from sections of "The World's Longest Melody," highlighting the gradual increase in size between adjacent "steps."


a) I.
0 63 112 84 89 52 126 231 53 53 0 112 112 49 112 63 49 56 126 267 196 35 231
1:1 28:27 16:15 21:20 1078:1024 34:33 128:119 8:7 33:32 33:32 1:1 16:15 16:15 36:35 16:15 28:27 36:35 595:576 128:119 7:6 384:343 49:48 8:7
1:1 1:1 27:14 36:35 96:49 33:32 17:16 8:7 1:1 33:32 1:1 1:1 15:8 1:1 36:35 27:14 1:1 36:35 17:16 8:7 96:49 7:4 12:7 3:2
b) II.
297 204 93 267 347 256 366 231 63 42 204 162 284 256 366 462 231 196 35 462 267 204
108:91 9:8 96:91 7:6 11:9 51:44 21:17 8:7 28:27 459:448 9:8 56:51 33:28 51:44 21:17 64:49 8:7 384:343 49:48 64:49 7:6 9:8
9:7 13:12 39:32 9:7 3:2 11:6 17:16 21:16 3:2 14:9 51:32 17:12 14:9 11:6 17:16 21:16 12:7 96:49 7:4 12:7 21:16 9:8 1:1
c) III.
471 93 297 93 464 34 359 267 267 498 435 36 471 231 471 498 462 462 435 498 418 613 729
21:16 96:91 108:91 96:91 17:13 52:51 16:13 7:6 7:6 4:3 9:7 49:48 21:16 8:7 21:16 4:3 64:49 64:49 9:7 4:3 14:11 769:539 32:21
3:2 8:7 13:12 9:7 39:32 51:32 13:8 1:1 12:7 1:1 3:2 7:6 8:7 3:2 12:7 9:8 3:2 96:49 3:2 7:6 7:4 11:8 96:49 9:7
d) IV.
765 435 267 702 231 204 621 503 112 116 782 795 795 532 357 897 666 666 284 586 765 231 732 231 386
14:9 9:7 7:6 3:2 8:7 9:8 63:44 385:288 16:15 77:72 33:21 144:91 144:91 208:153 1024:833 576:343 72:49 72:49 33:28 108:77 14:9 8:7 49:32 8:7 5:4
27:14 3:2 7:6 1:1 4:3 7:6 21:16 11:6 48:35 9:7 11:8 13:12 12:7 13:12 51:32 96:49 7:6 12:7 7:6 11:8 27:14 3:2 21:16 12:7 3:2 15:8
e) V.
870 1158 63 471 1173 853 214 702 920 1088 435 1081 1081 1164 231 702 1095 944 112 933 1061 1061 342
119:72 896:459 28:27 21:16 63:32 18:11 112:99 3:2 245:144 15:8 9:7 28:15 28:15 96:49 8:7 3:2 32:17 88:51 77:72 12:7 24:13 24:13 39:32
27:14 51:32 14:9 3:2 8:7 9:8 11:8 14:9 7:6 48:35 9:7 7:4 15:8 7:4 12:7 3:2 1:1 17:16 11:6 12:7 1:1 13:12 1:1 39:32

Other Works for Conventional Guitars

Having developed ways to incorporate the guitar into his just intonation frameworks with *for jim, ben, and lou*, Polansky returned to the instrument throughout the 1990s and 2000s to compose more solo and ensemble pieces. These are *ivtoo*; *Four Voice Canon #17*; *Yitgadal*; *9 Events*; and *10 Strings (9 Events)*. They represent different aspects of the composer's production, ranging in style from mensuration canons to open-form group pieces.

ivtoo, a solo dedicated to and premiered by the Argentinian guitarist Claudio Calmens in 2000, is part of a set of pieces written for equal tempered instruments, but still using the ratios of the harmonic series, making it a sort of cross-temperament hybrid.[20] In this guitar version, the tuning approximates just ratios for the 7th, 11th, and 13th harmonic, but uses tempered prime, fifth, and major third. Formally the piece develops as the gradual cross-fade betweens harmonic series on C and G (roman numerals one and five in the title), not unlike a simplified version of "fluid-tuning" pieces such as *Psaltery*, "Preamble," and *ii-v-i.*[21] The piece should be performed as a canon, either by a soloist using a delay effect, or by an ensemble of guitarists. *ivtoo* is another example of Polansky's flexible attitude towards intonation: He requires higher harmonics to be played on the appropriately-tuned strings (thus conflating the 11th and 13th harmonic to the same approximation of ~50¢), but

---

[20] *ivt* (2000, one or two pianos), for Sarah Cahill, uses rhythmic groupings derived from the harmonic series, but does not require the instrument(s) to be retuned.

[21] For more on Polansky's piece-naming conventions, see Larry Polansky, "Shemot," < http://eamusic.dartmouth.edu/%7Elarry/misc_writings/talks/shemot.pdf>

encourages the performer(s) to experiment with the intonation and fingering of the other pitches.

Four Voice Canon #17 continues Polansky's ongoing series of mensurations canons, which dates back to his student days at UC Santa Cruz. In particular, #17 is a realization of #13, a generalized set of instructions nicknamed *DIY Canon*. Each string constitutes an independent voice, making this particular Four Voice Canon a six-part one, despite its title (which is maintained to show the piece's relation to other works in the series). The pitch content of each voice consists of the twenty-four possible permutations of four harmonics for that string—harmonics 2, 3, 4, and 5 for the highest four strings, and 1 (open string), 3, 4, and 5 for the lowest two. The tempo for each voice is derived from the tuning of the string itself. The harmonic relations of the strings, low to high, are 4:6:9:11:7:5; these ratios result in the tempi 48:72:54:66:84:60 (the tempi are reduced to fit within one "tempo octave"—meaning that any value larger than 96, the "octave" of the lowest string's tempo, is halved). The resulting sonority of the piece is that of a consonant cloud of scattered attacks; although the mensural relations become too complex to be heard, the overall rhythmic effect is coherent and hypnotically soothing.

After Lou Harrison's death in August of 2003, Polansky and Diamond inherited half of the composer's house in Aptos, California; they eventually bought the other half from composer/conductor (and former Harrison student) Robert Hughes and his wife, choreographer Margaret Fisher, in an attempt to try to hold onto the

property. Polansky, Diamond, and their daughter Anna lived at the Aptos house for a few months in the winter of 2004 before finally selling the house; it was during this period that Polansky composed *Yitgadal*, a pair of chorales dedicated to Harrison and his partner Bill Colvig. *Yitgadal* was commissioned by David Rosenboom and the California Institute for the Arts New Century Players, who premiered it at the Redcat theater in Los Angeles on 9 March 2004. The mixed ensemble is divided into three groups: "harmony instruments" (violin, viola, cello, and guitar), which play only harmonics on retuned strings; "melody instruments," which are left unspecified—any instrument can play one of the six melody parts, provided that all six are sounded; and finally percussion and harp, supplying a more independent rhythmic punctuation to the unfolding music.

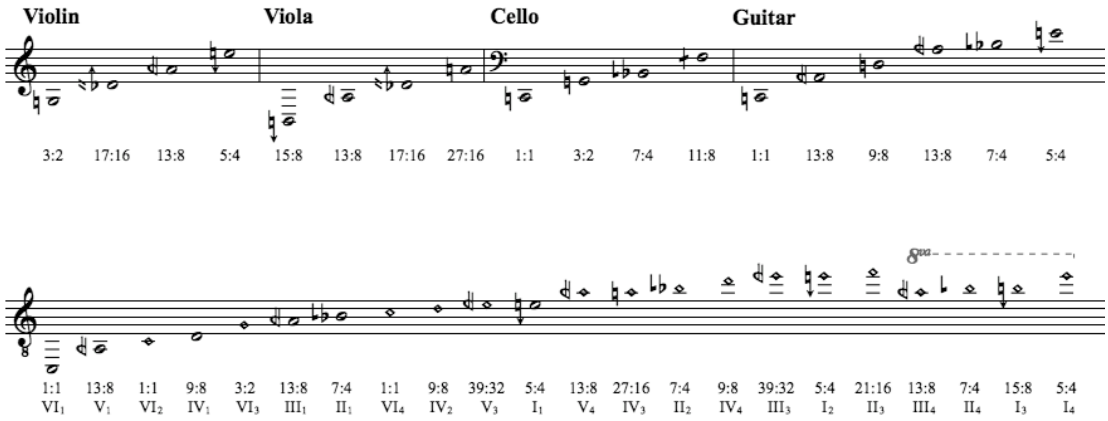
As hinted in the piece's title, the rhythms are derived from transcribed readings of the mourner's *kaddish*, averaging the inflections from several recordings by Polansky and Dartmouth student Sarah Meyers. This rhythmic line is then algorithmically harmonized through the application of Euler's *Gradus Suavitatis* function.[22] Polansky scored the result in two versions: "Ascending Viewpoint" moves from rhythmic and harmonic simplicity to complexity, and dedicated to Bill Colvig; and its inverse "Descending Viewpoint," which reverses the process and is dedicated to Harrison.[23] Example 3.6 shows the tunings for guitar and strings, as well as the

---

[22] See footnote 11 for an explaination of Euler's GS.

[23] The naming of the movements reflects both the location of Harrison and Colvig's house on top of View Point Drive, and the fact that even in old age Colvig would walk up the steep hill when returning from errands.

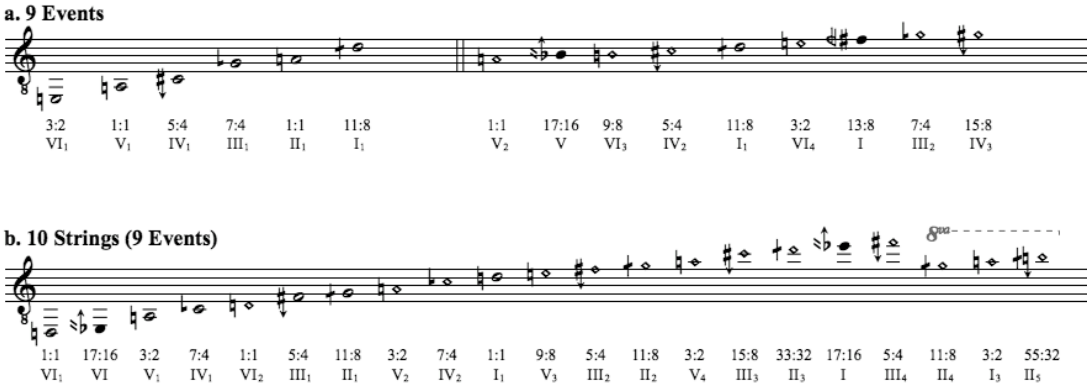
totality of pitches available to the guitarist (with fingering indications). Notice how the overlapping of harmonics across adjacent strings create densely-populated octaves in the mid- and upper register of the instrument, once again increasing the harmonic complexity without adversely impacting the playability of the piece.



Example 3.6 Guitar and Strings tuning for *Yitgadal*

Both *9 Events* pieces—one a quartet written specifically for Polansky on guitar, Christian Wolff on piano, Doug Perkins on percussion, and Robert Black on bass; the other a duo for guitarist James Moore and violinist Andie Springer—incorporate indeterminate elements with regard to form; their procedures are derived from another of Polansky's works, the flexible-instrumentation piece *Ensembles of Note* (1998). The scores of the *Events* pieces consist of a unison section, followed by sets of eleven "sound events" for each instrument; the players can play their events in any order over the course of a predetermined time span, before moving on to a unison

coda. For both pieces, the (fretted) guitar is treated as a flexible pitch instrument, using detuned strings to produce just-tuned pitches within a tolerance of 10¢; fixed-pitch instruments (the piano and percussion in the quartet) are free to play more distantly-tuned intervals or not, in a further example of tuning flexibility on the composer's part. Example 3.7 shows the tuning and actual sounding pitches for both pieces, with fretted notes indicated with filled note heads. As in previous examples, fingering indications for the harmonics are provided by Roman numerals for the string and Arabic subscripts for the node.



Example 3.7 Guitar tunings for *9 Events* and *10 Strings (9 Events)*

Part Two. Fluid Tuning by Electronic Means: From the *Psaltery* Set to *freeHorn*

A common criticism of just intonation tunings is that they restrict the possibility for modulation, since notes that are related by simple (and thus consonant) ratios to the same fundamental end up producing more complex intervals between themselves, as opposed to the same size, transposable steps of equal temperament. Although one could avoid this problem by introducing a higher number of notes per octave (as has been tried in several notable organological experiments throughout the history of music), such solutions yield instruments that are difficult to construct, and impractical for musicians to acquire—let alone to play. In the twentieth century there have been some additional attempts at bridging this modulation gap in rational tuning contexts. Harry Partch's forty-three note scale shows some modulatory possibilities, as demonstrated by Partch himself in *Genesis of a Music*.[24] Another approach was the one taken by Lou Harrison, who created a freely modulatory framework with compositions in his so-called Free Style. As we have seen, Harrison's Free Style works pose such an intonational challenge that they remain largely unperformed to date. With the advent of electronic music and in particular with the increased availability of sound synthesizers since the late 1960s, new ways of achieving modulatory flexibility within just tunings have become commonplace.

One such example is Polansky's *Psaltery*, a tape piece from 1978–1979 featuring an approach to harmony and tuning that would recur in the composer's

[24] Partch discusses modulations, cadences, and what he calls "tonality flux" (new modulatory possibilities inherent in his system) in *Genesis of a Music,* 181–194.

works, in various guises, up to the present. In *Psaltery* Polansky manages to generate a bewilderingly complex structure from a great economy of means, as the piece's fifty-one justly tuned pitches originate from a single bowed psaltery tone, manipulated with tape techniques. The pitches are harmonics 1–17 of three harmonic series, their fundamentals related by the close ratios of a just major triad (i.e. 4:5:6, or C–E–G). Consequently, all pitches in the piece belong to the harmonic series of the fundamental: the 3rd harmonic of G equals the 9th harmonic of C; the 17th harmonic of E equals the 85th harmonic of C; and so forth. Note, however, that the piece's higher harmonics do not appear in their original octave: The second and third series are transposed down so that their fundamentals are tuned 5:4 and 3:2 from the fundamental C, rather than 5:1 and 3:1, respectively. Harmonic series spacing is otherwise preserved.

The piece's unfolding is succinctly explained by Polansky in the notes for the original recording:

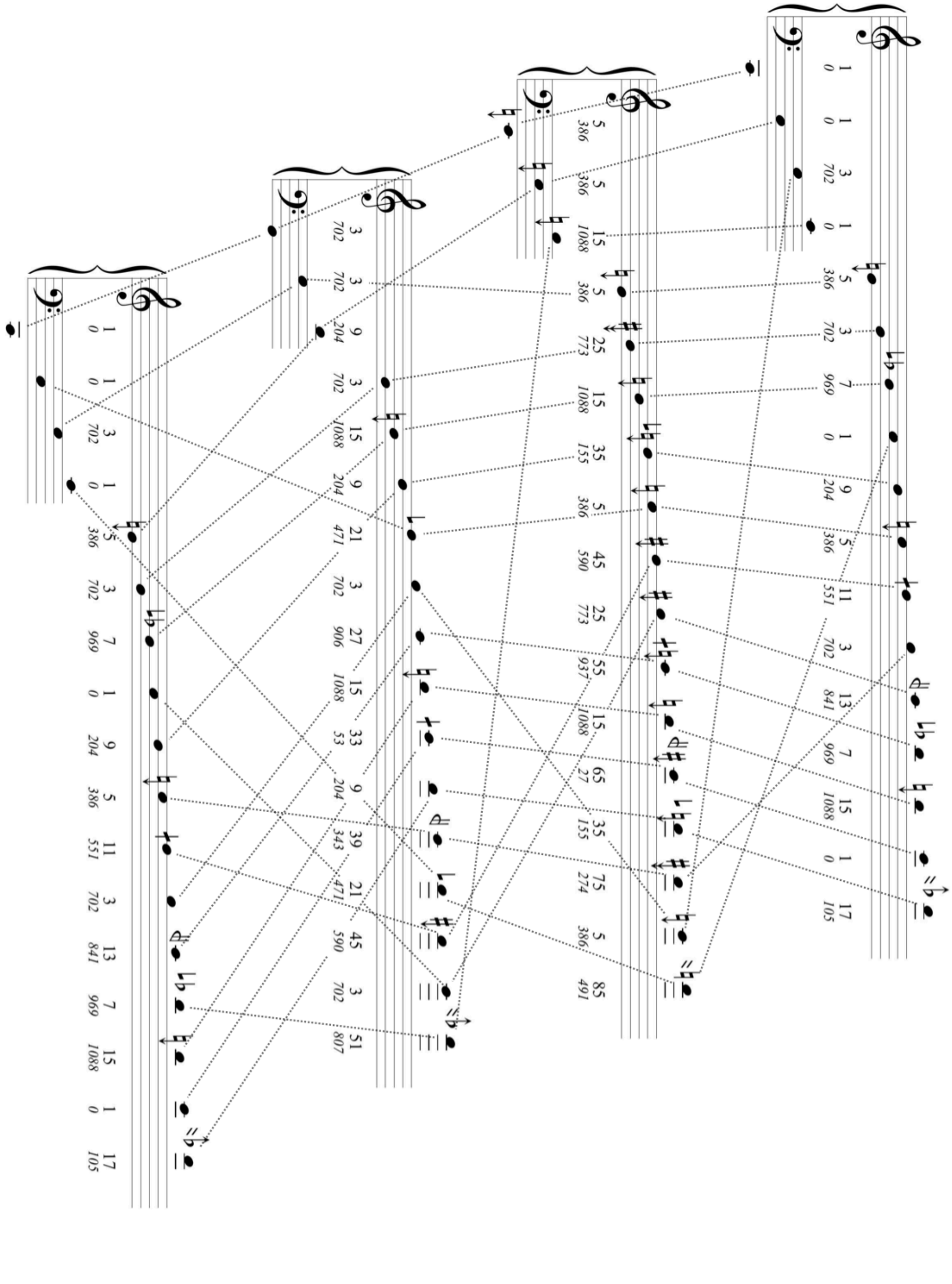
> After building up the initial series on the fundamental, pitches from the next series (5, or the major third) begin to replace their closest neighbors until the series on 5 is complete. This process happens twice more, moving to the perfect fifth (on 3), and then back to the fundamental. Finally, the series on the fundamental drops out.
>
> Harmonics enter according to their "prime complexity" in this order: 17, 13, 11, 14, 7, 15, 10, 5, 9, 12, 6, 3, 16, 8, 4, 2, 1. More distantly related harmonics of a new series enter first, crossfading with close pitches from the current series so that, at first only a "mistuning" is heard. Gradually, closer harmonics of the new series begin to imply the new fundamental, through difference tones and our own sense of harmony. The initial buildup of the first series is the reverse of this order, and in the end, the pitches of the final series

drop out in this order.[25]

In summary, then, there are two distinct processes at play: The first is the entrance of the harmonics of the series on C, which happens in prime order (meaning that all harmonics for a given prime will enter before any harmonics from the next higher prime; hence 4, 8, and 16 enter before 3). The second, and more complicated, process is the one by which the harmonics of successive series are substituted into the mix. The 17th harmonic of the E series is the first new pitch to enter in the second section, according to the "prime complexity" order as defined by the composer. This note, an F defined by the ratio 85:64, is 105¢ sharper than E (5:4, 386¢), and sounds as a slightly flat fourth (491¢) above the nearest octave of the fundamental C. Although generally new tones enter in place of closely-tuned ones, this new pitch substitutes a lower octave of the fundamental instead, as it is pitched higher than any note from the previous series. Example 3.8, a resetting of a diagram by the composer, illustrates every pitch substitution in the piece (note that it does not show the temporal unfolding of these processes, which again occurs from higher to lower primes). Closely-tuned pitch substitutions are especially apparent between harmonics 9–11 of the first series and 8–10 of the second; for example, the 7th harmonic of E (D=35:32, 155¢) substitutes the 9th harmonic of C (a "different" kind of D, 9:8 or 204¢). The 10th harmonic of C is the exact same as the 8th harmonic of E, and the 11th harmonic

[25] Larry Polansky, liner notes to *The Theory of Impossible Melody* (Artifact 1004; re-released on NWR 80684)

Example 3.8 Diagram outlining pitch substitutions in *Psaltery.*



of C (F about 50¢ sharp) exits in favor of a note 40¢ higher (the 5-limit tritone, F#=45:32).

The introduction of notes from each new series in descending order causes their entrances to sound like slightly out-of-tune pitches; yet, given that they can still be expressed rationally to the overall fundamental, the piece maintains a sense of euphony beyond its heterophonic tuning surface. As pointed out by Polansky in his notes to the piece, over time our ears gradually recognize the relationships implying the new fundamental, and thus complete the modulation.

The process and structure first introduced in *Psaltery* appear throughout the composer's career. Even before he had completed the tape piece, Polansky began making "orchestrations" of *Psaltery* for live instruments (often with tape). These are *'Cello* (1978), for live cello and tape; *Canon for Flute* (1978, revised 1990), for flute and tape; *Flutes* (1978), for flute choir; *Cata/Tonic* (1978), for solo viola; and *Glass* (1979), for eleven players and fifty-one tuned crystal glasses. In other works, such as *Gauss Music* (1979, for piano and "homebrewed" synthesizer), *B'rey'sheet* (*Cantillation Study #1,* 1986–87, for voice and live computer), and *Cocks crow, dogs bark, this all men know, but even the wisest cannot tell why cocks crow, dogs bark, when they do* (1987, for three performers, computers, and "stuff," as the composer calls the ensemble of synthesizers, controllers, and interfaces involved), Polansky introduced the concept of modulating harmonic series in the context of live performance with dynamic electronic and computer systems. This process prompted

yet another *Psaltery* orchestration, a piece for French horn and live electronics (or tape) appropriately entitled *Horn* (1989–92).

Horn was composed for Krystyna Bobrowski, a graduate student of Polansky's in electronic music at Mills; its most recent version, developed with help from Tom Erbe, uses a CSound program to generate three harmonic series—tuned 1:1–5:4–3:2 from a low F—in real time. The score consists of a series of arpeggios, indicating the available pitches that the performer can choose from to underline the unfolding harmonic motions. Because the computer generates the part dynamically (according to the *Psaltery* guidelines, yet randomizing parameters such as pitch duration, dynamic level, and so forth), the performer cannot simply memorize the accompaniment as an aid to intonation, but must react in real time to the ever-morphing soundscape. Despite its technical and technological demands, *Horn* has been performed several times by Bobrowski, who premiered it at Mills with the composer on live electronics in March 1990, and she later recorded the piece on the CD *Simple Harmonic Motion.*[26]

The latest derivation from the *Psaltery* set is directly related to *Horn*. *freeHorn* (2004) is a translation of the original HMSL algorithm for a more up-to-date Java programming platform, called Jsyn; the program was developed in collaboration with Phil Burk, the creator of Jsyn and one of the original developers of HMSL. As hinted by its title, *freeHorn* loosens some of the requirements of its predecessor: There is no

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[26] Larry Polansky, Krystyna Bobrowski, and others, *Simple Harmonic Motion*, Artifact 1011.

score, no predetermined harmonic progression, no prescribed degree of harmonic complexity, and even no requirement that the performer should be in tune with the sounds produced by the program. The performers, in fact, are in charge of some of the algorithm's parameters, a subset of which can even be changed during the course of a performance. The harmonic progression (expressed rationally in relation to the chosen fundamental), length of the piece, harmonic complexity, and pitch replacement method are all "static" variables, to be determined before the beginning of a performance; the parameters controlling the duration and dynamics of each pitch entrance, the temporal distribution of attacks (yielding a range of homorhythmic and polyphonic textures), the probability of rests, and other elements influencing the sounds produced by the program can be adjusted in real time.

The open-endedness of *freeHorn* is exemplified by the composer's willingness to mix differently-tuned instruments in performance: Players of fixed pitch, equal-tempered instrument should merely be listening and contributing what pitches they see fit, playing "against" the tuning as much as with it. A recent performance at the 2012 UCSC contemporary music festival "April in Santa Cruz" featured Polansky on fretless electric guitar, the author of this dissertation on just intonation resophonic guitar, Bobrowski on horn, as well as UCSC professor Amy Beal on piano, and composition graduate student in composition Ma'ayan Tsadka. Neither equal-tempered instrument was retuned for the occasion. In addition to the oddball collection of instruments, this performance also featured three instances of the

program running simultaneously. The three programs, which shared the same fundamental (F) and overall duration, were set to describe different progressions and incorporate different degrees of harmonic complexity, to accommodate the range of instruments participating. For example, Polansky's own program used slightly mistuned ratios, such as 1.4785 instead of 1.5 or 3:2, and was set to include harmonics up to the 17th, whereas the program run by the JI resophonic guitar performer matched the instrument's 11-limit tuning.[27]

Although *freeHorn* is not specifically a guitar piece, its flexibility makes it an ideal setting to showcase the composer's approach to just intonation on the guitar. Polansky, who has performed the piece with a variety of ensembles, tunes his fretless electric guitar to different harmonic tunings in accordance to the given performance's fundamental and harmonic progression; the fretless fingerboard allows him the necessary flexibility to match the pitches generated by the program, and outboard electric guitar effects such as delay, reverb, and volume pedals compensate for the fretless instrument's relative lack of sustain in the upper register. The adaptation of the just intonation resophonic guitar to this context is also worth discussing; for performances with the horn, the guitar was retuned to C–F–C–G–A–C, or 3–1–3–9–5–3 in terms of harmonics of F. This new tuning shares a similar intervallic structure with the original DADGAD tuning (3–9–3–1–9–3 in G), meaning that some regions

[27] Another example of the piece's flexibility is the three-hour version organized by Bobrowski and Polansky for the "Garden of Memory" music marathon at the Chapel of the Chimes columbarium in Oakland, CA, on June 21st, 2012, which featured a rotating group of eleven performers. Both performances can be heard on Polansky's website: http://eamusic.dartmouth.edu/~larry/archive.recordings.html

of the fingerboard—but not all—remain in tune across the strings. Table 3.1 highlights the range of intervals created by this new tuning. Another possible tuning, used by the author in several solo performances, takes advantage of the instrument's natural bias towards D as a fundamental by tuning the open strings D–A–D–F#–A–C (1–3–1–5–3–7).[28]

Open String	**C=3:2**	**F=1:1**	**C=3:2**	**G=9:8**	**A=5:4**	**C=3:2**
1st Fret	D♭=14:9	F♯=28:27	D♭=14:9	G♯=297:256	A♯=35:27	D♭=14:9
2nd Fret	**D=27:16**	G=10:9	**D=27:16**	**A=81:64**	B=25:18	**D=27:16**
3rd Fret	**E♭=7:4**	A♭=7:6	**E♭=7:4**	**B♭=21:16**	C=35:24	**E♭=7:4**
4th Fret	**E=15:8**	A=11:9	**E=15:8**	**B=45:32**	C♯=55:36	**E=15:8**
5th Fret	**F=1:1**	B♭=4:3	**F=1:1**	C=169:128	D=5:3	**F=1:1**
6th Fret	**F♯=33:32**	B=112:81	**F♯=33:32**	**C♯=99:64**	D♯=140:81	**F♯=33:32**
7th Fret	**G=9:8**	**C=3:2**	**G=9:8**	**D=27:16**	**E=15:8**	**G=9:8**
8th Fret	A♭=7:6	D♭=14:9	A♭=7:6	**E♭=7:4**	F=35:18	A♭=7:6
9th Fret	**A=5:4**	D=5:3	**A=5:4**	E=243:128	F♯=25:24	**A=5:4**
10th Fret	**B♭=21:16**	E♭=16:9	**B♭=21:16**	**F=63:32**	G=10:9	**B♭=21:16**
11th Fret	**B=11:8**	E=11:6	**B=11:8**	F♯=135:128	G♯=55:24	**B=11:8**
12th Fret	**C=3:2**	**F=1:1**	**C=3:2**	**G=9:8**	**A=5:4**	**C=3:2**

Table 3.2 Sample tuning for the JI resophonic guitar in *freeHorn*; bolded cells indicate notes in tune with the generated harmonic series, up to the 11th harmonic of each.

In addition to creating a serene yet complex harmonic soundscape, *freeHorn* is an effective synthesis of theoretical and aesthetic concerns that resurface throughout Polansky's career. The relaxation of constraints on the performers is counterbalanced by the complex tuning processes holding the structure together; in this light, Polansky

[28] A video recording of a performance for Tangents Guitar Series in San Francisco (21 May 2012) is available on YouTube: <http://www.youtube.com/watch?v=fBWClea-CwQ>

encourages the performers to signal the beginning (or completion) of a new harmonic series via a predetermined rhythmic or melodic motive.[29] Most of all, the heterophonic harmonies of *freeHorn* exemplify the composer's unique approach to tuning—one marked by the kind of open-mindedness that allows differently tuned instruments to coexist and work together.

Real-Time Retuning: "Preamble"

In addition to developing a substantial body of works that feature modulation among harmonic series with the aid of taped or live electronics, Polansky has also composed music that approaches the same problem using only acoustic instruments. The first example of this approach appeared in "Preamble," the opening movement of *for jim, ben, and lou* (for guitar, harp, and percussion).

The use of tuning in the work as a whole is extraordinarily complex. Not only does the harp have to be retuned after "Preamble," requiring a break in performance, but the tuning of the guitar actually changes *during the opening movement*, as the percussionist is instructed to retune the guitar while the guitarist is playing. The movement's structure outlines a progression identical to that of *Psaltery*, i.e. an arpeggiation of three 17-limit harmonic series, tuned a major triad apart from C, followed by a return to the fundamental. At a deeper level, however, the piece unfolds

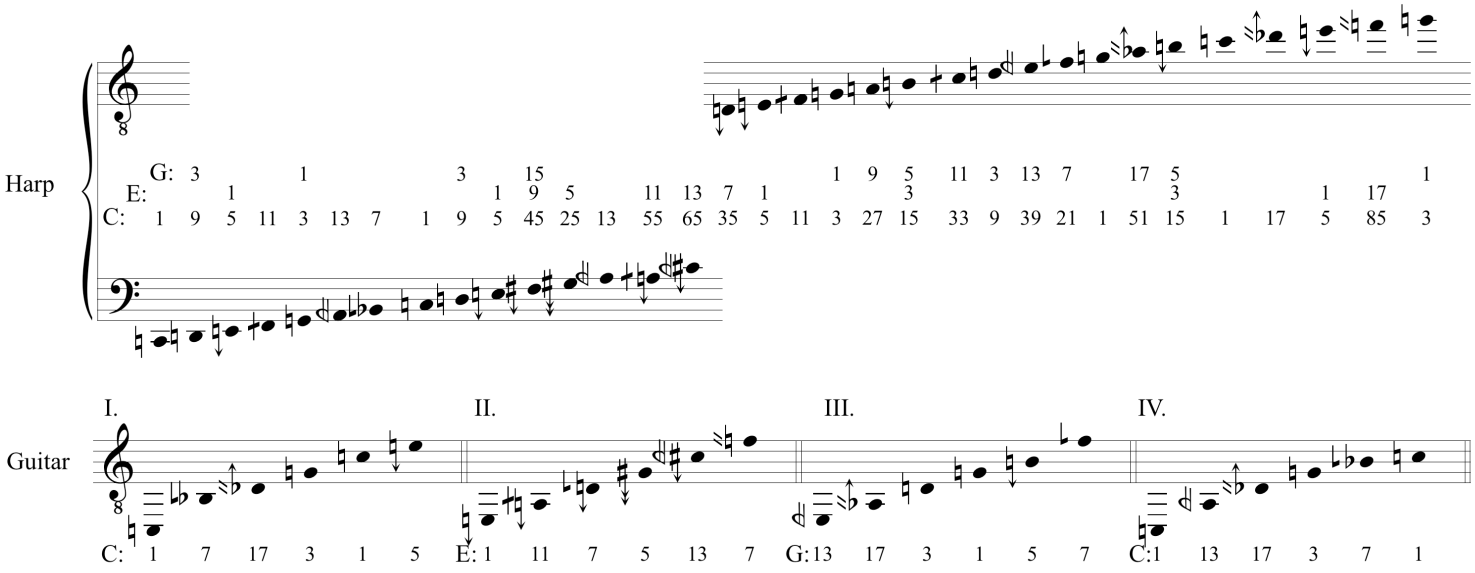
[29] This structural device was first introduced in the score of two earlier pieces, such as *Choir/ Empi's Solo* (1997, for voice and tape, another "orchestration" from the *Psaltery* set), and *ii-v-i* (1997, for one or two guitars, to be discussed below).

in a radically different way.

In order to afford the necessary harmonic range, Polansky tunes the harp and guitar using different approaches. The diatonic harp (a concert harp is usually employed, without operating the pedals) is tuned so that each of its four-and-half octaves contains a different seven-note mixture from the three harmonic series, as shown in the top staves of Example 3.9. Obviously, to avoid restringing the harp, harmonic series spacing is not preserved in this case. Conversely the six-string guitar morphs between four different tunings, one for each section of the piece. Example 3.9 also shows how these tunings contain a subset of primes for each series, meaning that the remaining ones will have to be provided by the harp in performance. The gamut of notes available to the guitar is limited to open strings and octaves, fifths, and twelfths, which can be played either fretted or as natural harmonics.

As with pieces from the *Psaltery* set*,* harmonics from a new series enter in reverse order; however in "Preamble" the order is dictated by harmonic number, rather than prime factor, so that, for example, E15 enters before E13, and E9 enters before E7. Depending on the actual tuning at the time of its entrance, a new harmonic can be introduced either in the harp or in the guitar: This latter option requires the percussionist to retune the appropriate string (generally, but not always, one tuned within a semitone of the target pitch) immediately after the guitarist has struck it. The guitar's tuning keys become in effect a part of the *musical* instrument, their manipulation a fundamental element in this performance.

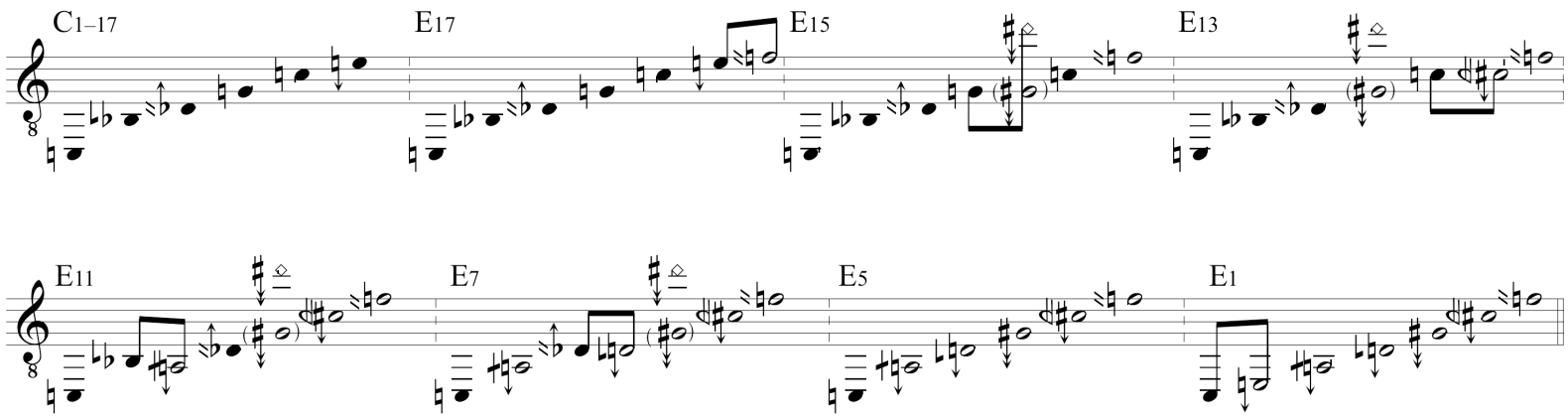
Example 3.9 Harp and Guitar tunings for “Preamble”


Harp
G: 3 1 3 15 1 9 5 11 3 13 7 17 5 1
E: 1 1 9 5 11 13 7 1 3 3 1 17
C: 1 9 5 11 3 13 7 1 9 5 45 25 13 55 65 35 5 11 3 27 15 33 9 39 21 1 51 15 1 17 5 85 3
Guitar
I.
II.
III.
IV.
C: 1 7 17 3 1 5
E: 1 11 7 5 13 7
G: 13 17 3 1 5 7
C: 1 13 17 3 7 1

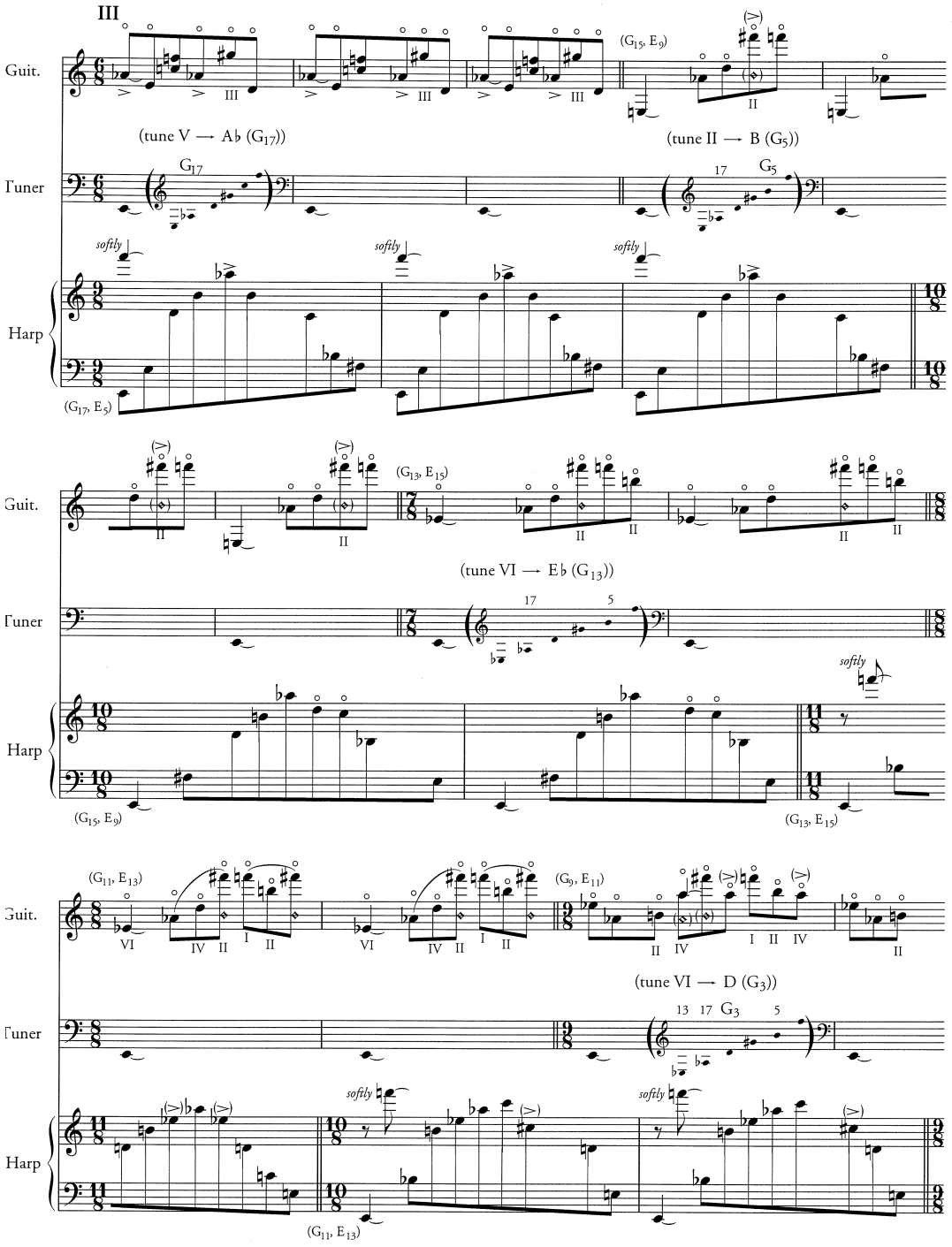
The gradual change between the harmonic series on C and E is synthesized graphically in Example 3.10. Filled notes represent notes belonging to the original C series, whereas unfilled ovals stand for their E counterparts. Note, once again, that in strictly acoustical terms all notes in the piece belong to the harmonic series on C; however, the intervallic relationship and close spacing of the new entering pitches lead our ears towards assuming a change in the fundamental from C to E. The halfway stages of this process perfectly illustrate the occurrence of what the composer would call a "heterophonic" tuning system—two conflicting intonations happening at once.

Unlike the semi-improvisatory contexts of pieces in the *Psaltery* set, "Preamble" is fully notated. The morphing between harmonic series happens in prescribed rhythmic and melodic contexts, as opposed to the droning atmosphere common to other works in this series. Although the eighth-note pulse stays constant throughout the piece, the meter is irregular, with odd groupings that match the number of the newest harmonic in a given measure. In section III, as the series modulates from E to G, the harp and guitar/percussion parts become metrically independent: their measures grow in counts from 9|8 and 6|8, respectively, to 11|8, yet their metrical climaxes are staggered. Both parts then reverse the process, finally rejoining their barlines three measures before the end of the section, just as the guitar completes retuning to the new G series. Example 3.11 shows the complex rhythmic nature of the writing as well as the ongoing tuning modifications.

Example 3.10 Section II from “Preamble,” reduced to show morphing between harmonic series.


C1–17
E17
E15
E13
E11
E7
E5
E1

Example 3.11 Changing meters matching harmonic numbers in Section III of "Preamble."


III
Guit.
Tuner
Harp
(tune V → A♭ (G17))
(tune II → B (G5))
(tune VI → E♭ (G13))
(tune VI → D (G3))
softly
(G17, E5)
(G15, E9)
(G13, E15)
(G11, E13)
(G9, E11)

"Preamble" is a movement that poses an unprecedented set of challenges to its performers. The remainder of the work, as we have seen in the previous section, is of comparable difficulty, if perhaps slightly more conventional (if we consider singing while playing a "conventional" demand to make of classically trained musicians, as the composer does). Although it took some time for the work to receive a complete performance, since the premiere there have been additional performances by other trios—proof of how the level of performers keeps rising to meet musical demands once considered unpractical, even unreasonable.[30]

More Real-Time Tuning: *ii-v-i* and *toovviivfor*

Considering Polansky's instrumental background, the implementation and eventual expansion of the idea of manipulating the guitar's tuning keys in performance should not come as a surprise. Other examples of real-time retuning include *...getting rid of the glue…* and *34 Chords* (1995)—in the former the retuning is used as an effect, and in the latter to expand the range of the guitar for chord voicing purposes. In neither case, however, does the realtime retuning play as integrated a role as in "Preamble." As such, these works belong alongside other uses of this particular extended technique in the repertoire—most notably in pieces like Tristan Murail's solo *Tellur* (1978) and Peter Sculthorpe's concerto *Nourlangie* (1988) and the guitar solo *From Kakadu* (1993).

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[30] See for example this performance by an (uncredited) Austrian ensemble on 18 October 2011: http://www.youtube.com/watch?v=TuZlnjK8x7o

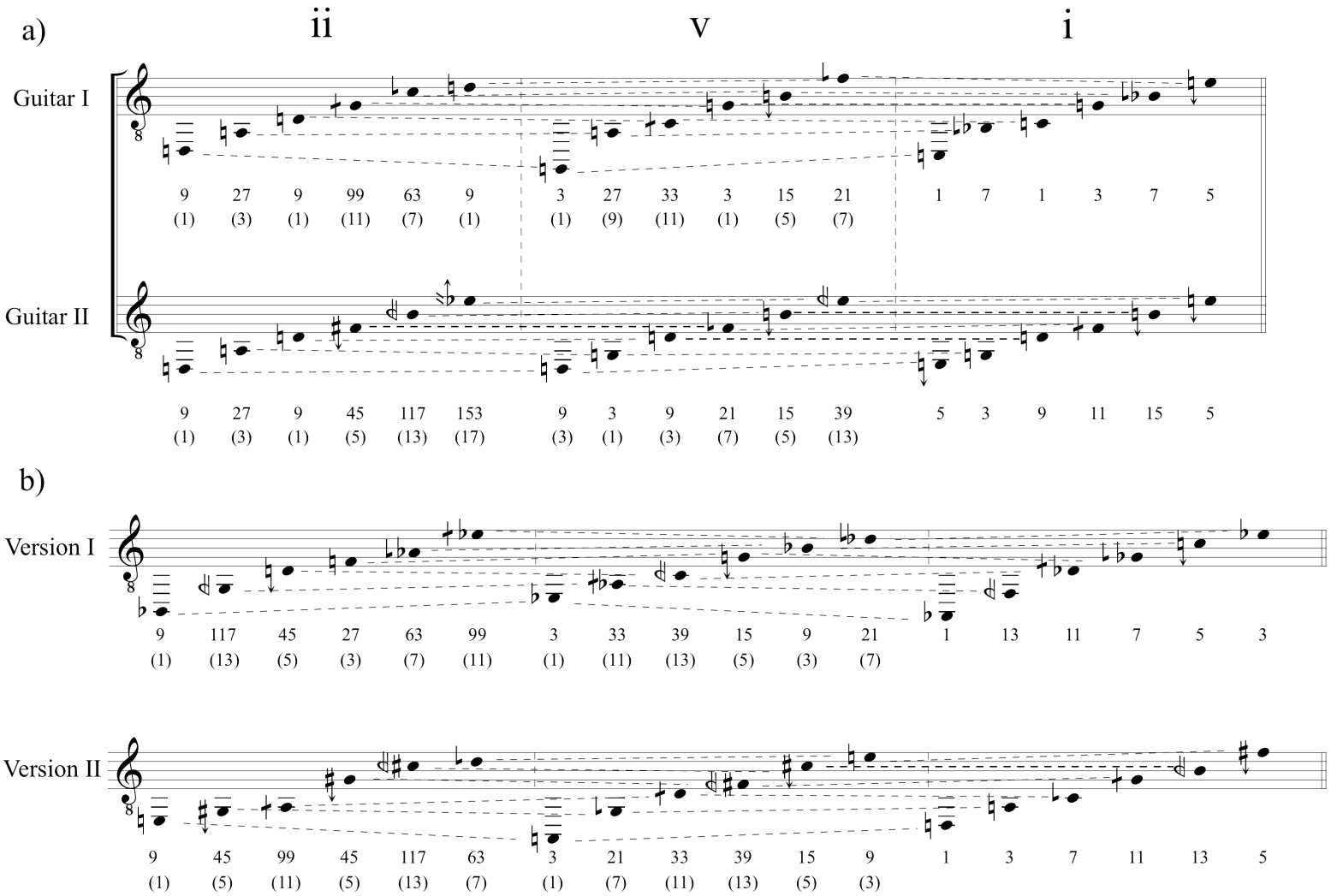
In late August 1997 pianist Thomas Bächli organized a series of performances at La Mama Galleria in New York City as a memorial for the late pianist Wladziu Liberace (1919–1987), and invited Polansky to participate. Polansky had been tinkering with the idea about retuning a pair of guitars in real time to demonstrate the common classical and jazz progression ii-V-I; for this performance he recruited guitarist/composer and frequent collaborator Nick Didkovsky. The piece's success (after a single rehearsal) led Polansky to formalize itss workings into a set of instructions, which in turn outline three possible versions. The score is dedicated to Brian McLaren and composer/theorist Carter Scholz, the latter in reference to the many conversations about the possibilities of tuning in performance that the two composers shared 1980s.

In a nutshell, *ii-v-i* is a study on the modulating sections of "Preamble:" the guitarists are instructed to retune gradually, waiting before fully tuning any given string in order to create a "smooth, reverberant cloud of moving intonation," and thus accomplishing the same musical effect that had been painstakingly notated in the earlier piece. *ii-v-i* exists in a version for two guitars (in C), and two alternatives for solo performer (in Ab and D); these fundamentals are chosen to keep all notes within a reasonable range of the standard pitch for each string (the lower strings offering some more flexibility in terms of down-tuning). As in the later piece *freeHorn*, Polansky asks the performers to highlight the structure of the piece by signaling the completion of a tuning sequence with the execution of a predetermined "cadential"

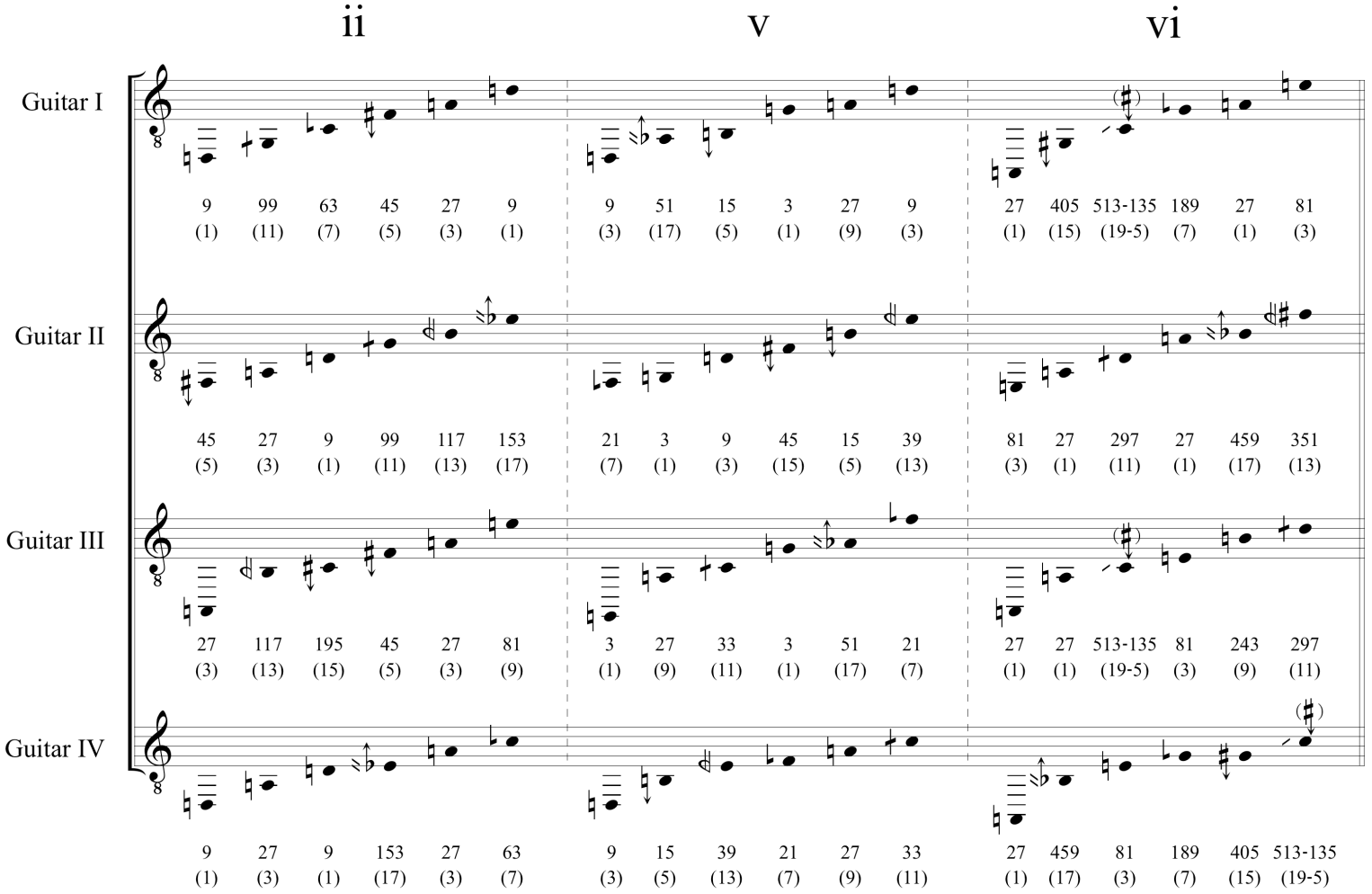
rhythmic or melodic pattern. Examples 3.12 outlines the tunings of the two guitars for the duo (a) and two solo versions (b), respectively. The main differences between the duo and solo versions are the gradual harmonic simplification that happens in the duo version (from a 17-limit, throu a 13-limit, to the final 11-limit harmony), and conversely the more compact set of primes employed in the solo versions—a result of the lower number of strings available.

A final example of real-time retuning—one we could call another "orchestration" of *ii-v-i*—is *toovviivfor*, pronounced "two-five-six for four." As its title cryptically implies, this piece describes a ii-V-vi deceptive cadence for four players; it was originally composed in 2002 for the Sap Dream Guitar Quartet, and later re-dedicated to Callier's ZWERM guitar quartet upon the piece's premiere in 2009. The twenty-four total strings of *toovviivfor* provide the players with a little more tuning support, as there are more perfect fifths and octaves to guide the retuning process. Example 3.13 diagrams the retuning for each guitar—notice the recurrence of common harmonics in adjacent sections for each guitar, acting as a sort of tuning guide. *toovviivfor* also features a nod to the Picardy third of common-practice theory: The final series, built over A, is initially tuned as an A minor chord, before a final twist of the tuning peg changes the C natural to a 5:4 major third.

Example 3.12 Tunings for duo (a) and solo (b) versions of *ii*-*v*-*i*.


a)
ii
v
i
Guitar I
Guitar II
9 27 9 99 63 9 3 27 33 3 15 21 1 7 1 3 7 5
(1) (3) (1) (11) (7) (1) (1) (9) (11) (1) (5) (7)
9 27 9 45 117 153 9 3 9 21 15 39 5 3 9 11 15 5
(1) (3) (1) (5) (13) (17) (3) (1) (3) (7) (5) (13)
b)
Version I
9 117 45 27 63 99 3 33 39 15 9 21 1 13 11 7 5 3
(1) (13) (5) (3) (7) (11) (1) (11) (13) (5) (3) (7)
Version II
9 45 99 45 117 63 3 21 33 39 15 9 1 3 7 11 13 5
(1) (5) (11) (5) (13) (7) (1) (7) (11) (13) (5) (3)

Example 3.13 Guitar tunings for *toovviivfor.*


ii
v
vi
Guitar I
Guitar II
Guitar III
Guitar IV
9 99 63 45 27 9
(1) (11) (7) (5) (3) (1)
9 51 15 3 27 9
(3) (17) (5) (1) (9) (3)
27 405 513-135 189 27 81
(1) (15) (19-5) (7) (1) (3)
45 27 9 99 117 153
(5) (3) (1) (11) (13) (17)
21 3 9 45 15 39
(7) (1) (3) (15) (5) (13)
81 27 297 27 459 351
(3) (1) (11) (1) (17) (13)
27 117 195 45 27 81
(3) (13) (15) (5) (3) (9)
3 27 33 3 51 21
(1) (9) (11) (1) (17) (7)
27 27 513-135 81 243 297
(1) (1) (19-5) (3) (9) (11)
9 27 9 153 27 63
(1) (3) (1) (17) (3) (7)
9 15 39 21 27 33
(3) (5) (13) (7) (9) (11)
27 459 81 189 405 513-135
(1) (17) (3) (7) (15) (19-5)

Part Three: Music for Refretted Guitars

Throughout his career Polansky amply demonstrated his resourcefulness in writing rationally-tuned music for conventional, equal-tempered instruments. In two instances, however, he called for customized guitars tuned to specific, and very complex, just intonation systems. The most recent of these two compositions, a collection called *Songs and Toods* written in 2005 for just intonation resophonic guitar, will be discussed later. Between 1994 and 1995, however, Polansky drafted a substantial work called *The Schneider Variations*. As the title suggests, the work was intended for microtonal guitar specialist John Schneider, and it uses an unprecedentedly complex tuning scheme. The nineteen projected movements found in early compositional sketches hint at a large-scale piece, along the lines of other variation works such as *Lonesome Road*, the solo violin set *Little Maggie*, and *Another You* (1981, for solo harp in just intonation). The latest clean draft contains eight finished variations. The piece shares its theme (the Yiddish song *Mayn Rue Plats*) with the middle movement of *for jim, ben, and lou*. Although the two pieces feature related tunings built on the same fundamental frequency, as well as a similar treatment of the thematic material, the writing for the two guitar parts is substantially different, most notably because the ensemble version employs a regular equal-tempered instrument.

The Tuning of *The Schneider Variations*

The completed variations use a complex, non-octave-repeating tuning that requires a refretted guitar with seventeen independently-placed frets per octave; because the intervallic pattern for each string is not regular, each octave of the guitar features a minimum of twenty notes, with the middle octave counting twenty-four. The open strings are tuned E–G–D–F ♯–B–E (1:1–7:6–7:4–8:7–3:2–1:1). By tuning two pairs of strings in thirds (E–G, D–F ♯), Polansky ensures maximum overlap between adjacent strings while still preserving playability—enabling for instance the cross-string performance of closely-tuned cognates. Although admittedly complicated, this fretting system maintains a practical number of frets per octave—another benefit of choosing to resort to cross-string fingering, rather than more closely-spaced frets, to produce smaller intervals. Table 3.3 illustrates the three lower octaves of the guitar, with cents indications and ratios for each individual pitch and adjacent steps. Some notes are only available in certain octaves—most notably, the lone tridecimal interval in the middle octave, acting as a sort of axis for the tuning as a whole. The abundance of ratios allows for a great variety of modal and tonal constructions: The main tonal center is E, but compositional sketches also show plans for variations in various modal flavors of A, D, and B.

Table 3.3 Fretboard tuning and interval inventory for *The Schneider Variations*, one column for each of the instrument's three full octaves.

Bottom Octave			Middle Octave			Top Octave		
Ratio	**Cents**	**Step**	**Ratio**	**Cents**	**Step**	**Ratio**	**Cents**	**Step**
1:1	0	84	1:1	0	53	1:1	0	53
			33:32	53	31	33:32	53	31
21:20	84	147	21:20	84	27	21:20	84	119
			16:15	112	119			
						9:8	204	27
8:7	231	36	8:7	231	36	8:7	231	36
7:6	267	49	7:6	267	49	7:6	267	49
6:5	316	71	6:5	316	71	6:5	316	71
5:4	386	84	5:4	386	84	5:4	386	84
21:16	471	27	21:16	471	27	21:16	471	27
4:3	498	53	4:3	498	53	4:3	498	53
11:8	551	31	11:8	551	66	11:8	551	66
7:5	583	119						
			10:7	617	84	10:7	617	36
						35:24	653	49
3:2	702	27	3:2	702	27	3:2	702	36
32:21	729	26	32:21	729	8			
			49:32	738	76	49:32	738	76
99:64	755	31						
63:40	786	147						
			8:5	814	27	8:5	814	71
			13:8	841	44			
			5:3	884	49	5:3	884	49
12:7	933	36	12:7	933	36	12:7	933	36
7:4	969	49	7:4	969	49	7:4	969	119
9:5	1018	71	9:5	1018	71			
15:8	1088	27	15:8	1088	27	15:8	1088	112
40:21	1116	57	40:21	1116	57			
63:32	1173	27	63:32	1173	27			
2:1	1200		2:1	1200		2:1	1200	

Non-octave replicating gamuts represent one of the principal methods Polansky has used to transcend the traditional concept of pitch scales—a musical convention he considered arbitrary and less interesting for his compositional purposes.[31] One early example is *Piano Study No.5 for JFR* (1975) for retuned Fender Rhodes keyboard, which uses three different tunings across four octaves; the intervals are arranged so to ensure that a pure fifth is available for each prime up to the eleventh.[32] *For jim, ben, and lou* also uses non-octave-repeating tunings in each of its three movements. Although Polansky often treats such scales as a resource for the construction of triadic harmonies, in other cases these irregular gamuts are not a precompositional choice, but rather result from compositional and tuning processes at play in the pieces themselves. Examples include the modulating harmonic series motions of *Psaltery, freeHorn*, and the opening movement ("Preamble") of *for jim, ben, and lou.*

From a musical standpoint, *The Schneider Variations* reaffirms Polansky's intimate knowledge of the guitar; each variation is meticulously fingered in order to yield the intended intonation, a feat made even more impressive by the fact that the instrument for which the piece was written had only been theorized on paper. The eight completed variations range in style from the chorale-like textures of the opening, to fast and furious pages of sheer virtuosity; yet throughout the work the

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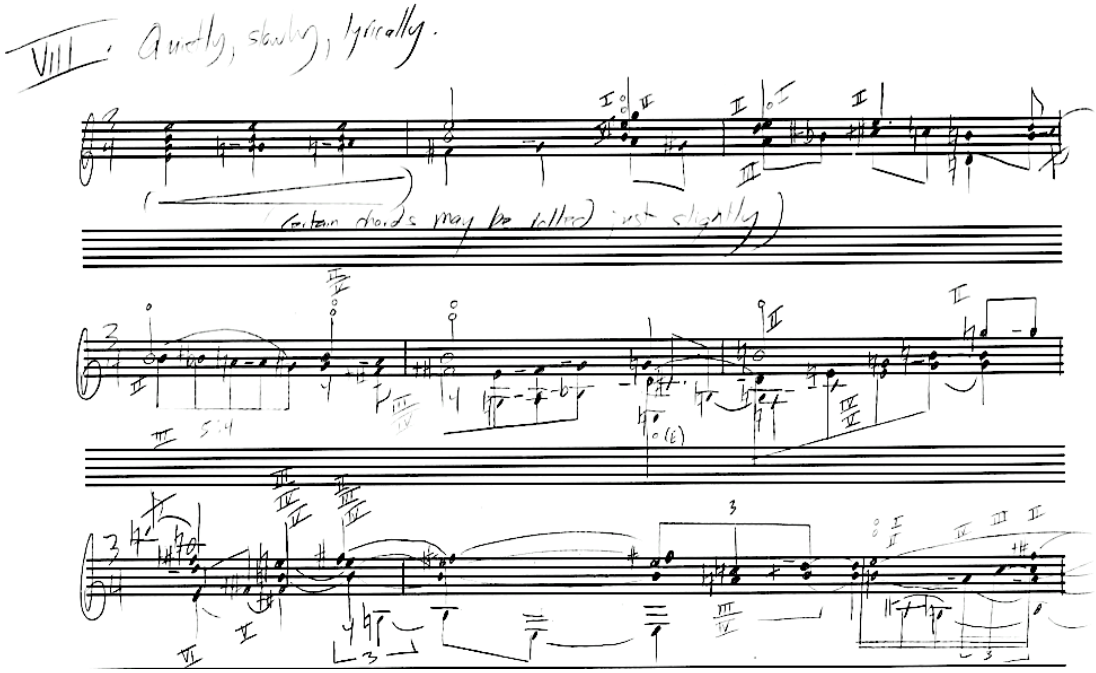
[31] Larry Polansky, interview with the author, October 27, 2012.

[32] Larry Polansky, "Notes on *Piano Study No.5 for JFR*," *1:1*, 1.4, p.14. The score for the piece was published in *Xenharmonikon* #7/8, 1978.

plaintive and distinctive melody is preserved and integrated into the musical texture. Although more than half of the originally planned variations were never completed, the existing ones still form a cohesive whole, tracing a dynamic arc that concludes quietly and lightly with the delicate, *rubato* stylings of Variation VIII (see Example 3.14).



Example 3.14 Variation VIII from *The Schneider Variations* manuscript. Courtesy of Larry Polansky.

The specific and intricate tuning from which *The Schneider Variations* originated was also the likely cause for their lack of completion. The work was intended for a guitar with moveable frets like the ones made by German luthier Walter Vogt, of which Schneider owns a specimen; the guitar's tunable fingerboard

allowed it to be treated as a compositional sketchpad, with the plans for a permanent fingerboard to be prepared after the work was completed. The process would have still entailed a labor-intensive overhaul, as the particular fretting pattern means that individual fretlets must be used for each of the seventeen tones across six strings (that is to say, 102 fretlets for the lower three octaves, plus another fifty-one for the top of the instrument's range). To date, the work remains unperformed. Whatever the practical difficulties of their eventual realization, the unique mix of harmonic complexity, sheer instrumental virtuosity, and lyricism of *The Schneider Variations* makes it one of Polansky's most intriguing works for guitar, and one that hopefully will be performed in the future.

Songs and Toods

A decade after his first experiments with a refretted guitar, Polansky remained an obvious candidate to compose for the just intonation reosphonic guitar, the instrument created for the performance of Lou Harrison's *Scenes from Nek Chand* in 2003 (See Chapter One). He had first heard of the guitar from Harrison when the project had originally surfaced two years earlier; furthermore Polansky had been working with Schneider to prepare the piece for publication with Frog Peak. In mid-2005 Polansky received one of five original reftetted guitars on loan from National, and began exploring the possibilities inherent in this unique and resonant instrument. By the end of the year he had completed *Songs and Toods*, a collection of three self-accompanied

songs and two computer-generated tuning studies.[33] Typical for Polansky, the three songs ("Sweet Betsy from Pike," "Eskimo Lullaby," and "Dismission of Great I") derive their texts from varied sources: "Sweet Betsy" is inspired by a Crawford Seeger setting of the American folk ballad; the lullaby comes from a collection of Canadian folk songs;[34] and "Dismission" from a Shaker hymn that Polansky learned from his close friend and colleague Mary Ann Haagen, leader of the Enfield Shaker Singers of Enfield, New Hampshire.[35] The two studies, called "Schneidertood" and "85 Chords (the Historical Tuning Problem)," explore in different ways the proliferation of cognates in microtonality gamuts and the progressive generation of harmonic complexity.

Due to its unique instrument (an element that is somewhat mitigated by Polansky's allowance of an equal-tempered substitute, although the pieces were composed expressly with the sonority of the retuned tricone in mind), and because of the diverse musical and technical challenges posed by the collection as a whole, the set has only been performed as separate movements to date.[36] Guitarist John Schneider added "Eskimo Lullaby" to his repertoire soon after its composition,

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[33] Polansky, interview with the author, October 27, 2012.

[34] Edith Fowke and Richard Johnson, the editors of the collection, claim that the song was recorded in Cape Dorset by a Reverend D.H Whitbread; it appears in a by-the-book, four-part harmonization, which Polansky maintains in his own arrangement.

[35] Polansky, Diamond, and their daughter Anna, have been members of this singing group for more than a decade. Polansky, personal communication.

[36] An improvised version of "Sweet Betsy from Pike" was recorded in an informal performance with the composer on guitar and filmmaker Nora Jacobson on voice and accordion in the fall of 2005, and can be heard on the composer's website.

premiering it on 18 February 2006 at the Redcat Theater in Los Angeles, and recording the piece for a release on Cold Blue.[37] More recently, New York guitarist James Moore gave the world premiere of the notated version of "Sweet Betsy from Pike" and "Dismission of Great I" at a recital for Brooklyn's new music series Music at First on 2 September 2011, and the author of this dissertation premiered "85 Chords" the wulf. in Los Angeles, on 30 March 2012. "Schneidertood" remains unperformed.[38]

Tuning Approaches

Polansky's *Songs and Tood* is a series of tuning and harmonic explorations that reach far beyond the usual scope of guitar pieces. The inventive reconfigurations of the instrument's tuning serve not only as a compositional point of departure, but also as a sophisticated commentary on the resources and idiosyncrasies of alternative intonation. "Sweet Betsy from Pike" is the only piece to maintain the guitar's original open-string tuning (D–A–D–G–A–D). As the instrument can be played conventionally, this choice of tuning allows Polansky to write some of the most idiomatic sections of the entire collection, such as the improvisatory, cascading runs that populate the instrumental solo interludes. Over the course of the piece Polansky's

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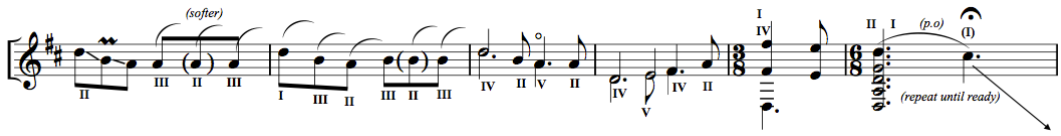
[37] The recording appears on the anthology collection *Cold Blue Two*, released September 2012.

[38] In addition, Moore and Fiore have both performed "Eskimo Lullaby" on different occasions; Belgian guitarist Tom Pauwels gave the European premiere of "Sweet Betsy" and "85 Chords" on November 29, 2012 as part of the annual festival of new music Rainy Days in Luxembourg, http://rainydays.lu/2012

use of the various inflections of the tuning transforms the simple harmonic language (a three-chord progression in D major) into a surprising and striking set of variations.

In the other two songs, the open tuning is changed to different extents: "Eskimo Lullaby" lowers the bottom string by a fifth to an extremely low G, highlighting the original fundamental of the tuning and providing new and richer resonances; "Dismission of Great I," on the other hand, employs the more radical tuning D–A–D–G–G↓–C. The top C is tuned as the harmonic seventh of D (and is therefore in tune with the "original" Cs on the fingerboard), whereas the second-string G is tuned a perfect fourth below it (7:4 ÷ 4:3 = 21:16) to produce a pitch that is about twenty-seven cents flat of the open third string (as indicated by the downward arrow). Notes across these two strings are microtonal "doubles," and Polansky employs them to create shimmering passagework reminiscent of Balinese "paired" tuning—an effect that the composer had already recreated in *...getting rid of the glue...* and "Rue Plats."



Example 3.15 Cross-string passagework in "Dismission of Great I"

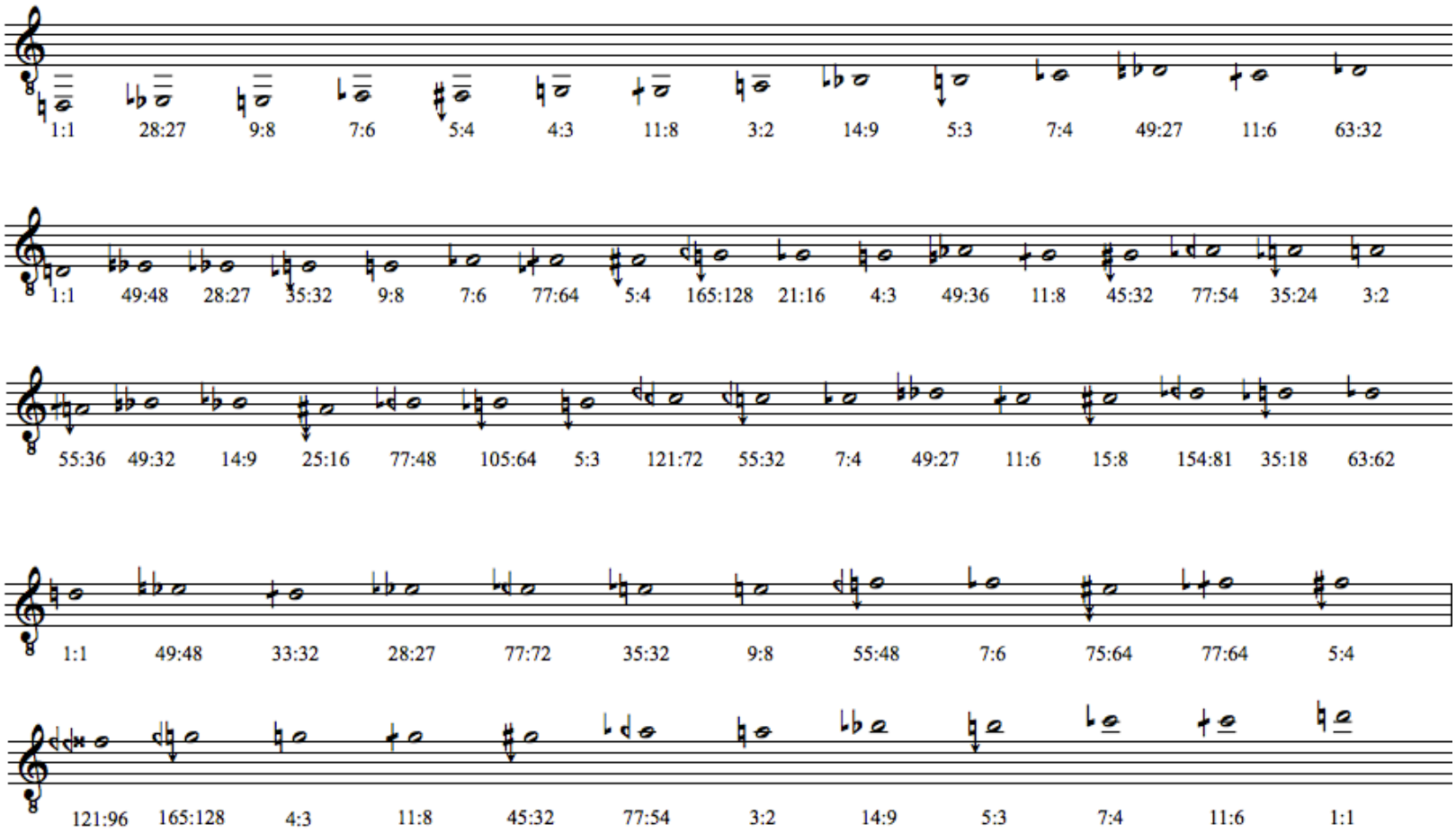
The first of the two *toods* takes the tuning even further away from its original template. "85 Chords (The Historical Tuning Problem)," uses a harmonic tuning (D–A–C–F ♯–G ♯–D, or 1–3–7–5–11–1, bottom to top); as shown in Table 3.4, the three

strings that are tuned differently from the guitar's intended layout produce an assortment of new intervals when fretted, yielding yet another non-octave repeating tuning (See Example 3.16). Similar to the approach taken in *the Schneider Variations*, Polansky overrides the assumption that notes across strings should be in tune, in order to access the higher reaches of the harmonic series by way of compound ratios. The subtitle of the movement hints at the fact that the harmonics of different primes (with the exception of their compounds) will never match; the music proceeds to demonstrate the point by allowing these closely-but-differently tuned cognates to resound against one another.

	D	A	C	F♯	G♯	D
Open String	1:1	3:2	7:4	5:4	11:8	1:1
1st Fret	28:27	14:9	49:27	165:128	77:54	28:27
2nd Fret	9:8	5:3	63:32	45:32	55:36	9:8
3rd Fret	7:6	7:4	49:48	35:24	77:48	7:6
4th Fret	4:5	11:6	35:32	25:16	121:72	4:5
5th Fret	4:3	1:1	7:6	105:64	11:6	4:3
6th Fret	11:8	28:27	77:64	55:32	154:81	11:8
7th Fret	3:2	9:8	21:16	15:8	33:32	3:2
8th Fret	14:9	7:6	49:36	35:18	77:72	14:9
9th Fret	5:3	5:4	35:24	135:128	55:48	5:3
10th Fret	7:4	4:3	49:32	35:32	11:9	7:4
11th Fret	11:6	11:8	77:48	75:64	121:96	11:6
12th Fret	1:1	3:2	7:4	5:4	11:8	1:1

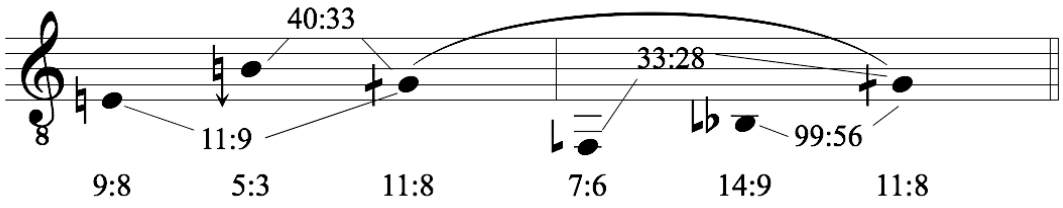
Table 3.4 Fingerboard tuning for "85 Chords."

Example 3.16 Overall gamut for “85 Chords.”


1:1 28:27 9:8 7:6 5:4 4:3 11:8 3:2 14:9 5:3 7:4 49:27 11:6 63:32
1:1 49:48 28:27 35:32 9:8 7:6 77:64 5:4 165:128 21:16 4:3 49:36 11:8 45:32 77:54 35:24 3:2
55:36 49:32 14:9 25:16 77:48 105:64 5:3 121:72 55:32 7:4 49:27 11:6 15:8 154:81 35:18 63:62
1:1 49:48 33:32 28:27 77:72 35:32 9:8 55:48 7:6 75:64 77:64 5:4
121:96 165:128 4:3 11:8 45:32 77:54 3:2 14:9 5:3 7:4 11:6 1:1

The uniquely rich gamut of "85 Chords" serves as a backdrop onto which the composer traces an arching harmonic trajectory, which grows from simple consonances to ear-bending dissonances. The algorithm used to generate the piece relies on a virtual model of the guitar's fingerboard to compute all possible chords and catalogue them according to their degree of harmonic complexity, which is calculated with Euler's *Gradus Suavitatis* function. Starting from a simple open string tone, the program picks each successive chord aiming for increased complexity in terms of both the number of notes and harmonic ratios, while at the same times trying to maintain the highest number of common tones between adjacent chords. The piece's chords grow progressively busy and dissonant before returning to simpler, sparser harmonies on the way back to the original fundamental D. The sustaining of common tones across chord changes makes for some revelatory moments, such as the one depicted in Example 3.17. Here the G ♯ is held over as a pivot, and its relationship with the surrounding notes changes from a neutral third against E (9:8–11:8) to a surprisingly sweet-sounding augmented sixth against B♭ (14:9–11:8). In order to bring out these common tones in performance, Polansky suggests amplifying the guitar and using a delay or echo effect, or alternatively recruiting additional instruments to match and sustain the held-over pitches. Either solution yields the added benefit of simplifying the resophonic guitar part, as many of piece's five- and

six-note chords are not playable while letting every note ring.[39]



Example 3.17 Pivot tone and changing ratios in "85 Chords."

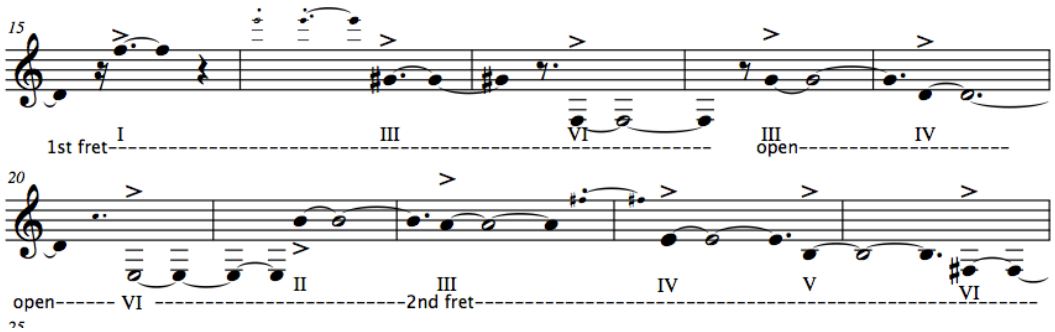
The other instrumental movement, "Schneidertood" features the most radical tuning scheme of all: Polansky requires the strings of the guitar to be (de)tuned in such a way that no pitch is duplicated anywhere else on the instrument, thus leading to a variety of "shades" for any given pitch class. This configuration is actually easier to obtain on a regular equal-tempered instrument, as offsetting each string by a different number of cents will perforce yield uniquely-tuned cognates across the fingerboard. However, such a tuning is more finicky to devise on the JI resophonic guitar, as the instruments offset frets require that each position be carefully checked to avoid duplicate notes. Tuning two strings to different primes, for example, could yield duplicates at certain positions of the fingerboard (e.g. tuning the third and fourth strings to 5:4 and 7:4 would yield identical Es (35:32) at the tenth and fourth frets, respectively); tuning each string to a different 12TET pitch class (avoiding those that are too close to the 11-limit just intonation tuning, such as fifths and fourths) would

[39] Although the algorithm "knows" the fingerboard, in the case of guitar chords the difference between possible and playable can be significant, especially considering the heavier action and staggered fret of the just intonation resophonic guitar.

provide a better start. Finally, as the fretboard modeled by the algorithm is that of the just intonation tricone, it has fewer frets than the average equal-tempered instrument: The bottom strings of the modified resophonic guitar only have frets up to the fifteenth position, as opposed to most acoustic and electric instruments, which have between nineteen and twenty-four full frets. Thus, when performing the score on a regular guitar, the performer is not actually playing *all* notes available on the instrument.

The algorithm unfolds by picking each note available on the fingerboard exactly once over the course of the piece (hence the nickname *onceatood* for the series of work using the same process). Polansky highlights these notes in the score using accents and larger note heads, and suggests that the performer underscore their uniqueness with a recognizable timbre and louder dynamic level. In addition to the accented notes, the algorithm also generates a secondary voice consisting entirely of the second to fourth harmonics of the open strings (also marked *fortissimo*); and an accompaniment layer of notes that are to be played quietly and in the background, with the method of production (such as left-handed tapping, picking with the flesh of the fingers, or using a darker tone color) left to the discretion of the performer. This layer, notated in smaller notes, creates a sort of statistical noise, a buzzing backdrop for the unfolding of the piece's signal, with the accented notes and harmonics outlining the particular sound-world of the chosen tuning. The algorithm is weighed in favor of accented notes in the beginning, and gradually increases the predominance

of the background layer as the piece progresses. As shown in Example 3.18, the melodic contour of the piece often emphasizes notes across the strings for a given fret position; the resulting patterns contribute to reinforcing, by means of transposed repetition, the sonority of the tuning chosen for performance. Consequently, in addition to exploring numerous possibilities of microtonal shadings, "Schneidertood" also incorporates a degree of indeterminacy in the score: although fretting indications are to be observed strictly in order to maintain the every-note-once premise of the piece, the actual sounding pitches are ultimately dependent on the tuning adopted for the occasion.

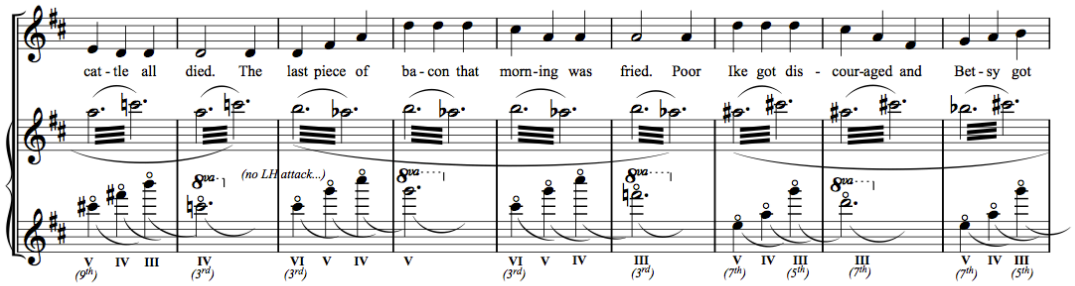


Example 3.18 "Across the fret" phrasing in "Schneidertood."

Paradigms of Virtuosity

In addition to those elements touched upon in the discussion of the instrumental etudes of *Songs and Toods*, the remainder of the set also contains a range of performance challenges not directly related to tuning. The three Songs can be ranked

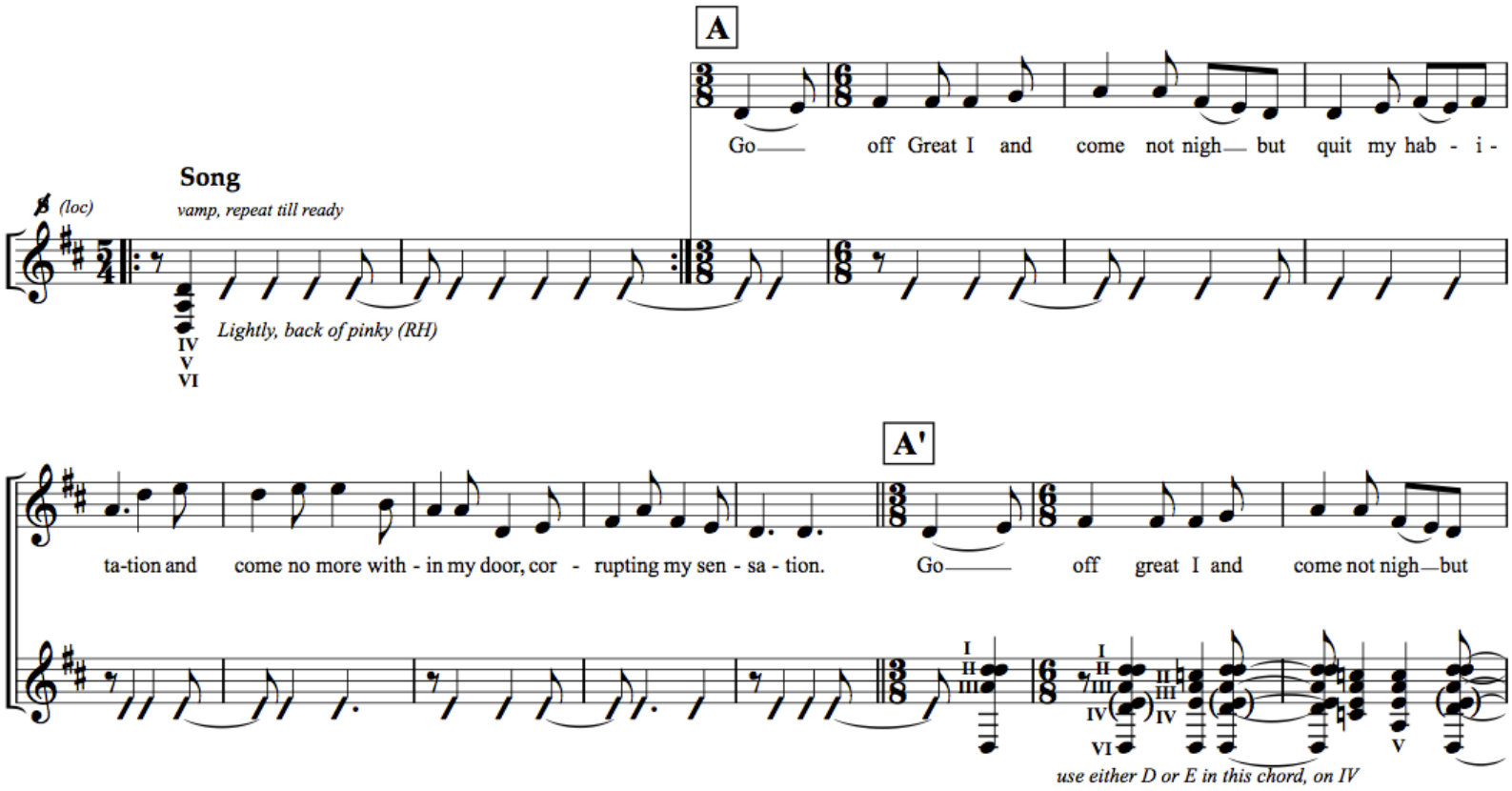
in terms of difficulty based mainly on the degree of independence between accompaniment and voice: “Eskimo Lullaby,” with its sparse texture, its simple four-note melody, and its reliance on the accompaniment to harmonize and support the vocal line, is the easiest to manage and, not surprisingly, the one most often performed. The other two songs are significantly more difficult. The opening page of “Sweet Betsy” seems reasonable enough, with an embellished homophonic accompaniment shadowing the melody; the following verses, however, grow increasingly independent, and require a performer with enough technical command to execute the instrumental part while also delivering the lyrics in an unaffected and relaxed manner. Passages such as the one in Example 3.19 illustrate this level of independence, as the guitarist is simultaneously executing a left-hand trill, arpeggiating right-handed artificial harmonics, and singing a verse. Even when not singing, the guitarist is confronted with extended solo passages that explore the entirety of the fingerboard, and demonstrate Polansky’s intimate understanding of the instrument as well as his facility as an improviser. Some of the techniques employed, such as the improvised “drop thumb” accompaniment that the performer is encouraged to incorporate in the solos, or the right-handed tapping passages, are borrowed from the repertoires of guitar heroes as diverse as Chet Atkins and Eddie Van Halen; together with the folk origins of the musical material, and coupled with the evocative timbre of the resophonic guitar, these stylings contribute to the synthesis of a quintessentially American sound.

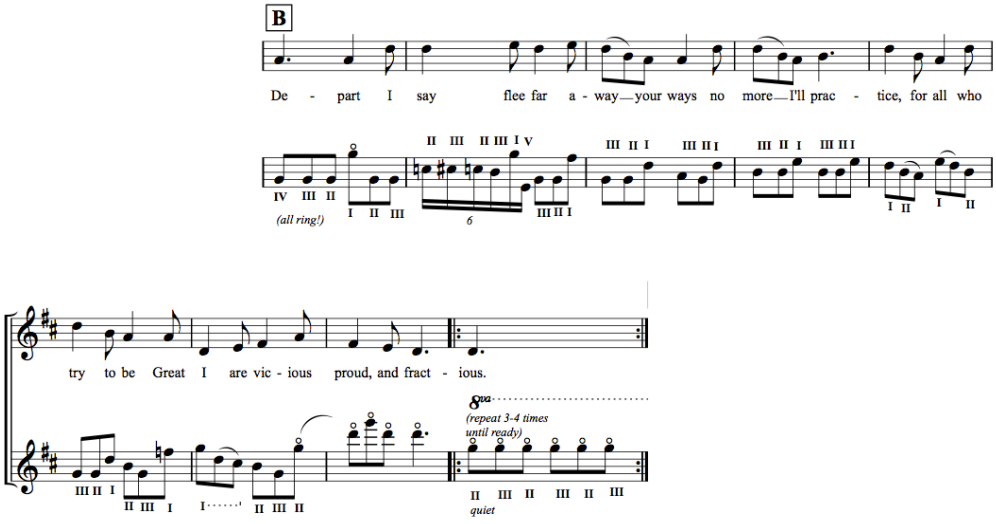


Example 3.19 Highly independent singing and accompaniment part in "Sweet Betsy from Pike."

"Dismission of Great I" is not as challening as "Betsy" from a strictly instrumental standpoint, but it requires an even greater degree of independence between the played and sung parts. This heterogeneity is both rhythmical, as apparent in the shifting syncopations of the opening verse, and harmonic: The last refrain, for example, verges on bitonality, with the accompaniment pitched a fourth away from the melody line. Examples 3.20 and 3.21 highlight the passages in question. The microtonal tuning of the second and third open strings pose an additional challenge, as the performer must be confident with his or her vocal intonation when delivering the melody against the quivering, beating accompaniment created by the closely-pitched cognates.

Example 3.20 Rhythmic independence in the opening of “Dismission of Great I.”


A
Song
vamp, repeat till ready
(loc)
IV
V
VI
Lightly, back of pinky (RH)
Go off Great I and come not nigh but quit my hab - i -
A'
ta-tion and come no more with - in my door, cor - rupting my sen - sa - tion.
Go off great I and come not nigh but
use either D or E in this chord, on IV



Example 3.21 Harmonic independence in the final verse of "Dismission of Great I."

Songs and Toods is an eloquent commentary on the possibilities and limitations of the application of extended intonations on fretted instruments. "Sweet Betsy from Pike," the one piece to maintain the instrument's intended tuning, fittingly bears a dedication to the memory of Lou Harrison and William Colvig—a couple who, like the protagonists of the song, found their happiness in California after physical and emotional hardships. For the other pieces, the refretted neck is treated with a different kind of reverence—one that pays homage to Harrison's experimental bent by approaching the instrument like a springboard towards unexpected and unprecedented harmonic results. These experimentations, however, come at the expense of flexibility. Tunings like the one for "85 Chords" render the guitar almost unplayable in conventional harmonic contexts, and ultimately lead to a breaking

point. In the case of “Schneidertood” the particular fretting pattern of the just intonation tricone is no longer a prerequisite for the desired intonation, but actually poses a hindrance compared to a regular 12TET fingerboard. As with many other instrumental works in his catalogue, Polansky demonstrates his ability to navigate an instrument’s musical heritage and technical resources, negotiating experimentation and tradition at the service of relentless curiosity.

Conclusion

The varied and numerous just intonation works featuring guitars in the music of Larry Polansky represent just one aspect of his overall output; although they feature several important themes that recur in his work as a whole, there is much more music (even guitar music!) to be discovered beyond the limits chosen for this study. In his approach to this particular kind of musical problem—the implementation of just ratios on a traditionally equal-tempered instrument—Polansky demonstrates an attitude related to both Harrison and Tenney. Like Harrison, he succeeds in referencing and harnessing the instrument’s history and emotivity; and like Tenney he employs the guitar as an instrument essentially “easy” to retune, serving as the perfect theoretical sketchpad for complex and novel harmonic creations.

Obviously, the fact that Polansky is a professional guitarist afforded him a different vantage point than either of his predecessors. Polansky’s sustained relationship with the guitar leads to a final reading of his role as a guitarist/composer,

a figure who has returned to prevalence in the instrument's repertoire in the twentieth century. Guitarists/composers such as Agustin Barrios (1885–1944), Leo Brouwer (b. 1939), Sergio Assad (b. 1952), and Andrew York (b. 1958), to cite some of the most widely-known, often write music that relies heavily on idiomatic features, springing forth from the instrument more so than challenging its technical boundaries. In Polansky's case, idiomatic material is counterbalanced and expanded by a constant stretching of the performative approach, and a re-imagination of the instrument as a platform for experimentation, in a way that is much closer to less canonical guitarists/ composers such as Nick Didkovsky, Elliott Sharp, Fred Frith, and Frank Zappa.[40] Yet, amidst this constant innovation Polansky's fondness for the instrument still transpires in various guises—now exuberance, now serenity, now heart-warming tenderness.

[40] Ironically, and unfortunately, these latter composers are arguably less known among guitarists than their "idiomatic" counterparts.

Conclusion: Crossing Borders and Musical Genres

In addition to forming a cohesive repertoire, the guitar works of Harrison, Tenney, and Polansky also reflect the interrelated nature of the three composers' lives and careers, and represent the continuing interest in rational tunings that has run through U.S. experimental music since Partch and into the present day. As shown throughout the previous pages, their compositional styles are as diverse as their personal poetics and musical concerns. Their approaches to retuning the guitar—an instrument that is both wedded to equal temperament and easy to adapt to unexpectedly complex contexts—are similarly varied, and reflect the broader aesthetics of each. Most importantly, the diversity and scope of their pieces for and with guitars contradicts the often-heard suggestion that fretted instruments and rational tunings do not mix.

Harrison's guitar works are intended for refretted guitars, unsurprisingly so given the composer's long history of organological innovation. Conversely, Tenney circumvented the usage of customized or otherwise difficult to obtain instruments by devising simple, yet innovative tuning solutions that challenge some of the most basic assumptions about fretted instrument intonation. By distributing the overall gamut of his compositions among multiple instruments (from the two guitars of *Harmonium II* to the seven of *Septet*) Tenney also managed to write music of unprecedented harmonic complexity for the medium, while retaining playability and accessibility. Finally, Polansky's approach integrates those of his two mentors and friends, while

also incorporating the kind of familiarity with (and affection for) the instrument that comes from a lifelong relationship with the guitar.

Another element that exemplifies the stylistic variety in the music under consideration is the range of melodic approaches taken by the three composers. For Harrison melody was of quintessential importance, as can be seen throughout *Scenes from Nek Chand*. From a compositional standpoint, Harrison's choice of a mode made of six adjacent harmonics (and therefore resulting in a series of steps that are different in size) shows his interest in gamuts that provide a wide variety of choices for sinuous, song-like melodic writing. At the opposite end of the spectrum, Tenney's works for guitar eschew traditional paradigms of melody, resorting instead to microscopic motions among closely-tuned cognates. Tenney's lack of interest for overt melodic writing was a good fit for his tuning solutions for the instrument, as the radical re-pitching of the guitar's open strings makes conventional playing difficult, if not impossible. Finally, Polansky's melodic solutions represent (once again) a sort of fusion of Harrison's and Tenney's. The long, snaking lines of "The World's Longest Melody" both evoke Harrison's fascination with Southeast Asian musics, and integrate stastistical and algorithmic elements to explore different possibilities for melodic contouring and variation. On the other hand, when setting vernacular songs like "Rue Plats" or "Sweet Betsy from Pike," Polansky demonstrates sensitivity and respect for the melodic models by crafting highly idiomatic, yet basically unaltered, instrumental adaptations.

However numerous, the works discussed here represent only a part of the existing repertoire for retuned guitars in twentieth century U.S. music. If the many works in temperaments other than twelve fall beyond the limits of this study simply for categorical reasons, some other examples of justly-tuned music will be surveyed in these last paragraphs to offer a glimpse of the stylistic variety and breadth of this repertoire.

At twenty-five minutes in length, Ben Johnston's *The Tavern* (1998), for reftretted guitar and baritone, is one of the most substantial works for guitar in just intonation of recent years. In this piece, Johnston set eight texts by the thirteenth Century Persian poet Rumi to a 13-limit accompaniment typical of his complex harmonic style. The music's difficulty led to a delayed premiere, which was given by John Schneider and baritone Paul Berkolds at the fourteenthOther Minds festival in San Francisco on March 5, 2009.[1] More recently, Schneider has learned to perform the entire work as a self-accompanied solo, carrying on the genre inaugurated by Partch and continued by Polansky, Garry Eister, and others.[2]

The Tavern's complex intonational requirements have been realized on a guitar with moveable fretlets designed by the late German luthier Walter Vogt in

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[1] The program for the premiere can be found on the Other Minds website: http://www.otherminds.org/shtml/Concerts14.shtml. There is also a recording from the same concert: http://newdissonance.com/2009/08/07/the-tavern

[2] Schneider had given a self-accompanied preview of the two movements from the work in the 2000 edition of Microfest, as attested by the L.A. Times review: Josef Woodward, "Microfest Sets Different but Pleasing Tone," *Los Angeles Times,* 9 May 2000. A full performance of the work by Schneider is available on YouTube: http://www.youtube.com/watch?v=GLi1XVBpgQQ

1985. Vogt originally designed the instrument to play in various well-temperaments by allowing individual notes to be fine-tuned according to the tonic of the music; Schneider's guitar features an increased range of motion for each individual fretlet, allowing for the accommodation of wider deviations from 12TET such as those necessary to perform in higher-limit just intonations. As we have seen, the Vogt guitar has been used by Schneider as a sort of musical sketchpad, encouraging composers to attempt different and more complicated tuning schemes without the need to commit to a refretted fingerboard. One potential drawback of the adjustable fretlets is that the performer becomes responsible for the correct intonation of the instrument; Schneider reports that preparing the Vogt fingerboard for a performance of *The Tavern* can take the better part of an hour, precluding the possibility of radically changing tunings within the course of a single concert.[3]

In 2008, the Vogt design was further refined by Turkish guitarist Tolgahan Cogulu, who was looking for the kind of tuning flexibility that would allow for the performance of *maqam*-based music. His microtonal guitar design features fretlets that can be moved freely along the entire length of the fingerboard, as well as the possibility of adding additional fretlets. Cogulu employs the guitar for the performance of traditional and new *maqam* music, as well as of works in alternative tunings such as Lou Harrison's *Serenade*.[4]

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[3] John Schneider, personal communication with the author, February 22, 2013.

[4] Tolgahan Cugulu's website contains an overview of his (now patented) fingerboard system. http://www.tolgahancogulu.com/en/?page_id=4. Several performances are available on YouTube.

Far from being confined strictly to experimental contexts, just intonation guitars also appear in other genres and styles of music. Guitarist Jon Catler's relationship with LaMonte Young exemplifies such a kind of crossing over. Catler met Young in 1981, and first collaborated with the composer on the adaptation of Young's early serial piece *for Guitar* (1958) to the just intonation framework that the composer had been using in works such as *The Well-Tuned Piano* (1964–81) by utilizing a variety of refretted and fretless electric guitars.[5] In 1990 Catler joined Young's "Forever Bad Blues Band," a project that fuses improvisation, just intonation, the blues, and North Indian classical influences into performances that can last several hours.

This particular experimental-popular connection was actually facilitated many years before by an article that Ivor Darreg had published in the fifteenth anniversary edition of the magazine *Guitar Player*.[6] The article consists mainly of recycled material from Darreg's *Xenharmonic Bulletins*—a series of homebrewed publications that were circulated in the experimental and instrument-making community. Darreg outlines the technical and aesthetic reasoning behind the adoption of what he calls *xenharmonic* tunings, meaning higher-division equal temperaments; the article came complete with fretting tables for those guitarists interested in exploring such "other"

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[5] See Jeremy Grimshaw, *Draw a Straight Line and Follow It* (New York: Oxford University Press, 2012), 24. Also Jon Catler, personal communication with the author, October 9, 2012.

[6] Ivor Darreg, "Non 12-tone Guitars: Refretting Guitars for Unususal Harmonic Possibilities," *Guitar Player*, (May 1978), 24–25, 82, 86.

tunings.[7] Darreg's tutorial represents an unprecedented and somewhat unexpected crossing of avant-garde tuning theories over to the popular music world. His words did not fall on deaf ears: Catler—along with other guitarists, such as Colorado-based Neil Harvestick—reports that Darreg's article served as a first, tantalizing introduction to alternative tunings.[8] The connection between tuning practices and popular music, after all, is not entirely far fetched: consider the bent thirds of blues singing and playing; the fact that harmonicas are often tuned in just intonation; or the likelihood that the feedback produced by a distorting guitar amplifier at high volumes may result in a harmonic seventh or other obvious, non-tempered pitch.

Another—and much more raucous—instance of experimental and popular music interaction is the music for orchestras of electric guitars, as exemplified in the work of Glenn Branca (b. 1948) and Rhys Chatham (b. 1952). Both composers were active in the New York downtown scene of the late 1970s—Chatham as the curator of The Kitchen, the first to introduce rock-influenced musical programming, and Branca as a former experimental theater artist who had been fronting the avant-rock band Theoretical Girls. Their complicated relationship, which evolved from early collaboration to resentment over issues of credit and primacy, has been discussed in

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[7] Darreg's twelve "Xenharmonic Bulletins" appeared in *Xenharmonikon* between 1974 and 1992.

[8] Jon Catler, personal communication, October 9, 2012; and Neil Harvestick, interview with the author, August 13, 2012.

other settings, both scholarly and not.[9] After Chatham's 1977 *Guitar Trio*, in which Branca performed, they independently produced an array of works for small and large ensembles of retuned guitars: Chatham's *An Angel Moves Too Fast to See* (1987) and Branca's *Hallucination City* (2001) both feature 100 guitars, and Chatham has been writing for even larger orchestras in more recent projects. Several of their pieces explore the overtone series by means of unison or octave-tuned guitars divided into sections, often employing high volume levels to maximize the acoustic results. Significantly, both Chatham and Branca have influenced a generation of younger guitarists in the noise-rock and punk genres, as members of the bands Band of Susans and Sonic Youth had participated in their respective ensembles.

More than half a century after Partch's Adapted Guitars and Harrison's whimsical tuning instructions to Frank Wigglesworth, the guitar continues to provide a flexible and powerful framework for composers interested in experimenting with intonation. In addition to the numerous recent works analyzed and discussed in the previous pages, there is a constant stream of new pieces for retuned guitars by the current generation of composers studying at schools with a history of tuning experimentation, such as Mills College and the California Institute of the Arts. As a matter of fact, the volume of this compositional and performance activity has already

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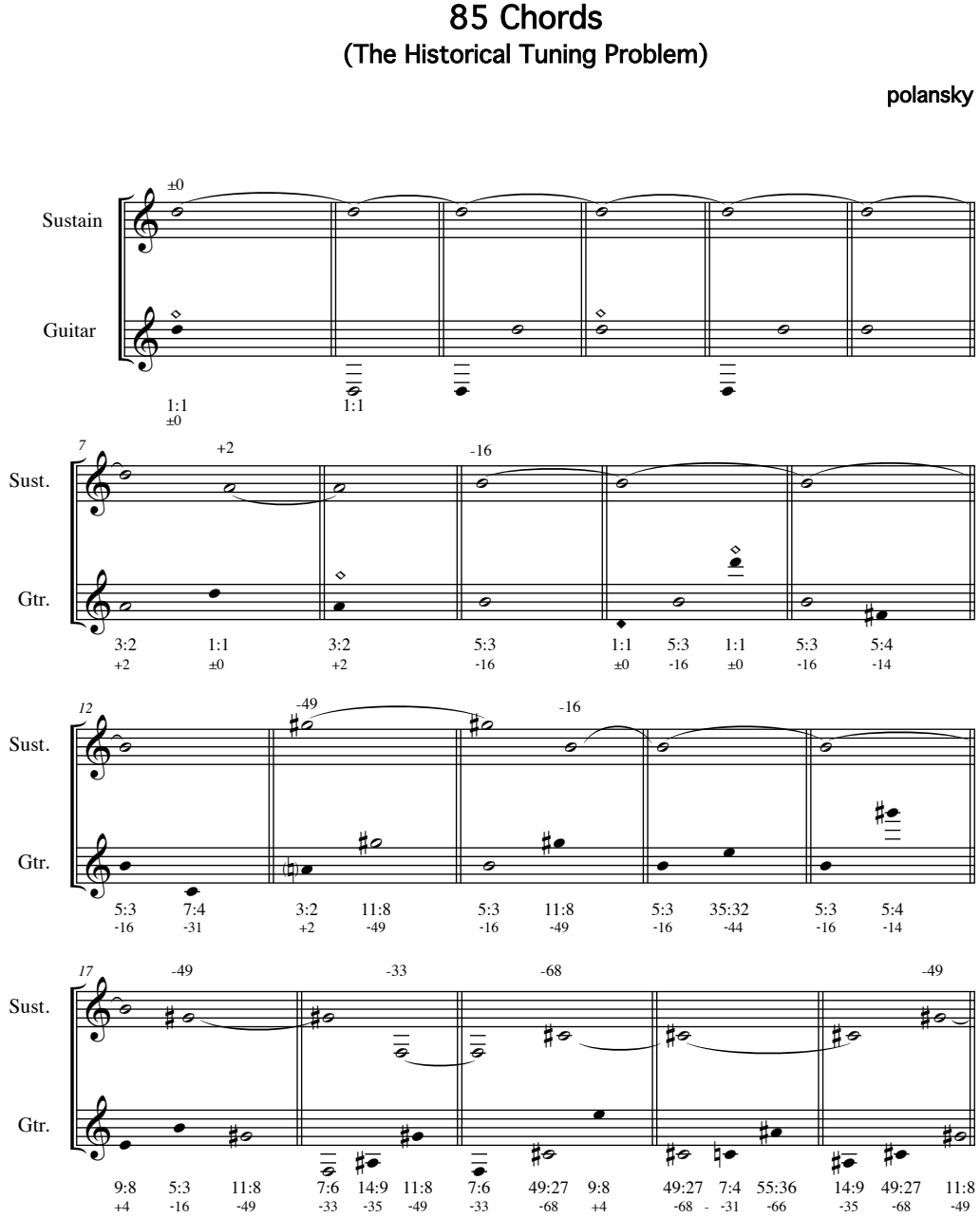
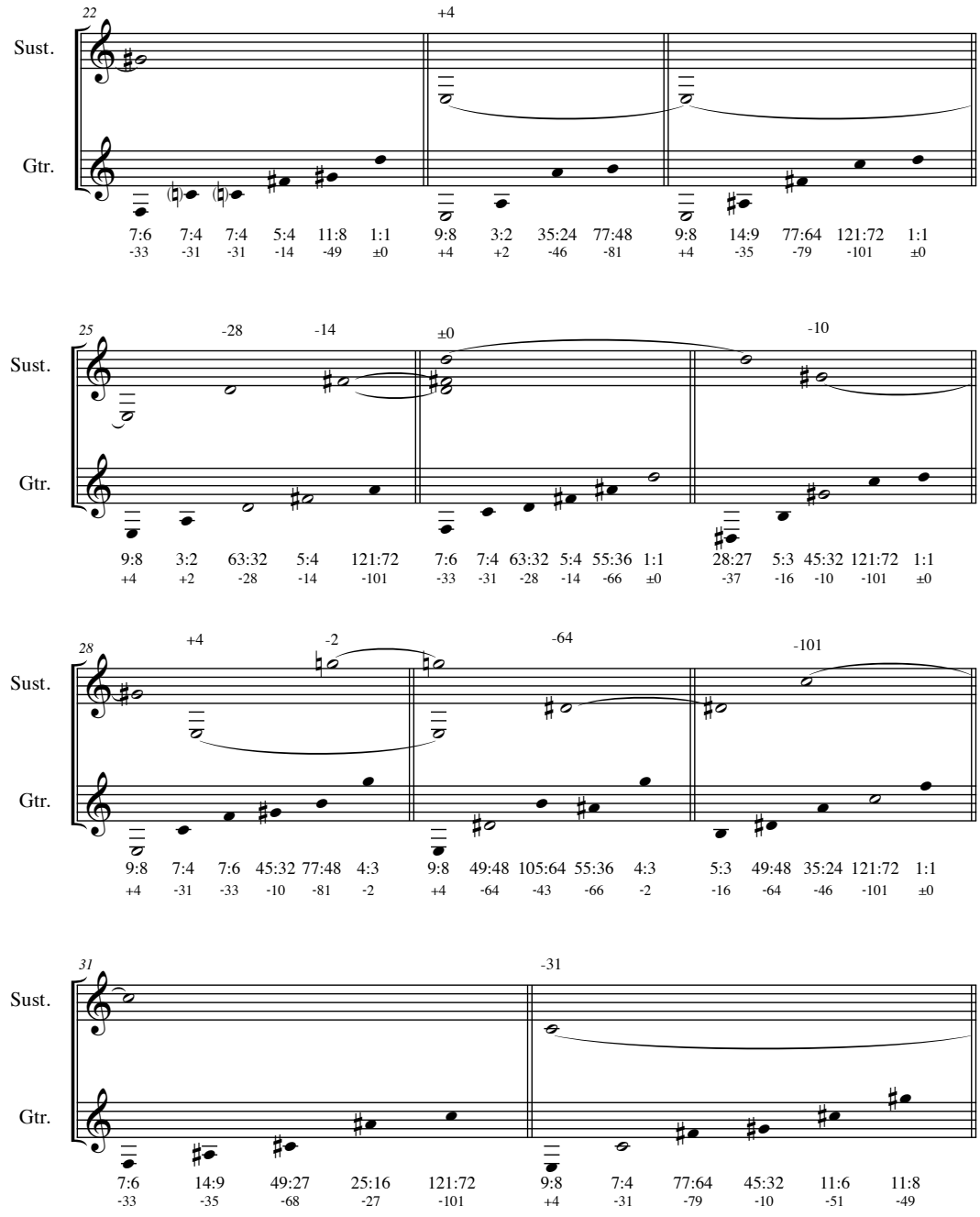
[9] Kyle Gann, *Music Downtown: Writings from the Village Voice* (Berkeley: UC Press, 2006), 46. Also, for a sample of the tone of the quarrel between Branca and Chatham, see Glenn Branca's biography on his official website: www.glennbranca.com/bio.html

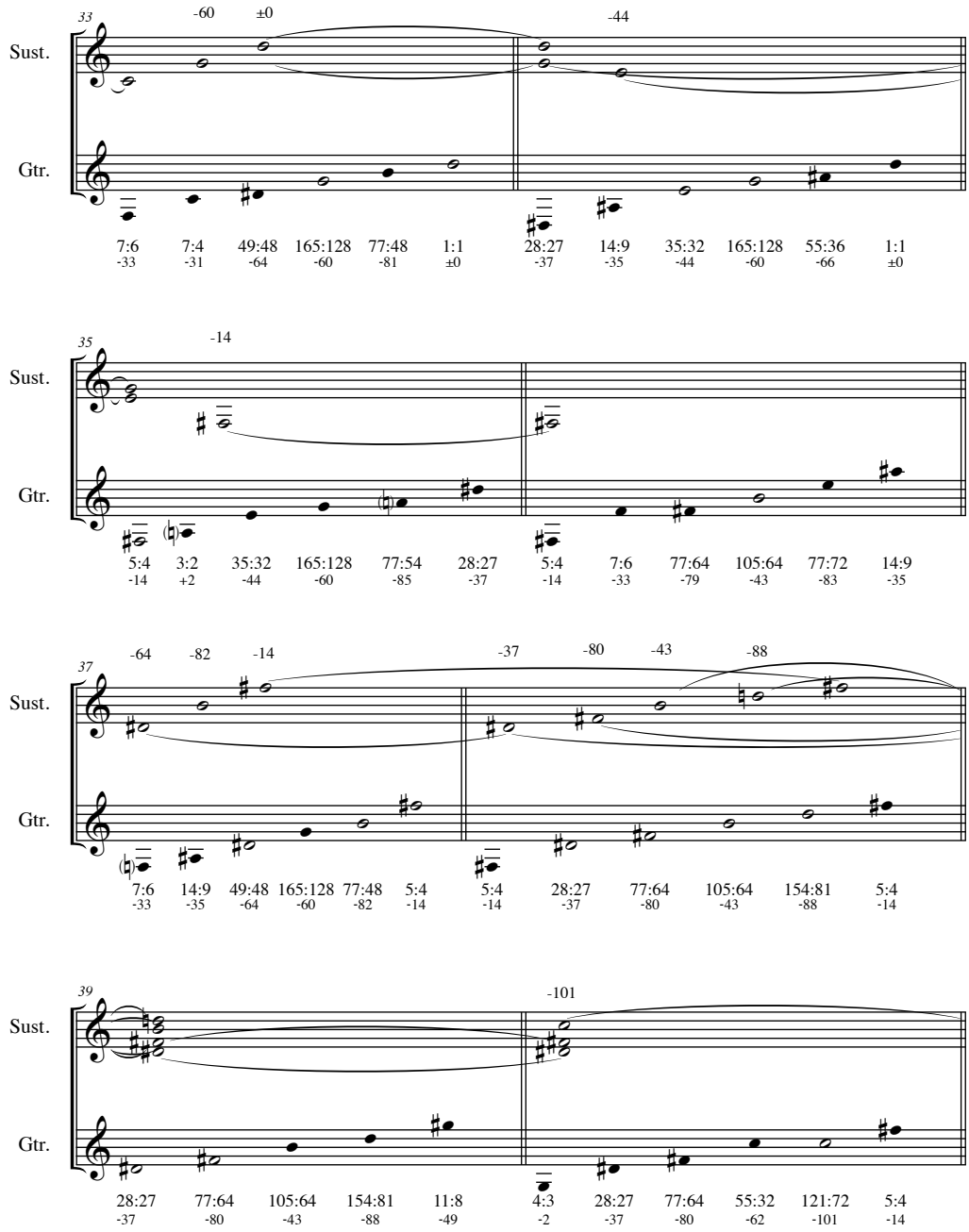
rendered this project outdated—a testimony to the continuing vitality and success of the genre.

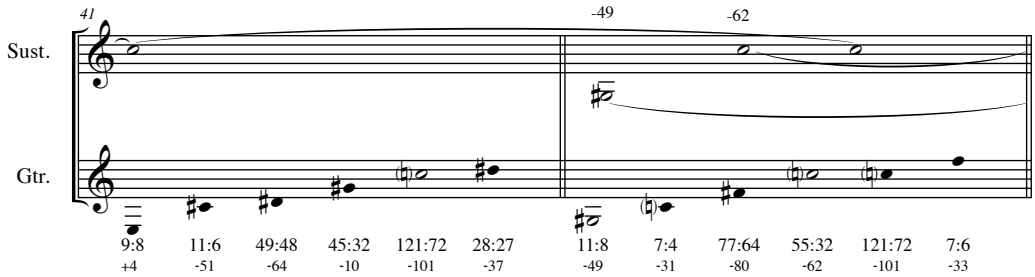
Appendix I

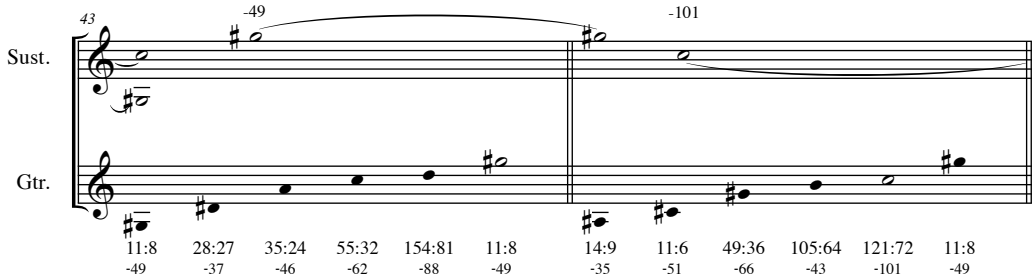
Performance score for “85 Chords” by Larry Polansky, including a realization of the implied, “held over” tones in the original score.




22
+4
Sust.
Gtr.
7:6 7:4 7:4 5:4 11:8 1:1 9:8 3:2 35:24 77:48 9:8 14:9 77:64 121:72 1:1
-33 -31 -31 -14 -49 ±0 +4 +2 -46 -81 +4 -35 -79 -101 ±0
25
-28 -14 ±0 -10
Sust.
Gtr.
9:8 3:2 63:32 5:4 121:72 7:6 7:4 63:32 5:4 55:36 1:1 28:27 5:3 45:32 121:72 1:1
+4 +2 -28 -14 -101 -33 -31 -28 -14 -66 ±0 -37 -16 -10 -101 ±0
28
+4 -2 -64 -101
Sust.
Gtr.
9:8 7:4 7:6 45:32 77:48 4:3 9:8 49:48 105:64 55:36 4:3 5:3 49:48 35:24 121:72 1:1
+4 -31 -33 -10 -81 -2 +4 -64 -43 -66 -2 -16 -64 -46 -101 ±0
31
-31
Sust.
Gtr.
7:6 14:9 49:27 25:16 121:72 9:8 7:4 77:64 45:32 11:6 11:8
-33 -35 -68 -27 -101 +4 -31 -79 -10 -51 -49


33
-60
±0
-44
Sust.
Gtr.
7:6 -33
7:4 -31
49:48 -64
165:128 -60
77:48 -81
1:1 ±0
28:27 -37
14:9 -35
35:32 -44
165:128 -60
55:36 -66
1:1 ±0
35
-14
Sust.
Gtr.
5:4 -14
3:2 +2
35:32 -44
165:128 -60
77:54 -85
28:27 -37
5:4 -14
7:6 -33
77:64 -79
105:64 -43
77:72 -83
14:9 -35
37
-64
-82
-14
-37
-80
-43
-88
Sust.
Gtr.
7:6 -33
14:9 -35
49:48 -64
165:128 -60
77:48 -82
5:4 -14
5:4 -14
28:27 -37
77:64 -80
105:64 -43
154:81 -88
5:4 -14
39
-101
Sust.
Gtr.
28:27 -37
77:64 -80
105:64 -43
154:81 -88
11:8 -49
4:3 -2
28:27 -37
77:64 -80
55:32 -62
121:72 -101
5:4 -14


41
-49
-62
Sust.
Gtr.
9:8 11:6 49:48 45:32 121:72 28:27 11:8 7:4 77:64 55:32 121:72 7:6
+4 -51 -64 -10 -101 -37 -49 -31 -80 -62 -101 -33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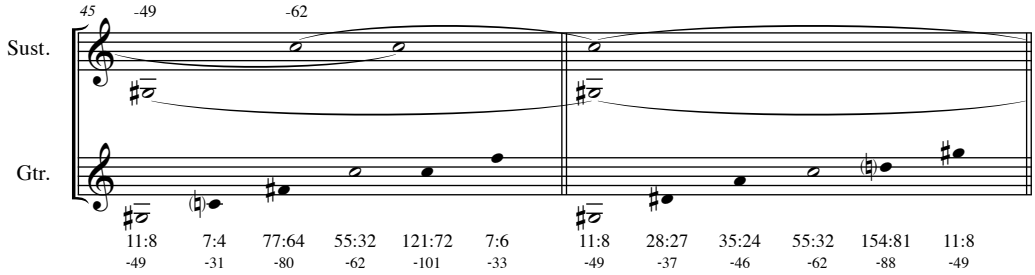
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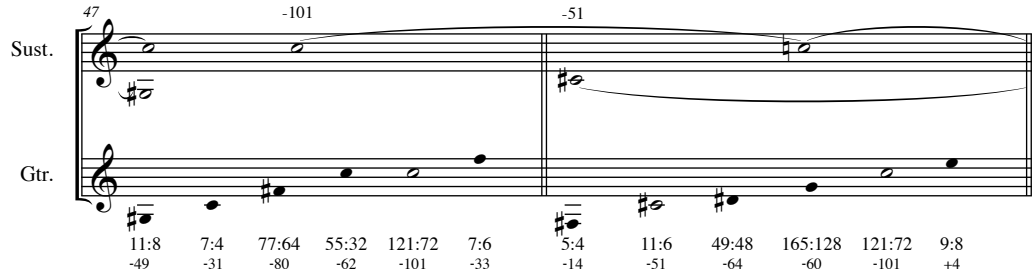
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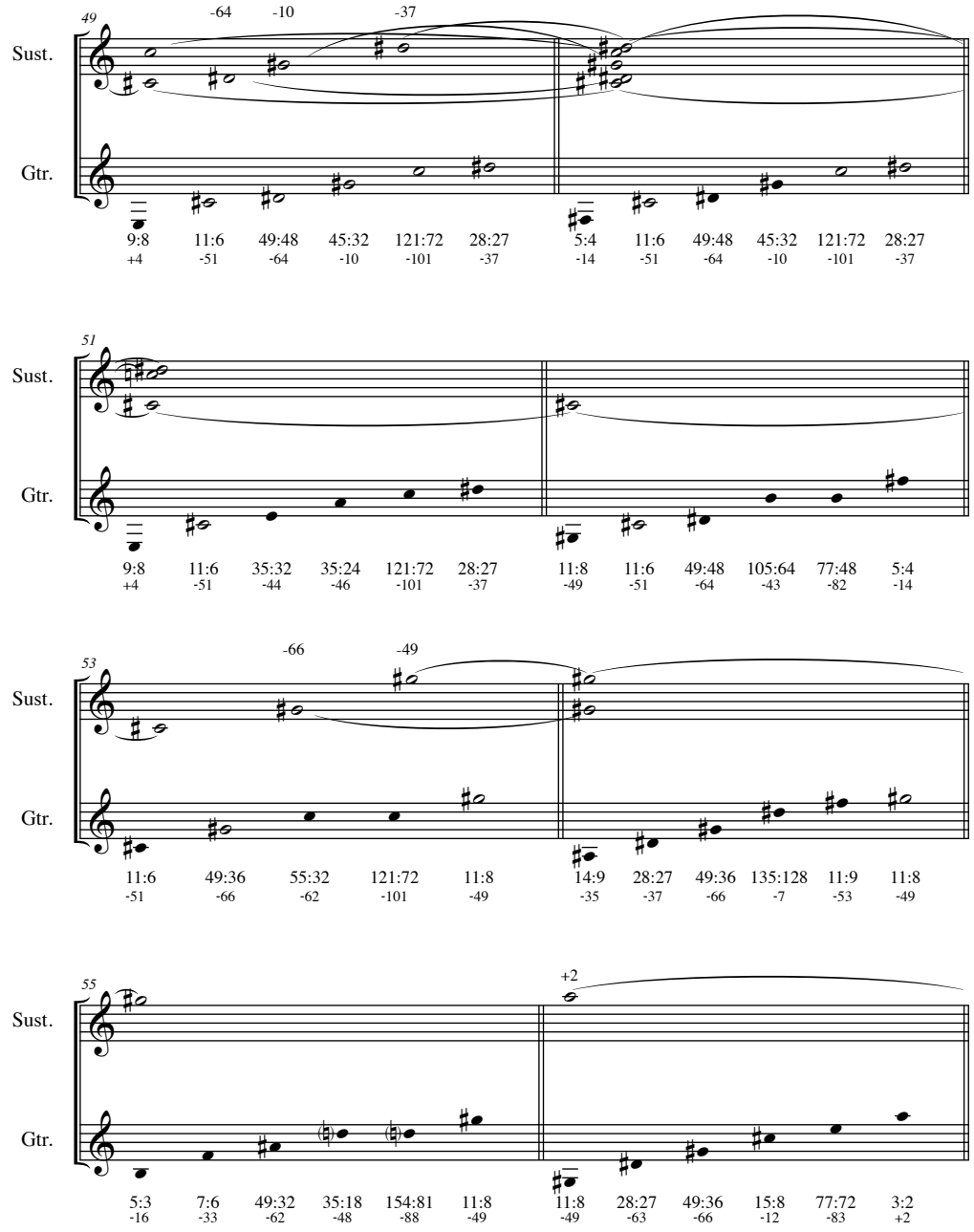
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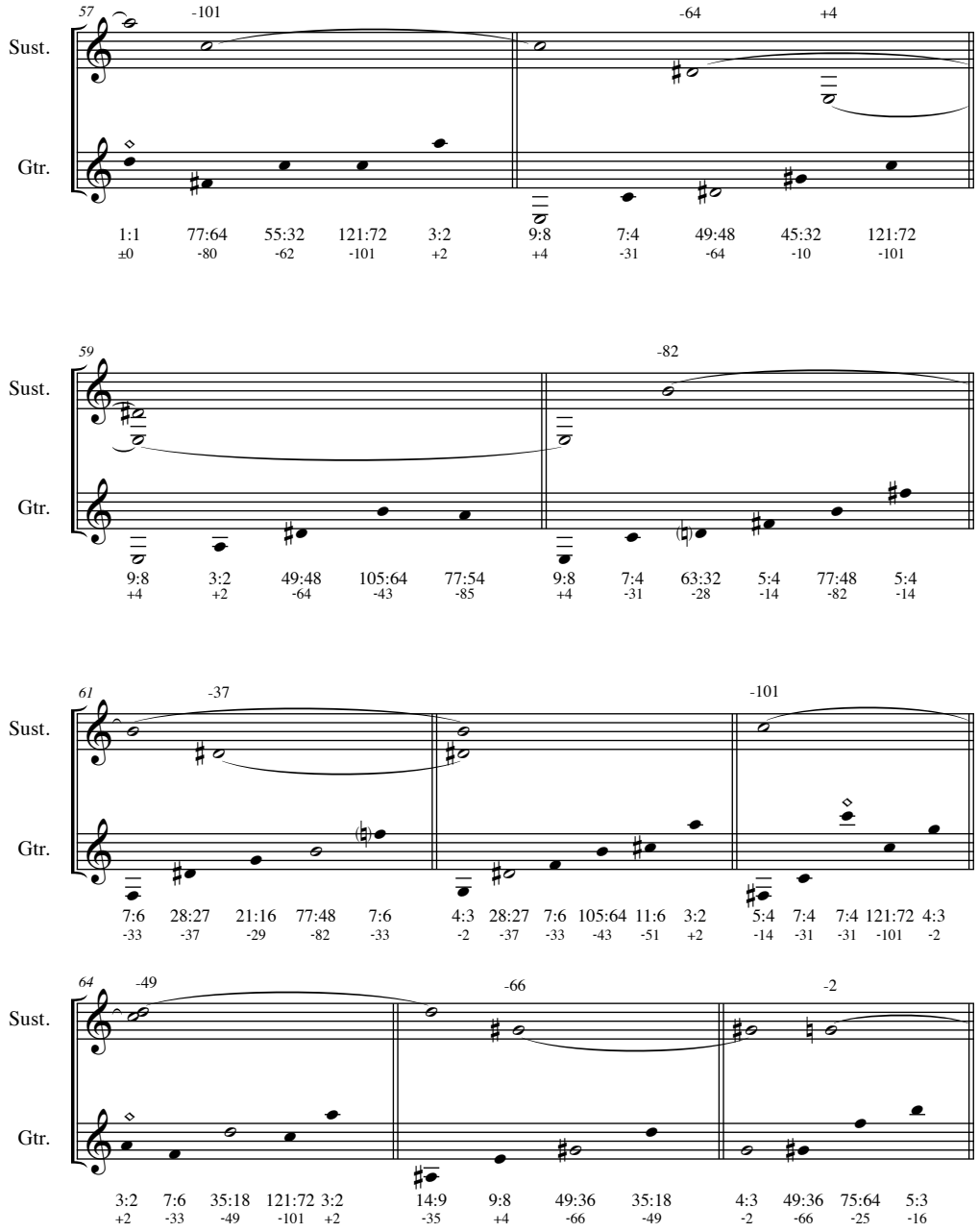
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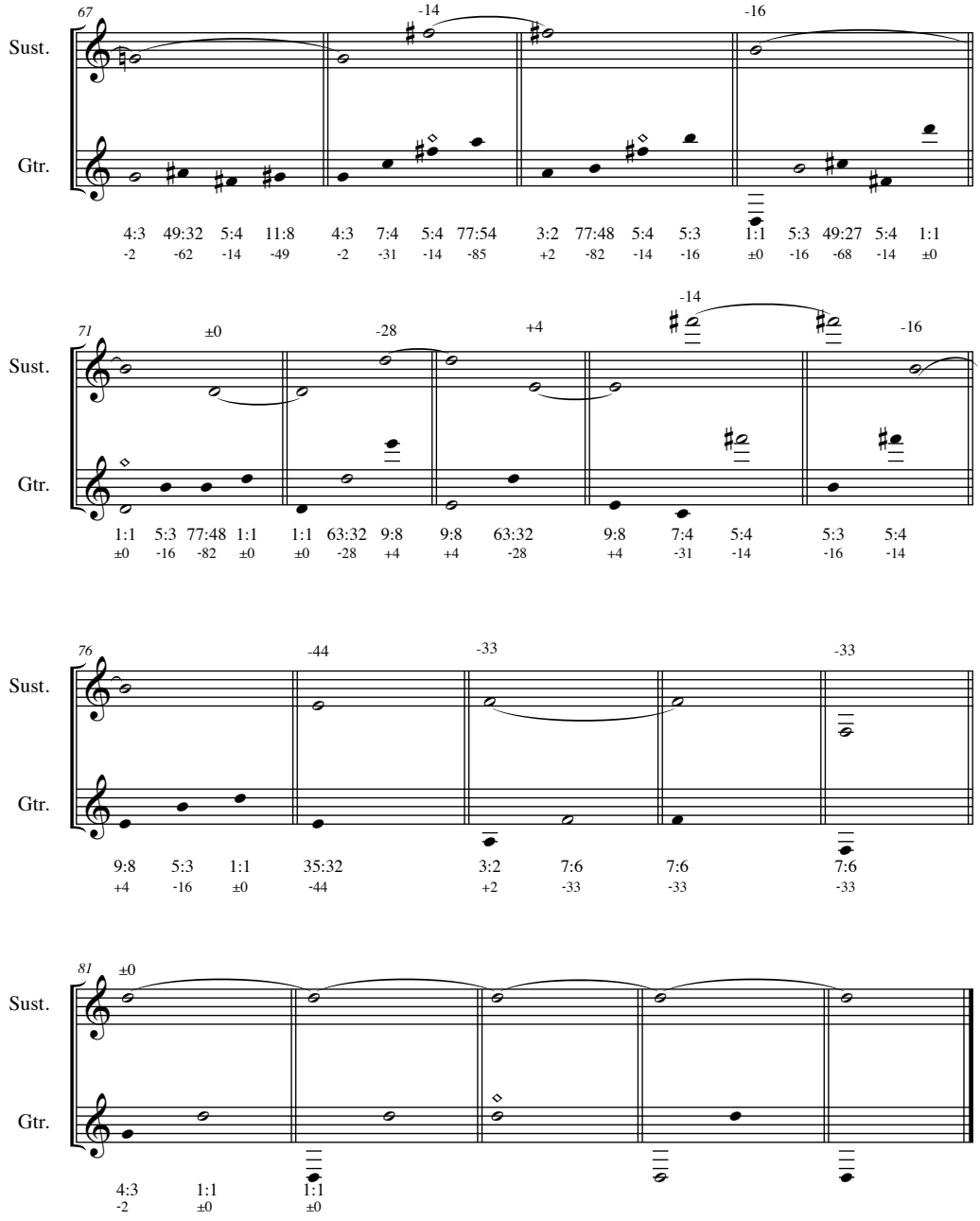
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