The Royal College of Music

Vanishing Points:
A personal approach to non-tempered tuning

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Abstract

The tuning of keyboard and zither instruments is tempered, that is, the system of tuning their intervals pragmatically approximates that of just (or pure) intervallic tuning. This has certain advantages, but results in a rigid, cyclic, closed system of tuning (and by extension, harmony). By comparison, non-tempered tuning is an open system requiring a flexible approach to tuning each interval in turn. The resulting harmonies are sonorous and distinctive. Much music written using non-tempered tunings has an acute awareness of the phenomena arising from the interactions between the vibrations causing the sensation of sound, the physiology of our ears and the psychology of our hearing faculty. Without diminishing this awareness, my work also investigates the evocative potential of this approach to harmony, in part through visual analogies and tactile processes of sketching. Examples informing this investigation include Vija Celmins' drawings, Dan Graham's pavilion *Double Exposure,* the architectural concept *terrain vague,* the poetry of Gerard Manley Hopkins, animated sound pioneers such as Arseni M. Avraamov, Percy Grainger's "free music machine" and the works of Giovanni Battista Piranesi. My portfolio spans works for chamber orchestra to pieces for ensemble or soloist with pre-recorded sound and image. Through composing, I grappled with recurring questions concerning my evolving approach to non-tempered tuning—questions arising out of a meeting of theory, practice and imagination. These include the place of melody in my works, the place of traditional acoustic instruments (including those tuned in —or tuning to—equal temperament) and the relationship between perceptual phenomena and a personal evocative world. My study is indebted to—and extends—the work of composers like James Tenney, Ben Johnston and Marc Sabat. The title *Vanishing Points* poetically encapsulates different aspects of this exploration.

Chapter 1
A Background to Non-Tempered Tuning and Rational Harmony

1.1 A Personal Approach

This commentary traces an evolving personal approach to non-tempered tuning in music written over a three-year period (September 2015 – September 2018). Broadly speaking, it works backwards: commencing with two works written in 2018 (Chapters Two and Three), before discussing earlier pieces for large ensemble (Chapter Four) and music composed for piano (Chapter Five). As such, the later works from 2018 shed light on their precursors. They draw together and distil many theoretical, practical and imaginative concerns initiating in the earlier pieces, and—in beginning to resolve some questions—are also presented as a point of departure for future experimentation.

When I applied for doctoral study in 2015, I anticipated I'd be working with adapted or custom made instruments, and composing works in non-tempered tunings[1] with a purely phenomenological orientation. This was to be a continuation of a series of pieces I had composed in 2013-15. In these, the music was written with an acute awareness of the phenomena arising from the interactions between the vibrations causing the sensation of sound, the physiology of our ears and the psychology of our hearing faculty. They encompassed works for Harry Partch's Adapted Guitar No. 1 and for Scordatura Ensemble,[2] compositions for strings demanding intricate scordatura set-ups, and pieces for prepared guitar. Over three years, however, these initial ideas were transformed through the process of composing for a range of ensembles and contexts; spanning works for chamber orchestra, voice, pre-recorded sound and smaller acoustic ensembles. Each piece raised practical concerns regarding the concrete limitations acoustic instruments, people and rehearsal practices place on realising less familiar intervals and subtle shifts in intonation. Rational harmony has historically had a similarly pragmatic bent: marrying abstract ideas with specific situations and challenges (for example in the work of Gioseffo Zarlino (1517-1590), Jean-Phillippe Rameau (1683-1764), and Hugo Riemann (1849-1919)).

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[1] Non-tempered tuning intones just (or 'pure') intervals (please see 1.2.1) i.e. the intervals are not

[2] These were works for two adapted instruments, originally designed by Harry Partch (1901-1974) to perform his own music (composed in just intonation): the Partch Adapted Guitar No. 1 (owned by Chris Rainier) and Elisabeth Smalt's Partch Adapted Viola.

I remained invested in the elemental properties of non-tempered tuning: of proportions and patterns mirroring those found in the natural world,[3] and of the perceptual phenomena arising from these. But I became increasingly interested in how such patterns could also be linked to sensations of an evocative quality, "to evoke rather than explain."[4] Or, put differently, how "music forms the most intimate bridge between the real exterior and the equally real interior" and how "the ear represents this bridge most sensitively."[5] The title of this thesis—*Vanishing Points*—poetically encapsulates different aspects of this exploration.

Firstly, in contrast to the cyclic, closed system made by equal temperaments,[6] non-tempered tuning is an open system requiring flexible intonation. This enables nuanced modulations and a theoretically infinite proliferation of harmonic contexts.[7] These relationships can be represented in interval chains or maps whose spread is potentially limitless, just as the vector of a vanishing point implies the unfolding of an unseen, limitless space. Over the course of my doctorate, I often composed with such maps (*Land's End,* (2015)). I also developed microtonal[8] modes where axial tones served to mediate multiple harmonic contexts (*A through-grown earth,* (2018)). I found connections between such patterns of organic, illimitable growth and Vija Celmins' serial images of an unbounded ocean surface, the phenomena produced by diffraction gratings and the flowering branches of an ash tree groping towards a gaping sky. These are discussed in detail in Chapters Two and Four.

Secondly, the interweaving of intervals underpinning such maps is sculptural in both appearance and application, creating a paradigm for imagining sound as an object with dimension and perspective—with an array of vanishing points. I became increasingly interested in how non-tempered tunings can potentially articulate aspects of space and time, through shifts in harmony[9] or presence (*Weather a Rare Blue,* (2018)). Dan Graham's

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[3] For example, logarithmic spirals (Erv Wilson, *The Wilson Archives,* accessed 6th December, 2016, http://anaphoria.com/wilson)

[4] Les Murray, *On Bunyah* (Collingwood, VIC: Black Inc., 2017), xii.

[5] Klaus Huber, *From Time to Time: The Complete Oeuvre, in conversation with Klaus Steffen-Mahnkopft,* translated by Wieland Hoban. (Hofheim: Volke Verlag, 2010), 12.

[6] In practice, dividing the octave into equal units numbering (most commonly) 12, 19, 31 (Huygens), 51, 53. In this commentary, 'equal temperament' means 12-tet equal temperament unless otherwise specified.

[7] For a definition of harmonic context see 1.3.2

[8] While a microtone is often defined as an interval smaller than a semitone, in this commentary it is defined in the broader sense, to encompass all intervals not found in twelve-tone equal temperament. Likewise, I refer to music using such intervals as 'microtonal'.

[9] The word 'harmony' is used in the sense described by James Tenney, who defines harmony in "general" and "aesthetically neutral" terms as "that aspect of musical perception which depends on harmonic relations between pitches". James Tenney, *John Cage and the Theory of Harmony,* 1983, accessed September 4, 2015 (http://www.plainsound.org/JTwork.html) 6, 34. In this commentary, creating the harmony for a piece

pavilion *Double Exposure,* the technique of raking light, the suspended state of insomnia, the architectural concept *terrain vague* and the works of Giovanni Battista Piranesi are discussed being as kindred to this paradigm. Chapter Three discusses how using non-tempered tunings can delineate sculptural aspects of sound.

Striking sonorities first drew me to working with non-tempered tuning. This is a thread running through my work, in which sonority emerges through unique modes where each note relates rationally[10] to every other, and through textures resembling mensural canons or tape delay. Regarding texture, I often address how sonorous, non-tempered intervals help different strata to fuse (*Weather a Rare Blue, Rose* (2016)).

From each of these three vantage points, complemented by analogies made between the audible and the visible, sound is viewed as pliable. Chapter Four also relays my interest in the malleability of sound, and the imaginative potential of transforming sounds through the lens of non-tempered tuning.

This commentary primarily focuses on the harmonic worlds of works in the portfolio submitted. I also discuss occasions where I have sought to find rhythmic or formal counterparts to my harmonic ideas: for example, an elusive pulse, or using restricted musical materials, or forms characterised by iteration. Chapter Five examines the ways I have attempted to work with the piano and prepares for works exploring a hybrid world blending equal tempered and non-tempered tunings. This opening chapter lays out some simple principles out of which my doctoral research grew.

1.2 Introduction to Non-tempered Tuning and Rational Harmony

Intonation concerns the fixing of pitch. This flexibility of pitch has led to the observation that music is "an art not of notes but of intervals."[11] Intervals performed in just intonation are 'pure': one set of sound vibrations (heard as one note) vibrates in whole number ratios with the other set of sound vibrations (heard as the other note).[12] Throughout this

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means deciding how to organise—in time—both the relationships between tones (forming precise intervals) and the relationships formed interval-to-interval.

[10] Two notes relate rationally when one set of sound vibrations (heard as one note) vibrates in whole number ratios with the other set of sound vibrations (heard as the other note). Simple ratios (3:2, 2:1) are perceived as more defined intervals.

[11] Llewellyn S. Lloyd and Hugh Boyle, *Intervals, Scales and Temperaments: An Introduction to the Study of Musical Notation* (London: MacDonald and Jane's, 1978), xviii.

[12] See: 1.3.1

commentary, intervals are described as ratios (for example, 3:2), while tones are ascribed their partial number ('3' or '17') within a given harmonic context.[13]

Temperaments are sets of pitches to which keyboard or zither instruments are tuned; their intonation is rigid[14] and the tuning of intervals deviates from just intonation to find a practical compromise, such that "some or all of the intervals are being *reinterpreted* as approximations of various just intervals."[15] Contrary to this, non-tempered tuning describes music using just or pure intervals. The term rational harmony encompasses the practices and phenomena of working with such intervals.[16]

Throughout the twentieth century new avenues in harmony unfurled, in response to electronic music and acoustic and psychoacoustic research—what Robert Wannamaker refers to as the "collision between musical and scientific cultures".[17] These three related areas place a microscope on sound and its perception, deriving harmonic models from the smallest elements (the spectra) of tones and sounds. Not fixed into a standard practice, the avenues they engendered in composition encompass an arc of composers experimenting with just intonation as well as those who are conveniently assembled under the label of 'spectralism'.[18] My research focuses on the former, acknowledging meaningful overlaps and resonances with the latter.

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[13] Usually they are ascribed their simplest partial number i.e. '3' rather than '6' or '12'.

[14] Excluding very small changes that can be made by changing the manner of playing.

[15] Marc Sabat, "Well temperament revisited:two tunings for two keyboards a quartertone apart in JI" (2019), accessed 11th March, 2019, http://www.marcsabat.com

[16] "I do not always *achieve* the just intonation which I hold as desirable—the clear choice of consonance or dissonance. Someone has said that ideals are like stars. We can't touch them but we can look to them for guidance. I believe in a rational—that is, acoustical—approach to the problems of musical materials as the *only* one leading to genuine insight." Harry Partch in Bob Gilmore, "Changing the Metaphor: Ratio Models of Musical Pitch in the Work of Harry Partch, Ben Johnston, and James Tenney." *Perspectives of New Music*, Vol. 33, No. 1/2 (1995): 460

[17] "This tradition, like its European counterpart, has aesthetic roots in the mid-century collision between musical and scientific cultures, but also in a more specifically North American musical phenomenalism rooted in the music and thought of John Cage, and channeled, among other ways, through late-1960s American process music." Robert Wannamaker, "North American Spectralism: The Music of James Tenney", *Istanbul Spectral Music Conference* (November 2003), accessed 10th January 2016 (http://www.robertwannamaker.com/writings/rwannamaker_north_american_spectralism. pdf), 18.

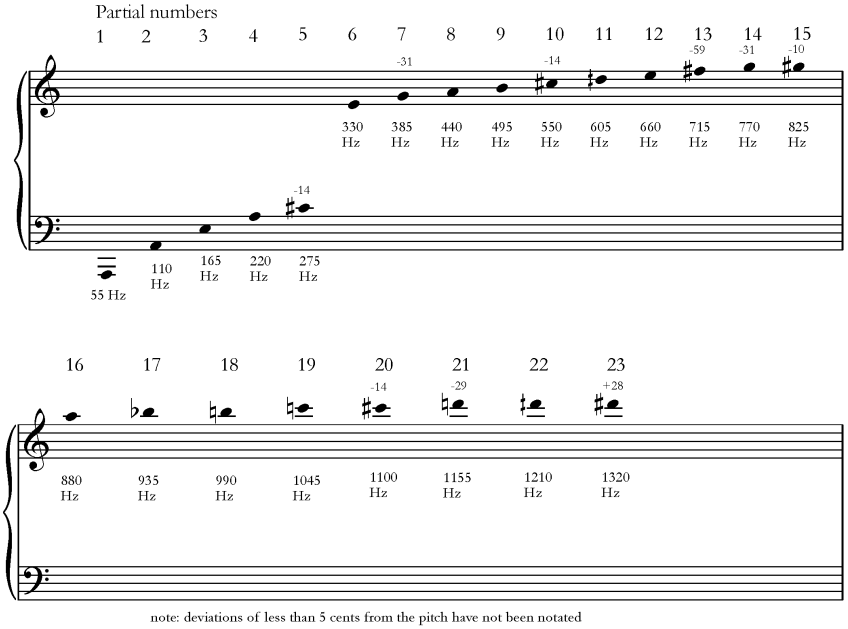
[18] A term coined by Dufort, commonly used to describe composers such as Gerard Grisey and Tristan Murail whose "compositional models" are "based on sound", and the analysis of sound into its constituent elements (Bob Gilmore. "On Claude Vivier's 'Lonely Child'", *Tempo* Vol. 61, No. 239 (Jan. 2007): 2). While there is a degree of overlap between the use of Just Intonation and 'spectral' composition, the latter places a slightly different emphasis on how aggregates of sound are perceived, favouring their perception as a timbre (or harmony-timbre) rather than as a network of relationships with an implied context.

1.3 Perceptual Principles of Rational Harmony

1.3.1 Definition of a 'Pure' Interval; the Perception of Consonance and Dissonance.

Just as light can be decomposed into a spectrum of beams of 'pure colour', any musical tone can be decomposed into its component elements: simple (sine) tones referred to as partials (see Figure 1).[19] Each partial has a characteristic frequency, amplitude and phase, vibrating in an integer multiple of the prime tone (or fundamental tone) and thus establishing a stable periodic pattern of interaction. This set of vibrations excites a regular pattern on the basilar membrane, which our aural perception blends into a musical note of definite pitch.[20]

Figure 1. A textbook harmonic series, showing the first 23 partials as notated pitches and in Hertz (cycles per second)

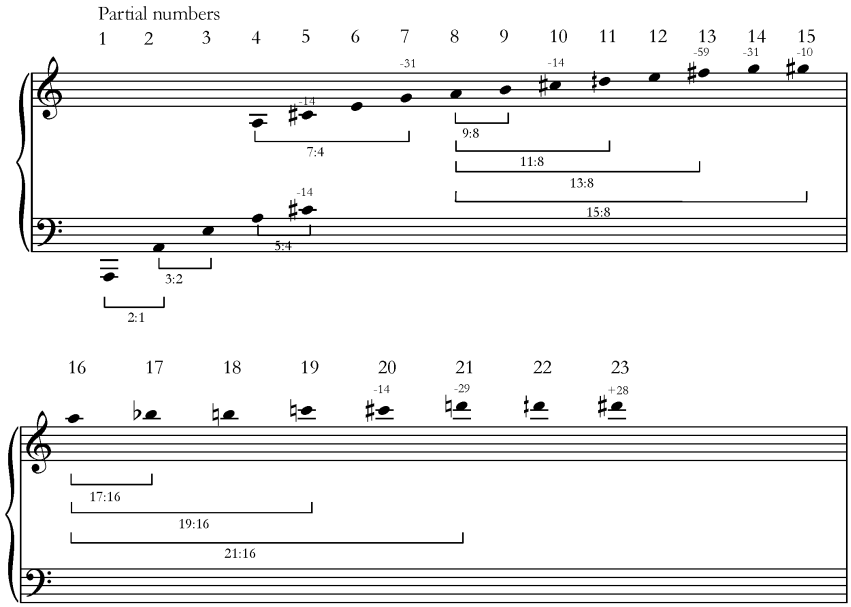


The intervals between the partials—which relate to one another in simple ratios—are sometimes referred to as 'natural' or 'pure' intervals (Figure 2).

[19] William Sethares, *Tuning, Timbre, Spectrum, Scale* (London, Springer-Verlag: 1999), 13

[20] Llewellyn S. Lloyd and Hugh Boyle, *Intervals, Scales and Temperaments: An Introduction to the Study of Musical Notation* (London: MacDonald and Jane's, 1978), 156.

Figure 2. A textbook harmonic series, showing the first 23 partials as notated pitches and a sample of intervals described as ratios



The simplest ratios give rise to consonant, defined intervals.[21] This can be attributed to an absence (or minimum) of 'beating' between the constituent partials of each tone. Beating occurs when the waveforms of two tones move in and out phase with one another, creating oscillating areas of destructive and constructive interference.[22] The perceived 'sensory dissonance' arising when two musical tones relating to one another in a complex ratio are sounded is the consequence of the rapid beating between their constituent partials. For example: two tones sounded a pure fifth apart (702 cents)[23] share alternating partials, giving rise to a clean and sonorous sounding interval. By contrast, if the fifth is tuned around 20 cents narrower (680 cents) or wider (720 cents), the interaction of the misaligned partials of the two tones gives rise to beating and, by extension, it is perceived as dissonant and less defined.

[21] I use 'consonant' and 'dissonant' as described by Helmholtz (where 'sensory consonance' describes smoothness, and an absence of beating; and 'sensory dissonance' describes roughness, and a the presence of beats). See also: James Tenney, *A history of: 'Consonance' and 'Dissonance'.* (New York, Excelsior Music Publishing Co.: 1988) accessed September 4, 2015 (http://www.plainsound.org/JTwork.html), 87-94

[22] William Sethares, *Tuning, Timbre, Spectrum, Scale,* 39

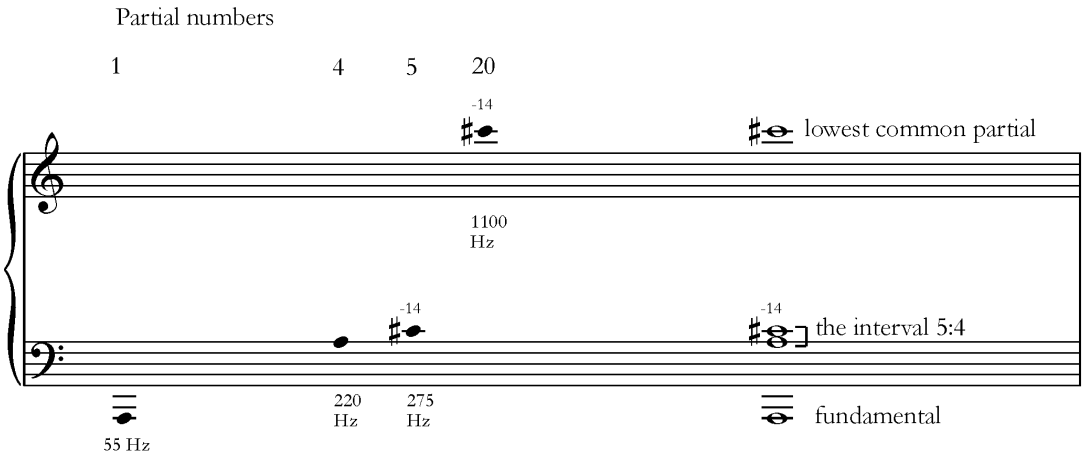
[23] Cents: A unit developed by Alexander Ellis to measure musical intervals, where one cent equals one-hundreth of an equal tempered semitone.

1.3.2 The Perception of an Harmonic Context

Non-tempered tuning is a means of producing an array of refined, distinctive intervals[24] with a breadth of sonic possibilities: where the relationship between two tones can be clarified or expressively 'distorted',[25] and where auditory phenomena can be thrown into relief against a consonant surface.[26] It is also a means of clearly communicating implied harmonic relationships.

As shown in Figure 3, any two tones imply an harmonic context, consisting of a silent (implied) fundamental and the partial tones shared by the two tones (the lowest shared partial is sometimes referred to as the 'lowest common partial').[27] In practice, precise ratios can be tuned by listening for a common partial. In addition, difference tones and summation tones can on occasion be heard emerging from a dyad, especially if these tones are emphasised by being subtly doubled in another instrument.[28]

Figure 3. The implied harmonic context of a dyad (the interval 5:4)



[24] Marc Sabat, "from Lisa Illean", email, 5 April 2016 (personal correspondence).
[25] Ben Johnston, "Proportionality and Expanded Musical Pitch Relations" *Perspectives of New Music*, Vol. 5, No. 1 (1966): 115
[26] "The absolute purity of these consonances focuses the sensations of beating and difference tones […] in the ear". Chiyoko Szlavnics. "Opening Ears: The Intimacy of the Detail of Sound", 5
[27] Marc Sabat, "from Lisa Illean", 2016
[28] See Figure 12.

1.3.3 'Fusion' and the Perception of Gestalt Units

I am especially interested in the role rational harmony plays in the formation of what can be called Clangs (that is, the tendency of simple pure intervals to fuse at a local level into a perceptual entity). For James Tenney (1934-2006), our perception of form depends on our ability to perceive cohesive units distinct and segregated from those prior and those following. These he calls gestalt units. Aural information is perceived and parsed into gestalt units on different scales within a piece of music (from the smallest 'elements' to the 'gestalt' which is the piece in its entirety.)[29] Tenney writes: "a piece of music [consists of] a hierarchically ordered network of sounds, motives, phrases, passages, sections, movements etc".[30]

There is interdependence between levels: gestalt units at a lower level may form a gestalt unit at a higher level if they are simultaneous, or contiguous, or sufficiently similar.[31] In James Tenney's *Spectra for Harry Partch* (1972), the composer plays with this inclination, expressing that the spectra sounded above a fundamental should be:

> "hovering near some threshold between being heard as individual tones at all, on the one hand, and being heard simply as intensifications of some harmonic in the spectrum of the bass's low F." [32]

It is this kind of contingency that also underpins the idea of 'harmony-timbre' described by Tristan Murail (b.1947),[33] and similarly, Harry Partch's (1901-1974) twelve tonalities;[34] each

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[29] For a detailed definition, please see:
James Tenney and Larry Polansky "Temporal Gestalt Perception in Music", 1980.
James Tenney, *META-HODOS*. N.H.: Frog Peak Music, 1986.

[30] James Tenney and Larry Polansky "Temporal Gestalt Perception in Music." *Journal of Music Theory,* Vol. 24, No. 2 (1980), 205

[31] For a precursor to Tenney's work, please see:
Ben Johnston, "Scalar Order as a Compositional Resource ", *Perspectives of New Music,* Vol. 2, No. 2 (1964), 56-76

[32] Wannamaker, "North American Spectralism: The Music of James Tenney", 9

[33] Tristan Murail, "The Revolution of Complex Sounds", transl. Joshua Cody, *Contemporary Music Review Vol. 24 No. 2/3* (2005), 122

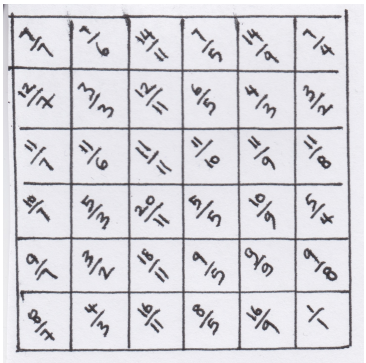
[34] Partch's Tonality Diamond, copied by hand below, details these twelve tonalities: six produced by reading vertically and another six produced by reading horizontally. Harry Partch, *Genesis of a Music: An Account of a Creative Work, its Roots and Fulfillment (2nd Edition),* (New York: Da Capo Press, 1974), 159. Note: as Partch has a fixed fundamental (G), ratios denote pitches in his work.

of which possesses an exclusive cohesion because it is composed of primary elements within one harmonic or sub-harmonic series. Partch attributes this quality to the pure, contagious resonance produced by just intervals vibrating in simple multiples of one another.

1.3.4 The Perception of Harmonic Space: Connecting the Eye and the Ear With Maps of 'Pure' Intervals

Non-tempered tuning produces networks of relationships between notes that unfold in (theoretically infinite) patterns from an origin; resembling perhaps a fan, or the unfolding latticed weave of a fabric extending from its corner, or the branches of a tree proliferating from its root.[35] There is an established practice of depicting these harmonic relations graphically in two-dimensional lattice diagrams of a multidimensional space (i.e. of mapping networks of intervals.) The purpose of these is to show the many axes of intervallic logic unfurling from a point of origin, and to support both quantitative and intuitive representations of 'close' and 'distant' harmonic relations. The maps thus organise an abstract, perceptual 'space' (defined, although theoretically infinite) into an expanding fabric of relationships marked as periodic points.[36] In the case of Tenney, Bob Gilmore links the appeal of these maps to John Cage's (1912-1992) more general, multi-dimensional approach to sound.[37]

Ben Johnston's (1926-2019) lattices are created by making chains of pure intervals with a unique axis for each prime number (noting that each prime number defines a specific



[35]These analogies are explored in greater detail by Bob Gilmore in: Bob Gilmore, "Changing the Metaphor: Ratio Models of Musical Pitch in the Work of Harry Partch, Ben Johnston, and James Tenney." *Perspectives of New Music*, Vol. 33, No. 1/2 (1995), 458-503

[36] "The overtone series must be regarded as, practically speaking, infinite. Ever subtler differentiations can be imagined, and from this point of view there's nothing against attempts at quarter-tone music and the like…" Webern, Anton. *The Path to the New Music.* Edited by Willi Reich.Translated by Leo Black. (London:Universal Edition, 1975), 15

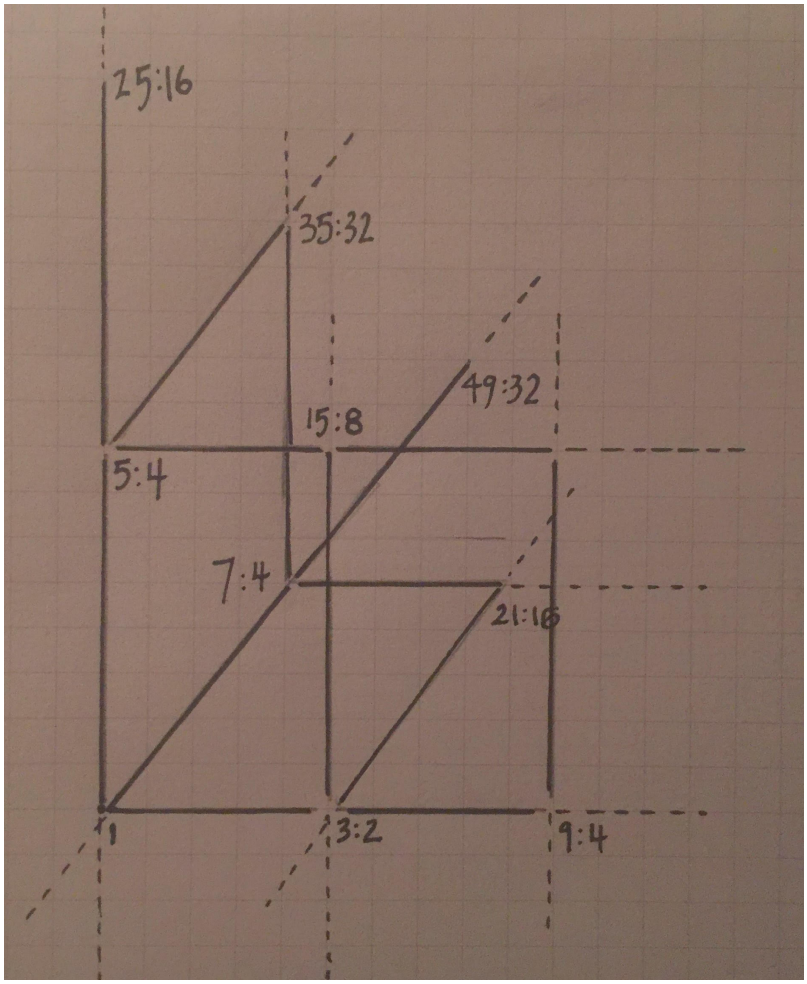
[37] Gilmore, "Changing the Metaphor: Ratio Models of Musical Pitch in the Work of Harry Partch, Ben Johnston, and James Tenney", 485

interval type). Figure 4 lists nine such interval chains; Figure 5 arranges these into a depiction of Harmonic Space.

Figure 4. Nine chains of pure intervals (using the intervals 3:2, 5:4, and 7:4 in various combinations)

1→3:2→9:8	1→5:4→15:8	1→7:4→21:16
1→3:2→15:8	1→5:4→25:16	1→7:4→35:32
1→3:2→21:16	1→5:4→35:32	1→7:4→49:32

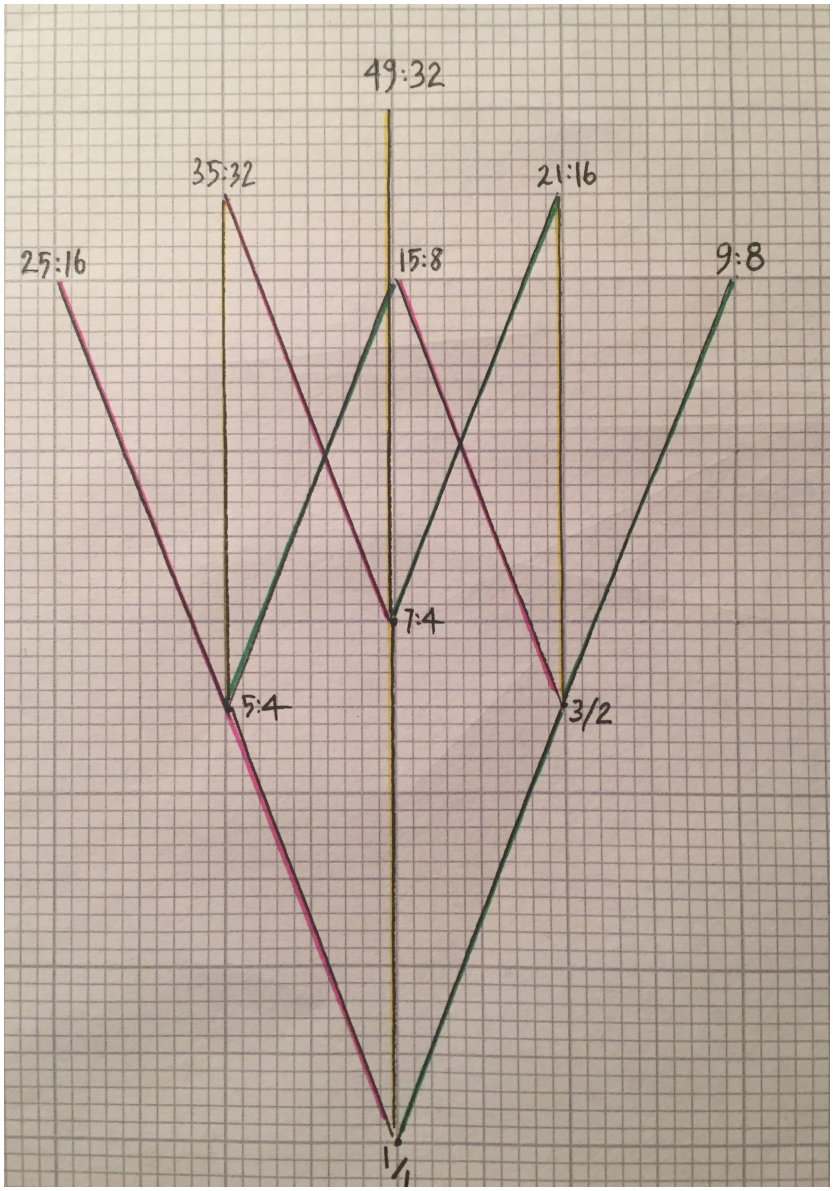
Figure 5: The interval chains from Figure 4 arranged into a depiction of Harmonic Space[38] (3:2 axis=horizontal; 5:4 axis=vertical; 7:4 axis=diagonal)



[38]This drawing is my own, borrowing aspects from Ben Johnston, Erv Wilson and James Tenney.

Alternatively, using the metaphor of a tree (see Figure 6) allows Tenney to discuss gestalt units at different hierarchical levels within the map metaphorically (for example, a branch as a gestalt unit at one level, or the entire tree as a gestalt unit at the highest organisational level). In other words, these maps potentially represent both a single gestalt entity (a 'whole') and the splintering of this entity into discrete, inter-related fragments.

Figure 6. The chains from Figure 4 imagined as a tree diagram (3:2 axis=green; 5:4 axis=pink; 7:4 axis=yellow)



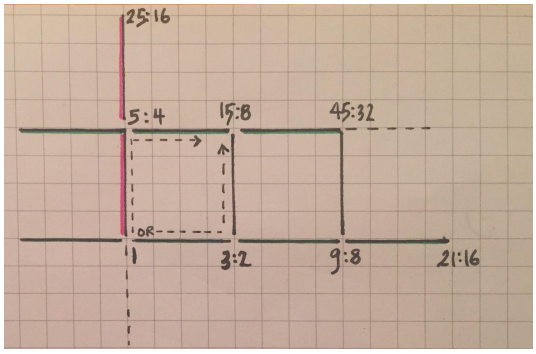
1.4 Composing "In The Ambience" [39] *of These Maps*

1.4.1 Harmonic Distance

The visual aspect of these diagrams lends them to being treated quite literally as maps, with the finger or eye tracing a path through different dimensions of the space. This makes what would be otherwise abstract relationships (such as harmonic distance) tactile and concrete. An harmonic distance value is a measure of sensory consonance (or dissonance). By ordering harmonic distance values from low to high (or vice versa) it is possible to move from intervals closely related to a fundamental to those more distantly related. This transitional ordering of pitch materials closely resembles the movement from 'harmonicity' to 'inharmonicity' in works by Gérard Grisey and Tristan Murail.[40] In these works, harmonic distance is variable. This can be used to shape the form of a piece (such as in Tenney's *Arbor Vitae* (2006)).

In Johnston's lattices, proximate points are also close harmonically. Tenney formalises this in his harmonic distance algorithm. The harmonic distance between two tones is essentially the distance between their implied fundamental and the lowest partial they share. Applied to a lattice, this information is conveyed by tracing a 'city-block' (i.e. non-euclidean) line along the relevant axes (see Figures 7 and 8). That is, the harmonic distance for an interval 5:3 is one step along the 5-axis and one step along the 3-axis.

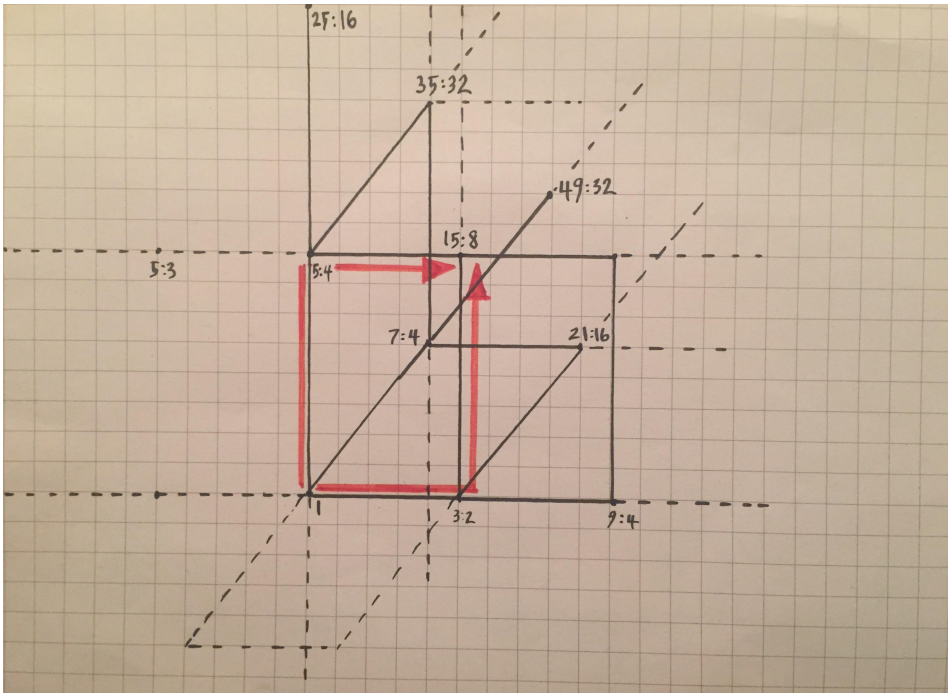
Figure 7. Arrows showing the measurement of the harmonic distance of 5:3 on a lattice as one step along the 3:2-axis (green) and one step along the 5:4 axis (pink) i.e from 1 to 15:8



[39] Gilmore, "Changing the Metaphor: Ratio Models of Musical Pitch in the Work of Harry Partch, Ben Johnston, and James Tenney", 472

[40] For example, in Grisey's *Prologue for solo viola* (1976) or Murail's *Désintégrations* (1982).
See also: James Tenney. *On Crystal Growth in Harmonic Space* 1993-1998, accessed 4 September 2015 (http://www.plainsound.org/JTwork.html).

Figure 8. Arrows (in red) showing the measurement of the harmonic distance of 5:3 on a sketch of Harmonic Space as one step along the 3:2-axis and one step along the 5:4 axis i.e. from 1 to 15:8



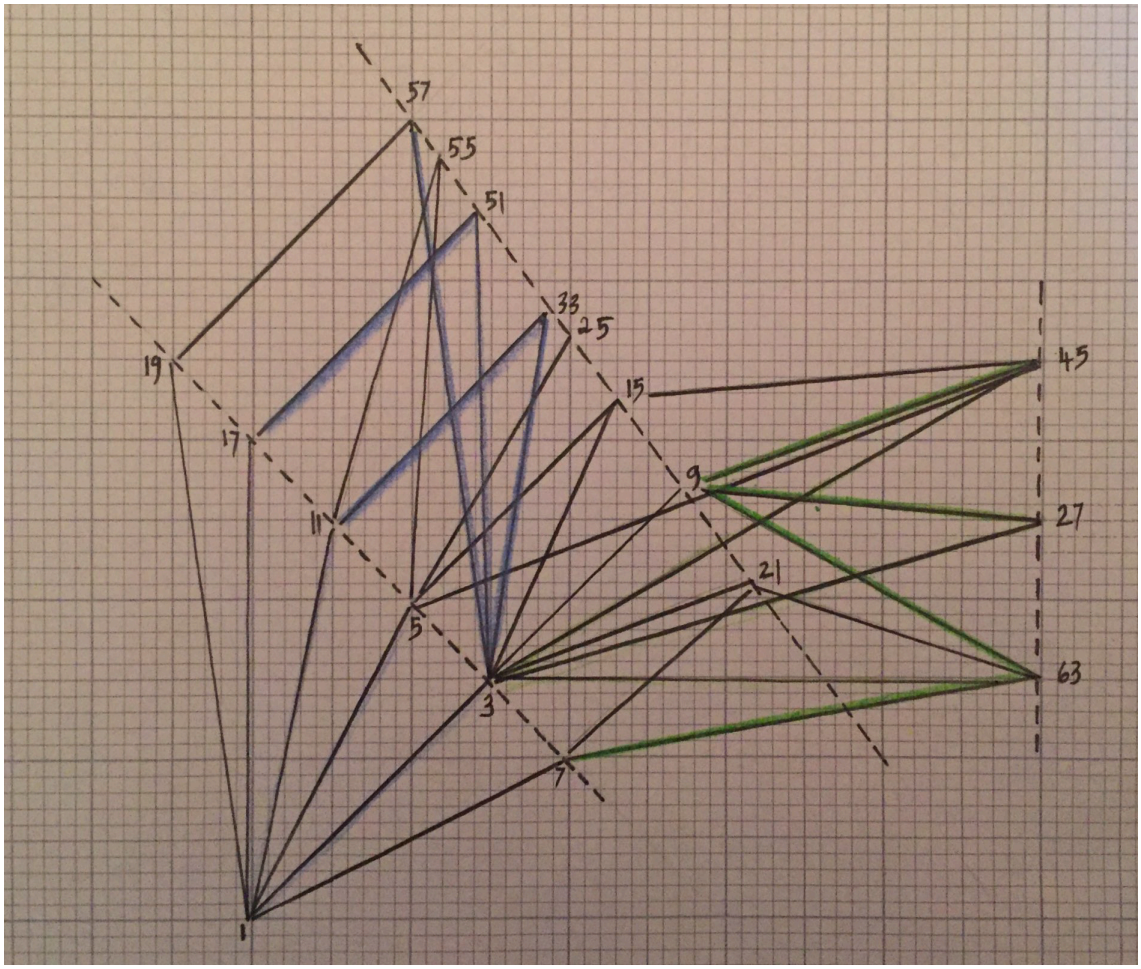
As demonstrated in Erv Wilson's (1928-2016) spiral of partials, these distances along the respective axes are not equal.[41] Tenney therefore weights each axis by a logarithm to the base 2.[42] The calculation of harmonic distance is thus $(\log_2 5) + (\log_2 3) = \log_2 (5x3)$.[43]

1.4.2 Modulation

Subtle networks of relations between pitches create a corresponding wealth of modulatory potential. Returning with eye and finger to a simple map of just intervals, it can be seen that a common tone (or tones) can act as an axis, about which discrete, inter-related fragments of the map revolve. This can be seen in Figure 9, which I created while working on *Januaries* (2017).

[41] The relationships between partials in a textbook harmonic spectrum are not linear but logarithmic (meaning that the distance between partials can be expressed as a decimal value of a defined distance, usually an octave (i.e. 2)). When these decimal values are mapped onto a circle, they produce a spiral, with octaves aligning to form radii. Erv Wilson issued an elegant diagram of the harmonic series as a logarithmic spiral on 1st March, 1965.
[42] Log2= the power to which 2 must be raised to equal 1, 2, 3, 4, 5 (and so forth), these being the terms of the harmonic series.
[43] Ratios are summed by multiplying them.

Figure 9. An example from *Januaries;* the 3rd partial is the axial tone, two fragments are shown in blue and green.



It is likewise possible to connect successive intervals by means of a common tone (Figure 10) or common partial (Figure 11), where the new interval defines a changed harmonic context:

Figure 10. A common tone (A, 440 Hz) joins two intervals (8:7 and 3:2). The implied fundamentals (notated in brackets) show the different harmonic contexts of these intervals

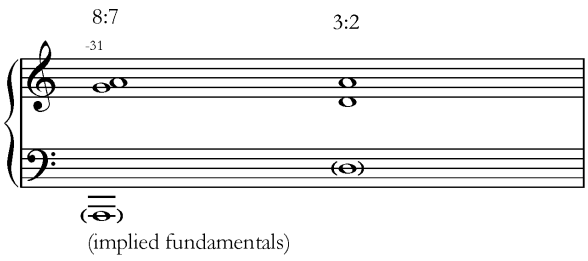
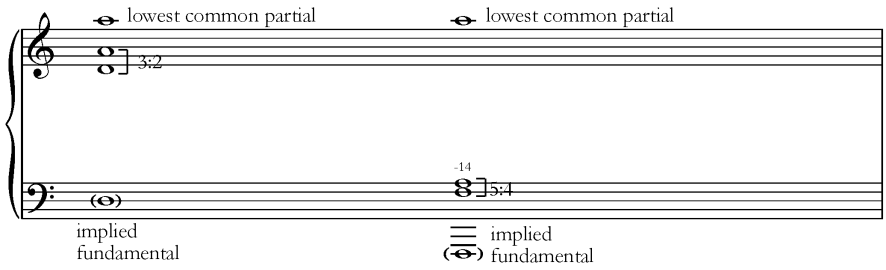


Figure 11. A common partial (A, 880 Hz) joins two intervals with different fundamentals (3:2 and 5:4)



Drawing on Leonard Euler's two-dimensional lattice mapping octaves, pure fifths and pure thirds, Marc Sabat's *Euler Lattice Spirals Scenery* (2011-12) modulates to "distant regions" of this lattice via a sequence of triads: "Each triad occurs only once, and for the most part connects to its neighbours by a shared common tone."[44]

1.4.3 Multidimensionality: Shadows and Sculptures

Figure 9 shows how maps of rational harmony recognise fragments (constellations of tones) as part of a greater perceptual whole. Therein lies the critical poetic potential to turn sounds 'inside-out', to change the harmonic emphasis or to shift focus or perspective. Difference and summation tones—as phenomena of pure intervals—further this potential.[45]

Murail has approached difference tones poetically as 'traces' or shadows of a dyad.[46] In other works of his, forms are predicated on reimagining material from a different perspective: in *Vues Aériennes* he recomposes a process four times, comparing this re-working of the same subject from different angles to Claude Monet's Rouen Cathedral paintings.[47] In Adrian Koye's article, *Le Tone Retrouvé,* Koye demonstrates the cyclical nature of successive difference and summation tone calculations (see Figures 12 and 13), suggesting that intervals can be connected as 'traces' of a structure in a previous sound: "as

[44] Marc Sabat, *Euler Lattice Spirals Scenery,* 2011-12. Accessed 9th September, 2016, www.marcsabat.com
[45] See Figures 12 and 13
[46] For example, in *Treize Couleurs du Soleil Couchant* (1978), discussed in Gilmore, "On Claude Vivier's 'Lonely Child'", 15
[47] Anderson and Murail, "In Harmony: Julian Anderson Introduces the Music and Ideas of Tristan Murail", 323

if […] being turned inside out, so to speak." Invoking Proust, Koye writes that this "allows us to taste the same sensations under completely different circumstances."[48]

Figure 12. Two tones produce difference tones (which in turn reproduce the original tones). The calculation of the difference tones is described beneath

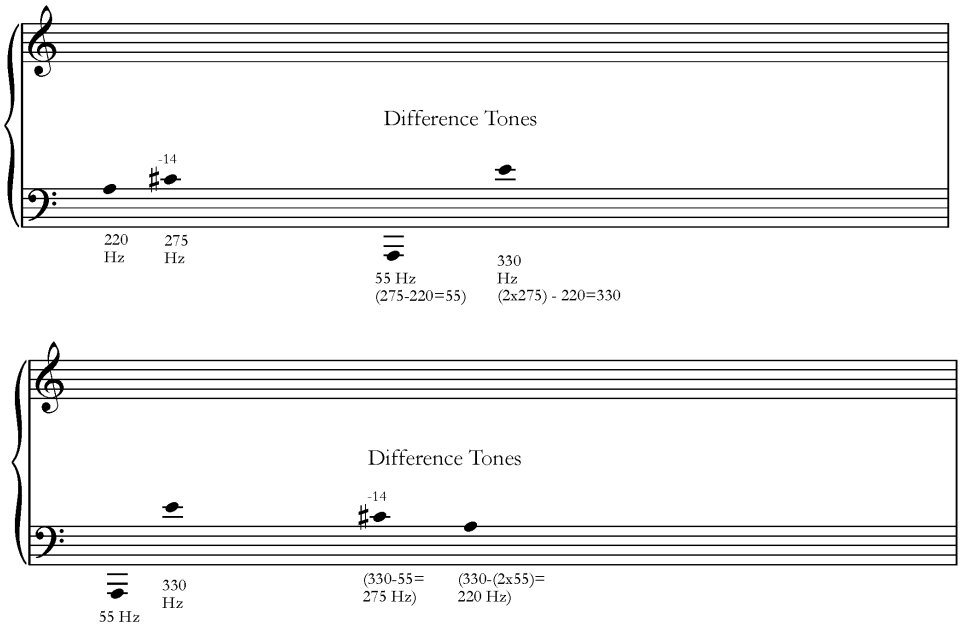
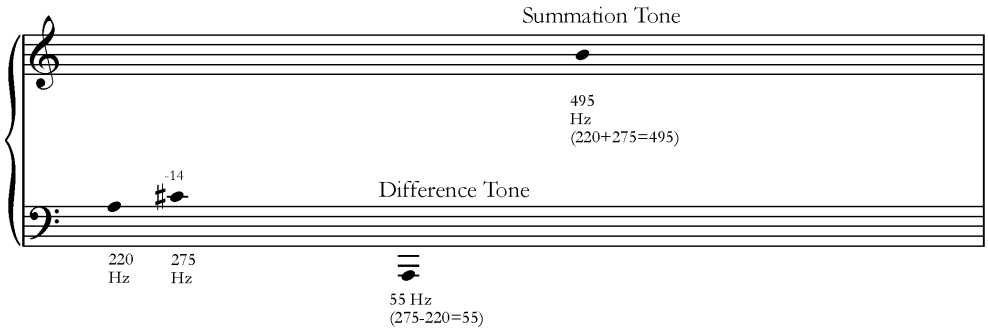
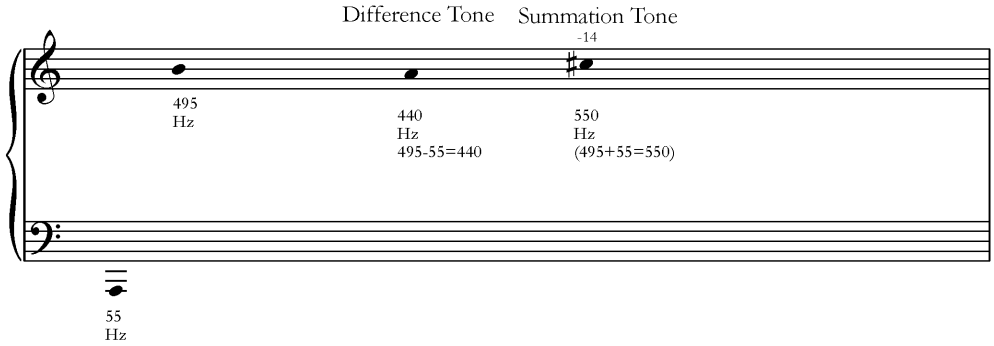


Figure 13. Two tones produce a difference tone and a summation tone (which in turn reproduce the original tones an octave higher). The calculation of these tones is described beneath



[48]Adrian Koye. "Le Tone Retrouvé" *Kunstmusik* 16 (2014), 51



These observations consistently expand a particular approach to rational harmony: one attentive to memory[49] and akin to the contemplation of a sculpture. Maryanne Amacher has likewise described her work with difference tones (developed in depth by Alex Chechile) as a "perceptual geography"—a "multi-layered listening of microscopic and macroscopic" perspectives.[50]

1.5 Precision and Perception

It has been proposed that perceiving harmonic information is basically a process of pattern-matching that seeks the simplest 'fit' possible between the heard interval and a pure interval. This approach is an extension of Hugo Riemann's theory of tone representation, recognising that pure intervals are referential intervals that parse and organise the aural information received.[51] There is thought to be a fairly large tolerance range[52] within which the ear will match imprecisely tuned intervals to pure ones, most likely finding a compromise between three elements:

a) What the *closest* pure interval it could refer to (with minimum retuning) is.
b) What the *simplest* pure interval it could refer to is.
c) The *harmonic context* (favoring a minimum number of implied fundamentals).

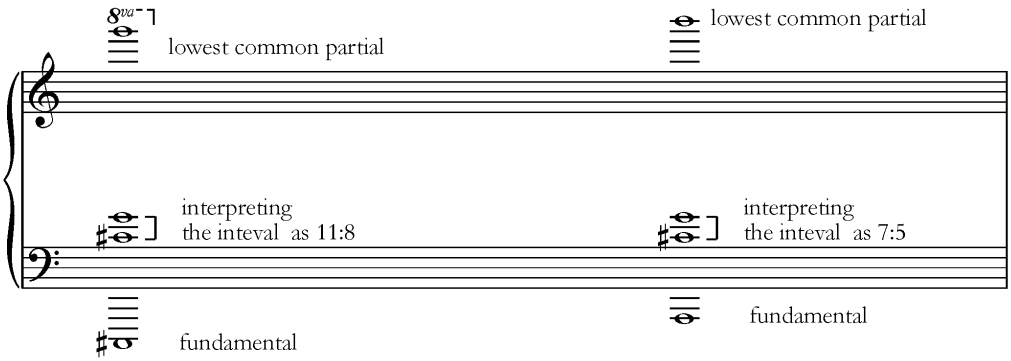
Research into a perceptual tolerance range may support the use of quartertones or 12-tone equal temperament beneath a non-tempered lens, as shown by Robert Hasegawa in his papers applying these principles to works by Schoenberg, Ligeti and Grisey. Hasegawa also separates a "listening grammar" from "compositional grammar": "When we view the chord through the lens of tone representation, its derivation … is irrelevant—we focus instead on

[49]In particular, a Proustian *Mémoire involuntaire*
[50]Alex Chechile. "Creating Spatial Depth Using Distortion Product Otoacoustic Emissions in Music Composition" 2015, accessed 21st January 2016, 1
[51]Robert Hasegawa, "Gerard Grisey and the Nature of Harmony" *Music Analysis*, 28/ii-iii (2009): 356
[52] See also: Richard Parncutt and Hans Strasburger, "Applying Psychoacoustic in Composition: "Harmonic" Progressions of "Non-harmonic Sonorities", *Perspectives of New Music,* Vol. 32, No. 2 (1994): 88-129

the complex ways in which the harmony plays on our aural intuitions."[53]

As such, less precise tuning can also potentially cloud the harmonic perception of intervals that with more precise tuning would be perceived as distinct. (For example, as shown in Figure 14, a diminished 5th played on a piano could be perceived as either the pure interval 11:8 or 7:5, each implying an individual harmonic context.)[54] It is for this reason that Ben Johnston considers his work in just intonation a vital extension of Debussy's harmony, where just intonation can make the overtone structures of Debussy "unambiguously recognisable as such."[55]

Figure 14. Two possible ways of perceiving a diminished 5th performed in 12-tone equal temperament (as the just intervals 11:8 and 7:5)



The finely spun sonic palette formed through precise tuning is discussed in Chapter Two, with reference to the gently dynamic scenes in poems by Gerard Manley Hopkins.

[53] Robert Hasegawa, "Gerard Grisey and the Nature of Harmony", 356
[54] Robert Hasegawa, "Gerard Grisey and the Nature of Harmony", 359
[55] Ben Johnston, "A.S. U. C. Keynote Address", *Perspectives of New Music,* Vol. 26, No. 1 (1988): 236

Chapter Two

A through-grown earth

2.1 Background to A through-grown earth

2.1.1 "I saw the inscape though freshly, as if my eye were still growing…"[56]

A through-grown earth is a work setting extracts of Gerard Manley Hopkins' poetry for solo voice and pre-recorded sound. It was composed for Juliet Fraser, with whom I met several times throughout 2018 to refine the musical ideas.

Observed patterns of tapestry in the natural world—such as foliations in wood or stone, or the 'lashtender combs' of ash trees—occur frequently in the poetry of Gerard Manley Hopkins (1844-89). In a journal entry from 1867, Hopkins' relays the play of his eyes as they trace a "double tree"— the variously overlapping contours of two ash trees:

> "But what struck me was a pair of ashes in going up the lane again…By taking a few steps one could pass the further behind the nearer or make the stems close, either coinciding, so far as disagreeing outlines will coincide, or allowing a slit on either side, or again on either side making a broader stem than either would make alone. It was this which was so beautiful—making a noble shaft and base to the double tree, which was crested by the horns of the nearer ash and shaped on the right by the bosom of the hinder one with its springing bough…I saw how great the richness and subtlety is of the curves in the clusters, both in the forward bow mentioned before and in some most graceful hangers on the other side: it combines somewhat-slanted outward strokes with rounding…"[57]

His writings reveal a highly personal affinity between perceptual phenomena— the "…design, pattern or what I am in the habit of calling 'inscape'"[58]— and the evocative world they summon, that is: "the effect of each pattern upon [Hopkins'] own imagination."[59]

To expand on this idea, one can perhaps turn to Richard Diebenkorn's *Inscape* (1953), where the painter's understanding of his observed world is imparted through internal relationships made between abstract colours and shapes, scored with an array of brush strokes: a painting that "is not *of* something but *is* that something under the form of paint."[60] Or one can consider the inscription Aaron Copland gave his music composition

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[56] Gerard Manley Hopkins, *The Major Works,* (Oxford: Oxford University Press, 2009), 214
[57] Gerard Manley Hopkins, *The Major Works, 192*
[58] Gerard Manley Hopkins, *The Major Works,* 235
[59] Meredith Monk, *The Rise and Fall of Meter,* (Princeton: Princeton University Press, 2012), 55
[60] I have borrowed and reinterpreted this phrase from David Jones. Aidan Nicholls *Redeeming Beauty: Soundings in Sacral Aesthetics.* (Oxford: Routledge, 2016), 138

of the same title: "a sudden perception of that deeper pattern, order and unity which gives meaning to external forms."[61] The "effect of each pattern"—which Hopkins called *instress*—supposes a rich interior life, and a communion of intellect, emotion and instinct. One could be reminded of the artist Paul Nash's (1889-1946) vivid impression that *the shape* of an old beech tree was "working upon his nervous system"… "holding 'the promise of a joy utterly unreal"'.[62]

This chapter describes the setting of three extracts from Hopkins' poetry. The process of setting text invited a particular approach: I found myself exploring the potential of rational harmony to excite in me something of the poems' evocative world. While I didn't expect a listener's experience to necessarily mirror my own, this potential guided many of the compositional decisions made while writing. I found myself creating a personal world where the music was informed by mental images.

2.1.2 Patterns Seen and Heard

Hopkins' personal writings also disclose a sensitive kinship between the seen and the heard. His attentive observations of natural phenomena, both of visible patterns in nature and the act of perception itself, find reciprocity in his own mark-making: his experiments in sound patterning.[63] These are neither literal nor illustrative renderings of the visual, but rather an expression of its *instress* upon his imagination: an intelligibility beyond mere delight in number, form and measure.

A "deeper pattern" (potentially connecting the eye and the ear) has long been expressed in mathematical terms by theorists of rational harmony, from Boethius' thesis that music is "number made audible"[64] to the exquisite drawings of Erv Wilson.[65] These are infused with the logic of number and proportion: a spiral drawing of the harmonic series exhibiting its logarithmic structure resembles the cross-section of a delicate shell. Underpinned by explicit and precise terms, in these (as in architectural symmetry, or the measured syllables of verse) "the delight hearing and sight afford is itself rational."[66]
From the perspective of those composers often conveniently assembled under the term 'spectral', sound is likewise logical (albeit not necessarily composed of such ideal

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[61] Robert Hendersen, "Copland's 'Inscape'." *Tempo.* No. 87 (1968-9): 30
[62] Simon Grant, *Informal Beauty: The Photographs of Paul Nash.* (London: Tate Enterprises Limited, 2016), 15
[63] Meredith Monk, *The Rise and Fall of Meter*, 60
[64] Hugh Benham, *Latin Church Music in England 1460-1575.* (London: Barrie and Jenkins, 1977), 28
[65] An archive of Erv Wilson's work is available online at http://www.anaphoria.com/wilson.html
[66] Aidan Nicholls, *Redeeming Beauty: Soundings in Sacral Aesthetics,* 6

proportions, nor Classical in conception). Often fascinated with unfolding the discrete, internal structures of a given sound organically over time, their approach reminds one of the detailed descriptions found in Hopkins' journals, which are "as if a magnifying glass were being passed slowly over the object".[67]

> "I looked long up at it till the tall height and beauty of the scaping—regularly curled knots springing if I remember from fine stems, like foliation in wood and stone—had strongly grown on me. It changed beautiful changes, growing more into ribs and one stretch of running into branch like coral. Unless you refresh the mind from time to time you cannot always remember or believe how deep the inscape in things is."[68]

A through-grown earth explores whether qualities perceptible in rational harmony can evoke such sensations as the wavering of an unsettled conscience or the branches of an ash tree groping towards a limitless sky.

2.1.3 "*It changed beautiful changes…": Hopkins' Own Patterns in Sound.*

It was at Juliet's suggestion that I began exploring Hopkins' poems for *A through-grown earth.* I was as drawn to the sound of the poems I chose as to their imagery and meaning: the 'sprung rhythm'[69], enjambement and sound clusters animated texts that pondered a single image—an ash tree, or a lantern winding its way into the darkened distance. The introspective repose of these scenes fitted my wish to create music within the subtly unfolding harmonic forms non-tempered tuning allows. Unknown to me at the time, aspects of Hopkins' musical pursuits—his idiosyncratic use of modes and rhythms—resembled my own.

A scholar of Greek, in music he was drawn to the ancient Greek modes, preferring the specificity of these modes—and the subtle variety of different modes springing from a shared axis note—to the major and minor scales of common practice. Often setting his own poems, the melodies he composed used quartertones (a nuance likely born of the Greek enharmonic system) and recalled plainchant in their rhythmic flexibility. Intriguingly, Hopkins is known to have read Saint Augustine's *De Musica,* an early treatise chiefly dedicated to discussions on rhythm, meter and verse. One can only speculate about its influence on his composing, but perhaps his subtle methods are compelled by a sentiment

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[67] Gerard Manley Hopkins, *The Major Works,* xxii
[68] Gerard Manley Hopkins, *The Major Works,* 204
[69] A poetic metre seeking to imitate common English speech, with a set number of stressed syllables per line and a variable number of unstressed syllables.

encapsulated in the opening pages, where Augustine wrote: "Music should be defined as *ars bene modulandi:* that is, how to make controlled variations of sound in the right way."[70]

2.1.4 Dynamic tuning

I find slight variations in tuning or harmony absorbing. I am reminded of a childhood game, described by the photographer Jacques-Henri Lartigue:

> "It's something I did when I was little. When I half-closed my eyes, there remained only a narrow slot through which I regarded intensely what I wanted to see. Then I turned around three times and thought, by doing so, I'd caught—trapped—what I was looking at..."

The philosopher Paul Virilio comments:

> "But with each return, when he tried to resolve the image, he obtained only a clearer perception of its variations."[71]

Viewing harmony through the lens of just intonation creates a network of nuanced relationships between intervals and— by extension—the potential for gentle and unusual modulations. The previous chapter mentions works composed in the ambience of maps of just intonation—the branching diagrams underpinning Tenney's *Arbor Vitae,* Johnston's elegant lattice architectures, Sabat's unfurling *Euler Lattice Spirals*. The delight of these maps is not only visual or formal. In describing an open system of harmonic relationships, they show sonorous intervals developed in lace-like sequences, representing a finely spun sonic palette. For Sabat:

> "The intention of the intonation is to maximise the resonance and sensation of both consonance and dissonance, the impression that melody and harmony are interwoven in a beautiful, at times complex network of relationships perceptible to the ear…"[72]

And for Bob Gilmore, describing how recurring musical ideas in Johnston's music embody a change in focus when they acquire a new harmonic context through slight adjustments in intonation:

> "Interval fine-tuning gives the recapitulated material a quite different sonority and a correspondingly different impact than on its first appearance."[73]

This echoes Lartigue's anecdote:

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[70] Goulburn W. Crossley, "St Augustine's 'De Musica': A Recent Synopsis. *The Musical Times,* Vol. 2, No. 1297, (1951): 127

[71] Paul Virilio, *The Aesthetics of Disappearance,* transl. Philip Beitchman, (Los Angeles: Semiotext(e), 2009), 24.

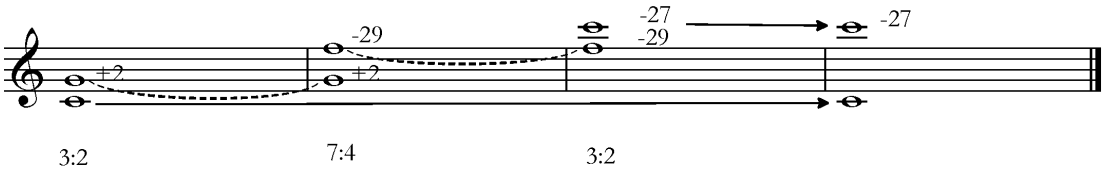
[72] Marc Sabat, *Asking Ocean.* Plainsound Music Edition, 2016, ii, accessed 2nd February, 2017, (www.marcsabat.com/pdfs/ocean.pdf)

[73] Bob Gilmore, "Changing the Metaphor: Ratio Models of Musical Pitch in the Work of Harry Partch, Ben Johnston, and James Tenney", 479

> "But with each return, when he tried to resolve the image, he obtained only a clearer perception of its variations." [74]

Slight adjustments in intonation require a dynamic approach to tuning. In this commentary, 'dynamic' (or adaptive) tuning means the use of microtonal adjustments in pitch to create consistently pure intervals and, by extension, frequent shifts in harmonic context (as shown in Figure 15, where a chain of pure intervals leads to two different tunings for 'C').

Figure 15. A chain of pure intervals leads to two different tunings for 'C'



2.1.5 Practical Concerns of Dynamic Tuning

Attempts to govern such nuanced variations are often elusive, because the effective perception of these relies on very precise tuning (see Figure 15). Perhaps for this reason, rational harmony shares a fruitful association with custom-made instruments designed to reliably produce microtones (of which there are many beautiful examples, including those of Harry Partch, Lou Harrison, Bill Colvig, Ivor Darreg and Cris Forster). James Tenney devised elegant, ingenious and pragmatic approaches for realising or closely approximating just intervals on western concert instruments, although these are limited in their modulatory flexibility. To explore a more extended harmonic field, Marc Sabat's *Asking Ocean* (2016) requires an intricately conceived scordatura, including minutely adjusted valves used in unconventional combinations for the brass, and an array of objects fine-tuned to sound at specific cent-deviations from a tempered pitch by applying small amounts of modelling clay. For pronounced melodic and modulatory flexibility, the dynamic (real-time) tuning systems of Larry Polansky (b.1954) and Jeff Snyder (b.1978) are mostly executed in an electro-acoustic context: Synder realises his *Adaptable Just Intonation System* electronically through new electro-acoustic instruments,[75] while Polansky's compositions in his *Psaltery* series (1978-2004) use tape or live electronics to provide an aural reference for intonation on acoustic instruments. In rare cases, Polansky has experimented with extremely demanding real-time retuning of the guitar using its machine heads.[76]

A through-grown earth proposes its own solution. The commission was for solo soprano

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[74] Paul Virilio, *The Aesthetics of Disappearance,* transl. Philip Beitchman, (Los Angeles: Semiotext(e), 2009), 24.
[75] See: Jeff Snyder. "Exploration of an Adaptable Just Intonation System." Ph.D. Diss, Columbia University, N.Y., 2010.
[76] Giocomo Fiore, "Heterophonic Tunings in the Music of Larry Polansky." Tempo, Vol.68 (2014): 29-41. A discussion of the *Psaltery* series is on page 34.

voice, to be performed with pre-recorded sound. The core of the pre-recorded sound material is composed of retuned zithers—a painstaking process that allowed me to be very precise with tuning and shift between microtonal modes in a way that is near-impossible in live performance on acoustic instruments.

2.1.6 Zithers in microtonal music

Because of the relative stability with which they can hold altered tunings, members of the zither family (neckless instruments, with parallel strings fastened across a frame) are central to microtonal music. Beguiled by the chords he heard in church bells—and unable to place them on his piano—George Ives (1845-94)[77] created a "quarter-tone machine" by stringing 24 violin strings on a frame and effectively doubling the number of notes within each octave.[78] In 1947, Julián Carrillo composed *Horizontes,* with a zither tuning further dividing the octave equally into 96 parts.[79] Stimulated by playing psalteries, in 1980 Gayle Young designed and built the Amaranth, an instrument with 24-strings 1000 mm in length and an unfretted curved topside fitted with moveable bridges for flexible tuning.[80] This handful of examples barely touches on the wealth of instruments, tuning systems and compositions one could discuss in this context.

It is also not possible in this commentary to cover ancient instruments and traditions from the Middle East, Asia or Africa—the Japanese Koto, Chinese Guqin, Rwandan Inānga or Turkish Qanun, for example. My own work with inexpensive German zithers properly began in 2015 under the supervision of harpsichord organologist Darryl Martin. A cursory glance at microtonal music for harpsichord or piano (in essence, zithers with keyboards)[81] encompasses Nicola Vincento's 1555 description of his archicembalo, music for the quarter-tone pianos of Hans Barth and Alois Hába, and comparatively recent compositions for retuned pianos such as Georg Friedrich Haas' *Limited Approximations* (2010) or Terry Riley's *The Harp of New Albion* (1984).

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[77] Father of Charles Ives (1874-1954)
[78] James Wood, "Microtonality: Aesthetics and Practicality." *The Musical Times.* Vol. 127, No. 1719 (1986): 328-330
[79] For more on Julián Carrillo see: Alejandro L. Madrid, *In Search of Julian Carrillo and Sonido 13*. Oxford: Oxford University Press, 2015.
[80] Gayle Young, "The Pitch Organization of Harmonium for James Tenney", *Perspectives of New Music,* Vol. 26, No. 2: 204-212
[81] Horațiu Rădulescu termed a lidless grand piano on its side a 'sound icon.' For him, pianos became huge zithers, often bowed with nylon string. See: Bob Gilmore. "Wild Ocean: An Interview with Horațiu Rădulescu." *Contemporary Music Review.* Vol 22, Nos. 1-2 (2003): 105-122.

I was partly drawn to these zithers' rudimentary design: their ability to hold a stable tuning, and to navigate simply between different intonations with a resonant timbre. But I was also attracted to a quality I perceived to be both timeless and quotidian. They are natural companions for the voice—which can also possess these qualities—and for storytelling itself (in this case, three quiet dramas of regret and mercy). In a presentation at the Museum of Contemporary Art Detroit, Ellen Fullman (b. 1957), whose Long String Instrument acts as a vast zither, comments simply on the work of dancers Yvonne Rainer, Trisha Brown and Deborah Hay: "These artists were incorporating everyday movement into their work and I liked the idea of that." Fullman assimilated the everyday by making the modest act of walking essential to her playing. The zithers I chose—portable and quite crudely made— also had a candour and simplicity that seems unadorned. Working with such zithers let me refine musical ideas explored in earlier compositions for scordatura guitar and in those for the Partch adapted guitar no. 1, where unassuming musical phrases are iterated in different, related modes. Audio Sample 1 mixes short excerpts from three such compositions: the opening bars of *Lu* (for Partch adapted guitar no. 1 and Partch Adapted Viola, 2016), Letter C from ***Timestead*** (for alto flute, clarinet, scordatura guitar, scordatura violin and soprano voice, 2015) and Part II of ***Sahul III*** (for Partch adapted guitar no. 1, 2015).

Audio sample 1. Excerpts from three early pieces, *Lu, Timestead* and *Sahul III*

When composing *A through-grown earth*, the zither I used became the "arbiter of the relationship between theory and compositional practice."[82] I wrote what I could play, while the recording process allowed innumerable re-tunings. The zither held these tunings reliably, but the strings were inharmonic (when plucked, the partials they produced did not conform to a textbook harmonic series; sometimes even the octave partial was slightly different to the fundamental). So I decided to pluck gently. At a soft volume, the inharmonicity added a liveliness and shimmer to the sound without diminishing the pure relationships between fundamental tones. As observed by many instrument builders, the concrete nature of acoustic instruments places limitations on the abstract,[83] but in doing so creates the specific conditions for genuinely new musical ideas to arise:

> "With the creation of a new acoustic instrument, one creates a set of interrelated musical and extra-musical parameters, and these parameters are often rather

[82] Bob Gilmore, "On Harry Partch's 'Seventeen Lyrics by Li Po'." *Perspectives of New Music,* Vol. 30, No.2. (1992): 29

[83] For example, harmonic ideas arrived at mathematically.

> different in nature than those produced by [electronic systems] ... they often bring forth particular sets of possibilities at which one working from the abstract would never have arrived."[84]

2.2 Defining the Harmonic World: Early Sketches Concerned with Sonority and Modulation

The work was likewise shaped by the approach I took to writing for Juliet's voice. Wanting to write a freely moving vocal line, from which the rest of the piece could emanate, I was naturally drawn to modal thinking.[85] Although *A through-grown earth* was not composed with existing maps of just intonation, it demands a comparably refined mutability and borrows their modulatory principles. Outlined in detail later, it uses modes assembled from (up to 19-limit) just intervals, modulating around fixed axes.[86]

I created a number of early sketches for *A through-grown earth*: small studies setting single lines of poetry in a new mode.[87] Previous modes I had worked with were often created through 'octave-reduction' (see Figure 16): a method of ordering notes—either of an overtone series, or notes arrived at through cycles of just intervals (e.g. pure fifths)—within an octave span.[88] However I sometimes found their sonority too familiar, and the intervals between some notes too ungainly for the murmuring melodies I hoped to make. Inspired by techniques in pieces as disparate as Tenney's *Saxony* (1978) and Thomas Tallis' (c. 1505 - 1585) *Gaude Gloriosa,* I was interested in creating new, self-reinforcing modes that could be harmoniously[89] layered upon one another at various speeds. My plan was to assemble examples of these from the ground up: combining small pure intervals to form larger pure intervals. Each note would relate rationally to every other and would have multiple functions (for example, as 7 to one note and 13 to another). In this way, each note, acting as a pivot, could engender modulation.[90] Figures 17-20 following detail my work with intervals up to 19th-limit, permitting a reasonable tolerance range of 5 cents (but taking care that this didn't accrue). After making initial lists of pure 2nds and 3rds, the process developed intuitively, not exhaustively. I distilled my materials at every step, guided both by what I liked and what I could reproduce with my voice. Intervals more distinct from those of tempered tuning (such as 11:10 or 7:6) were favoured.

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[84] Bart Hopkin. "Trends in New Acoustic Musical Instrument Design." *Leonardo Music Journal*, Vol. 1, No. 1 (1991): 11-16

[85] We discussed the appeal of embracing movement and elasticity in the vocal parts, countered by long notes (which, although tiring, are useful for calibrating tuning). By "modal thinking" I mean the way that " relations of melodic tones to each other… and the choice of cadence points, determine the 'mode' of the music" (as, for example, in plainchant.) Ben Johnston, "Proportionality and Expanded Musical Pitch Relations."

[86] 19 limit: making all intervals up to those defined by the nineteenth partial available to use

[87] By 'mode', I mean a pattern of (often microtonal) intervals, forming a scale where any note can function as a point of rest.

[88] See Chapter Four. In essence, Pythagorean tuning arrives at scales by creating cycles of pure fifths and 'reducing' them to sit within an octave.

[89] See footnote 9, on page 2.

[90] Compare this to Chapter Three, where I discuss how a suspended stasis can arise under conditions where each note in a mode can act as a point of rest.

Figure 16. The notes from Figure 15 octave-reduced

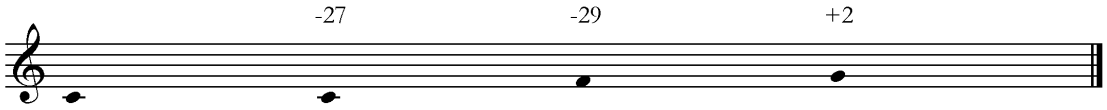


Figure 17. 19-limit pure intervals (seconds and thirds) from a central tone A

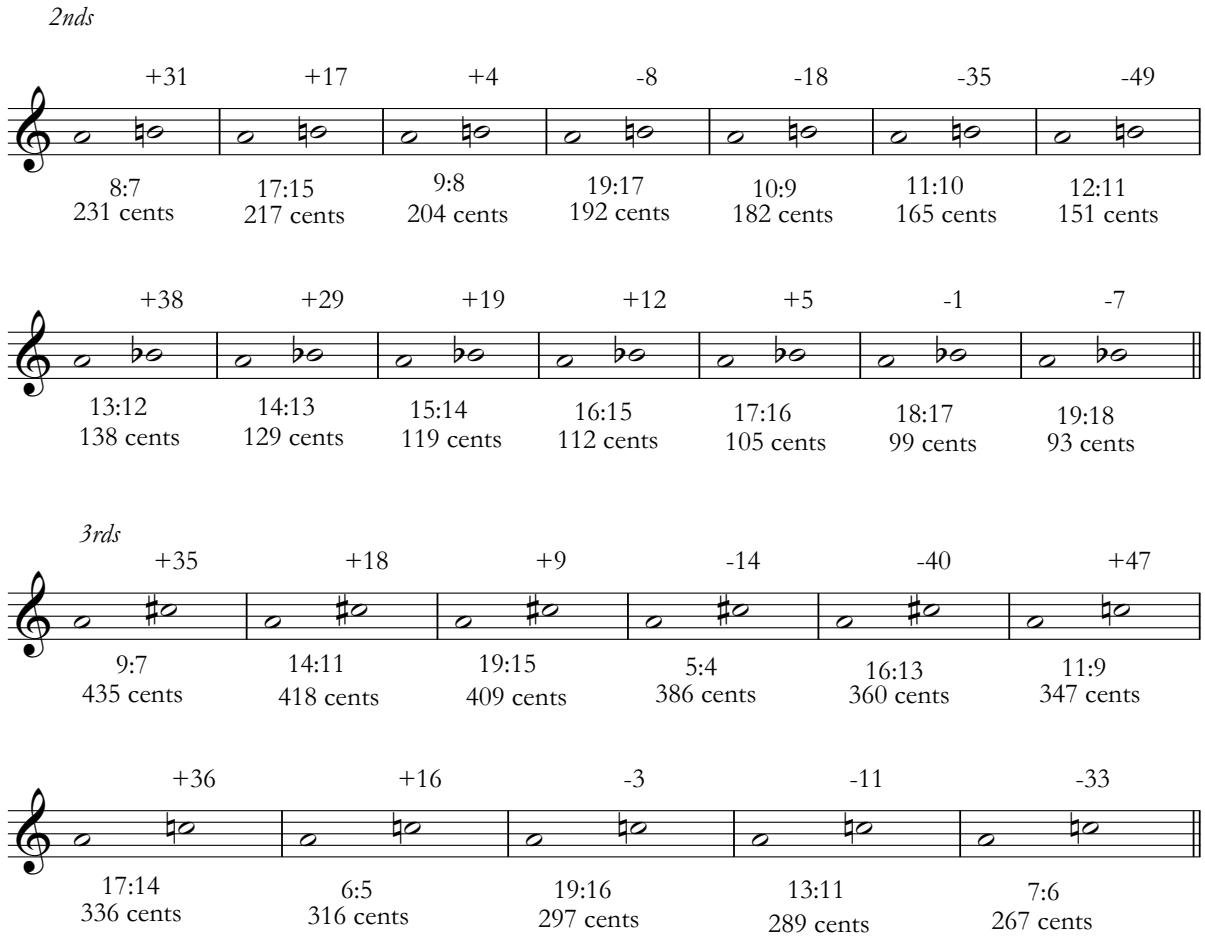


Figure 18. Pure seconds are combined to make five kinds of third (5:4, 6:5, 7:6, 11:9, 13:11)

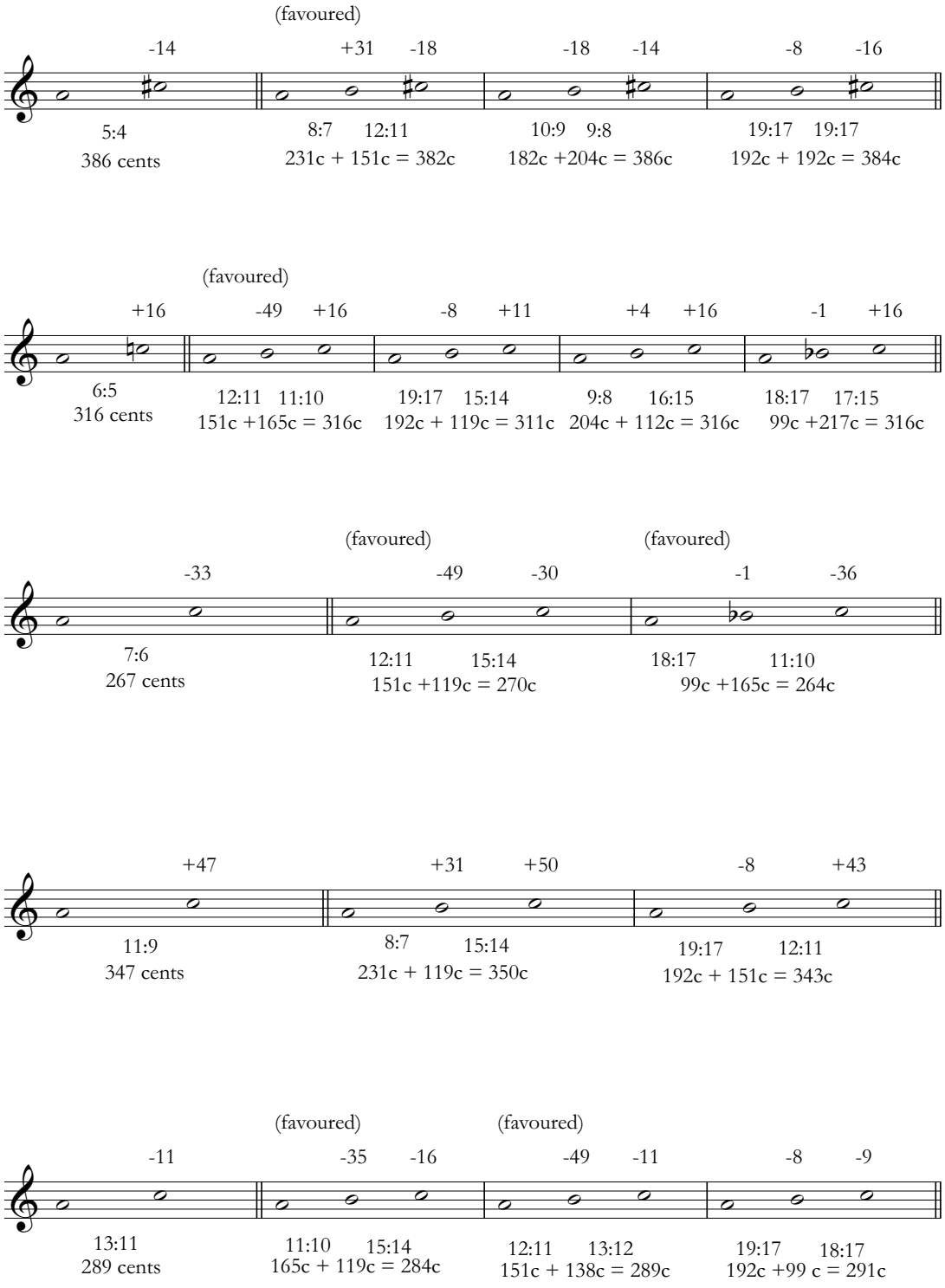


Figure 19. Further composites of these thirds forming pure sevenths.

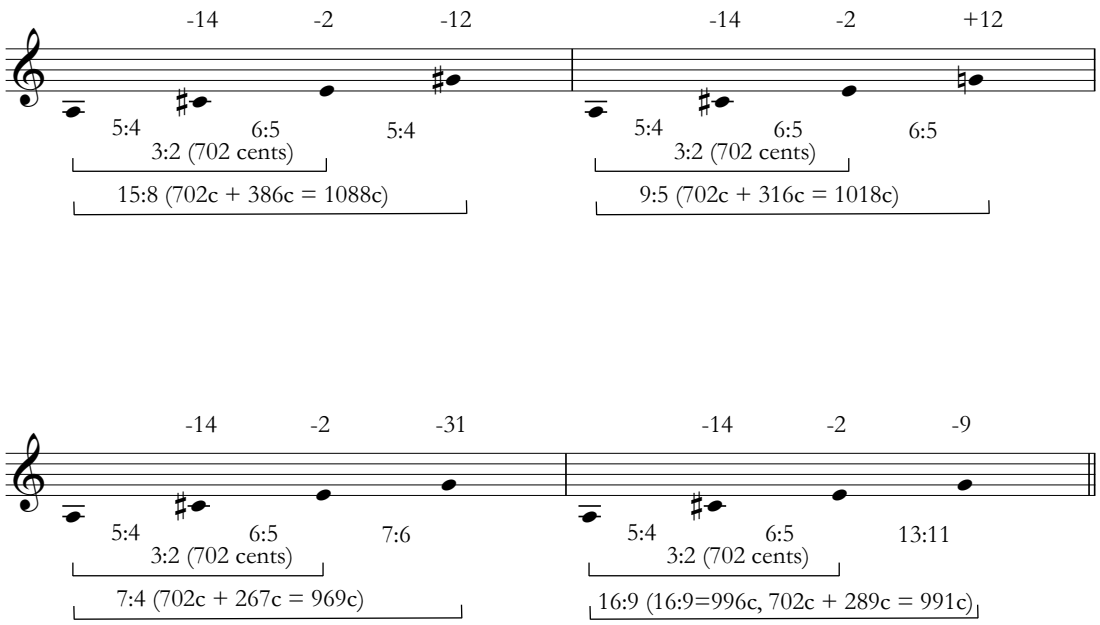
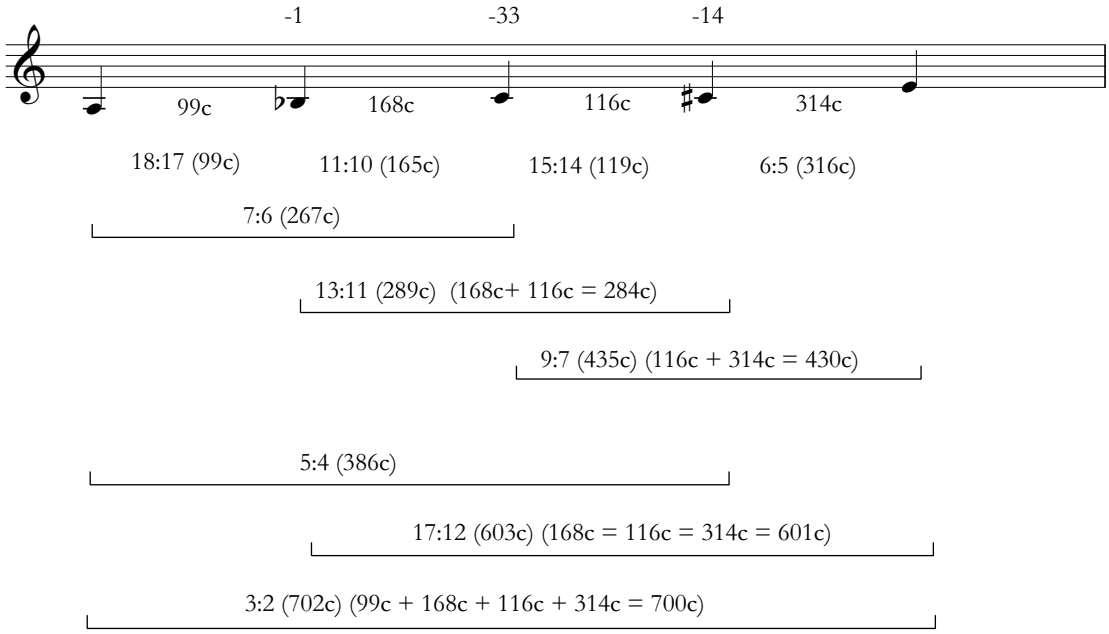


Figure 20. An example of a mode where each note relates rationally to every other

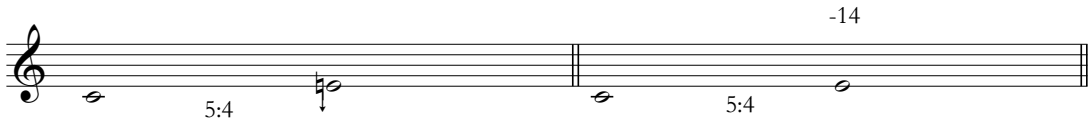


Juliet and I deliberated over the notation for *A through-grown earth*, but settled on notating microtones as cent deviations from tempered pitches (where A=440 Hz). This was the notation she found simplest to work with. I often sketched ideas using Extended Helmholtz-Ellis notation:[91]at the time, finding that it meaningfully clarified the

[91] Notation developed by Marc Sabat and Wolfgang von Schweinitz, where the accidentals one uses also elucidate harmonic relationships between notes. For a full explanation please see: Marc Sabat and Wolfgang von Schweintiz, *The Extended Helmholtz-Ellis JI Pitch Notation*. Plainsound Music Edition (2005) accessed 10th January 2016 (http://www.marcsabat.com/)

relationships between tones (for example, that X is likely to be perceived as the 7th partial). I now however prefer to use cents myself. (See examples of both in Figure 21). I more quickly relate just intervals to their size (in cents) and—more importantly—prefer to leave the harmonic function of a note unfixed (and open to multiple interpretations).

Figure 21. The interval 5:4 notated in Extended Helmholtz-Ellis notation (left) and notated using cents (right)



2.3 The Lantern Out of Doors: Sounding "Wading Light."

> "Sometimes a lantern moves along the night.
> That interests our eyes. And who goes there?
> I think; where from and bound, I wonder, where,
> With, all down darkness wide, his wading light?"
> - from *The Lantern Out of Doors* [92]

2.3.1 Harmony in The Lantern Out of Doors

The opening of Hopkins' *The Lantern Out of Doors* presents a beguiling image of wading light. We know that the light is produced by a lantern, and that something about its movement is as mesmerising as it is effortful. In a letter to Robert Bridges, dated February 15th, 1879, Hopkins describes his object of contemplation as "winding": "a lantern passing further and further away and bearing now east, now west of one right line…".[93] Respectively, in correspondence to Juliet (February, 2017) concerning the sound-world of an early draft, I write of "ebbing sounds, shifting in and out of focus", "overlapping flares", and of elongating the formants on the soft consonants 'm' and 'n' "as if disappearing into the distance."[94] Drawing on harmonic ideas from my sketches, I composed a vocal line based on a pattern of intervals unfolding from an Ab, centring the intervals 7:6, 8:7 and 14:13 (see Figures 22 and 23). Layering of the vocal line in two pre-recorded vocal parts reinforced the mellow, blended quality of these intervals, and created a texture in which the voice vacillated between being entwined and exposed (see Figure 24).

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[92] Gerard Manley Hopkins, *The Major Works,* 134
[93] Gerard Manley Hopkins, *The Major Works,* 235
[94] Lisa Illean, handwritten note to Juliet Fraser, February, 2017.

Figure 22. The opening mode of *The Lantern Out of Doors,* split into two symmetrical pitch sets with an Ab axis

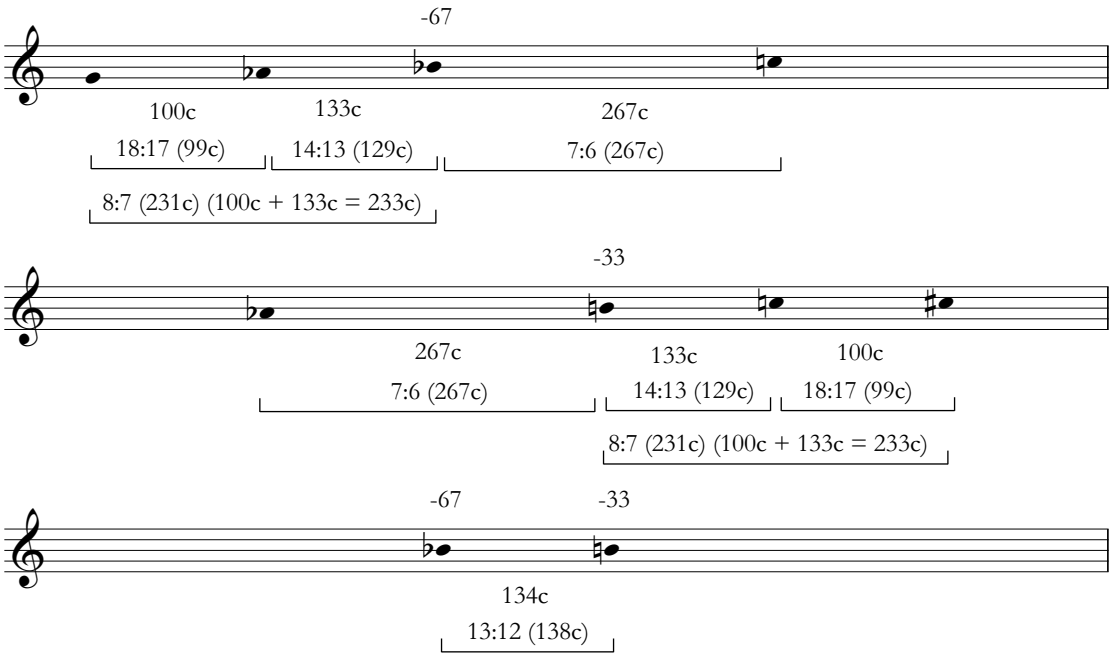


Figure 23. Rough sketches by hand of Figure 22 from my notebooks

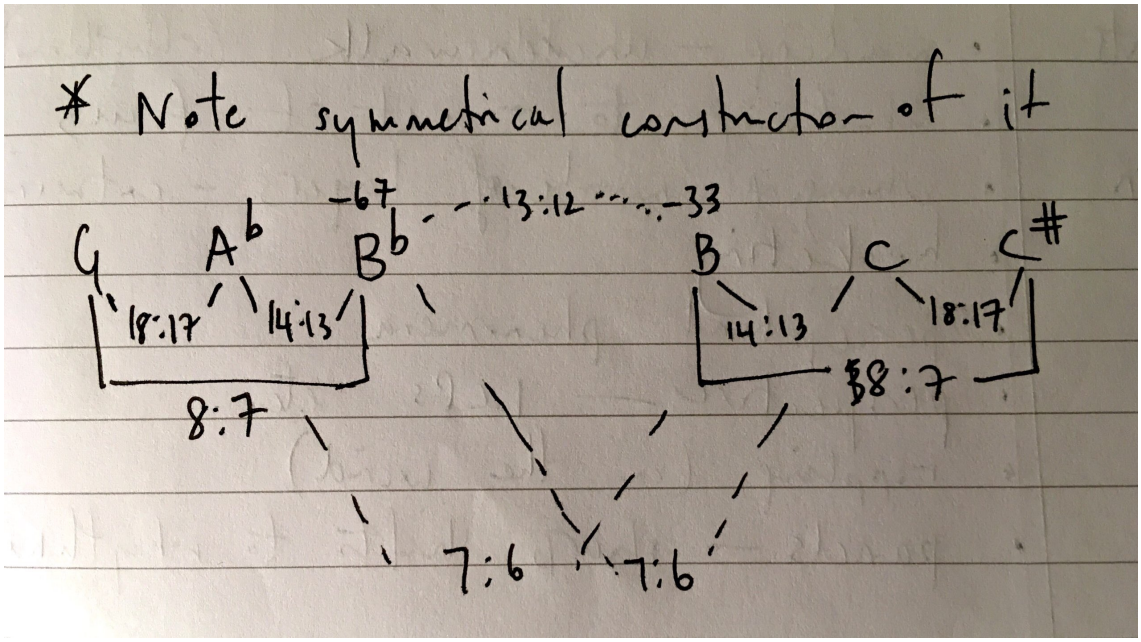
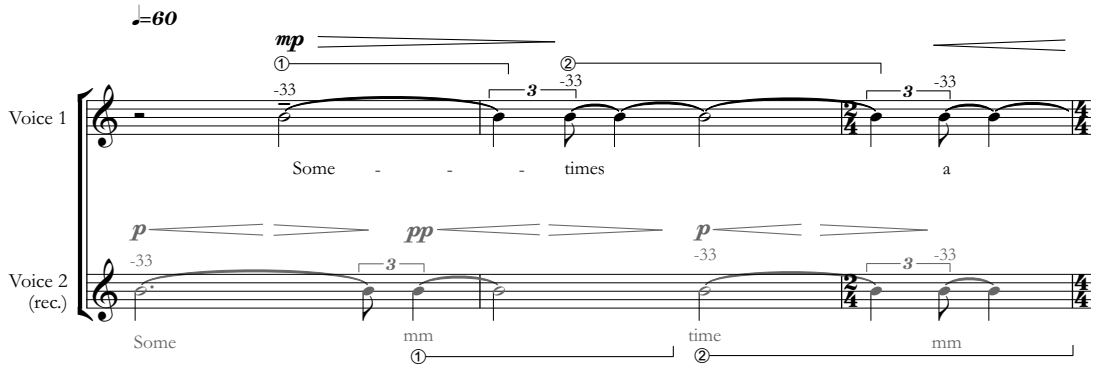


Figure 24. Opening of *The Lantern Out of Doors:* the two vocal parts open in simple canon



The perceptual fusion that occurs between two frequencies in simple proportion to one another (see *1.3.3*) means that discerning the three voices from one another in a live performance is often difficult. In the opening pitch set, the Ab-axis (see Figure 22) allows for intervals implying different harmonic contexts to be juxtaposed; and enables flickering shifts between these (Figure 25).[95] The vocal parts are augmented by instruments and sine tones which—in addition to refracting those core intervals heard in the voice—sound summation tones (see *1.4.3*) and common partials (see *1.3.2*) which enhance the perception of different harmonic contexts (Figure 26).

[95] See 1.3.2 for an explanation of how the intonation of pure intervals creates an associated harmonic context.

Figure 25. Intervals in the opening to *The Lantern Out of Doors*

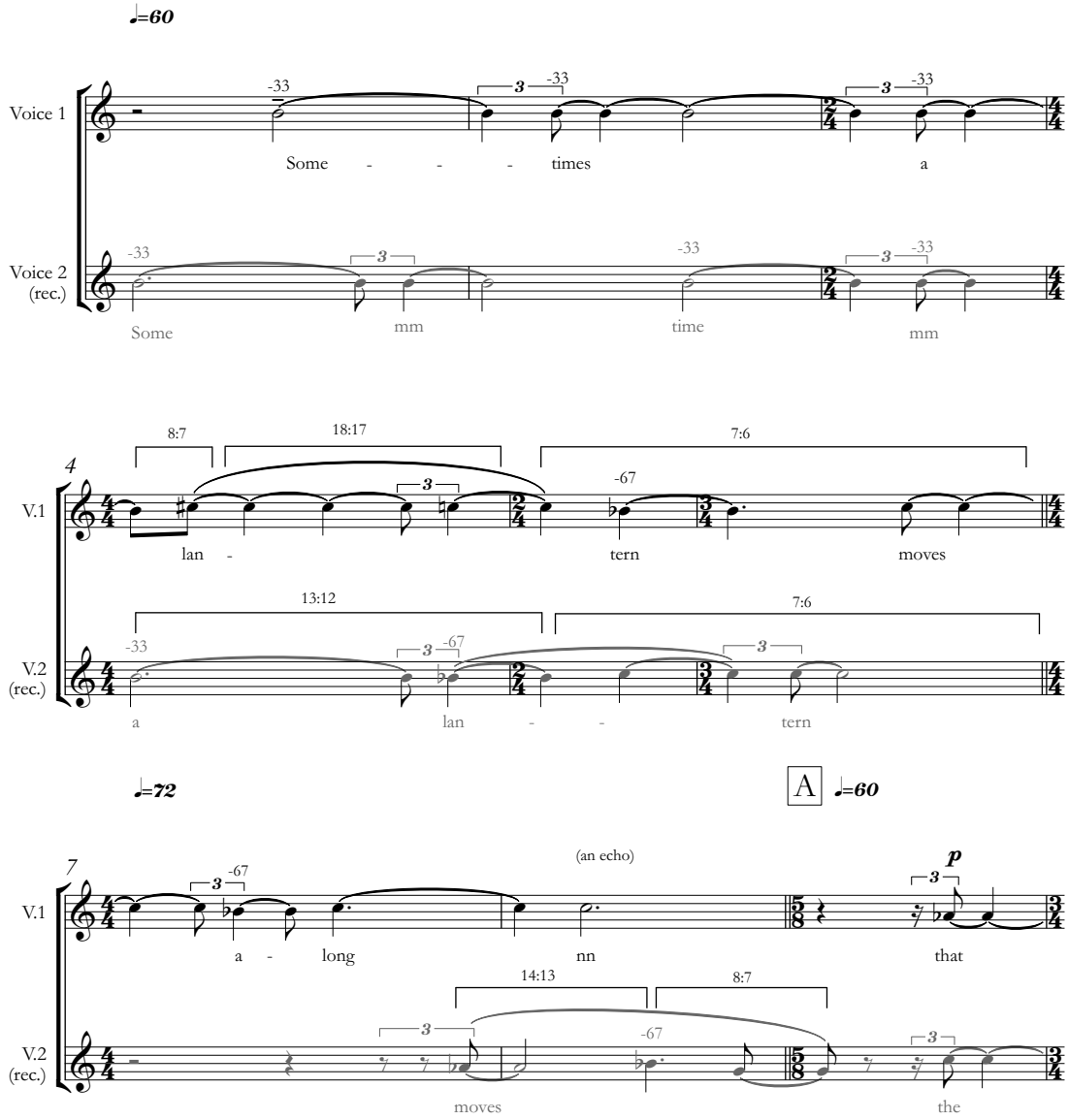
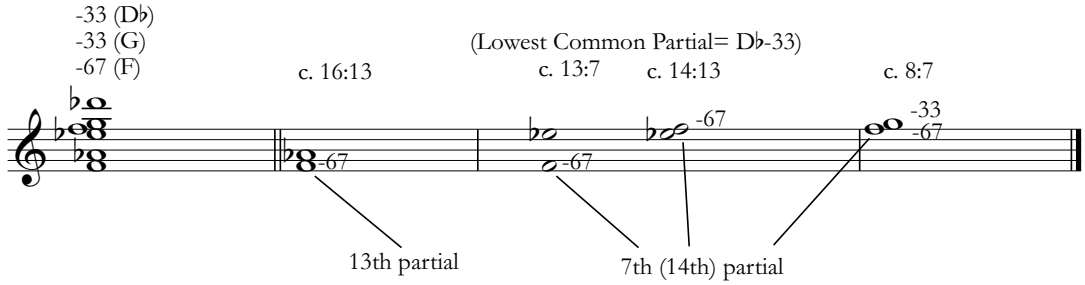


Figure 26. The intervallic construction of the string chords in bars 27-32 of *The Lantern Out of Doors*. F is an axial tone, functioning as both a 13th and a 7th/14th partial.



In the opening to *The Lantern Out of Doors,* the Ab also serves as an axis for modulation (see Figure 27). A third mode, shuffling the intervals of the first two and adopting the descending contours in the zither part, is introduced at Letter F (see Figure 28). The use of pivot tones to modulate between microtonal modes can be traced to both ancient modal practices and contemporary works such as Jonathan Harvey's *Mortuos Plango, Vivos Voco* (1980),[96] Gerard Grisey's *Quatre chants pour franchir le seuil* (1999) and processes of cyclic transposition in Iannis Xenakis' *Mists* (1980).[97]

[96] Jonathan Harvey, "Mortuos Plango, Vivos Voco": A Realization at IRCAM." *Computer Music Journal* 5, no. 4 (1981): 22-24

[97] See: Ronald Sqibbs, "Some observations on pitch, texture, and form in Xenakis' *Mists.*" *Contemporary Music Review* Vol. 21, Nos. 2-3 (2002): 91-10

Figure 27. Modulation between modes in *The Lantern Out of Doors:* Ab is an axial tone mediating Mode 1 (split over the top two staves) and Mode 2 (split over the bottom two staves). Mode 2 is a transposition of Mode 1.

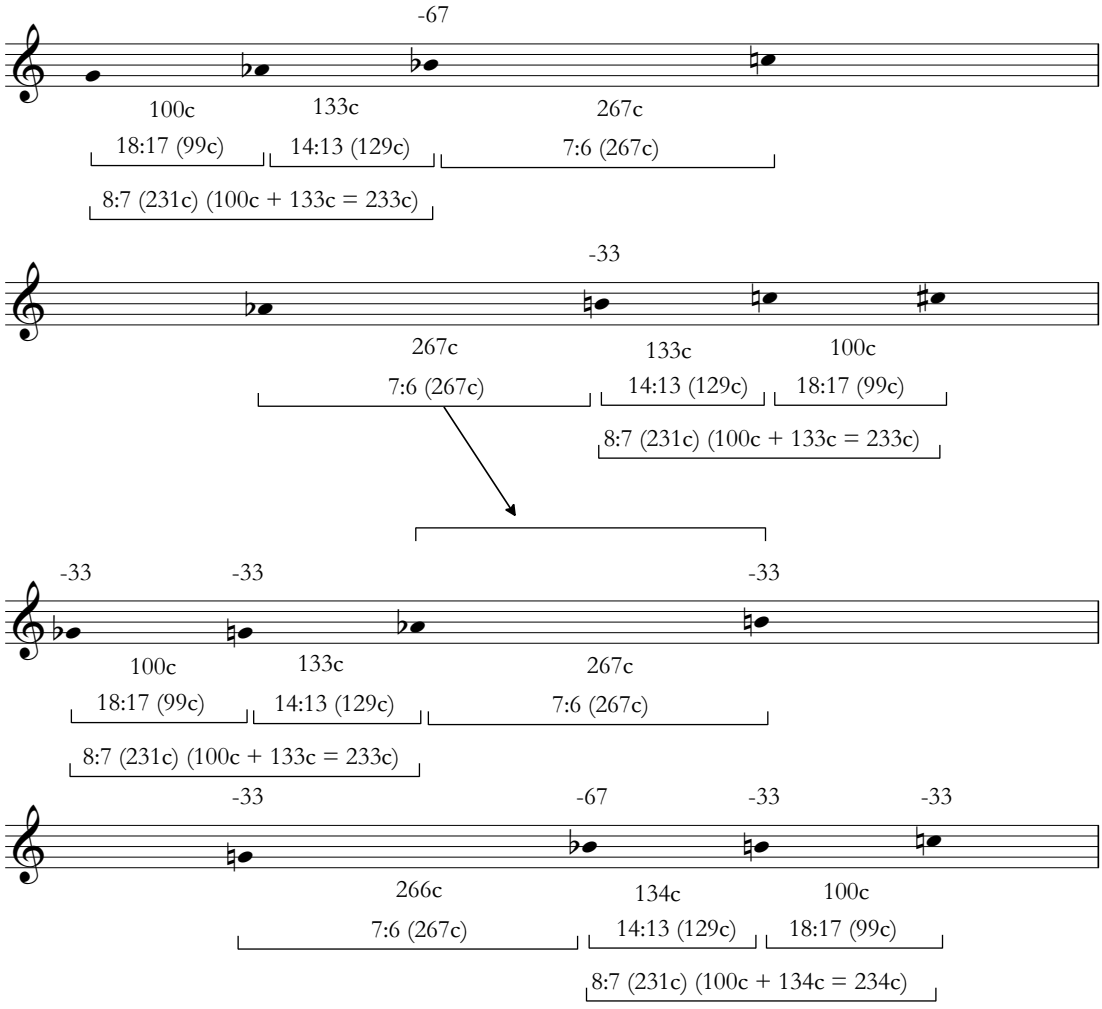
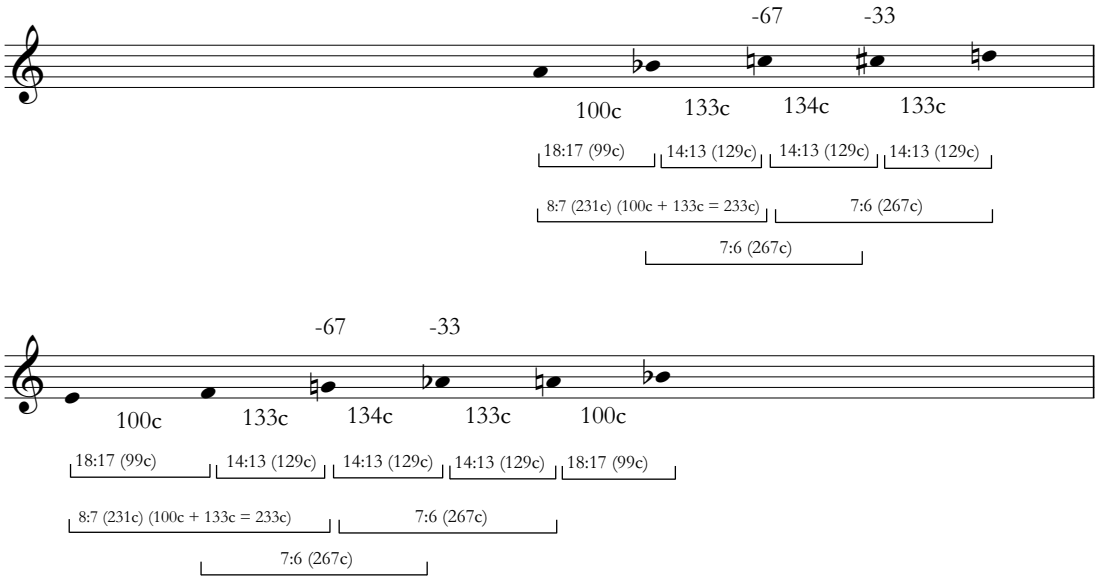


Figure 28. Mode 3, introduced in *The Lantern Out of Doors* at Letter F (top stave), and its transposition, Mode 4 (bottom stave). A is the axial tone.



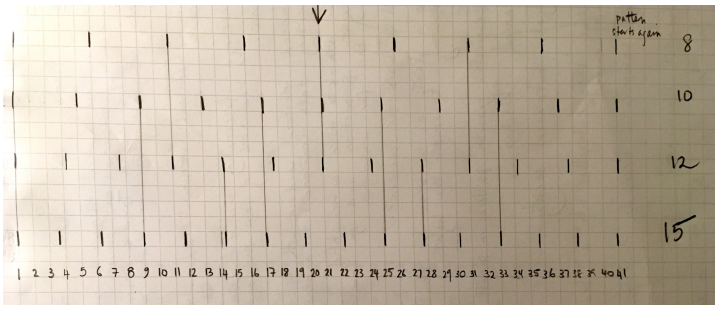
Through such modulations, one can perceive the unfolding of an harmonic space, such that the reiteration of the opening material (Letter J) is sounded 100 cents (a tempered semitone) lower than on its first presentation.

2.3.2 "Murmuring: an irregular pattern that creates a surface sound."[98] *Finding a Rhythmic Counterpart.*

I sought an approach to rhythm complementary to this harmonic language. Just as the sway of a lantern—or its ungraspable play of light—is uneven, so rhythmic patterns in *The Lantern Out of Doors* undulate to veil the inner pulse. Early in the process, I made a sketch of *Lantern* with simple rhythms.

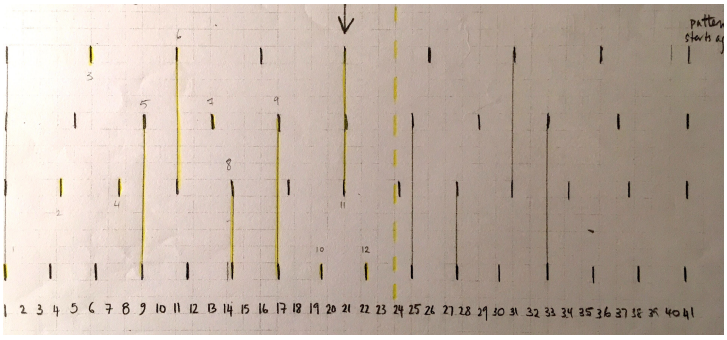
I then created a grid of pulses overlaying four tempi in the proportions 15:12:10:8 (Figure 29). Complementary to the modes from my sketches, each layer related rationally with every other. The grid etched a rippling template of pulses, recurring cyclically at the mark shown.

Figure 29. A sketch of the grid 15:12:10:8



The grid of pulses—as with maps of just intonation—was visual and tactile to work with. By highlighting patterns of marks (see Figure 30) rhythms were pried from this grid, essentially "perforating [it] with [the] rests" of those marks not highlighted.[99]

Figure 30. A rhythm extracted from the grid (in yellow)



[98] Lisa Illean, Journal notes, 11th February 2018.
[99] Lisa Illean, Journal notes, 15th May 2018.

Sharp shifts in the rhythmic pattern delineate the music into panels (e.g. at Letter G). Grafted onto these are also proportional fluctuations in tempo, which, because they could be produced simply and reliably, befitted the pre-recorded material. For unimpeded comprehension of the score, it was clearer to vary the tempo in this way than to transcribe the notated values to fit a uniform tempo.

2.3.3 Veiling the inner pulse: metric simultaneity and simple technologies.

Creating the impressions of an "elastic pulse" and "wave movements" has been a recurring preoccupation of mine. In several works, this has been arrived at through the intersection of overlaid tempi. It was Edgard Varése who commented: "One of the greatest assets that electronics has added to musical composition is that metrical simultaneity."[100] Fittingly, for its second performance, *A through-grown earth* was programmed alongside three canons of Conlon Nancarrow (originally written for player piano).[101] I was reminded of a shared interest in both works to harness simple technology to realise abstract rhythmic ideas.[102] However, in choosing to pre-record material, rather than have it performed by an automaton (a player piano, or the modern equivalent—a computer or programmed disklavier) I retain a human aspect. The zither lines are performed with something closer to an expressive rubato—"to eschew the impression of mechanicalness"[103]—than an absolute precision.

I can also detect the indirect influence of Klaus Huber's work with superimposed time grids in my approach.[104] Describing his string quartet *Ecce Homines* (1998), Huber says:

> "I often worked with non-quantifiable rhythms, stemming from the layering of wave movements, that form an elastic pulse."[105]

This quote has passed through several of my notebooks, expressing succinctly something that captured my imagination.

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[100] John D. Anderson, "Varese and the Lyricism of the New Physics", *The Musical Quaterly,* Vol. 85, No. 1 (1991):31-49

[101] Conlon Nancarrow (1912-1997) is best known for his studies for player piano using complex prolation canons. For example, Study 37 is composed with twelve independant melodic lines, each moving at its own tempo.

[102] For an extension to Nancarrow's work see: Nick Collins and Staften Liljegren. "Microtonal tempo canon generator after Nancarrow and Jaffe." Accessed 3rd September, 2019 https://www.semanticscholar.org/paper/A-Microtonal-Tempo-Canon-Generator-After-Nancarrow-Collins/f2ae112f8d1342480449621d91003c421be2cc9a

[103] Dragana Stojanovic-Novicic, "The Carter-Nancarrow Correspondence." *American Music,* Vol. 29, No. 1, (2011): 74

[104] Huber acknowledges the influence of Igor Stravinsky's *A sermon, A narrative, A prayer* (1960-61).

[105] Klaus Huber, *From Time to Time: The Complete Oeuvre, in conversation with Klaus Steffen-Mahnkopft,* 10.

2.4 Ash-Boughs

2.4.1 Introduction to the Text of Ash-Boughs

In *The Lantern Out of Doors,* the writer's empathy with an unknown lantern bearer arises from contemplating the captivating image of his progress into darkness. Many of Hopkins' poems counter the instability of perception with the reality of things as yet unseen.

> "But only try with eyesight to divide
> One star by daylight from the strong blue air
> And find it will not therefore be descried
> Because its place is known and charted there"
> -from *Floris in Italy*[106]

Hopkin's late poem *Ash-Boughs* contemplates the skyward branches of an ash tree "groping towards a steep heaven" throughout seasonal changes. The poem, adopting an ascending gaze, evokes a quiet, elemental dignity, anticipating— then observing—the tree's knotty maturation and flowering "out of nothing nothing." As protagonists, the tree is paired with the sky: an infinite expanse, at times a "smouldering enormous winter welkin."[107]

> "End of March and beginning of April—This is the time to study inscape in the spraying of trees, for the swelling buds carry them to a pitch which the eye could not else gather—for out of much much more, out of little not much, out of nothing nothing: in these sprays at all events there is a new world of inscape. The male ashes are very boldly jotted with the heads of the bloom which tuft the outer ends of the branches. The staff of each of these branches is closely knotted with the places where the buds have been, so that it is something like a finger which has been tied up with string and keeps the marks."
>
> - Hopkins, journal entry from 1871[108]

2.4.2 Trees as Compositional Models

Two-dimensional maps of rational harmony have often assumed the anatomy of a branching tree,[109] as explored explicitly in James Tenney's *Arbor Vitae* (2006) where "the image of a tree presents as the central metaphor for the work's harmonic structure."[110] In this piece, Tenney maps tones stemming from a B-flat fundamental. Two processes arbitrate note-to-note continuity. On the one hand, the piece moves from distantly related tones to those more closely related to B-flat. One could trace this visually, proceeding from

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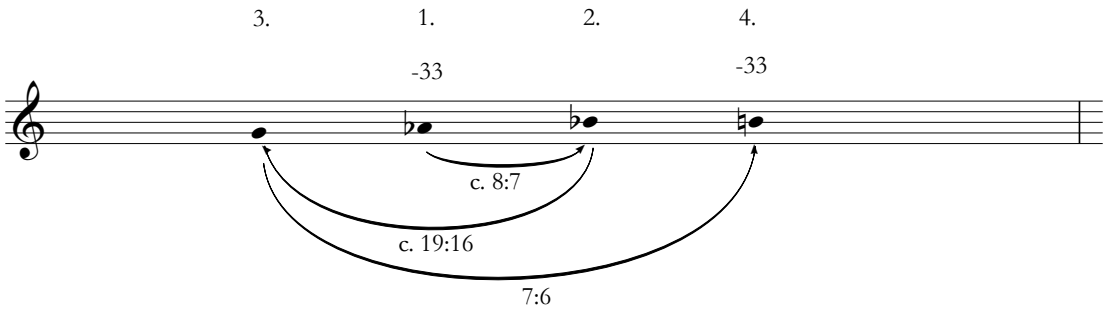
106 Gerard Manley Hopkins, *The Major Works,* 38
107 Please see full text of *Ash-Boughs* in the Appendix.
108 Gerard Manley Hopkins, *The Major Works,* 205
109 See: *1.3.4*
110 Michael Winter, "On James Tenney's Arbor Vitae for String Quartet", *Contemporary Music Review*, Vol 27. No.1 (2008):131-150

the outer edges of the branches to their root. At the same time, distantly related pitches are heard against closely related ones, and thus the perceived harmonic complexity of the combined tones increases.

The overall form of *Ash-Boughs* is, inversely, a flowering (documented in Figures 31-33). This is governed by the iteration of a small number set of melodic phrases. These restrictions on the melodic material help focus the ear on the moment-to moment harmonic changes and the perceived overall expansion of harmonic space. To borrow a phrase from Jeff Snyder, there is an "harmonic propulsion" proceeding from the harmony's distinct intervals that may serve to illuminate the poem's central image.[111]

Figure 31. Pedal points structuring the work unfold from a central tone Ab-33



[111] "There is something melodically advantageous in unequal temperaments, where the horizontal direction of the music can be afforded additional propulsion through the motion of the distinct intervals." Jeff Snyder, "Exploration of an Adaptable Just Intonation System." Ph.D. Diss, (Columbia University, N.Y., 2010), 10

Figure 32. Annotations to the opening of *Ash-Boughs,* showing the unfolding of an harmonic space through modes, pedal tones and axial tones

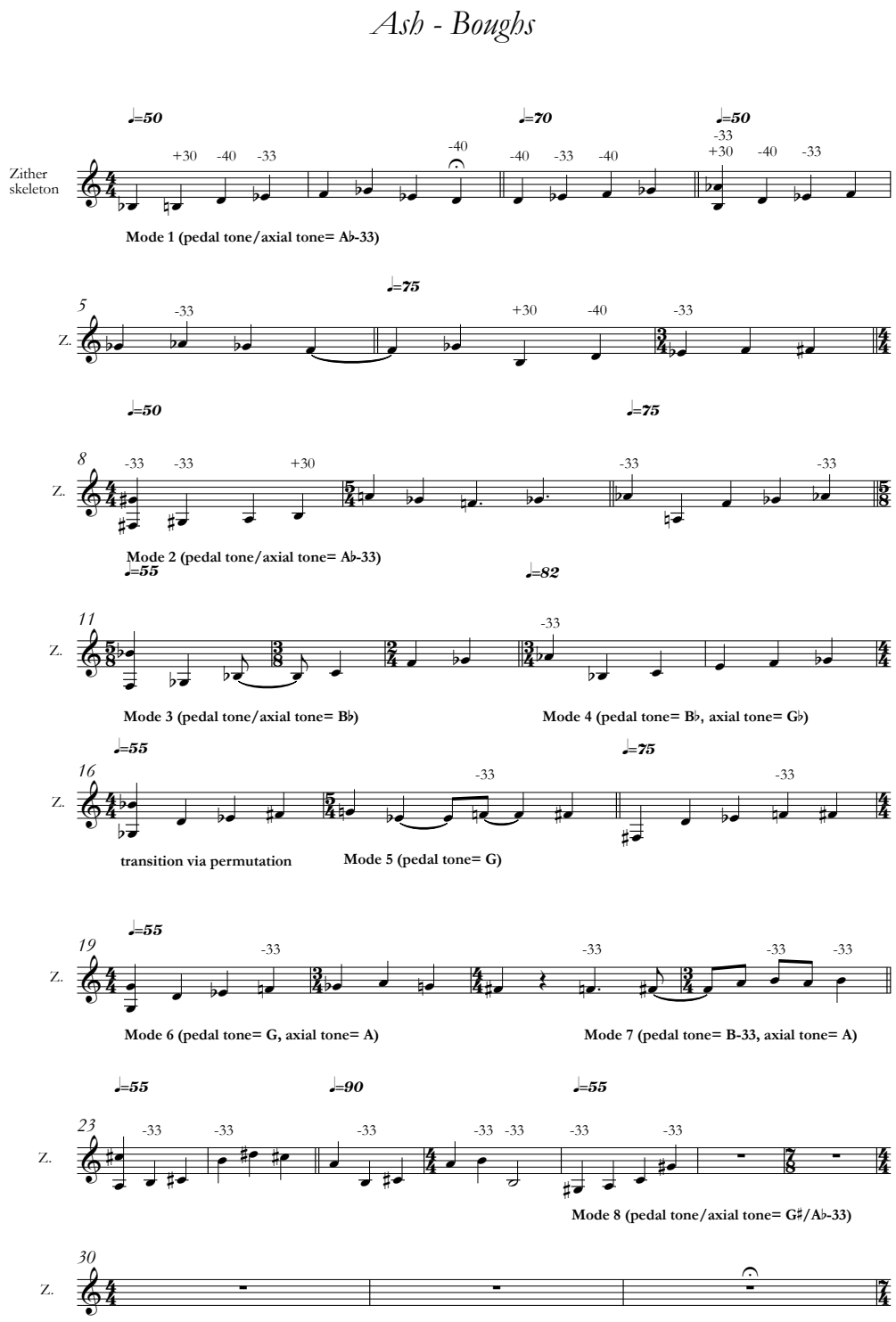
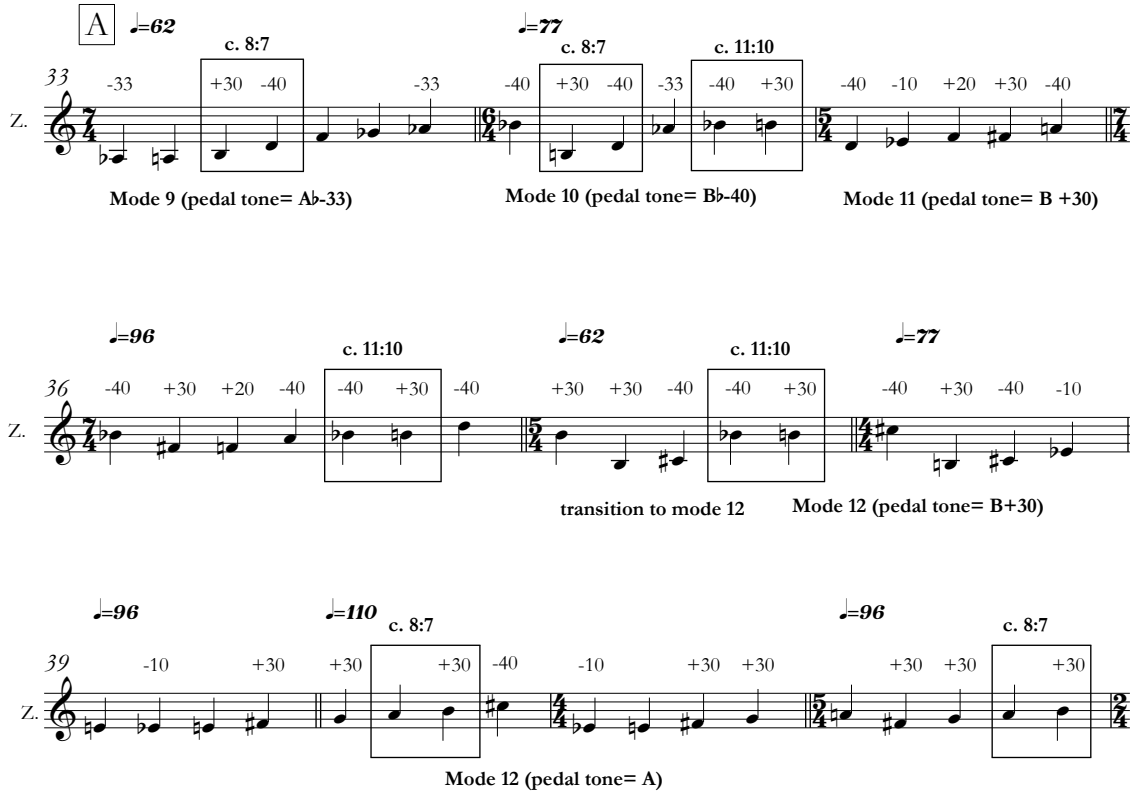


Figure 33. Annotations to the Letter A of *Ash-Boughs*: modes, pedal tones and axial tones (boxed).



2.4.3 "The bass moves into the middle" [112]*: Modulation through Axial Tones*

In setting the first line of *Ash-Boughs,* the voice unfolds from a pivotal Ab tone lowered-33c (from equal-tempered tuning of Ab where A=440 Hz). By lowering in this manner one central tone and one other, I could build a web of chiefly pure intervals around an axis (Figures 34). It was viable for a vocalist to reproduce these microtones within a tendrillar, flowing melody (Figure 35).[113] The patterns of Hopkins' observed inscapes are not clean, but often craggy, irregular lines or unfurling coils. My setting of *Ash-Boughs* seeks to combine unruly lines with the rational proportions of natural geometry.

[112] Jonathan Harvey, "Reflection after Composition." *Tempo,* No. 140 (1982): 2-4 doi:10.1017/S0040298200035397

[113] I was concerned with how to most practically incorporate just tunings into sung melodies.

Figure 34. The vocal harmony opening of *Ash-Boughs,* unfolding from Ab-33

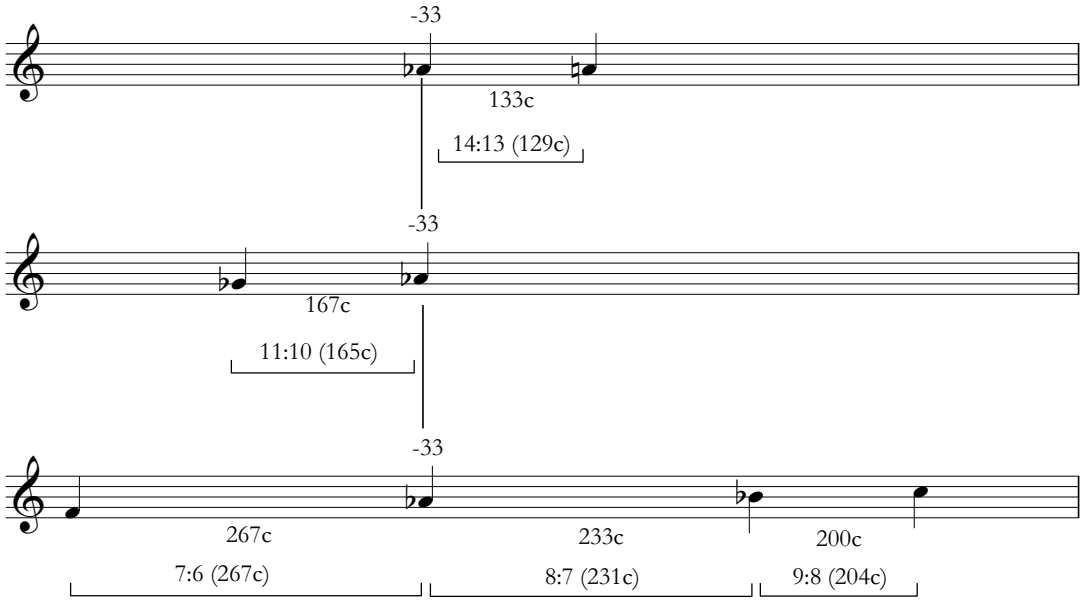
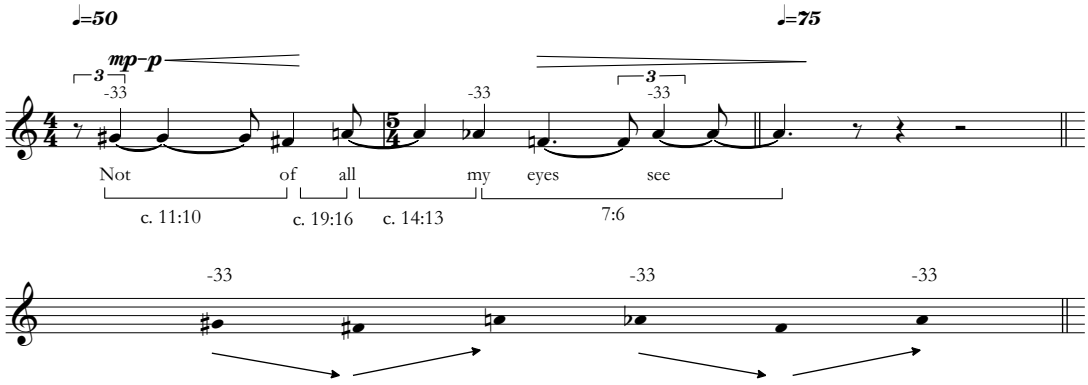


Figure 35. The vocal line opening of *Ash-Boughs,* unfolding from Ab-33



The second line unravels as a near-inversion of the first (Figure 36), while the third lines reimagines intervals from the first (Figure 38).

Figure 36. ***Ash-Boughs:*** **the second vocal line**

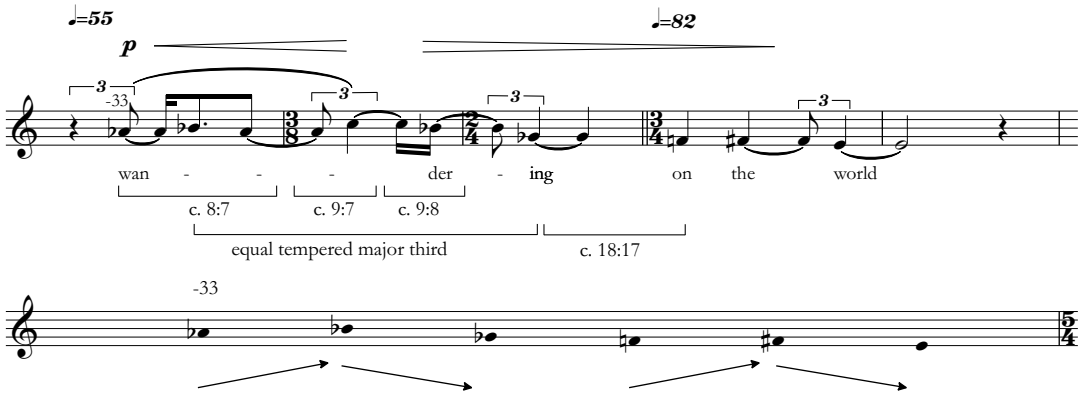


Figure 37. ***Ash-Boughs:*** **the fifth vocal line transposes the second**

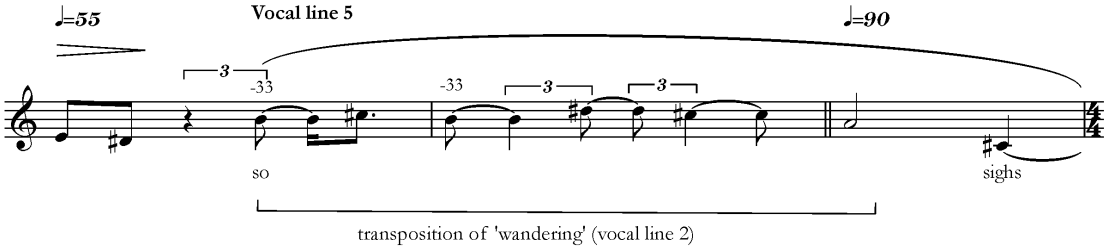
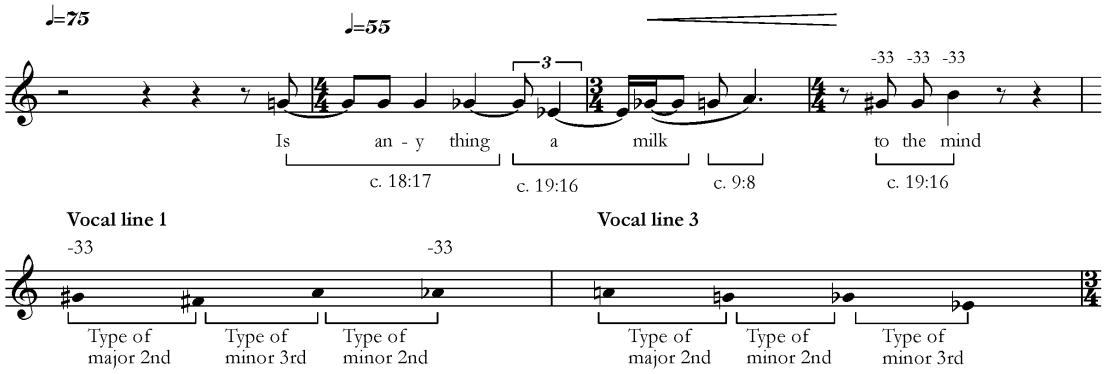


Figure 38. ***Ash-Boughs:*** **the third vocal line**



In his paper *Reflection After Composition*, Jonathan Harvey describes his own fascination—one he traces also in Anton Webern—with harmonic structures radiating from a central axis. This "omni-directionality" Harvey links to a "floating state", a liberation of musical space from gravitational systems[114] and an atmosphere of serenity: "more contemplative

[114] Such as the gravitational pull of the tonic found in Western music using the common practice major and minor scales.

than active in spirit… with being rather than becoming…closer to Palestrina, with his deemphasised, floating curves."[115] One is also reminded of the mirroring process that generates Per Nørgård's 'Infinity Series',[116] and from which lines resembling the unfolding symmetry of fractal geometry are spun.[117] Ligeti has spoken of the imaginative influence of fractal geometry in his work: "Its kind of growth, degeneration, decay and branching-out."[118] The paradigm of fractal geometry links music and nature, when it is found in both iterating intervallic patterns issuing from a central tone (or tones) and patterns in the natural world.

2.4.4 Rhythm in Ash-Boughs: Sprung Rhythm and Elusive Pulse

Wanting to also emulate the inherently musical rhythms in Hopkins' writing, I recorded myself reciting the poem and began by transcribing this at slower speeds, modifying intuitively. I annotated the poem, marking cadences, apexes and phrases resonant with rich internal rhymes. The original rhythms for each line were palindromic, but this varied more as work on the piece progressed (see Figures 39 and 40). Hopkins considered the sheer variety of the 'sprung rhythm' that haunted his ear "the most natural of things",[119] being found in common speech and written prose. One could aptly apply his own description of 'reversed rhythms' to it: "that irregularity which all natural growth and motion shews."[120] Relatedly, Elliot Carter has given the term "prose rhythm" to the variety of successive note lengths appearing in Varese's music and the elusive pulse that ensues. A similar aperiodicity in *A through-grown earth* keeps the vocal lines buoyant.

---

[115] Harvey also relates this to a spiritual mysticism: in Schoenberg, Swedenborg's heaven, in Webern, the "monumental immobility" of the alps and in his own work, the writings of Rudolf Steiner.
Jonathan Harvey, "Reflection after Composition." *Tempo,* No. 140 (1982): 2-4 doi:10.1017/S0040298200035397

[116] Erik Christensen, "Overt and Hidden Processes in Twentieth Century Music." *Axiomathes* 14 **(**2004): 97-117

[117] In shapes exhibiting an "unfolding symmetry" similar patterns are found at every scale ("self-similarity").

[118] Satory. "An Interview with György Ligeti in Hamburg", *Canadian University Music Review, 10,* 112-113

[119] Gerard Manley Hopkins, *The Major Works,* 108. For a discussion of Hopkins' Sprung Rhythm see pp. 106-109

[120] Gerard Manley Hopkins, *The Major Works,,* 107-8

Figure 39. The rhythm of the opening vocal line of *Ash-Boughs* is palindromic

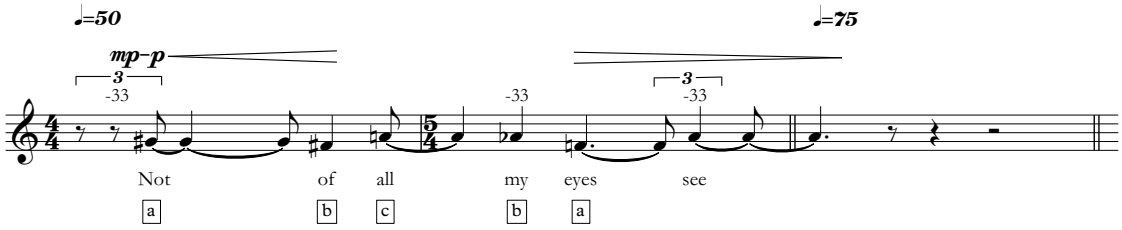
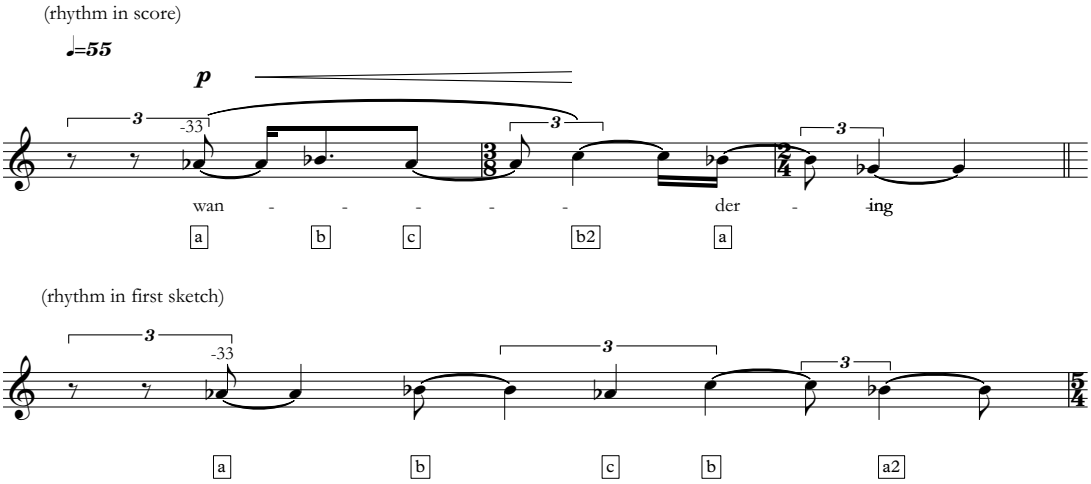
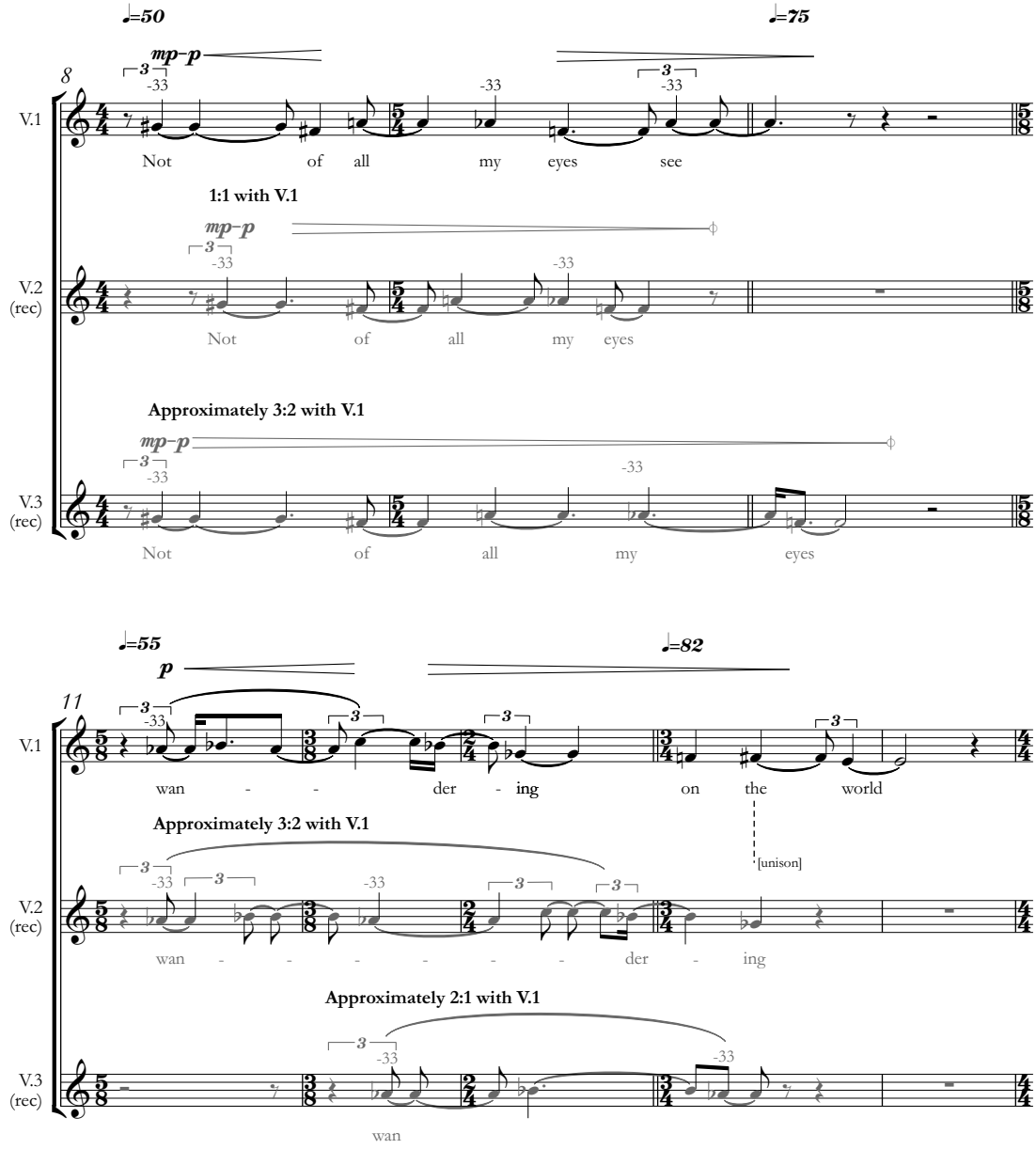


Figure 40. An excerpt from the second vocal line of Ash-Boughs, showing changes in rhythm between the sketch and the final score



The pre-recorded vocal lines were written as diffractions of the primary line. I imagined the primary vocal line had been splintered, as waves are splintered when they pass through an interference grating (see Chapter Four). The vocal lines were variously augmented (in the proportions 3:2 or 2:1) or delayed; and tapered, as if drawn into the distance (Figure 41). As in *The Lantern Out of Doors,* the use of just intervals creates a sonorous plait of voices that is difficult to untangle.

Figure 41. An annotated excerpt from *Ash-Boughs* showing the simple proportional relationships between the three vocal lines



The zither harmony extends that of the vocal lines (see Figure 42). The opening mode reinforces harmonic contexts where the Ab-31 is perceived as 7 and 13. The merging of two harmonic contexts creates a complex, dense murkiness (Figure 42). The harmonic context then clarifies, accompanied by a sense of openness (bars 16-18, Figure 43).

Figure 42. The construction of Mode 1 in *Ash-Boughs*: the zither part augments pitches from the opening vocal line (centred)

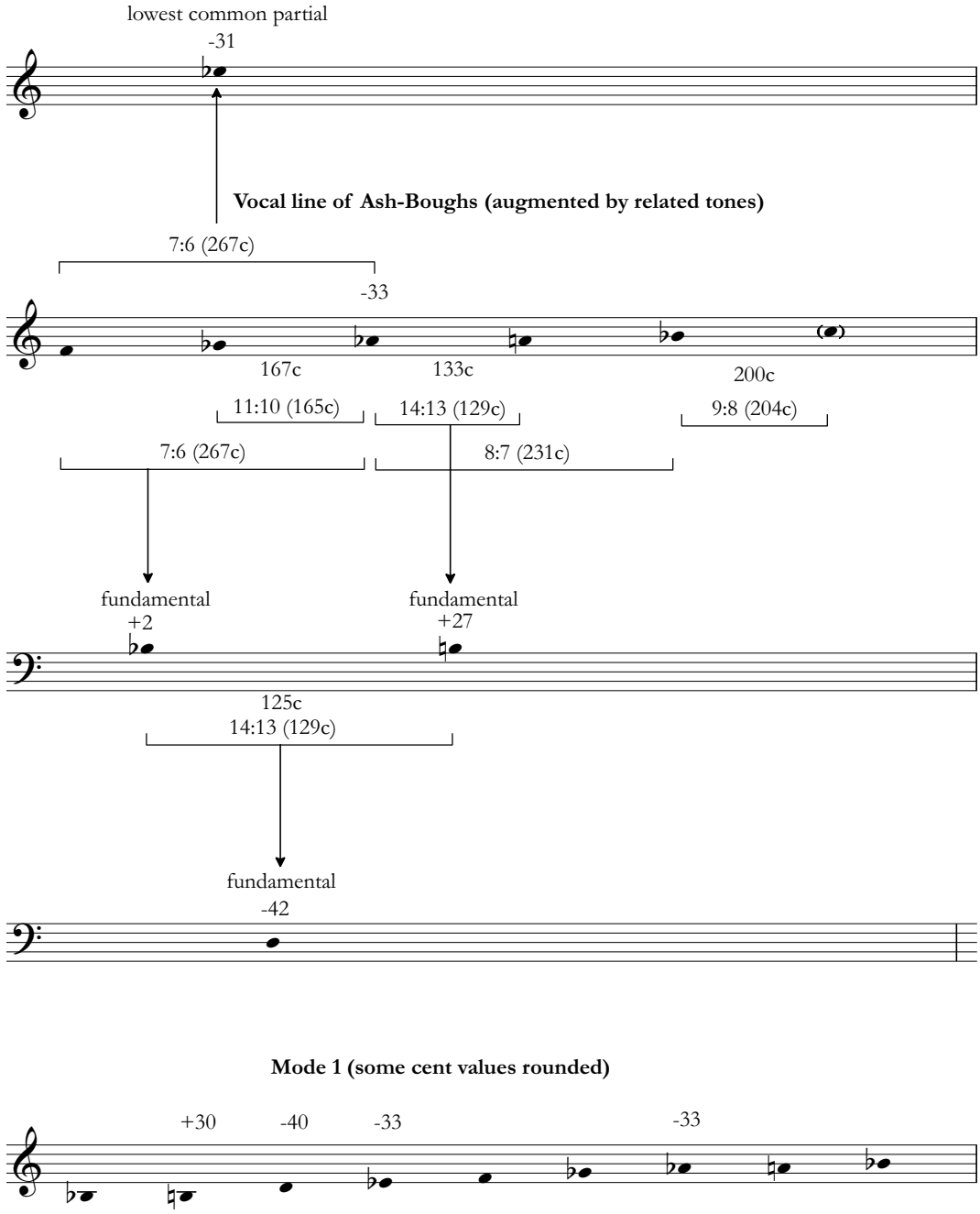
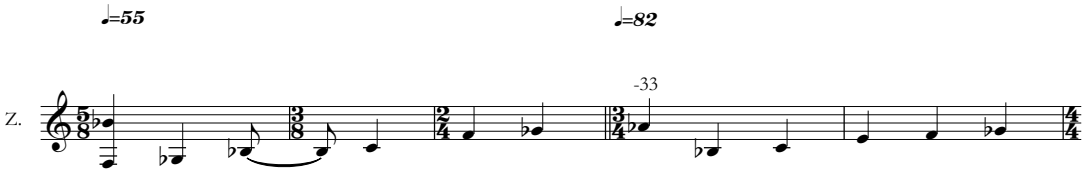
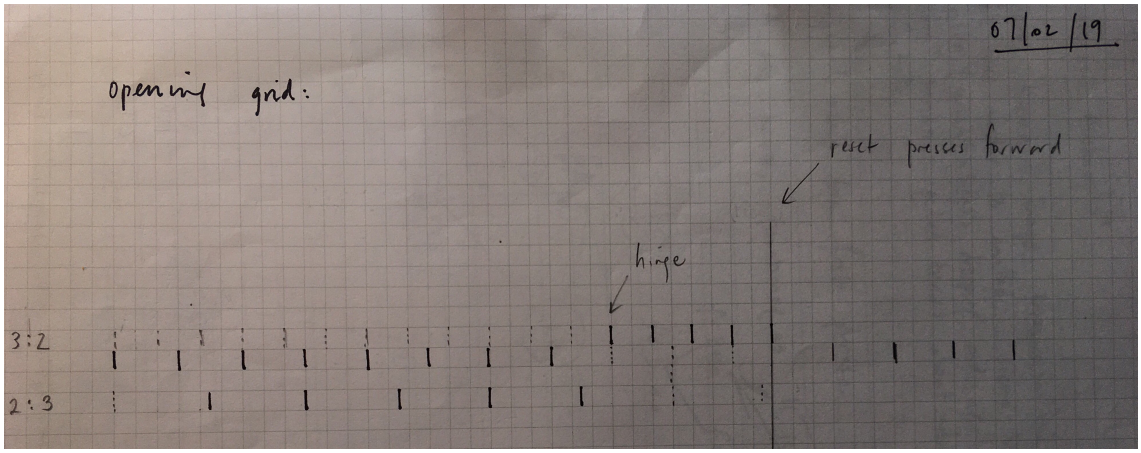


Figure 43. The zither part from *Ash-Boughs,* Bars 16-18



The harmony—sounded through irregular lines, shifting in pace—unfolds through branching patterns and rational proportions. In the opening, three different layers of tempi intersect in a manner creating gentle forward propulsion.[121] Patterns of rising and falling tones mark out time discretely, each like a branch indented with marks "*where the buds have been."*[122] A basic grid of tempo relationships (Figure 44) underpins the whole movement, but the weave of the grid and the density of the lines—sometimes with close, knotty intervals and at other times more open—varies.

Figure 44. Original hand sketch for *Ash-Boughs,* showing three tempo layers overlaid



In these ways, I sought a correspondence between the world of the poem and the sound world of its setting, hoping to create a gently restless harmonic and rhythmic language evoking growth or the sense of an 'infinite beyond.' This endeavour at least set an expressive framework within which I could work with rational harmony in a personal way.

[121] Originally in strict relation to one another, but re-notated with small discrepancies that arose during the recording process.
[122] Gerard Manley Hopkins, *The Major Works,* 205

2.5 My Own Heart

In the third setting, the vacillating disposition depicted in the text of *My Own Heart* is mirrored in harmony that is irresolute. In the opening, modulation between Modes 1 and 2, and between Modes 2 and 3, is mediated by the tones they share (see Figures 45 and 46). More than in the preceding settings, unique modes (presented as descending lines) fuse as unusual sonorities that take time to settle in the ear (see also in Figure 45 how each note of a mode relates rationally to every other).

Figure 45. Modulation between Modes 1 and 2 in *My own heart*

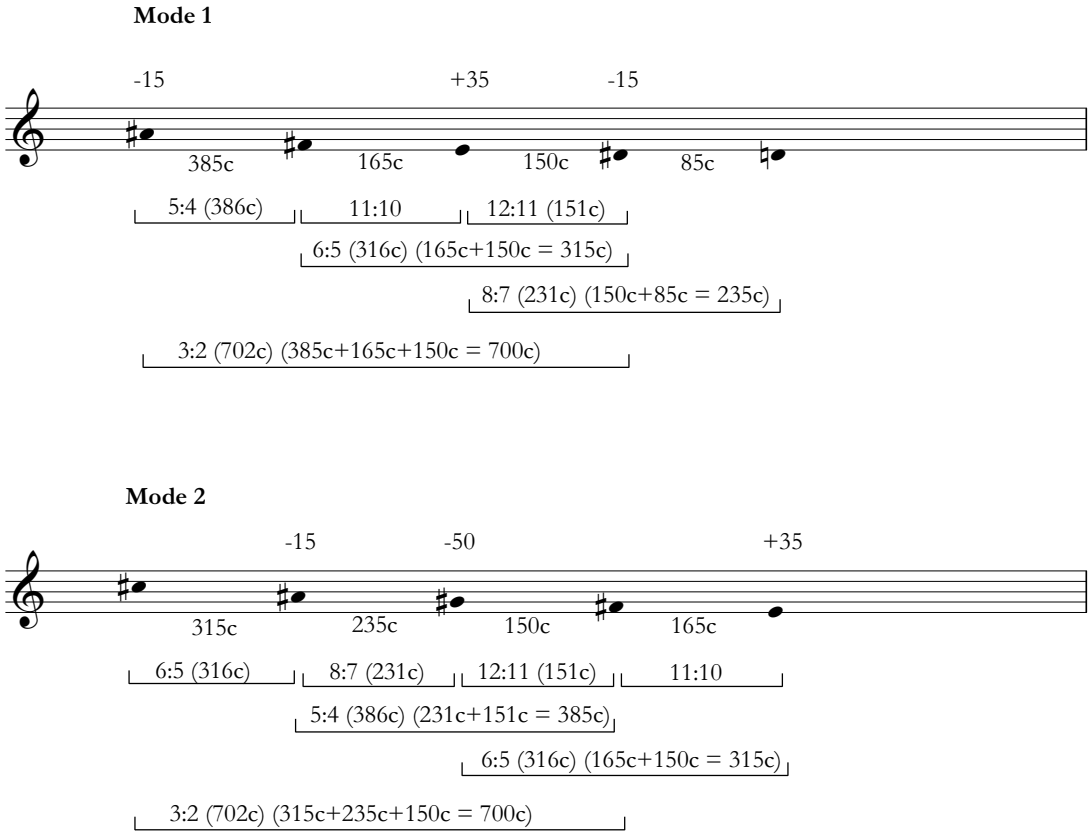
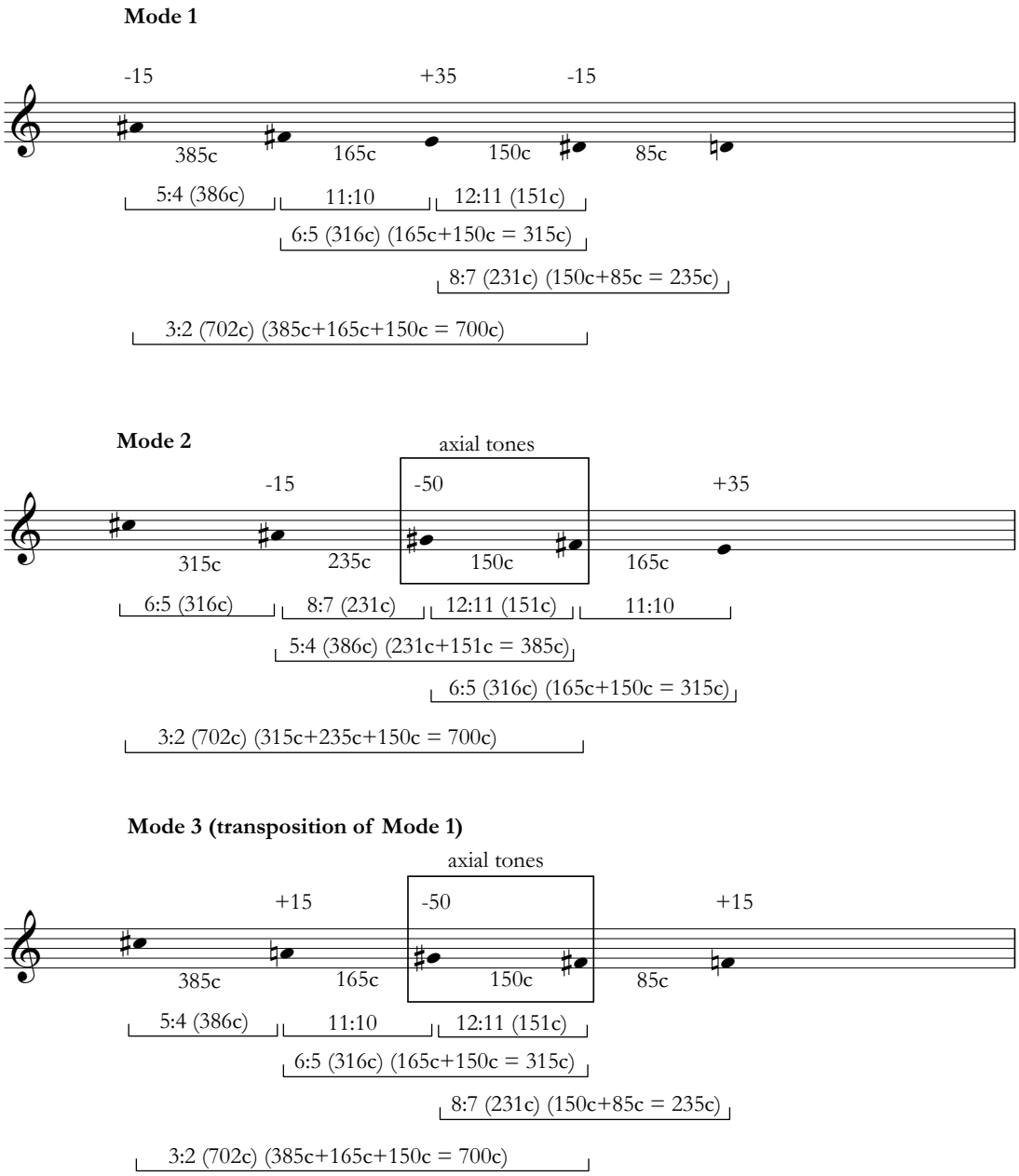
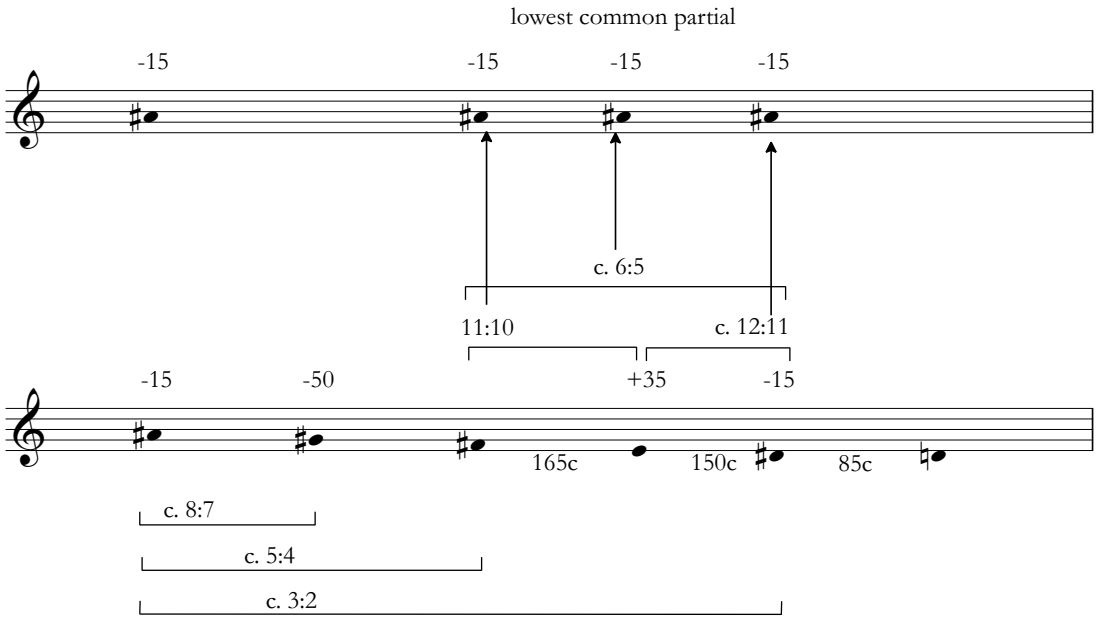


Figure 46. Modulation between Modes 2 and 3 in *My own heart*



The subtle variations between these modes means that they could be perceived as aspects of an harmonic field unfolding from a single shared tone (Figure 47).

Figure 47. ***My own heart*** **: Modes 1 and 2 as two aspects of a sonority unfolding from an A#-15**



2.6 A Short Reflection

The worlds of these settings are introverted and contained. To achieve this, I removed chunks of each poem and streamlined modulations if they became labyrinthine. As shown in Figure 47, I thought of modes as aspects of one another. This way of working with sound prefigures ideas in the following chapter, which pays close attention to the reciprocity between rational harmony and sculptural aspects of sound (such as dimension and perspective).

Chapter Three
Weather a Rare Blue

3.1 An Introduction to Weather a Rare Blue

Weather a Rare Blue was composed for Explore Ensemble and first performed at Kings Place, London, in September 2018.

3.1.1 Rational Harmony and a Multidimensional Conception of Sound.

The opening chapter laid out a particular approach to rational harmony: one "attentive to memory and akin to the contemplation of a sculpture."[123] It tenders that any vertical 'slice' of sound or music (forming a sum of pure intervals) resembles an object, in the sense that it bears dimension and perspective.[124] As with oil painting, dimension is created through the building up of thin, transparent layers (in this case, a sum of tones). Changes in emphasis—the composition of these tones or the distribution of weight among them—are comparable to a shift in perspective: to creating different lighting conditions or degrees of presence. Imagining sound in this way depends on evocative visual and spatial metaphors, so I find making comparisons to the visual arts, architecture and film illuminating.[125]

For example, I found these ideas about sound enriched by an encounter with Dan Graham's pavilion *Double Exposure* (1995/2003).[126] Installed in the gardens of Serralves Park, Porto, *Double Exposure* is a triangular prism: two sides of mirrored glass conjoining a colour transparency—an image of the location "photographed at dusk on a spring day" (see Figure 48).[127]

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123 Lisa Illean, "Vanishing Points", 17

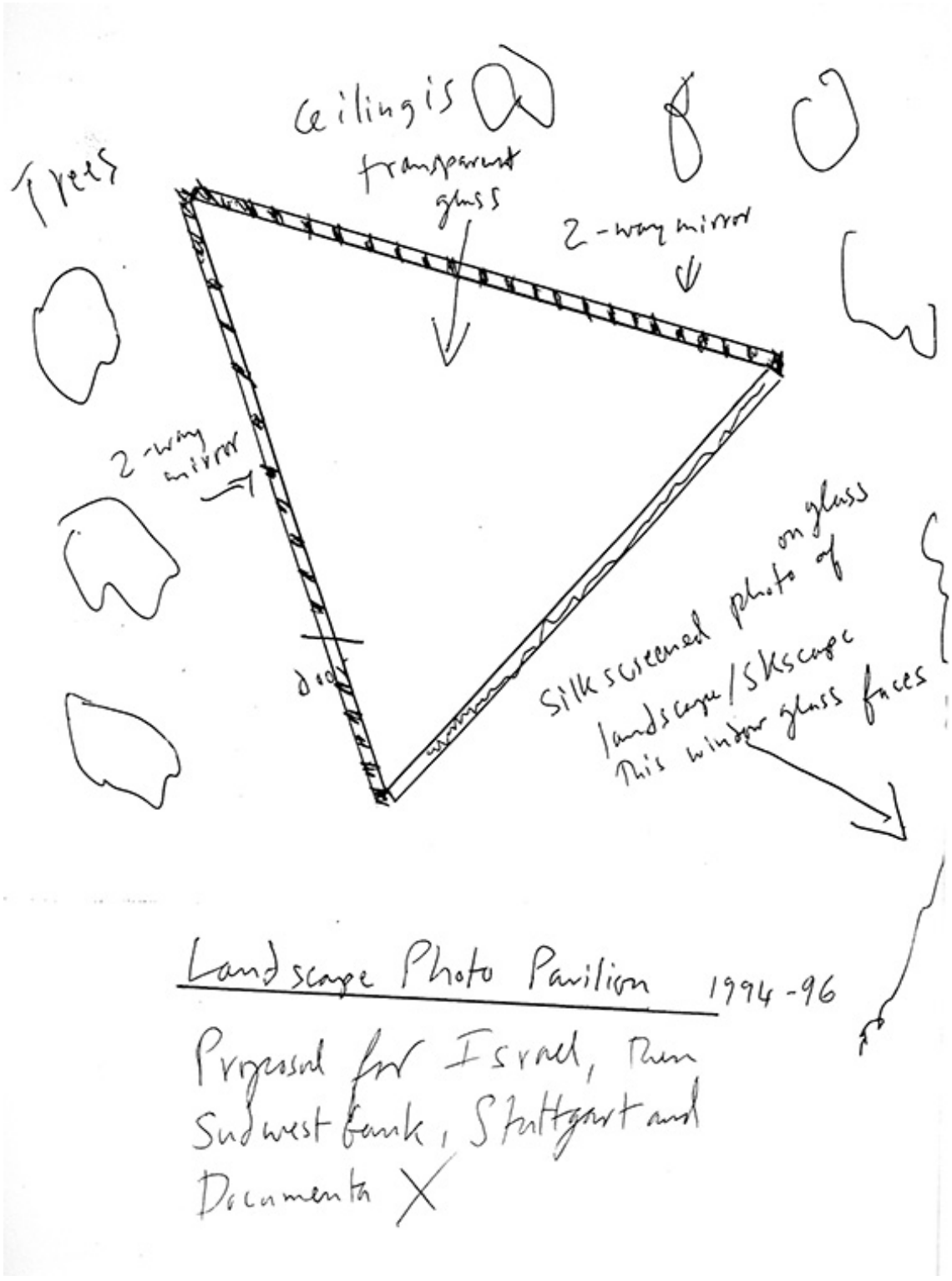
124 Consider, for example, Klaus Lang and Andrei Tarkovsky's respective prismatic descriptions of music and image: the former as a "free and self-standing acoustical object" which can be experienced from limitless vantage points and the latter as "an entire world reflected as in a drop of water." Klaus Lang, "The Fat Time and the Thin Time", Youtube, accessed 21st Feb. 2019 https://www.youtube.com/watch?v=Q0smZO4GbIk. Andrey Tarkovsky, *Sculpting in Time: Reflections on Cinema.* Translated by Kitty Hunter-Blair, (Austin: University of Texas Press, 1986), 11

125 I feel a kinship with György Ligeti's words: "Optial assocations like envelopes are constantly in front of me when I compose. I always think of spatial forms as units, visual or tangible units. From this standpoint my acoustical conception always has a synaesthetic side. I concern myself with colours, forms, continuities. And I always put them into a spatial model, like an object in space." S. Satory. "An Interview with György Ligeti in Hamburg", *Canadian University Music Review, 10,* 110-17

126 Dan Graham, *Double Exposure*, 1995/200. Mirrored glass, glass, stainless steel, Cibachrome transparency. 248 x 410 x 355 cm
Coll. Fundação de Serralves — Museu de Arte Contemporânea, Porto

127 "Dan Graham (Urbana, Illinois, USA, 1942) uses the conventions of architecture as a form of social interaction. Double Exposure, one of a body of works using of the form of the pavilion, consists of a triangular-base pavilion with a door through which the interior can be accessed. The external face is mirrored on two sides. On the third a colour transparency has been applied that reproduces the image of the surrounding landscape photographed at dusk on a spring day. From the inside, viewers can see the landscape through the transparency, while the two other sides reflect the Park outside and allow for viewing from the

Figure 48. Dan Graham's original sketch for *Double Exposure* 1995-6, accessed 11th March, 2019, https://aup.e-flux.com/project/dan-graham/



inside. Vision is thus broken down into multiple perspectives in terms of who is looking at what, and from overlapping of a present moment, the actual landscape, and a past moment, the same landscape but photographed. Double Exposure was commissioned for the Serralves Park as part of the retrospective exhibition at the Museum in 2001, 'Dan Graham: Works 1965–2000'. The piece was installed in 2003." "Dan Graham" accessed 11th March, 2019, serralves.pt/en/pathways/dan-graham/

The architecture of the pavilion allows the surroundings to be viewed from multiple perspectives, but also for the living, moving landscape to overlay a static photograph of it in an eerily beautiful way (Figures 49 and 50). The passage of present time is subtly underlined by fixing a given moment in the colour transparency.[128] Fluctuations in natural light affect the reflectivity/transparency of the two-way mirror glass, while movements of other spectators add another layer of contingency. *Double Exposure* seems to extend beyond its literal edges in endless continuity with its environment. While the title alludes to photography, the pavilion undoes the "finitude" of the photographic image.[129] Instead, it is more closely connected with the works of Giovanni Battista Piranesi (1720-1778)—whose "multiplicity of vanishing points give his prints a sense of motion"[130] or the technique of *mise en abîme,* where an infinite 'feedback loop' of an image is implied.[131] The splintering of an image (or sound)—its diffraction—is central to the following chapter. Here I will take the double exposure itself as my departure: in this particular case, the translucent overlaying of a fixed past and an evolving present.

Figure 49. Dan Graham's *Double Exposure* source: https://commons.wikimedia.org/wiki/File:Double_Exposure_(Graham).jpg

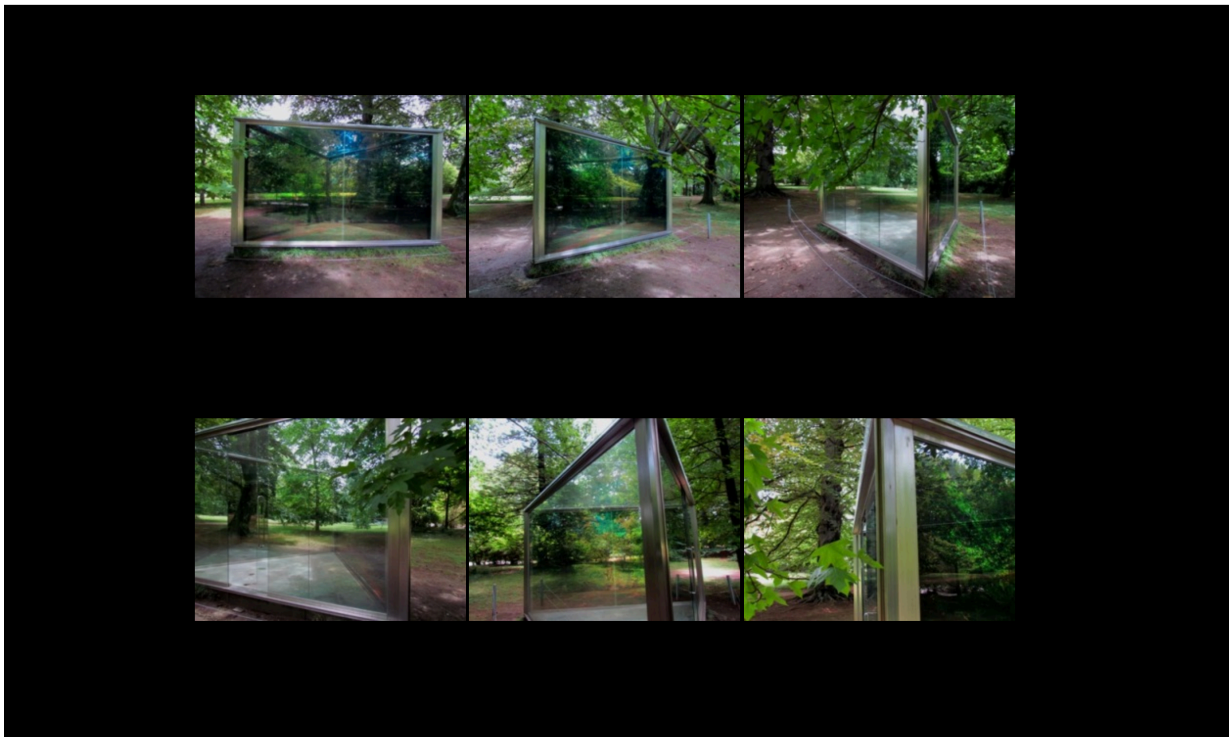
[128] "The idea comes both out of 19th century American landscape artists like Frederic Church or Albert Bierstadt, but it also comes out of how to make a time delay without using machines. The piece is a triangular structure, two sides are two-way mirrors and the front side is a colour transparency superimposed on the glass. Fifty meters in front you can see through the image to observe the landscape shifting in terms of times of day and season." Dan Graham, accessed 11th March, 2019, http://www.tiojai.com/Photo/Foto2015/DoubleExposure.htm

[129] Yves Bonnefoy, *Poetry and Photography*. Translated by Chris Turner. (Calcutta: Seagull Books, 2017), 9-10

[130] Steven Jacobs, "Eisenstein's Piranesi and Cinematic Space", accessed 3rd March 2019, https://www.academia.edu/23035954/_Eisensteins_Piranesi_and_Cinematic_Space_2016_

[131] For example, in visual art, repetitions--seemingly infinite--of an image within an image.

Figure 50. Dan Graham's *Double Exposure* source: http://www.tiojai.com/Photo/Foto2015/DoubleExposure.htm



3.1.2 Weather a Rare Blue I. Two Layers: Tuning, Tempo and Space

Translucence is artfully depicted in this line from an Anne Stevenson poem: "Rain's rained weather a rare blue, so you can see the thinness in it." [132] Taking the central four words for its title, *Weather a Rare Blue I* overlays music performed live by a pianist, accompanying ensemble and pre-recorded ensemble. In this piece I was especially interested in creating concordance and continuity between equal temperament (the piano and its resonance)[133] and non-tempered sonorities (mostly pre-recorded). Superimposed are two acoustic spaces: the performance venue and recording studio. The pre-recorded sound has an almost inevitable regularity, resembling breathing. Conversely, the music to be performed live undulates, and gradually accelerates in a non-linear fashion across four and a half minutes. The pre-recorded sound is also more diffuse, as if recalling a past sound of which "only the perfume remains."[134] The pre-recorded (non-tempered) sonorities colour the performance space, creating at times a halo-type effect. The acoustic ensemble appears continuous with these sounds in its immediate environment, yet is ultimately slightly displaced.

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[132] Anne Stevenson, "Buzzard and Alder" *In the Orchard: Poems with Birds.* (England: Enitharmon Press, 2016)
[133] For a discussion about piano tuning and equal temperament please see Chapter Five.
[134] Graham Lack, "Objects of Contemplation and Artifice of Design: Sonic Structures in the Music of George Benjamin", *Tempo.* No.215 (2001): 14

3.2 Historical Precedents for—and Influences on—Weather a Rare Blue

3.2.1 Double Exposures in Sound

Weather a Rare Blue doesn't attempt to translate Dan Graham's *Double Exposure* into sound, but is influenced by its manner of overlaying images. Musically, this notion has an early antecedent in the experiments with animated sound, surfacing in Europe during the 1930s and 40s. Because sound was recorded optically, in this context the overlaying of images and the overlaying of sounds were the same thing. Sound was recorded on film as black and white patterns that were converted to electrical impulses by a photoelectric cell in the film projector, and rendered audible by an amplifier and loudspeaker. Animated sound pioneers, such as Arseni M. Avraamov, N.V. Voinov, Arthur Hoérée and Jack Ellit, painted or photographed patterns directly onto the film. Avraamov's method of drawing repeated geometric shapes onto film enabled him to create a 48-tone microtonal system: 'The Universal System of Tones.' Double exposures of these graphics allowed a limited form of polyphony.[135] For Avraamov, composition is visual and tactile.

3.2.2 Other Precedents Meaningfully Impacting my Approach

The overlaying of two ways of tuning in *Weather a Rare Blue* also resembles works of a phenomenological orientation where two interacting layers alternately blend and conflict. In his series of compositions *Harmonium #1 - #7* (1976-2000), Tenney explores how harmonic relationships between pitches are perceived, via a process of modulating from the overtones of one fundamental to those of another. The simultaneous sounding of pitches from divergent overtone series creates a *perceived interference*, which is resolved when the arrival at a new fundamental is accompanied by a sense of sonic fusion, a phenomenon described by Tenney as the 'sudden making of sense' of the harmonic relationships between the pitches.[136] This overlaying also creates a *physical interference* (in the form of beating patterns resulting from the sounding of tones from divergent series against one another). Larry Polansky has developed the term 'heterophonic tuning' to describe pitch processes that produce "two incomplete series [that] are present at once and thus perceived at the same time (one exiting, the other coalescing)."[137] Other examples of this include the pre-recorded tanpuras in Marc Sabat's *Light Ground* (2014/15), which move between gamuts of tones based on different fundamentals, and Alvin Lucier's works for acoustic instrument(s) and slow sweep pure wave oscillators.[138]

Conversely, there exist works for pre-recorded sound/tape and acoustic instruments that meld these two elements, essentially collapsing the distinction between layers. These pieces

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[135] Richard S. James, "Avant-garde Sound-on-Film Techniques and their Relationship to Electro-Acoustic Music", *The Musical Quarterly* Vol. 72, No. 1 (1986): 81
[136] Robert A. Wannmaker, "The spectral music of James Tenney", *Contemporary Music Review,*72:1, 2008: 118
[137] Giocomo Fiore, "Heterophonic Tunings in the Music of Larry Polansky." *Tempo*, Vol. 68 (2014): 39
[138] For example, *Music for piano with slow sweep wave pure oscillators* (1992).

often blur the distinction between instrumental timbre and harmony to great effect, such as in Jonathan Harvey's *Inner Light 1* (1973).[139] *Weather a Rare Blue* shares concerns with both approaches. I was attentive to the interaction between the acoustic and pre-recorded layers, and moments of potential perceptual interest arising from this. In live performance, the piano resonance and pre-recorded sonorities blend in a way that makes them at times compellingly indistinct. Similarly, the overlaid multiphonics (for example, in bar 2) are by nature volatile, and have the capacity to either merge with the pre-recorded sound or disrupt it. On the whole, however, I tried to create a situation where tempered and non-tempered tunings converge harmoniously yet retain independent identities.

3.2.3 Spatial Perception

This independence arises both from the different tunings and through principles of spatial perception. Drawing on the writings of Simon Emmerson, two different frames of space (the 'stage' and the 'landscape') are superimposed; the 'stage' here referring to the acoustic ensemble and the 'landscape' the projections of pre-recorded sound.[140] Despite instructions that the pre-recorded material should imitate as closely as possible the acoustic quality of the live instruments,[141] small discrepancies are inevitably perceived. Just as one perceives the spatial and material properties of an unlit room through sound—through the quality of reverberation, for example—so the dimensions of this double exposure are partly decoded through the body. Dimension is also created over time, in the mind and imagination (what Jonathan Harvey calls the 'mental object': "The immanent object we ourselves construct, joining together the moments of time in our memories and making a pattern and meaning.")[142] In *Weather a Rare Blue I,* this mental object is disclosed through a small medley of recurring motifs, slightly altered with each utterance.

3.2.4 Suspension; Lacunae; Omnidirectionality

The effect of *Weather a Rare Blue I* is ideally one of hushed repose and eddying stillness. Reflecting on this, two latent ideas came to mind: one is of the lacunae or klangfläche ('sound sheets') found in the music of Richard Wagner, Gustav Mahler and Jean Sibelius.[143] The other is the "musical expression of suspension in space" Jonathan Harvey associates with the pentatonic mode.[144]

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[139] Jonathan Harvey,"Inner Light (3)." *The Musical Times* 117, no. 1596 (1976): 125-27.
[140] See: Simon Emmerson, "Aural landscape: musical space" *Organised Sound.* Vol. 3, No. 2 (1998): 135-140
[141] The pre-recorded part has both a 'dry' track and a track with reverb, so that the amount of reverb on the recorded material can be mixed in the performance space to imitate the quality of the live instruments in the space.
[142] Jonathan Harvey, "Electronics in Music: A New Aesthetic?" *Journal of the Royal Society of Arts* 133, no. 5345 (1985): 313-19
[143] See: Thomas Patteson, "Sibelius and the "Sound-sheet": Orchestral Innovations in the Early 20th Century", accessed 1st March, 2019, http://www.thomaspatteson.com/writings.html and
Thomas Peattie, *Gustav Mahler's Symphonic Landscapes*, (Cambridge: Cambridge University Press, 2015), 97
[144] Jonathan Harvey, *In Quest of Spirit: Thoughts on Music* (Berkeley: University of California Press, 1999), 71-73

The principle of modes such as this—which, rather than having a single pitch centre, allow any tone to function as a point of repose— underpins *A through-grown earth* (Chapter 2) and *Land's End* (Chapter 4). In *Weather a Rare Blue I,* a similar logic concerns the nine sonorities forming the pre-recorded material (samples 1-9). While diverse in density and mood, each could serve as a place of rest. Their order is exchangeable: there is no underlying process moving from one state to its opposite.[145] They recall, rather, sound "broken down into multiple perspectives"[146] or perhaps Anton Webern's description of "omni-directionality" in his *First Cantata* (1938-40):

> "There is not a single centre of gravity in this piece. The harmonic construction is such that everything remains in a floating state."[147]

3.2.6 Lightsense No. 2: A Study in Sonority

Lightsense No. 2 became a preparatory study in sonority, paying close attention to both harmony and orchestration. Specific care was given with the placement of the clarinet within the ensemble (considering the strength of the odd partials in the tones it produces).

3.3 Composing the Pre-recorded Sonorities

Initial sketches for *Weather a Rare Blue* produced a family of materials: piano figures, non-tempered zither figures, and veiled chords composed to colour and reinforce each of these. The chords were often allied with the figures through tones at their outer limits: a shared fundamental or a pronounced high common partial fusing both elements. As work progressed, some of these chords formed the basis for nine pre-recorded sonorities. Although eventually separated from their original role colouring figures, as a set they retained the close harmonic associations developed during the sketching process.

Renewing my earlier analogy to oil painting, each sonority was composed of several pre-recorded layers. Within each sonority, a foregrounded interval—or salient pitch—influences the harmonic context one perceives. As shown in the table below (Figure 51), these tones are all related to a fundamental tone G, often through pure intervals and sometimes through tempered ones (an imperfection emerging from the sketching process).[148] My writing of a congruous complementary piano part was directed by these shifts in perceived harmonic context.

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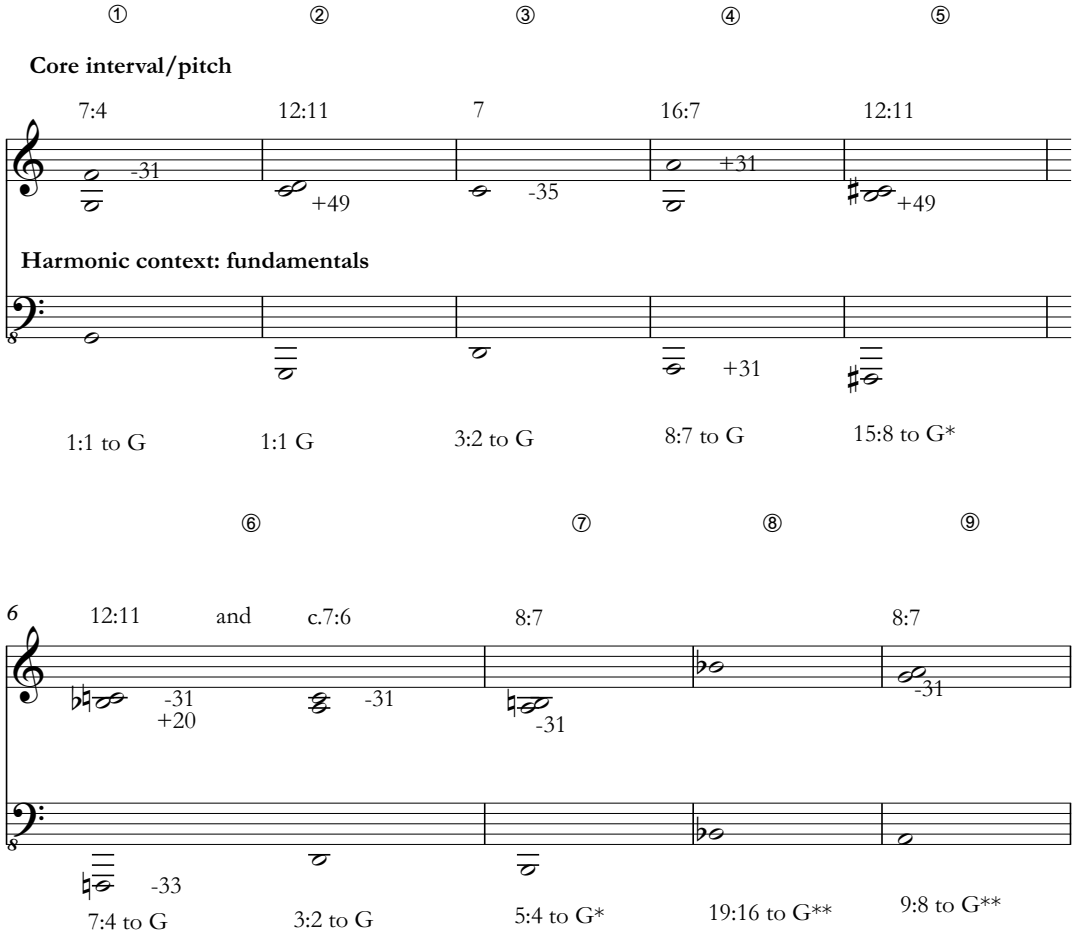
[145] For example, from 'harmonicity' to 'inharmonicity'.
[146] "Dan Graham" accessed 11th March, 2019, serralves.pt/en/pathways/dan-graham/
[147] Jonathan Harvey, *Reflection After Composition*, 2
[148] This imperfection proved useful in developing the piano part.

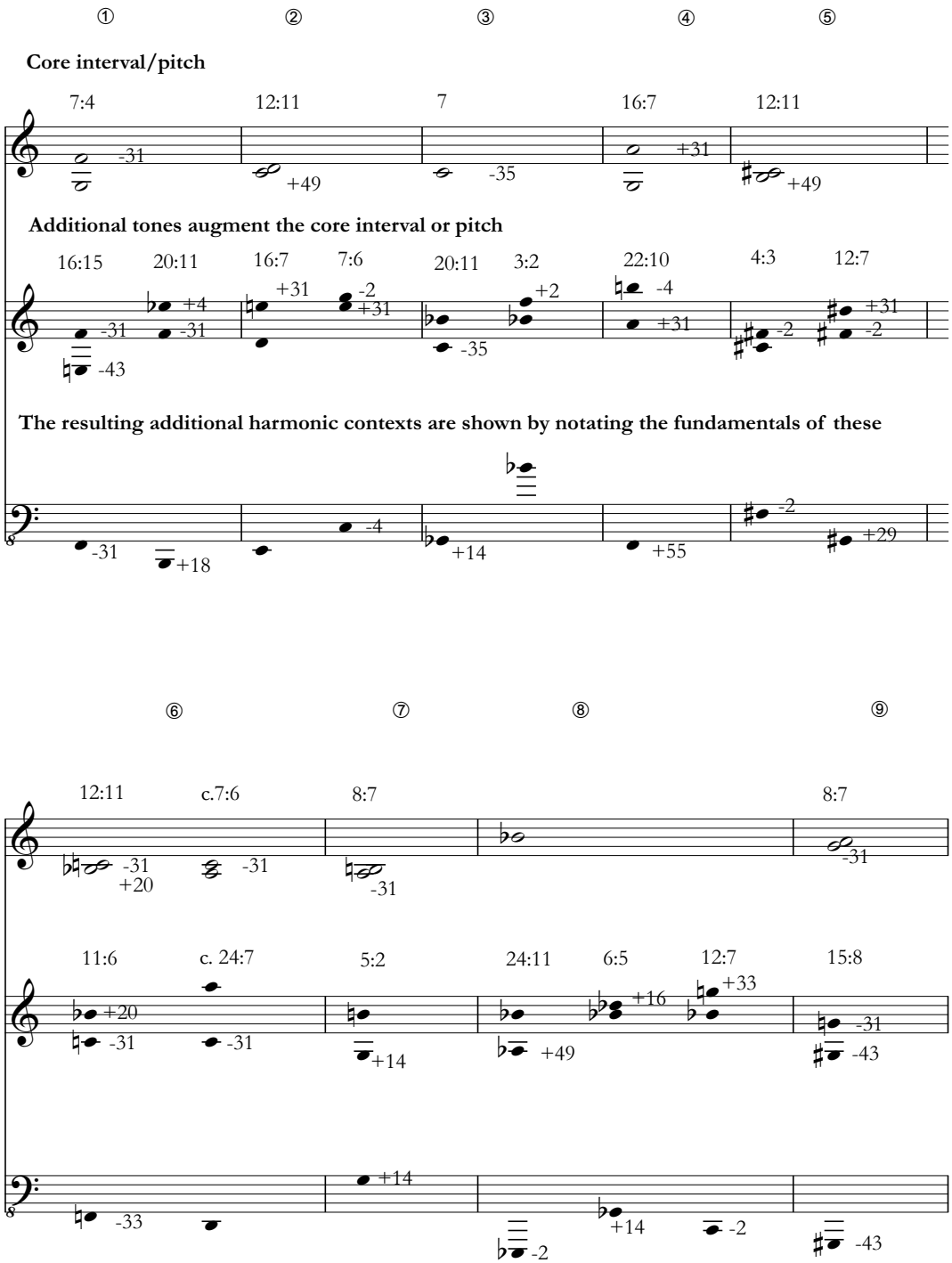
Figure 51. ***Weather a Rare Blue.*** **Top stave: The core interval or pitch of nine sonorities (in notation and ratios). Bottom stave: The fundamental implied by these intervals and its relationship to G**



* tempered interval
** approximate just interval (within 5 cents deviation from the precise tuning)

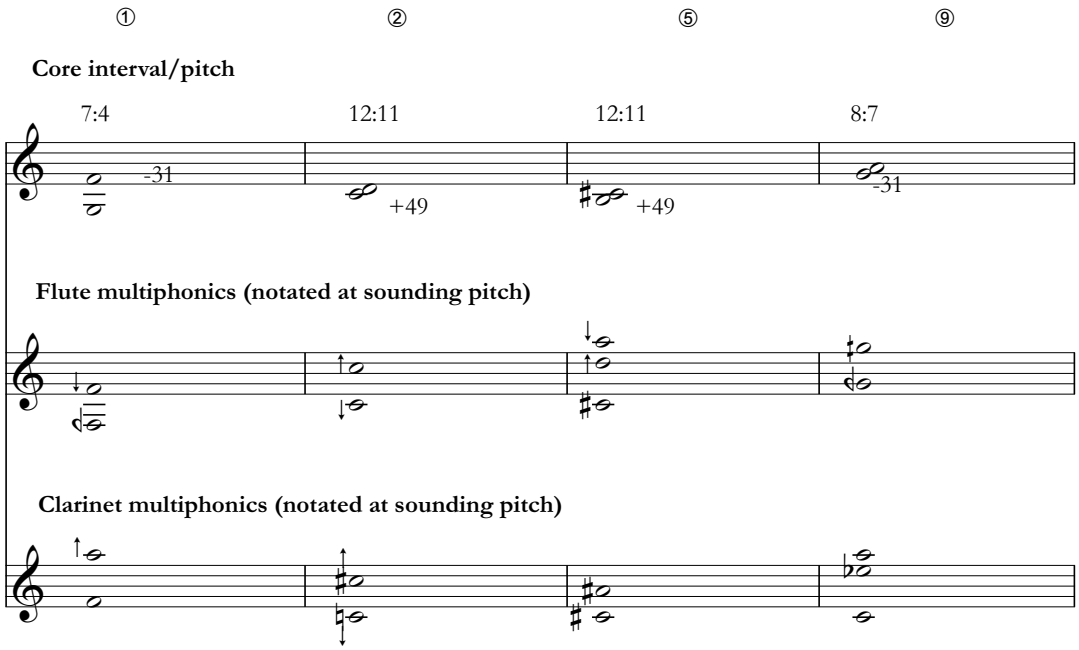
In composing each sonority, the core tones tabled above were sonorously augmented by further tones in (mostly) just relations (Figure 52). Beginning with the logic of rational harmony, I was led largely by my ear, auditioning possibilities and often favoring the intervals 12:11, 11:10, 8:7 and 7:6. In a day's experimentation with Explore Ensemble, I explored the composite sound through making incremental adjustments in dynamic, balance and timbre.

Figure 52. ***Weather a Rare Blue,*** **nine sonorities. The core tones tabled in Figure 51 were sonorously augmented by further tones**



Several of the pre-recorded sonorities included a layer of unruly fragile multiphonics. These created a fluctuating, vague halo of sound around a pronounced pitch or interval, as if weathering its precise edges (Figure 53).

Figure 53. *Weather a Rare Blue*: The multiphonics used for sonorities 1, 2, 5 and 9



In Audio Sample 2 sonorities the nine sonorities are presented in order; this is the same order as they appear in the opening minutes of *Weather a Rare Blue.*

Audio sample 2. The nine sonorities for *Weather a Rare Blue* heard in succession.

Fashioning these sonorities was a deeply satisfying process but it was not neat. Likewise, writing the piano part (to be performed live on a piano tuned in equal temperament) was guided by my ears as much as by logic. Chords were cast in waves onto a mobile rhythmic grid, similar in conception to that used in *The Lantern Out of Doors.* The music tightens like a coil, increasing in density and speed across four minutes, in contrast to the dependable arcs of the pre-recorded material. In practice, there is, I think, a disquieting tension between the acoustic and pre-recorded material: as layered elements, they are continuous with one another but not always concordant.

3.4 Terrain Vague

3.4.1 Weather a Rare Blue – III – XI

The third section (movements III-XI) of *Weather a Rare Blue* also plays with the multidimensional nature of sound space, however it approaches affinities between sound and architecture quite differently. It has its origins in *terrain vague,* an earlier work for viola and piano bearing as its title a term introduced by Catalan architect Ignasi de Solà-Morales

Rubió to describe "spaces as internal to the city yet external to its everyday use...apparently forgotten places [where] the memory of the past seems to predominate over the present...".[149] Possessing a cyclical, incantatory quality, these movements are haunted by the attrition of the pre-recorded sonorities heard in the first movement and the elusive character of the montaged melodies scored for ensemble.

3.4.2 'Weathering': Attenuated Presence

Just as exposure to ultraviolet light causes photos to fade, and materials exposed to the atmosphere exhibit wear, *weathering* alters the presence of a thing. This altered presence evokes the passing of time and the fragility of all that is susceptible to it. The Soviet journalist Vsevolod Ovchinnokov (b. 1926) describes a particular charm for the evidence of old age he detects in Japanese culture: "…the darkened tone of an old tree, the ruggedness of a stone…to all these signs of age they give the name, s*aba,* which literally means "rust"…"[150] Saba implies a diminished presence, but a more compelling essence. In this movement, the presence of musical materials is attenuated by:

a) Decomposing the sonorities from the first movement into a splintered set. **Audio sample 3** presents samples 10-30 in succession.
b) Preparing the violin, viola and cello with corks and hairpins to produce a disembodied sound on certain strings (please see the front matter of the score for details). **Audio sample 4** is a short video I created to demonstrate this technique.
c) Presenting fleeting snapshots of musical ideas, which possess an amorphous quality. This can be heard in **Audio sample 5** (three excerpts from *Weather a Rare Blue:* bars 172-180, bars 160-168 and bars 205-206).
d) Discontinuous renditions of a recurring piano theme, alluding to something continuous, yet only sporadically heard. **Audio sample 6** presents four such examples in succession: parts *V, VII, IX and XI* of *Weather a Rare Blue.*

3.4.3 The Prismatic Possibilities of Montage

These processes are a further way of breaking sound down into multiple perspectives. They instill the movements with a sculptural quality, again recalling Piranesi's "montage-like

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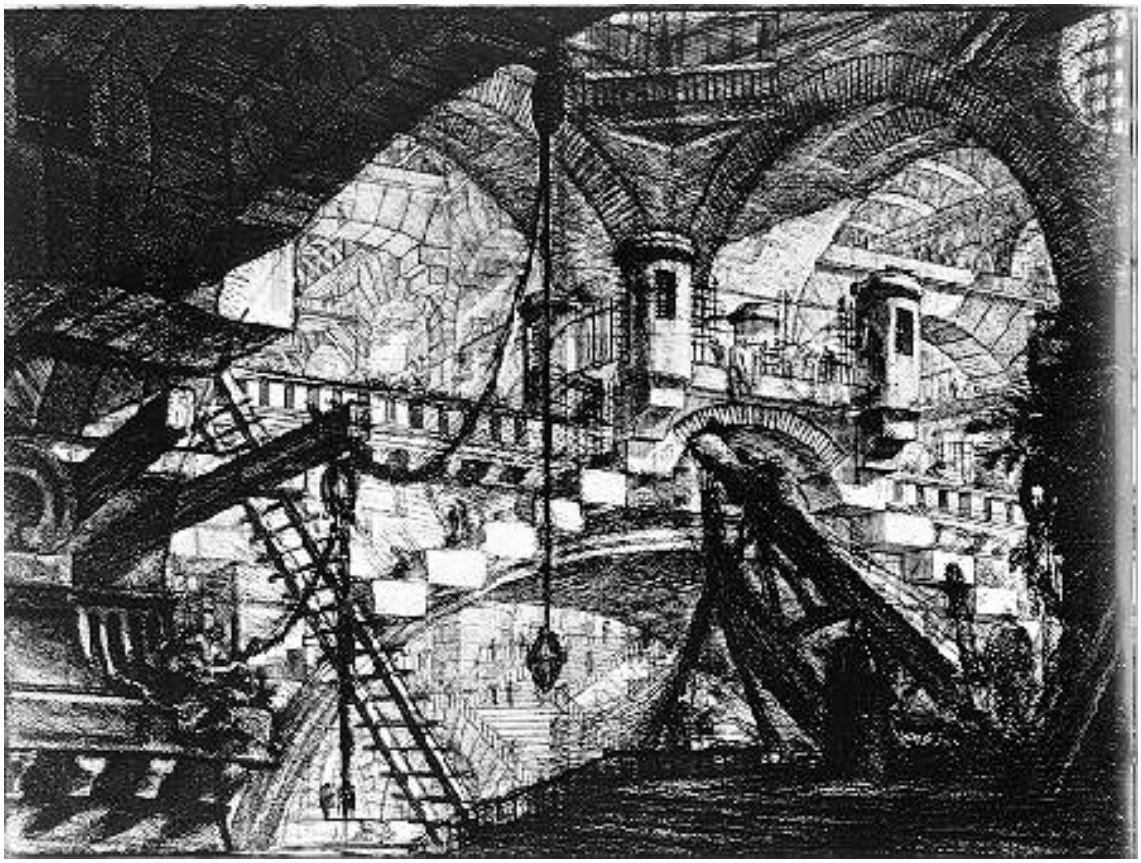
[149] "Terrain Vague: de Sola Morales", Accessed 31st December 2017, http://landscapeandurbanism.blogspot.com/2011/07/source-terrain-vague-de-sola-morales.html
[150] Andrey Tarkovsky, *Sculpting in Time: Reflections on Cinema, 59*

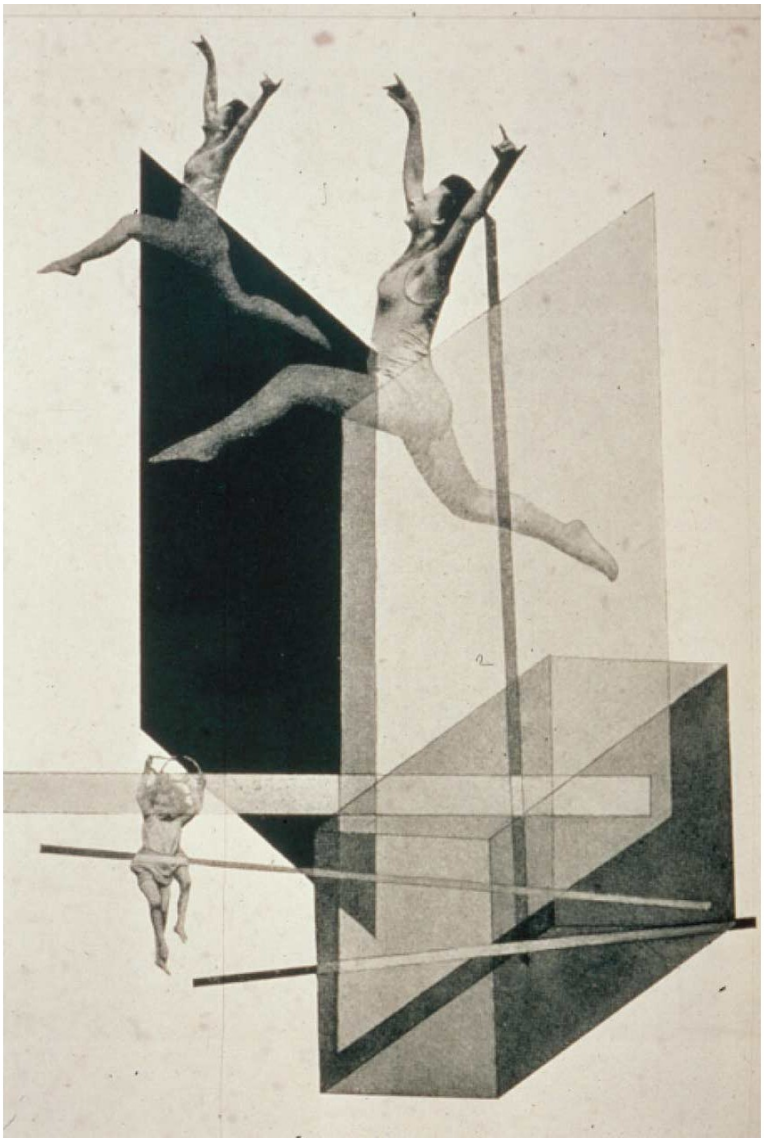
combination of discontinuous fragments, "[151] enhanced by his dramatic use of chiascuro (Figure 54). In *Terrain Vague*, fragmentation is exaggerated by the way the ensemble is 'lit' by the pre-recorded material, in a manner not dissimilar to "a collision of luminescent projections with the ruins of gaping darkness between them."[152] The prismatic possibilities of montage animate the works of László Moholy-Nagy (such as his *Human Mechanics* (1925), Figure 55). Moholy-Nagy was a Bauhaus painter and photographer who, like Sergei Eisenstein, Vsevolod Pudovkin and C.V. Alexandrov, advocated the technique of montage for sound on film (prefiguring musique concréte).[153]

Figure 54. Piranesi, Plate from the *Carceri d'invenzione* series (https://commons.wikimedia.org/wiki/Category:Le_Carceri_d%27Invenzione)



[151] Steven Jacobs, "Eisenstein's Piranesi and Cinematic Space", 147
[152] Steven Jacobs, "Eisenstein's Piranesi and Cinematic Space", 147
[153] Collaged acousmatic sounds

Figure 55. László Moholy-Nagy, *Human Mechanics,* 1925 (https://library.calvin.edu/hda/node/1443)



3.5 Reflection

Through two models—the double-exposure and the concept of 'terrain vague'—*Weather a Rare Blue* plays with the way rational harmony can articulate aspects of space (dimension and perspective) and time (a 'weathered' presence). Perceptual interest converges on the interaction of layers and the synergy between contiguous sound objects (perceiving one 'aspect' of a sound from another). *Weather a Rare Blue* also explores the potential continuity between rational harmony, equal temperament and noise elements (such as the multiphonics and distorted sounds produced by the prepared strings). This is possible because the fusion of pure intervals allows different surfaces of sound to be permeable to one another. In a short article on a related idea, Panayiotis Kokoros defends a quality of

texture he calls "holophonic": "Holophonic musical texture is best perceived as the synthesis of simultaneous sound streams into a coherent whole."[154] It seems to me that non-tempered tuning is ideally disposed towards realising 'holophony'.

Finding cohesion between layers of music has become a defining aspect of the works I've written for large ensemble and chamber orchestra: *Land's End, Rose* and *Januaries*. These were the first pieces composed for my doctoral portfolio and they unearthed early the tension existing between ideas arrived at abstractly and the performance of these; that is, the limitations possibly placed on theory by instruments, people and circumstance. Chapter Four discusses these works, also focusing on the malleability of sounds animated by non-tempered tuning. The chapter also draws an analogy between maps of rational harmony and the phenomenon of diffraction: a kind of patterning that is both sensorial and evocative.

[154] Panayiotis Kokoros "Towards a holophonic musical texture" accessed 23rd August, 2015 http://www.panayiotiskokoras.com/en/writings.html

Chapter Four

Land's End, Rose and Januaries

4.1 Background to Land's End (2015), Rose (2016) and Januaries (2017).

4.1.1 Introduction

My work with non-tempered tunings grew out of a fascination with sound itself: with auditory phenomena, sonority, the microscopic structure of sounds and their manipulation. Over time, the multidimensional nature of these sound phenomena acquired an abiding imaginative aspect with strong visual correlations, which—as seen in the previous two chapters—has deeply coloured my listening and writing. Chapter Four traces this early transformation through the process of composing three works for orchestral musicians. *Land's End* was commissioned by Sydney Symphony Orchestra, while *Rose* and *Januaries* were written for London Philharmonic Orchestra and members of the Philharmonia Orchestra respectively. Although these works are composed through the lens of just intonation, they often use intervals tempered to 48-tone equal temperament.[155] They are included in this commentary because there is a direct lineage between these and later works using precise, non-tempered tunings.

All three pieces are interested in perception and the malleability of sound material, and challenge the players to enter into a practice of a discreet virtuosity of finely attuned listening, tuning and balance. In them, I used modes to develop simple, iterative melodic lines. The pulse is at times elastic, and regular tempo changes segregate the music to underline changes in the harmony. In each piece, surfaces act as forms, through which subtle change can be perceived and felt. While writing *Land's End* I found that harmonic space, as represented in maps of pure intervals, resembles the diffraction patterns of light or water. *Rose* embroiders this notion by absorbing a sculptural approach at a local level into the formal ideas proposed by *Land's End.*

4.1.2 The Materiality of Sound as Central to Rational Harmony

> "A sound does not view itself as thought […] it is occupied with the performance of its characteristics […] its frequency, its loudness, its length, its overtone structure and the precise morphology of the sound itself." [156]

From the empirical origins of just intonation[157] (arising from experimentation with string

[155] i.e. to the nearest quartertone (50 cents).
[156] John Cage, "Extract from "Silence", Now, Sculpture Musicale. *Contemporary Music Review,* Vol. 1, part 2 (1987): 1

lengths, periodic patterns of vibration and the physical membrane of the human ear) to performance practice, the materiality of sound—as described by John Cage above—is at the heart of non-tempered tuning. Hermann von Helmholtz (1821-1894) produced a body of research that crucially drew attention to the physicality of sound and its perception. For instance, he argued that the perception of pitch was related to quantifiable, physical properties, and advocated theories of melodic succession, consonance and dissonance that depended "on sensation not on consciousness."[158] Moreover, recent psychoacoustic research into otoacoustic emissions confirms the vital role played by the physical membrane of the human ear as "active-not passive receiver, one in which positive feedback, not just passive detection is involved."[159]

James Tenney favoured forms that encourage the listener to be aware of themselves as a perceiving subject, engaged in acts of weighing, discriminating, comprehending and appreciating sound. Or, as he phrases it, "ear-determined only":[160] of "sound for the sake of perceptual insight—some kind of perceptual revelation […] searching to understand our own perceptual processes."[161] To this end he pursues rational 'neutrality'—a divorcing of the self from the work—through processes (often indeterminate or stochastic), ergodic[162] textures and dilated time-scales. In Tenney's works, and many of those that have followed, the perception of tone relations and auditory phenomena is prioritised, and musical elements that could draw the ear's attention elsewhere, such as line and rhythm, are suppressed. Larry Polansky describes Tenney's early works as "generative studies which are themselves metaphors, representations or even invocations of philosophical, physical, or perceptual processes" […] "Tenney likes to set a process in motion and let its aural

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[157]In 1933, Harry Partch wrote: "It is not important whether one chooses to say that musical intervals have their source in the ratio of simple number, as did Pythagoras of Samos in the sixth century B.C., or that their source is in the overtone series, the phenomenon discovered by Marin Mersenne, French Monk of the seventeenth century. The result is the same ... Just Intonation is any system of tuning with intervals exactly the same as the intervals of the overtone series" (in: Bob Gilmore, "On Harry Partch's Seventeen Lyrics by Li Po", *Perspectives of New Music*, Vol. 30, No. 2. (1992): p. 28)

[158]Helmholtz (transl. Ellis). *On the Sensations of Tone* (London: Longmans, Green and Co., 1875), 572

[159] Maryanne Amacher, "Psychoacoustic Phenomena in Musical Composition: some features of a perceptual geography," 1977, accessed October 3rd 2015, (http://www.sonami.net/Articles/Amacher/OAE.pdf)

[160] James Tenney, "John Cage and the Theory of Harmony", 1983, accessed 4 September 2015 (http://www.plainsound.org/JTwork.html), 19

[161] Robert Hasegawa. "Introduction: 'Sound for the Sake of Perceptual Insight'." *Contemporary Music Review*, Vol. 27, No.1, (2008): 1

[162] Ergodic textures (a term taken from thermodynamics) create uniformity-through-variety: indeterminate or probabilistic procedures ensure a statistical homogeneity at one level of organisation. For example, in Cage's indeterminate works, shared statistical characteristics at one level ensure that portions of the music otherwise different in detail are perceived as like. Or, to paraphrase Polansky, any "temporal slice" of music has the same statistical characteristics at some level of hierarchical perception as any other slice. See: Polansky, "The Early Works Of James Tenney", 50

manifestation be a kind of meditatative fabric."[163] This description echoes the phenomenological notion of 'constitution':

> "Constitution must be understood as a process that […] permits that which is constituted to appear, unfold, articulate and show itself as what it is. As Heidegger was to observe: "Constituting does not mean producing in the sense of making and fabricating; it means to be letting the entity be seen in its objectivity."" [164]

4.1.3 Rational Harmony and the Malleability of Sound

In the twentieth and twenty-first centuries, an array of technologies have rendered sound pliable and one can observe mutual exchanges between electronic music and acoustic music. While early work in electronic music using oscillators experimented with the basic elements of sound and the psychoacoustic results of combining these,[165] exponential progress in software technology has since enabled the close examination of sound phenomena and the detailed analysis of sound into its composite frequencies: a "journey to the interior of sounds, to observe their internal structures."[166] Phonographs and magnetic tape—with its limber qualities of stretching, montage, overlaying and reversing—also made sound tangibly pliant. There is often a playful, human aspect to such processes. In conversation about his second string quartet, Lachenmann ascribes a recurring 'wah-wah' sound in his music to his experience of hearing Luigi Nono's voice played backwards on an early tape recorder.[167] Similarly, sounds transformed abstractly and speculatively in the studio have been transcribed or reinterpreted within an acoustic context, indelibly altering approaches to composition.

4.1.4 Glissandi: Stretching Sound, Articulating Space

Electricity made possible sounds of "infinite duration, stable masses of sound, continuums."[168] Inspired by the sounds of sirens, Edgar Varese described his desire for machines producing "a continuous curve that instruments could not give me."[169] I have an abiding interest in the relationship between these practices and rational harmony, and have

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163 Larry Polansky, "The Early Works Of James Tenney." *Centre for Contemporary Music, Mills College* (1983): 7, 9
164 Zahavi in Erik Christensen, "Music Phenomenology: A Tool for Describing the Listening Experience" (Ph.D. Diss., Aalborg University, 2012), 4
165For one discussion of this, see the first two chapters of Daphne Oram's unusual publication *An Individual Note: Of Music, Sound and Electronics* (London: Galliard Ltd, 1972).
166 Tristan Murail, "The Revolution Of Complex Sounds". *Contemporary Music Review,* Vol. 24, No 2/3 (2005): 122
167 Lisa Illean, Notebook from Darmstädter Ferienkurse, August 2014.
168 Tristan Murail, "The Revolution Of Complex Sounds". Transl. Joshua Cody, *Contemporary Music Review,* Vol. 24, No 2/3 (2005): 23
169 Jo Anderson, John D. "Varese and the Lyricism of the New Physics." *The Musical Quarterly,* Vol. 85, No. 1 (1991): 32

teased out a few examples of specific significance from my notebooks. Glissandi—which I associate both with the sirens involved in Helmholtz's research and the theremin—are also often a by-product of stretching sound in time. Glissandi can examine a host of auditory phenomena,[170] but also relate the audible to the visible by affiliating frequency with velocity, motion and pitch.[171]

This connection between the audible and the visible was put to use by Percy Grainger in his "free music machine": eight oscillators capable of "gliding tones", maneuvered by paper graphs in the manner of a pianola.[172] Grainger created his machine to realise a "free music" based on eighth-tones and beat-less rhythms, after first experimenting with altering the speed of theremin recordings on phonographs. The Doppler effect[173] observes a similar interplay between frequency and visible parameters (such as the speed and direction of a moving object). Tenney's electronic work *For Ann (rising*) (1969), which illustrates the acoustic illusion of the Shepard-Risset glissando, has its visual counterpart in the barber's pole, which likewise seems to rise or fall infinitely. For me, this ungraspable articulation of space in sound, like sand through one's fingers, is both beguiling and strangely moving.

I often find the experience of simple manipulations—of speed (Stockhausen's *Hymnen,* 1966-7*)* or saturation (Tenney's *Critical Band,* 1988)— perceptually fascinating and evocative. Formally, I am drawn to simple processes of transforming sound, such as the reinjection loop underpinning Alvin Lucier's *I am sitting in a room* (1969) and composed into Tristan Murail's *Mémoire/erosion* (1976). At times I project this manner of listening onto past works, just as Thomas Patteson compares the opening of Sibelius' *The Swan of Tuonela* (from the *Lemmenkäinen Suite* of 1895-97) to a 70's synthesizer's "filter sweep".[174] While composing *Land's End,* I became interested in changes to sound that implied movement (like those produced by a Leslie speaker[175]) or a shift in environment, such as the alterations to sound heard underwater.

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[170] See: Szlavnics, Chiyoko. "Opening Ears: The Intimacy of the Detail of Sound" *Filigrane*, Issue #4, 2006, accessed September 4, 2015 (http://www.chiyokoszlavnics.org/plainsound/csmain.html)

[171] See: Peter Pesic. "Helmholtz, Riemann, and the Sirens: Sound, Color, and the "Problem of Space"." *Physics in Perspective*, September 2013, Volume 15, Issue 3: 256–294

[172] "120 years of Electronic Music", accessed 2nd February, 2019, http://120years.net/the-free-music-machinepercy-grainger-burnett-crossusaaustralia1948-2/

[173] An observer perceives a decrease in the frequency of a sound as it moves away from them (and the inverse).

[174] Thomas Patteson, "Sibelius and the "Sound-sheet":Orchestral Innovations in the Early 20th Century." Accessed 1st March, 2019, http://www.thomaspatteson.com/writings.html, 9

[175] An amplifier and loudspeaker, commonly associated with Hammond organs. It has a rotating drum, relying upon the Doppler effect to modify the sound (modulating amplitude and pitch to produce a tremolo effect).

4.1.5 Speculative Sound Manipulation

For me, this introduced an imaginative aspect into sound manipulation. Water, for example, filters high frequencies (such as consonants) and often introduces both reverb ("an irregular, quivering, slowly decaying tone")[176] and a Doppler shift. Rather than relying on cumbersome transcription methods or software (such as Orchids),[177] I enjoyed a more speculative approach: applying a process to a sound informed by basic principles and the lens provided by rational harmony. In the early stages of writing, sounds were reimagined and transformed by posing questions or scenarios. This has several precedents: the concept of *inharmonicity* in the later music of Grisey and Murail drives a concrete acoustic phenomenon to a speculative extreme, while Tenney's *Clang* (1972) replicates on its own terms the gradual opening of a band pass filter.

As mentioned in the previous chapter, non-tempered intervals' tendency towards fusion encourages a permeable state to develop between different strata of music. Disposed to both a striking clarity and a brooding murkiness, rational harmony sustains musical passages shaped by moments of focus, and shifts in focus.

4.2 The Sound-world of Januaries

The former can be seen in an extract from *Januaries*, from the second bar of Letter H to Letter O (listen to this extract as **Audio sample 7**.) Just as Tenney used tape delay to produce dense spectra with small instrumental forces (e.g. *Glissade,* 1982), here a delayed layer of sound serves to similarly reinforce a dusky sonority in the descending lines.

A hazy unrest characterises Letters O through to R, via a shifting of emphasis within a tight cluster. In contrast, crafted glissandi then move through harmonic space, as if receding remotely. These passages can be heard in **Audio sample 8.** I finished composing *Januaries* after spending some time with my grandmother in Northern Australia. What I inevitably brought to the desk in this final phase were lingering sensations and memories that were awakened while I was travelling, such as the shifting nature of the elements: "a rain you can

[176] Lisa Illean, diary, June 2015. See also: Robert J Urick. Principles of Underwater Sound. 3rd Edition. U.S: McGraw Hill Inc., 1983.
[177] See: "Orchids", IRCAM, accessed 9th September 2019, http://forumnet.ircam.fr/product/orchids-en/

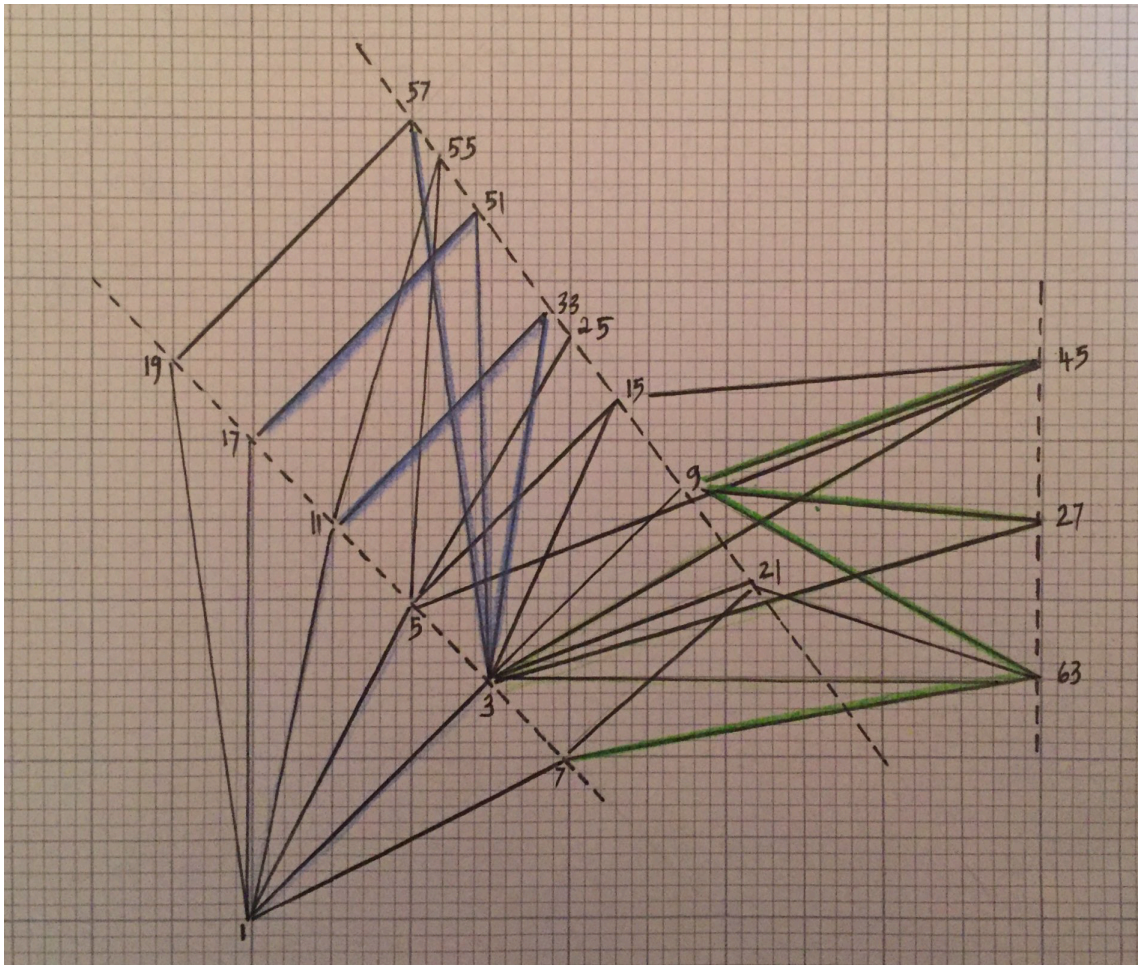
sweat in, it steams in the sun."[178] I also had in mind the ungraspable quality of Australian landscape captured so well by the writer Simon Leys:

> "Australian scenery is of inexpressible beauty, it is true, but it is also utterly inconspicuous and nonspectacular—and impossible to capture with a camera: this worndown immensity, with its halferased profiles constitutes a magic space entirely devoid of focal point; like ghosts, mirages, and supernatural visions, it escapes the photographer, it does not leave any impression on film."[179]

Between letters W and X, the harmony oscillates between alternate sides of a defined, mapped harmonic space, which has been splintered into two cleanly fused sound entities. Figure 56 maps this harmonic space, with the two sound entities coloured in blue and green. The horn and trumpet bestow a chorus effect to these alternating chords.[180] This passage can be heard in **Audio sample 9**.

[178] Les Murray, *On Bunyah.* Collingwood, (VIC: Black Inc., 2017), 38
[179] Simon Leys. "Lawrence of Arabia", New York Review of Books, April 21,1994, accessed 1st May, 2017, https://www.nybooks.com/articles/1994/04/21/lawrence-of-australia
[180] Similar to a Leslie speaker; see footnote 170.

Figure 56. Example from *Januaries* (Letter W-Letter X)*:* Mapped harmonic space splintered into two collections of tones (coloured blue and green). These are heard as two alternating chords in Audio sample 9



4.3 Diffraction

4.3.1 Diffraction, Form and Maps of Rational Harmony

> diffrāctiō *(Medieval Latin, "action of breaking in pieces"), from Latin* diffrag-, *variant stem of* diffringere, diffrangere *"to break up, break apart, shatter"* [181]

Partch asserts that all harmonic relationships within rational harmony are an "expansion from unity."[182] As seen in Chapter One, these relationships can be organised into three-

[181] "Diffraction", Miriam-Webster dictionary, accessed 3rd March, 2019, https://www.merriam-webster.com/dictionary/diffraction

[182] Partch, Harry. *Genesis of a Music: An Account of a Creative Work, it's Roots and Fulfillment (2nd Edition).* (New York: Da Capo Press, 1974), 7

dimensional lattices or branching maps illustrating a network of intervals expanding from a shared origin. Chapter One also discusses the tendency of pure intervals to fuse at a local level into a perceptual entity. As such, maps of rational harmony can be differentiated into smaller, self-reinforcing, discrete units. This process of differentiation is essentially *the splintering of a cohesive entity (a 'whole') into unique, inter-related fragments, such that each fragment is perceived as an aspect of the whole* (see Figure 56).

The splintering of harmonic space portrayed above is akin formally to the splitting of light waves (Figure 57) or the spreading of water accomplished by diffraction (interference) gratings (Figure 58).[183]

Figure 57. White light dispersed by a diffraction grating (https://www.daviddarling.info/encyclopedia/L/light_waves.html)

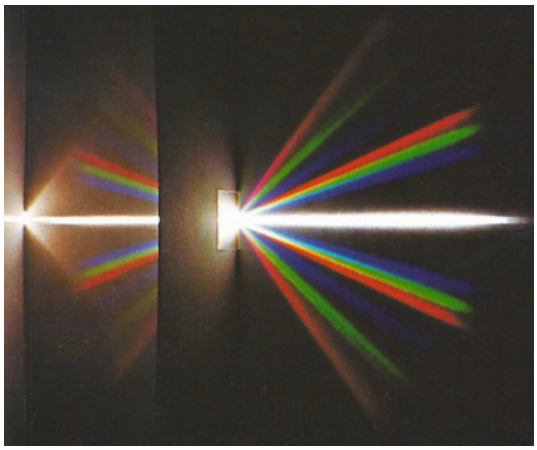


Figure 58. Diffraction patterns in water (http://physics.wm.edu/~armd/Diffraction1.jpeg)

[183] A different process to the dispersion of light when it is refracted through a prism.

For this reason, I use the word 'diffraction' poetically, when describing in my music:

a) An harmonic space conceived as unique, inter-related chords (see Figure 56 and listen to Audio sample 9 for an example of this)
b) An harmonic space conceived as unique, inter-related fundamentals and harmonic fields[184] (see Figure 62, *Land's End*)
c) When a single line is orchestrated such that it is dispersed in small fragments—and possibly different speeds—across an ensemble (for an example, listen to Audio sample 7)

I have often been drawn to pieces—by Giacinto Scelsi (1905-1988), or Fred Frith (b. 1949)—in which the splintering of sound seems to be an indispensible quality of the music. In his article on Scelsi, Murail describes Scelsi's inclination towards 'de-compos[ing] the sound into its spectrum'[185] allowing details in the sound (transients, beats) to emerge. Murail also observes that Scelsi sometimes diffracted a unison dyad into new pitches from its harmonic (or sub-harmonic) spectrum.[186] This he associates with the Mongolian technique of diffracting partials, used by vocal groups such as the Harmonic Choir and Prima Materia (with whom Scelsi was familiar). For the 1974 album *Guitar Solos*, Fred Frith fragmented the fret board of his guitar, splitting it with a capo and alligator clip preparations, and adding a second pickup near the nut to create a mesmerising proliferation of sound sources. The final track *No Birds* uses two such guitars tuned to a single note to hypnotic effect.

In papers and books I have read, there may also be a latent, intuitive grasping towards considering rational harmony within a poetic model of diffraction. In this literature, the image of a shadow is frequently invoked as a metaphor for a change in emphasis harmonically (see 1.4.3) In the natural world, the shadow of an obstacle forms a diffraction pattern (rather than a simple geometric pattern).

4.3.2 Diffraction and Permutational Forms

Envisioning harmonic space as split into unique, inter-related chords or fundamentals invites an approach to form which synthesises the commonly held opposition between

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[184] A collection of pitch classes connected to a given harmonic context
[185] Tristan Murail, "Scelsi, De-composer." Translated by Robert Hasegawa. *Contemporary Music Review,* Vol. 24, No. 2/3, (2005): 173
[186] Murail, "Scelsi, De-composer", 178

forms predicated on gradual change and those comprised of juxtaposed 'sound objects'.[187] Simple musical ideas (chords or lines) can gradually 'sound-out' these fragments of harmonic space, creating subtle shifts in harmony (gradual change) through a series of discrete perceptual entities (sound objects). Slight permutations in harmony can be more acutely perceived by keeping other musical elements consistent. This offers a way to pursue working with line and rhythm that resists the borrowed or decorative.

I discern an affinity between maps of harmonic space and permutational forms, both of which can be conceived as proliferations of closely related fragments. I borrow the term 'permutational' from Tenney's paper *Form in 20th Century Music* (1969-70). Tenney's description of permutational forms closely resembles the organisation of Morton Feldman's (1926-1987) late music, which is characterised by a "perceptual malleability" borne from a "proliferation of near-repetitions".[188] Such forms demand continual adjustments in listening, play with memory, and allow meaning to emerge through a relational (rather than causal) interaction between units.

4.3.3 Models of Diffraction and Virilio's Phenomenology

I am intrigued by the way we make relationships between the abstract and the highly personal, between specific instances and a more general 'whole'. For example, the way that— perhaps through ritual or repetition—abstract ideas are not only internalized but, with each particular realisation, display a multitude of personal variations. In Paul Virilio's phenomenology these 'instantiations'[189] underpin our experience of duration—of time passing—just as time itself is marked out by perceptible, discrete changes: the changing position of shadow on a sundial, or of hands on a clock face.[190] (By contrast, he suggests that we associate an abstract 'timelessness' with the erasure of such discrete markers: the eternal, fluorescent 'day' of a Las Vegas casino, or the absence of shadow upon vast surfaces of the desert or ocean.) Virilio's writings offer a context for the models of diffraction discussed above. On the one hand, like the philosophy of Maurice Merleau-Ponty or the art of Robert Irwin, his work attempts to crucially counter a "reification of

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[187] See: Julian Anderson and Tristan Murail. "In Harmony: Julian Anderson Introduces the Music and Ideas of Tristan Murail." *The Musical Times*, Vol. 134, No. 1804, (1993): 322

[188]Dora Hanninen. "Feldman, Analysis, Experience." *Twentieth Century Music 1/2,* (2004): 226
For example, Dora Hanninen describes how the orchestral texture of *Coptic Light* (1986) is comprised of many such near-repetitions of individual fragments of music, which she proposes are organised at a higher level into 'populations'.

[189]A term from programming, meaning a particular realisation of an abstract idea or template.

[190]Virilio, *The Aesthetics of Disappearance,* 24.

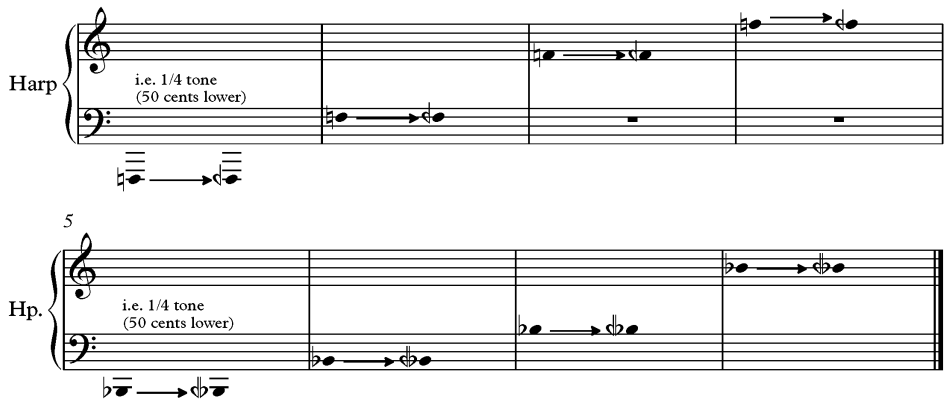
lived experience"[191] that is the consequence of predominantly symbolic forms of comprehension. On the other, it does so unexpectedly through proliferation and fragmentation, the very forces to which Walter Benjamin attributed an "increasing atrophy of experience" … "the perceived inability to really know, encounter or register" the present.[192]

4.4 Land's End

4.4.1 *Notation and Scordatura*

Land's End is tied to a particular map of interval relations resembling a diffraction pattern. After much deliberation I decided to notate the work in quartertones, compromising some of the advantages of the precision discussed in previous chapters. In hindsight, this arose partly from a desire to introduce simple melodic elements.[193] To facilitate the microtonal lines, I asked that the clarinet and soprano saxophone be tuned a quartertone lower for the entire piece; and that the second cellist tune their A-string a quartertone lower. Eight strings on the harp are also tuned a quartertone lower (see Figure 59):

Figure 59: The harp scordatura for *Land's End*



Quartertones generate more possible axes for modulation than precise tuning. This is because frequencies that are several cents apart when precisely tuned can now be conflated when shifting between modes. The harmony gained in flexibility what it lost in clarity. As

[191] Robert Irwin. *Notes Towards A Conditional Art.* (Los Angeles: Getty Publications, 2011), 7.
[192] Paula Amad. *Counter-Archive: Film, the Everyday and Albert Kahn's Archives de la Planète.* (New York: Columbia University Press, 2010), 134.
[193] It was also a practical decision, as rehearsal time was scarce.

in the late works of Grisey, modes were assembled from partials untethered to their pitch height.

4.4.2 Vija Celmins' Subtle Modulations

The tenor of *Land's End* is indebted to the quiet images of the Latvian-American visual artist Vija Celmins. Celmins' serial "redescriptions" (in graphite, paint and ink) of a handful of photographs—of the ocean surface, desert and night sky—are simultaneously anonymous vistas and meticulous, personal works.[194] The particularity of Celmins' realisations is the result of a focused and tender practice. The few photographic images she repeatedly reworks approach abstraction, devoid of perspective and apparently frozen in time (see Figure 60). However, the reproductions of these bear witness to the assiduous, human process of remaking them as drawings, lithographs or engravings; the trace of her hand, its reckoning with time and the materiality of the graphite, wood and knife. Of her galaxy drawings she says:

> "Even though you may think they came from lying under the stars, for me, they came out of loving the blackness of the pencil. It's almost as if I was exploring the blackness of the pencil along with the image that went with it." [195]

Further, "exploring the blackness of the pencil" is a means of exploring subtle modulation between different shades of graphite:

> "One of the things I've noticed in doing the drawings is that I tend to take very small incremental steps in changing. An example was that I had been working with the pencil and I began to see the graphite itself had a certain life to it. So I did a series of images of oceans and deserts using different grades of graphite and pushing each to its limits. I learnt a lot about the possibility of expressiveness in graphite by doing this." [196]

The restricted nature of Celmins' subject matter allows her to foreground both the pact of perceiving and the "possibility of expressiveness" in incremental shading.

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[194] Samantha Rippner, *The Prints of Vija Celmins* (New York: The Metropolitan Museum of Art, 2002), 23.
[195] Tania Kovats. *Drawing Water* : *Drawing as a mechanism for exploration.* (Edinburgh: Fruitmarket Gallery, 2014), 27
[196]Kovats. *Drawing Water* : *Drawing as a mechanism for exploration*, 27.

Figure 60. Vija Celmins *Lead Sea #2* (1969). Graphite on paper. (Image from: https://www.christies.com/lotfinder/Lot/vija-celmins-b-1938-lead-sea-2-6110562-details.aspx)

Land's End is a work for chamber orchestra, composed during the autumn of 2015.[197] I kept two notebooks throughout the composition process, and reading these reveals a preoccupation with certain concerns:"traces of sounds […] displaced echo structures […] captures the light in different ways […] like a change of temperature in the water […]breathing[…]." Time is imagined as a canvas spreading beyond the edges of a defined space, just as for Celmins' "the image stretches out into infinity."[198]

Land's End is divided into three sections roughly equal in duration (with an incision of concentrated silence between each). In hindsight, this may have stemmed (not consciously) from a quote kept in one of my notebooks:

[197] Alto flute (doubling piccolo), Oboe, Clarinet in Bb (doubling Bass Cl.), Clarinet in Bb (tuned a ¼ tone lower), Alto Saxophone (doubling Soprano Saxophone – soprano tuned a ¼ tone lower), Bassoon (doubling contrabassoon), 2 horns, Trumpet (Bb), Trombone, Tuba, Percussion I (Marimba (4.5 octaves), Large Tam-tam, Medium Tam-tam, Low Tom-tom, Suspended cymbal, Large triangle, Aluminium foil sheet), Percussion II (Crotales (2 octaves), Vibraphone (3.5 octaves), Bass drum, Thunder sheet, Suspended cymbal, 2 Tuned gongs), Harp, Piano, Violin 1, Violin 2, Violin 3, Viola 1, Viola 2, Viola 3, Cello 1, Cello 2, Double Bass

[198] I have borrowed a line from Tarkovsky: Andrey Tarkovsky, *Sculpting in Time: Reflections on Cinema,* 104

"The most beautiful music is that which gives the greatest intensity to a moment's silence, which forces the listener to listen to the silence. First by capturing sounds, one brings them towards inner silence; then one adds outer silence."[199]

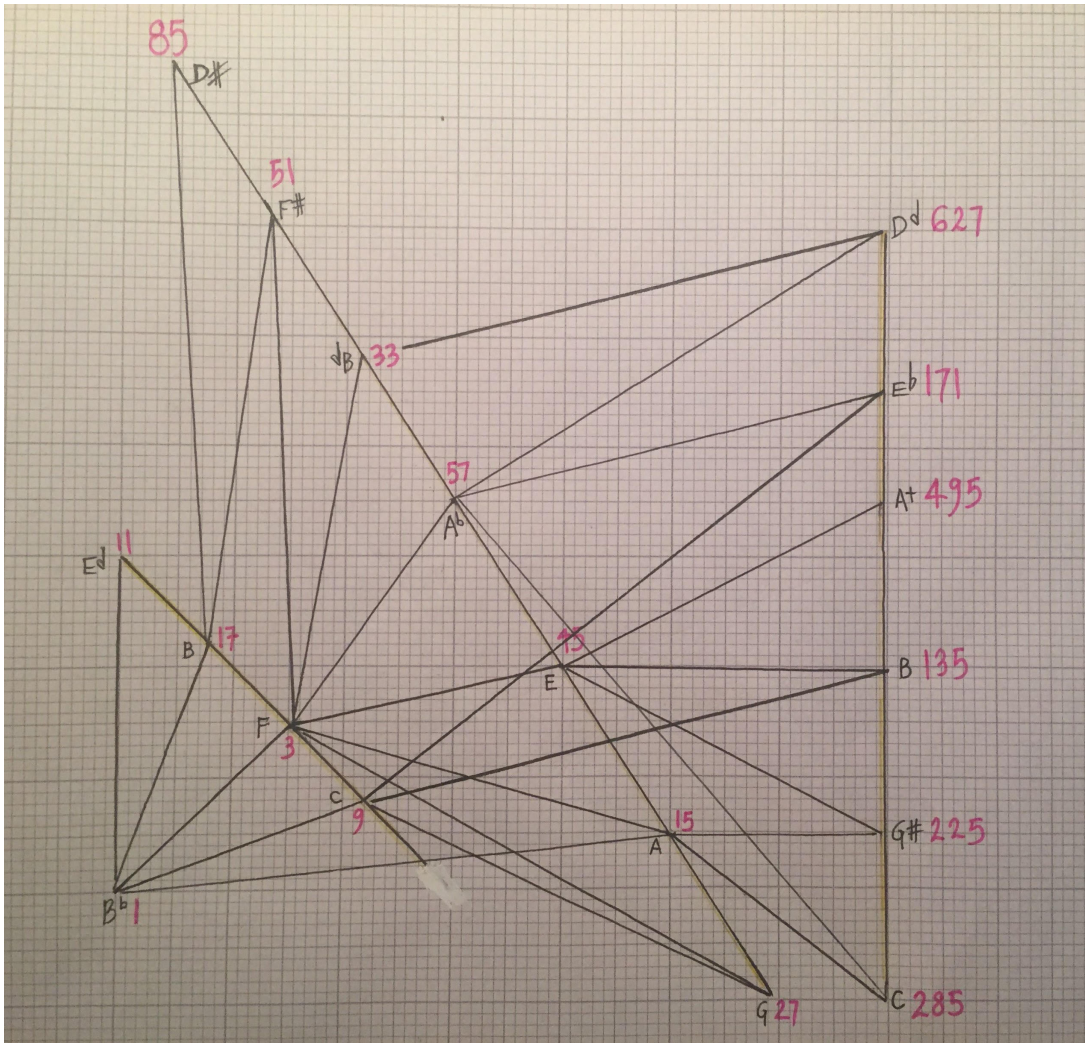
4.4.3 An Harmonic Map of Land's End

In *Land's End,* quietude emerges through a hushed dynamic, ethereal orchestration, gentle contours and inconspicuous modulations. The entire harmonic form is conceived as a map resembling a diffraction pattern from a B-flat fundamental. Figure 61 is a hand-drawn, tree-like map of related partials extending from B-flat by pure intervals (including intervals up to those defined by the 19th partial). I will refer to this whole map as a 'B-flat tonality' (the map is incomplete, showing only those partials used in *Land's End*).

In different fragments of music, the partials mapped here function as fundamentals themselves (sometimes called 'secondary' fundamentals in the literature, or 'roots'). As such, the section moves through different, related harmonic contexts ('fields') that are conceived as aspects of an extended B-flat tonality. In this section the tonality of B-flat is explored from seventeen different harmonic perspectives (i.e. seventeen different roots)—some more closely related to B-flat and others more distantly so.

[199] Simone Weil, quoted in Klaus Huber, *From Time to Time: The Complete Oeuvre, in conversation with Klaus Steffen-Mahnkopft,* 128

Figure 61: Hand drawn map for the first section of *Land's End*, showing the diffraction of a B-flat tonality into related harmonic contexts (the roots are described as pitch classes rounded to the nearest quarter-tone in black). The numbers in pink describe each 'root' as a precise partial of B-flat. Black lines denote precise relationships between these partials.



4.4.4 Harmony: A Broad View

Figure 62 (below) tabulates Figure 61 along with sections 2 and 3 of *Land's End*. The 'root' of each harmonic field in *Land's End* is listed hierarchically, as an aspect of the presiding B-flat tonality. Musically, each root begets a specific harmonic field, realised in a fragment of music usually somewhere between 1-4 bars in length (examined in detail in *4.4.5*). A glance at the table shows clear patterns of movement towards and away from the fundamental in essentially two waves. While I was always conscious of this harmonic intention while

composing *Land's End*, the form became complete only through a complex assembling of sketches, and the draft was written in a patchwork (rather than a linear) order.

Figure 62. Harmonic Fields in *Land's End*

Rehearsal Letter	Level 1 (Primary tonality Bb)	Level 2 (Partials of Bb)	Level 3 (Partials of Level 2)	Further subsets of tonalities
Section 1				
Opening			**Ab** (19 of F)	5 – 3 – 11 (of Ab)
A		**F** (3 of Bb)		5 – 3 – 11 (of F)
B			**E** (15 of F)	5 – 3 – 11 (of E)
C		**F** (3 of Bb)→ **C** (9 of Bb)		1 – 3 – 9 (of F) 1 – 3 (of C)
D	**Bb**			
E	**Bb**			5 – 9 (of Bb)
F		**F** (3 of Bb) **E** – 49c (11 of Bb)	**Ab** (19 of F)	
G		**B** (17 of Bb)→ **F** (3 of Bb)		1, 5 of B; 15 of F
H		**B** (17 of Bb)		
Section 2				
I		**A** (15 of Bb)		
J		**A** (15 of Bb) **F** (3 of Bb) **C** (9 of Bb)	**G#** (15 of A; 17 of F) **C (**19 of A **)**	1-17 - 3 - 15 – 3
K		**F** (3 of Bb)		
L	**Bb**			
M	**Bb**	17 -11- 15 – 5 – 13 – 9 -3		
N		**F** (3 of Bb)		
Section 3				
O		**F** (3 of Bb)		
P			**F#** (17 of F)	
Q			**F#** (17 of F)	
R		**F** (3: of Bb) **E** – 49c (11of Bb)	**Ab** (19 of F)	
S	**Bb**	1 – 9 - 3		

Movement between the harmonic fields was sometimes facilitated via shared roots. (For example, at rehearsal letter C, 9 of the root 'F' = 3 of the root 'C'). I have tended towards choosing roots that are close to tempered pitches (i.e. 3rd, 9th, 17th, or 19th partials) or a clean quartertone (i.e the 11th partial). At this level of organisation I have mapped out the relationships precisely (for example, I don't conflate the 9th and 285th partial, see Figure 61).

However, to avoid clutter, I have chosen to write these as pitch-classes rounded to the nearest quartertone in Figures 61 and 62.[200]

4.4.5 Sounding Out the Map in Musical Fragments

In *Land's End,* fragments of music are composed within a relatively narrow, comfortable tessitura as I hoped to create subtle shifts of harmony within a defined frequency band. This defies the logic of acoustics, where fields more distantly related to B-flat reside in the higher partials of B-flat (as shown on the branches to the right of Figure 61) and those more closely related reside in the lower partials (the bottom left hand corner). The technique of sounding partials from different registers of the spectrum in the same tessitura is called 'reduction'[201] and involves conceiving of frequencies as pitch-classes untethered to a specific pitch-height. I believe that this intentional separation from acoustics helps to segregate harmonic fields more distinctly; and facilitates comparisons between repetitions of similar musical fragments.

The harmony is 'sounded-out' through iterative units drawn from four different kinds of musical material:

a) Sequences of chords connected in a scale-like fashion by subtle glissandi (where the rising/descending line of the chords is prominently heard).
b) Slow glissandi between sustained pitches (conceived as a dilated approach to (a)).
c) Simple figures, often scales (conceived as a contraction of (a)).
d) Oscillations (either between two pitches or two chords).

At the time, I consciously avoided materials that seemed borrowed or decorative or dramatic. Early on in his career, Ben Johnston spoke of how he endeavored to avoid "the gestures, structures and idioms familiar from a different tuning".[202] Although differentiated, the musical materials listed above seep into one another: glissandi hover in the background of the rising lines at Figure D and scales of different speeds ascend at Figure H. Pedal points often function as a connective tissue between cycles of musical fragments. In March 2016, before the premiere of *Land's End,* I wrote:

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[200] It is beyond the scope of this paper to discuss the various approaches to notating just micro-intervals.
[201] See Figure 16.
[202] Keislar et al, "Six American Composers on Nonstandard Tunings," *Perspectives of New Music* Vol. 29, No. 1 (1991):197

> "The word 'mormorando' is written into a musical score when the music should be performed with a gentle, murmuring quality. I've become attached to working in environments with their own in-built murmuring—my flat in Edinburgh, with its ebbing local traffic, and the sea-and-wind-infused air of the coast […] For me, this murmuring is a way of beginning to imagine music with a natural quietude. It's also an aural frame of reference, providing an ever-varying sound-surface unfolding within an understated, elemental consistency.
> […] Sounds such as wind and rain have a kind of neutrality, which means they can act as conduits for memories, sensations and perceptions. When observed closely, these sounds engender a mode of listening, through which it's possible to imagine and create musical compositions that do the same.
> I like to work with comparatively neutral musical materials—lines, fragments of melody, glissandi and impulses—in my compositions. These materials can come from anywhere and allow me to create music that is sometimes drawn from something very personal, while still adopting a level of remove. I appreciate that these materials don't press themselves on the listener, but instead grant the space for each sound to be perceived, felt, weighed, explored and compared."[203]

I'm not convinced that these materials achieve the kind of 'neutrality' I mention in this text; what interests me in hindsight is the manner in which they function as aspects of one another (dilations, contractions) and the way their sharp juxtapositions create abrupt changes in perspective akin to pleating.

In addition to varying the harmonic context of fragments, I also wanted to vary their harmonic complexity. I set extremes of this idea at the heart of the piece: in bar 83, a transparent, exposed dyad is followed by a more harmonically 'saturated' figure (an ambiguous descending line coloured by a superimposed canon—resembling tape delay—in the string section.) This can be heard in Audio sample 10.

Audio sample 10 (*Land's End,* bars 75-93)

The table below (Figure 63) reproduces Figure 62, now colour-coded to show the distribution of types of material across the form of *Land's End:*

(a) is yellow (b) is blue (c) is grey and (d) is green.

[203] Lisa Illean. "How I Start Writing Music", 2016. Accessed 12th December, 2016 (http://www.sydneysymphony.com/backstage-news-plus/160307_article_lisaillean.aspx)

Figure 63: The distribution of four different kinds of musical material in *Land's End*

Rehearsal Letter	Level 1 (Primary tonality Bb)	Level 2 (Partials of Bb)	Level 3 (Partials of Level 2)	Further subsets of tonalities
Section 1				
Opening			**Ab** (19 of F)	5 – 3 – 11 (of Ab)
A		**F** (3 of Bb)		5 – 3 – 11 (of F)
B			**E** (15 of F)	5 – 3 – 11 (of E)
C		**F** (3 of Bb)→ **C** (9 of Bb)		1 – 3 – 9 (of F) 1 – 3 (of C)
D	**Bb**			
E	**Bb**			5 – 9 (of Bb)
F		**F** (3 of Bb) **E** – 49c (11 of Bb)	**Ab** (19 of F)	
G		**B** (17 of Bb)→ **F** (3 of Bb)		1, 5 (of B) 15 (of F)
H		**B** (17 of Bb)		
Section 2				
I		**A** (15 of Bb)		
J		**A** (15) of Bb **F** (3 of Bb	**G#** (15 of A; 17 of F) **C** (19 of A)	1-17 - 3 - 15 – 3 **C** (3 of G#)
K		**F** (3 of Bb		
L	**Bb**			
M	**Bb**	17 – 11 - 15 – 5 – 13 – 9 – 3		
N		**F** (3 of Bb)		
Section 3				
O		**F** (3 of Bb)		
P			**F#** (17 of F)	
Q			**F#** (17 of F)	
R		**F** (3 of Bb) **E** – 49c (11 of Bb)	**Ab** (19 of F)	
S	**Bb**	1 – 9 - 3		

4.4.6 The harmonic fields close up

In *Land's End,* the 'field' of a given root is the first 16 odd partials of that root, treated as pitch-classes[204] rounded to the nearest quartertone. The figure below shows this for the root B (the 17th partial of B-flat) and the following page from my notebooks (Figure 65) sketches the harmonic fields for the 11th, 13th, 15th and 17th partials of B-flat. At this

[204] Tones untethered to pitch height

organisational level, the frequencies were also reduced to sit within an octave, rounded to the nearest quartertone and assembled to resemble scales.

Figure 64. The harmonic field of the root 'B', the 17th partial of B-flat. Arranged into two scales (partials 3-17 and partials 19-33).

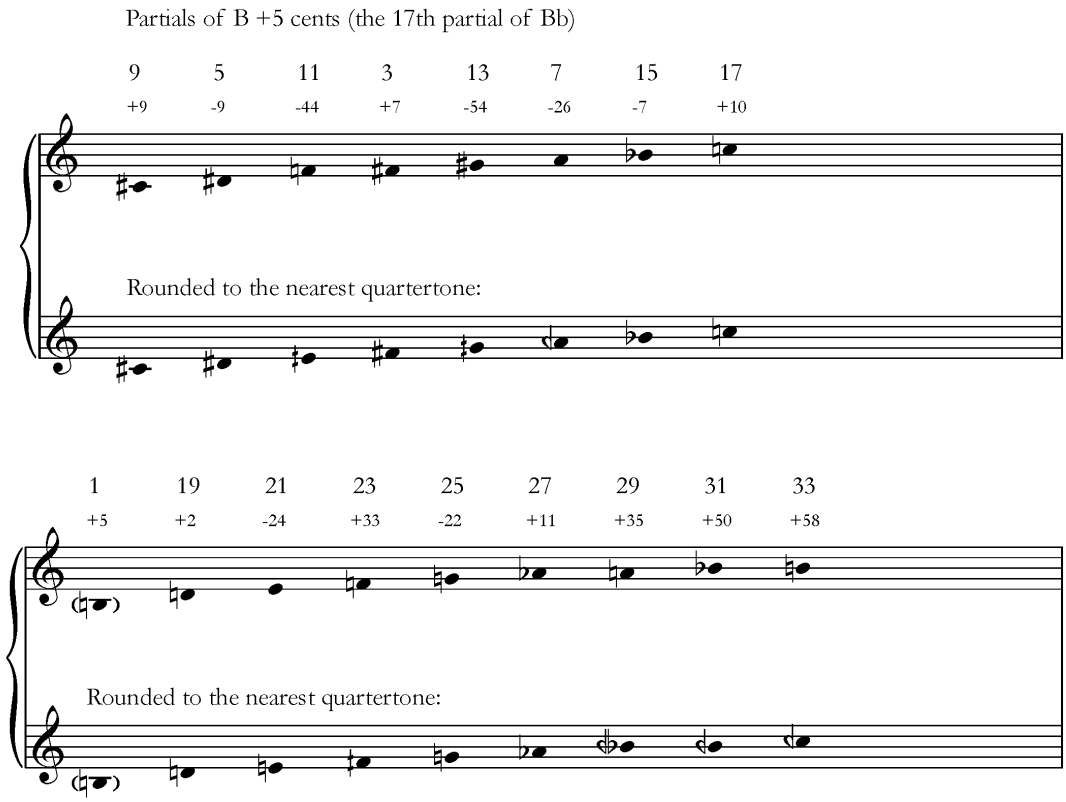
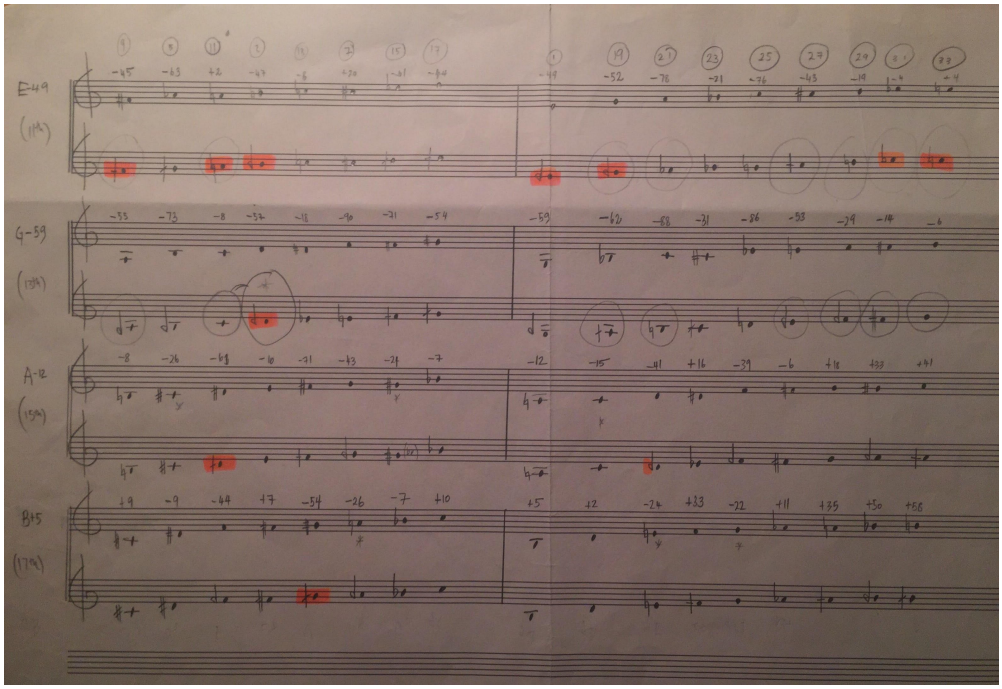


Figure 65. A scan from my notebook, showing sketches of the harmonic fields for the 11th, 13th, 15th and 17th partials of B-flat (in that vertical order). Colouring and circling bear witness to its use as a practical tool for composing musical fragments.

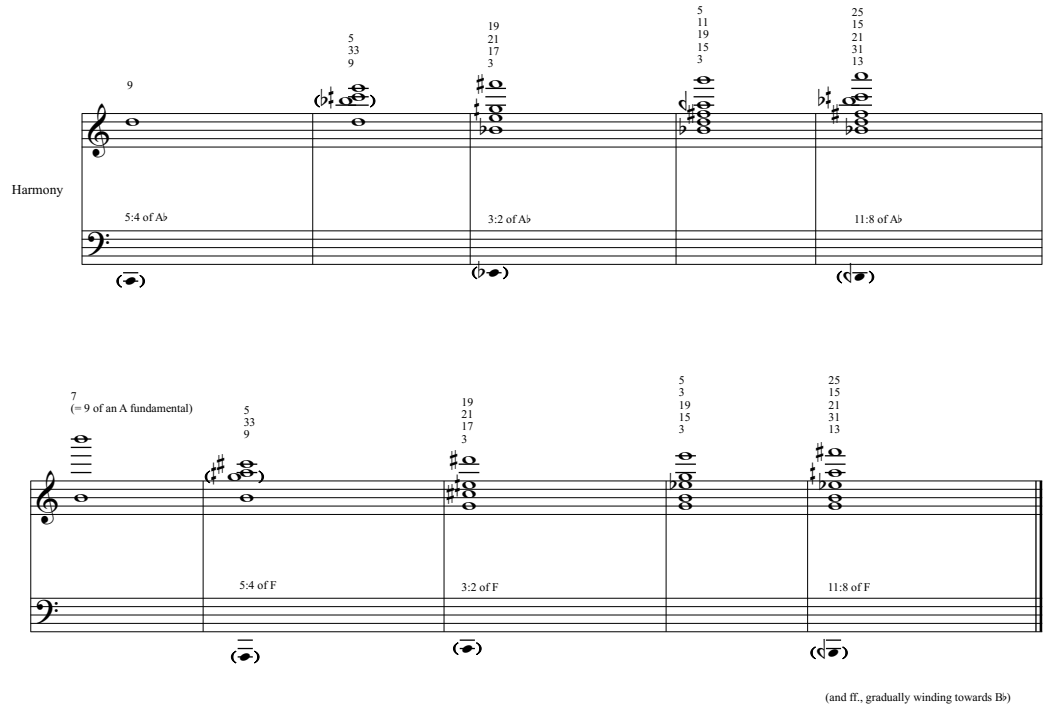


I was able to work with these scales fluidly: creating chords, lines and melodic fragments. The composition of *Land's End* was shaped by how I presented this information to myself. Since writing these works, pitch height and precise intonation have become increasingly important to me: I enjoy the elegance of modes where each pitch is related to every other.

Figure 66 describes the string chords opening *Land's End*. Each chord is comprised of harmonic partials (drawn from the 'field') relating to a silent fundamental (the 'root'). The partials are labelled by the numerals above each chord and the root is notated in brackets on the lower stave.[205] Note spellings are as they occur in the score—some enharmonic spellings were used as they were more practical to perform.

[205] In this (and all the following figures), the partials and fundamentals have been reduced to fit comfortably into a desired tessitura (and onto the stave).

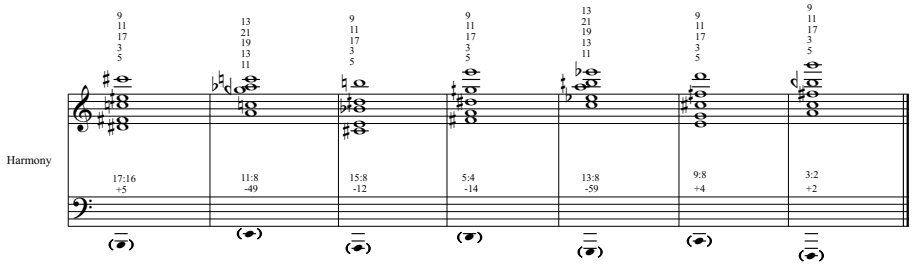
Figure 66. The opening string chords to *Land's End*



Notes at the end of each cycle form a pivot between two harmonic fields (in the above example, Figure 66, the note B is conceived as the 7th partial of the chord preceding it and the 9th partial of the chord following it).[206] The rising upper voice of these chords re-occurs with different degrees of presence—and in different speeds and directions—throughout. The intervals between the (silent) roots are later foregrounded as melodic fragments.

Figure 67 illustrates the composition of the string chords at rehearsal letter M in *Land's End*. The roots on the lower stave are expressed using cent deviations and ratios describing their relationship to B-flat.

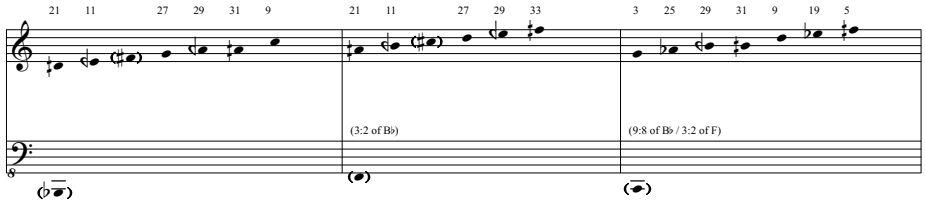
Figure 67: The string chords at rehearsal letter M in *Land's End*



[206] This admits a fairly large tolerance range, which flows from the decision to notate pitches to the nearest quartertone. In some recent works I have been far more precise. I enjoy working in both ways and find that each throws up unusual harmonic and modulatory possibilities.

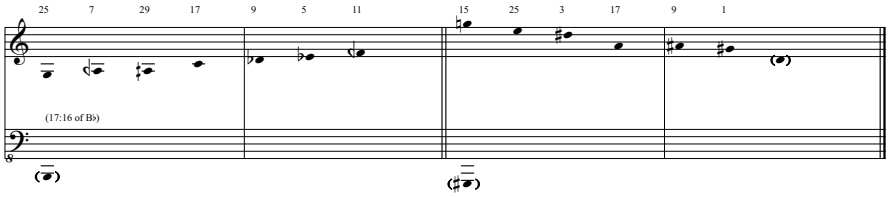
The diagram below (Figure 68) notates the three scales underpinning rehearsal letter D, drawn from the harmonic fields of B-flat, F and C respectively. The partials are represented numerically above the notes.

Figure 68. Three scales underpinning rehearsal letter D, ***Land's End***



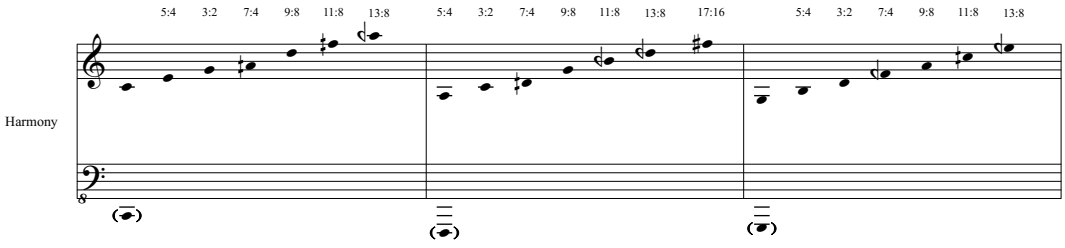
Similarly, Figure 69 shows how the harp scales underpinning rehearsal letter H are drawn from a B harmonic field; and that the piano figure at rehearsal letter J arises from the harmonic field of G-sharp:

Figure 69. Scales underpinning rehearsal letters H and J, ***Land's End***



At rehearsal letters C, G and S I wanted to create simpler and more clearly apprehended harmonic fields. At C I used three harmonic fields (documented below in Figure 70), related by roots a perfect 5th apart (roots of F, C and G).

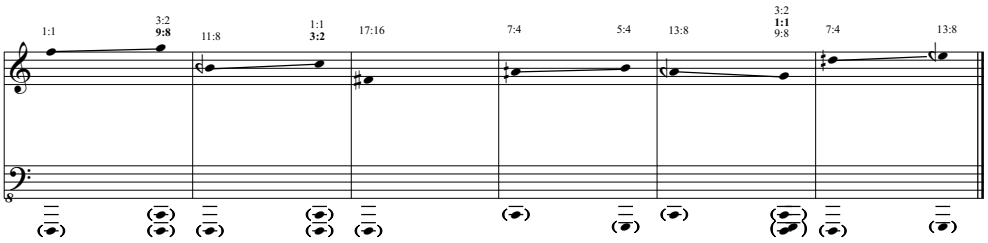
Figure 70. The harmonic fields underpinning rehearsal letter C, ***Land's End***



Stretched glissandi between these pitches create the impression of a gradually shifting axis of sound, much as occurs in a traditional siren. The consecutive, overlapping entries in the piece are notated below in isolation (Figure 71), with their implied roots bracketed on the lower stave. Where these notes (as simplified to quartertones) could be perceived as

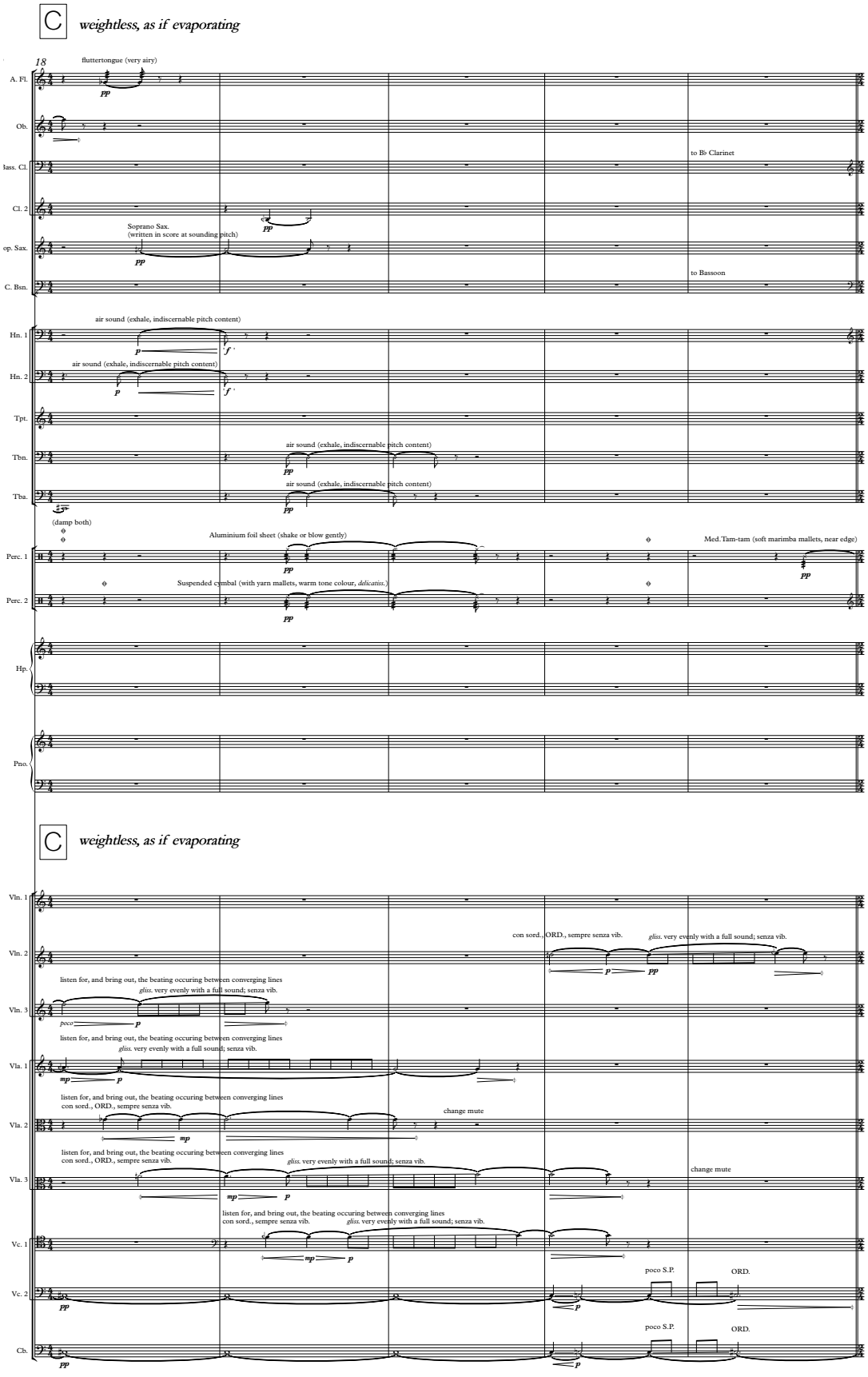
belonging to more than one of the three roots, all possible roots are shown (with my particular conception highlighted in bold).

Figure 71. The separate glissandi that amount to rehearsal letter C, *Land's End*



Note the transfer in weight from F to G, via C.

Figure 72. Figure 71, as realised at rehearsal letter C in the score



Rehearsal letter G uses the same principles, with harmonic fields arising from the roots E, B and F-sharp. Two figures below (Figures 73 and 74) show (firstly) these harmonic fields and (secondly) the overlapping glissandi constructed from these.

Figure 73. Three harmonic fields from the roots B, F-sharp and E respectively

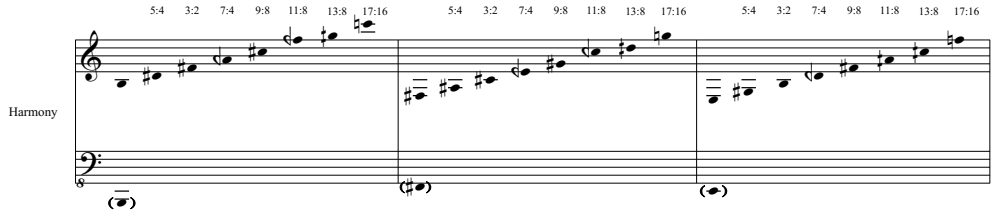
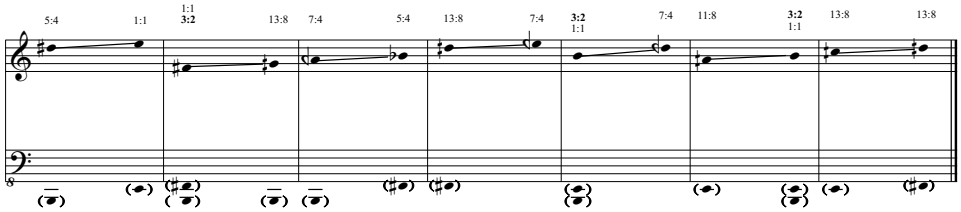


Figure 74. The separate glissandi that amount to rehearsal letter G, *Land's End*



Simple oscillations between two pitches (an A-flat and B quarter-tone flat) are introduced at rehearsal letter F (recurring at rehearsal letter S). I was interested in these oscillations acting as a pivot, about which different harmonic contexts were gently refracted. Figure 75 details how—via common tones—notes from the harmonic fields of A-flat and E-quartertone-flat are refracted about this pivot (an idea later developed in *A through-grown earth).*

Figure 75.

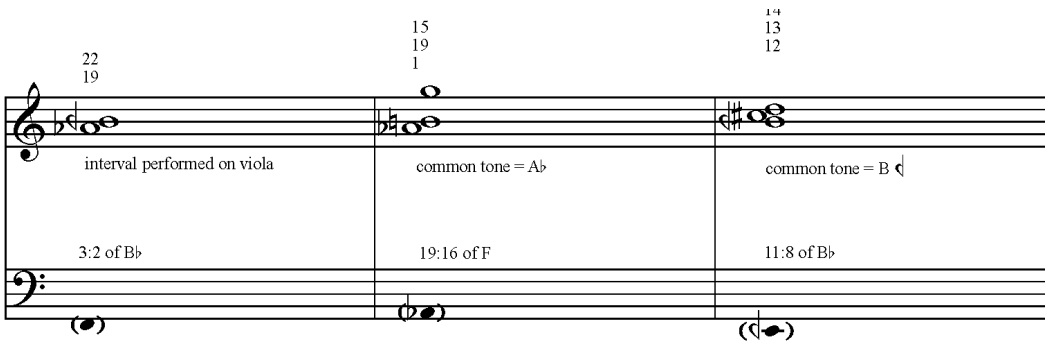
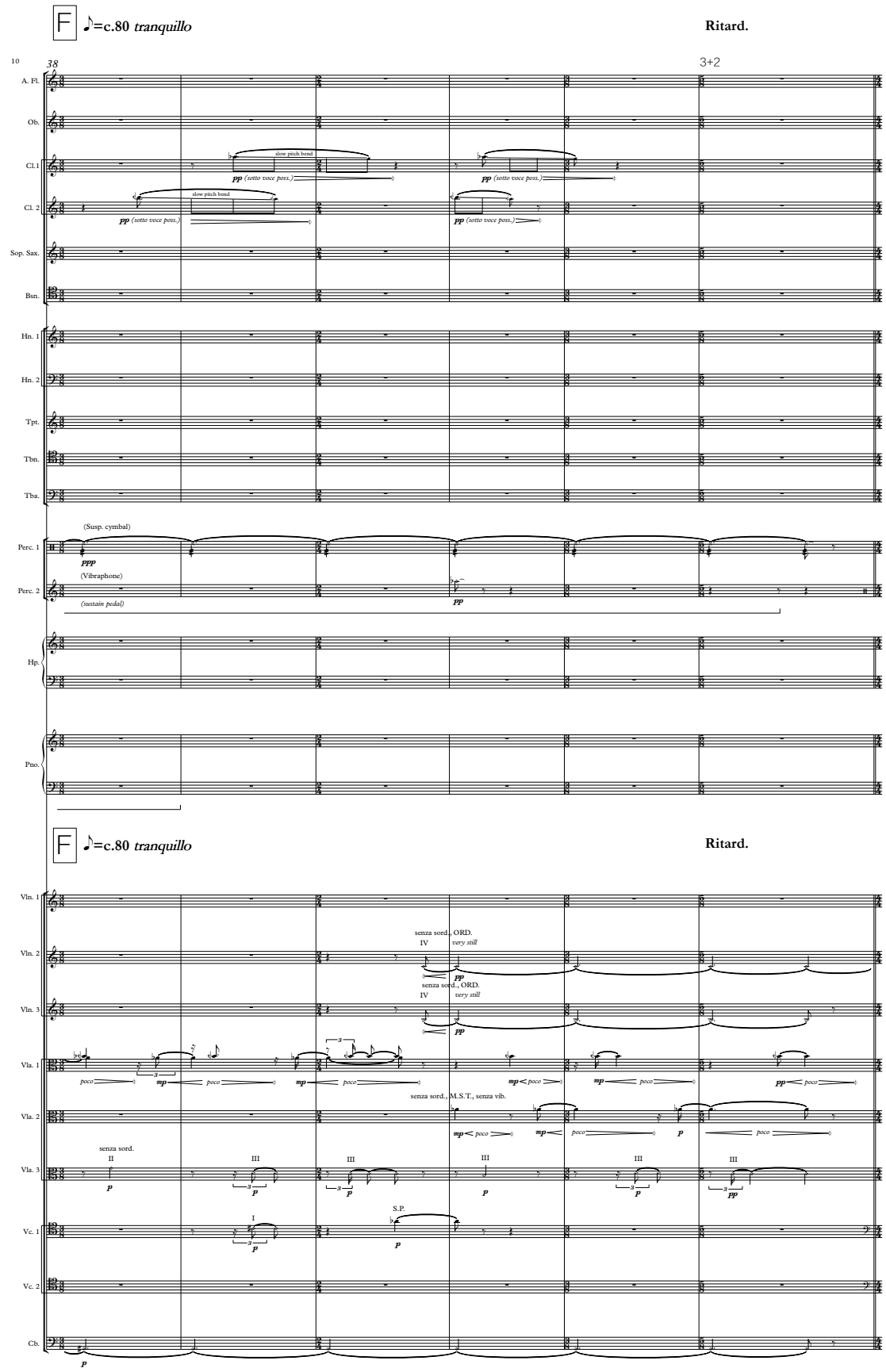
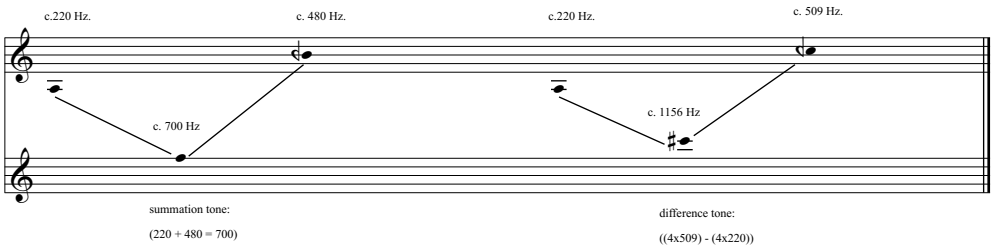


Figure 76. A realisation of Figure 75 in the string section at rehearsal letter F, *Land's End*



Throughout rehearsal letters O, P and Q, chords derived from the harmonic fields of F and F-sharp are coloured with combination tones, as a means of creating sonorous, self-reinforcing chords and playing with perspective. Figure 77 demonstrates this for the chord at rehearsal mark 'P'.

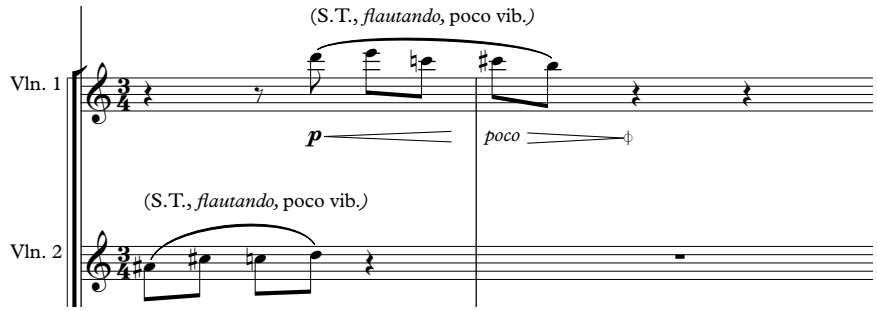
Figure 77. Two examples of colouring a dyad with a combination tone: dyads are notated on the top stave, the difference and summation tones on the lower stave (with an explanation of the calculation below the tone).



4.4.7 'Diffraction' in Other Parameters

In *Land's End* , diffraction was most fully addressed as a splintering of harmonic space, presented through contracting and dilating musical fragments. There are ideas latent within *Land's End* that perhaps suggest ways to consider diffraction along other parameters: in the unfolding of a melody or in juxtaposing small fragments of instrumental timbre. At rehearsal letter I the violin lines unfurl symmetrically (around the note D in Figure 78).

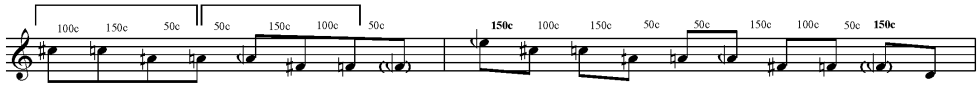
Figure 78. Violin lines at rehearsal letter I, *Land's End*



Likewise, the descending lines at rehearsal letter K are constructed (almost) symmetrically, and expand symmetrically unit-to-unit. Figure 79 shows the near-symmetry of the opening

line (describing the intervals in cents above each). It also demonstrates the expansion of this line by an interval of 150 cents at either end.

Figure 79. The descending melodic lines at rehearsal letter K, *Land's End*



At rehearsal letter D the ascending lines in Figure 68 (reproduced below) are splintered into small phrases through different instrumental groups. Each cycle of the line is marked by a slight fluctuation in tempo. This helps to demarcate phrases.

Figure 68.

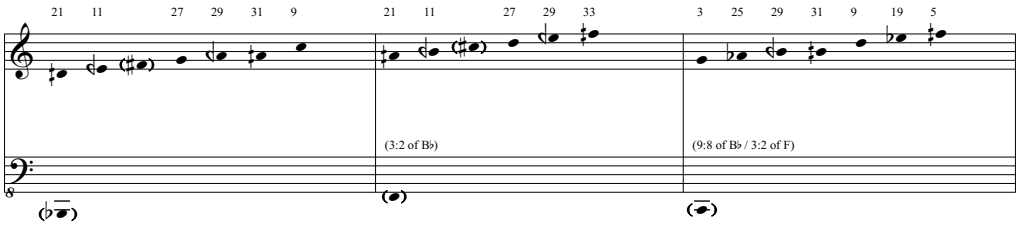
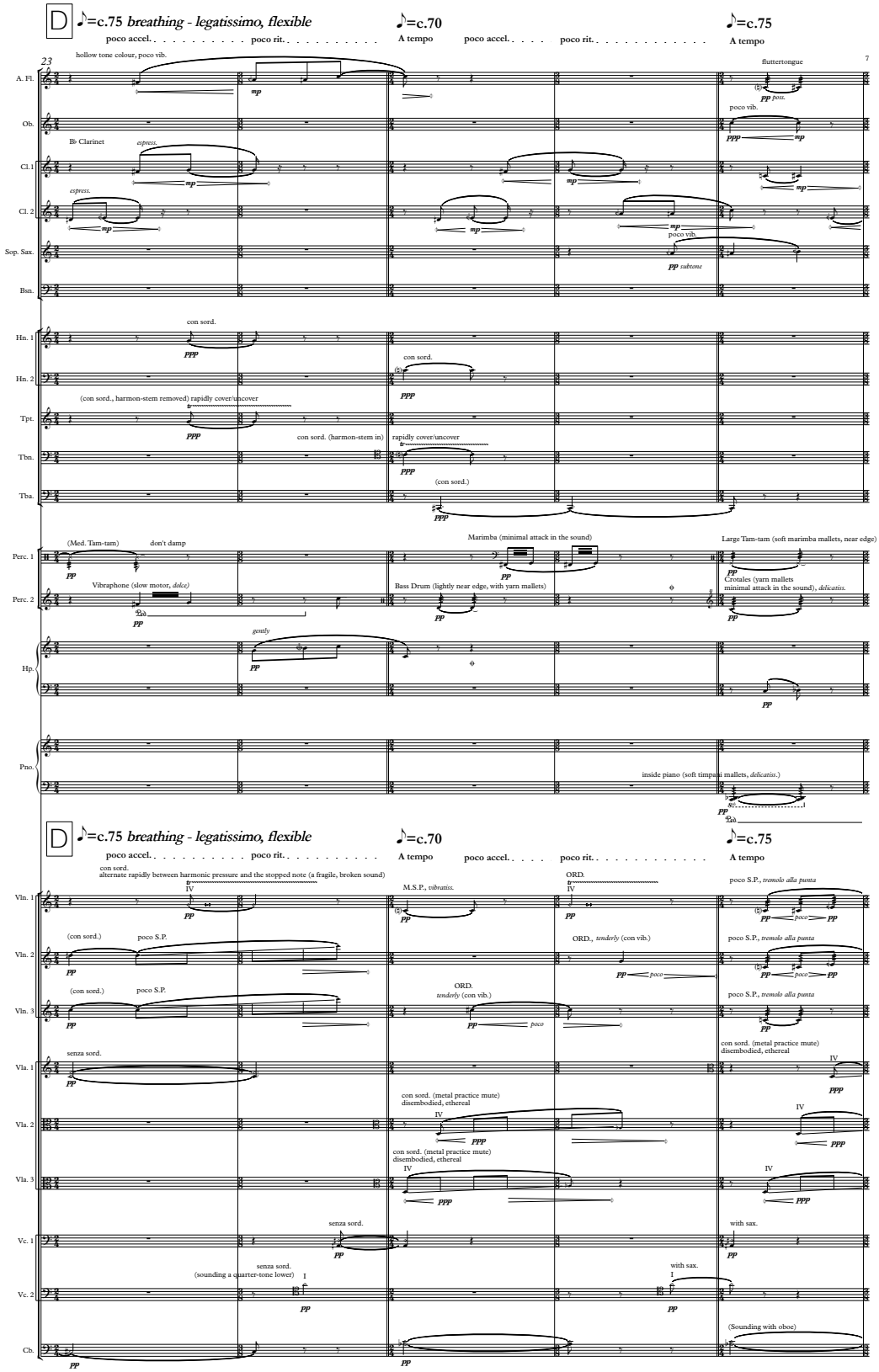


Figure 80. A page from the score of *Land's End*: rehearsal letter D, showing the orchestration of the first melodic line in Figure 68



4.5 Rose

4.5.1 Raking Light

Surveying the notes I made from the rehearsals for *Land's End,*[207] I was struck by the prevalence of certain themes. I made several comments asking for different *degrees of presence* in the sound ("strings full piano when not glissing", "fuller sound on the noteheads", "glissandi equally present", "top line most audible", "clear attack")[208] and others asking for a *shift in focus* (which required careful notation of— and attention to— dynamics). In retrospect, I understand *Rose* as an early attempt to grapple with these notes. I paid more attention to the dimension of sound moment to moment, prefiguring ideas discussed in Chapter Three. Re-reading the programme note to *Rose* reveals this change in emphasis:

> "Over the recent Scottish winter I got great joy from walking in the morning's low, raking light: a glow illuminating the still-waking world obliquely and throwing the austere Georgian facades into relief. The way the light acted upon these surfaces was very beautiful, highlighting minutiae and casting incisions of deep shadow. I later learned that this phenomenon underpins a process in fields like art conservation, where raking light is used to reveal the textural details of a surface, and inconsistencies such as small distortions, tears and creases. *Rose* arose out of contemplating this image and idea, as I speculated about what it might sound like if melodic fragments were analogously lit. As a piece of music, *Rose* unfolds gradually in cycles of simple lines and remnants of melody, through which subtle disparities can be perceived and felt. The uniform quietude of the work allows space for this surface to glow, darken and breathe."

The overall harmonic organisation of *Rose* closely resembles that of *Land's End*: the piece is divided into two sections roughly equal in length and affixed with a coda, each section moves through different, related harmonic fields that are conceived as aspects of a presiding tonality. *Rose* is made out of similar musical materials to *Land's End*: glissandi, lines and impulses. I've therefore chosen to focus in this commentary on those aspects of *Rose* that make small changes in presence and focus locally, drawing upon principles of rational harmony.

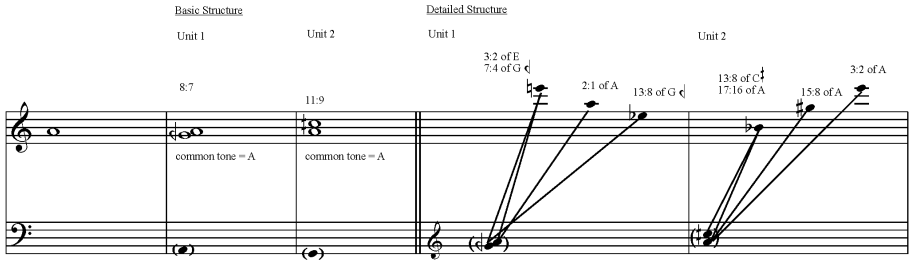
4.5.2 Sound Objects, Dimension and Perspective in Rose

At rehearsal letter E, the music pivots around a central pitch A, shifting between two dyads (Unit 1 and Unit 2 in Figure 81). These dyads share the common tone A, but belong to

[207] (3 rehearsals in March 2016 with Sydney Symphony Orchestra, and 3 rehearsals in April 2016 with BBC Symphony Orchestra)
[208] Lisa Illean, Journal entry, 31st March, 2016.

different harmonic contexts (with fundamentals of A and G respectively). The 'detailed structure' of Figure 81 generates a second layer of related pitches to create dimension and reinforce the distinct perspective of each dyad.[209]

Figure 81. How the harmony at rehearsal letter E, *Rose,* is generated from a central pitch (A=440 Hz)

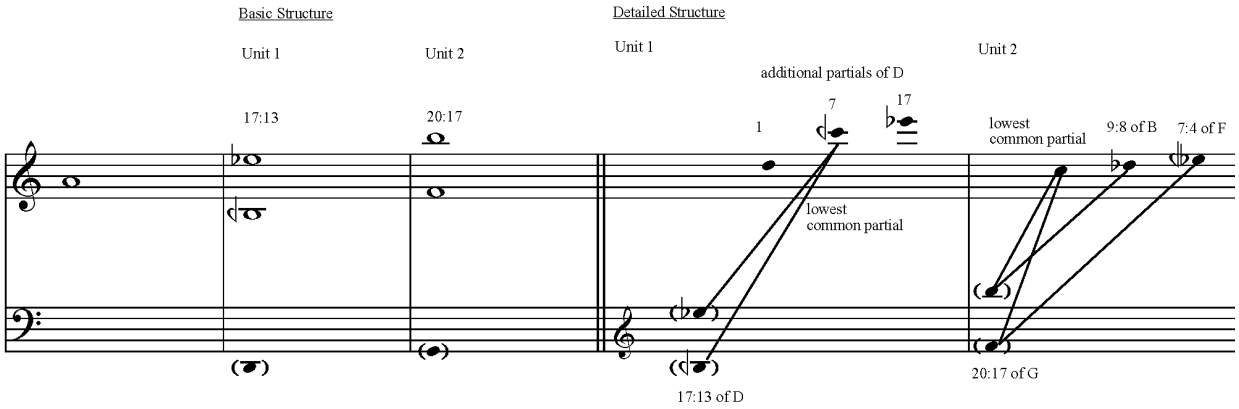


Throughout *Rose*, I grouped melodic fragments and chords into pairs of notes. I calculated common partials and other tones through intermodulation (making a second hierarchical layer of harmony assembled into resonant, self-reinforcing chords.) This process could theoretically proliferate, producing many more layers in a kind of feedback process. Each strata of sound has a unique onset and swell shape: the overlapping of these was intended to create the sensation of a sound 'shifting in focus'.

For example, Figure 82 shows the clarinet multiphonics at rehearsal letter N as one layer and the string chords as a second. The first multiphonic (Unit 1) is paired with a chord containing the lowest common partial of these two notes, and other tones belonging to the shared harmonic field of D (partial numbers notated numerically above the pitches). The second multiphonic (Unit 2) is paired with notes generated by the dyad, including its lowest common partial, C. As in *Land's End*, I 'reduced' partials into a central tessitura.

[209] In all the figures for *Rose*, the partials and fundamentals have been reduced to sit within a desired tessitura (and on the stave).

Figure 82. *Rose,* Rehearsal letter N

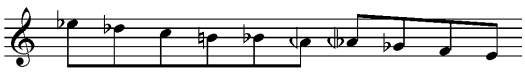


This way of working affected the pacing in *Rose.* Melodic fragments and lines expanded to accommodate this 'playing with perspective', but as a result the sharp juxtapositions between materials that characterised *Land's End* became more diluted. The added layers of harmonic information created an opacity (or 'harmonic density') that also diffuses the broader harmonic organisation.[210]

4.5.3 Analogies to Tape Delay in Rose

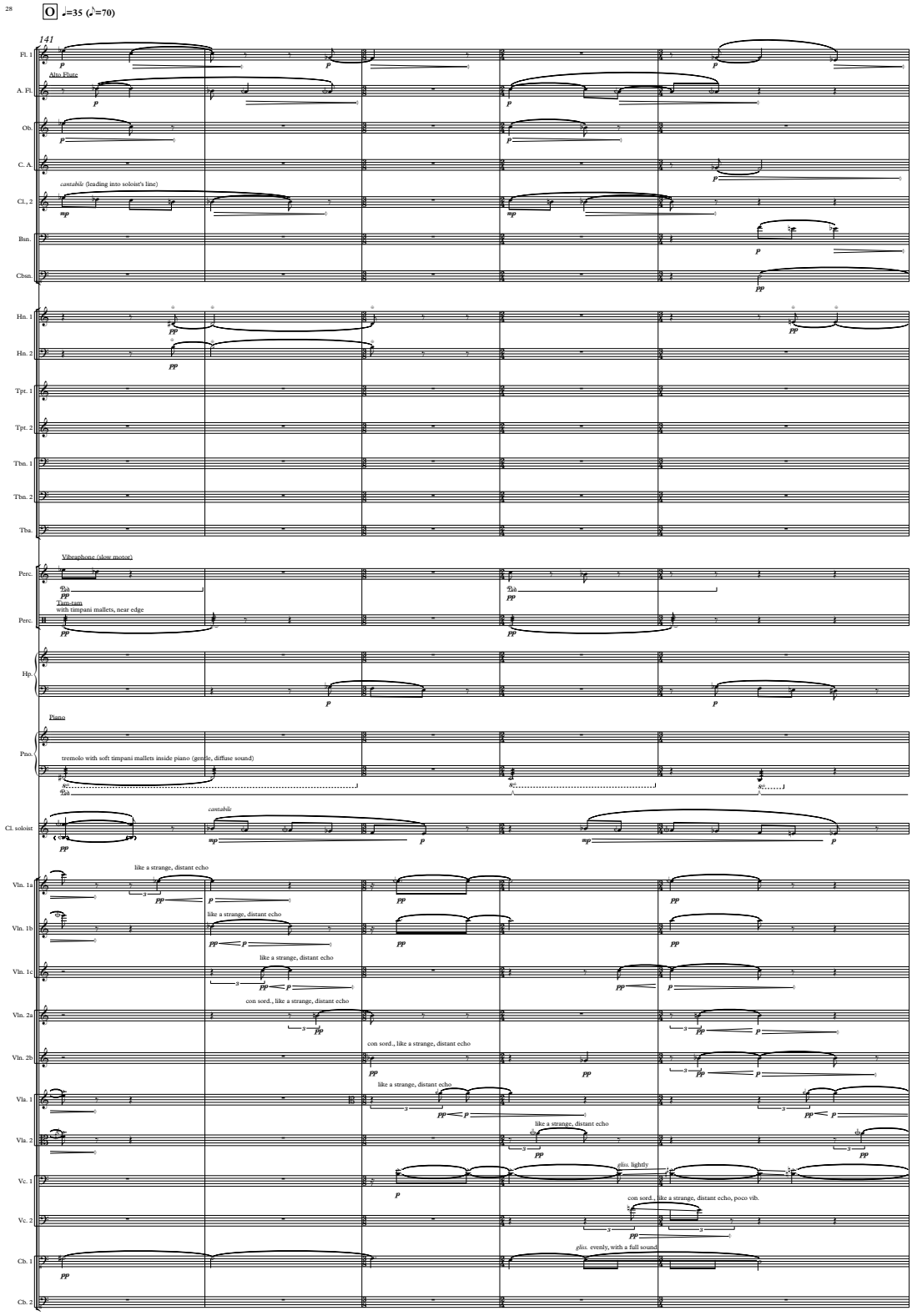
As discussed in *Januaries*, example 1, tape delay provides a model that can be applied to acoustic music with imagination and technical freedom.[211] Figure 84 shows a page from the score of *Rose* at rehearsal letter O. In this section, aspects of a line (Figure 83) are presented at different times and different speeds. These aspects are not permutations of the line itself (as in canonic forms) but something more akin to traces or refractions of the line, that contribute ultimately to the harmonic density of the unit.

Figure 83. The line underpinning the music in Figure 84



[210] This could be clarified with more precise tuning.
[211] Anderson and Murail, "In Harmony: Julian Anderson Introduces the Music and Ideas of Tristan Murail.", 323

Figure 84. Excerpt from the score of *Rose* at rehearsal letter O

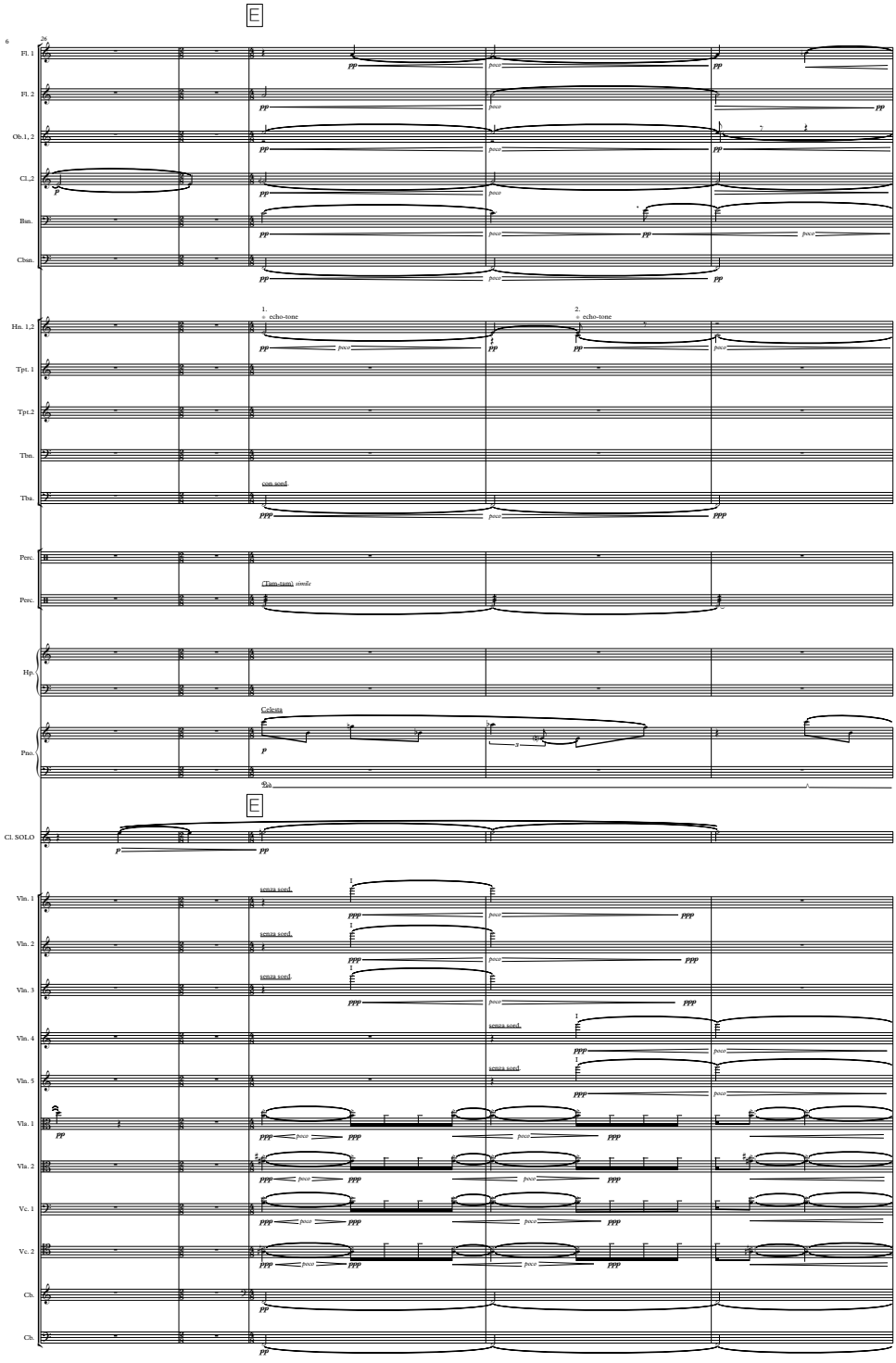


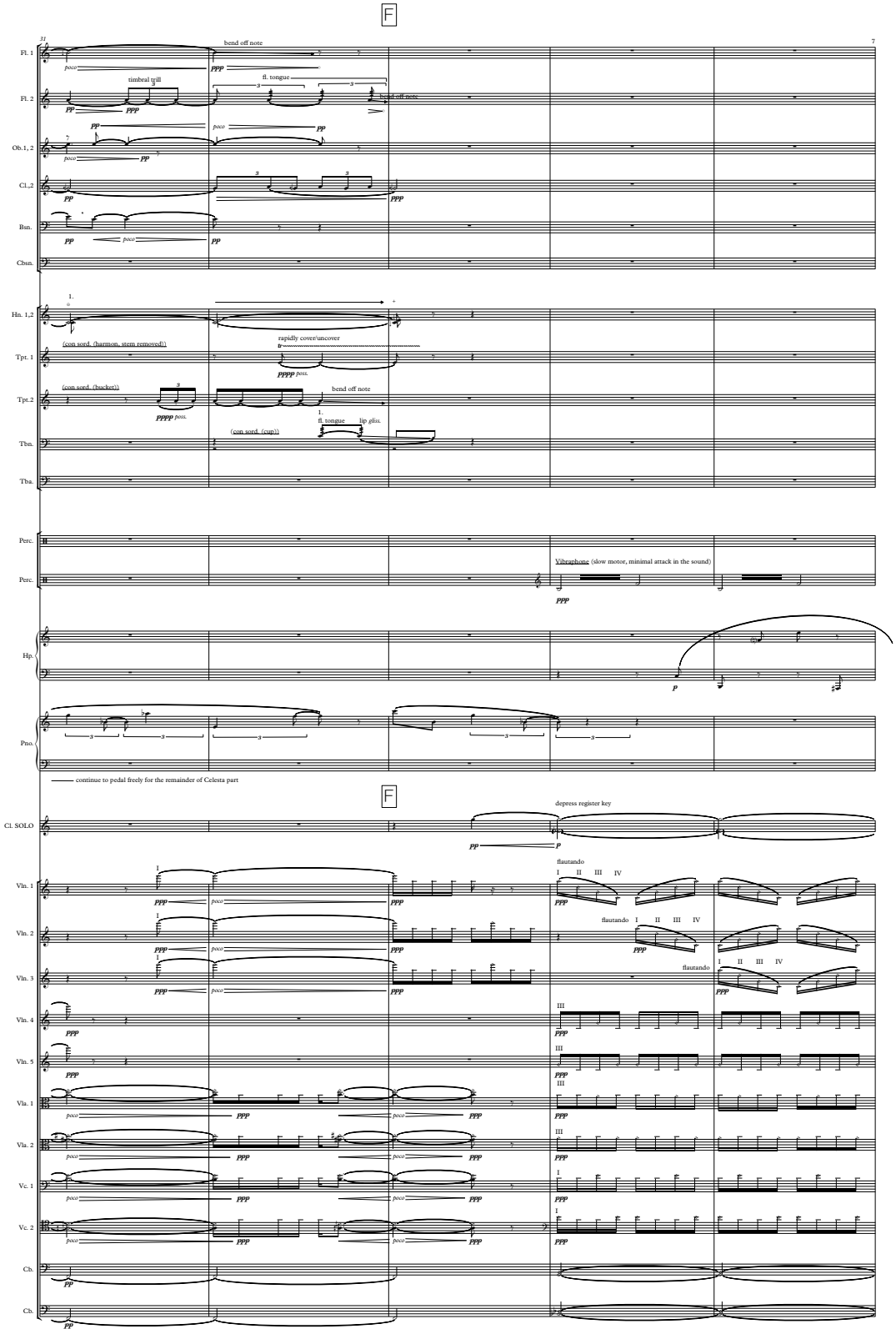
4.5.4 On Melodic Interest

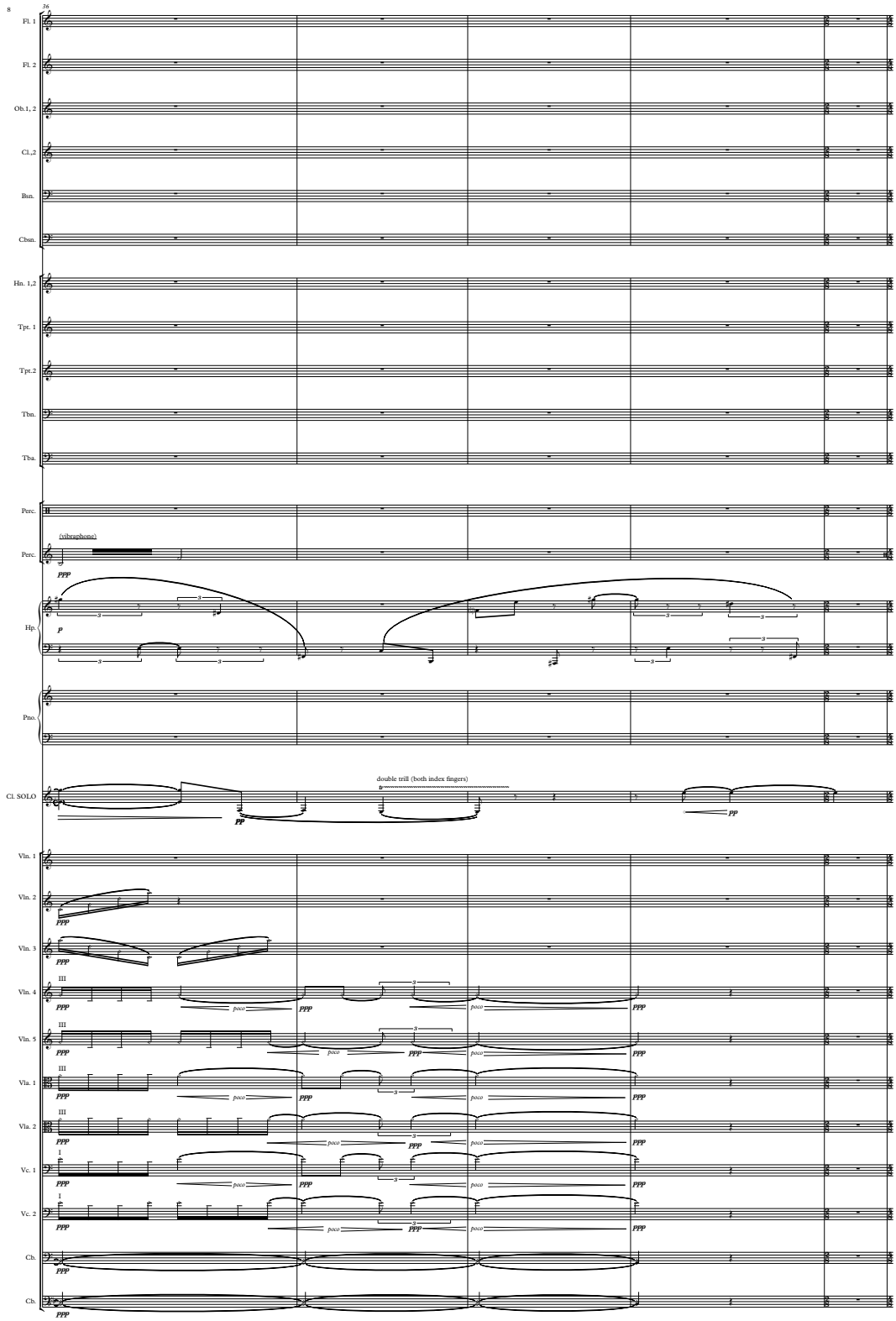
My first sketches for *Rose* were quite different in character: static yet malleable masses of layered sound. An excerpt from these, recorded at a workshop with London Philharmonic Orchestra, can be heard as Audio sample 11 alongside Figure 85.

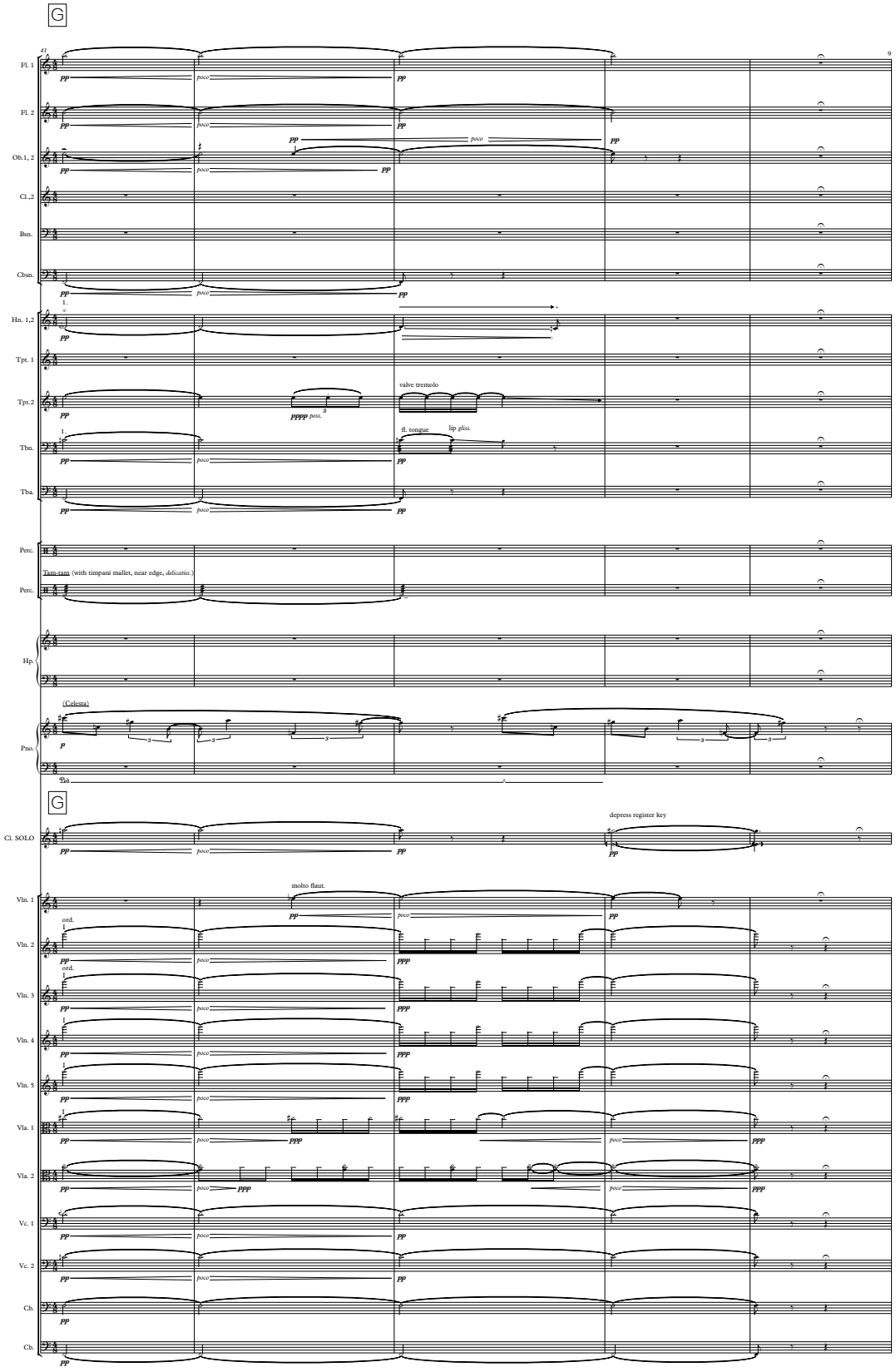
Audio sample 11. Excerpt from the first draft of *Rose,* Letter E to Letter H.

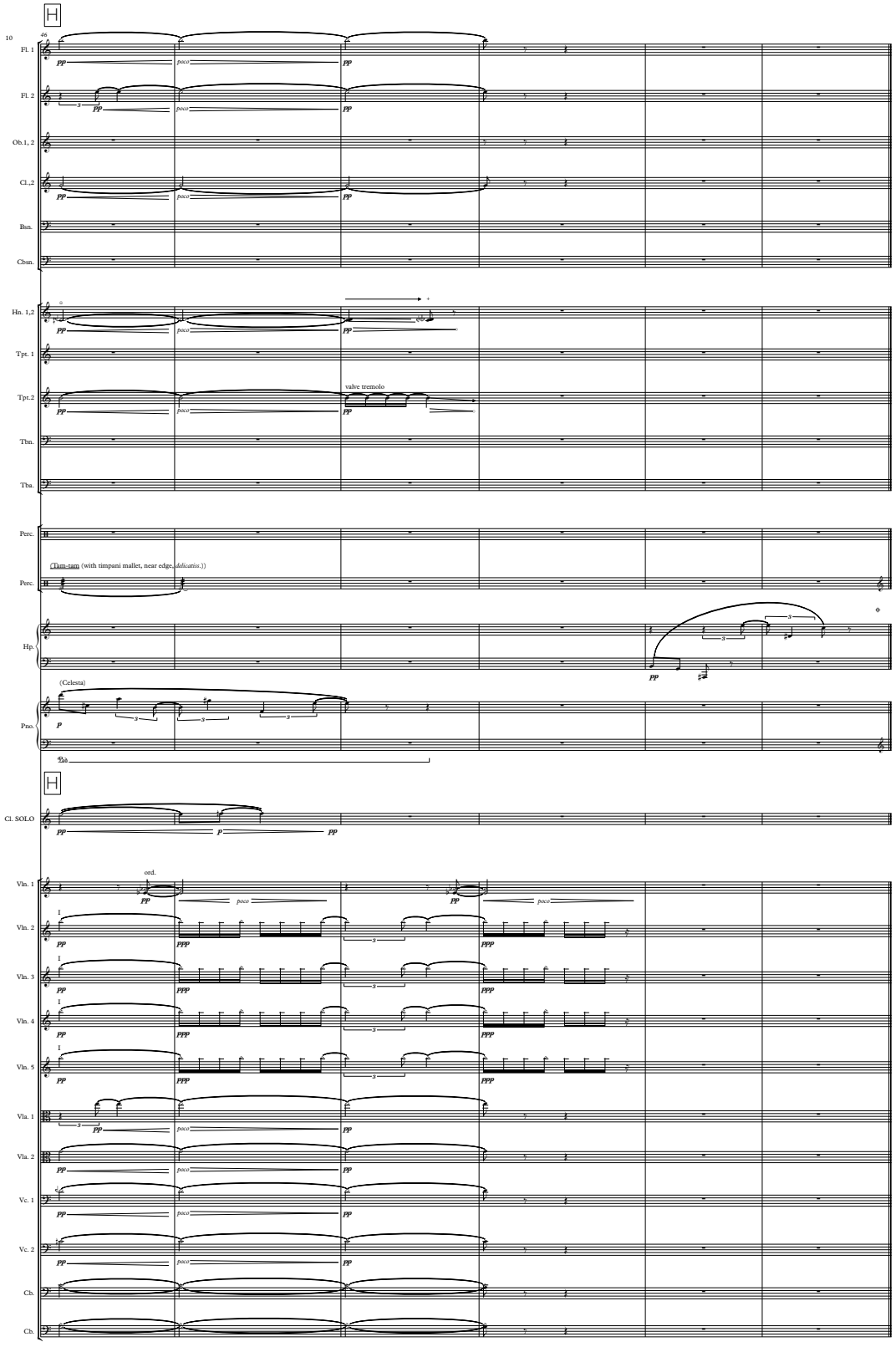
Figure 85. Excerpt of the score from the first draft of *Rose*




F
31
bend off note
7
Fl. 1
poco
ppp
timbral trill
Fl. 2
fl. tongue
bend off note
pp
Ob.1, 2
Cl.,2
Bsn.
Cbsn.
1.
Hn. 1,2
(con sord. (harmon, stem removed))
rapidly cover/uncover
Tpt. 1
pppp poss.
(con sord. (bucket))
Tpt.2
bend off note
1.
fl. tongue
lip gliss.
(con sord. (cup))
Tbn.
Tba.
Perc.
Vibraphone (slow motor, minimal attack in the sound)
Hp.
Pno.
continue to pedal freely for the remainder of Celesta part
F
depress register key
Cl. SOLO
p
flautando
I II III IV
Vln. 1
Vln. 2
Vln. 3
Vln. 4
Vln. 5
Vla. 1
Vla. 2
Vc. 1
Vc. 2
Cb.
Cb.


8
36
Fl. 1
Fl. 2
Ob.1, 2
Cl.,2
Bsn.
Cbsn.
Hn. 1,2
Tpt. 1
Tpt.2
Tbn.
Tba.
Perc.
Perc.
(vibraphone)
ppp
Hp.
p
Pno.
Cl. SOLO
double trill (both index fingers)
pp
Vln. 1
Vln. 2
Vln. 3
Vln. 4
Vln. 5
Vla. 1
Vla. 2
Vc. 1
Vc. 2
Cb.
Cb.
III
I
poco


G
41
9
Fl. 1
Fl. 2
Ob.1, 2
Cl.,2
Bsn.
Cbsn.
Hn. 1,2
Tpt. 1
Tpt.2
valve tremolo
Tbn.
fl. tongue
lip gliss.
Tba.
Perc.
Tam-tam (with timpani mallet, near edge, delicatiss.)
Perc.
Hp.
(Celesta)
Pno.
G
Cl. SOLO
depress register key
molto flaut.
Vln. 1
Vln. 2
Vln. 3
Vln. 4
Vln. 5
Vla. 1
Vla. 2
Vc. 1
Vc. 2
Cb.
Cb.


10
46
Fl. 1
Fl. 2
Ob.1, 2
Cl.,2
Bsn.
Cbsn.
Hn. 1,2
Tpt. 1
Tpt.2
valve tremolo
Tbn.
Tba.
Perc.
Perc.
Tam-tam (with timpani mallet, near edge, delicatiss.)
Hp.
(Celesta)
Pno.
Cl. SOLO
ord.
Vln. 1
Vln. 2
Vln. 3
Vln. 4
Vln. 5
Vla. 1
Vla. 2
Vc. 1
Vc. 2
Cb.
Cb.

I found myself, however, increasingly drawn to creating modest melodies, partly as a means of addressing the role played by the clarinet soloist. The use of modes in *Land's End* and *Rose* was directly tied to melodic thinking. The practical question of how to work with melody while using non-standard tunings is an enduring thread throughout my notebook entries. How could nuanced microtonal intervals be reliably reproduced and sustained, so that unusual harmonies settle in the ear? Could melodies tuned in equal temperament sound coherent in the context of non-tempered tunings? What approach to equal temperament might invite this?

Chapter Five examines these questions in light of three pieces composed with prominent voice and piano parts: *Sleeplessness … Sails, after-image* and *Cantor*. In each, the nature of the commission required that both the voice and piano used the tunings of equal temperament.

Chapter Five

Writing for piano: equal temperament through the lens of non-tempered tuning

5.1 The Piano

5.1.1 The Piano in My Work

Over the course of my doctorate I wanted to work with a wide variety of musicians: specialists in just intonation (such as my friend Chris Rainier), individuals I could work closely with (Juliet Fraser, Explore Ensemble) and those perhaps trained differently or under stricter working conditions (such as the tight schedules of orchestras). Dismantling any preconceptions I held, I wanted to discover in which environments I found composing most fulfilling. Particular challenges arose when I was asked to write for voice, musicians uncomfortable with microtonality or for ensembles with piano. Having found the use of quartertones limiting and ultimately unsatisfying, I began to explore a hybrid world using (12-tone) equal tempered and non-tempered tunings. This chapter examines the ways I attempted to work with the piano's fixed, equal tempered intonation on the same terms as non-tempered tuning.

5.1.2 The Piano's Riches

> "If the ear gets close enough to the spectrum it will 'hear' the spectrum…[the spectrum is] blurred, like our heart, like our walking…with that margin of fluctuation that is the source of all interest."
>
> -Gerard Grisey[212]

In many ways, the piano—like rational harmony—is predisposed to a multidimensional approach to sound phenomena. Its construction allows one to build up strata of sound across of vast register, while full, half and quarter pedallings can sustain "sonorities suspended in various states of decay."[213] Chords approximating overtone structures are found in the music of Liszt, Debussy, Scriabin[214] and Bill Evans[215]—music that conjointly addresses form, temporality and virtuosity in striking ways. This harmony relies on the idea that "if the ear gets close enough to the spectrum it will 'hear' the spectrum" or that "the trained musical ear enables it to hear the fixed tuning as something which can deviate from

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[212] Marilyn Nonken, *The Spectral Piano: From Liszt, Scriabin and Debussy to the Digital Age.* (Cambridge: Cambridge University Press, 2014), 47

[213] Marilyn Nonken, *The Spectral Piano,* 52

[214] Scriabin's mystic chord is composed with overtones 7-14.

[215] See: George Russell, *Lydian Chromatic Concept of Tonal Organisation,* New York: Concept Publishing Co., 2001. (First published in 1953).

its physical origin."[216] Pianist and author Marilyn Nonken has also identified a 'spectral attitude' to writing for the piano in music by Stefan Niculescu, Iancu Dumitrescu, György Ligeti,[217] Karlheinz Stockhausen, Yiannis Xenakis, Giacinto Scelsi, Jonathan Harvey, and Horatio Radulescu (to name a few). Regarding the piano as a colossal zither, Jasna Veličković's research using electromagnetic fields employs magnets and coils to ply haunting "Shadow Studies" from the piano strings.[218] These uncover the instrument's rich and idiosyncratic acoustic possibilities.

5.1.3 Simple Piano Acoustics

Analysis of the vibrations and spectra of a piano string reveals complex patterns. The vibration as a whole is non-periodic, quickly diminishing in intensity. Component vibrations change in intensity across the duration of the sound and do not mirror a textbook harmonic series. This well-documented 'inharmonicity' of piano strings (see Figure 86) causes the partials of a given string to deviate towards higher frequencies than those in an 'ideal' overtone series: the 10th partial sounding around 33 cents higher, the 15th roughly 100 cents higher and the 20th partial about 200 cents higher.[219] This inharmonicity varies proportionate to the tension the string is under (strings in the bass and treble registers are under higher tension) and the force of the piano action (and by extension, dynamic of the sound produced). The spectrum also varies over time, with partials in the middle register (especially the 3rd, 4th, 5th, 10th and 15th) being most present in the resonance of a low note.[220]

Beneficially, the resulting lack of definition in the sound may help "to cover up the deficiencies of equal temperament" and allow the ear "sufficient freedom for it to take advantage of this uncertainty" such that "our aural perception is given more latitude when

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[216] Lloyd and Boyle, *Intervals, Scales and Temperaments: An Introduction to the Study of Musical Notation,* 174. "This is simply a case of the ear asserting its right to judge—within the limits of choice allowed to it—when such an instrument is most nearly in tune with itself *musically,* and provides a good example of the danger of leaving out the ear and regarding any particular musical interval as being defined primarily and absolutely by a *mathematical* ratio." Lloyd and Boyle, *Intervals, Scales and Temperaments: An Introduction to the Study of Musical Notation,* 166

[217] For example, in his 18 Piano Études (1984-2001)

[218] Jasna Veličković, "Shadow Study #2", accessed 10th November, 2016 http://jasnavelickovic.com/shadow_study_2.htm

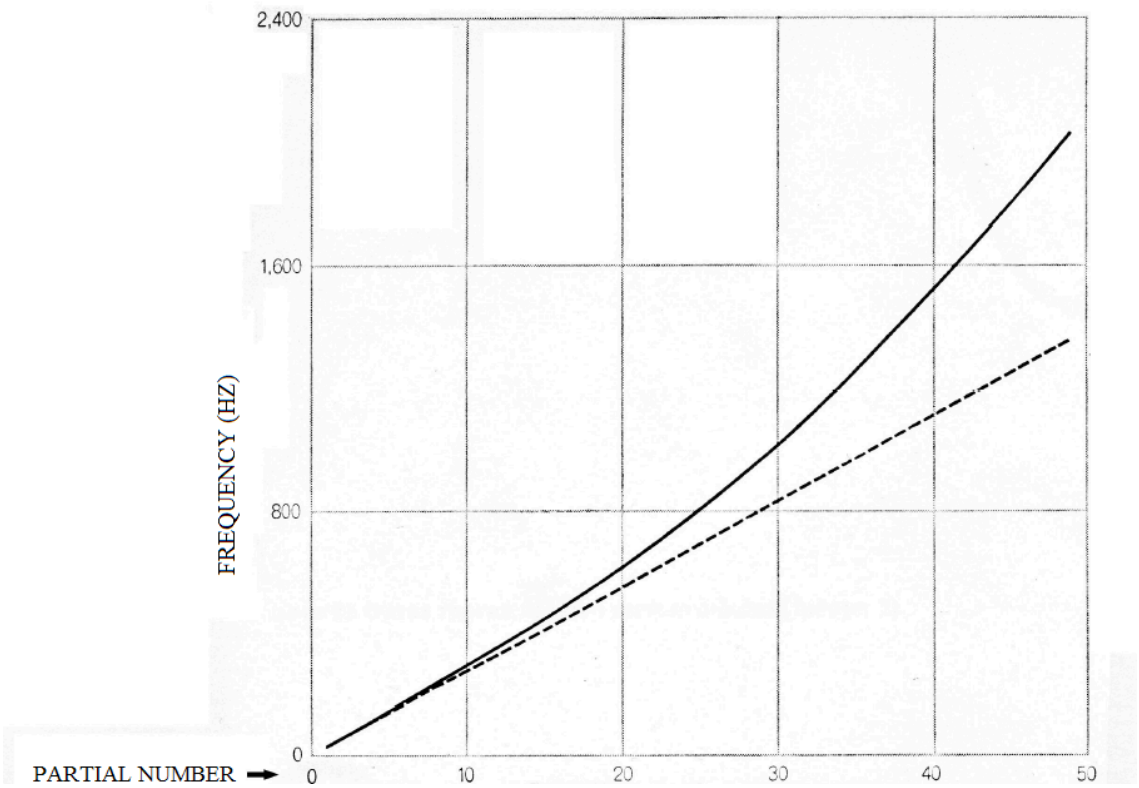
[219] Juan José Burred, "The Acoustics of the Piano" Translated by David Ripplinger, Accessed 3rd January 2017, https://www.scribd.com/document/187729437/Burred-Acoustics-Piano, 23

[220] This Burred attributes to the double decay present in the piano's middle register. Juan José Burred, "The Acoustics of the Piano", 31.

dealing with damped [i.e. natural] vibrations than it is given when dealing with periodic ones."[221]

Figure 86. The inharmonicity of piano string's partials

(Juan José Burred, "The Acoustics of the Piano" Translated by David Ripplinger, Accessed 3rd January 2017, https://www.scribd.com/document/187729437/Burred-Acoustics-Piano, 23)



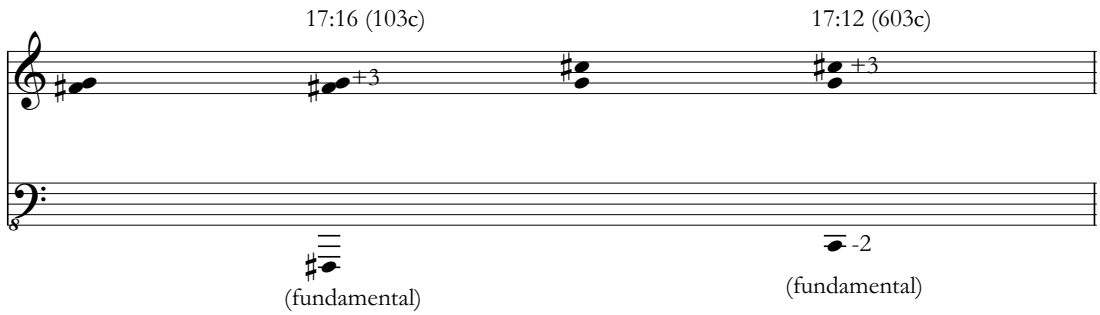
5.2 Writing for the Piano

5.2.1 Writing for Piano in an Ensemble Context

When writing for the piano, I began by working with overtone chords composed of those partials deviating least from equal tempered tuning (up to the 19th partial this encompasses partials 1 (2, 4, 8) 3 (6,12), 9, 15, 17 and 19, and occasionally I included the 5th (10th)). Alternatively, I started with dyads, considering them as very close approximations of just intervals (for example, the intervals 17:16 or 17:12, as shown in Figure 87).

[221] Lloyd and Boyle, *Intervals, Scales and Temperaments: An Introduction to the Study of Musical Notation,* 7-8

Figure 87. The interpretation of semitone as the just interval 17:16 and a tritone as the just interval 17:12



These dyads were then reinforced with secondary partials,[222] also drawing on the above set (1, 3, 9, 15, 17, 19). The examples in the figures below are from *Januaries*, bars 92-94.

Figure 88. Constructing a chord: a semitone, conceived as 17:16 and reinforced

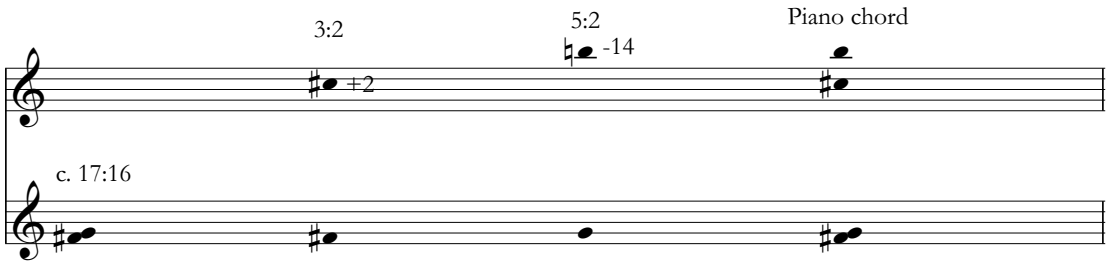
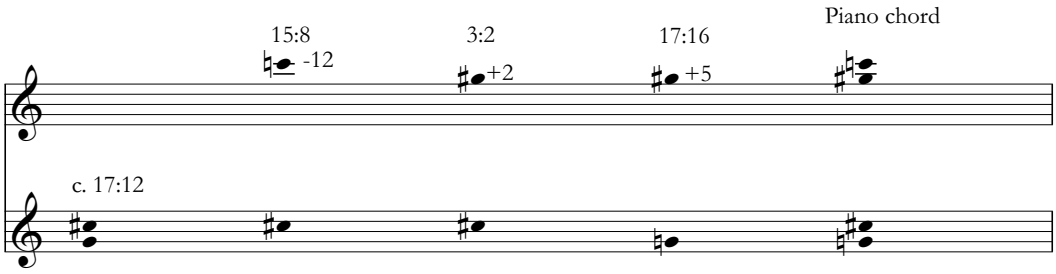


Figure 89. Constructing a chord: a tritone, conceived as 17:12 and reinforced



In *Cantor,* I reinforced dyads with their lowest common partials (see Figure 90). Minor seconds, major seconds and minor thirds were the most useful starting points, because they approximate more than one just interval (again drawing only on partials 1, 3, 9, 15, 17, 19; see Figure 91). In both instances, I hoped to make chords or figures that had a clear, fused sonority. On these occasions I used the middle and upper registers of the piano, allowing the surrounding ensemble to reinforce an implied harmonic context without interference

[222] If needed, partials were lowered an octave or two to bring them into the desired tessitura.

from low, inharmonic bass piano notes. Figures 92 and 93 show the working-out and the realisation of the opening piano figures of *Cantor*.

Figure 90. A minor second conceived as 17:16, 18:17, 19:18 (16:15 and 20:19)

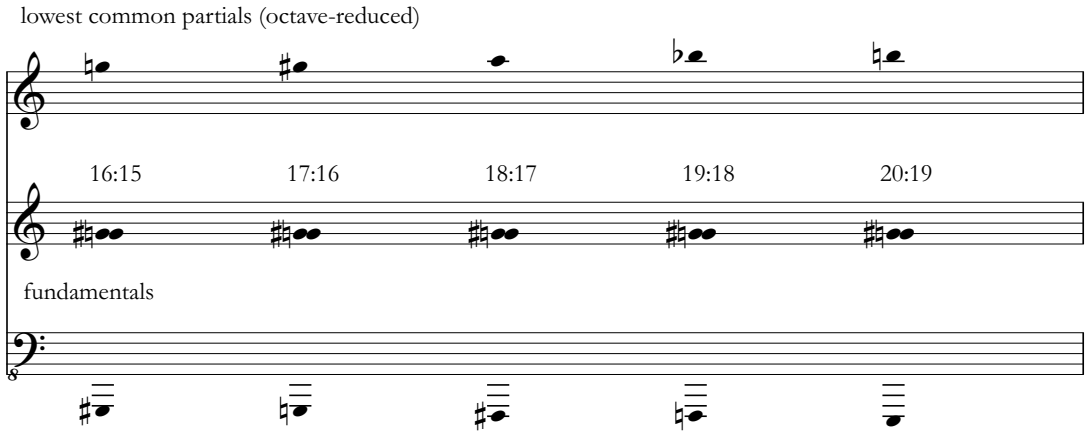


Figure 91. A major second conceived as 9:8 and 19:17

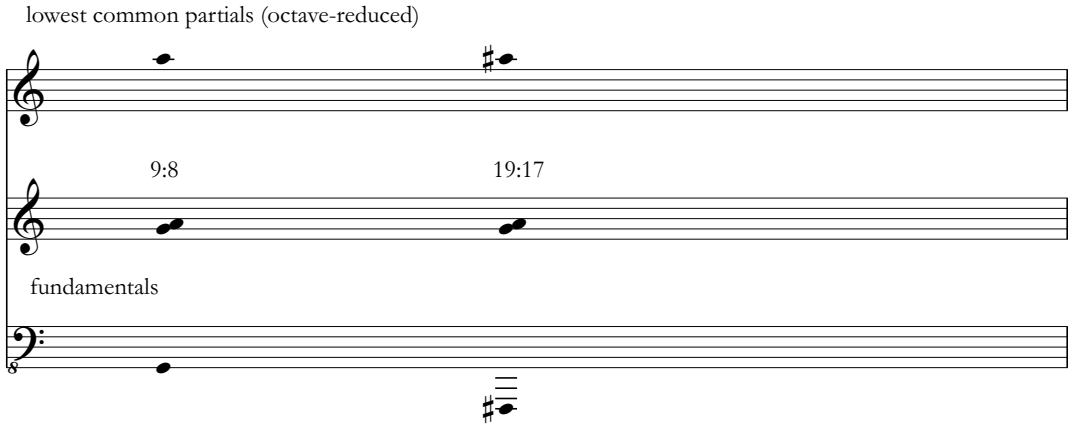


Figure 92. The translation of these principles into the opening piano figuration of *Cantor*

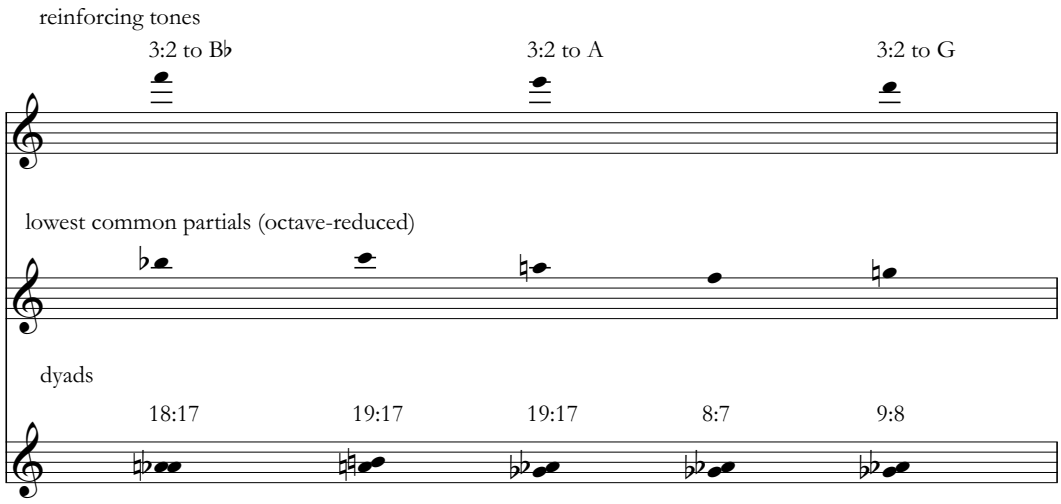
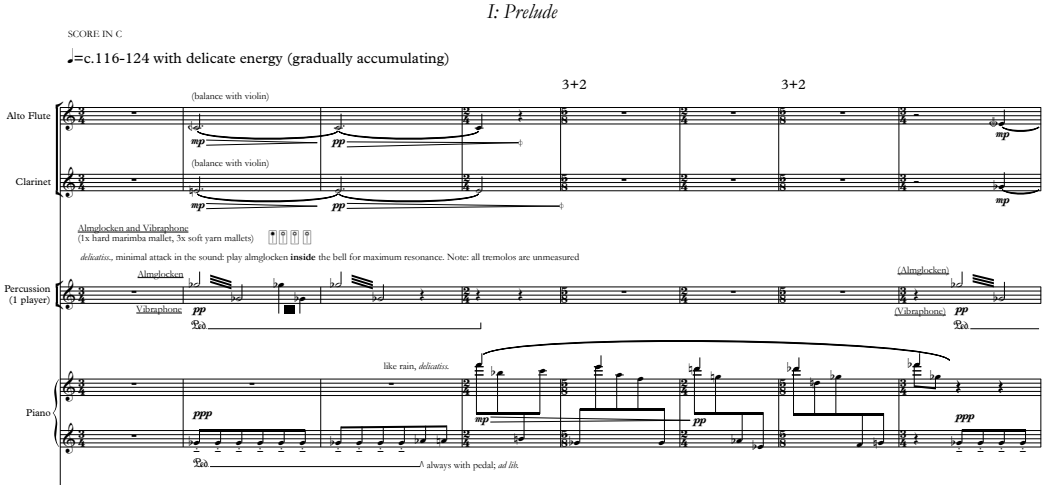


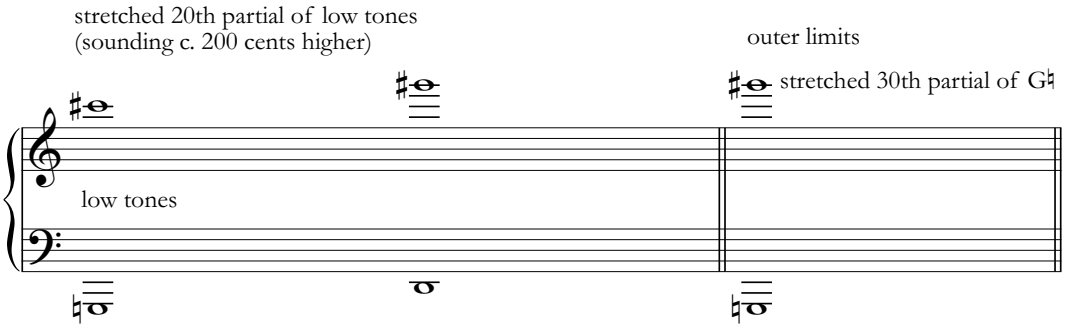
Figure 93. A score extract from the opening of *Cantor*



5.2.2 Writing for Piano as a Solo or Accompanying Instrument

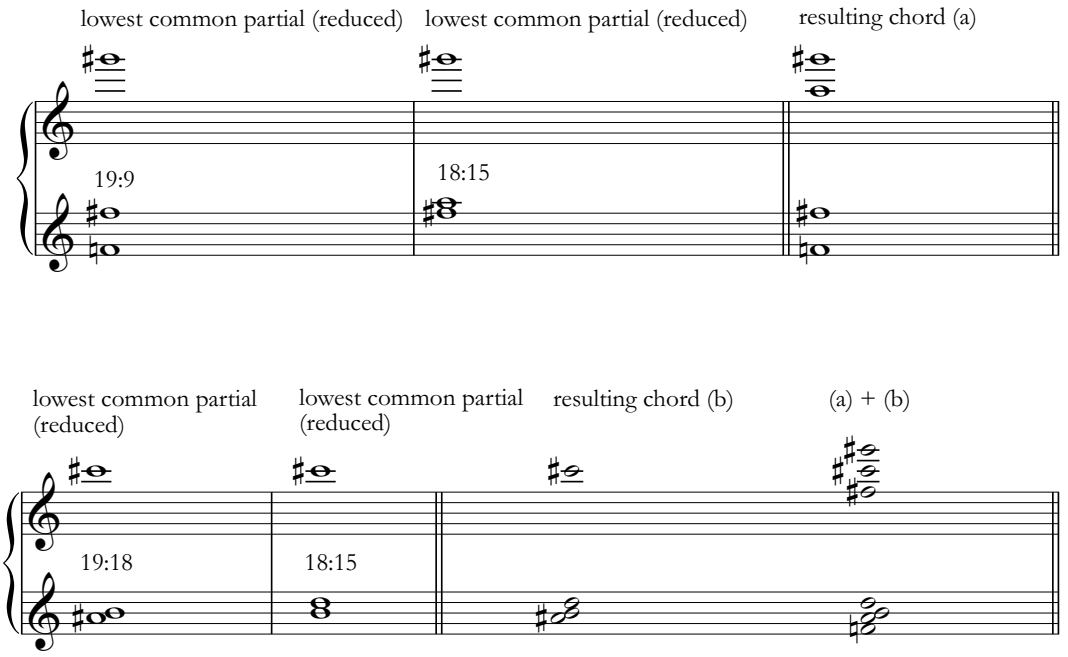
On other occasions, where I wanted to create strata of sounds, I addressed piano harmony slightly differently. In *after-image*, I made an initial set of chords by setting two frequencies as outer limits: a low G fundamental and the high G# which is a stretched partial of the G (see Figure 94.)

Figure 94. Tones as 'outer limits' in *after-image*



Chords were then constructed in the middle register, based on different combinations of frequencies that produce either a high G# and high C# as a common partial (Figure 95). This way of working was more attentive to pitch height than that described in 5.2.1.

Figure 95. The construction of chords in *after-image*



After-image was a short work composed for Eidit Golder and Lotte Betts-Dean after their chosen text *Katun River.* As the title suggests, this distilled piece was concerned with what remains—in words, music and sensation—once an original source is no longer present. Like *The Lantern Out of Doors,* the piano part is composed on a metrical grid of different tempi that has sustained varying degrees of erasure. This creates gently undulating patterns over which the voice hovers. The suspended sonorities I hoped would create an eddying repose: an idea explored further in *Weather a Rare Blue I* and *Sleeplessness … Sails.*

5.2.3 Sleeplessness … Sails

Viewing piano harmony in this multi-layered way introduces sculptural notions of dimension and perspective conforming to those discussed in Chapter Three. It also engenders subtle modulations which 'make sense'—acoustically, and therefore to the ear. For me, nuanced permutations to chords and figures can induce an atmosphere of glacial stillness, graceful buoyancy or muted lyricism. In *Sleeplessness … Sails* I hoped to recreate the 'twilight' logic of the narrator, in ruminative patterns simulating both his breathing and the hushed tidal pull and push of the black sea.[223]

Sleeplessness … Sails (for voice and piano) sets an untitled poem by Osip Mandelstam ('number 78', inscribed *Crimea, 1915*) from his collection *Kamen* (Stone). In the opening lines the narrator cannot sleep. As he reads, the suspended state of insomnia is lithely mingled with the image of a fleet of ships suspended mid-voyage, resembling a herd of cranes in flight. The vocal line unfolds slowly, recalling Joseph Brodsky's observation that in Mandelstam "words, even their letters—vowels especially—are almost palpable vessels of time."[224] The piece uses a restricted set of five chords in two cycles (Figure 96). The restrained transposition of these underpins the opening section (see Figures 97 and 98). By deferring resolution of these cycles, I hoped I would create harmonies that hovered, and a surface malleable to small fluctuations in tempi. Like pleated water catching the light in different ways, I anticipated that these fleeting changes could be both evocative and perceptually compelling.

I was encouraged, in part, by Mamoru Fujieda's *Patterns of Plants* (1996-2011), which has both a microtonal version (for traditional Japanese instruments) and a version for piano. The musical permutations—composed patterns, derived from converted data (electrical readings of the surface-electric potential on leaves)—proved compelling listening in both contexts.

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[223] As an enclosed basin, tidal oscillations in the black sea are subdued.
[224] Joseph Brodsky, "The Child of Civilisation", *Less Than One: Selected Essays,* (U.K.: Penguin, 2011), 125

Figure 96. Two cycles of chords in *Sleeplessness … Sails*

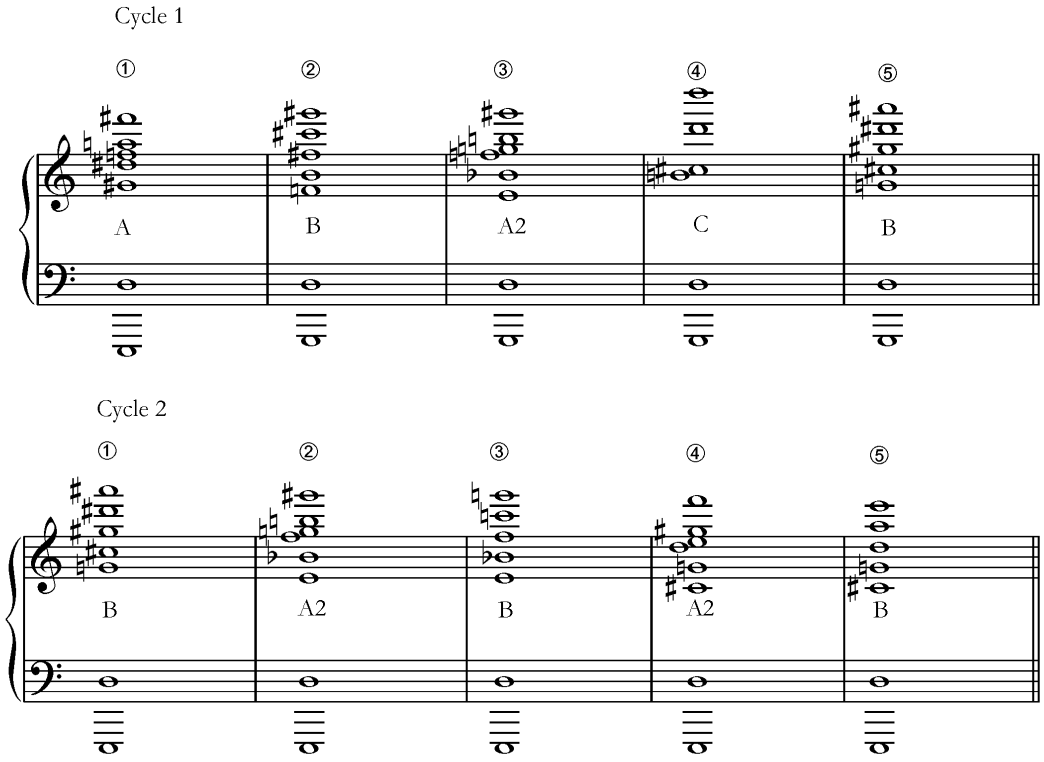
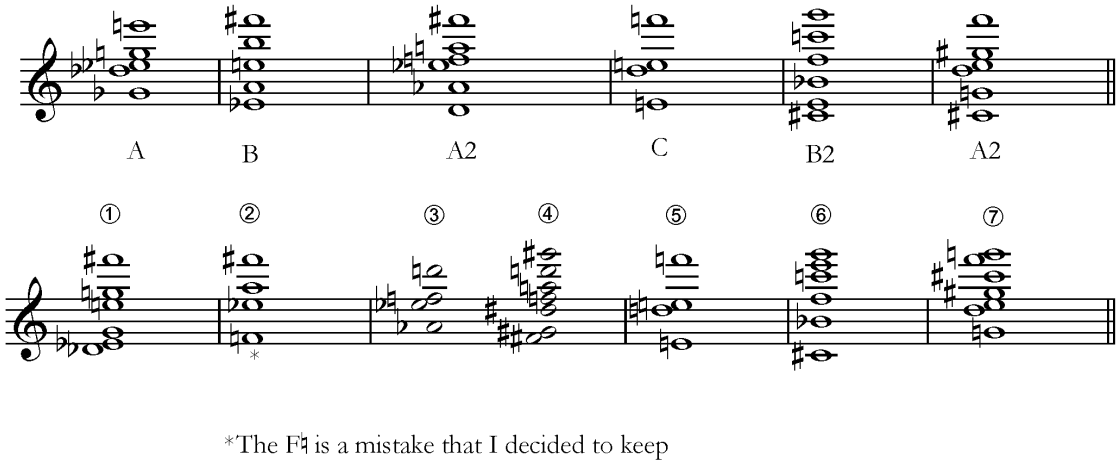
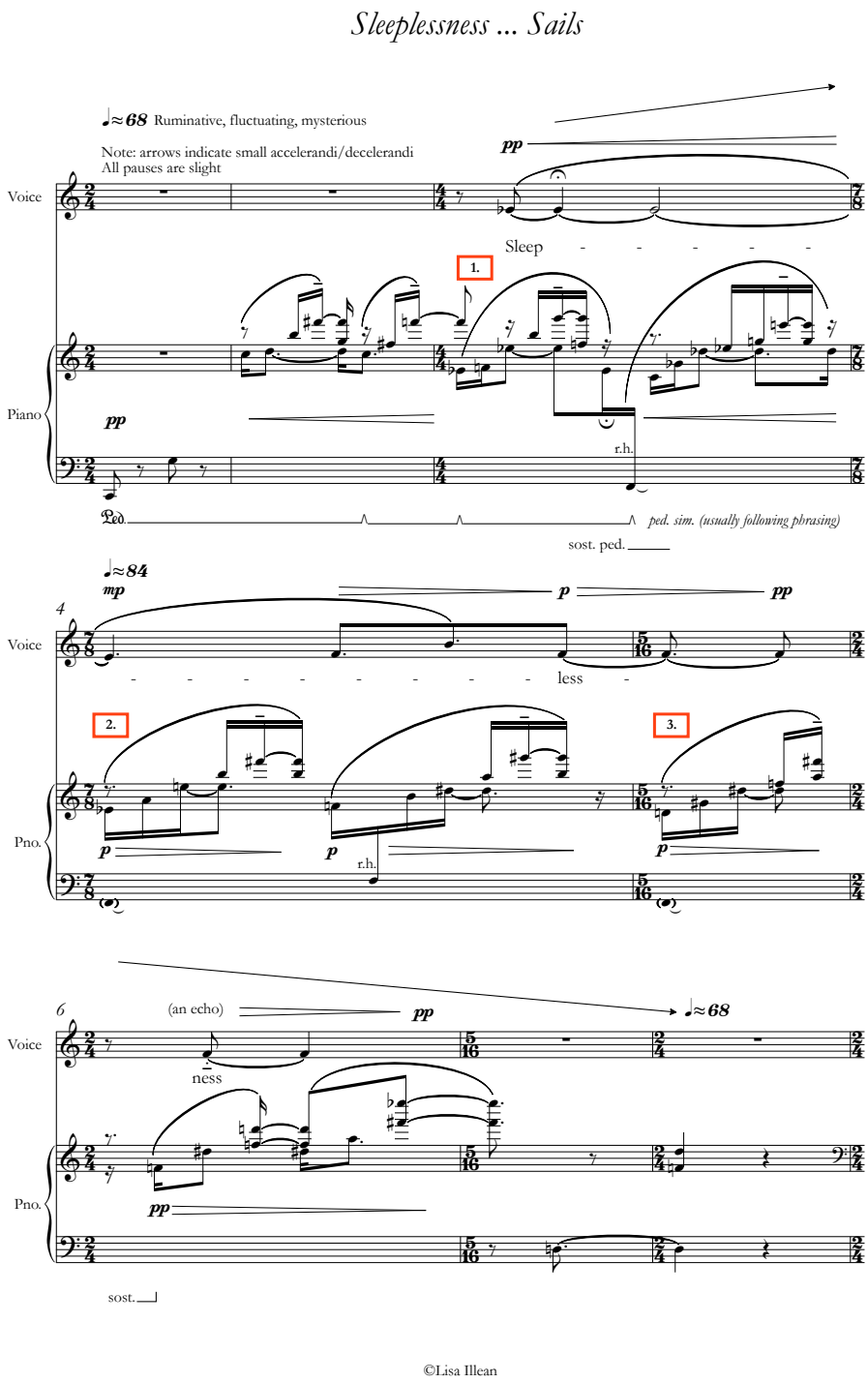


Figure 97. A transposition of cycle 1 (top stave) and the voicing of the chords in *Sleeplessness … Sails* (bottom stave)



*The F♮ is a mistake that I decided to keep

Figure 98. Opening page of the final score for *Sleeplessness … Sails,* marking the chord cycles from Figure 97



5.3 The Interplay Between Equal Tempered and Non-Tempered Tunings

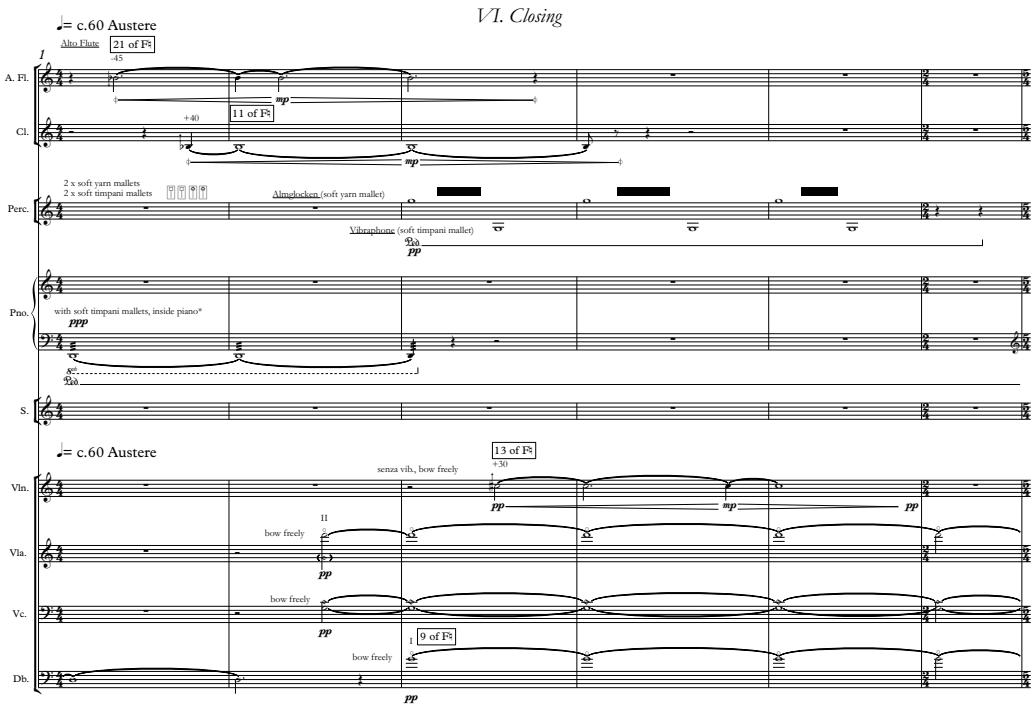
These works for piano and voice were a step towards creating a hybrid world of equal tempered and non-tempered tunings. Returning to the analogy of oil painting, I hoped ideally to develop a process in which thin, transparent, complementary layers of both tunings created shimmer and depth.

The opening of *Cantor VI* (Figure 99) was a first attempt at this idea, prefiguring ideas developed in *Weather a Rare Blue I*. It overlays the equal-tempered piano and vocal lines with austere sheets of non-tempered harmony which were first rehearsed with friends at the Royal College of Music (Audio sample 12). These sustained chords were devised from a set of 30 pitches: partials of the related fundamentals F#, C# and F-natural (-10 cents) arranged in order of their harmonic distance from F#. This created an extended palette of tones that shift by increments (for example, from a Bb lowered 45 cents to a Bb). Such subtle shifts in hue are similar in sensation to the gradual dimming or quickening of light in the sky. The chords themselves were chosen for their sonority, which I found transparent and disquieting. The piano part was composed to be similarly translucent, so the two layers could exist in a permeable but unsettling relationship.

Audio sample 12. Chords from a workshop with RCM[225] musicians (extract from a personal recording of the chords later used in *Cantor*).

[225] Royal College of Music, London.

Figure 99. An annotated extract from the score of *Cantor*



5.4 Permeability in Cantor

While composing *Cantor,* I wondered if non-tempered tunings could help create a harmonious blend of stylistically different music. I was drawn to the directness and simplicity of Cather's text as a conduit for imagining the way a variety of mannerisms might be folded and absorbed in subtle ways into the music. The vocal writing in *Cantor* is clean and unadorned. Bearing solitude gracefully is a recurring theme, and in atmosphere the piece is both desolate and intimate. At times the music is to be sung or played with spontaneity, as if it is being improvised to oneself. Drawing on the locale of the text, Czech polka rhythms, aural references to hammer dulcimer playing, mountain hollers and lullabies are stitched unobtrusively into the fabric of the music.

In early sketches, the guiding concept was that musically distinct elements would become permeable to one another when translated into a shared, cohesive harmonic world. Once refracted through the harmonic world of the piece, the intermingling musical ideas would ultimately sound quite different —and a step removed—from the musical language of their time and place.

Reflecting on *Cantor*, however, I was dissatisfied with much of its harmonic world. My unease with this piece was directly addressed in the very different choices I made while composing *A through-grown earth.*

Chapter Six
Future avenues for my work

My portfolio of works documents an attempt to grapple with recurring questions: the place of melody in my works, the place of traditional acoustic instruments (including those tuned in —or tuning to—equal temperament) and the relationship between perceptual phenomena and a personal evocative world, mediated by analogies between the audible and the visible. This final idea enriched my process of composition, giving poetic and imaginative force to harmonic ideas arising out of scientific observation. It also prompted me to revise my views on the interdependence of intonation and form. Having explored these questions in ways both exciting and unsatisfying, I feel better placed to work with adapted or custom made instruments on my own terms: so that decisions are guided primarily by artistic ideas, and secondarily by the unique properties of the instrument.

I have only begun to find ways of composing within a hybrid world of tempered and non-tempered tunings. While it is common to place different tuning systems in conflict with one another, I am particularly interested in continuing to explore ways in which both manners of tuning coexist coherently and meaningfully. Likewise, in *A through-grown earth,* I began to find a way of working with melody which incorporated just intervals in a practical yet transformative way. Preferring this to augmenting tempered melodies with microtonal harmony, or to working in blurred quartertones, this piece proposes an approach ripe for future investigation.

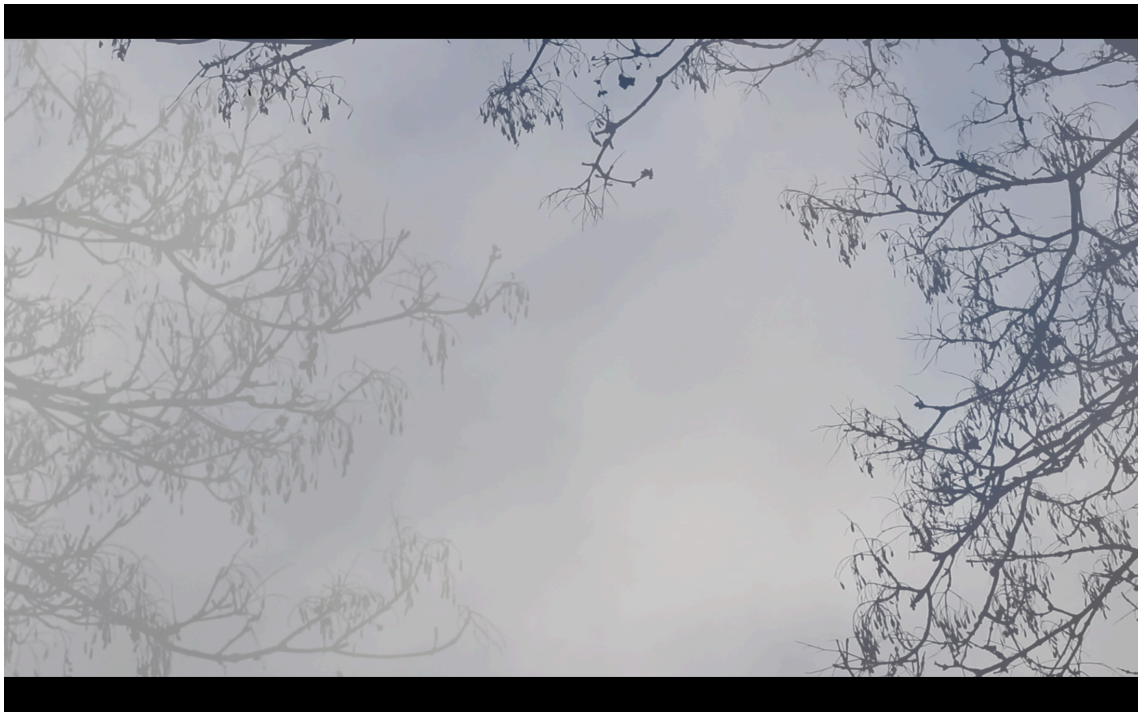
The potential for permeability between sounds—between 'found' materials (such as in *Cantor*) or between noise elements and non-tempered tuning (*Weather a Rare Blue*) — requires experimentation in greater depth. More research is also required on the relationship between the shifts in harmony or presence non-tempered tuning allows and form: as a means of articulating space and time. This could enhance the ruminative, often iterative approach to form in several of my portfolio works. It could also inform an approach to works of much longer duration, or those composed for a unique space (as an installation) rather than as a concert piece.

While I am primarily interested in sound, visual and tactile materials play an important role in the composition process. For this reason, I would like to explore in more depth the history of animated sound, and of complementary visuals for my instrumental music. during the winter of 2018-19 I created a video to accompany *A through-grown earth* (see

Figures 100 and 101). The video provides both a formal analogue for the music and a staged element/scenography to the performance. Through various means, the video creates a convergence of layers comprised of simple elements. It is conceived to be projected onto a single wall or screen, or multilayered (on up to three surfaces).

Figure 100. A still from the video *A through-grown earth*

Figure 101. A still from the video *A through-grown earth*



In summary, during the concentrated period of time completing my doctorate I accumulated a wealth of ideas, many of which I feel I have only begun to explore. My three years of doctoral research embraced creating a range of works—from pieces for chamber orchestra to those for ensemble or soloist with pre-recorded sound and image—and imaginative sources spanning Vija Celmins' serial images of an unbounded ocean surface, the phenomena produced by diffraction gratings, the poetry of Gerard Manley Hopkins, Dan Graham's pavilion *Double Exposure,* the technique of raking light, the architectural concept *terrain vague,* animated sound pioneers such as Arseni M. Avraamov, Percy Grainger's "free music machine" and the works of Giovanni Battista Piranesi. Through the process of making and reflecting, I have resolved for myself some of the questions forged in this meeting of theory, practice and imagination; and defined the future orientation of my practice and experimentation as a composer.

Appendices

A. List of compositions and recordings

Land's End, (2015), 11'

For chamber orchestra (Alto flute (doubling piccolo), Oboe, Clarinet in Bb (doubling Bass Cl.), Clarinet in Bb (tuned a ¼ tone lower), Alto Saxophone (doubling Soprano Saxophone – soprano tuned a ¼ tone lower), Bassoon (doubling contrabassoon), 2 horns, Trumpet (Bb), Trombone, Tuba, Percussion I (Marimba (4.5 octaves), Large Tam-tam, Medium Tam-tam, Low Tom-tom, Suspended cymbal, Large triangle, Aluminium foil sheet), Percussion II (Crotales (2 octaves), Vibraphone (3.5 octaves), Bass drum, Thunder sheet, Suspended cymbal, 2 Tuned gongs), Harp, Piano, Violin 1, Violin 2, Violin 3, Viola 1, Viola 2, Viola 3, Cello 1, Cello 2, Double Bass).

Commissioned by Sydney Symphony Orchestra, with support from Raji Ambikairajah. First performed by Sydney Symphony Orchestra, conducted by David Robertson on 13th March, 2016, at Carriageworks, Australia. Recording performed by Sydney Symphony Orchestra, conducted by David Robertson. Recording courtesy of ABC Classic FM.

Rose (2016), 12'

For Solo Clarinet in Bb, 2 flutes (1 doubling piccolo and alto flute), Oboe, Cor Anglais, Clarinet in Bb, Bassoon, Contrabassoon, 2 horns in F, 2 Trumpets (Bb), 2 Trombones, Tuba, Percussion 1 (Glockenspiel, Vibraphone, Suspended cymbal (shared)), Percussion 2 (Tam-tam, Marimba (4.3 octaves), Bass Drum, Triangle (suspended), Metal tubes (aluminium or brass, 1-2 cm in diameter), Suspended Cymbal (shared)), Harp, Piano (doubling Celesta), Violin 1a, Violin 1b, Violin 1c, Violin 2a, Violin 2b, Viola 1, Viola 2, Cello 1, Cello 2, Double Bass 1, Double Bass 2

Commissioned by the London Philharmonic Orchestra for their *Debut Sounds* series. First performed by Thomas Watmough, members of the London Philharmonic Orchestra and Foyles' Future Firsts, conducted by Magnus Lindberg, at the Royal College of Music on 4th July, 2016. Recording performed by Thomas Watmough, members of the London Philharmonic Orchestra and Foyles' Future Firsts, conducted by Magnus Lindberg. Recorded by the RCM studios.

Januaries **(2017), 12'**

12 players: Flute (doubling alto), Clarinet in Bb, Horn in F, Trumpet in Bb, Percussion (Vibraphone, Tubular Bells, Small Tam-tam, Bass Drum, Suspended cymbal, Bell plate tuned C#), Harp, Piano, Violin I, Violin II, Viola, Cello, Double Bass (solo strings).

Commissioned by the Royal Philharmonic Society for the Philharmonia Orchestra as part of their 2016 RPS Composition Prize. First performed members of by the Philharmonia Orchestra, conducted by Patrick Bailey on 21st June 2017 at Royal Festival Hall, London. Recording performed bymembers of the Philharmonia Orchestra, conducted by Patrick Bailey. Recorded by Jon Stokes at Classic Sound Ltd for NMC.

Cantor **(2017), 15'**

For Soprano, Flute (doubling alto), Clarinet in Bb, Piano, Percussion, Violin, Viola, Cello, Double Bass

Commissioned by Ensemble Offspring with funding from the APRA AMCOS Art Music Fund. First performed by Jessica Aszodi and Ensemble Offspring on 23rd September, 2018, at Carriageworks, Australia. Recording performed by Jessica Aszodi and Ensemble Offspring. Recorded by Bob Scott.

after-image **(2018), 4'**

For solo mezzo-soprano voice and piano.

Created for Lotte Betts-Dean and Eidit Golder. First performed by Lotte Betts-Dean and Eidit Golder on 15th March, 2018, Melbourne Recital Centre, Australia.Video performed by Lotte Betts-Dean and Eidit Golder, recorded by Melbourne Recital Centre.

***Lightsense No. 2* (2018), 6'**

For alto flute, bass flute, Clarinet in Bb, electric guitar, percussion.

Creation of Lightsense No. 2 supported by Kupka's Piano and Australia Council for the Arts. First performed by Kupka's Piano on 31st August, 2018, at Griffith Conservatorium, Australia. Recording performed by Kupka's Piano. Recorded by ABC Classic FM.

***Sleeplessness…Sails* (2018), 6'**

For mezzo soprano voice and piano.

Commissioned by BBC Radio 3 for the BBC Proms. First performed by Sarah Connolly and Joseph Middleton on 6th August, 2018, at Cadogan Hall, London. Recording performed by Sarah Connolly and Joseph Middleton. Recorded by BBC Radio 3.

***Weather a Rare Blue* (2018), 11'**

For pianist, ensemble (alto flute, Bb Clarinet doubling Bass Cl.,Violin, Viola, Cello) and pre-recorded ensemble.

Commissioned by Explore Ensemble. First performed by Explore Ensemble on 30th September, 2018 at King's Place, London as part of their *Time Unwrapped* series. Recording performed by Explore Ensemble and Lisa Illean, November 2018. Recorded by Stephen Harrington and mixed by Lisa Illean, RCM Studios, London.

***A through-grown earth* (2018), 14' (two songs), 20' (three songs).**

For solo soprano voice and pre-recorded sound (optional video).

Commissioned by Juliet Fraser with funding from Australia Council for the Arts. First performed by Juliet Fraser and Lisa Illean on 29th September, 2018 as part of BBC Radio 3 Open Ear at Jerwood Hall, LSO St Luke's, London. Recording performed by Juliet Fraser and Lisa Illean, September, 2018 (shorter version). Recorded by BBC Radio 3.

B. Texts of works included in my portfolio

A through-grown earth

The text sets excerpts from poems by Gerard Manley Hopkins.

*(*from *The Lantern Out of Doors*)
Sometimes a lantern moves along the night
That interests our eyes. And who goes there?
I think; where from and bound, I wonder, where,
With, all down darkness wide, his wading light?

Men go by me, whom either beauty bright
In mould or mind or what not else makes rare:
They rain against our much-thick and marsh air
Rich beams, till death or distance buys them quite.

(from *Ash-Boughs*)
Not of all my eyes see, wandering on the world,
Is anything a milk to the mind so, so sighs deep
Poetry to it, as a tree whose boughs break in the sky.

…

They touch heaven, tabour on it; how their talons sweep
The smouldering enormous winter welkin! May
Mells blue and snowhite through them, a fringe and fray
Of greenery: it is old earth's groping towards the steep
Heaven whom she childs us by.

(from *Epithalamion*)
Rafts and rafts of flake-leaves light … painted on the air …

Cantor

Adapted from April Twilights *by* Willa Cather, *first published in 1903.*

II. Stirring
A crimson fire, that vanquishes the stars
An odour from the dusty sage
A sudden stirring of the herds.
A breaking of the distant land…
And the flare of water, silver in the light
A swift, bright lance flung low across the world
A sudden pang for the hills of home

IV: Stealing
Somewhere, sometime…
When the hills are hid in shadows
When brooks are still and hushed for wonder
Let them gather
Stealing from the trackless dust

VI: Closing
Since thou came'st not at morn
Come not at ev'n
Let night close peaceful
Where it hath begun
Affrighten not the restful stars of heav'n
With futile after-glimpses of the sun
My heart implores me
But my lands are wasted
And evening closes in
I have no house for Love, to shelter him.

VII: L'Envoi
Then for that the moon was ours of olden
Let it for an April night transform us
From our grosser selves
To happy shadows.

after-image

…their stunning reel of beauty to display…
…but she knows her beauty fades…
…learn it… or trust its total waits
in heaven

(fragments from *Katun River* by Cassie Lewis)

Sleeplessness … Sails

Sleeplessness. Homer. The sails tense.
I have read the list of ships to the middle:
This long train, this herd of cranes
That once arose over Hellas.

Like a fleet of cranes to strange frontiers—
A divine spray on the heads of kings—
Where are you sailing? If not for Helen,
What is Troy alone to you, Achaean men?

And the sea, and Homer—all is moved by love.
To whom shall I listen? And Homer falls silent now,
And the black sea, declaiming, resounds
And rolls towards the bedhead with a heavy growl.

Osip Mandelstam.
Translated from the Russian by Rachel Polonsky, with Lisa Illean

C. Details of Audio samples

Audio sample 1. Excerpts from *Lu* (Performed by Scordatura Ensemble)
Timestead (Performed by Josephine Stephenson, Miriam Bergset, Taylor MacLennan, Baldur Tryggvason, Michael Hughes, conducted by Asier Puga)
Sahul III (performed by Chris Rainier)

Audio sample 2. Pre-recorded sonorities for *Weather a Rare Blue I*. Performed by Explore Ensemble, recorded by Stephen Harrington, mixed by Lisa Illean.

Audio sample 3. Pre-recorded sonorities for *Weather a Rare Blue III-XI*. Performed by Explore Ensemble, recorded by Stephen Harrington, mixed by Lisa Illean.

Audio sample 4 (video). Viola preparation, Lisa Illean.

Audio sample 5. Extracts from *Weather a Rare Blue*. Performed by Explore Ensemble, recorded by Stephen Harrington, mixed by Lisa Illean.

Audio sample 6. Extracts from *Weather a Rare Blue*. Performed by Explore Ensemble, recorded by Stephen Harrington, mixed by Lisa Illean.

Audio sample 7. Extract from *Januaries,* performed by members of the Philharmonia Orchestra, conducted by Patrick Bailey, recorded by NMC.

Audio sample 8. Extract from *Januaries,* performed by members of the Philharmonia Orchestra, conducted by Patrick Bailey, recorded by NMC.

Audio sample 9. Extract from *Januaries,* performed by members of the Philharmonia Orchestra, conducted by Patrick Bailey, recorded by NMC.

Audio sample 10. Extract from *Land's End*. Performed by Sydney Symphony Orchestra, Conducted by David Robertson. Recorded by ABC Classic FM, Australia.

Audio sample 11. Extract from a draft of *Rose*. Performed by members of the London Philharmonic Orchestra and Foyles Future First artists, conducted by Magnus Lindberg. Recorded on my zoom handheld recorder.

Audio sample 12. Sonorities performed by Josephine Stephenson, Miriam Bergset, Taylor MacLennan, Baldur Tryggvason, Michael Hughes.

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