Time Fixtures

(Volume 1 of 3: Analysis)

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Abstract

Time Fixtures, a composition for chamber ensemble and electronics, attempts to provide some compelling perspectives on fixing a conception of time. The electronics feature six speakers placed symmetrically around the audience that broadcast live electronic transformations and pre-constructed audio files. The ensemble consists of eleven players: flute (doubling alto flute), oboe, Bb clarinet (doubling bass clarinet), horn, percussion, harp, piano, MIDI keyboard (doubling crotale/tangkas placed out of sight of the audience), violin, viola, and violoncello. Performance also requires a conductor as well as a technician who operates a Max/MSP performance patch and the mixing board.

Time Fixtures est une composition pour orchestre de chambre et instruments électroniques. L'œuvre tente de présenter des perspectives intéressantes en ce qui concerne le contrôle du concept du temps. La configuration électronique comporte six haut-parleurs, placés de manière symétrique autour de la salle, qui diffusent des transformations des sons instrumentaux en temps réel ainsi que des sons électroniques pré-enregistrés. La formation instrumentale compte onze musiciens : flûte (cumul, flûte en sol et petite flûte), hautbois, clarinette en si bémol (cumul, clarinette basse), cor, percussion, harpe, piano, clavier MIDI (cumul, crotale/tangkas), violon, alto et violoncelle. L'interprétation requiert aussi un chef d'orchestre et un technicien travaillant avec une patch Max/MSP et une console de mixage.

Acknowledgements

First and foremost, I would like to thank John Rea for his dedicated guidance, friendship, as well as our engaging and often revelatory discussions during the conception and realization of this project. I owe particular gratitude to the McGill Schulich School of Music's Composition program for their gratitude and confidence in providing me the first-ever composer-in-residence position for the McGill Contemporary Music Ensemble with the assistance of the Digital Composition Studio. I would also like to heartily thank Denys Bouliane for his tireless dedication and enthusiasm while rehearsing and conducting *Time Fixtures*. Many thanks go to the members of the McGill Contemporary Music Ensemble who dedicated their time and dedication learning this composition – particularly those who provided their time for recording sessions, Sarah Pagé for her help and enthusiasm with the harp part, Fernando Rocha for his outstanding work on a difficult percussion part, and Xenia Pestova for the unique and vital contribution of learning how to cue all the electronics during rehearsals and performance. Many thanks also go to Sean Ferguson for his friendship, enthusiasm, and providing the full technical support of the McGill Digital Composition Studios – without which the performance and realization of *Time Fixtures* would have been impossible. My final thanks and love go to my parents, Peg and David Sudol, who have consistently provided the very necessary moral support for my musical studies and pursuits and, despite their limited technical and musical knowledge, provided invaluable assistance with editing and revising this text.

Table of Contents:

Chapter 1. Introduction

This chapter focuses on the general context, content, and concept behind my composition *Time Fixtures*. The first section briefly describes the composition's instrumentation and the electronics required for performance. The second section describes how the title *Time Fixtures* relates to the composition's poetic focus.

1-a. Basic context and content

I wrote *Time Fixtures* as part of the first-ever composer-in-residence position for the McGill Contemporary Music Ensemble in collaboration with the McGill Digital Composition Studio. The work is scored for flute (doubling alto flute), oboe, Bb clarinet (doubling bass clarinet), French horn, percussion (crotales, glockenspiel, three cymbals, vibraphone, and marimba), harp, piano, MIDI keyboard (doubling crotale/tangkas placed out of sight of the audience), violin, viola, and violoncello. It has a duration of thirteen minutes.

During performance, six loudspeakers placed symmetrically around the audience broadcast electronic transformations and pre-constructed audio files. MIDI data sent from the keyboard controls all electronic cues through a Max/MSP patch that I programmed. The electronics both amplify and perform live digital signal processing on all the acoustic instruments. In addition, many electronic cues dynamically trigger audio files for playback.

1-b. Poetic Focus

The title *Time Fixtures* draws part of its inspiration from the etymology and archaic usage of the word "fixture," which derives from the late Latin *fixura,* from Latin *fixere, "to fix"* (OED). When this definition is combined with the word "time" the work's poetic focus becomes a series of perspectives on fixing a conception of time. In addition, the title is a play on the words, "light fixtures." This double meaning suggests the words "time" and "light" may interchange.

While composing *Time Fixtures* I focused on the epistemological definition of light to suggest a relationship between knowledge and time's movement or accumulation. This is a concept that I have been fascinated with for most my life and one that has been central to most of my compositional projects, such as *Resonances* (2004-2005), *Oscillations* (2003-2004, 2006), and *Black Stream* (2000-2004). In *Time Fixtures* I do not attempt to solve any of the philosophical or phenomenological arguments about epistemology and time; but rather I attempt to develop and unfold some systematic and intuitively constructed perspectives that I find compelling.

Chapter 2. Form and Structure

This chapter describes the general formal and structural procedures used in *Time Fixtures*. The first section describes some general guidelines that I used to balance form and structure, symmetry and asymmetry, and the manipulation of a fractal model. The second section introduces the concept of implicit trajectories and provides some musical examples of how specific trajectories relate to passages from the score.

2-a. General Guidelines for Form and Structure

In *Time Fixtures*, form and structure coexist in an architecture generally governed by the principle of good balance; that is, when underlying formal elements are rigidly controlled, the more surface-related structural elements become looser and freer, and *vice-versa*. Chapter 6 provides detailed musical examples demonstrating how this principle works.

The interaction and balance of symmetry and asymmetry also play significant roles in controlling form and structure in *Time Fixtures*. Generally speaking, this interaction is used to define oppositional musical elements. For example, Figure 2-1 presents two oppositional rhythmic figures and pitch-based harmonies – one symmetrical rhythm (A) and one asymmetrical rhythm (B), as well as one symmetrical harmony (B) and one asymmetrical harmony (A).

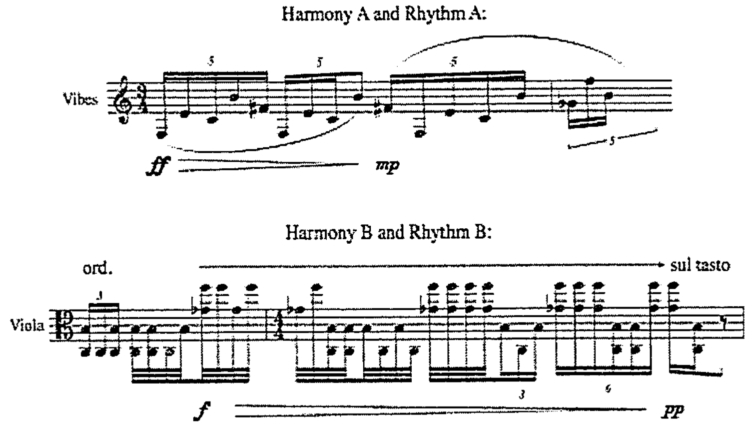


Figure 2-1: Two oppositional rhythmic figures and harmonies

This form of rhythmic and harmonic opposition has played a significant role in my previous compositions *Black Stream* (2002-5), *Many Voices* (2004-5), *Oscillations* (2003-4, 2006), and *Resonances* (2004-2005).

In *Time Fixtures* I add another element to the interaction and balance of symmetry and asymmetry – questioning the type of symmetry. Phenomenologically, all symmetrical objects have either a real or imaginary centre. For example, Figure 2-2 presents two symmetrical rhythms and pitch-based harmonies – rhythm A and harmony A both have a note at their centre, whereas rhythm B and harmony B do not.

Figure 2-2: Two symmetrical rhythms and harmonies

Symmetry can also be identified contextually. For example, Figure 2-3 presents two symmetrical harmonies – harmony A is symmetrical in terms of frequency (Hz) and harmony B contains hexachords transposed approximately 315.5 Hz above and below B4[1] (493.9 Hz).

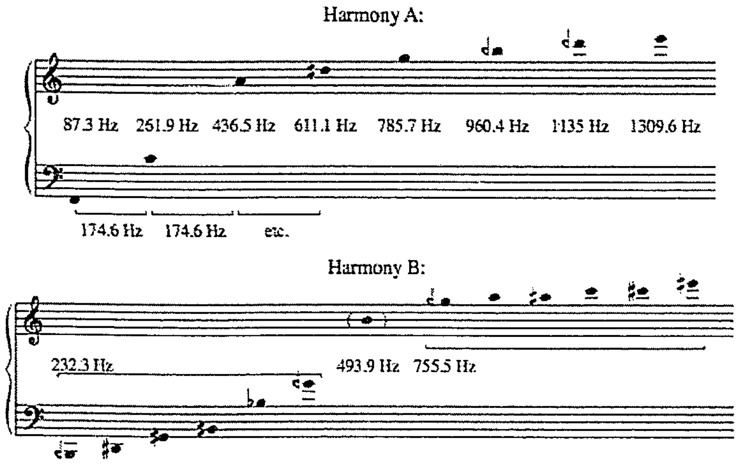


Figure 2-3: Two symmetrical rhythms and harmonies

[1] I refer to all pitch names following the convention where middle C is C4.

A fractal model using self-symmetry, self-similarity, recursion, and iteration (Roads 880-886) also governs form and structure. In *Time Fixtures*, rather than use a specific mathematical fractal model, I mostly draw my inspiration from how fractals' macrostructure and microstructure contain self-symmetry and self-similarity. Furthermore, the inherent interlinking of macrostructure and microstructure in fractals aids in the otherwise difficult perception of symmetry and asymmetry. (Grisey, *Tempus* 242-243) Dynamically weaving linked musical elements on both a macro-level and micro-level facilitates a progressive contextual perception and can therefore produce the dramatic formal and structural revelations that my poetic focus suggests.

2-b. Implicit Trajectories

Three implicit trajectories guide global form and local structural elements in *Time Fixtures*. These implicit trajectories serve as visual archetypes, something like a visual guide around which all musical materials focus and relate in the same manner in which a poem or painting centres around a collection of images. Furthermore, I favoured using implicit trajectories to themes and motives because the former allows greater freedom to construct musical materials that are linked in many parameters at both global and local levels.

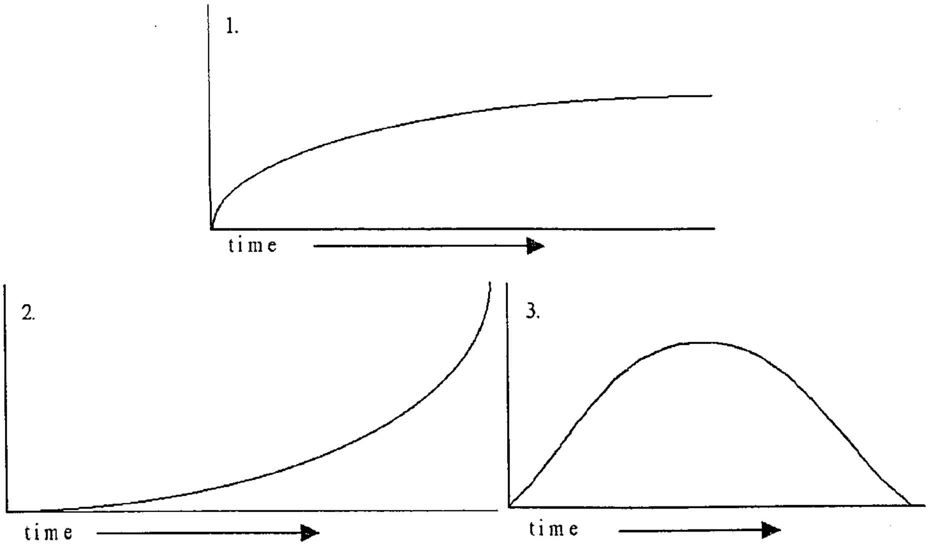


Figure 2-4: The three independent implicit trajectories used in *Time Fixtures*

The above figure displays the three independent implicit trajectories used in *Time Fixtures*. All three are identifiable by mathematical models or linear curves. For example, the first trajectory is a portion of a logarithmic function, where the beginning approaches an asymptote or axial line; the second trajectory is a portion of an exponential function, where the ending approaches an asymptote; and the third trajectory is a window on the positive side of a decelerating wave such as a Bessel function (*Handbook* 355-373). The mathematical models that describe these implicit structural trajectories are also governed by the composition's structural and formal focus on symmetry and asymmetry. For instance, a logarithmic function is the inverse function or mirror of an exponential function (*Handbook* 65-71), and the position portion of a perfectly periodic wave has an axis of symmetry at the crest of every wave (Figure 2-5).

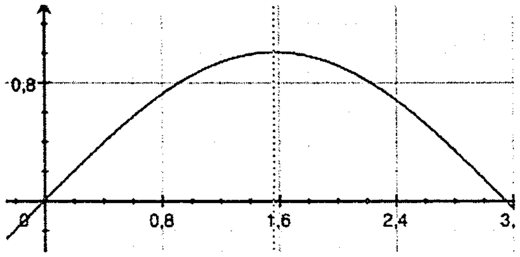


Figure 2-5: Axis of symmetry on the positive portion of a perfectly periodic wave

Although the three implicit trajectories operate on most compositional layers in *Time Fixtures*, their role is most clearly demonstrated at the local level. In melodies or gestures, for example, implicit trajectories are easily mapped onto general pitch contours. Figure 2-6 demonstrates this procedure by overlaying the third implicit trajectory twice over a reduction of the melody/gesture in Mm. 12-13.[2]

[2] In this essay, I refer to collections of measure numbers as Mm. first-last. I refer to specific quarter note beats as Measure.beat. Unless otherwise indicated, I always refer to the full duration of a measure.

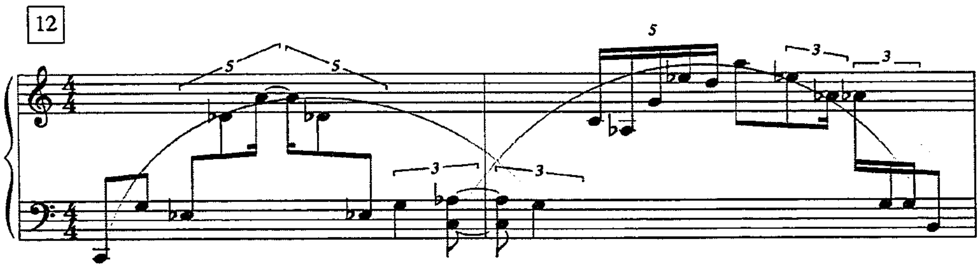


Figure 2-6: Example of an implicit trajectory determining melody/gesture

The implicit trajectories also play a significant role in determining rhythmic gestures. Figure 2-7 demonstrates how an implicit trajectory is mapped onto rhythm. The vertical axis represents the progression of events, and the horizontal axis represents the progression of time.

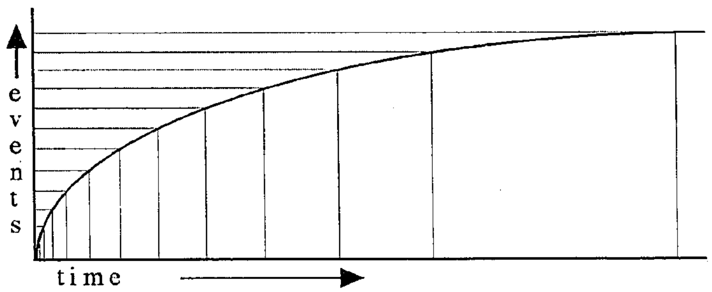


Figure 2-7: An implicit trajectory plotting the progression of events against time

In the above figure the vertical dotted horizontal lines define event thresholds or the junctions of the dimension "time" with those of "event." Figure 2-8 contains a rhythmic reduction from Mm. 95-96 that demonstrates the mapping outlined in Figure 2-7.

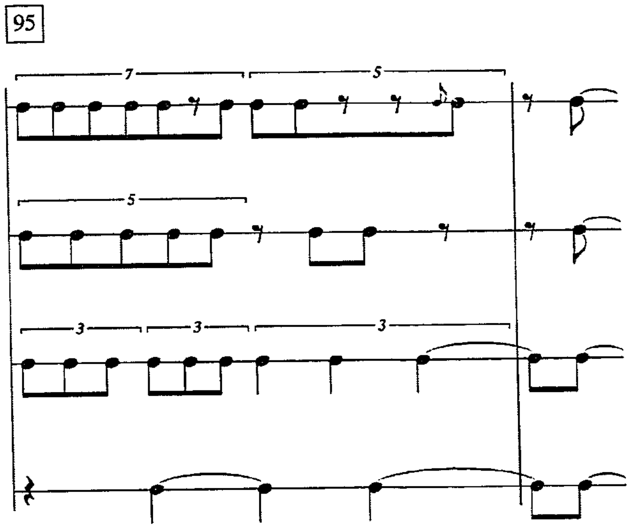


Figure 2-8: Rhythmic reduction of Mm. 95-96

The above examples, which demonstrate the techniques of mapping implicit structural trajectories onto music, contain a significant quantity of statistical deviation. These deviations represent the operation of larger structural or formal techniques, such as the interaction of implicit trajectories, and – more importantly – serendipity and compositional intuition. Chapter 6 provides more extensive explanations of how these implicit structural curves operate on larger formal and structural concerns.

Chapter 3. *Harmony/Timbre* and Pitch

The next two chapters describe the procedures used to simultaneously construct and categorize harmonies for the composition *Time Fixtures.* The first section describes the technique of instrumental synthesis and the computer programs used to analyze the sound of three archetypal bells. The second section describes the three harmonies constructed with intervals and their archetypal musical organization in a quasi-tonal environment.

3-a. Instrumental Synthesis and Archetypal Bells

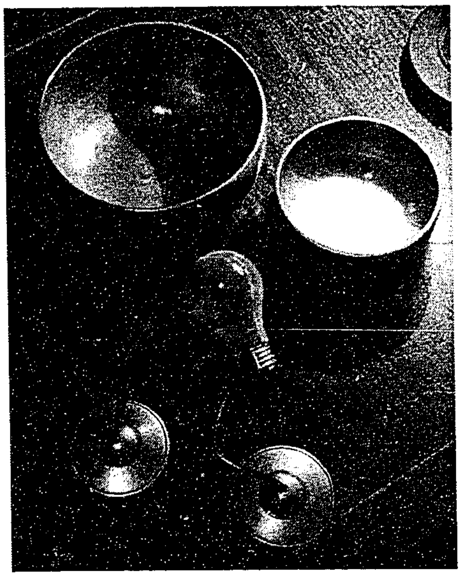


Figure 3-1: The three archetypal Tibetan Bells

Several years ago I acquired three Tibetan bells – two singing bowls and one pair of tangkas (Figure 3-1). Aside from their gorgeous timbres, I have always been musically drawn to the singing bowls' sustainable metallic resonances and the tangkas' seemingly endless silver decay. In my composition *Resonances* I used the bells' timbres and sinusoidal additive synthesis to construct a collection of archetypal electronic sounds. In *Time Fixtures* I went further and used not only these elements, but also "instrumental synthesis" (Grisey, *interview* 13) to create an independent category of three static archetypal bell *harmonies/timbres* (Saariaho).

I constructed these unified harmonies/timbres using the concept of "frequency harmony" (Fineberg 81-82) which utilizes the principle of additive synthesis: that any sound or timbre can be recreated by combining sinusoidal waves at frequencies which are equal to the sound's or the timbre's component partials (Dodge & Jerse 73). To derive these *harmonies/timbres*, I first recorded the three Tibetan bells and extracted a short audio clip for each bell. I then used the programs AudioSculpt and OpenMusic to analyze the component partials and derive the specific "frequency harmonies" from these three audio files.

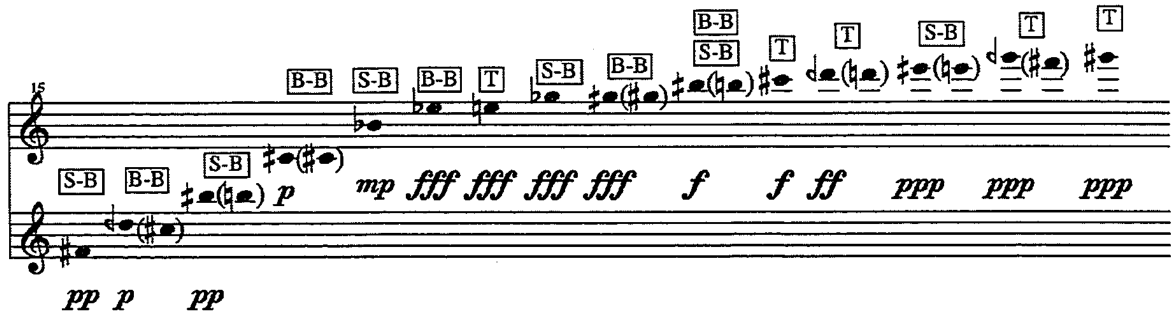


Figure 3-2: The three archetypal bell *harmonies/timbres*

I quantized the results of this analysis in dynamics that range from *pianississimo* (*ppp*) to *fortississimo* (*fff*), a twenty-four tone per octave system, and a standard twelve tone per octave system (Figure 3-2). As a convention to approximate the constituent parts of "frequency harmonies," the winds, strings, and electronic instrumental samples use both the twenty-four and twelve tone per octave systems, but the percussion instruments use only the twelve tone per octave system. In the above figure "B-B" represents the *harmony/timbre* derived from the bigger Tibetan singing bowl; "S-B" represents the *harmony/timbre* derived from the smaller Tibetan singing bowl; and "T" represents the *harmony/timbre* derived from the pair of tangkas. In the score the quieter pitches are freely transposed down an octave, whereas the louder pitches generally stay in a fixed-pitch position. Also, on the last measure of the score the synthesizer player plays the actual sound of the tangkas.

In the electronics the three archetypal Tibetan bells appear in both synthesized and mildly processed versions. To construct the synthesized bells, I gathered a different collection of more refined results using the method explained above. This data was run through a patch I programmed in OpenMusic (Appendix 3-1)[3] to create a list for each Tibetan singing bowl (Appendix 3-2), which could then be processed by the Max/MSP eternal object *resonators~* (Jehran, Freed, & Dudas). Swells of pink and white noise, instrumental noise sounds, and pulses of noise ran through the *resonators~* object in a subpatch I programmed (Figure 3-3) to generate the synthesized "shadow bell timbres" and "phantom bells" heard in electronics during Mm. 1-4, 93-98, 108-124, 135-153, 228-230, 232-235, 239-244, and 247-260.

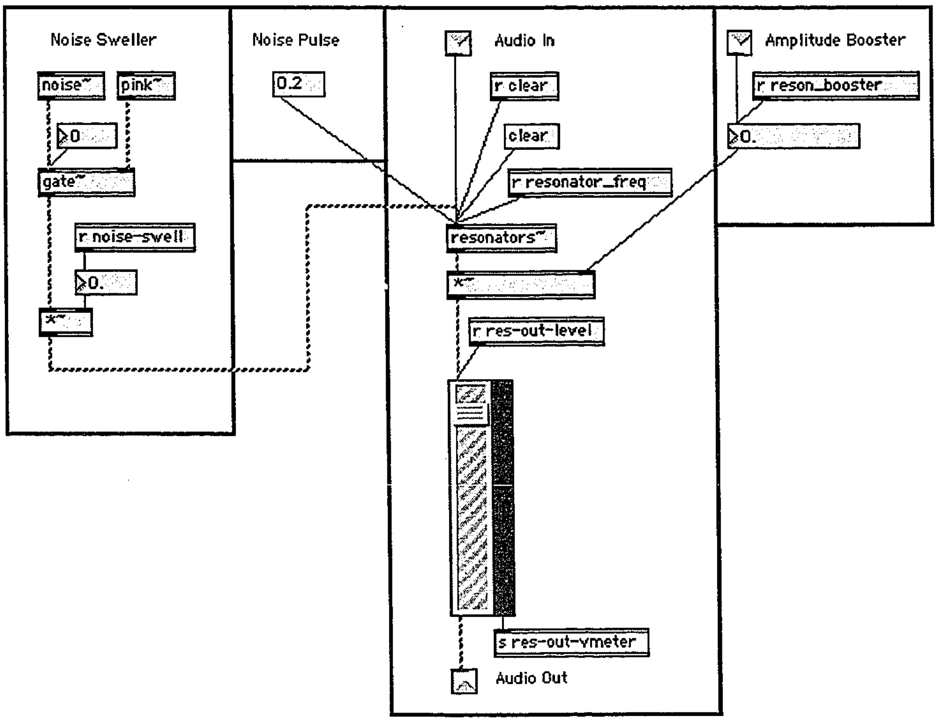


Figure 3-3: Max/MSP patch used to generate shadow bell sounds

3-b. Interval Processes and the Quasi-Tonal Environment

The second category of harmonies differs strongly from the first category in two ways. While the first category uses "frequential harmony" to obfuscate the distinction between harmony and timbre, the second category uses only pitch and interval-derived harmonies. Furthermore, while the *harmonies/timbres* in the first category are functionally static, the harmonies in the second category serve clearly directional

[3] Visual examples too large to place in the body of the essay can be found in the Appendixes.

functions in a quasi-tonal environment. I first created the intervallic process to construct these harmonies in the second movement of my composition *Resonances*, and created the quasi-tonal environment for these harmonies in my unfinished composition *Tathagata* (2005), as well as in my first piano prelude, *Stream* (2005) (Appendix 3-3).

The first harmony in this category, harmony 'A', focuses on possibly the most expressive interval in modal writing – the minor sixth. Harmony 'A' is comprised of an initial minor sixth (C4 and Ab4), its transposition up a perfect fifth (G4 and Eb), as well as the transposition of the second minor sixth up a tritone (Db5 and A6) (Figure 3-4).

Figure 3-4: Harmony 'A' and its method of construction

In the quasi-tonal environment designed for *Time Fixtures*, harmony 'A' functions as the tonic and never undergoes any pitch class transpositions. The lowest note in harmony 'A' – the pitch C – is also the first and last pitch class in *Time Fixtures*, as well as the composition's tonic note.

Because of its sonorous presence in the timbres of my composition, harmony 'C' focuses on the Major seventh (Risset). Harmony 'C' is comprised of an initial Major seventh (F3 and E4), its transposition up a perfect fifth (C4 and B4), as well as the transposition of the second Major seventh up a tritone (Gb4 and F5) (Figure 3-5).

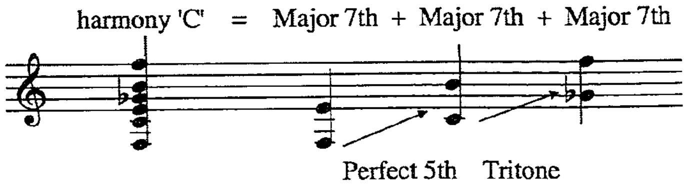


Figure 3-5: Harmony 'C' and its method of construction

For harmony 'C' the process of successively transposing a static interval by a successively contracting interval often continues upward, full and fragmented, to create the denser and richer harmonies used in Mm. 6-8, 17-18, 27-29, 42-44, 107-108, 127-

130, 163-166, 185-186, and 235-237. In the quasi-tonal environment harmony 'C' functions as the dominant and undergoes partial and complete transpositions.

Harmony 'B' is the least concretely defined collection in the second harmonic category. It freely combines fragments, transpositions, and the interval processes from harmony 'A' and harmony 'C'. Figure 3-6 shows three different versions of harmony 'B' from Mm. 14-17, 22-24.2, and 158-160.

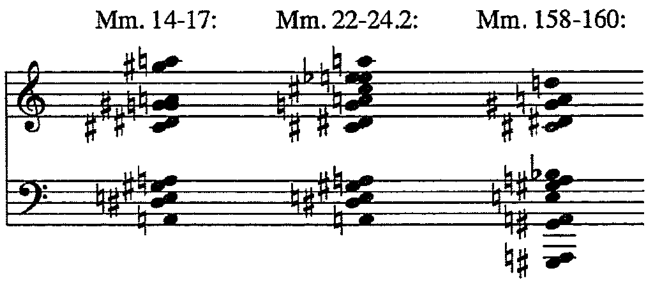


Figure 3-6: Three different versions of harmony B

In the quasi-tonal environment harmony 'B' is loosely defined as a subdominant since it typically falls between the tonic (harmony 'A') and dominant (harmony 'C').

In *Time Fixtures* harmonies 'A,' 'B,' and 'C' frequently unfold in a melodic manner that demonstrates the forward and reverse of the interval processes explained above. For example, Figure 3-7 shows the three archetypal melodic gestures that I designed for harmonies 'A,' 'B,' and 'C.'

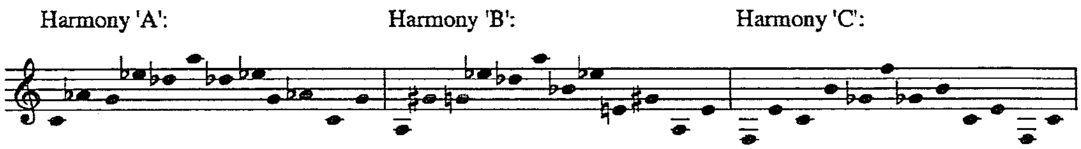


Figure 3-7: The archetypal melodic gestures for harmonies 'A,' 'B,' and 'C'

Harmonies 'A' and 'C' primarily occupy the archetypal pitch space outlined in Figures 3-3 and 3-4. Unlike *harmonies/timbres* "B-B," "S-B," and "T," however, the notes of harmonies 'A,' 'B,' and 'C' more closely resemble pitch classes and undergo numerous octave transpositions.

Chapter 4. *Harmony/Timbre* and Pitch Continued

The first section of this chapter explains two types of distortion synthesis. It also explains two computer patches I programmed to calculate the effects of distortion synthesis and construct five hybrid *harmonies/timbres* for *Time Fixtures*. The second section describes the interpolation path used to create a reservoir of chords, as well as some techniques and computer patches I used to select chords from this reservoir.

4-a: Distortion Synthesis

The third category of *harmonies/timbres* relies upon distortion synthesis – particularly ring modulation and frequency modulation – in which "a controlled amount of distortion is applied to a simple tone to obtain a more complex one" (Dodge & Jerse 88). This category relies upon calculating the results of distortion synthesis and "frequency harmonies." I modelled this technique on the extensive ring modulation in Karlheinz Stockhausen's composition *Mantra* (Harvey 126-130) and the progressive spectral distortion in Gérard Grisey's composition *Modulations* (Grisey, *Espaces* 16-17).

From an acoustical point of view, distortion synthesis creates a collection of combination tones based upon the interaction of the carrier frequencies in Hz (C) and the modulator frequency in Hz (M). For example, ring modulation multiplies some carriers by a modulator to produce a collection of sum tones and a collection of difference tones. To determine the results of ring modulation one calculates the sum tones by adding each carrier to the modulator (C+M); and one calculates the difference tones by taking the difference between each carrier and the modulator (the absolute value [Abs.] of C-M) (Roads 216-221). Figure 4-1 shows a Max/MSP subpatch I created to perform live ring modulation on an incoming signal or collection of carriers.

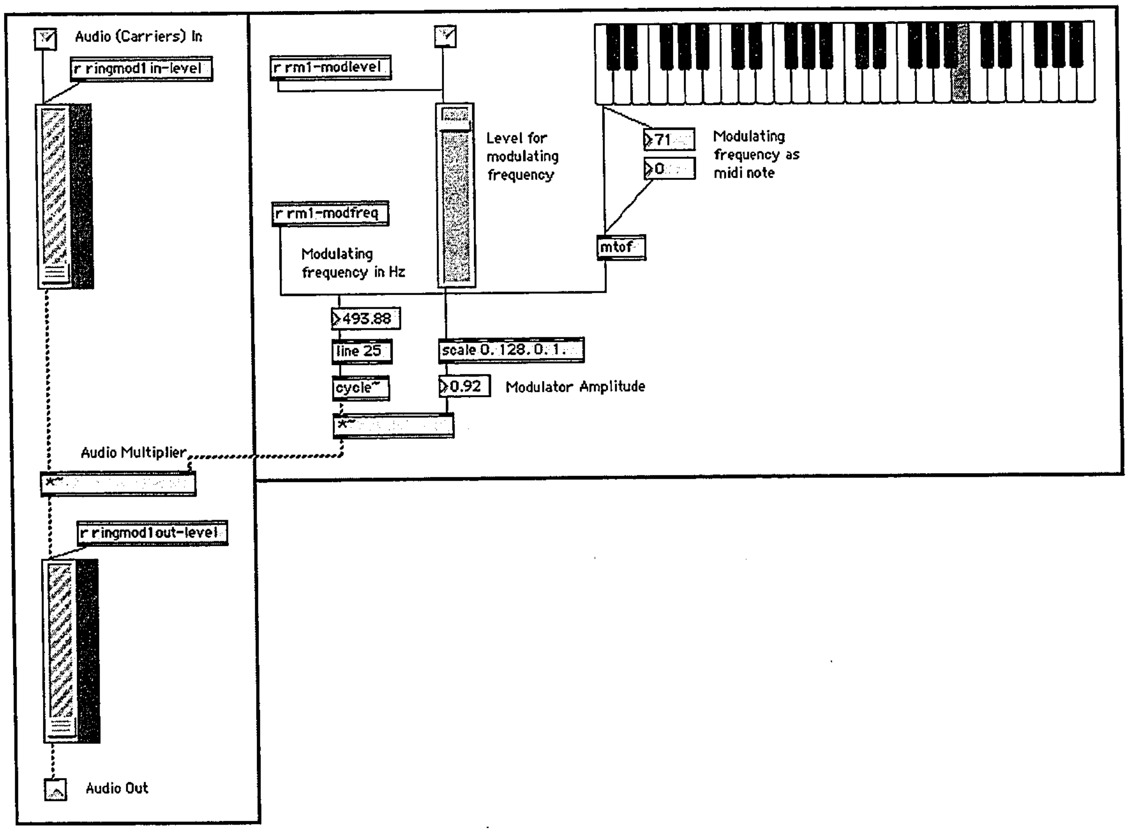


Figure 4-1: Max/MSP subpatch used to perform live ring modulation

In the electronic component for my composition *Resonances*, I had developed a technique of ring-modulating a chord by a central "ghost pitch," which creates a directly related dissonant and symmetrical hybrid *harmony/timbre* (Figure 2-3, harmony B). In *Time Fixtures* I calculate the results of ring modulation using an OpenMusic patch I programmed (Figure 4-2) to create the same type of hybrid *harmonies/timbres* for the instrumental writing.

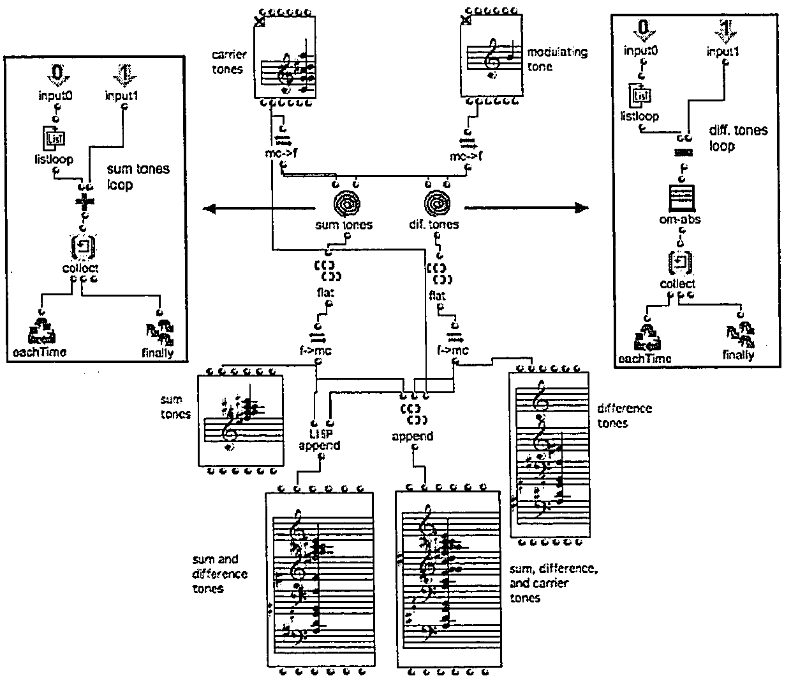


Figure 4-2: OpenMusic patch used to calculate the 'frequency harmonies' generated by ring modulation

The above patch shows the calculation of harmony 'A'-Ring(B4). For a reason that I explain in section 4-b of this chapter (below), this particular hybrid *harmony/timbre* serves as the functional dominant of all the *harmonies/timbres* outlined in this section and Chapter 3-a and section 4-b in this chapter. I identify all other hybrid *harmonies/timbres* created by ring modulation following the same template I used to name harmony 'A'-Ring(B4), in which harmony 'A'-Ring(B4) is harmony 'A' ring-modulated by B4.

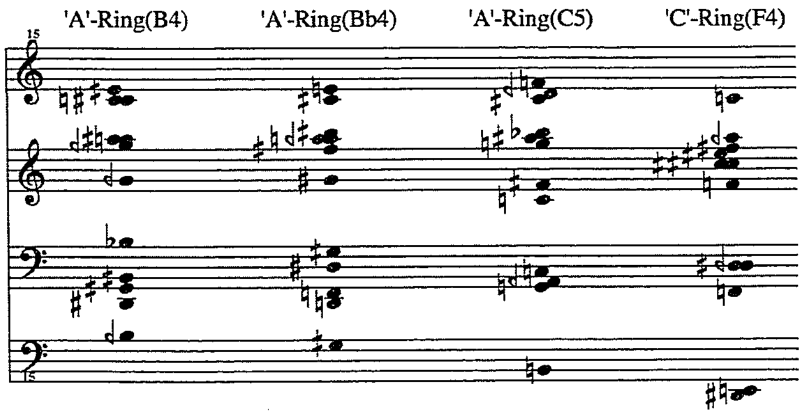


Figure 4-3: All hybrid *harmonies/timbres* created by ring modulation in *Time Fixtures*

Simple frequency modulation (FM) produces a collection of sum tones and difference tones by adding the carrier frequency to the modulator frequency and sending the result to an oscillator. In addition, in FM synthesis a modulation index quantifies the modulation's intensity and the number of sidebands produced (Chowning). Figure 4-4 shows a Max/MSP patch I programmed to perform simple FM synthesis.

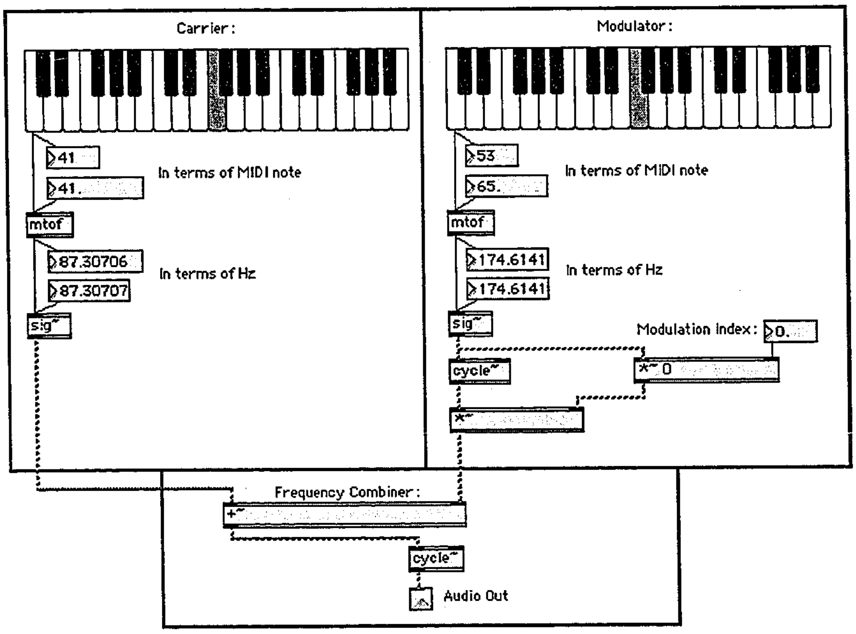


Figure 4-4: Max/MSP subpatch used to perform FM synthesis

FM synthesis produces a collection of sidebands that are calculated by multiplying a list of integers ascending from 1 to the maximum modulation index (IMAX) by the sum tones and the differences tones. For example, given IMAX = n the sum tones equal C + M, ... n - 1 * (C + M), n * (C + M), and the difference tones equal the absolute value (Abs.) of (C - M), ... n - 1 * (Abs. (C - M)), n * (Abs. (C – M)) (Roads 224-236).

In *Time Fixtures* I use one FM synthesis model (FM-F) with a carrier at F2 (approximately 87.3 Hz), a modulator at F3 (approximately 174.6 Hz), an IMAX of 8 for the instrumental writing, and an IMAX of 25 for the electronics. This FM model generates only odd harmonics to create "a crude clarinet simulation" (Roads 235) and is frequentially symmetrical at every IMAX. Figure 4-5, shows the OpenMusic patch I programmed to calculate FM-F's ''frequency harmonies" for the instrumental writing in

Mm. 98- 101, 128-131, and 243-246.

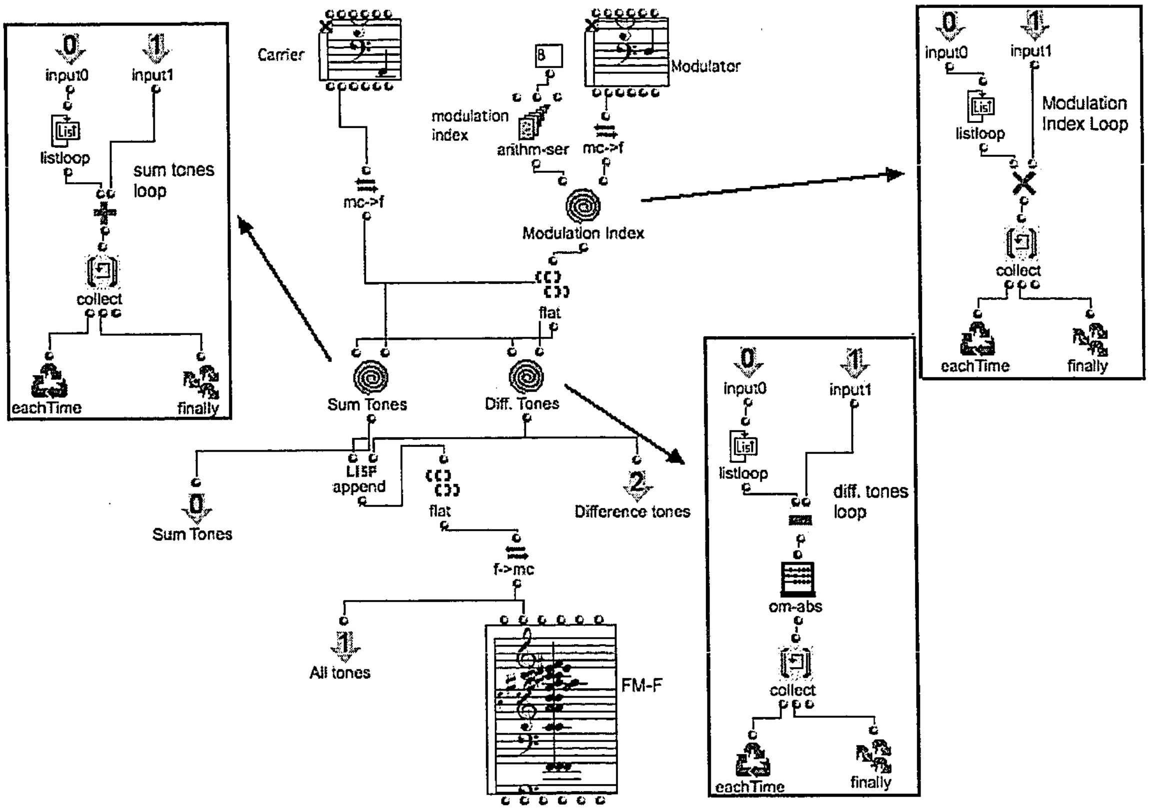


Figure 4-5: OpenMusic patch used calculate the 'frequency harmonies' of FM-F

This FM model also occurs transposed down a fifth in the electronics during Mm. 194-200.

As with the other *harmonies/timbres* described in Chapter 3-a, the winds, strings, and electronic instrumental samples use quarter-tones and half-steps while the percussion instruments only use half-steps. To meet local musical concerns such as voice leading and instrumental registers, I freely transposed the ring-modulated pitches by octaves; however, I kept the pitches in FM-F always within fixed registers in the instrumental writing. In contrast, all *harmonies/timbres* in this category always appear untempered at their archetypal registral positions in the electronics.

4-b. Interpolation and Methods of Selection

In the final category of the *harmonies/timbres* employed in this composition, I used interpolation to construct a chordal bridge between the intervallic harmonies described in Chapter 3-b and the hybrid *harmonies/timbres* in Chapter 4-a. I modelled this method on the post-spectral methods used by Philippe Hurel in *Pour l'Image*, Marc-André Dalbavie in *Diadémes* (Pousset 88-102), Philippe Leroux in *Apocalypsis* (Leroux), and Magnus Lindberg in *Ur* (Anderson 14-17).

In simple interpolation one selects a first and last note, draws a straight line between them, calculates this line's slope, divides the line equally by a number of steps, and uses the slope to calculate the steps along the interpolation path. To interpolate between two chords that each have the same number of notes, one repeats the same procedure between each note of the first chord and its equivalent note in the last chord (Figure 4-6). Appendix 4-1 shows the OpenMusic patch I programmed to interpolate between two chords and quantify the results within any equally-tempered system.

Figure 4-6: Interpolation along ten steps between two chords

As noted above, I chose harmony 'A'-Ring(B4) as the *harmony/timbre* functional dominant. To emphasize this decision, I created a collection of interpolation paths between the functional tonic harmony 'A' and the two hexachords in harmony 'A'-Ring(B4). Appendix 4-2 shows the chords along the quarter-tone interpolation path to harmony 'A'-Ring(B4)'s sum tones [Sum-Interp(Q)1-102]. Appendix 4-3 shows the chords along the quarter-tone interpolation path to harmony 'A'-Ring(B4)'s difference tones [Diff-Interp(Q)1-102]. Appendix 4-4 shows the chords along the half-step interpolation path to harmony 'A'-Ring(B4)'s sum tones [Sum-Interp(H)1-102]. Appendix 4-5 shows the half-step interpolation path to harmony 'A'-Ring(B4)'s difference tones [Diff-Interp(H)1-102]. All four interpolation paths follow 102 complementary steps to establish a complete descending quarter-tone line between harmony 'A''s lowest note and the lowest note of harmony 'A'-Ring(B4)'s difference tones. The winds, strings, and electronic samples freely draw from the quarter-tone and half-step interpolation paths, but the percussion instruments draw only from the half-step interpolation paths.

These 408 chords comprise a reservoir of harmonic choices. While composing I freely selected chords based upon global and local concerns such as inner voice leading, bass and soprano melodic contour, harmonic dissonance or inharmonicity, the presence of a specific pitch, the presence or absence of certain intervals, and the distance along the interpolation path. To facilitate this process, I programmed a collection of OpenMusic patches that process lists of chords.

Appendix 4-6 shows a patch that sorts a list of chords by harmonic dissonance or, more specifically, ascending or descending inharmonicity. This patch uses Ernst Terhardt's virtual fundamental function (Terhardt 1061-1069), in which the lower a chord's virtual fundamental, the more inharmonic the chord and *vice-versa.* Appendix 4-7 shows a patch that returns only chords with a desired pitch. Appendix 4-8 shows a patch that returns chords lacking a particular interval, and Appendix 4-9 shows another patch that returns a chord every time it has a desired interval. I often used these last two patches to eliminate chords with octaves and then to choose chords with either minor sixths, Major sevenths, or octaves detuned up or down by a quarter-tone. Finally, Appendix 4-10 shows a patch that selects chords based upon their distance along the interpolation path.

As Chapter 6 explains I do not make extensive use of the all chords listed in Appendixes 4-2 – 4-5 or the selection patches shown in Appendixes 4-6 – 4-10; however, I decided to include them to demonstrate the breadth of musical resources that they could provide for my future compositional projects.

Chapter 5. Orchestration and Electronics

This chapter focuses on the general orchestration guidelines and specific electronics used in *Time Fixtures*. The first section describes the groupings and archetypal functions for the live instruments and electronics. The second section details the spatialization methods, concepts, and strategies used in the hexaphonic loudspeaker setup. The third section describes the other live digital signal processing techniques. The final section describes some of the preconstructed electronic sounds and how the synthesizer controls events.

5-a. Groupings and Archetypal Functions

The live instruments are divided into three groups based primarily upon their means of production: the wind group (flute [+ alto], oboe, clarinet in Bb [+ bass], horn), the percussive group (percussion, harp, piano), and the friction or string group (violin, viola, violoncello). These instrumental groupings and specific instruments have interconnected and clearly defined archetypal roles. Figure 5-1 outlines these roles, placing the acoustic instruments alone and within their groupings on a "functional instrumental axis" running from most important to least important.

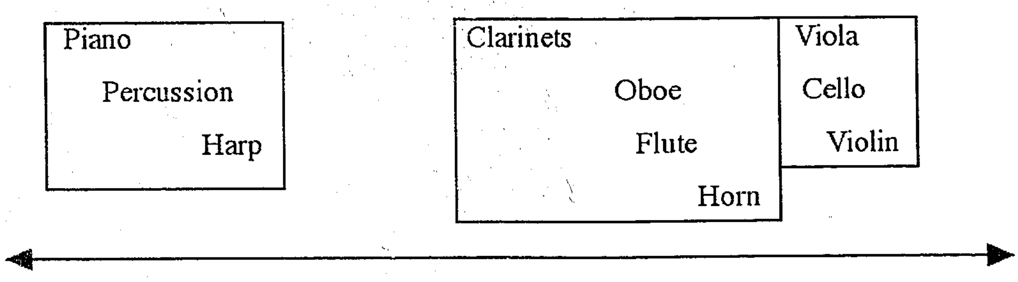


Figure 5-1: The "functional instrumental axis" used in *Time Fixtures*

Since most melodic, gestural, rhythmic, and textural figures originate in the percussion group, *Time Fixtures* can be considered almost a triple concerto in disguise for piano, percussion, and harp. In this setting, the string and wind groups primarily provide resonance, timbral variety, and heterophonic textural variations. These relationships between instrumental groups also occur, to a lesser extent, between the instruments in each group. In the wind group, for example, most music originates in the clarinets while the flute, oboe, and horn provide heterophonic support. The balancing and readjusting of these functional roles between instrumental groupings and instruments help to define structural and formal guide points in the work.

The routing of the amplified live instruments also plays a significant role in the orchestration. Figure 5-2 displays how the live instruments are sent to the mixer and routed to five auxiliary channels before being sent to the computer.

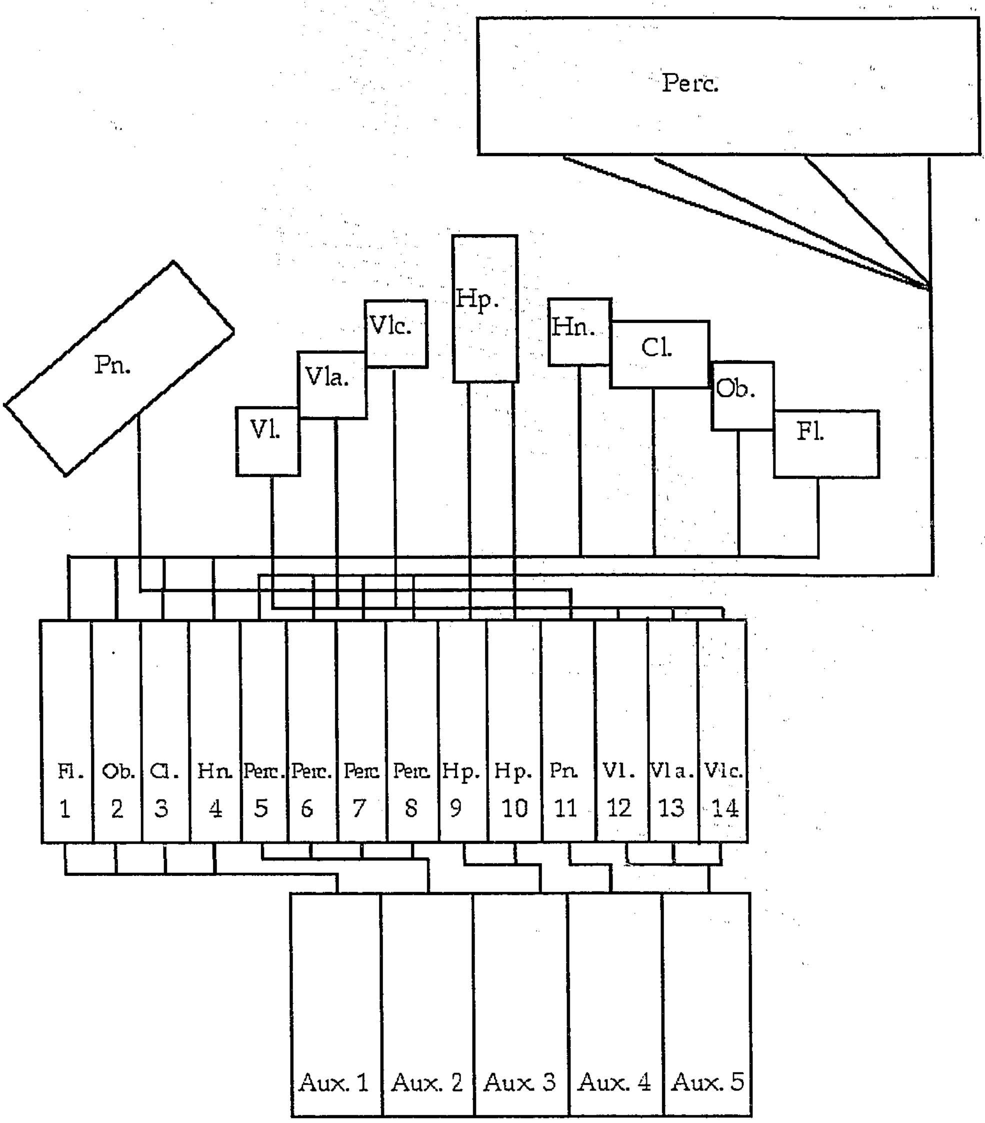


Figure 5-2: Amplified instrumental routing inside the mixer

The routing gives priority to the three individual percussion instruments as shown in

Figure 5-1. Routing each of the wind and string instruments into two channels reflects their less significant orchestration roles. These merged routings also mirror the unavoidable bleeding that occurs whenever amplifying multiple instruments in a concert setting. And this merging reflects the electronics' primary orchestration function – to aid in rebalancing and unifying the various orchestral forces.

5-b. Spatialization

Spatialization is one of the most important extra-instrumental orchestral features in *Time Fixtures*. During performance, six loudspeakers and three subwoofers symmetrically surround the centre of the audience (Figure 5-3).

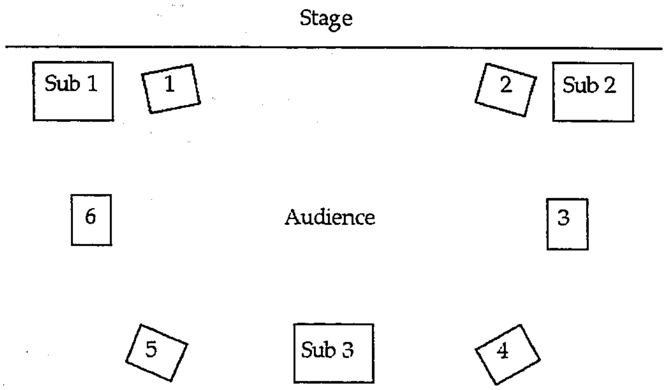


Figure 5-3: Speaker configuration for *Time Fixtures*

In this configuration loudspeakers 1-6 play middle and high frequencies, and each subwoofer plays the accompanying low frequencies for its two neighbouring loudspeakers. The computer sends sound to all nine speakers through a Max/MSP performance patch that I programmed. The mixer also sends a quiet stereo mix-down of the live instruments to the front two speakers and subwoofers, reinforcing the acoustic sound's spatial origin.

Two general principles guide spatialization. The first requires that sound always comes out of all six loudspeakers. This principle relies mostly upon combinatoriality to create a fully balanced and immersive sonic environment. The second principle requires that there must always be some form of spatial movement, which aims to alternatively obfuscate spatial certainty and to provide a constant source of interest. In combination, these two principals aim to create in space the dynamic and unified musical environment that the poetic focus dictates.

The Max/MSP performance patch that I programmed for *Time Fixtures* alternatively spatializes each live mono signal through two different types of subpatches. Figure 5-4 shows one of the five identical diffusion subpatches I designed to perform live spatialization.

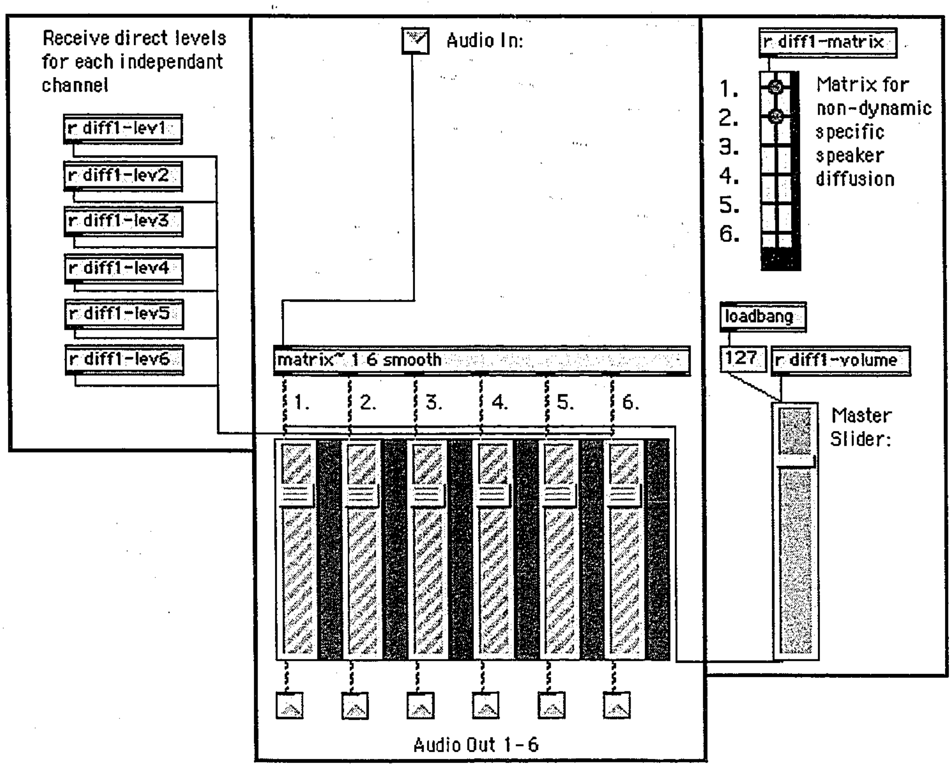


Figure 5-4: A diffusion subpatch

In this subpatch a live mono signal can be dynamically routed out to each of the six loudspeakers. The matrix object in the top right corner of the above figure controls to which speakers the signal goes. Sliders 1-6, which correspond to each of the speakers, and a master slider, which controls all the sliders, provide additional volume control for the output of each speaker. In the above figure, for example, the mono signal is routed out the front speakers at an amplitude of 0 dB.

The five diffusion subpatches primarily spatialize the mono signals in stable positions to facilitate constructing balanced spatial environments. In performance, the diffusion subpatch typically sends live mono signals to two different speakers. This creates a larger sound and simulates acoustic reflections. Figure 5-5 shows the most common speaker positions for each of the five live mono signals.

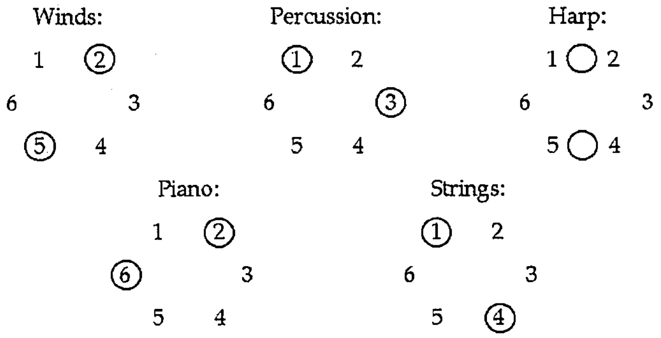


Figure 5-5: The most common speaker positions for the five live mono signals

Figure 5-6 shows one of the five identical subpatches I programmed that utilizes the vbap or "Vectoral base amplitude panning" (Pulkki) Max/MSP external object to alternatively spatialize movement for the five live mono signals.

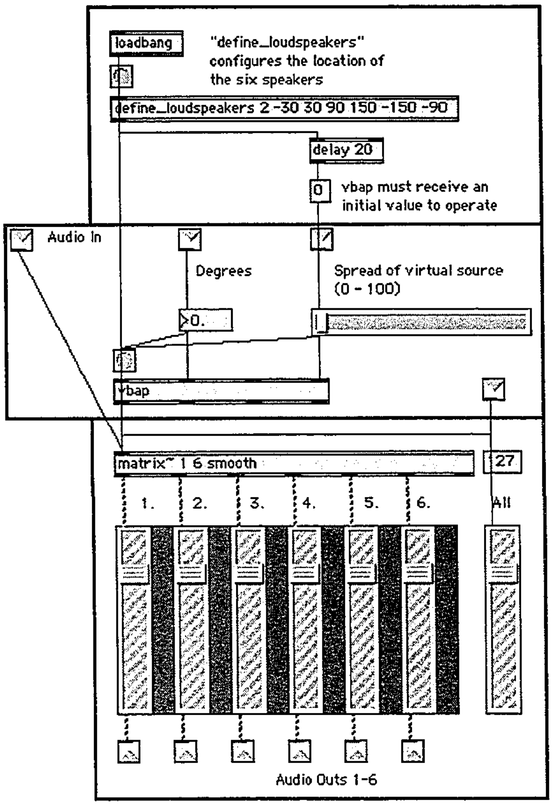


Figure 5-6: A vbap-spatializer subpatch

The vbap object takes two arguments to move sound in a two-dimensional circular space – degrees and "spread of the virtual source." In this patch 0 degrees is defined as the centre of the stage. "Spread of the virtual source" defines the position of the sound in relationship to the centre of the audience. The calibration of one hundred (100) places a sound in the hall's centre and 0 places sound at its distant threshold.

I also programmed five identical Max/MSP vbap-control subpatches (Figure 5-7). These control two types of spatial movement in the vbap object – random and circular.

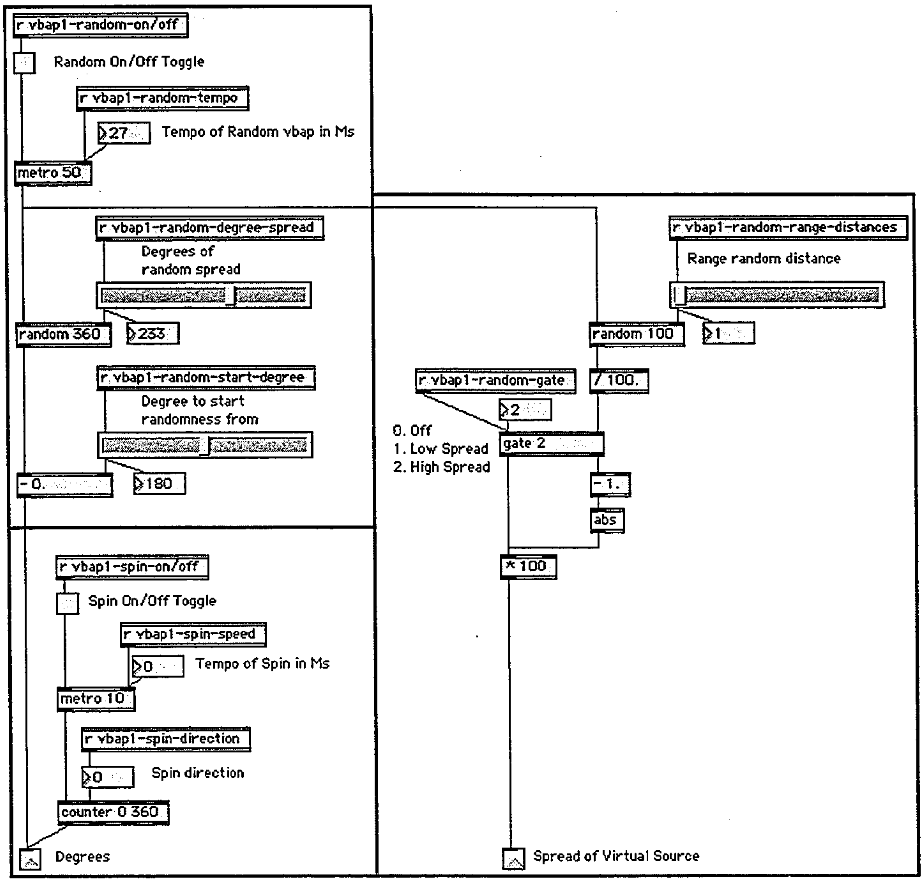


Figure 5-7: A vbap-control subpatch

In the above figure all the controls on the left modify degrees, and all the controls on the right control the "Spread of the virtual source." At any time one vbap-control can control only random or circular movement. The vbap-random-gate turns the random movement off when 0, 1 or "Low Spread" starts random movement from the centre of the audience, and 2 or "High Spread" starts random movement from the edges of the hall. Sending 0 from the vbap-spin-direction object spins sound clockwise; calibration 1 spins sound counter-clockwise; and 2 rocks the sound back and forth by spinning sound clockwise until it reaches 0, then spinning counter-clockwise until reaches 0 and so on.

All spatialized sound from the vbap-spatializer3, diffusion1, and diffusion5 subpatches pass through three different delay-speakers subpatches (Figure 5-7) that I programmed.

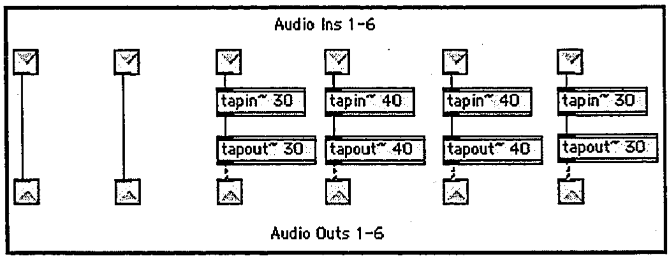


Figure 5-7: A delay-speakers

The above subpatch delays the audio output to specific speakers, which creates a barely perceivable rhythmic delay, a form of perceptible distance that is not computationally intense, and a percieved mild Doppler effect when moving sound in space (Dodge & Jerse 316-317). I produced some other interesting spatial effects by using the Cubase multichannel spatializer to move pre-recorded electronic sounds and by cross-fading moving sounds to static sounds and *vice-versa.*

5-c. Other Live Digital Signal Processing Techniques

Besides spatialization, the performance patch for *Time Fixtures* performs three other types of digital signal processing (DSP) that transform live instruments' sound in real time. Three identical ring modulation subpatches (Figure 4-1 in Chapter 4-b), for example, perform as many as three different ring modulation configurations at once. The live instruments are often ring modulated by the exact same modulator frequency (e.g., B4, Bb4, C4) used to construct the music's hybrid *harmonies/timbres* (see Mm. 10-11, 13-14, 34, 38-39, 64-79, 84-86, 103-104, 107-108, and 124-126). In some other instances a live signal is ring modulated by subsonic sinusoidal waves ranging from 0 Hz to 36 Hz (see Mm. 6-8, 35, 138-141, and 232- 236).

Three identical echo subpatches (Figure 5-8) perform as many as three different live echo configurations at once.

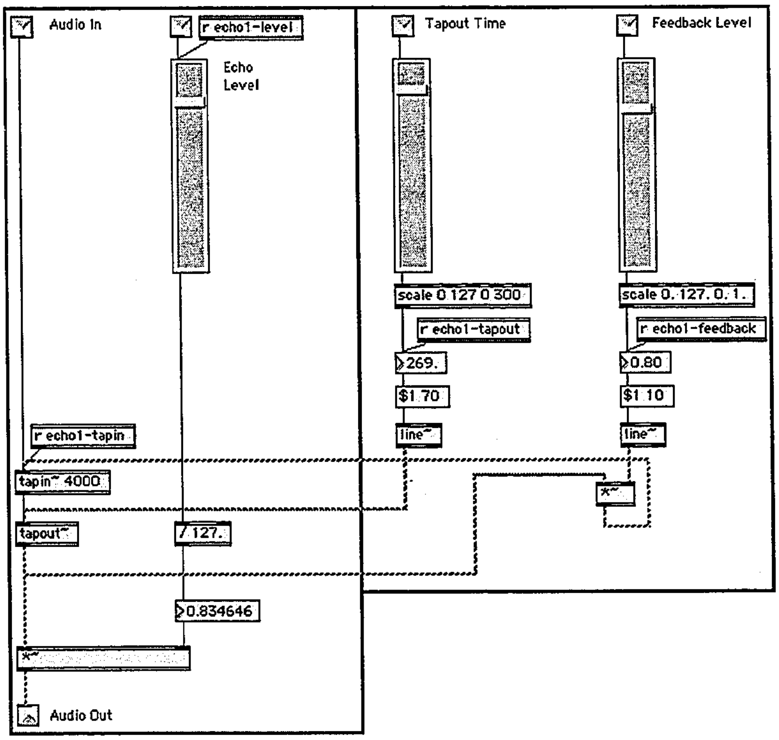


Figure 5-8: An echo subpatch

The subpatch in the above figure creates an echo by iteratively feeding a decaying delay into itself. "Echo Level" controls the DSP's total amplitude; the argument for tapin~ indicates how much audio is constantly sampled in milliseconds; "Tapout Time" controls the signal's delay length; and "Feedback Level" controls the multiplicative decay factor.

Finally, two identical resonator subpatches (Figure 5-9) use the resonators~ Max/MSP external object to perform as many as two different live DSP configurations at once.

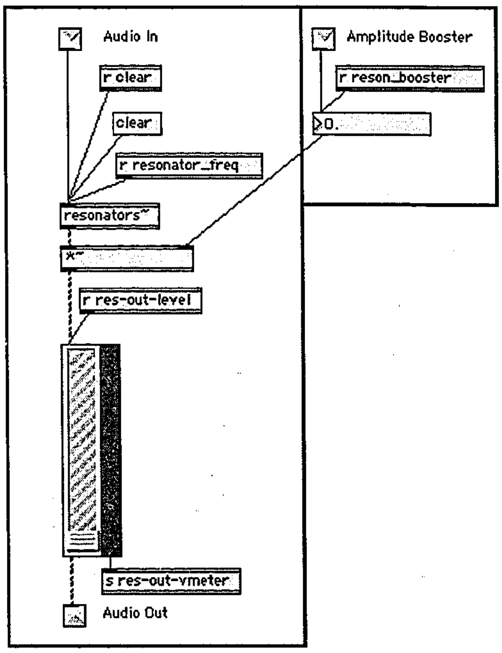


Figure 5-9: A resonator subpatch

The resonators~ object acts like a large bank of equalization filters with resonant Q values at the desired frequencies (Jehran, Freed, & Dudas). For each resonant frequency the resonaters~ object requires three consecutive variables: "frequency, gain, and decay rate" (Jehran, Freed, & Dudas). I created the lists used in live processing with the patch shown in Figure 5-10, with the OpenMusic patch described in section 3-a, and with much trial and error.

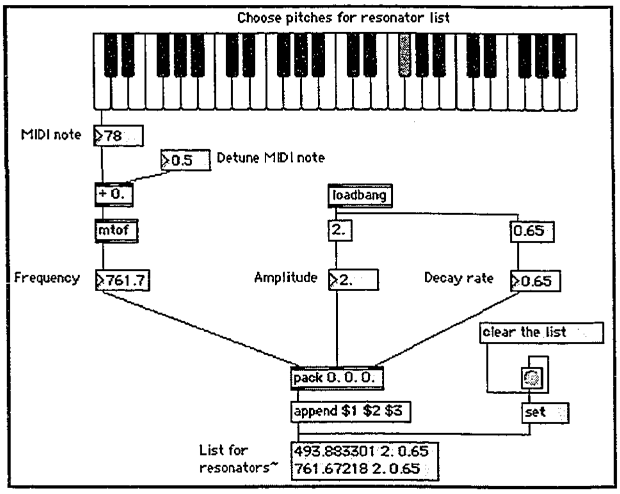


Figure 5-10: Subpatch used to construct lists for the resonators~ object

5-d. Electronic Sounds and Event Control

Acoustic sounds serve as the model for almost every electronic sound used in *Time Fixtures*. I initially recorded myself playing the three Tibetan bells described in Chapter 3-a. Then I recorded musicians from the McGill Contemporary Music Ensemble performing passages from the score and other instrumental sounds such as multiphonics, breathing sounds, key clicks, held tones, tremolos, pedal buzzes, pedal trills, string grain, jeté, harmonics, and harmonic glissandi. I also used the resonators~ object and the techniques described in Chapters 3-a and 5-c to synthesize digital sounds. I edited and catalogued these audio files, as well as some instrumental samples from the Vienna Symphonic Library and the McGill University Master Samples, to create a large library of sounds (DVD-Rom/Sample-Library).

I edited and modified sounds in this library using Peak 4.0, AudioSculpt 2.5.2 and 1.7.3, the OM<->AS library in OpenMusic 4.9.1, Cubase 3SX, and a collection of patches I programmed in Max/MSP 4.5.6 (See DVD-Rom/Max-Audio-Generators). I compiled these audio files in Cubase SX 3 to create a complete montage of all the electronic sounds (See DVD-Rom/Cubase/Full/Full). Finally, for rehearsals and performance, I mixed down 215 smaller audio files from this Cubase document (DVD-Rom/TimeFixtures(Patch)/Mixed Down Samples/).

During performance MIDI data sent from the keyboard controls the audio sample playback through the Max/MSP performance patch (DVD-Rom/TimeFixtures(patch)/ Performance-Patch). Frequently the keyboard's notes correspond directly to the samples played (see Mm. 5-6, 9, 19-21, 30-32, 41, 45-55, 57-63, 66-67, 69-70, 72-73, 76-80.1, 83.3-87, 95-98, 103, 109-110, 121-125, 141-145,147, 153-154, 158, 160-161, 167, 172, 187-189, 191, 194-200, 202, 206-216, 220-225, 235, 238, 240-243, 249-252, and 254) and, in other instances, the keyboard notes may trigger longer and more abstract samples (see Mm. 1-20, 22-30, 33-39, 42-45, 55-57, 59-62, 64-155, 163-170, 178-186, 189-192, 194-201, 202-206, 217-219, 222-260). Almost every MIDI note also reconfigures the DSP, sets up dynamic live processing, or just advances the score follower (DVD-Rom/TimeFixtures(Patch)/Score-Follower) within the performance patch.

Chapter 6. Musical Synthesis

This chapter explains how I synthesized the musical materials in *Time Fixtures* to illustrate the poetic focus. The first section explains how the three implicit trajectories determine formal divisions and the general structural surface materials of the composition. The last three sections describe the technical, formal, and structural features for each major part.

6-a. Implicit Trajectories and Global Design

The implicit trajectories clearly manifest themselves in *Time Fixture's* apportionment (sectional durations). The three trajectories explicitely determine length of each section and plot the general implicit progression of events in a musical process against the progression of time (Figure 6-1).

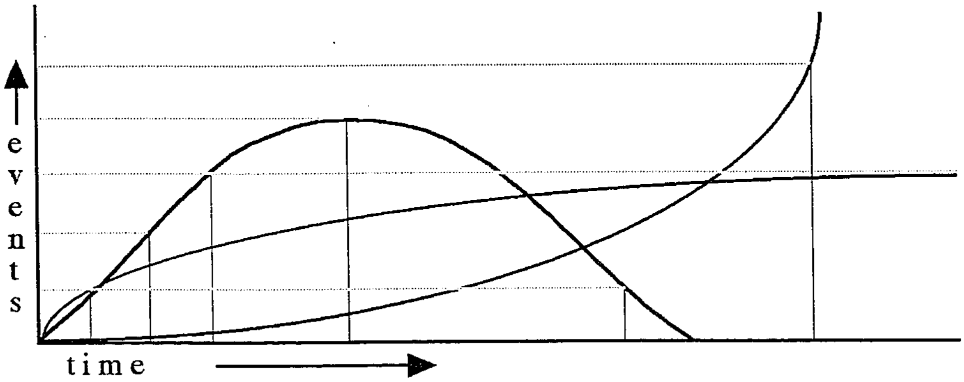


Figure 6-1: The three trajectories plotting the progression of events against time

In the above figure the dotted horizontal lines define event thresholds, or the junctions of the dimension "time" with those of "event." The vertical lines represent the position in time of formal sectional divisions and musical cadences, which are defined as the meeting points of different proportional rhythmic streams (Carson).

Figure 6-2 shows the temporal positions in *Time Fixtures* of the vertical lines or section divisions shown above in Figure 6-1.

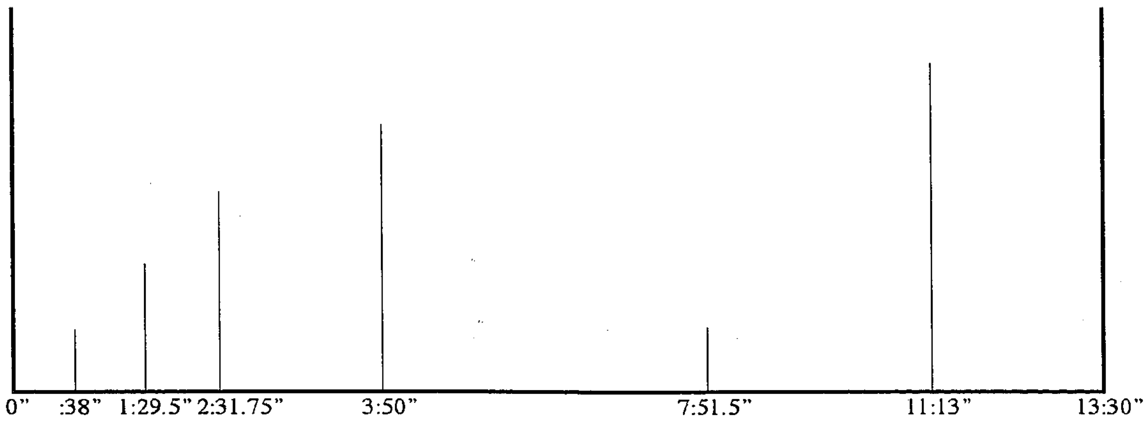


Figure 6-2: Temporal positions for the sectional divisions in *Time Fixtures*[4]

In the score every sectional division corresponds to a double bar line. At a structural level, the trajectories also correspond to the generally implicit character of the trajectories contained within these sections.

Following the principle of good balance outlined in Chapter 2-b, a section's duration corresponds inversely to its level of structural complexity and freedom. This complexity and freedom is defined and identified by proportional tempi, surface rhythmic activity, polyrhythmic densities, and the overall surface activity. These are all based upon Robert Ornstein's cognitive "storage-size metaphor," which states: "when input is increased...duration experience lengthens" (and *vice-versa* for decreased input) (Ornstein 48). *Time Fixtures* attempts to expand time during moments of lower structural complexity or freedom, and contract time during moments of greater complexity or freedom (Grisey, *Tempus* 259). In essence, I try to explore how we perceive time as it unfolds and passes.

At a formal level some of these sectional divisions group together to create the three major parts or the hidden *attacca* movements of the composition – Mm. 1-86, 87-153, and 154-260. The smaller sectional divisions and larger divisions also relate to each other in a fractal manner. I use the fractal model in a less deterministic and direct way than is commonly used in compositions like *Diadèmes* by Marc-André Dalbavie *Shadowlands* by Bent Sørensen, where the movements contain the same proportions as the whole piece (Dalbavie 28-29; Sørensen). In *Time Fixtures* the ratio between the first

[4] I indicate all temporal positions as minute:second.tenth" of a second

part's second and third sections (Mm. 12-35 : Mm. 36-63 or 51.25" : 65.25") is the same as the inverted ratio between the last part's two sections (Mm. 232-260 : Mm. 154-231 or 112" : 201.5"). In addition, the ratio between the first part's third and fourth sections (Mm. 36-63 : Mm. 64-86 or 65.25" : 78.25") is the same as the ratio between the third part's first section (or the last three sections of the first part) and the second part (Mm. 154-231 (Mm. 10-86) : Mm. 87-153 or 201.5" : 241.25").

6-b. Measures 1-86

"I am Time, the waster of the peoples,
Ready for the hour that ripens to their ruin."
-Bhagavad-Gita

The first part of *Time Fixtures* is the most formally detailed and structurally free complex. In fact, the four sectional divisions can be perceived and regrouped in a number of ways. The declamatory first section (Mm. 1-11) functions as an introduction, and the last three sections (Mm. 13-86) function as an exposition. Structural attributes aid in grouping the second and third sections (Mm. 12-63) together independent of the fourth section (Mm. 64-86). These perceptual groupings also reflect an intended self-symmetry: the sum of the first and last sections (Mm. 1-11 and 64-86) and the sum of the second and third sections (Mm. 13-63) both equal 116.5 seconds.

The introduction (Mm. 1-11) functions as a "fractal window" that encapsulates the work's gestural contour, as well as most of the structural and surface materials. In this section, the instrumental writing employs only the tonic note C and harmonies 'A', 'A'-Ring(B4), and 'C'. In Mm. 2-4, the electronics introduce the three archetypal bells in the same rhythm as their initial introduction in the instrumental part at Mm. 95. In Mm. 5-6 the electronics play the archetypal bells up an octave, and in Mm. 7-11 the electronics fuse with the acoustic resonances in the instrumental writing. Figure 6-3 shows an overlapping harmonic reduction of the introduction.

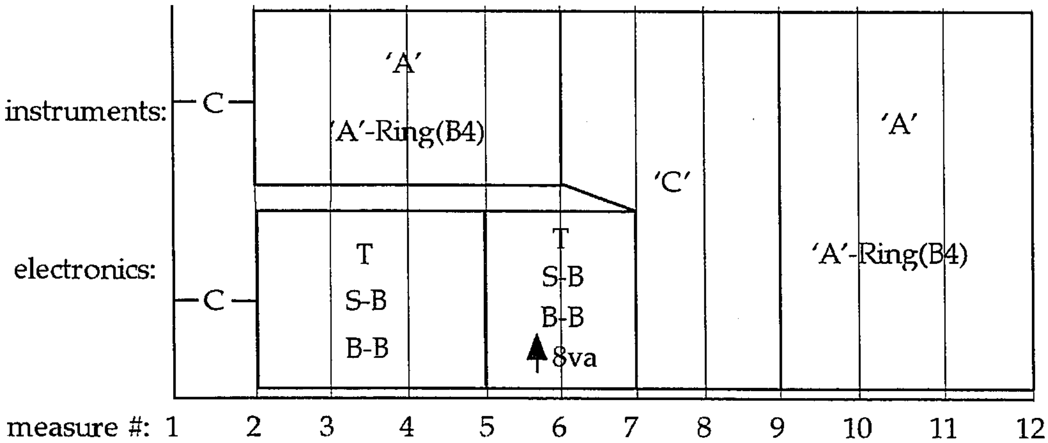


Figure 6-3: Harmonic reduction of Mm. 1-11

Mm. 12-63 are adapted from my piano Prelude #1, *Stream* (Appendix 3-3, Mm. 1-39). This prelude is roughly modelled on J. S. Bach's Prelude #1 in C major from the *Wohltemperiertes Klavier* Book 1. Mm. 12-18 of *Time Fixtures* move through harmonies 'A,' 'B.' 'C' in the quasi-tonal environment in the same way Bach moves through harmonies in a tonal environment in Mm. 1-3 of his prelude.

I also use this detailed form as the frame for a free, yet complex structural surface. For example, in Mm. 13-63 the music consists of an iterative collection of processes and interpolations that alternatively clarify and obfuscate the unfolding of time. During this section I follow two orchestration processes – one where I gradually reverse the "functional instrumental axis" of the instrumental groups and another where I repeatedly cycle the instruments' hierarchical importance within their own groups. In the chordal writing here I interpolate how often I insert chords progressing along the interpolation paths outlined in Chapter 4-b. Then I interpolate how often I move back and forth along these interpolation paths, as well as how frequently I transpose these chords by an octave. Rhythmically, I interpolate from a symmetrical rhythm that resembles the third trajectory to an accelerating rhythm that resembles the second trajectory (see Chapter 2-c). On top of this rhythmic process, I increase the rate at which I add and balance accelerandi and rallentandi.

Mm. 64-86 are adapted from the coda of my Prelude #1, *Stream* (see Appendix 3-3, Mm. 40-46). This section consists primarily of the ring-modulated hybrid *harmonies/ timbres* outlined in Chapter 4-a, as well as a duo between the clarinet in Bb and the horn.

Figure 6-4 shows the harmonic progression of this section.

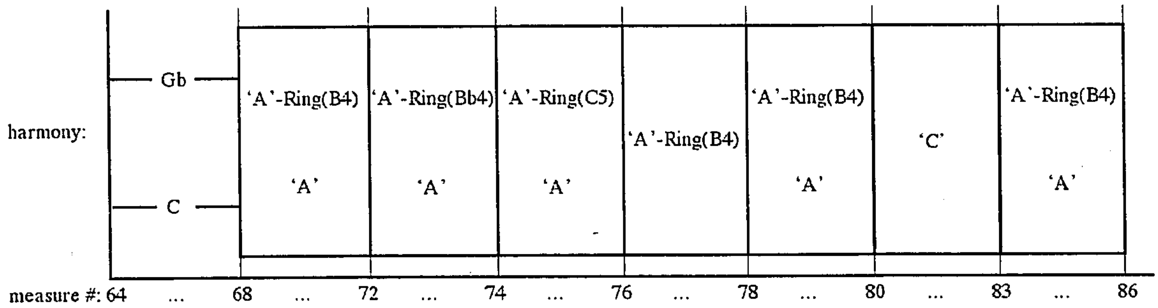


Figure 6-4: Harmonic progression of Mm. 64-86

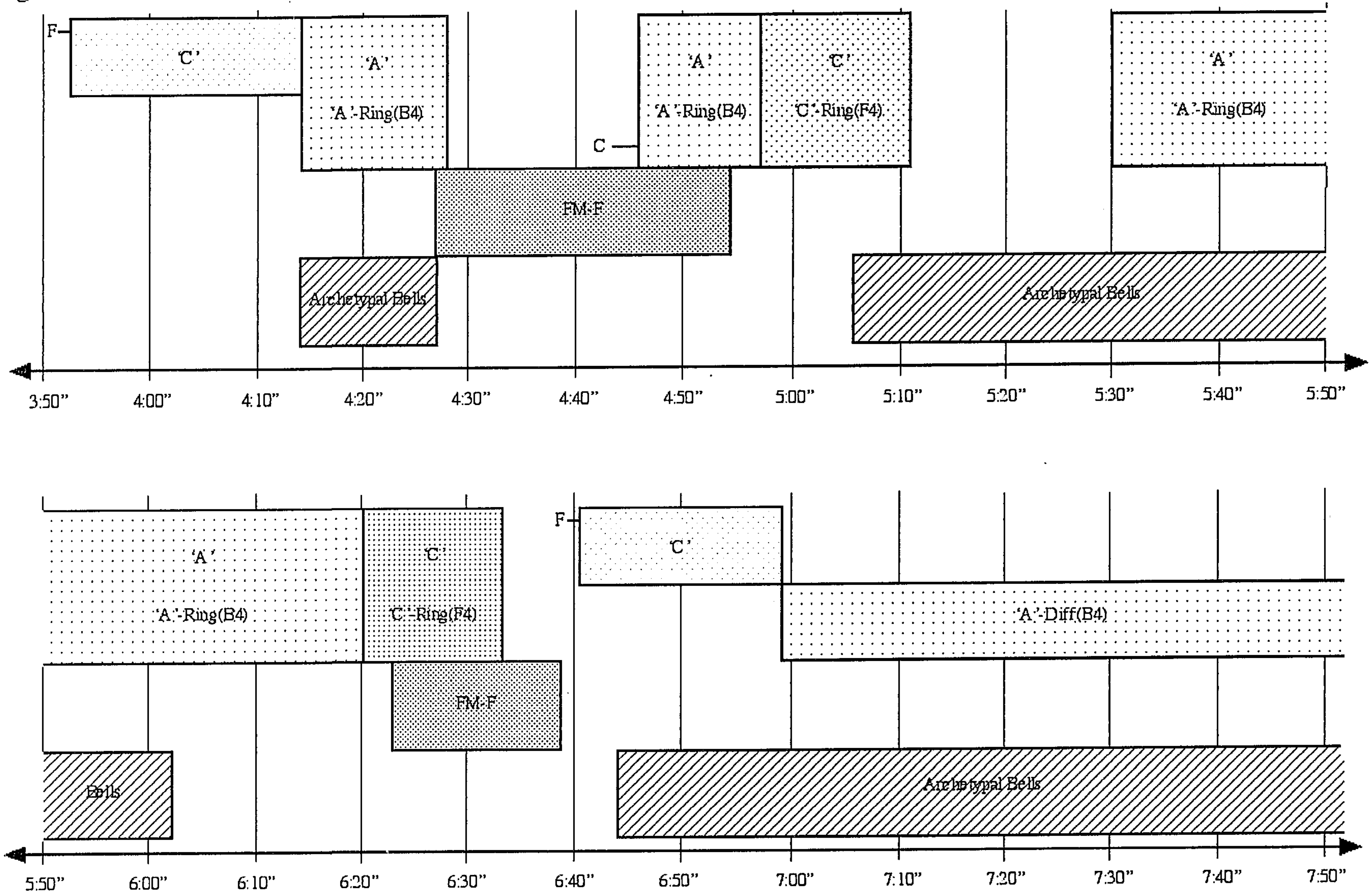
Although this section primarily uses mostly new transition material, the highly fused instrumental timbre in Mm. 64-66 foreshadows the beginning of the next part of the piece, as well as the transition to the coda in Mm. 228-230. Similarly, Mm. 78-82 recalls Mm. 5-8 of the introduction and foreshadows this material's further transformations.

6-c. Measures 87-153

"Time is what keeps the light from reaching us.
There is no greater obstacle to God than time."
-Meister Eckhart

Because Mm. 87-153 focus primarily on fusing harmony with timbre – and the live instruments with the electronics – I like to refer to the second part of *Time Fixtures* as a "timbral abyss." The music in this part obfuscates any clear formal divisions while relying upon rigid structural procedures such as expansion and a slow overlapping harmonic/timbral rotation that resembles a slowly turning Calder mobile. This clear rotating movement towards stasis represents both the second implicit trajectory's slowing ascent and the third implicit trajectory's gradual decline from 3:50" to 7:50" (Figures 6-1 and 6-2).

Figure 6-5: Harmonic/timbral flux in the "timbral abyss"



The above figure shows that the second part contains mostly *harmonies/timbres* from the categories described in Chapters 3-a and 4-a. Common tones and extra instrumental sounds such as string grain, jeté, pedal buzzes, thunder strikes, blowing noises, multiphonics, key clicks, and tongue slaps aid this gradual harmonic/timbral movement in the instrumental writing. The spatialization effects outlined in Chapter 5-b, live echoes, live ring modulation, live resonance, pre-recorded instrumental samples, and long resonant sound washes aid this movement in the electronics.

In the "timbral abyss" the three archetypal bells sound together on three different occasions and collectively occur more than any other *harmony/timbre* (148" of a total 240," approximately the golden mean of Mm. 86-153). In Mm. 95-99 they sound in both acoustic instruments and electronics and appear again in Mm. 109-115. They continue in the electronics while the acoustic instruments simulate harmonies 'A' and 'A'-Ring(B4) in Mm. 116-123. The bells appear for the third and longest time from Mm. 135-153. Here, they first sound in the electronics (Mm. 135-138) and then in both the acoustic instruments and electronics, as the electronics also play the filtered resonance of harmony 'A'-Ring(B4)'s difference tones (Mm. 139-153).

6-d. Measures 154-260

> "Of course in music too the problem of time is central.
> Here, however, its solution is quite different:
> the life force of music is materialized on
> the brink of its own total disappearance."
>
> -Andrei Tarkovsky

The last part of *Time Fixtures* contains two major sections that further develop and provide new contexts for the previous musical materials. The first section (Mm. 154-231) generally follows the same harmonic progression as Mm. 12-64 (Figure 6-6).

time:	6"	~ 5.85"	~ 5.9"	5"	~ 5.2"	~ 5.2"	~ 7.2"
measures:	12 - 13;	14 - 16;	17 - 18;	19 - 21;	22 - 24.2;	24.3 - 26;	27 - 29;
	↕	↕	↕	↕	↕	↕	↕
measures:	154 - 157;	158 - 162;	163 - 166;	167 - 171;	172 - 177;	178 - 184;	185 - 186;
time:	8"	~ 13.1"	~ 11.4"	~ 15.7"	~ 15.3"	~ 15"	~ 7.2"

time:	~ 5.4"	6.5"	6"	~ 50.5"	3"	~ 4"	5.25"
measures:	30 - 32;	33 - 35;	36 - 38;	39 - 58;	59;	60 - 62;	63 - 64
	↕	↕	↕	↕	↕	↕	↕
measures:	187 - 189;	191 - 193;	194 - 199;	200 - 221;	222 - 223;	224 - 225;	226 - 231
time:	~ 6.8"	~ 9"	~ 10"	~ 50.5"	7"	~ 4"	~ 16"

Figure 6-6: Similarity between Mm. 12-64 and Mm. 154-231

As the above figure shows, the harmonic blocks from Mm. 154-199 initially last longer than their corresponding blocks in Mm. 12-38. To contradict the perception of this expansion, the music's structural surface in Mm. 154-199 changes at a much quicker pace than in Mm. 12-38. In Mm. 200-231 the rate of textural change slows and, except for Mm. 222-223 and 226-231, the harmonic blocks last as long as their corresponding blocks in Mm. 39-64. This cross between accelerating and slowing musical materials in Mm. 154-231 represents the interaction of the first trajectory's acceleration toward its asymptote and the second trajectory's slowing ascent from 7:51.5"–11:13" (Figures 6-1 and 6-2).

The coda (Mm. 232-260) represents the second trajectory's endlessly slowing ascent, as well as the movement towards a unified *harmony/timbre* and a static or "fixed" conception of time. Similar to what happens in the "timbral abyss," the three archetypal bells collectively sound more often in the coda than any other *harmony/timbre* (65" of a total 113", approximately the golden mean of Mm. 232-260) (Figure 6-7).

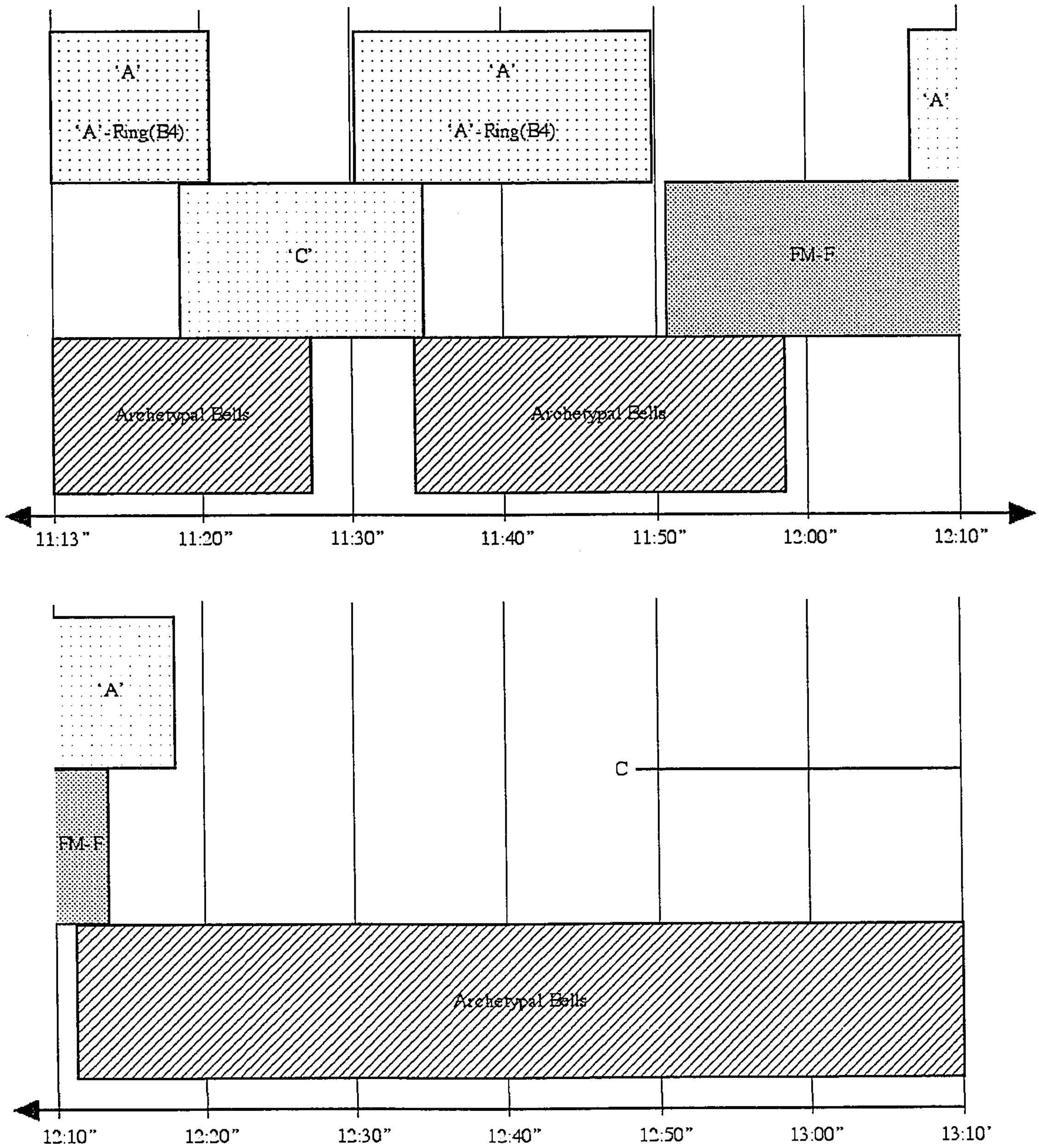


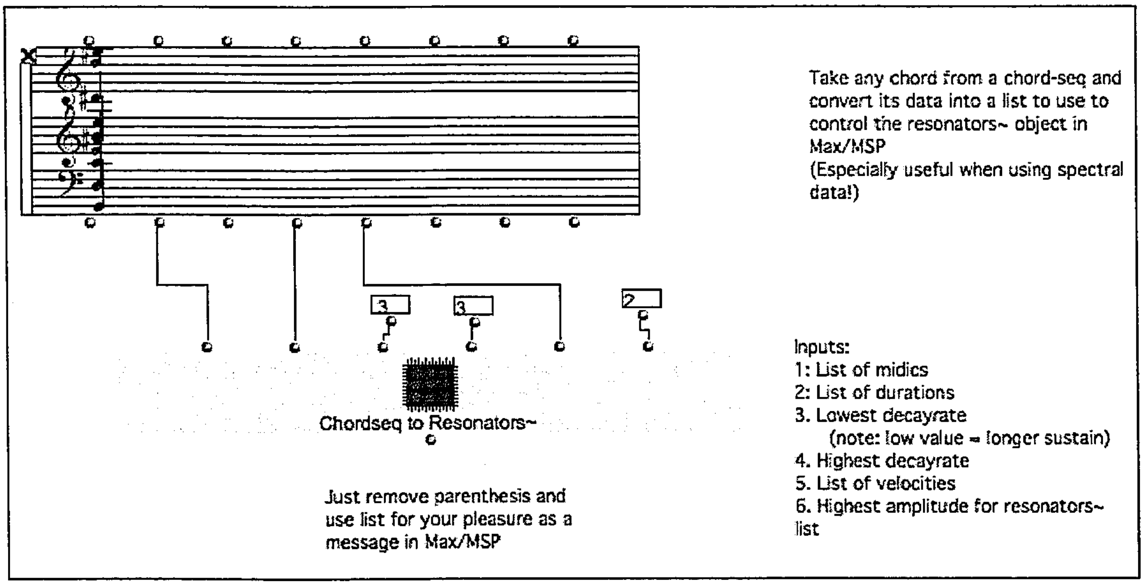
Figure 6-7: Harmonic/timbral flux in the coda

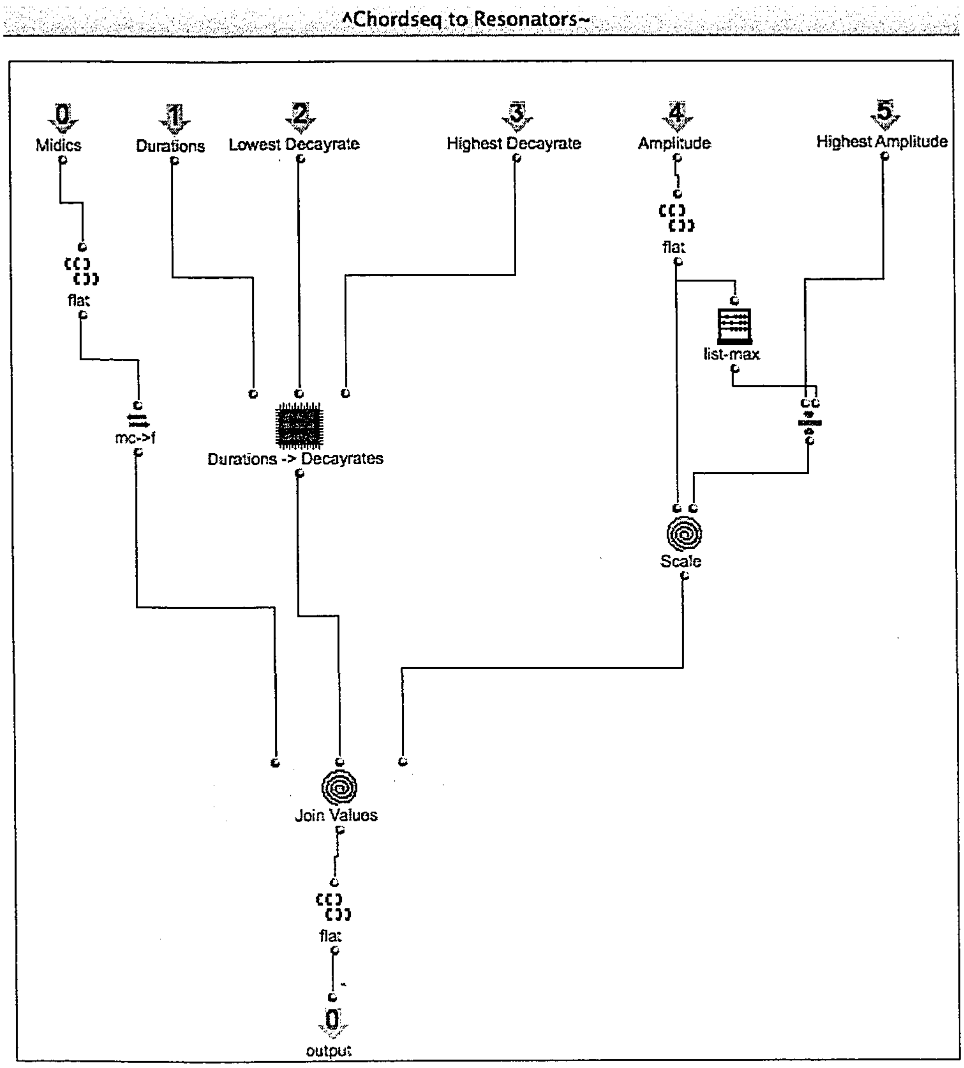
In Mm. 249-259 the bell *harmonies/timbres* sound alone in both the electronics and live instruments for the longest duration of any chord, harmony, or *harmony/timbre* in the entire composition. In the last measure, the cello and a bowed crotale complement the unified *harmony/timbre* with two instances of the tonic C six octaves apart. At the same time, the synthesizer player rings the actual pair of tangkas out of sight of the audience to unify the fading electronic and acoustic sounds.

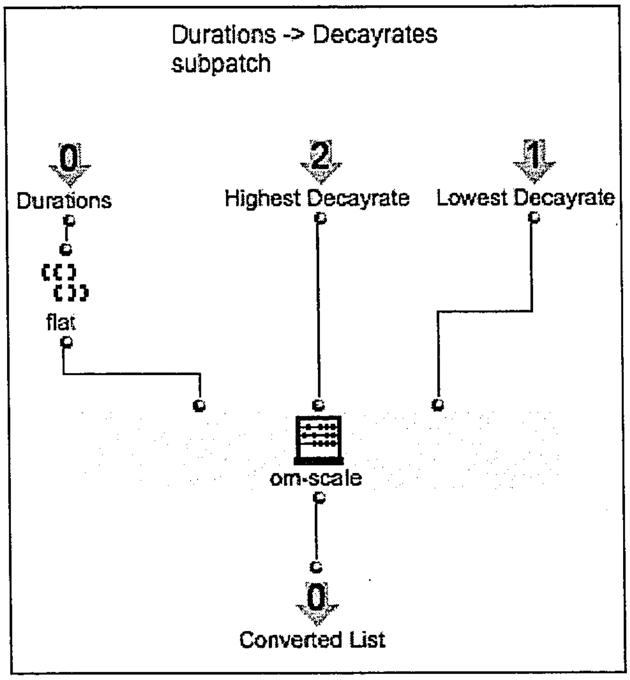
Conclusion

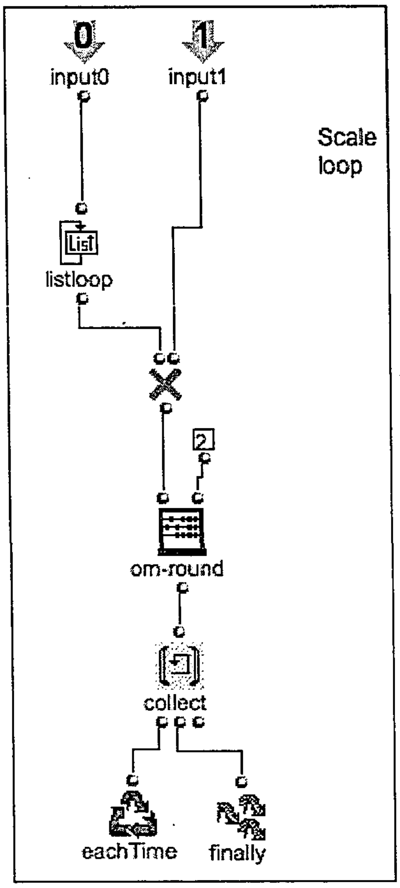
As I stated previously, the poetic focus for *Time Fixtures* is to develop and unfold some systematic and intuitively constructed perspective on fixing a conception of time. Categorical organization, structural and formal principles, phenomenological models, as well as the numerous tools I developed and describe in this essay helped me generate completed music as well as a large resevoir of materials to draw from intuitively. Furthermore, I found using such abstract compositional methods generated many successful ways to create a dramatic and organic relationship between the acoustic instruments and the electronic materials. In the future, I plan to continue to use, develop, and expand these methods and tools to help me better achieve and understand my personal esthetic goals.

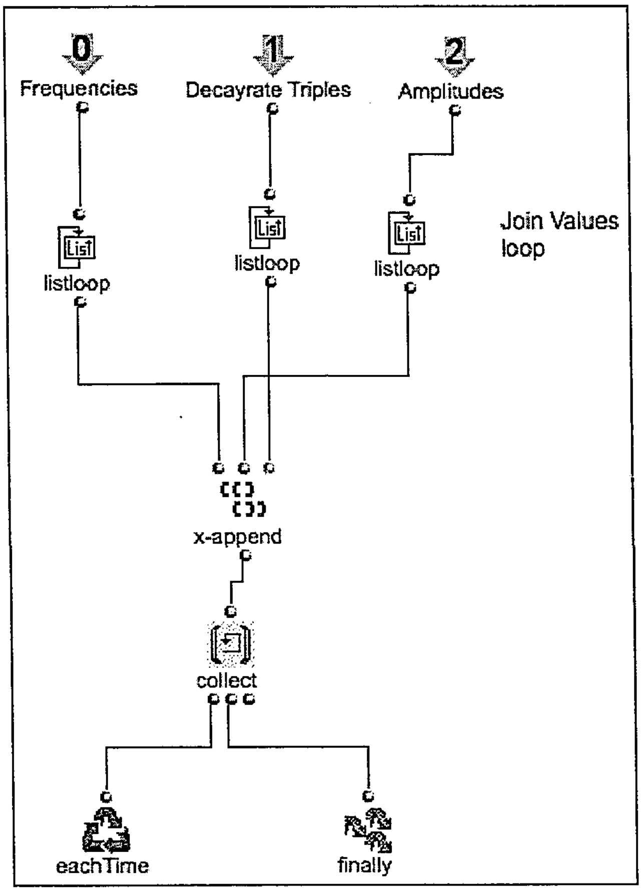
Appendix 3-1: OpenMusic patch used to convert spectral data into resonators~ list






Durations -> Decayrates
subpatch
0
Durations
flat
2
Highest Decayrate
1
Lowest Decayrate
om-scale
0
Converted List


0
input0
1
input1
Scale
loop
listloop
2
om-round
collect
eachTime
finally


0
Frequencies
1
Decayrate Triples
2
Amplitudes
Join Values
loop
listloop
listloop
listloop
x-append
collect
eachTime
finally

Appendix: 3-2: resonators~ lists for the two Tibetan singing bowls

Big bowl:

```
;
resonator_freq 1090.942749 1. 0.54
566.013672 0.87 0.54
2443.431641 0.68 0.54
3231.585449 0.67 0.54
2457.586426 0.51 0.851613
1723.779663 0.48 0.54
4166.71 0.3 0.54
197.81752 0.3 0.54
5678.757812 0.29 0.54
4066.841553 0.25 0.54
1132.027344 0.19 0.54
2156.824463 0.17 0.54
2816.510254 0.16 0.54
4886.863281 0.11 0.54
4926.54248 0.07 0.54
5292.351074 0. 1.
5705.06 0.14 0.614194
2797.055176 0.03 0.747742
3022.150391 0.01 0.777419
4955.081543 0.03 1.
3451.544434 0.01 0.688387
4171.526367 0.1 0.925806
1921.512085 0. 0.985161 9
61.866638 0. 0.985161
63.397751 0. 0.985161 3
0.302391 0. 0.955484
2457.586426 0.35 1.
2156.824463 0. 0.925806
5665.652344 0.02 0.925806
56.939571 0. 0.851613
1713.85144 0.1 1.
5504.362305 0. 0.925806
29.576096 0. 0.925806
4181.175781 0.1 0.955484
2797.055176 0.02 0.955484
5940.463379 0. 0.955484
2457.586426 0.21 0.985161
5587.651855 0. 0.985161
4373.865234 0. 0.985161
2652.296631 0. 0.985161
```

Small bowl:

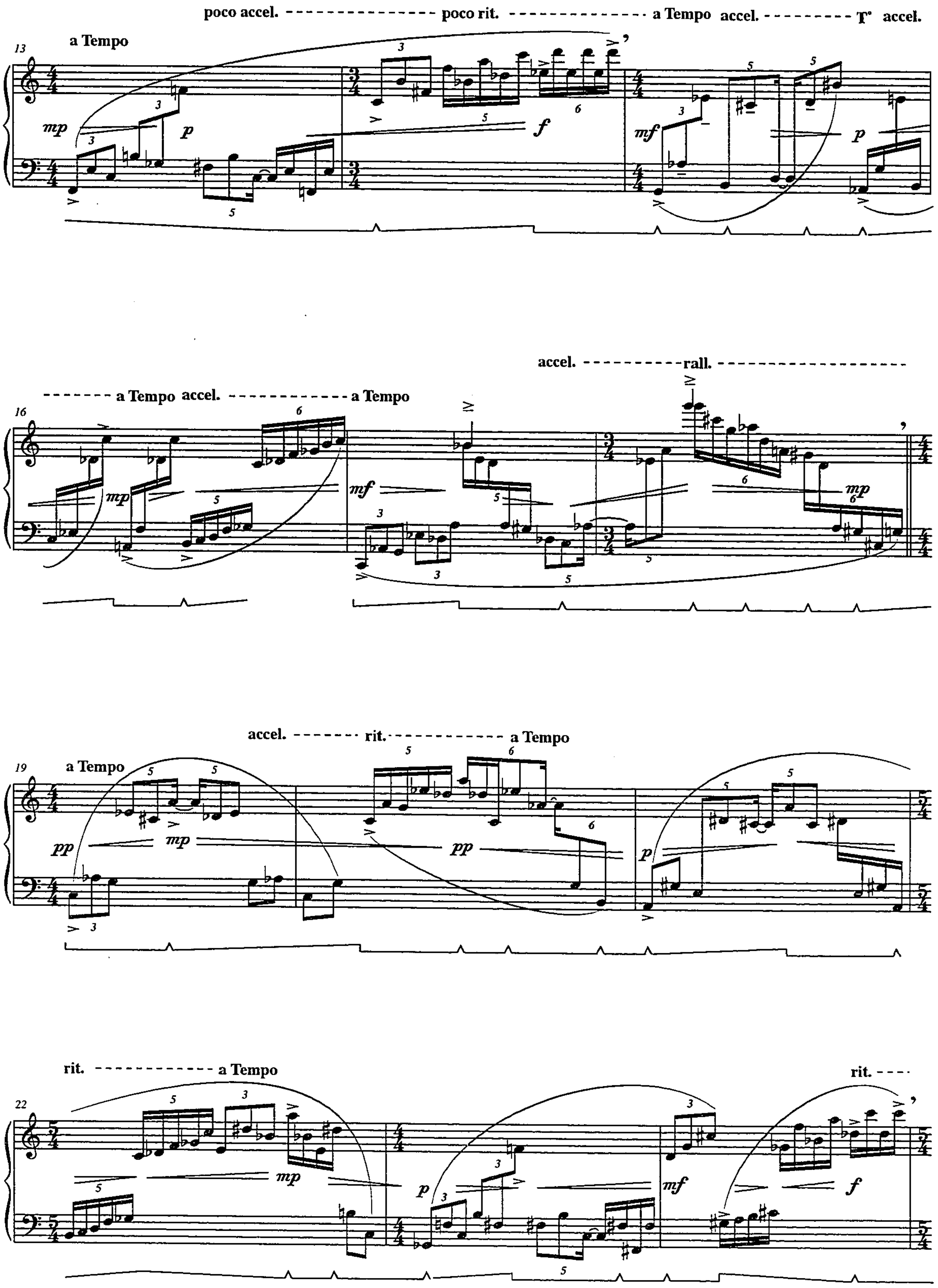
```
;
resonator_freq 5466.34082 1. 0.54
1860.351807 0.51 0.54
4133.150879 0.49 0.54
1015.536499 0.35 0.54
4062.145996 0.33 0.54
2919.204834 0.24 0.54
6935.062012 0.18 0.54
3720.703613 0.17 0.54
8266.301758 0.17 0.54
6951.104004 0.16 0.54
8587.523438 0.11 0.54
4780.76709 0.11 0.54
6016.43457 0.09 0.54
372.137787 0.08 0.54
2875.691162 0.07 0.54
4775.24707 0.07 0.605714
8275.857422 0.02 0.868571
8049.553711 0. 1.
3231.585449 0. 0.605714
735.726807 0. 0.605714
8362.351562 0.03 1.
3923.774414 0.01 0.934286
6388.935059 0. 0.802857
5460.029785 0.08 0.737143
356.154572 0.02 0.868571
1092.203857 0.01 0.802857
5153.581543 0. 0.737143
1843.237671 0. 1.
8687.305664 0.01 0.802857
6951.104004 0.01 0.934286
2026.38562 0.02 0.868571
5995.619141 0.02 1.
8617.336914 0.01 0.868571
3284.276123 0. 0.868571
7536.57373 0.01 0.934286
9561.53418 0. 1.
9386.422852 0. 1.
```

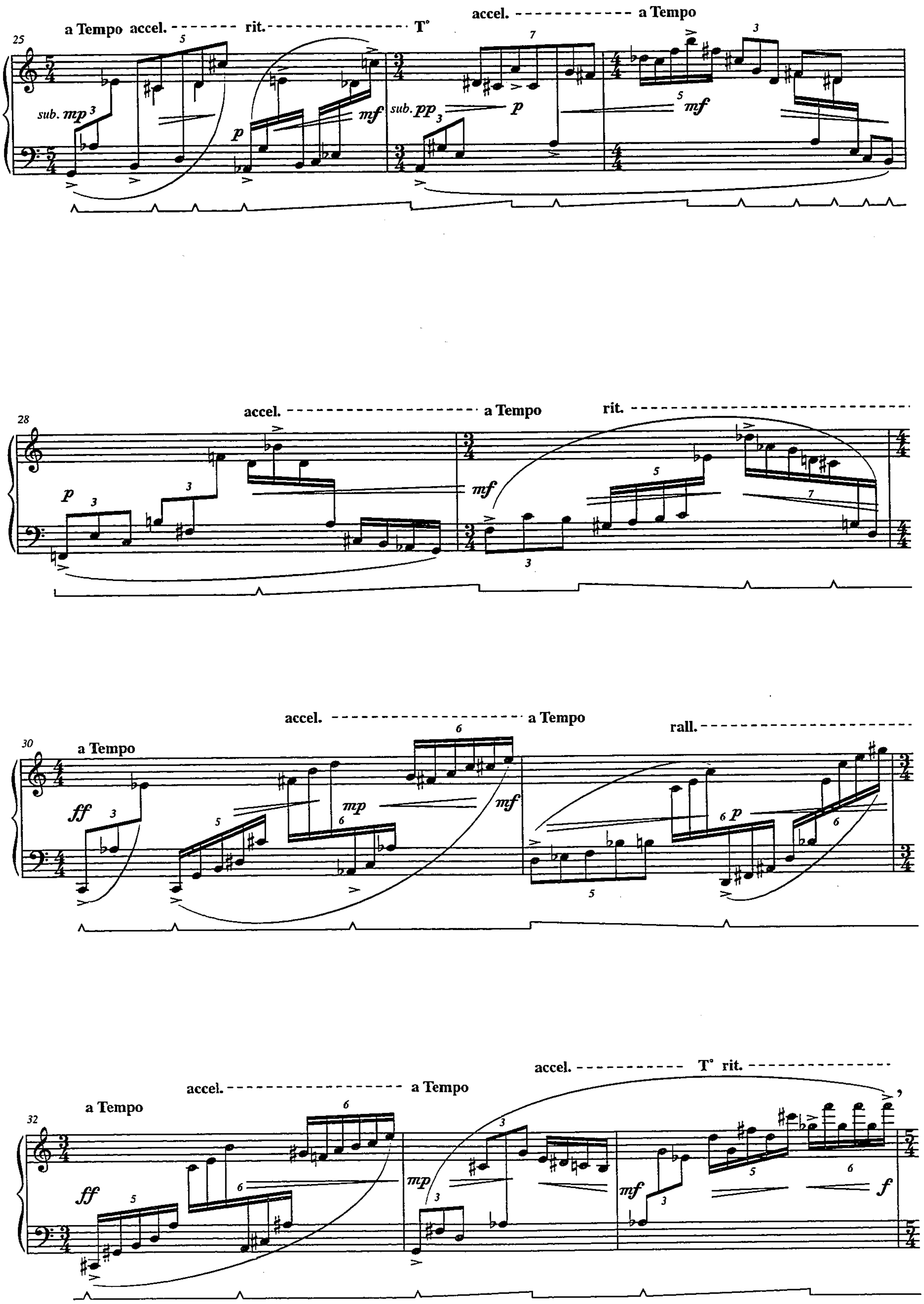
Appendix 3-3: Prelude #1 *Stream* (2005)

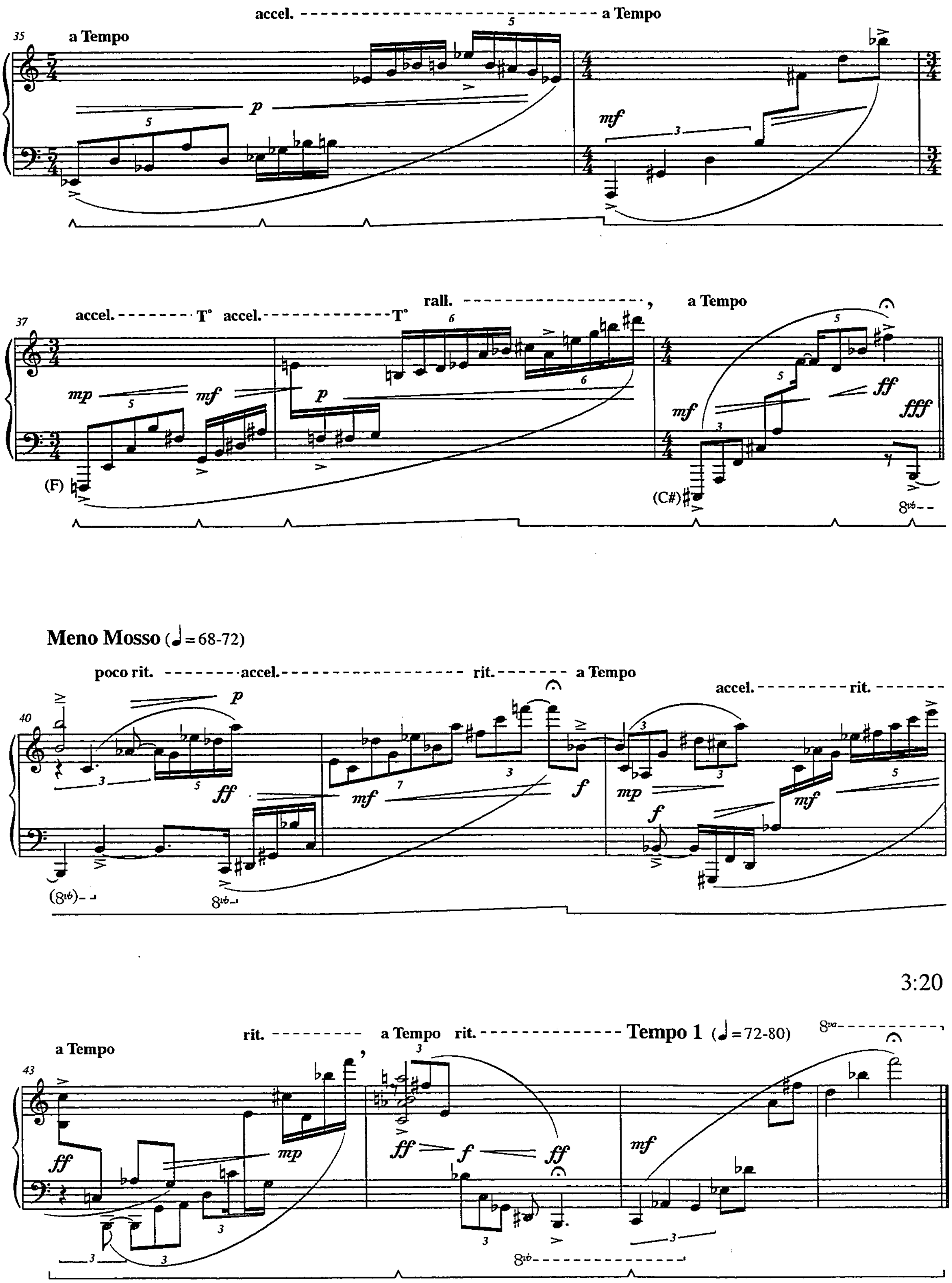
I. Stream

Jacob David Sudol

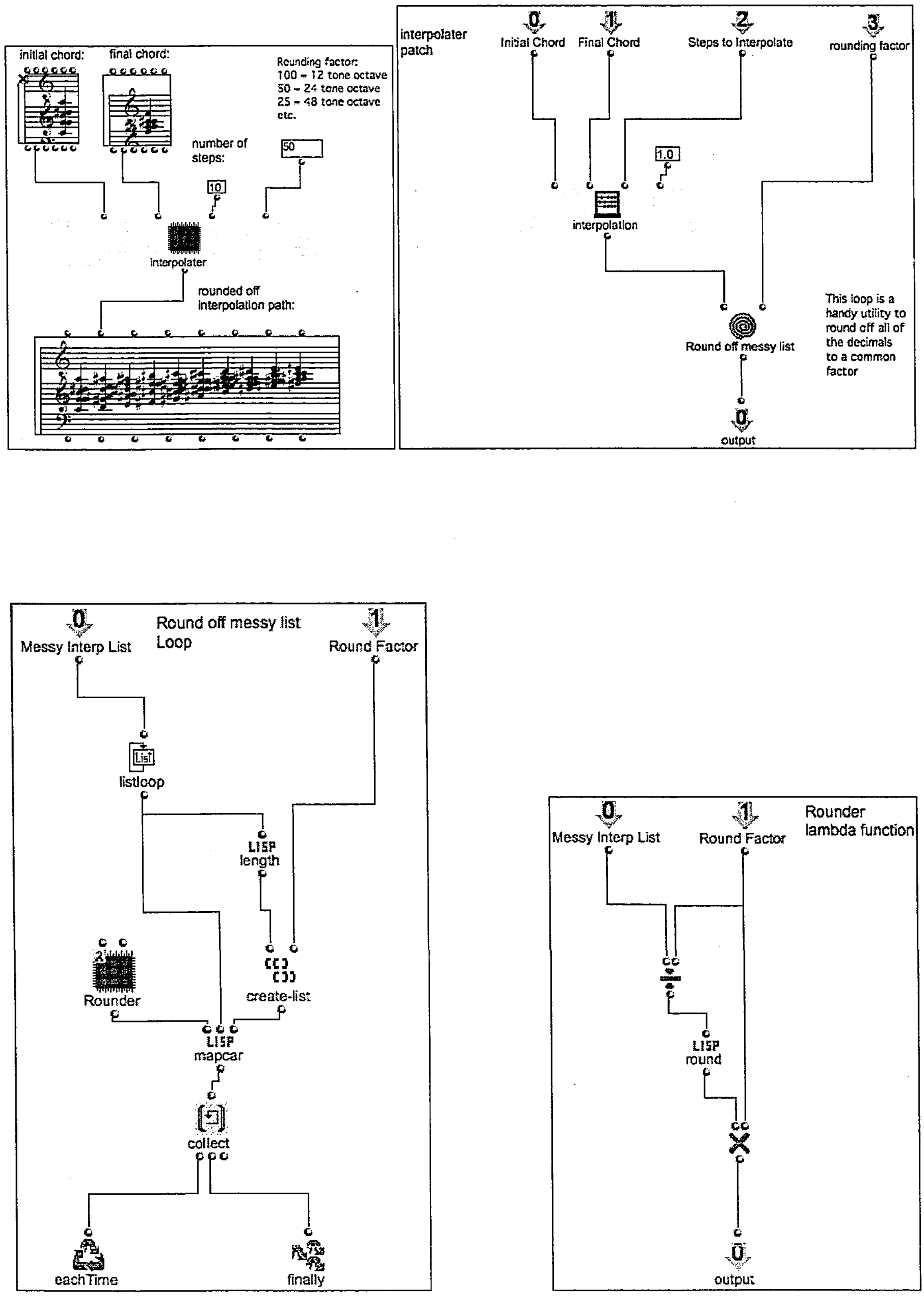
* All tempo indications are meant to fluctuate around the main tempo as in rubato or jazz.


poco accel.
poco rit.
a Tempo
accel.
T°
accel.
a Tempo
a Tempo
accel.
a Tempo
accel.
rall.
accel.
rit.
a Tempo
a Tempo
rit.
a Tempo
rit.

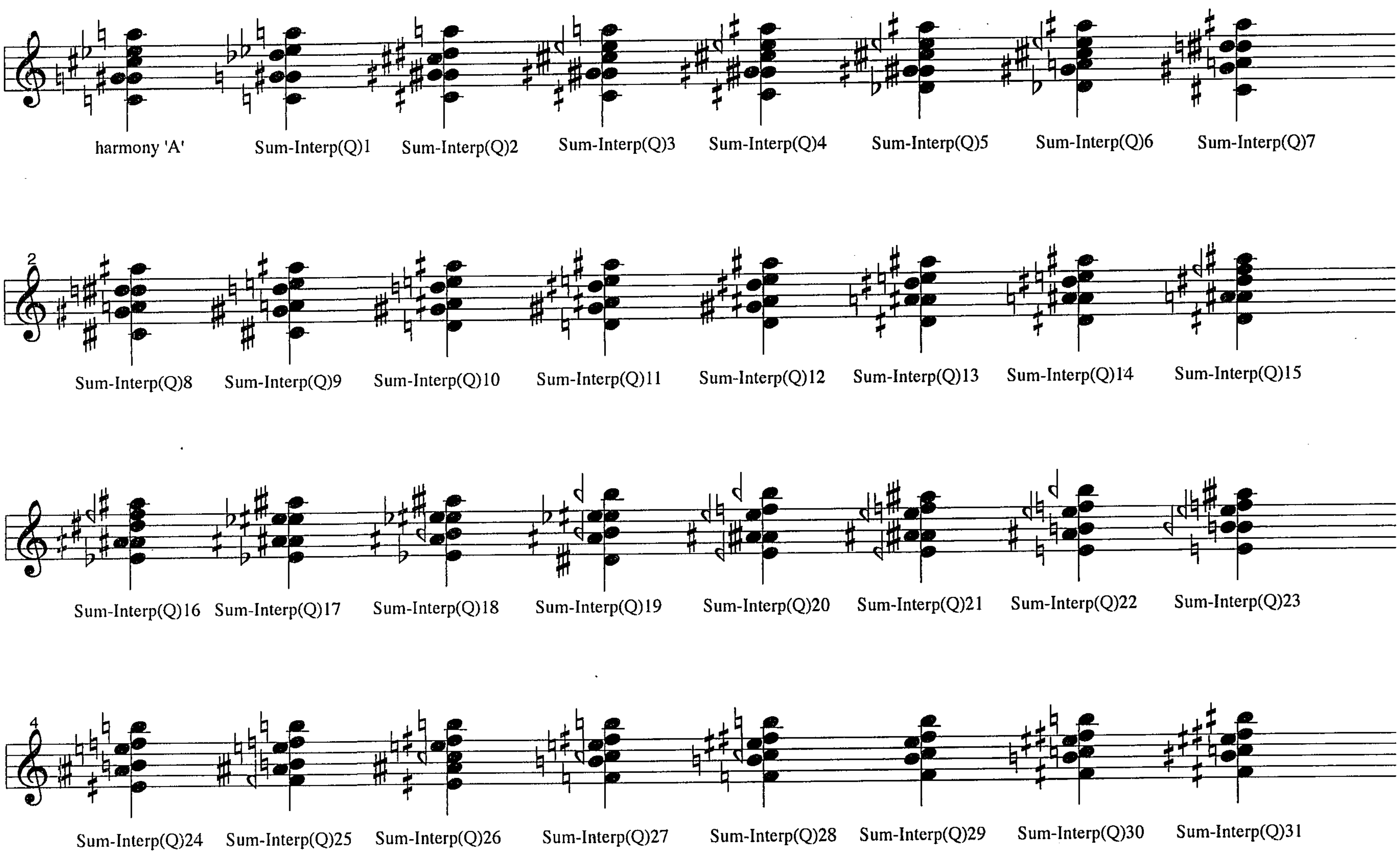

25
a Tempo accel. rit. T°
sub. mp
p
mf
accel. a Tempo
sub. pp
p
mf
28
accel. a Tempo
rit.
p
mf
30
a Tempo
accel. a Tempo
rall.
ff
mp
mf
p
32
a Tempo
accel. a Tempo
accel. T° rit.
ff
mp
mf
f


accel. a Tempo
35 a Tempo
p
mf
37 accel. T° accel. T°
rall. a Tempo
mp mf p
mf ff fff
(F) (C#) 8vb
Meno Mosso (♩=68-72)
poco rit. accel. rit. a Tempo
accel. rit.
40 p
ff mf f
mp f mf
(8vb) 8vb
3:20
rit. a Tempo rit. Tempo 1 (♩=72-80) 8va
43 a Tempo
ff mp
ff f ff
mf
8vb

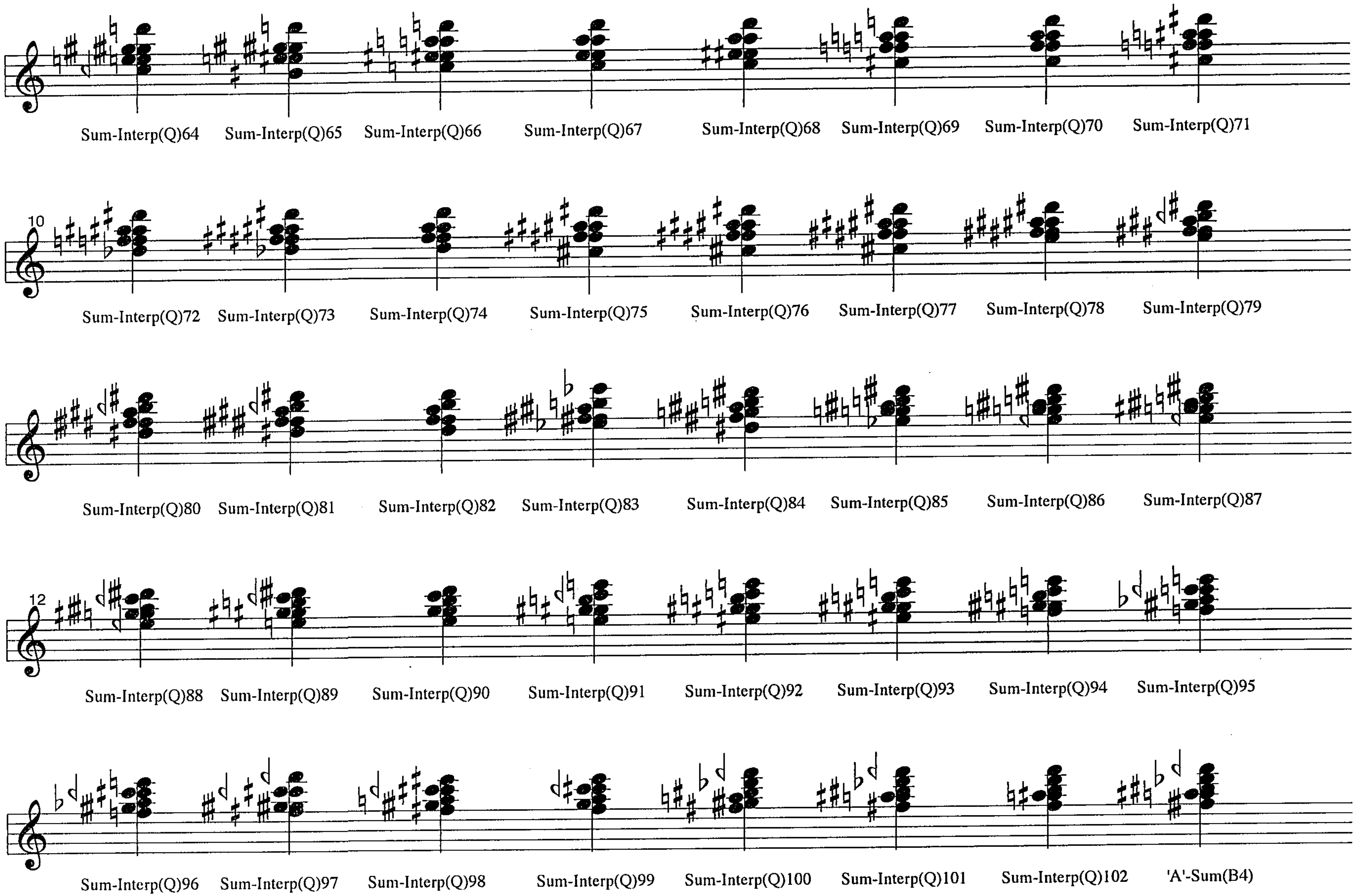
Appendix 4-1: OpenMusic patch that interpolates between two chords and quantifies the results



Appendix 4-2: Harmony 'A,' Sum-Interp(Q)1-102, and harmony 'A'-Sum(B4)



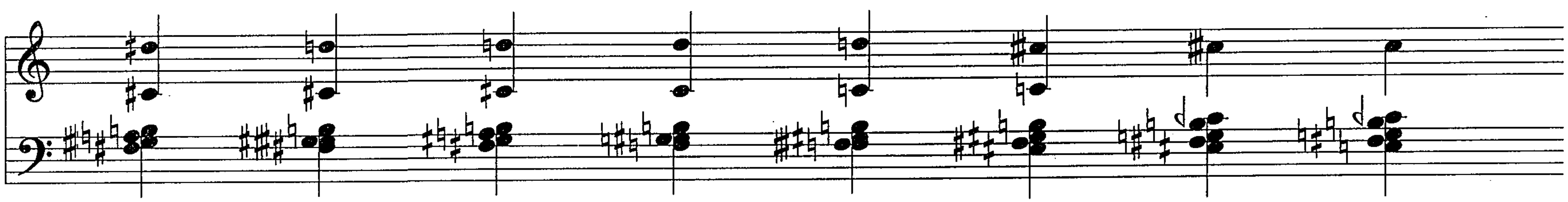

Sum-Interp(Q)32
Sum-Interp(Q)33
Sum-Interp(Q)34
Sum-Interp(Q)35
Sum-Interp(Q)36
Sum-Interp(Q)37
Sum-Interp(Q)38
Sum-Interp(Q)39
6
Sum-Interp(Q)40
Sum-Interp(Q)41
Sum-Interp(Q)42
Sum-Interp(Q)43
Sum-Interp(Q)44
Sum-Interp(Q)45
Sum-Interp(Q)46
Sum-Interp(Q)47
Sum-Interp(Q)48
Sum-Interp(Q)49
Sum-Interp(Q)50
Sum-Interp(Q)51
Sum-Interp(Q)52
Sum-Interp(Q)53
Sum-Interp(Q)54
Sum-Interp(Q)55
8
Sum-Interp(Q)56
Sum-Interp(Q)57
Sum-Interp(Q)58
Sum-Interp(Q)59
Sum-Interp(Q)60
Sum-Interp(Q)61
Sum-Interp(Q)62
Sum-Interp(Q)63


Sum-Interp(Q)64
Sum-Interp(Q)65
Sum-Interp(Q)66
Sum-Interp(Q)67
Sum-Interp(Q)68
Sum-Interp(Q)69
Sum-Interp(Q)70
Sum-Interp(Q)71
10
Sum-Interp(Q)72
Sum-Interp(Q)73
Sum-Interp(Q)74
Sum-Interp(Q)75
Sum-Interp(Q)76
Sum-Interp(Q)77
Sum-Interp(Q)78
Sum-Interp(Q)79
Sum-Interp(Q)80
Sum-Interp(Q)81
Sum-Interp(Q)82
Sum-Interp(Q)83
Sum-Interp(Q)84
Sum-Interp(Q)85
Sum-Interp(Q)86
Sum-Interp(Q)87
12
Sum-Interp(Q)88
Sum-Interp(Q)89
Sum-Interp(Q)90
Sum-Interp(Q)91
Sum-Interp(Q)92
Sum-Interp(Q)93
Sum-Interp(Q)94
Sum-Interp(Q)95
Sum-Interp(Q)96
Sum-Interp(Q)97
Sum-Interp(Q)98
Sum-Interp(Q)99
Sum-Interp(Q)100
Sum-Interp(Q)101
Sum-Interp(Q)102
'A'-Sum(B4)

Appendix 4-3: Harmony 'A,' Diff-Interp(Q)1-102, and harmony 'A'-Diff(B4)

Diff-Interp(Q)32 Diff-Interp(Q)33 Diff-Interp(Q)34 Diff-Interp(Q)35 Diff-Interp(Q)36 Diff-Interp(Q)37 Diff-Interp(Q)38 Diff-Interp(Q)39

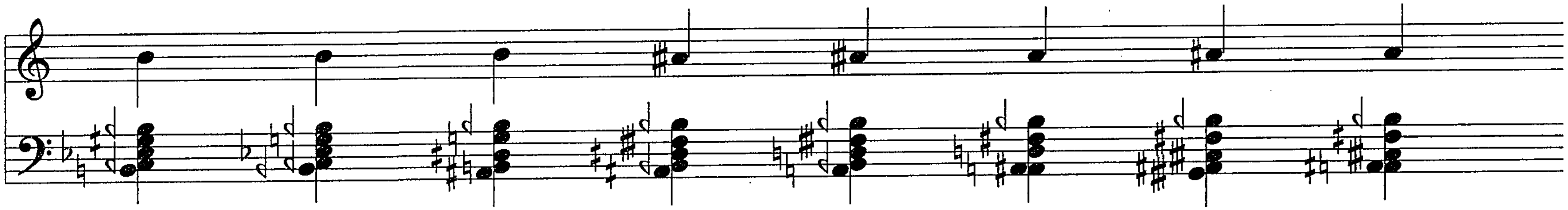
Diff-Interp(Q)40 Diff-Interp(Q)41 Diff-Interp(Q)42 Diff-Interp(Q)43 Diff-Interp(Q)44 Diff-Interp(Q)45 Diff-Interp(Q)46 Diff-Interp(Q)47



Diff-Interp(Q)48 Diff-Interp(Q)49 Diff-Interp(Q)50 Diff-Interp(Q)51 Diff-Interp(Q)52 Diff-Interp(Q)53 Diff-Interp(Q)54 Diff-Interp(Q)55

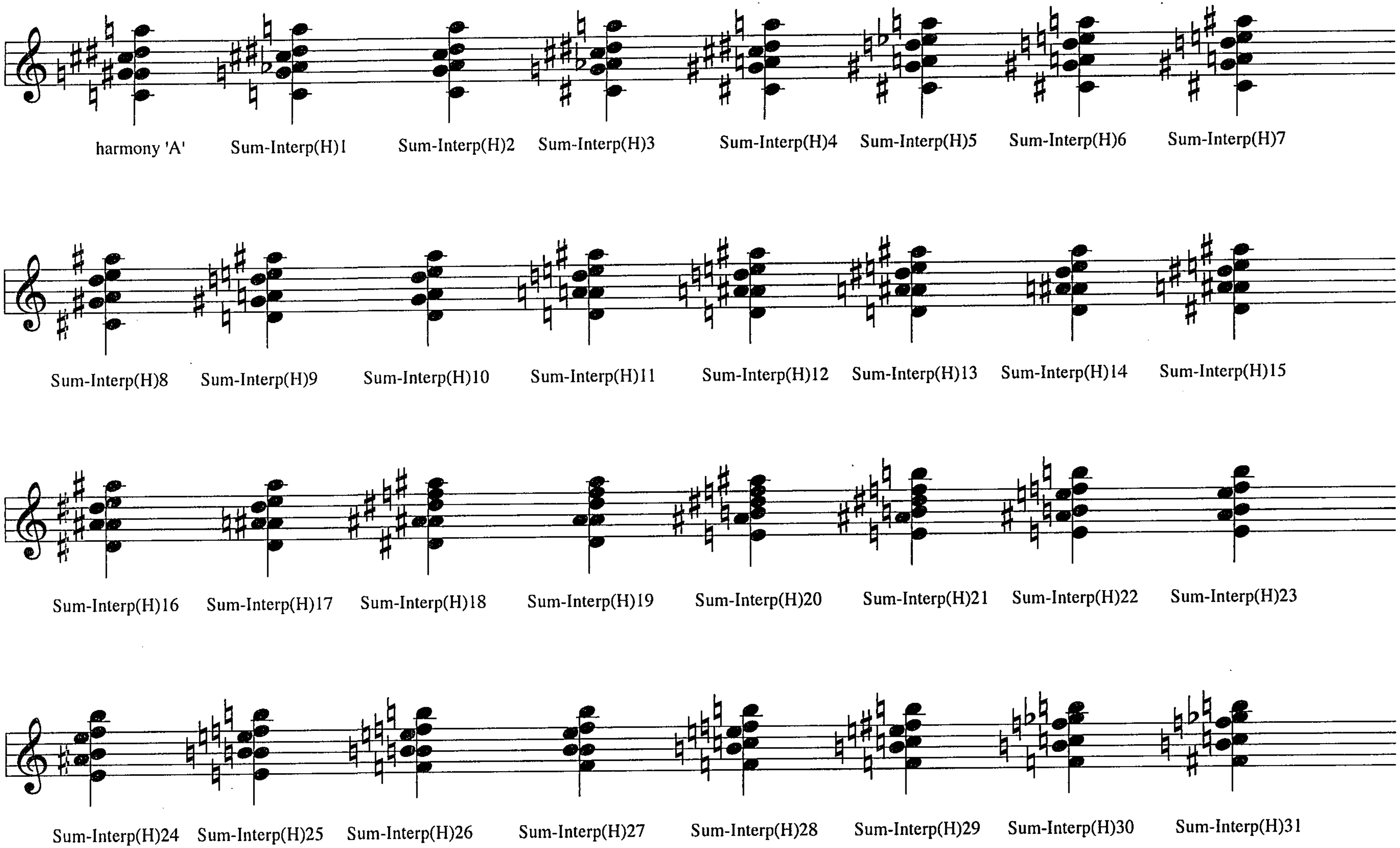

Diff-Interp(Q)56
Diff-Interp(Q)57
Diff-Interp(Q)58
Diff-Interp(Q)59
Diff-Interp(Q)60
Diff-Interp(Q)61
Diff-Interp(Q)62
Diff-Interp(Q)63


Diff-Interp(Q)64
Diff-Interp(Q)65
Diff-Interp(Q)66
Diff-Interp(Q)67
Diff-Interp(Q)68
Diff-Interp(Q)69
Diff-Interp(Q)70
Diff-Interp(Q)71


Diff-Interp(Q)72
Diff-Interp(Q)73
Diff-Interp(Q)74
Diff-Interp(Q)75
Diff-Interp(Q)76
Diff-Interp(Q)77
Diff-Interp(Q)78
Diff-Interp(Q)79


Diff-Interp(Q)80
Diff-Interp(Q)81
Diff-Interp(Q)82
Diff-Interp(Q)83
Diff-Interp(Q)84
Diff-Interp(Q)85
Diff-Interp(Q)86
Diff-Interp(Q)87
Diff-Interp(Q)88
Diff-Interp(Q)89
Diff-Interp(Q)90
Diff-Interp(Q)91
Diff-Interp(Q)92
Diff-Interp(Q)93
Diff-Interp(Q)94
Diff-Interp(Q)95
Diff-Interp(Q)96
Diff-Interp(Q)97
Diff-Interp(Q)98
Diff-Interp(Q)99
Diff-Interp(Q)100
Diff-Interp(Q)101
Diff-Interp(Q)102
'A'-Diff(B4)

Appendix 4-4: Harmony 'A,' Sum-Interp(H)1-102, and harmony 'A'-Sum(B4)

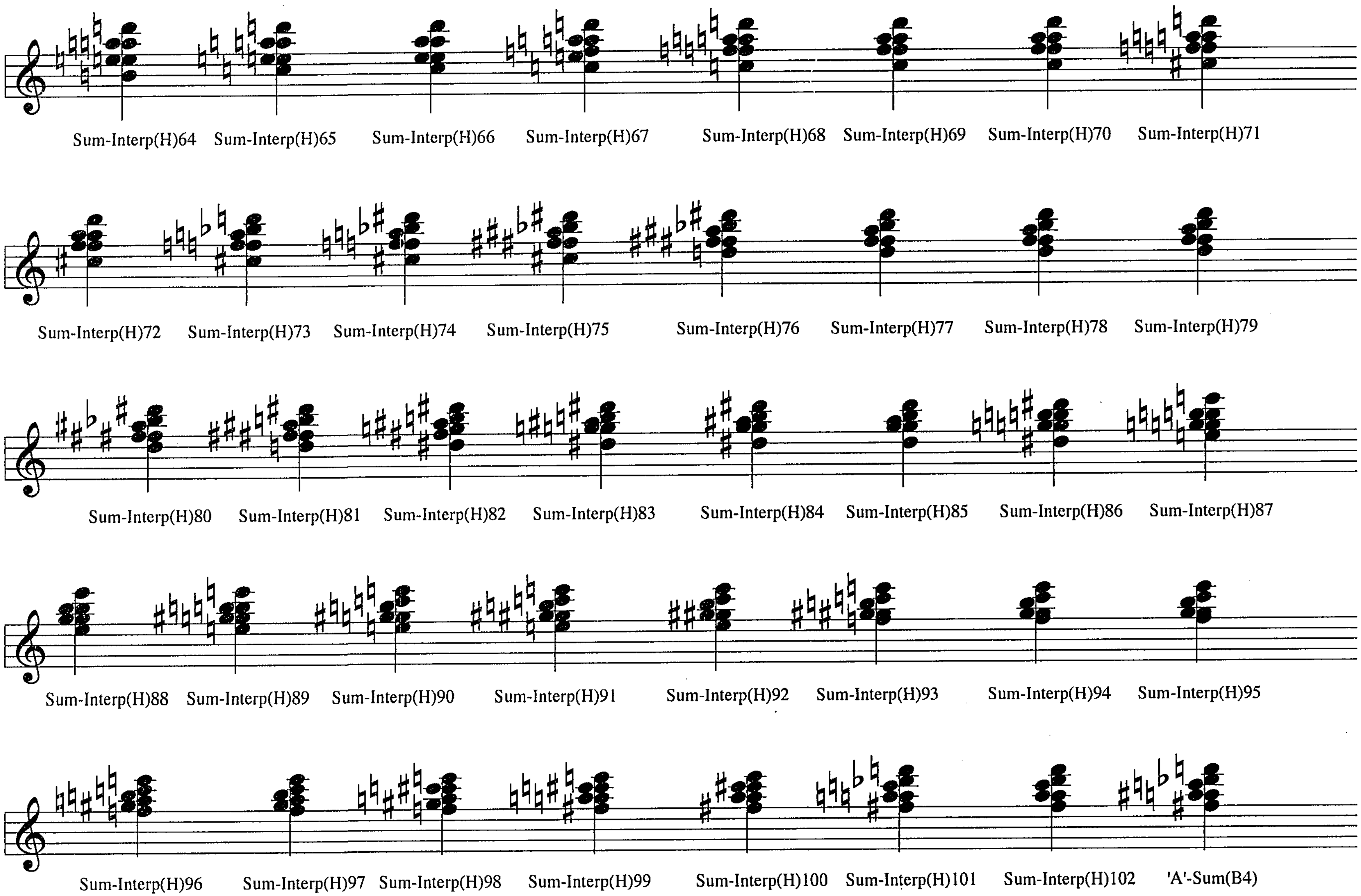


Sum-Interp(H)32 Sum-Interp(H)33 Sum-Interp(H)34 Sum-Interp(H)35 Sum-Interp(H)36 Sum-Interp(H)37 Sum-Interp(H)38 Sum-Interp(H)39

Sum-Interp(H)40 Sum-Interp(H)41 Sum-Interp(H)42 Sum-Interp(H)43 Sum-Interp(H)44 Sum-Interp(H)45 Sum-Interp(H)46 Sum-Interp(H)47

Sum-Interp(H)48 Sum-Interp(H)49 Sum-Interp(H)50 Sum-Interp(H)51 Sum-Interp(H)52 Sum-Interp(H)53 Sum-Interp(H)54 Sum-Interp(H)55

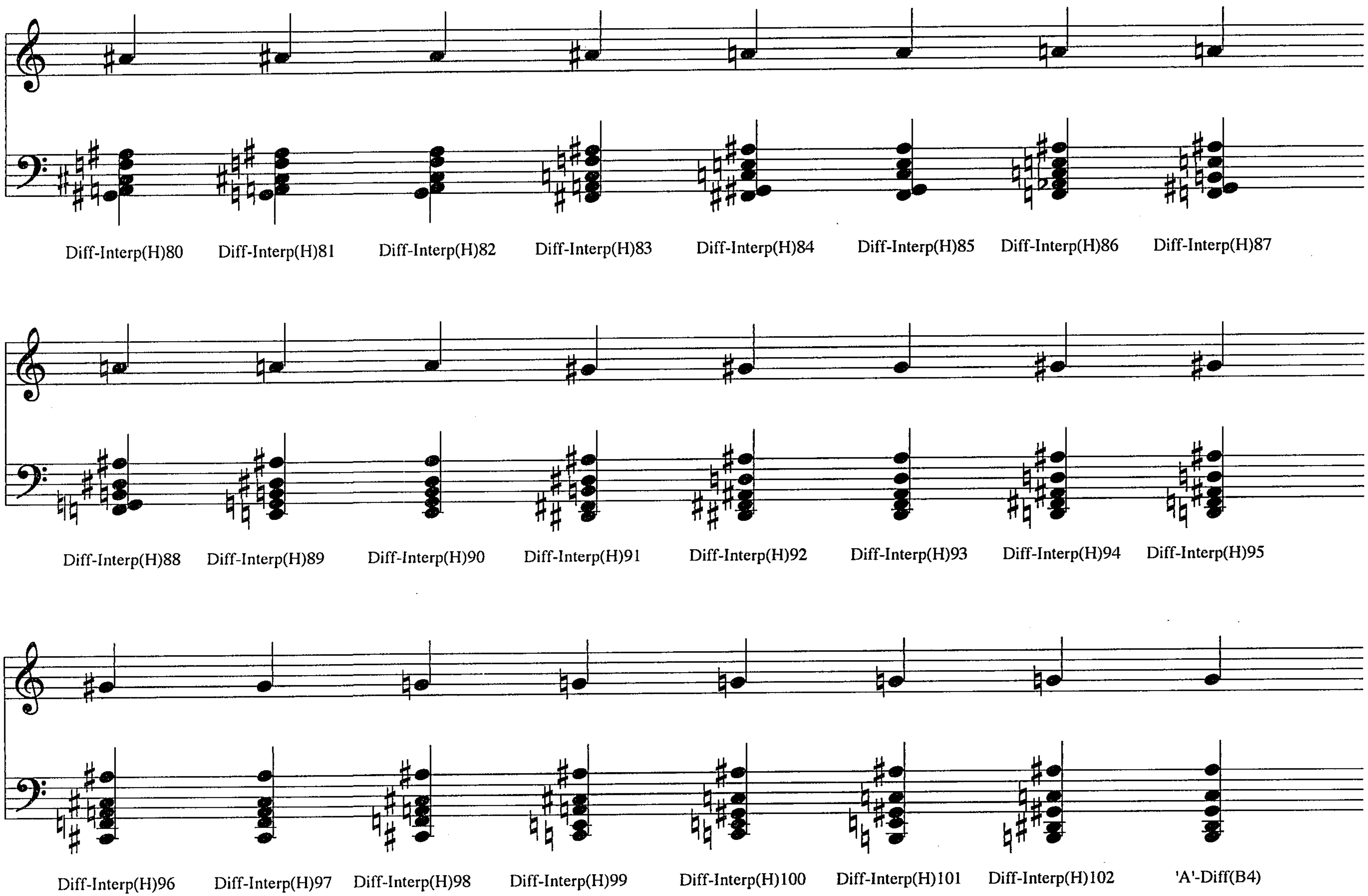
Sum-Interp(H)56 Sum-Interp(H)57 Sum-Interp(H)58 Sum-Interp(H)59 Sum-Interp(H)60 Sum-Interp(H)61 Sum-Interp(H)62 Sum-Interp(H)63

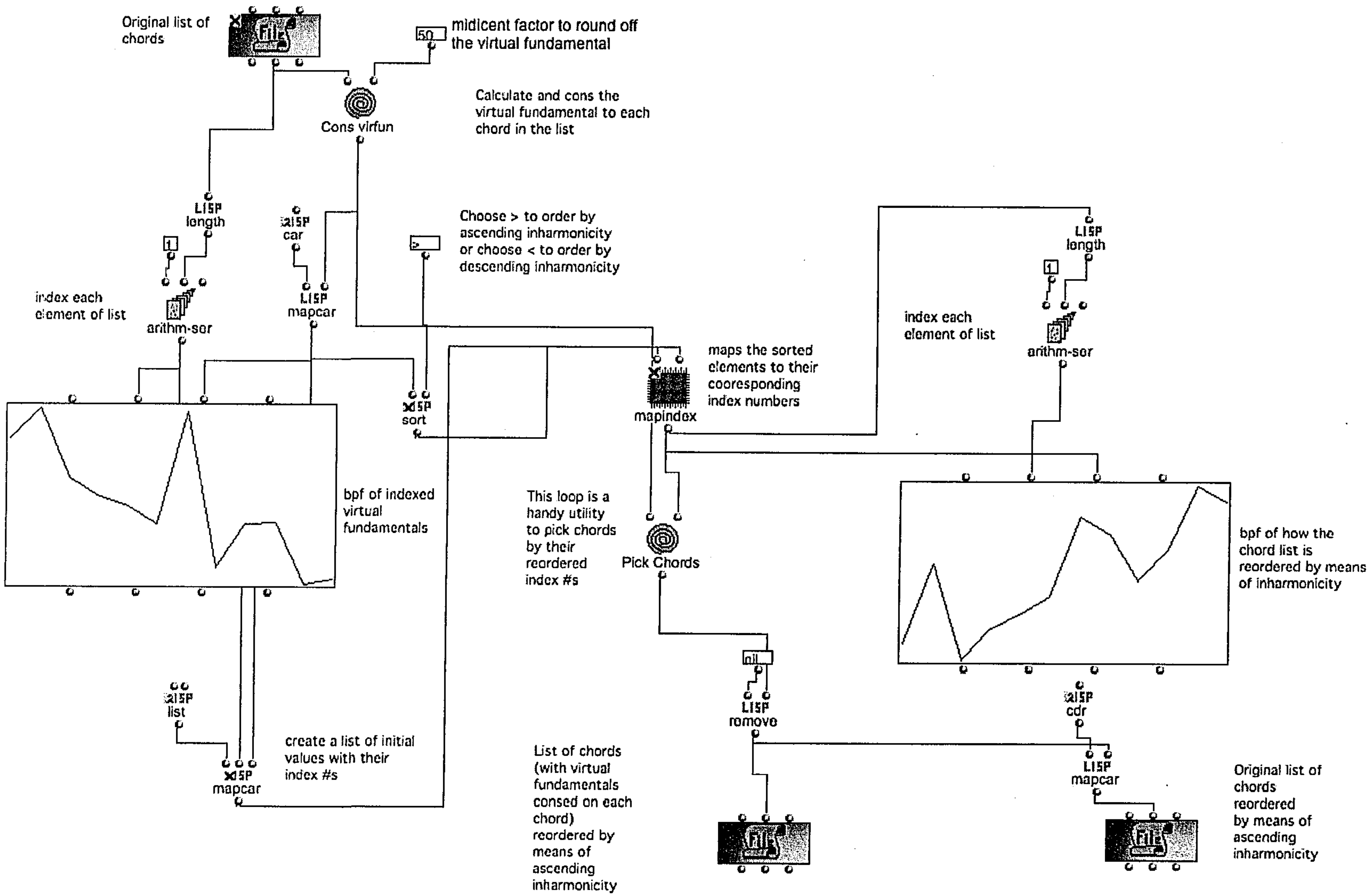

Sum-Interp(H)64 Sum-Interp(H)65 Sum-Interp(H)66 Sum-Interp(H)67 Sum-Interp(H)68 Sum-Interp(H)69 Sum-Interp(H)70 Sum-Interp(H)71
Sum-Interp(H)72 Sum-Interp(H)73 Sum-Interp(H)74 Sum-Interp(H)75 Sum-Interp(H)76 Sum-Interp(H)77 Sum-Interp(H)78 Sum-Interp(H)79
Sum-Interp(H)80 Sum-Interp(H)81 Sum-Interp(H)82 Sum-Interp(H)83 Sum-Interp(H)84 Sum-Interp(H)85 Sum-Interp(H)86 Sum-Interp(H)87
Sum-Interp(H)88 Sum-Interp(H)89 Sum-Interp(H)90 Sum-Interp(H)91 Sum-Interp(H)92 Sum-Interp(H)93 Sum-Interp(H)94 Sum-Interp(H)95
Sum-Interp(H)96 Sum-Interp(H)97 Sum-Interp(H)98 Sum-Interp(H)99 Sum-Interp(H)100 Sum-Interp(H)101 Sum-Interp(H)102 'A'-Sum(B4)

Appendix 4-5: Harmony 'A,' Diff-Interp(H)1-102, and harmony 'A'-Diff(B4)

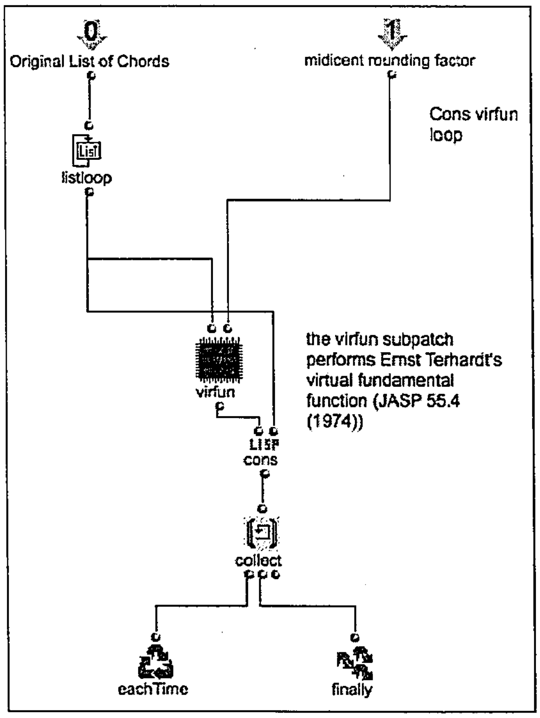

Diff-Interp(H)32
Diff-Interp(H)33
Diff-Interp(H)34
Diff-Interp(H)35
Diff-Interp(H)36
Diff-Interp(H)37
Diff-Interp(H)38
Diff-Interp(H)39
Diff-Interp(H)40
Diff-Interp(H)41
Diff-Interp(H)42
Diff-Interp(H)43
Diff-Interp(H)44
Diff-Interp(H)45
Diff-Interp(H)46
Diff-Interp(H)47
Diff-Interp(H)48
Diff-Interp(H)49
Diff-Interp(H)50
Diff-Interp(H)51
Diff-Interp(H)52
Diff-Interp(H)53
Diff-Interp(H)54
Diff-Interp(H)55

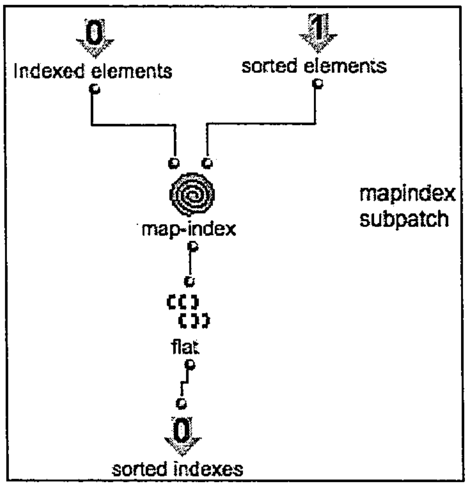

Diff-Interp(H)56
Diff-Interp(H)57
Diff-Interp(H)58
Diff-Interp(H)59
Diff-Interp(H)60
Diff-Interp(H)61
Diff-Interp(H)62
Diff-Interp(H)63
Diff-Interp(H)64
Diff-Interp(H)65
Diff-Interp(H)66
Diff-Interp(H)67
Diff-Interp(H)68
Diff-Interp(H)69
Diff-Interp(H)70
Diff-Interp(H)71
Diff-Interp(H)72
Diff-Interp(H)73
Diff-Interp(H)74
Diff-Interp(H)75
Diff-Interp(H)76
Diff-Interp(H)77
Diff-Interp(H)78
Diff-Interp(H)79

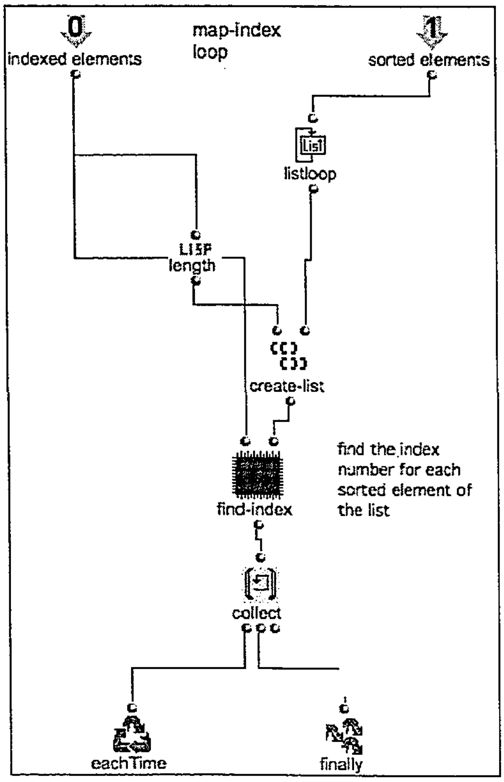

Diff-Interp(H)80
Diff-Interp(H)81
Diff-Interp(H)82
Diff-Interp(H)83
Diff-Interp(H)84
Diff-Interp(H)85
Diff-Interp(H)86
Diff-Interp(H)87
Diff-Interp(H)88
Diff-Interp(H)89
Diff-Interp(H)90
Diff-Interp(H)91
Diff-Interp(H)92
Diff-Interp(H)93
Diff-Interp(H)94
Diff-Interp(H)95
Diff-Interp(H)96
Diff-Interp(H)97
Diff-Interp(H)98
Diff-Interp(H)99
Diff-Interp(H)100
Diff-Interp(H)101
Diff-Interp(H)102
'A'-Diff(B4)

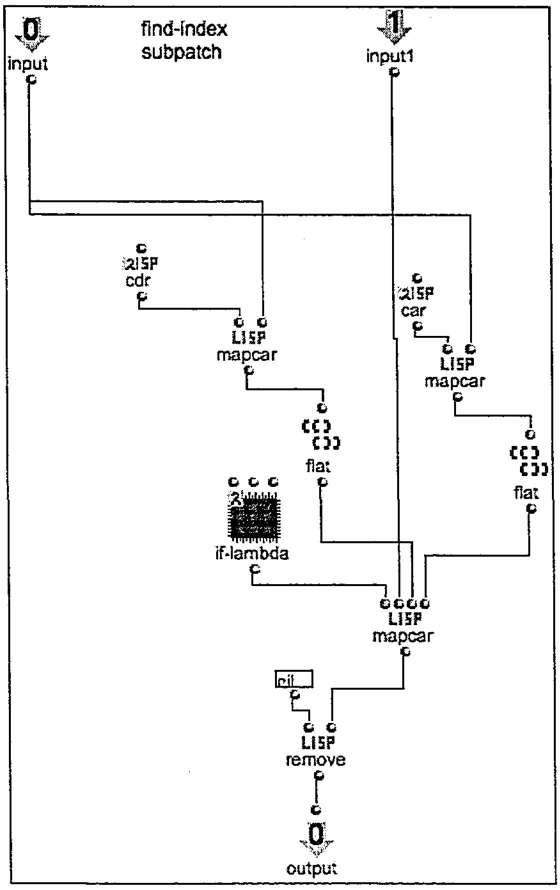


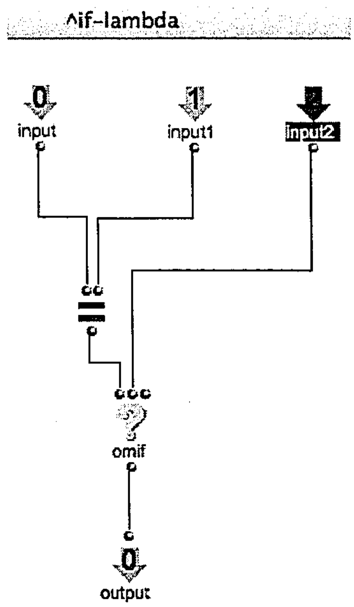
Appendix 4-6: OpenMusic patch that sorts a list of chords by harmonicity

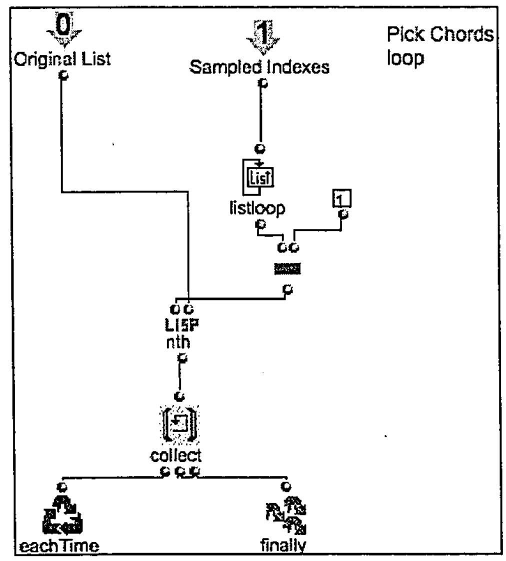

Original List of Chords
midicent rounding factor
Cons virfun loop
listloop
the virfun subpatch performs Ernst Terhardt's virtual fundamental function (JASP 55.4 (1974))
virfun
LISP cons
collect
eachTime
finally


Indexed elements
sorted elements
map-index
mapindex subpatch
flat
sorted indexes

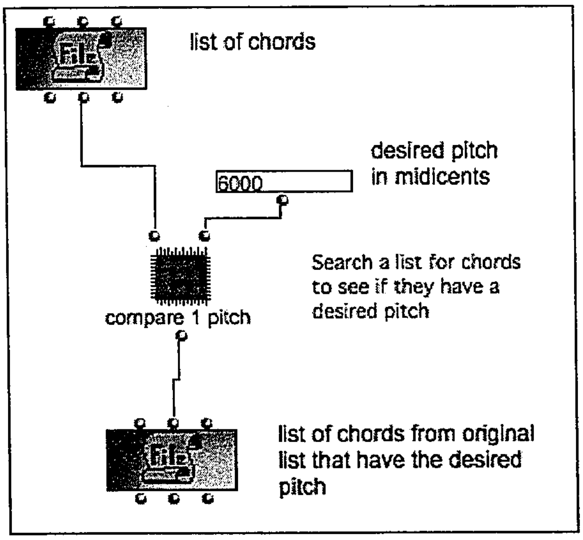

indexed elements
map-index loop
sorted elements
listloop
LISP length
create-list
find-index
find the index number for each sorted element of the list
collect
eachTime
finally

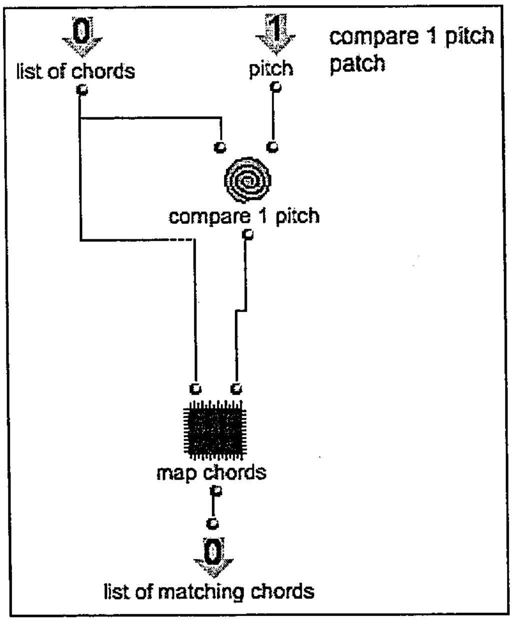

input
find-index subpatch
input1
LISP cdr
LISP car
LISP mapcar
LISP mapcar
flat
flat
if-lambda
LISP mapcar
nil
LISP remove
output

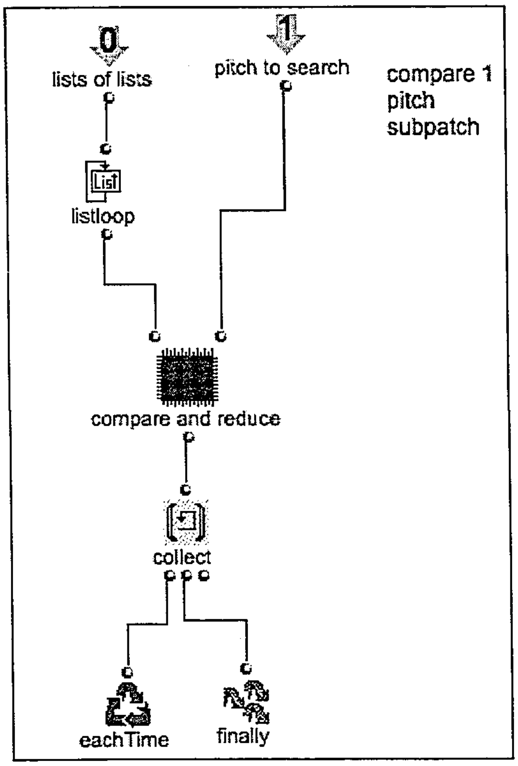

^if-lambda
0
input
1
input1
input2
omif
0
output

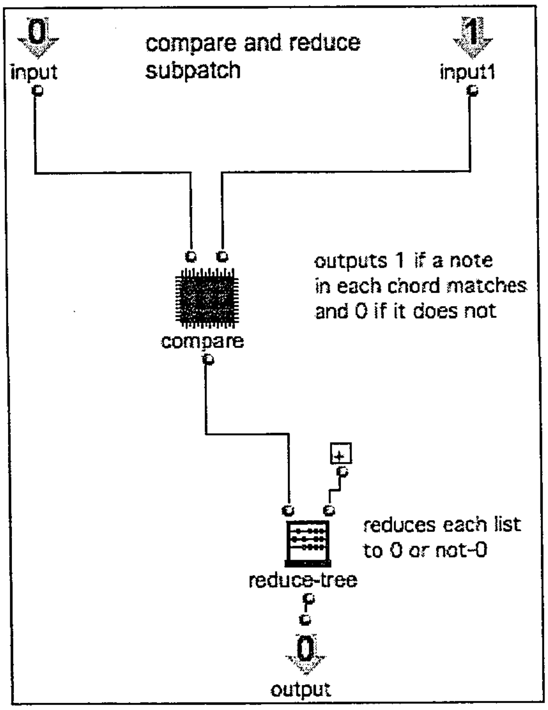

0
Original List
1
Sampled Indexes
Pick Chords
loop
List
listloop
1
LISP
nth
collect
eachTime
finally

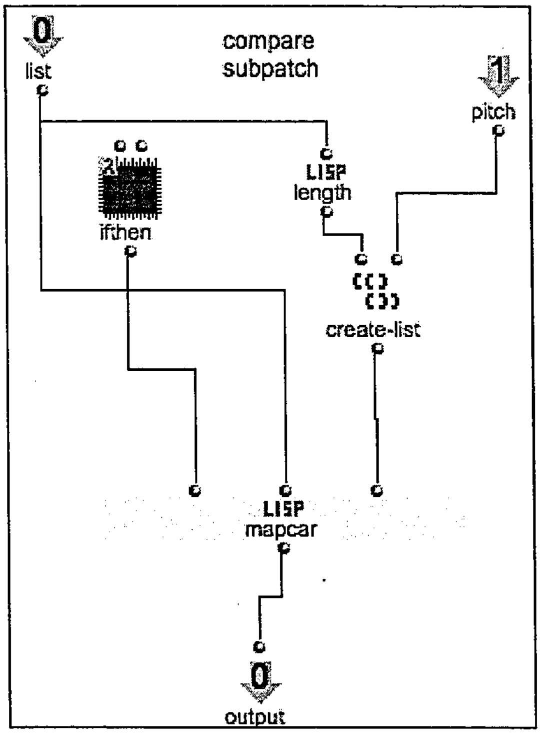
Appendix 4-7: OpenMusic patch that only returns chord with a desired pitch

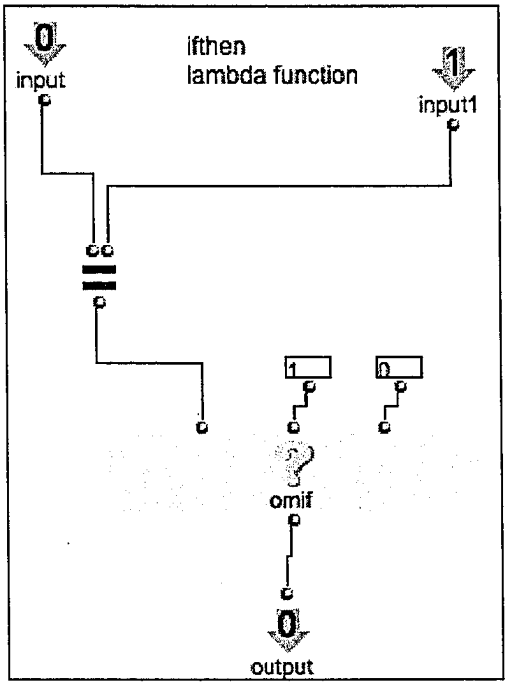


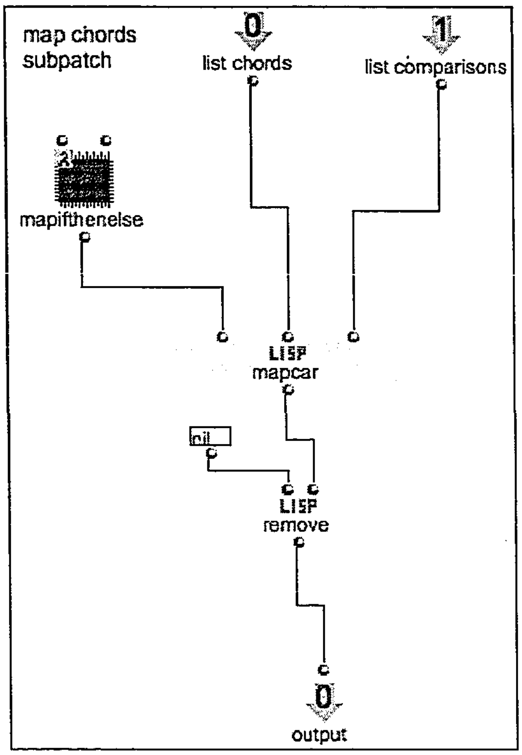


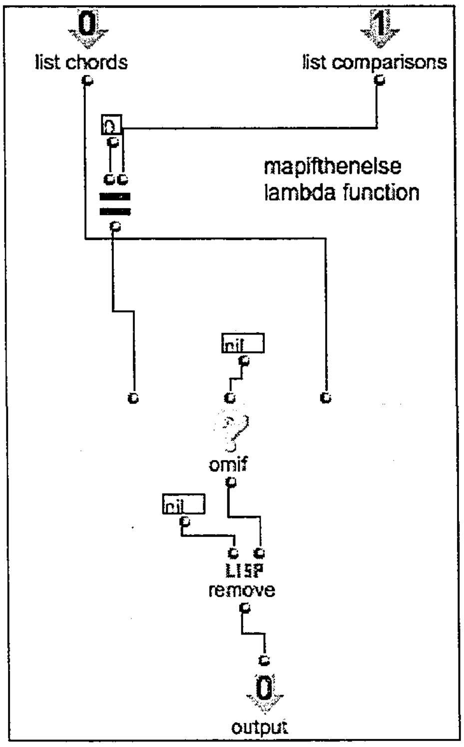




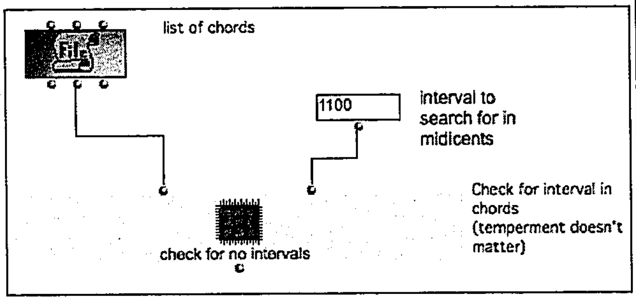

compare
subpatch
0
list
1
pitch
LISP
length
ifthen
create-list
LISP
mapcar
0
output

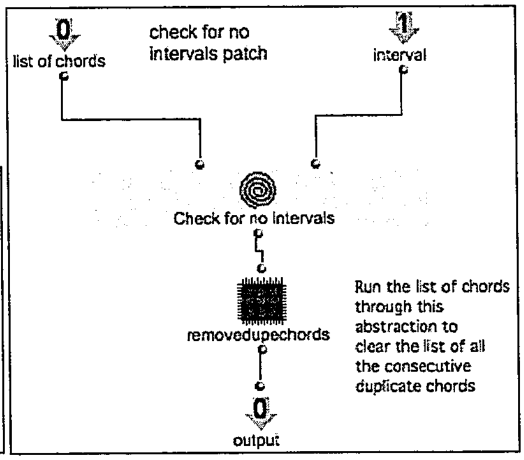

ifthen
lambda function
0
input
1
input1
1
0
omif
0
output

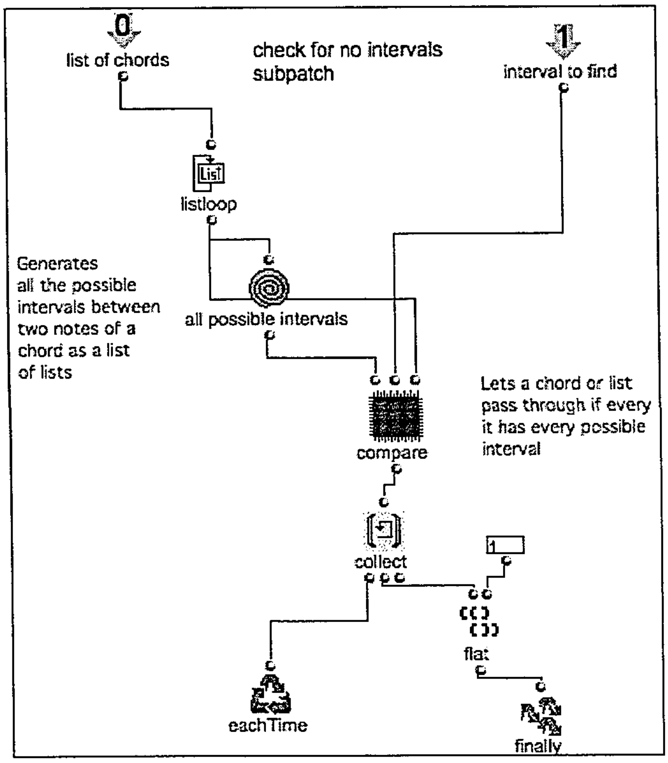

map chords
subpatch
0
list chords
1
list comparisons
mapifthenelse
LISP
mapcar
nil
LISP
remove
0
output

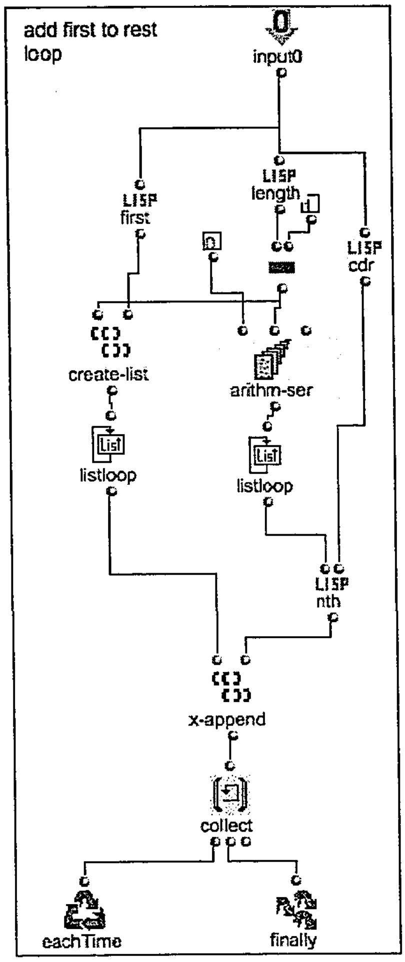

0
list chords
1
list comparisons
0
mapifthenelse
lambda function
nil
omif
nil
LISP
remove
0
output

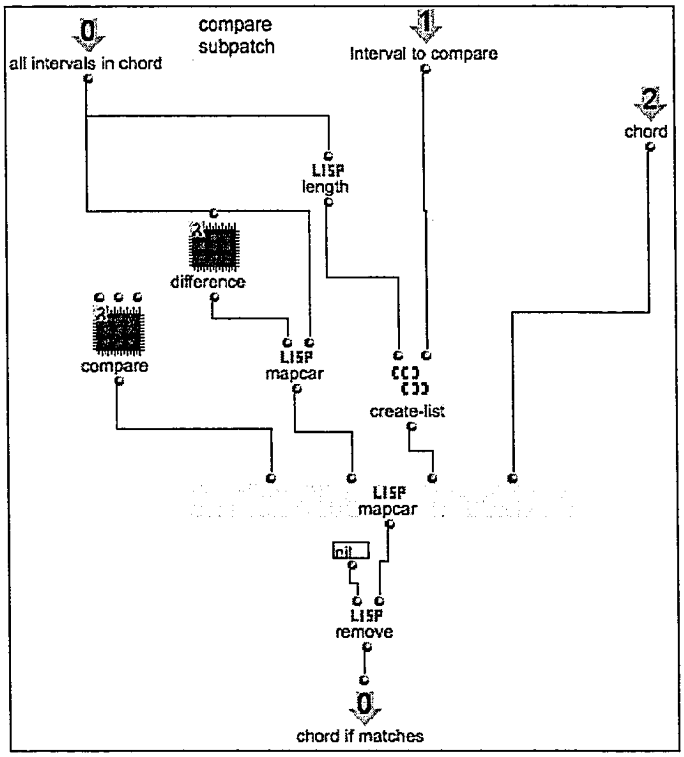
Appendix 4-8: OpenMusic patch to select chords that lack a particular interval

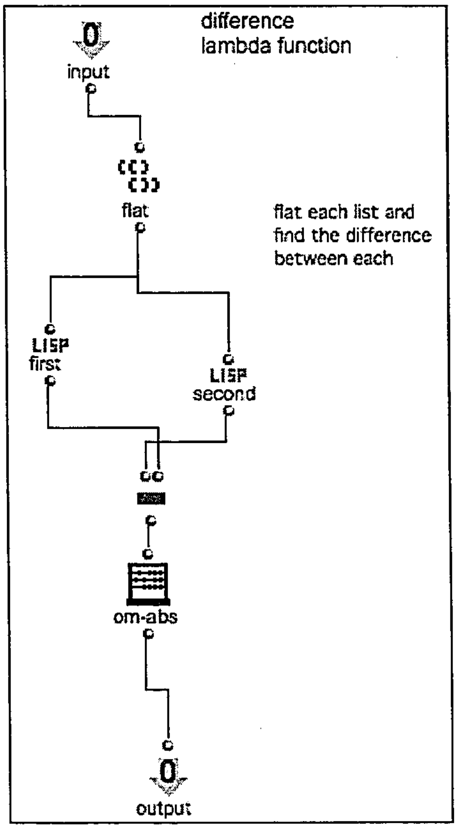


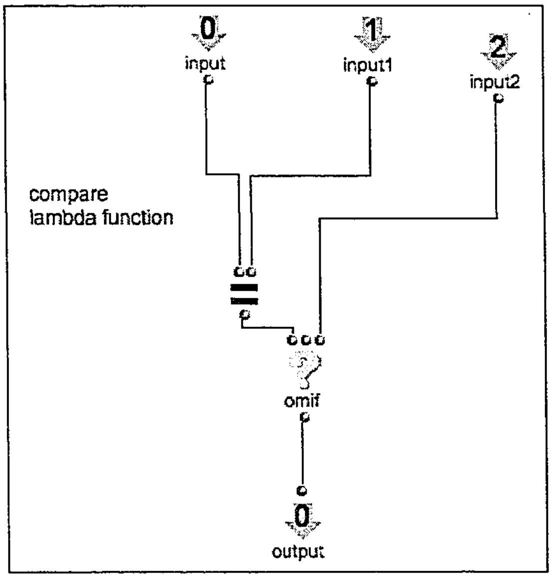


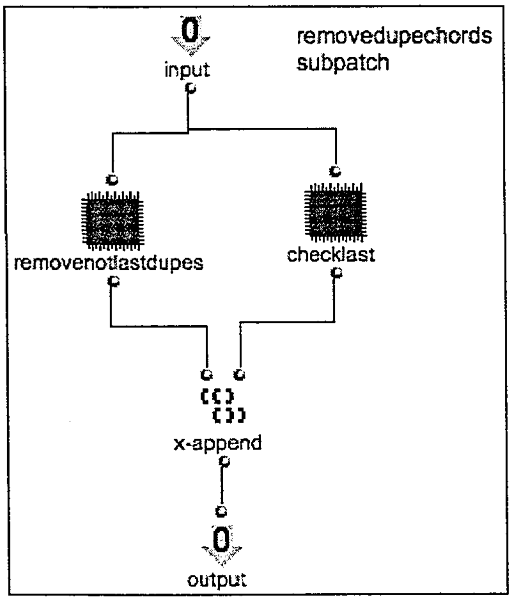


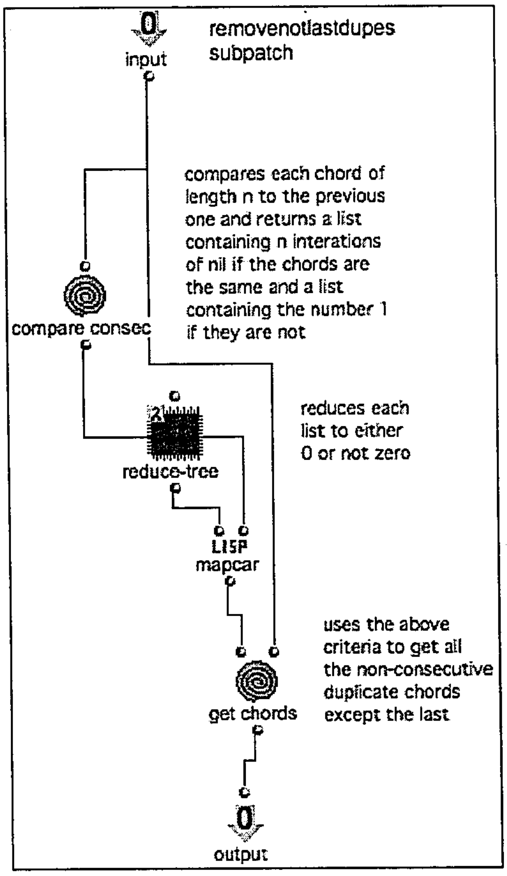


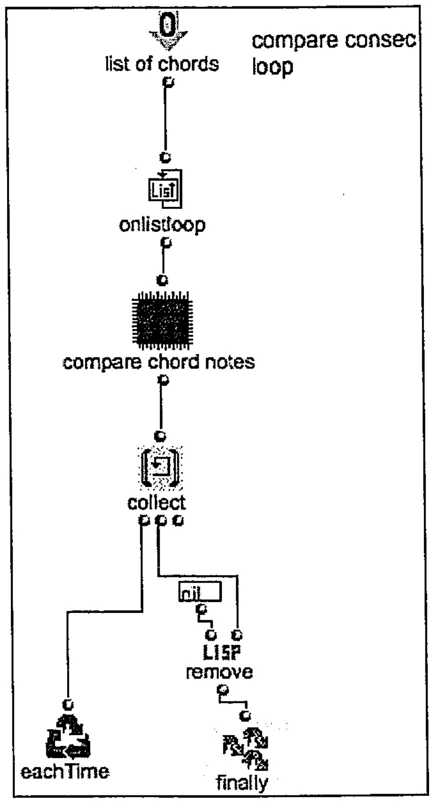

compare
subpatch
all intervals in chord
Interval to compare
chord
length
difference
compare
mapcar
create-list
mapcar
nil
remove
chord if matches

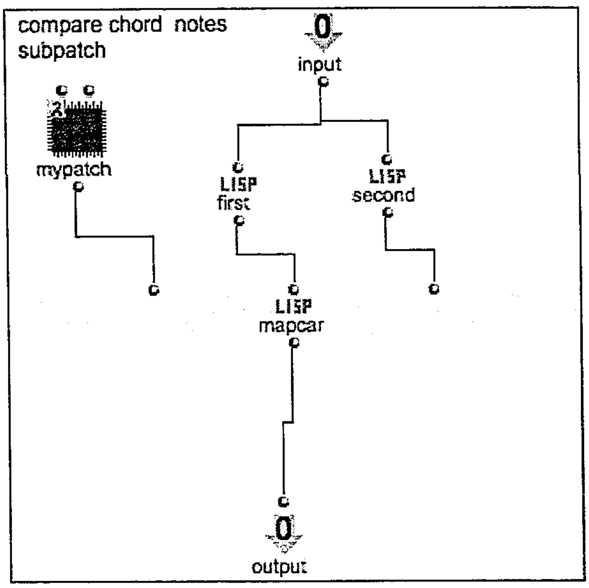

difference
lambda function
input
flat
flat each list and
find the difference
between each
first
second
om-abs
output

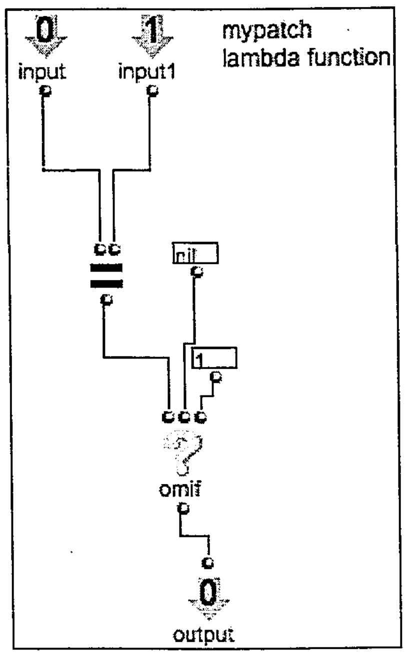

input
input1
input2
compare
lambda function
omif
output

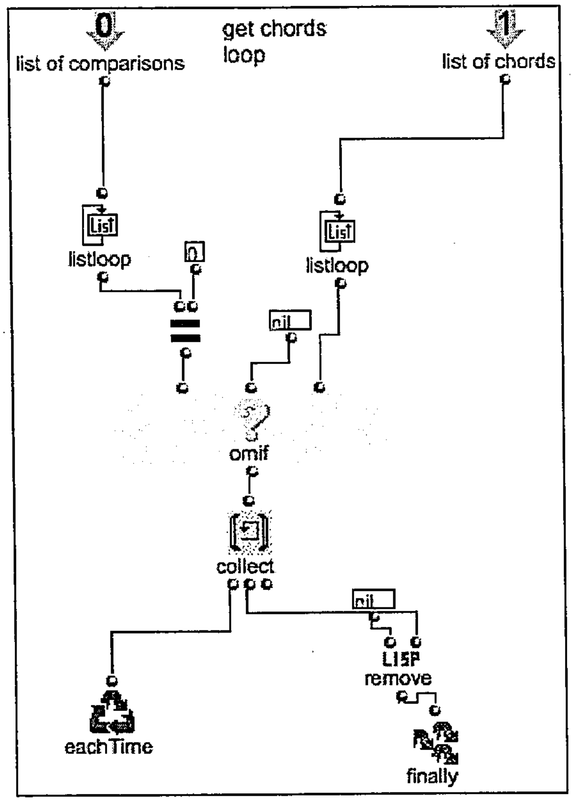

removedupechords
subpatch
input
removenotlastdupes
checklast
x-append
output

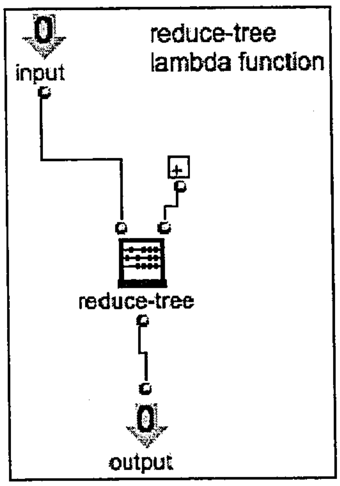

input
removenotlastdupes
subpatch
compares each chord of
length n to the previous
one and returns a list
containing n interations
of nil if the chords are
the same and a list
containing the number 1
if they are not
compare consec
reduce-tree
reduces each
list to either
0 or not zero
LISP
mapcar
get chords
uses the above
criteria to get all
the non-consecutive
duplicate chords
except the last
output

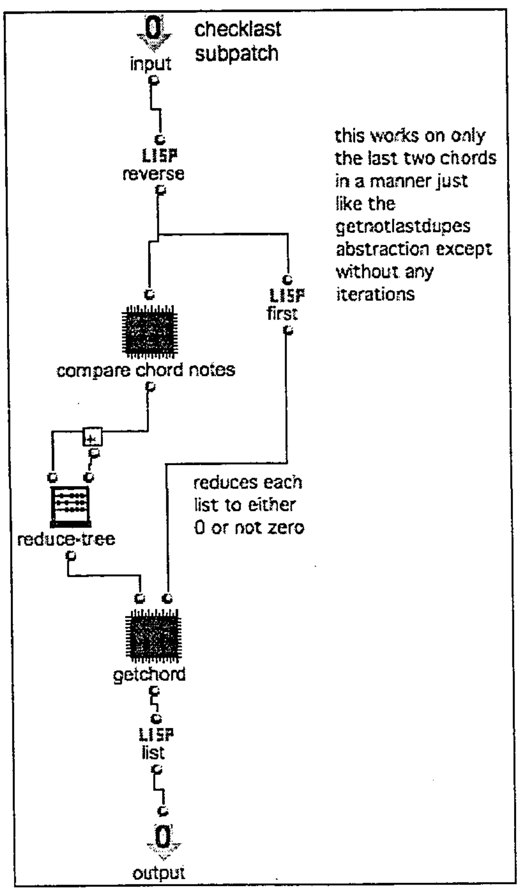

list of chords
compare consec
loop
onlistloop
compare chord notes
collect
nil
LISP
remove
eachTime
finally

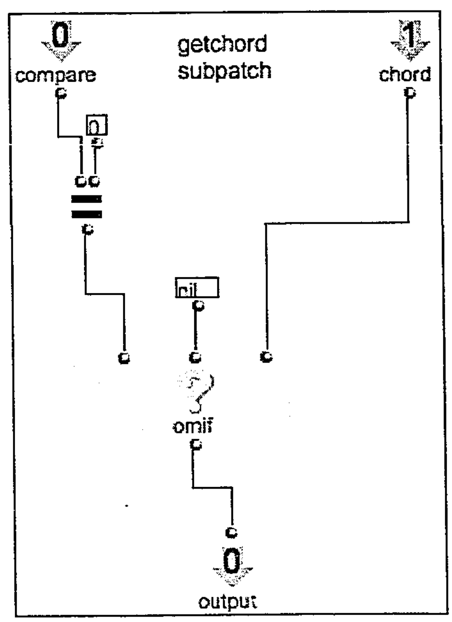

compare chord notes
subpatch
input
mypatch
LISP
first
LISP
second
LISP
mapcar
output


input
input1
mypatch
lambda function
nil
1
omif
output

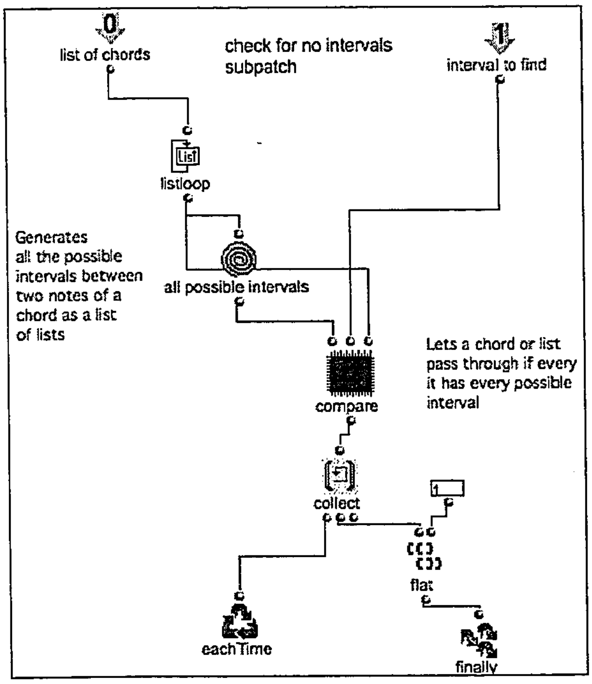

get chords
loop
list of comparisons
list of chords
listloop
listloop
nil
omif
collect
nil
LISP
remove
eachTime
finally

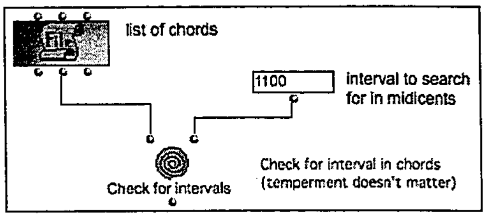

input
reduce-tree
lambda function
reduce-tree
output

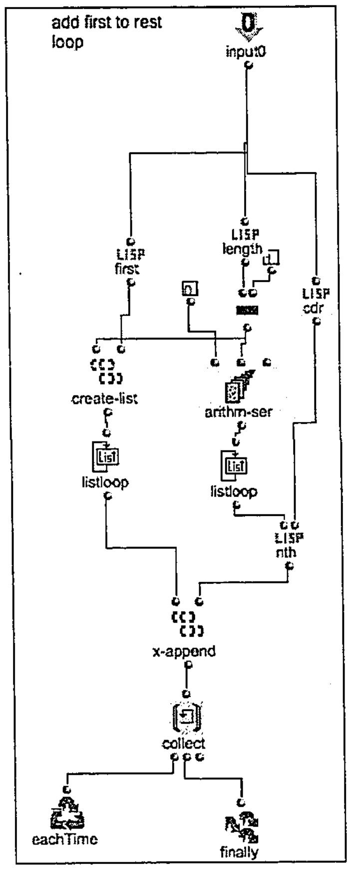

input
checklast
subpatch
LISP
reverse
this works on only
the last two chords
in a manner just
like the
getnotlastdupes
abstraction except
without any
iterations
LISP
first
compare chord notes
reduce-tree
reduces each
list to either
0 or not zero
getchord
LISP
list
output

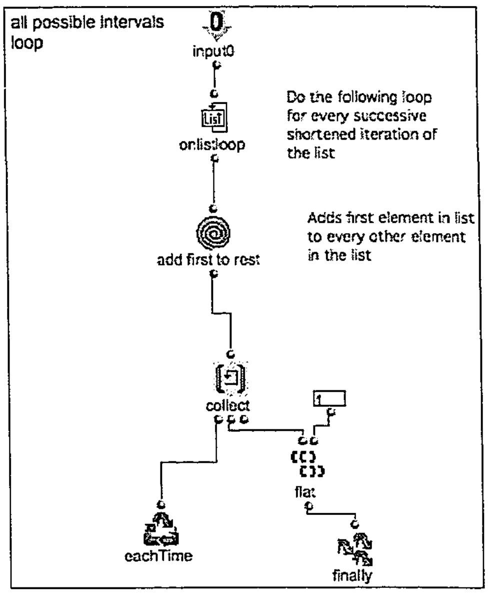

compare
getchord
subpatch
chord
nil
omif
output

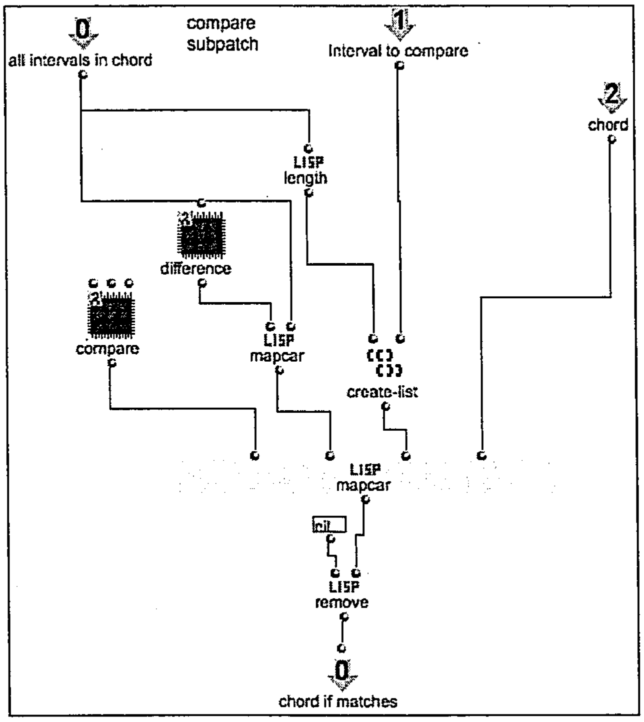
Appendix 4-9: OpenMusic patch that returns a chord from a list every time it has a particular interval

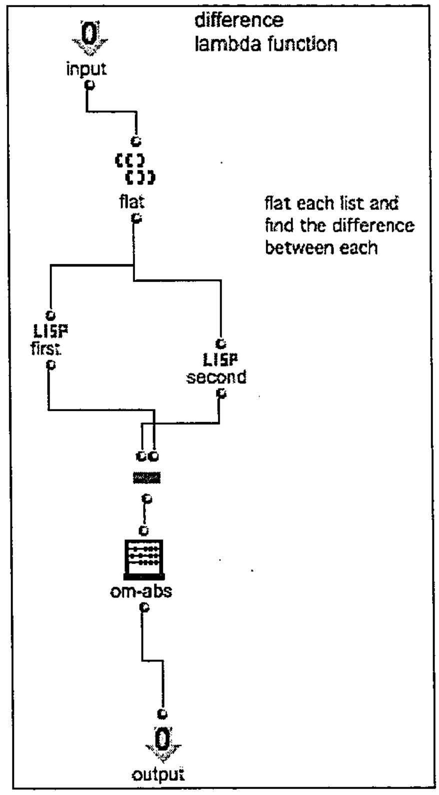


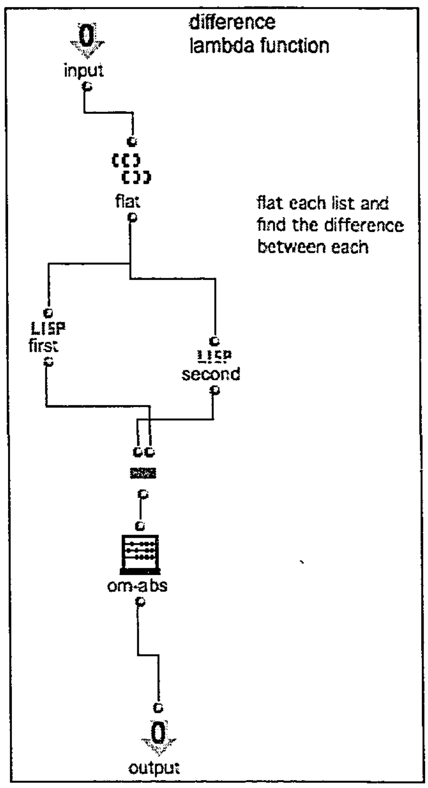




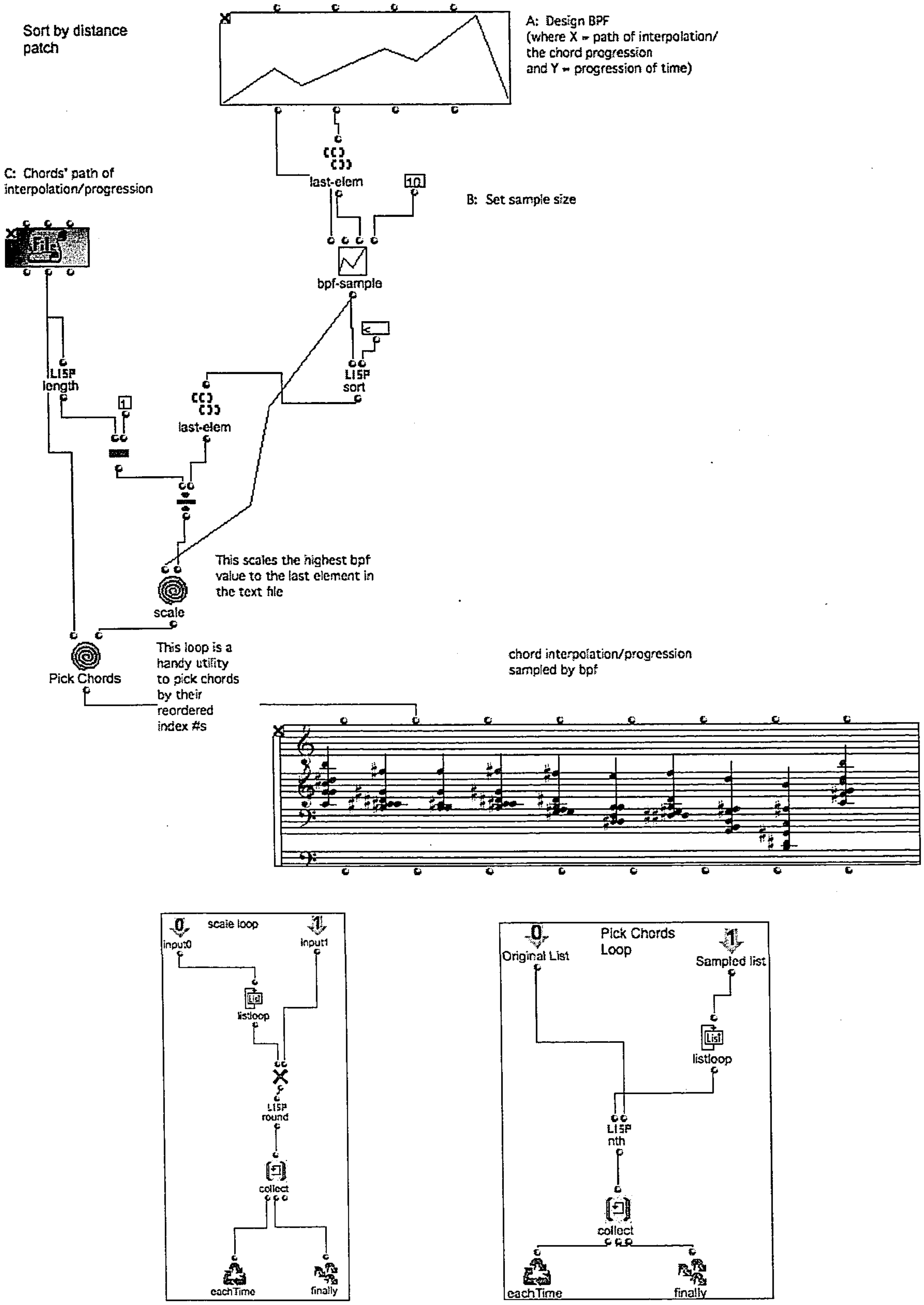



compare
subpatch
all intervals in chord
Interval to compare
chord
LISP
length
difference
compare
LISP
mapcar
create-list
LISP
mapcar
nil
LISP
remove
chord if matches


difference
lambda function
input
flat
flat each list and
find the difference
between each
LISP
first
LISP
second
om-abs
output


difference
lambda function
input
flat
flat each list and
find the difference
between each
LISP
first
LISP
second
om-abs
output

Appendix 4-10: OpenMusic patch that selects chords based upon their distance along an interpolation path



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Time Fixtures

(Volume 2 of 3: Score)

Jacob David Sudol

Department of Music (M. Mus.)

Copy 1

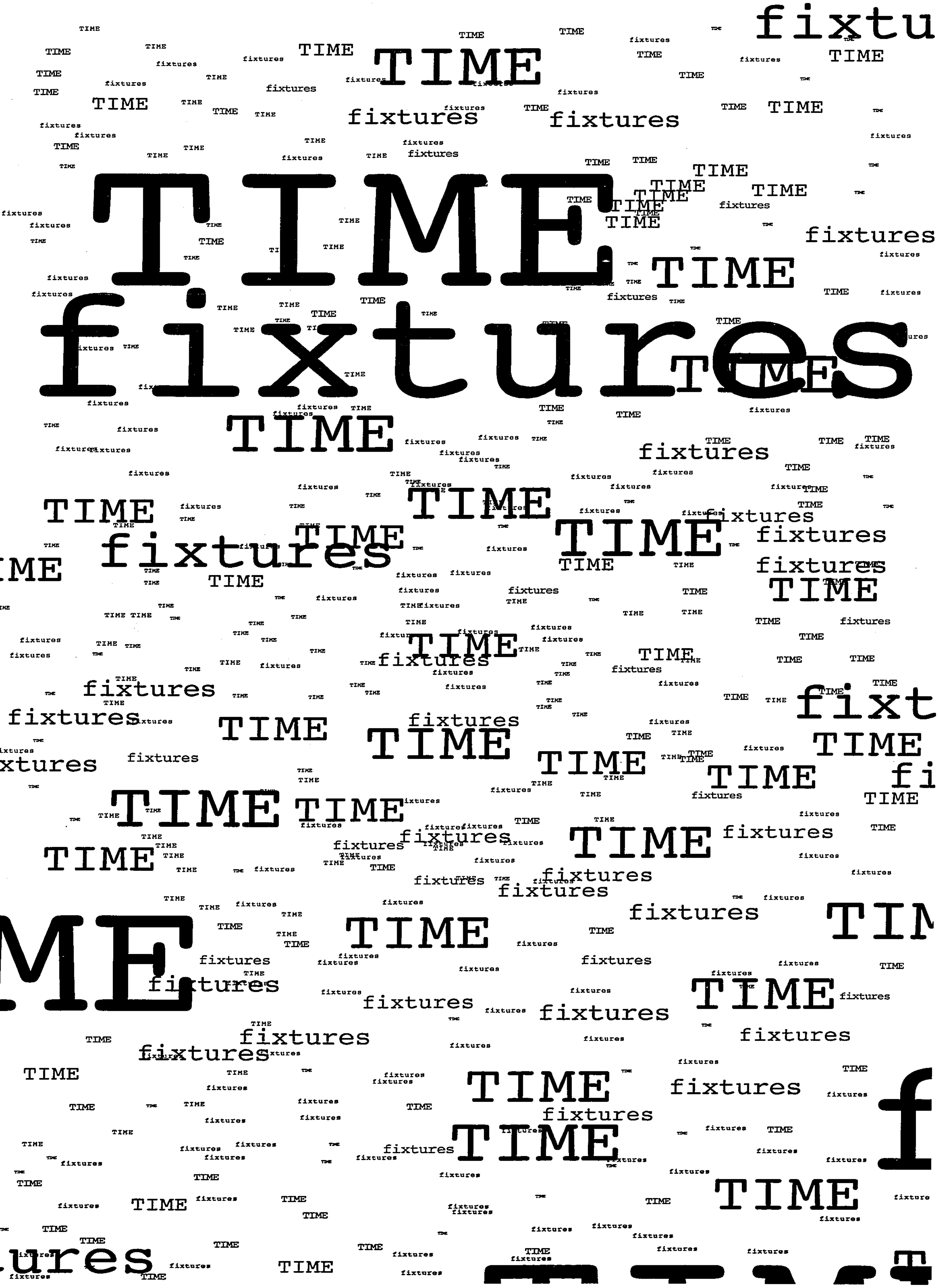
Time Fixtures

(Volume 2 of 3: Score and Documentation)

Jacob David Sudol
Department of Music
McGill University, Montreal

October 2006

A thesis submitted in partial fulfilment of the requirements of the degree of Master of Music


TIME
fixtures

Time Fixtures

For Chamber Ensemble and Electronics

Instrumentation (11 players):

Flute/Alto Flute in G
Oboe
Clarinet in Bb/Bass Clarinet in Bb

Horn in F

Percussion:
Crotales, 3 Suspended Cymbals (18" sizzle, 18", and 21"),
Glockenspiel, Vibraphone, Marimba

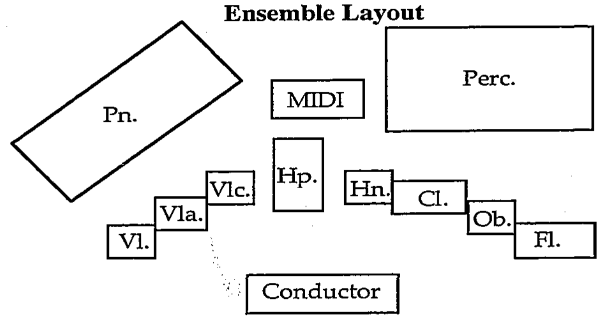
Harp

Piano

MIDI Keyboard / E Crotales/Tangkas (placed out of sight of the audience)

Violin
Viola
Violoncello

Ensemble Layout



Amplification:

All instruments are amplified equally with microphones, except for the strings and harp which are amplified louder than the rest of the ensemble. This is done to provide material for live digital signal processing and to blend the acoustic instruments with the electronic sounds. (See the following electronics' documentation for more details.)

Special Notation & Techniques:

d = approximately a quartertone flat

‡ = approximately a quartertone sharp

regular tremelo = prefectly steady tremelo
irregular tremelo = chaotic and eratic tremelo
grain = apply extra bow pressure to emphasize noisier elements of the timbre such as the subtone

Suggesting fingerings for all woodwind multiphonic are included in parts and are taken from the following sources:
Robert Dick, *The Other Flute* (Oxford, 1975)
Lawrence Singer: *Metedo per Oboe* (Zerboni, 1969)
Phillip Rehfeldt: *New Directions for Clarinet* (University of California Press, 1977)

Time Fixtures was written as part of the first-ever composer-in-residence position for the McGill Schulich School of Music's Contemporary Music Ensemble with the assistance of the McGill Digital Composition Studio.

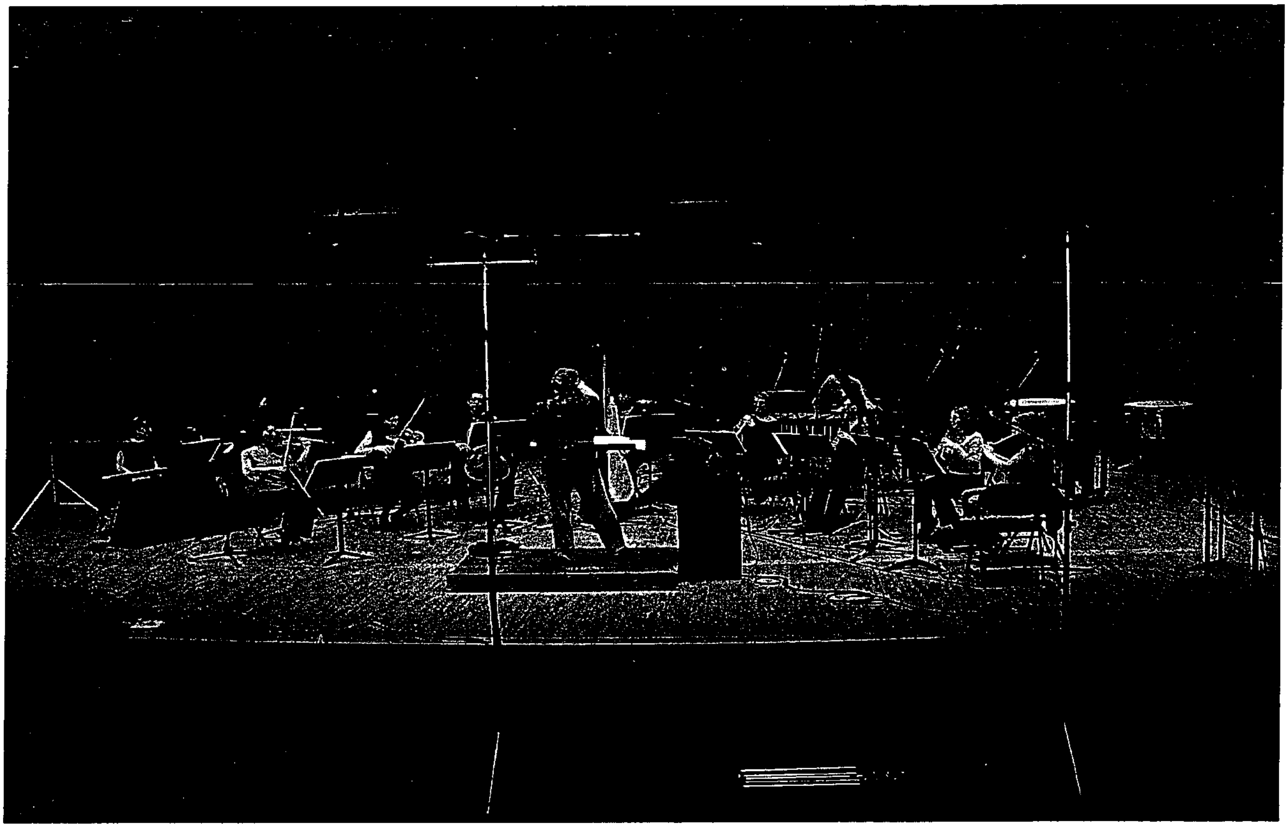
The work is dedicated to Denys Bouliane (director of the Contemporary Music Ensemble), Sean Ferguson (director of the Digital Composition Studio), and John Rea (my mentor during the realization of the project).

-Jacob David Sudol
December 13th, 2005
Montréal, Québec

Score is in Concert Pitch

(except for the crotales and glockenspiel, which follow standard transpositions)

Electronics' Documentation:



The McGill Contemporary Music Ensemble Rehearsing *Time Fixtures* in Pollack Hall

Introduction:

Time Fixtures for 11 players and live electronics was composed from May 2005 through April 2006 as part of the first-ever composer-in-residence position for the McGill Contemporary Music Ensemble in collaboration with the McGill Digital Composition Studio. The composer assembled the electronics and audio cues in the McGill Digital Composition Studios from January 2006 through April 2006. The world premiere was given on April 12th, 2006 at Pollack Hall in Montréal, Québec. The work was performed by the commissioning groups. DenysBouliane conducted the CME and the composer operated the computer.

The electronic sounds are diffused through a hexaphonic system placed around the audience. A patch programmed by the composer for Max/MSP (version 4.5.6 or higher) controls the electronics for performance and rehearsal. The patch cues audio files and performs live digital signal processing on the amplified signal of every instrument in the ensemble. The ensemble's MIDI keyboard controls the event score following in the patch during performance and rehearsal.

Technical Requirements:

General:

The specifics detailed below are suggestions based upon successful tests and utilization in concert. In most cases – such as microphones, MIDI keyboard, speakers, and mixer – high-quality substitutions may be used as they are available; however, with the computer, only an equal or more powerful Apple computer will work successfully in rehearsal and performance.

Microphones:

For performance every instrument must be amplified equally except for the Harp, which should be boosted approximately 3-6 decibels above the other instruments. Close miking is recommended to isolate each instrument's signal as best as possible. To facilitate this, cardioid microphones are highly recommended.

The following is a list that details the microphone or microphones that were used and their placement on each instrument in the ensemble for the initial performance.

- Flute: 1 Neumann cardioid KM184 (placed above the embouchure hole)

- Oboe: 1 Neumann cardioid KM184 (slightly off set from the bell)
- Clarinet: 1 Neumann cardioid KM184 (placed horizontally at the bell to capture an equal signal from the Bb and bass clarinets)
- Horn: 1 Electro-Voice cardioid RE20 (placed directly in front of the bell)
- Percussion: 2 Neumann hyper-cardioid KM185s (placed equidistantly above the metallic instruments) and 2 Neumann cardioid KM184s (placed equidistantly above the marimba)
- Harp: 2 Shure cardioid SM81s (one placed near the high strings, one near the low strings)
- Piano: 1 AKG 414 set to cardioid (placed at the opening of a half-stick opened lid)
- Violin: 1 Neumann cardioid KM184 (placed above the f-hole)
- Viola: 1 Neumann cardioid KM184 (placed above the f-hole)
- Cello: 1 AKG 414 set to cardioid with a 70 Hz roll-off (placed near the left f-hole)

Mixer:

A mixer with a minimum of 32 channels is required for performance. The mixer must also have seven speaker outs, four distinct channel pairs, a direct out for every channel, and a minimum of six auxiliary (four independent) channels. A Mackie 32x8 analog mixer was used for the first performance.

It is recommended that at least one person control the levels of the signals routed through the mixer during performance.

Speakers:

Six equal speakers and three correspondingly sized equal sub woofers are required for performance. Six EAW JFX100s and three Mackie SWA 1501 15" active subs were used for the first performance.

In addition, it is helpful to have two small stage speakers to be used as monitors for the conductor and MIDI keyboard player. It is important that these speakers are not so loud that they are picked up by the stage microphones.

MIDI Keyboard:

A 88-key MIDI keyboard is required for performance. The keyboard must have a MIDI out port in order to send the necessary data to the computer to control the electronics. A Yamaha S90 was used for the first performance.

Digital Audio Interface:

A firewire digital audio interface is required to send the amplified live instruments from the mixer to the computer. The interface must have a MIDI in port, a minimum of five audio inputs, and a minimum of eight audio outputs. A MOTU 828MkII was used for the first performance.

Computer and Software:

An Apple computer with OS 10.4.5 or higher, Max/MSP version 4.5.6 or higher, and the appropriate digital audio interface driver installed is required for performance. A Power Mac dual 2 Gigahertz G5 with 1.5 Gigabytes of RAM has successfully been tested in the studio; however, a Power Mac quad 2.5 Gigahertz G5 with 1.5 Gigabytes of RAM was used for the first performance.

One person is required to operate the computer during performance; if necessary, this same person may also operate the mixer.

Technical Setup:

Routing Signals 1:

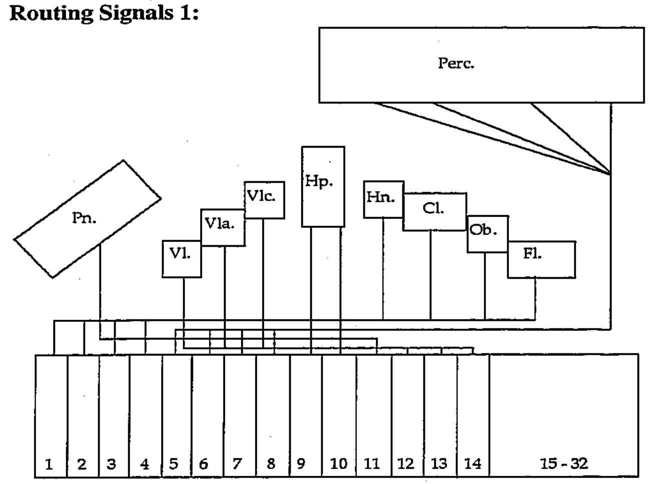


Figure 1: Routing of microphones to mixer channels 1-14

The above figure demonstrates how to route the microphones to the first fourteen channels of the mixer. For the sake of simplicity the instruments have been routed to the mixer following the score order outlined in the score.

To send audio from the mixer to the digital audio interface (which is connected to the computer) channels 1-4 (woodwinds) must be mixed equally and sent post-fader to Aux. 1, channels 5-8 (percussion) must be mixed equally and sent post-fader to Aux. 2, channels 9-10 (harp) must be mixed equally to and sent post-fader to Aux. 3, and channels 12-14 must be mixed equally and sent post-fader to Aux. 4. These first four auxiliary channel outs and the direct out of channel 11 (piano) are sent to the five inputs of the digital audio interface in the manner depicted in Figure 2. Furthermore, the seven outs from the digital audio interface must be sent to seven empty channels on the mixer as is demonstrated in Figure 2.

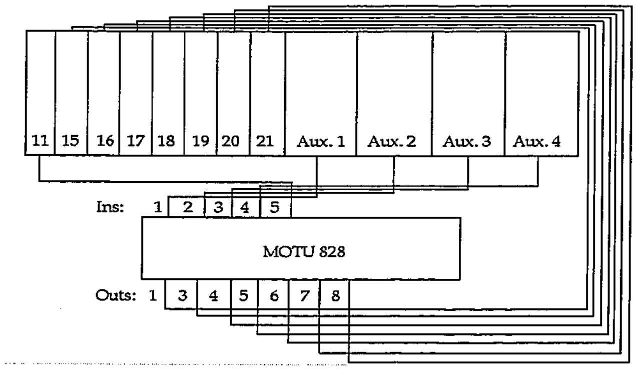


Figure 2: Routing between mixer and the digital audio interface

Routing Signals 2:

Channels 1-4 (woodwinds) must be mixed equally and sent pre-fader to Aux. 5, channels 5-8 (percussion) must be mixed equally and sent pre-fader to Aux 6, and channels 9-14 must be sent direct out to channels 24-29. In addition, Aux. 5 must be sent to channel 22 and Aux. 6 must be sent to channel 23. This is done so that channels 22-29 can provide a complete and equally balanced amplified stereo image of the live instruments which is sent at approximately -30 decibels to the front two speakers at all times.

To send audio to the speakers, first make sure that channels 16-21 (channels 3-8 from the digital audio interface) have an equal output level. Channel 15 (channel 1 from the digital audio interface) is the stage monitor channel and should be controlled independently from the other six channels.

Channel 3 from the digital audio interface must be sent to speaker pair 1-2 and panned hard left. Channel 4 from the digital audio interface must be sent to speaker pair 1-2 and panned hard right. Channel 5 from the digital audio interface must be sent to speaker pair 3-4 and panned hard left. Channel 6 from the digital audio interface must be sent to speaker pair 3-4 and panned hard right. Channel 7 from the digital audio interface must be sent to speaker pair 5-6 and panned hard left. Channel 8 from the digital audio interface must be sent to speaker pair 5-6 and panned hard right. Channel 1 from the digital audio interface must be sent to speaker pair 7-8 and panned to the center.

To insure that the computer receives the correct MIDI data a MIDI cable must be connected from the MIDI Out port of the MIDI keyboard to the MIDI In port of the digital audio interface and the digital audio interface must be connected to the computer.

Speaker Setup:

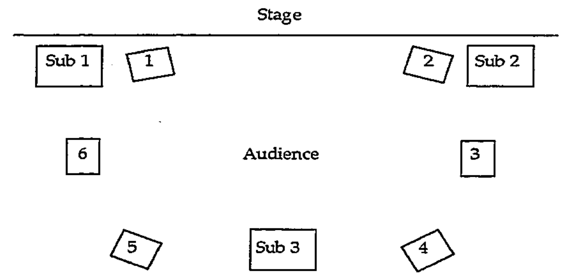


Figure 3: Speaker setup around the audience

The six speakers should be placed around the audience *equidistantly from a central point in the hall* (ideally where the mixer and computer are placed). The speakers should be ordered in clockwise motion starting from the front left stage speaker. The three sub woofers should be placed around the audience equidistantly from a central point and also numbered in clockwise motion starting from the front left stage position. It is recommended that the front speakers be placed in front of the stage to minimize feedback.

The mixer's six speaker outs must be sent to their corresponding speakers in the hall. Also, the low frequency signals for speakers 1 and 6 should be sent to Sub 1, the low frequency signals for speakers 2 and 3 should be send to Sub 2, and the low frequency signals for speakers 4 and 5 should be sent to Sub 3.

The Max/MSP Patch:

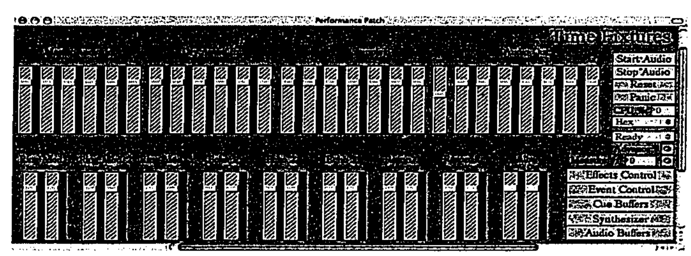


Figure 4: Screen shot of the Max/MSP performance patch for *Time Fixtures*

Configuring Max/MSP:

All the files required to run the Max/MSP performance patch (externals, the performance patch, and audio files) are inside the folder titled TimeFixtures(patch) on the technical CD titled "Time Fixtures Patch." Copy this folder to the hard drive. To create the proper file pathways, open Max/MSP and go to the "Options" menu and select "File Preferences..." Inside the File Preferences window choose the folder "TimeFixtures(patch)" from the hard drive.

Following this, open the DSP Status window from the "Options" menu. Make sure that your driver is correct and that the "Sampling Rate" is set to 44100 Hz. After this, change the "I/O Vector Size" to 1024 and the "Signal Vector Size" to 128. Restart Max/MSP, open the file titled "Performance Patch" from the TimeFixtures(patch) folder to run the electronics.

Live User Control and Options:

Inside the main window of the performance patch a number of sliders are provided to allow for the dynamic gain control during performance and rehearsal. The sliders under "Main Audio In" allow the user to change the initial independent and master gains for the ADC~ inputs. The sliders under "Dry Audio In" allow the user to change the independent and master gains for all the ADC~ inputs that are only processed by spatialization. The sliders labeled 1-6 under "Samples" allow the user to change the master gain of the samples that are sent to the corresponding speakers 1-6. The slider labeled "All" under "Samples" allows the user to change the master gain of all samples. The slider labeled "Ins." under "Samples" allows the user to change the gain of the MIDI controlled sampler (during performance this slider should hover about -20 decibels below the rest of the samples). The sliders under "Audio Out" allow the user to change the independent gains of the corresponding speaker output as well as for all speakers. The remaining sliders (Ring Mod 1-3, Echo 1-3, Reson. 1-2, and All) control the levels of the signals coming to and leaving all forms of the live digital signal processing besides spatialization. By default, all levels are set to unity for performance.

On the left hand side of there are "Reset" and "Panic" buttons. These can be pressed whenever one needs to turn off audio and stop all audio files. Below the CPU% number box is a pull-down menu that allows the user to select either the default Hex (or hexaphonic version) or Stereo (a hacked stereo version). The latter of these two options is provided for rehearsal situations where a hexaphonic setup is not practical. The stereo version is not intended for performance unless the expressed consent of the composer is granted beforehand.

Running the Patch:

To run the patch in concert first press the button labeled "Start Audio" in the top left corner of the patch. Once the CPU% shows a reading, click on the pull-down menu that says "Ready" and select "Beginning." At this point, the MIDI keyboard is ready to cue the beginning and the rest of the piece. If the synthesizer player ever misses the cue necessary to advance a rehearsal letter one can press the button labeled "Advance" which is below the rehearsal letter menu. It is recommended that, during performance, the person monitoring the computer be mindful of the rehearsal letter advancement in relationship to the score as well as ride the sliders (particularly the ones located under the labels "Samples" and "Audio Out.")

The performance patch can also be used for rehearsal. To set up the patch for rehearsal press "Start Audio" and choose the desired rehearsal letter to start from in the pull-down menu. At this point the synthesizer player only has to play the appropriate MIDI note for the electronics to start in the correct place One can also turn on audio by pressing the spacebar and select the rehearsal letter by pressing the eponymous key on the computer keyboard. These features also function as a fail-safe for performance.

One additional feature, intended for rehearsal, is the ability to cue specific measure numbers. To do this, simply type in the desired measure number and press the button to the left of the measure number. At this point the MIDI keyboard player only has to play the appropriate MIDI note for the electronics to start in the correct place. However, be forewarned that this final feature is currently in a beta phase.

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Canada

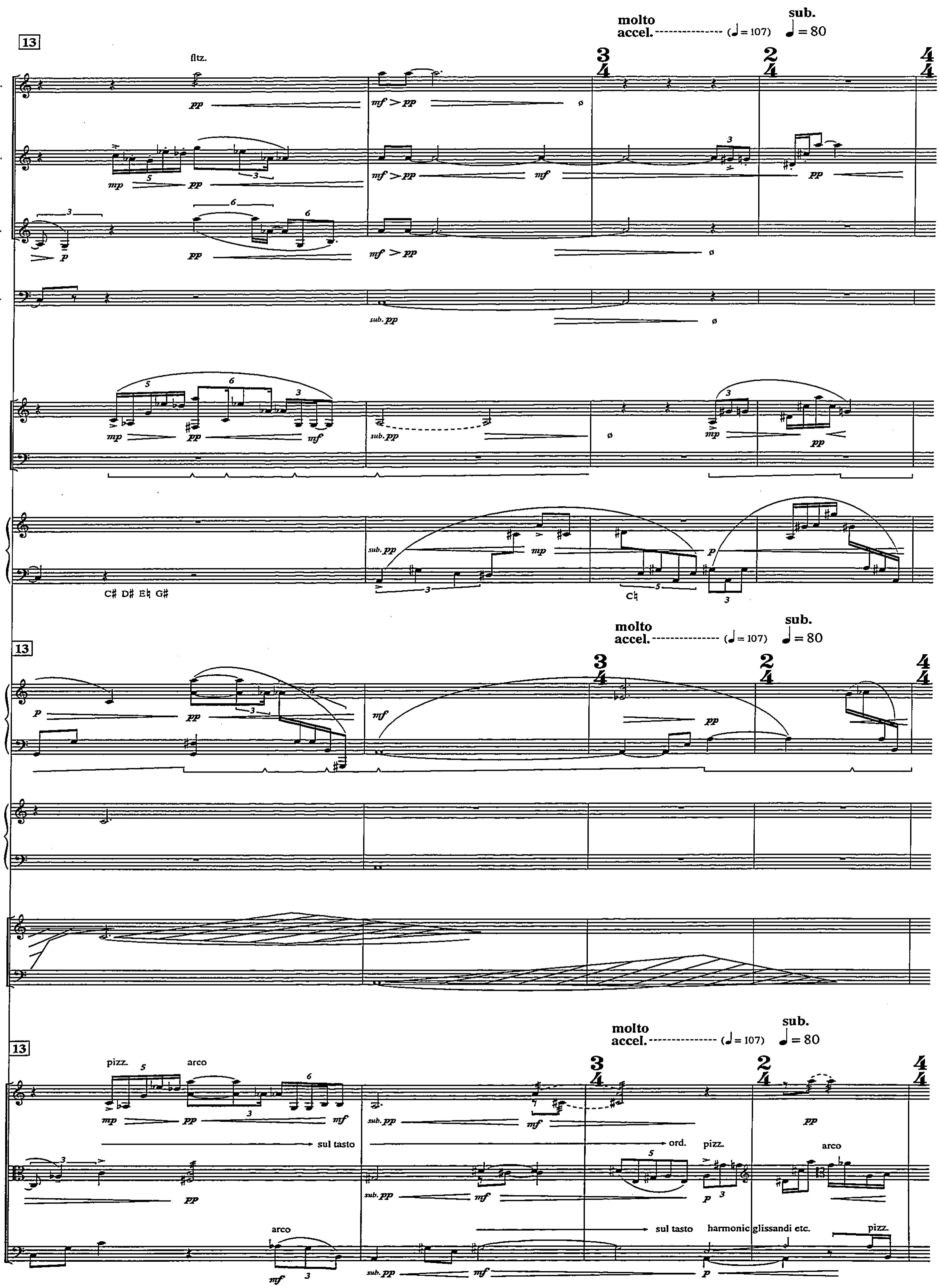
Time Fixtures

Jacob David Sudol

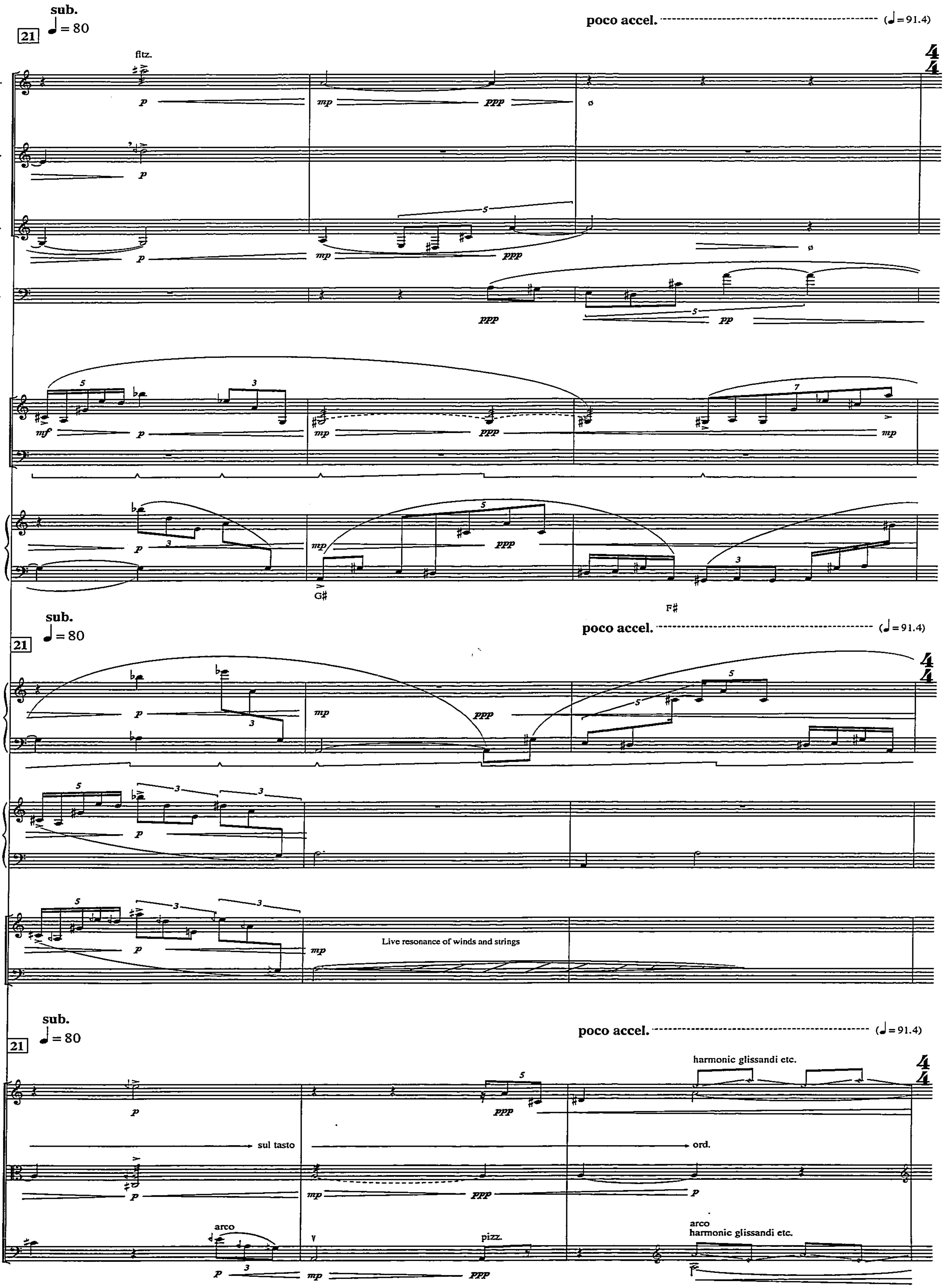

4
molto rall.
(♩=40) // sub. ♩=60
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
gliss.
Resonant wash, increasing in frequency width
Short burst of time-stretched bell timbres
Gong
ord.
sul pont.
molto sul pont.
E♮ G♭ B♮

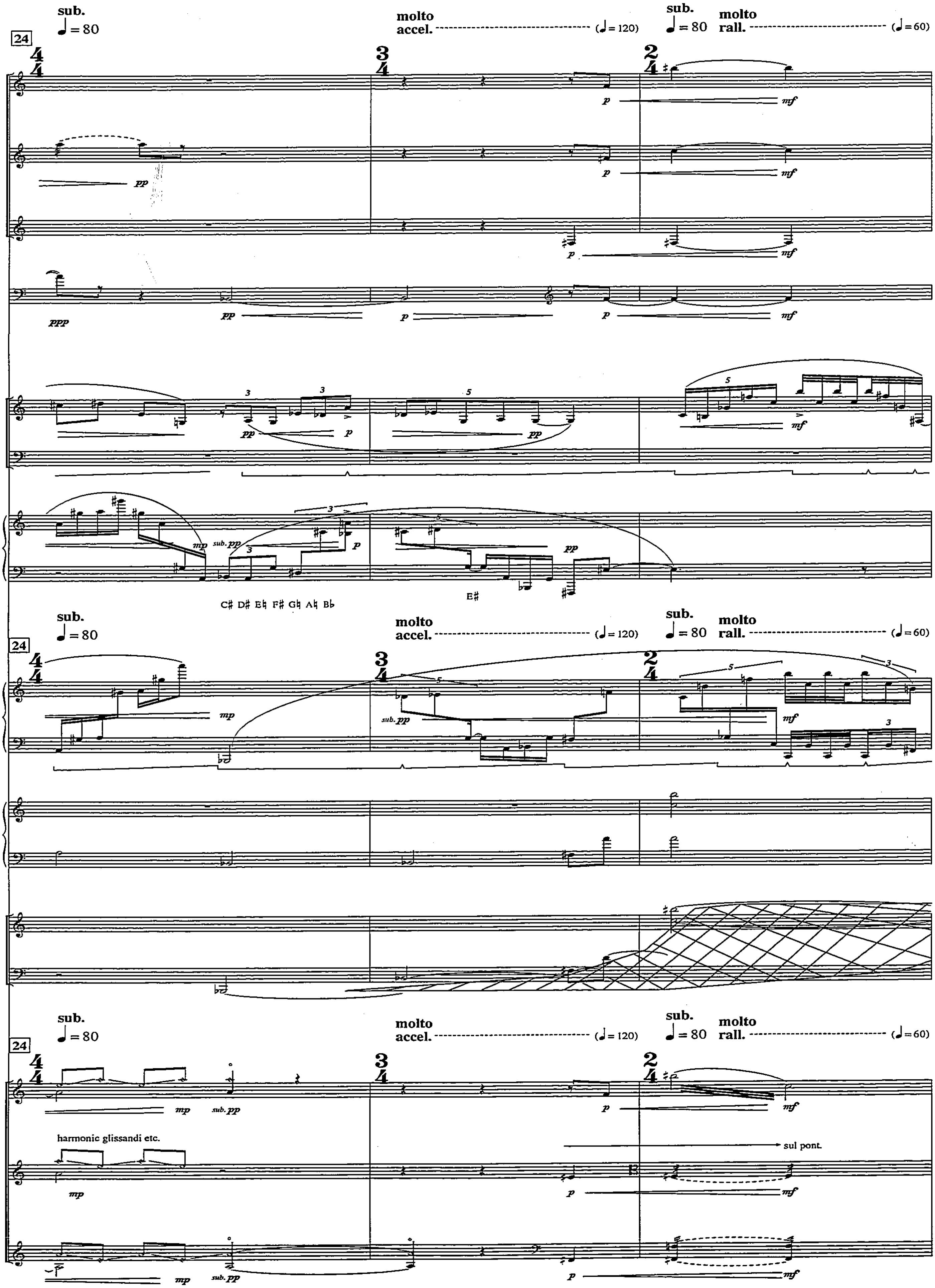

accel.
♩= 72 molto rall.
(♩= 40)
7
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
poco a poco multiphonic
sordina
E♭ G♯
Gong
ord.
sul tasto
sul C
gliss.
harmonic glissandi etc.
pizz.


sub. ♩= 80
molto rall. ♩= 60
A sub. ♩= 80
10
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
sempre una corda ad lib.
Crossfade with live resonance of real instruments
sul pont.
ord.
arco
pizz.


13
molto accel.
sub.
fltz.
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
C♯ D♯ E♮ G♯
C♮
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
pizz.
arco
sul tasto
ord.
harmonic glissandi etc.


B
molto rall. (♩ = 40) //
sub. ♩ = 80
molto accel. (♩ = 120)
17
Fl.
Ob.
fltz.
Cl.
Hn.
Perc.
Harp
G♭
C♯ G♮ B♭
Pno.
Synth
Elect.
Quarter tone Vibraphone
Vln.
Vla.
gliss.
Vc.
arco
pizz.


sub.
21
poco accel.
fltz.
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
G#
F#
Pno.
Synth
Elect.
Live resonance of winds and strings
Vln.
harmonic glissandi etc.
sul tasto
ord.
Vla.
arco
pizz.
Vc.
arco
harmonic glissandi etc.

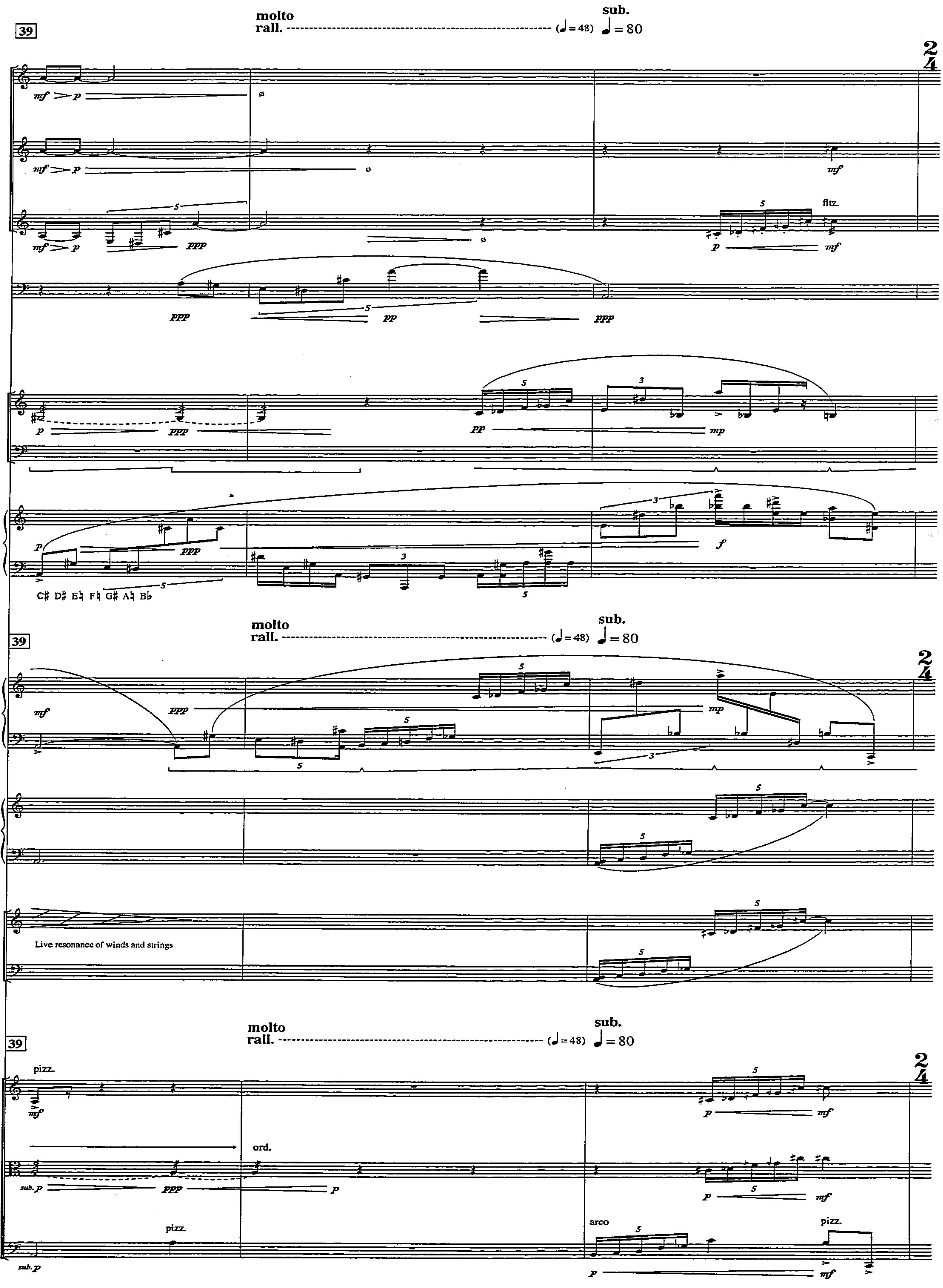

sub.
♩= 80
molto accel. (♩= 120)
sub. ♩= 80
molto rall. (♩= 60)
24
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
C♯ D♯ E♮ F♯ G♮ A♮ B♭
E♯
Pno.
Synth
Elect.
Vln.
Vla.
harmonic glissandi etc.
sul pont.
Vc.


27
sub.
♩= 80
molto accel.
(♩= 107)
sub.
♩= 80
molto rall.
♩= 60
Fl.
Ob.
poco a poco multiphonic
Cl.
Hn.
Perc.
Harp
C♮ D♯ E♮ F♮ G♭ A♮ B♮
D♮ A♭
Pno.
sub. pp
Synth
Elect.
Vln.
gliss.
ord.
Grain
Vla.
Vc.

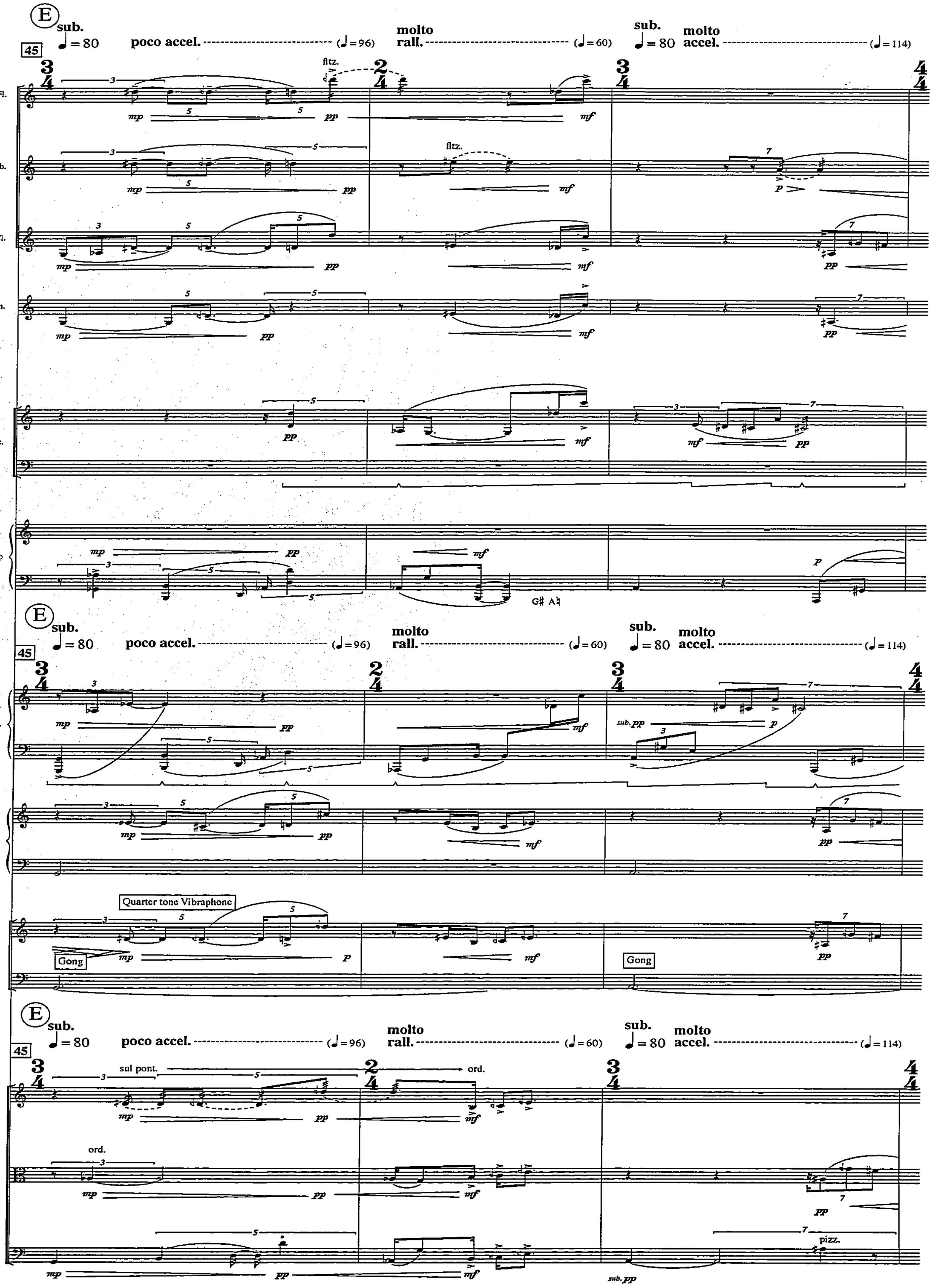

C
30
sub. ♩=80
molto accel.
(♩=96)
(♩=107)
(♩=120)
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
Quarter tone Vibraphone
Gong
sul pont.
ord.
pizz.


sub.
= 80
33
accel.
(= 96)
molto rall.
(= 40)
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
E♭ A♮ B♭
D♭ G♮
Pno.
Synth
Elect.
Ruler slap cross-synthesized with resonance
Vln.
Vla.
arco
sul C
Vc.
Grain


D
sub.
♩= 80
molto accel.
(♩= 120)
sub. ♩= 80
molto rall.
(♩= 60)
sub. ♩= 80
36
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
C♮ D♭ E♭ F♮ G♮ A♮ B♭
C♯ D♯ G♯
pizz.
arco
sul tasto


39
molto rall. (♩=48)
sub. ♩=80
Fl.
Ob.
Cl.
fltz.
Hn.
Perc.
Harp
C♯ D♯ E♮ F♮ G♯ A♮ B♭
Pno.
Synth
Elect.
Live resonance of winds and strings
Vln.
pizz.
Vla.
ord.
Vc.
pizz.
arco


molto rall. ♩= 60
42
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
D♮ A♭ B♮
Pno.
Synth
Elect.
Reversed Gong
Crossfade with twisted resonances of Mm. 39-44
Gong
Vln.
Vla.
Vc.
arco
sul pont.
Grain


E
45
sub.
♩ = 80
poco accel.
(♩ = 96)
molto rall.
(♩ = 60)
molto accel.
(♩ = 114)
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
G♯ A♮
Quarter tone Vibraphone
Gong
sul pont.
ord.
pizz.
sub. pp

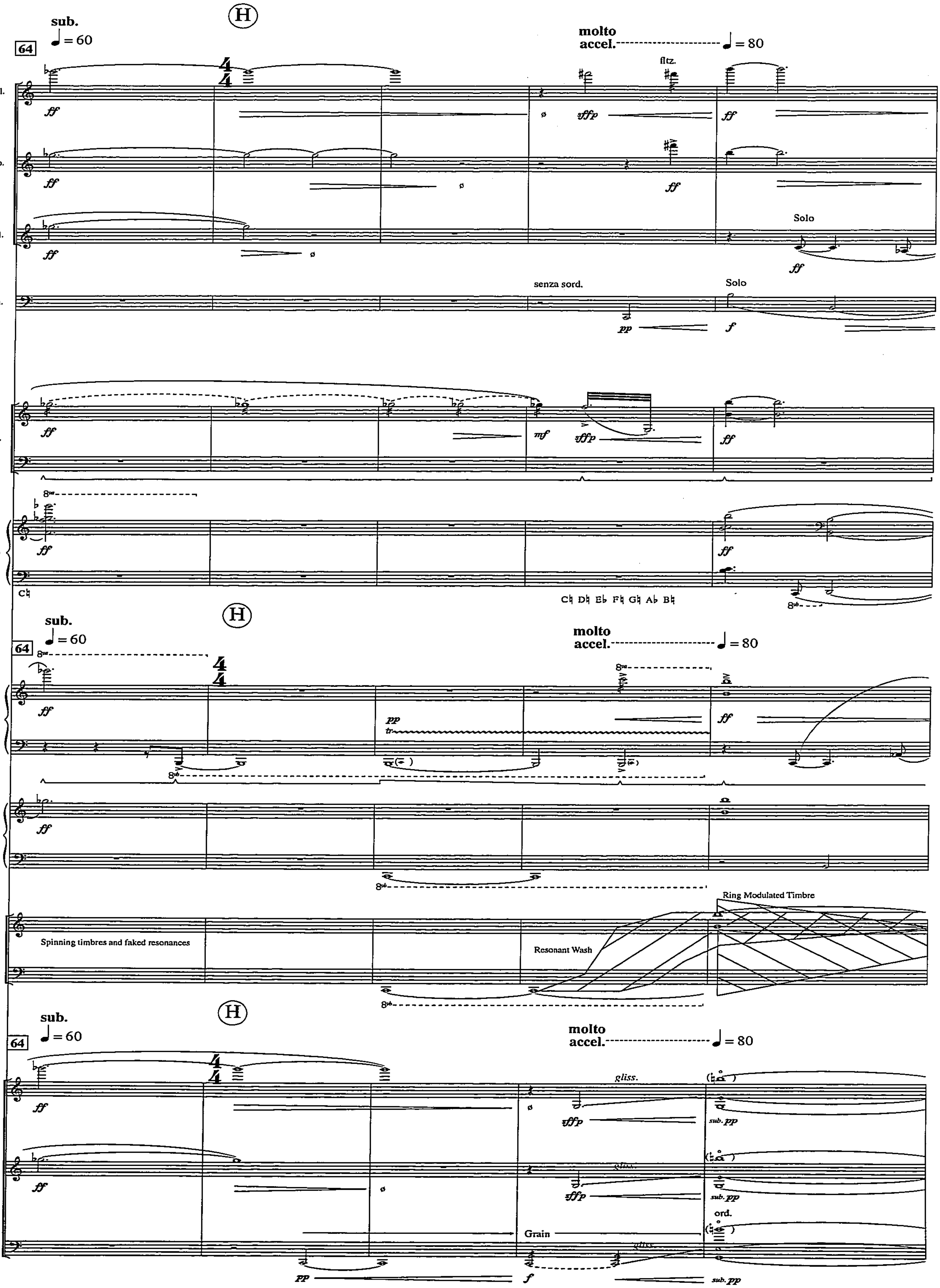

sub.
♩ = 80
molto accel. (♩ = 107)
sub. ♩ = 80
molto rall. (♩ = 69)
48
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
fltz.
C♮ D♮ E♮ F♮ G♭ A♭ B♮
G♭
Pno.
Synth
Elect.
Reversed Gong
Vln.
Vla.
Vc.
pizz.
arco
Grain


F
sub.
51
poco accel.
sub.
molto rall.
Fl.
fltz.
Ob.
Cl.
Hn.
Perc.
Harp
F♯ G♮
C♯
Pno.
Synth
Elect.
Gong
Vln.
molto sul pont.
gliss.
pizz.
ord. arco
Vla.
Vc.
arco
pizz.


54
sub.
♩= 80
molto
accel.
(♩= 120)
molto
accel.
(♩= 96)
molto
rall.
(♩= 67)
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
gliss.
C# D♮ E♭ F# G♮ A♭ B♭
Gong
multi-layered glissandi
pizz.
arco
ff
mp
mf
f
p

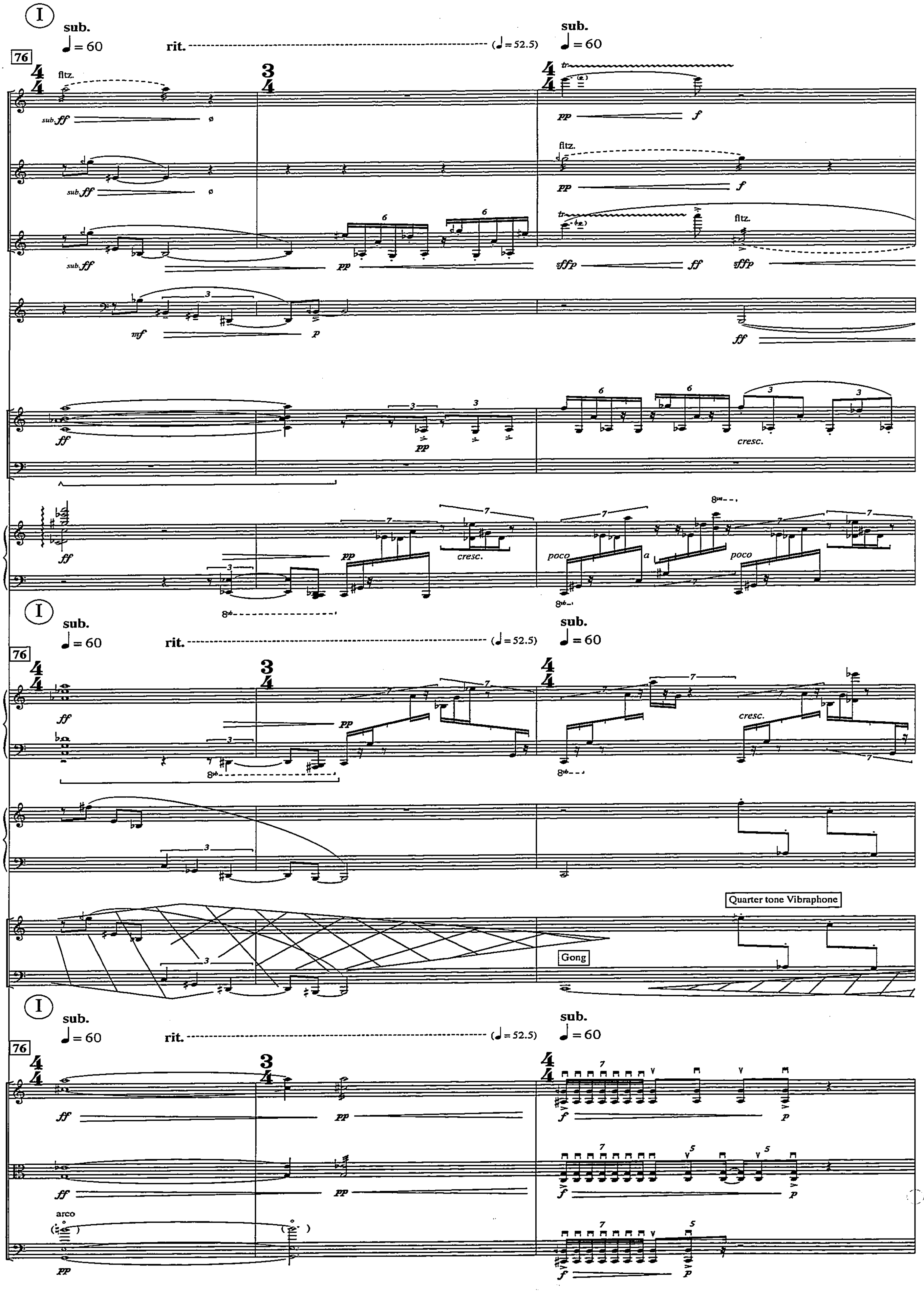

G
57
sub.
♩= 80
molto
accel.
(♩= 96)
sub.
♩= 80
Fl.
fltz.
Ob.
Cl.
fltz.
Hn.
Perc.
Harp
F♮
Pno.
Synth
Elect.
Harp pedal buzz
Gong
Vln.
sul tasto
Vla.
sul tasto
Vc.


molto accel. (♩=107) sub. ♩=80 molto rall. (♩=40) // sub. ♩=80
60
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
fltz.
C♯ D♮ E♭ F♯ G♭ A♮ B♭
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
ord.


sub.
♩= 60
H
64
molto accel.
♩= 80
fltz.
Fl.
Ob.
Cl.
Solo
Hn.
senza sord.
Solo
Perc.
Harp
C♮
C♮ D♮ E♭ F♮ G♮ A♭ B♮
Pno.
Synth
Elect.
Spinning timbres and faked resonances
Resonant Wash
Ring Modulated Timbre
Vln.
gliss.
Vla.
Vc.
Grain
ord.
sub. pp


rit.
♩ = 60
69
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
fltz.
8vb
Db
A♮
Pno.
Synth
Elect.
Faint swell of ring modulated timbre
Vln.
Vla.
Vc.
sul pont.
ord.
molto sul pont.

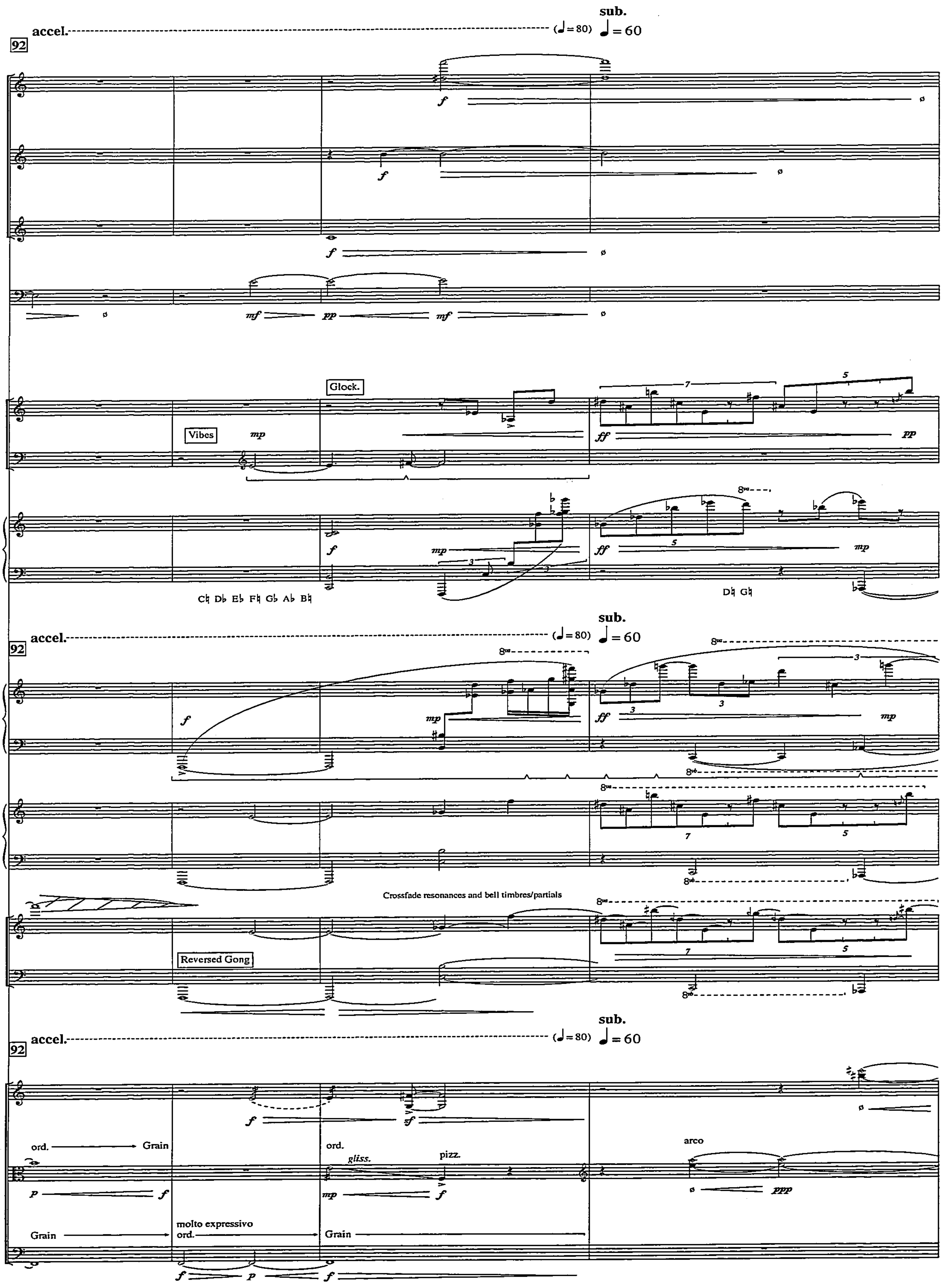

accel.
♩= 72
molto rall.
(♩= 40)
72
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
C♮ D♭ E♭ F♮ G♮ A♭ B♮
G♯
Pno.
Synth
Ring modulated timbre
Elect.
Vln.
Vla.
Vc.
Grain
ord.
pizz.
sub.pp
sub.p

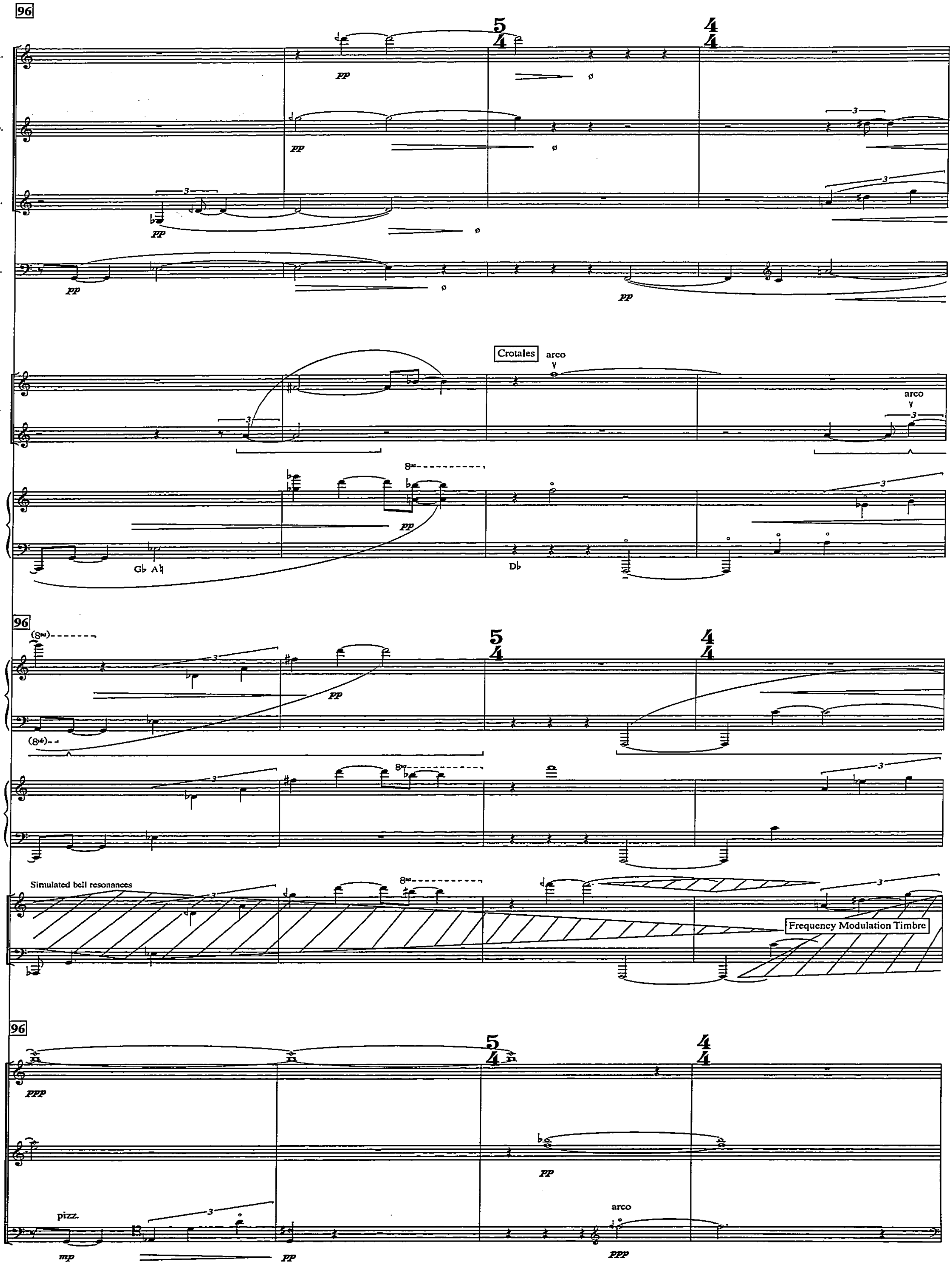

I
sub.
♩= 60
rit.
(♩= 52.5)
76
Fl.
fltz.
sub. ff
tr
pp
f
Ob.
fltz.
Cl.
sffp
ff
Hn.
mf
p
Perc.
cresc.
Harp
poco
a
Pno.
Synth
Elect.
Quarter tone Vibraphone
Gong
Vln.
Vla.
arco
Vc.

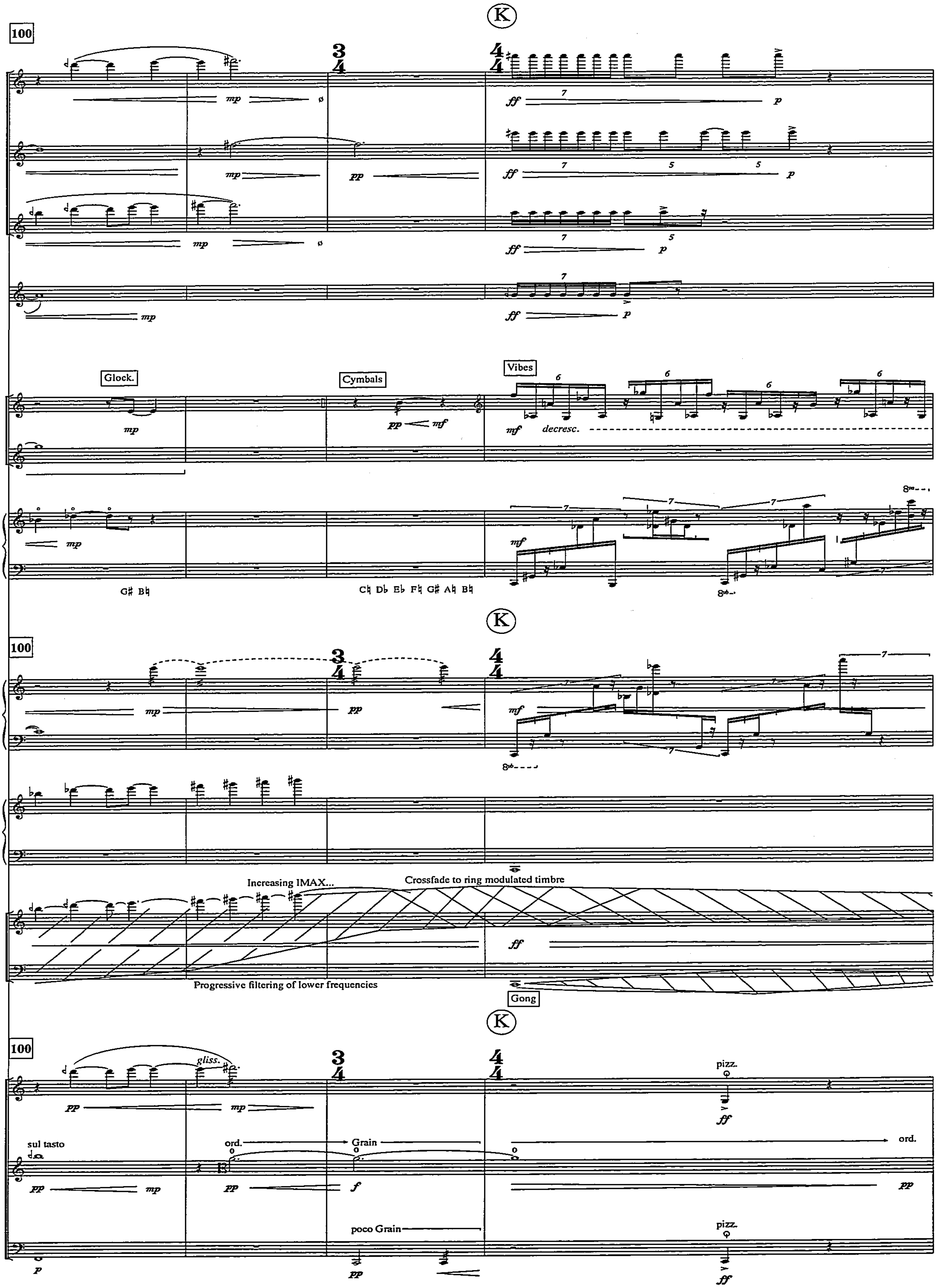

79
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
E♮ G♭
Pno.
Synth
Elect.
Gong
Vln.
Grain
Vla.
molto sul pont.
Vc.
Grain


82
molto accel.
♩= 80
rit.
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
G♮
C♮ D♭ E♭ F♮ G♮ A♭ B♮
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
ord.
sul pont.
gliss.
sub. pp


J
86
♩ = 60
fltz.
Fl.
sffmp
mp
End Solo
Ob.
mf
sfmp
Cl.
f
Hn.
sordina
Perc.
Harp
G♭
Pno.
Synth
Elect.
High spinning resonant partials
ord.
Vln.
molto expressivo
sul pont.
Vla.
Grain
Vc.

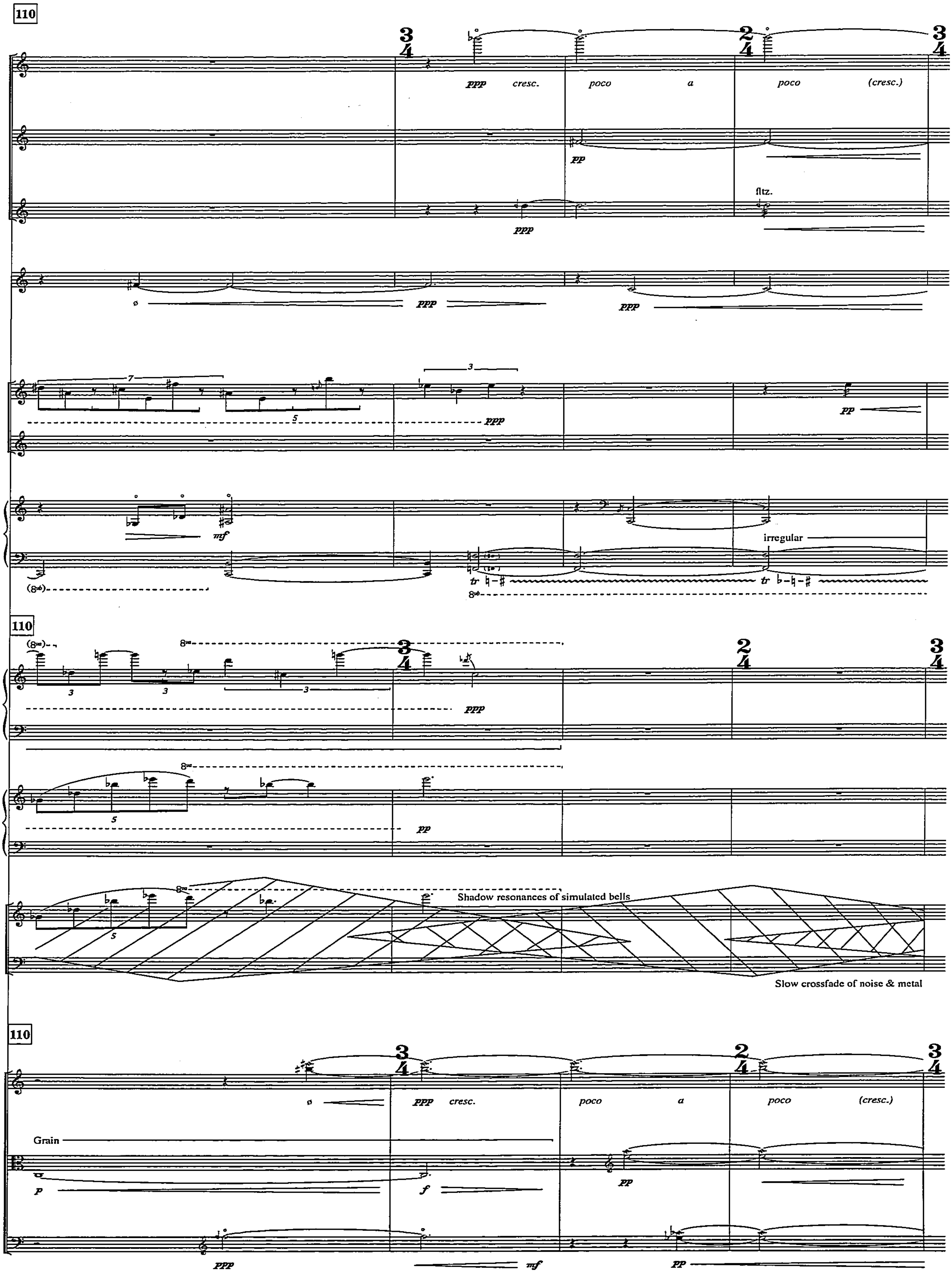

92
accel.
(♩=80)
sub. ♩=60
Fl.
Ob.
Cl.
Hn.
Glock.
Vibes
Perc.
Harp
C♮ D♭ E♭ F♮ G♭ A♭ B♮
D♮ G♮
92
accel.
(♩=80)
sub. ♩=60
Pno.
Synth
Crossfade resonances and bell timbres/partials
Reversed Gong
Elect.
92
accel.
(♩=80)
sub. ♩=60
Vln.
ord.
Grain
ord.
gliss.
pizz.
arco
Vla.
Grain
molto expressivo
ord.
Grain
Vc.

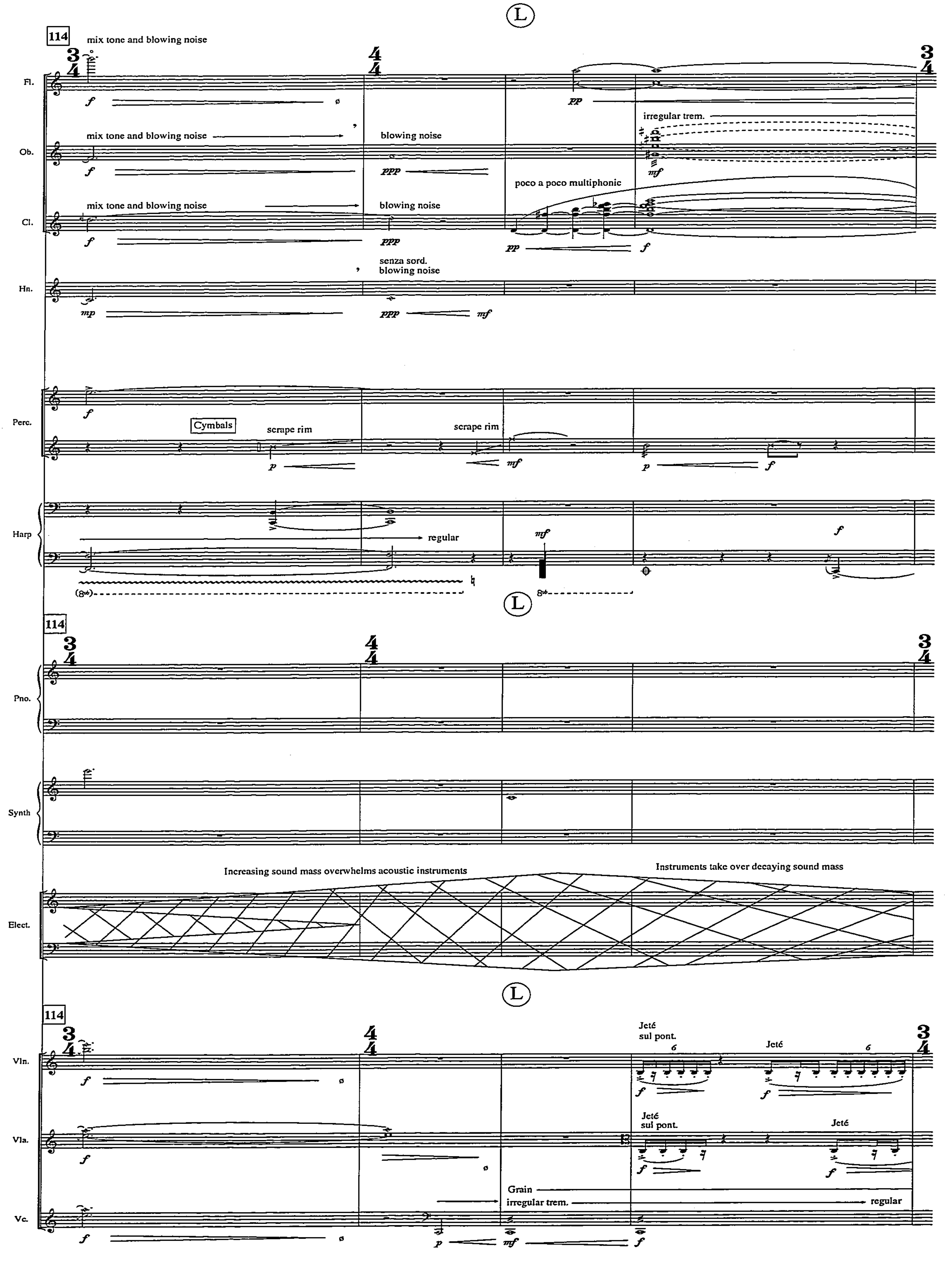

96
Fl.
Ob.
Cl.
Hn.
Crotales
arco
Perc.
arco
Harp
Gb A♮
Db
96
Pno.
Synth
Simulated bell resonances
Elect.
Frequency Modulation Timbre
96
Vln.
Vla.
pizz.
Vc.
arco


K
100
Fl.
Ob.
Cl.
Hn.
Perc.
Glock.
Cymbals
Vibes
decresc.
Harp
G♯ B♮
C♮ D♭ E♭ F♮ G♯ A♮ B♮
Pno.
Synth
Elect.
Increasing IMAX...
Crossfade to ring modulated timbre
Progressive filtering of lower frequencies
Gong
Vln.
gliss.
pizz.
Vla.
sul tasto
ord.
Grain
ord.
Vc.
poco Grain
pizz.


104
Fl.
Ob.
Cl.
Hn.
Perc.
Solo
Harp
E♮ G♭ A♯
Pno.
Synth
Elect.
Vln.
pizz.
Vla.
arco
Grain
Vc.

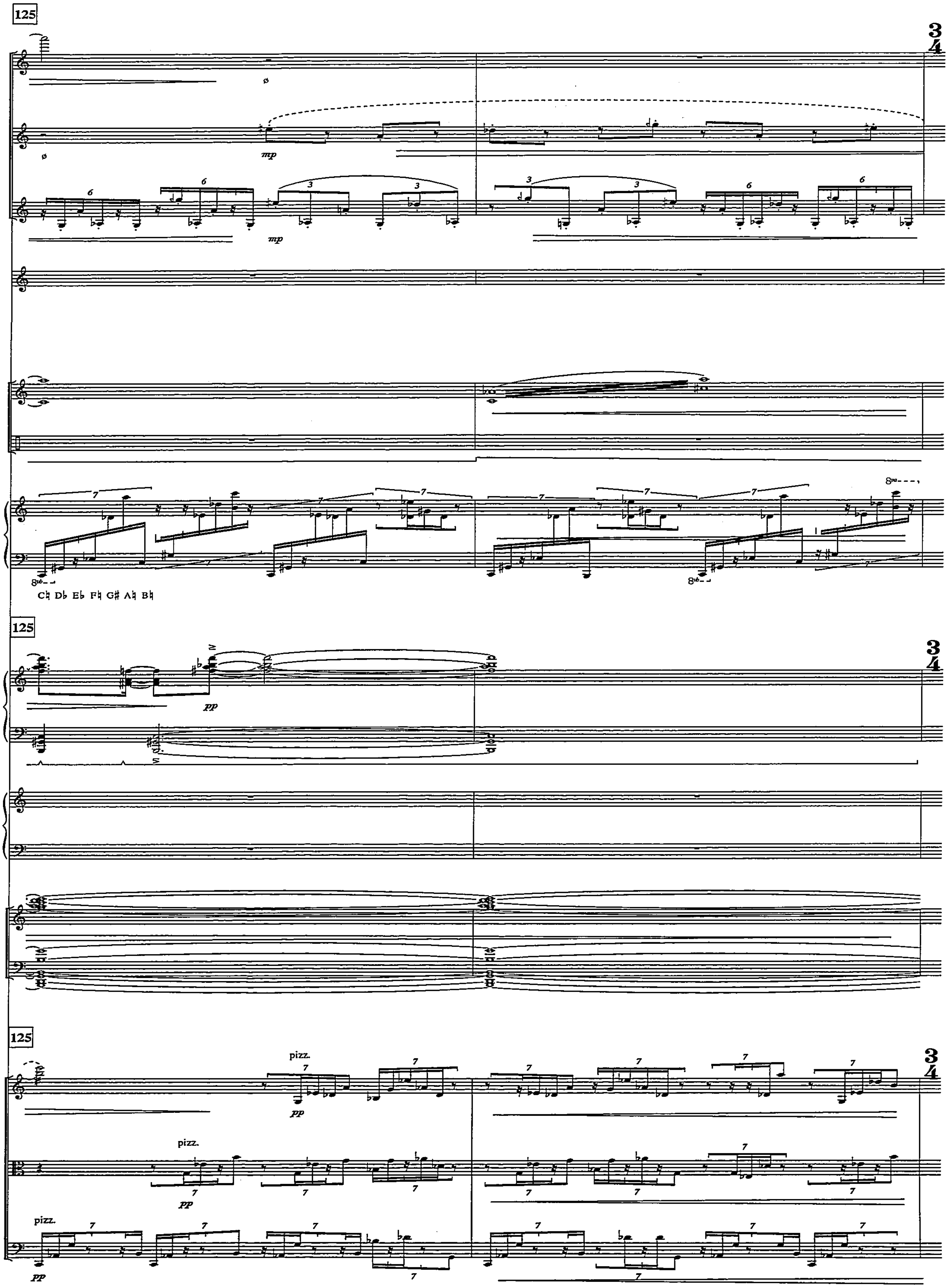

107
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
Glock.
C♮/C♯
(place pedal between ♮ and ♯)
decresc.
Rising granularization of ring modulated timbre
Shimmering resonances of phantom bells
arco
sul G
arco
Grain
ord.
ord.


110
Fl.
ppp cresc.
poco a poco (cresc.)
Ob.
pp
Cl.
ppp
fltz.
Hn.
ppp
ppp
Perc.
ppp
pp
Harp
mf
irregular
110
Pno.
ppp
Synth
pp
Elect.
Shadow resonances of simulated bells
Slow crossfade of noise & metal
110
Vln.
ppp cresc.
poco a poco (cresc.)
Grain
Vla.
p
f
pp
Vc.
ppp
mf
pp


L
114
mix tone and blowing noise
Fl.
Ob.
Cl.
Hn.
irregular trem.
blowing noise
poco a poco multiphonic
senza sord.
blowing noise
Perc.
Cymbals
scrape rim
Harp
regular
114
Pno.
Synth
Increasing sound mass overwhelms acoustic instruments
Instruments take over decaying sound mass
Elect.
Vln.
Vla.
Vc.
Jeté
sul pont.
Grain
irregular trem.

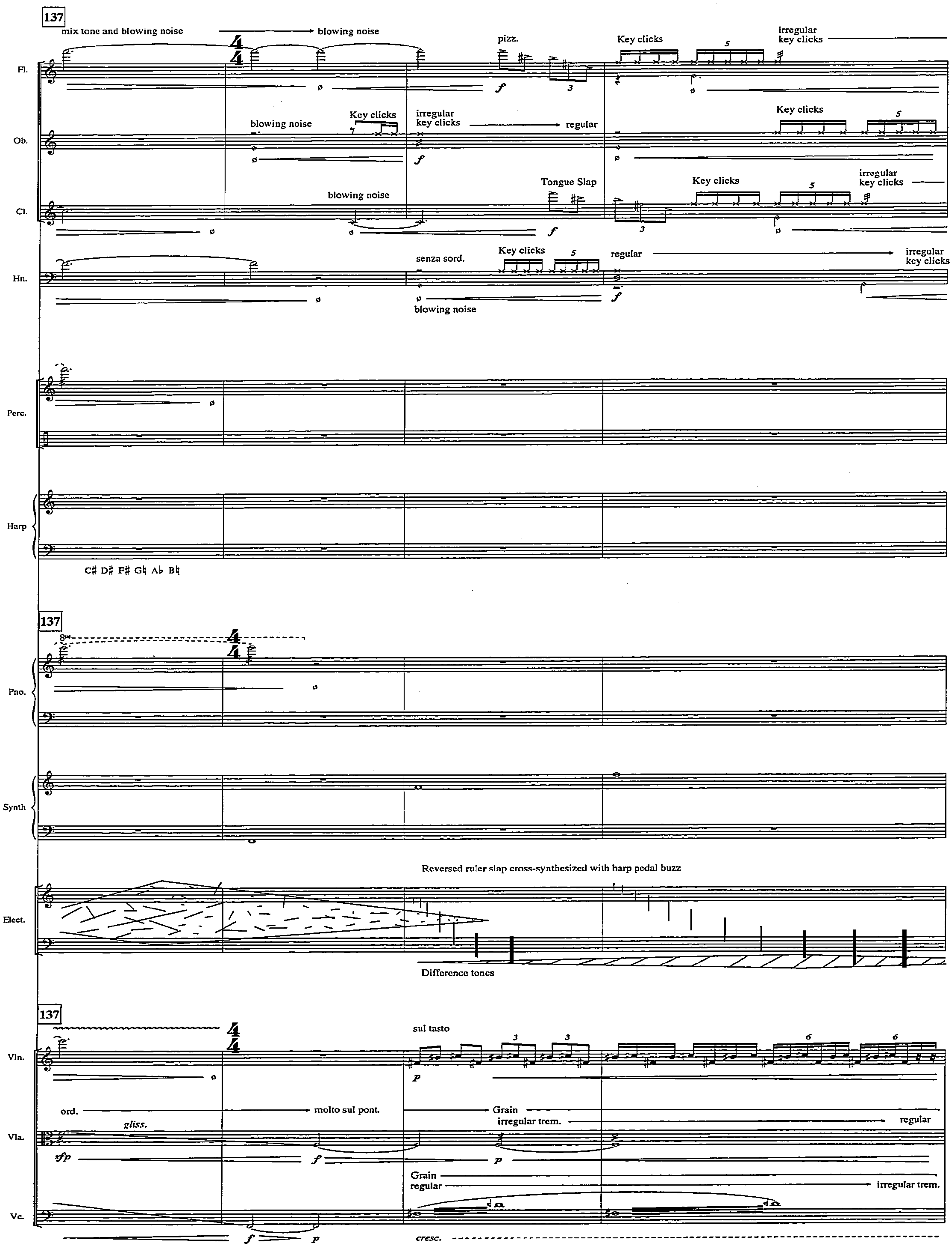

118
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
blowing noise
pizz.
mix tone and blowing noise
regular
mix tone and blowing noise
blowing noise
Tongue Slap
blowing noise
Tongue Slap
sordina
Vibes
arco
scrape rim
G♯ A♮
Synthesizer solo
Jeté
gliss.
ord.
Jeté
gliss.
ord.
gliss.

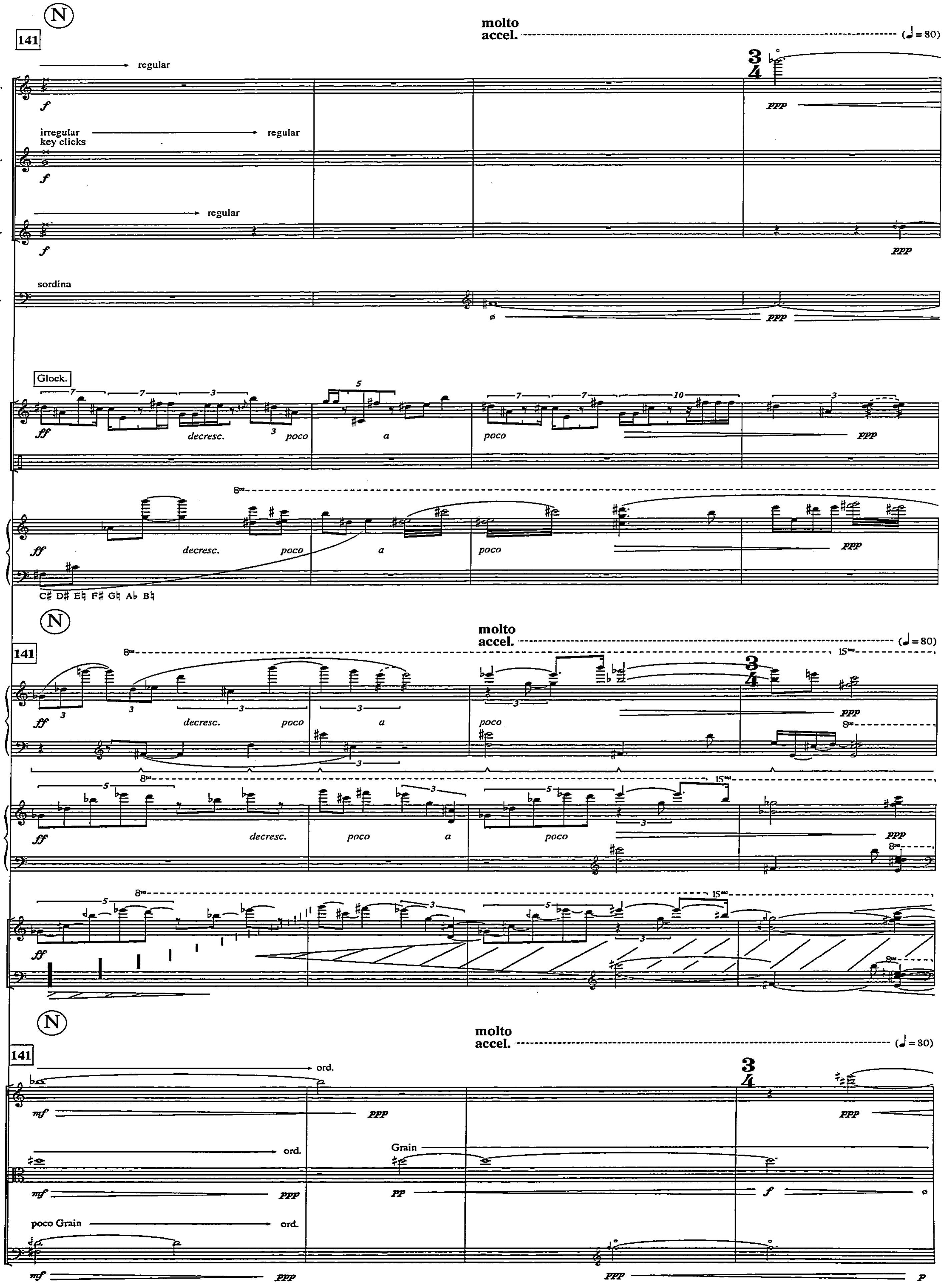

M
122
blowing noise
ord.
Fl.
ppp
ff
ord.
Ob.
mix tone and blowing noise
ord.
Cl.
pp
senza sord.
blowing noise
sordina
Hn.
Perc.
p
f
Harp
C♮
M
122
Pno.
Synth
Elect.
M
122
sul pont.
Vln.
Vla.
Grain
Vc.

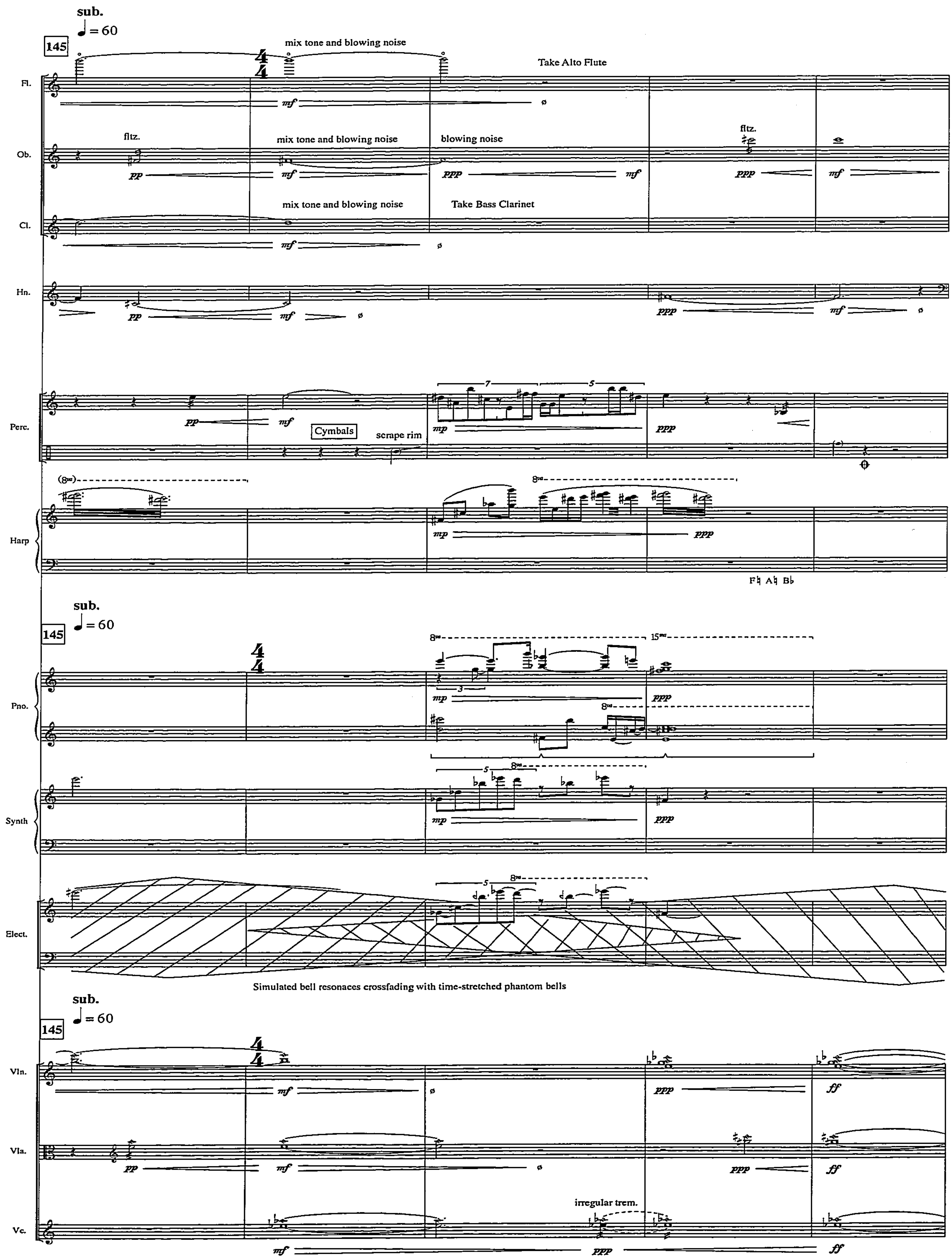

125
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
C♮ D♭ E♭ F♮ G♯ A♮ B♮
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
pizz.
mp
pp
3
4

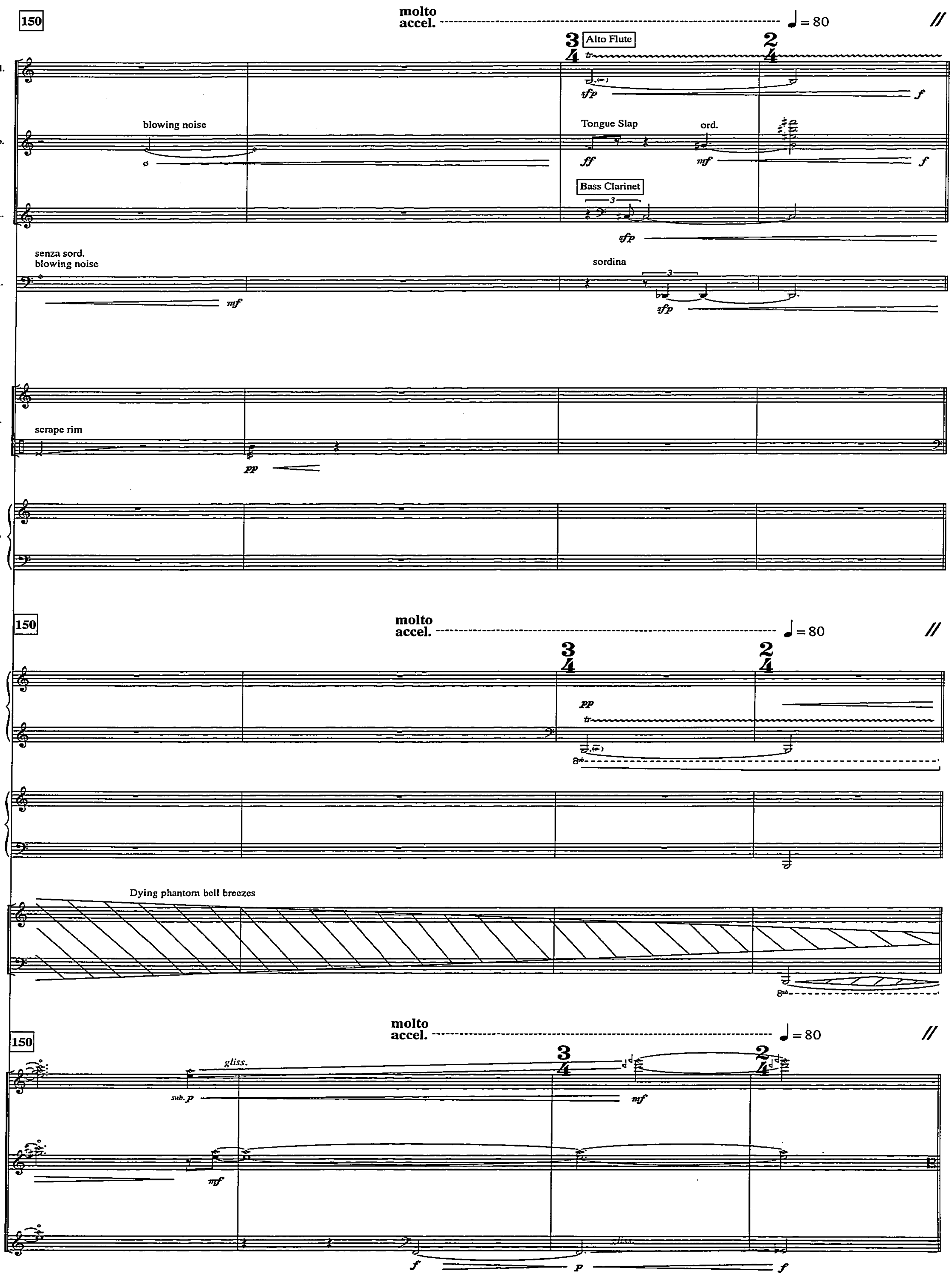

127
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
End Solo
D♮ E♮ G♮
E♮
Pno.
Synth
Elect.
Ring modulated resonance
Crossfade
Frequency Modulation Timbre
Progressive filtering of lower frequencies
Vln.
arco
Vla.
arco
sul tasto
Vc.
arco
Grain
ord.
sul tasto


131
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Gb
Pno.
Synth
High progressively granularized resonant partials
Elect.
Filtered instrumental noises
Vln.
sul pont.
molto expressivo
Vla.
ord.
gliss.
Vc.


137
mix tone and blowing noise
blowing noise
pizz.
Key clicks
irregular key clicks
Fl.
blowing noise
Key clicks
irregular key clicks
regular
Ob.
Tongue Slap
Key clicks
irregular key clicks
Cl.
senza sord.
Key clicks
regular
irregular key clicks
blowing noise
Hn.
Perc.
Harp
C♯ D♯ F♯ G♮ A♭ B♮
137
Pno.
Synth
Reversed ruler slap cross-synthesized with harp pedal buzz
Elect.
Difference tones
137
sul tasto
Vln.
ord.
molto sul pont.
Grain
irregular trem.
regular
gliss.
Vla.
Grain
regular
irregular trem.
Vc.
cresc.


N
141
molto accel.
(♩= 80)
regular
irregular key clicks
regular
regular
sordina
Glock.
decresc.
poco
a
poco
C♯ D♯ E♮ F♯ G♮ A♭ B♮
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
ord.
ord.
Grain
poco Grain
ord.

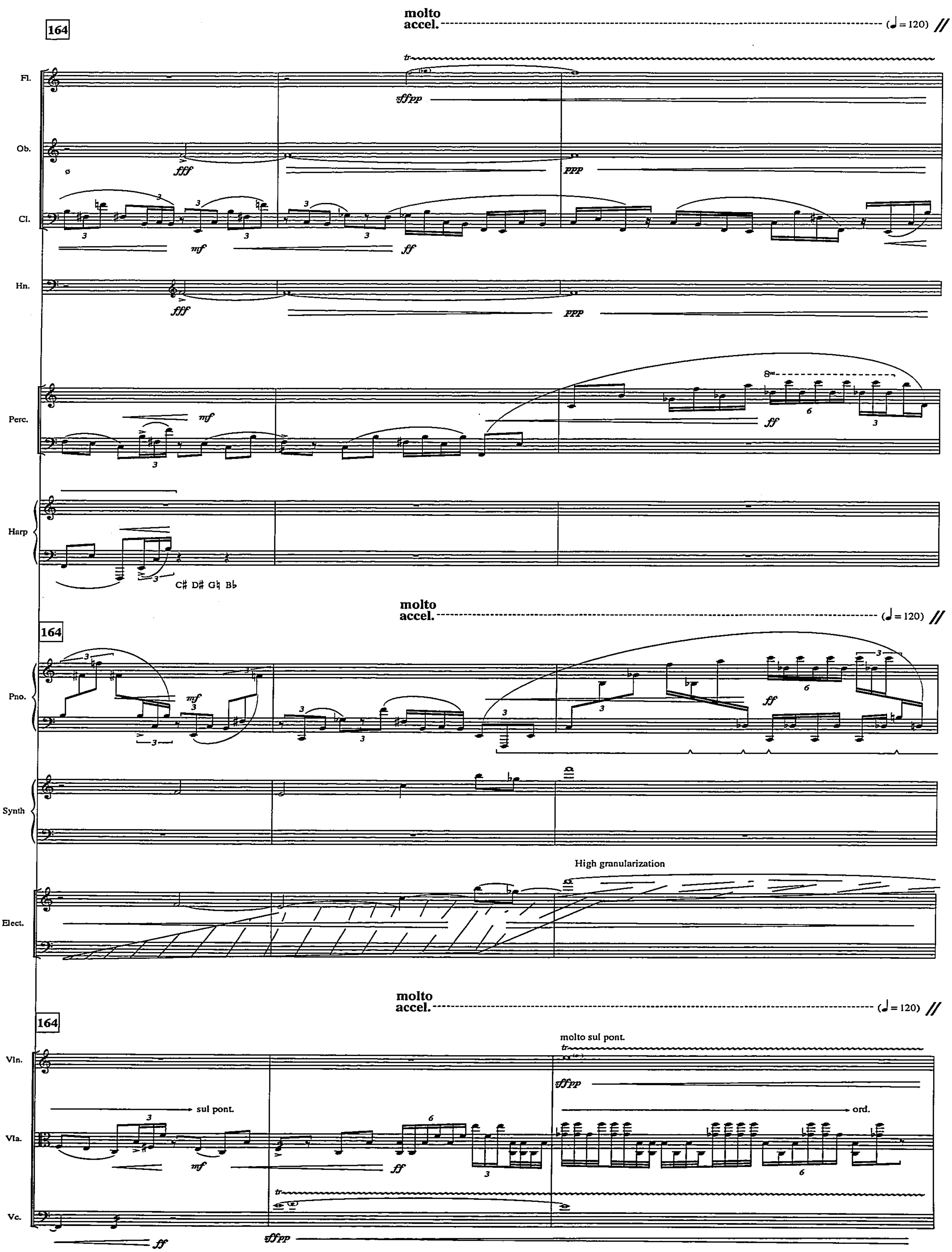

sub.
♩ = 60
145
mix tone and blowing noise
Take Alto Flute
Fl.
fltz.
mix tone and blowing noise
blowing noise
fltz.
Ob.
mix tone and blowing noise
Take Bass Clarinet
Cl.
Hn.
Cymbals
scrape rim
Perc.
Harp
F♮ A♮ B♭
sub.
♩ = 60
145
Pno.
Synth
Elect.
Simulated bell resonaces crossfading with time-stretched phantom bells
sub.
♩ = 60
145
Vln.
Vla.
irregular trem.
Vc.

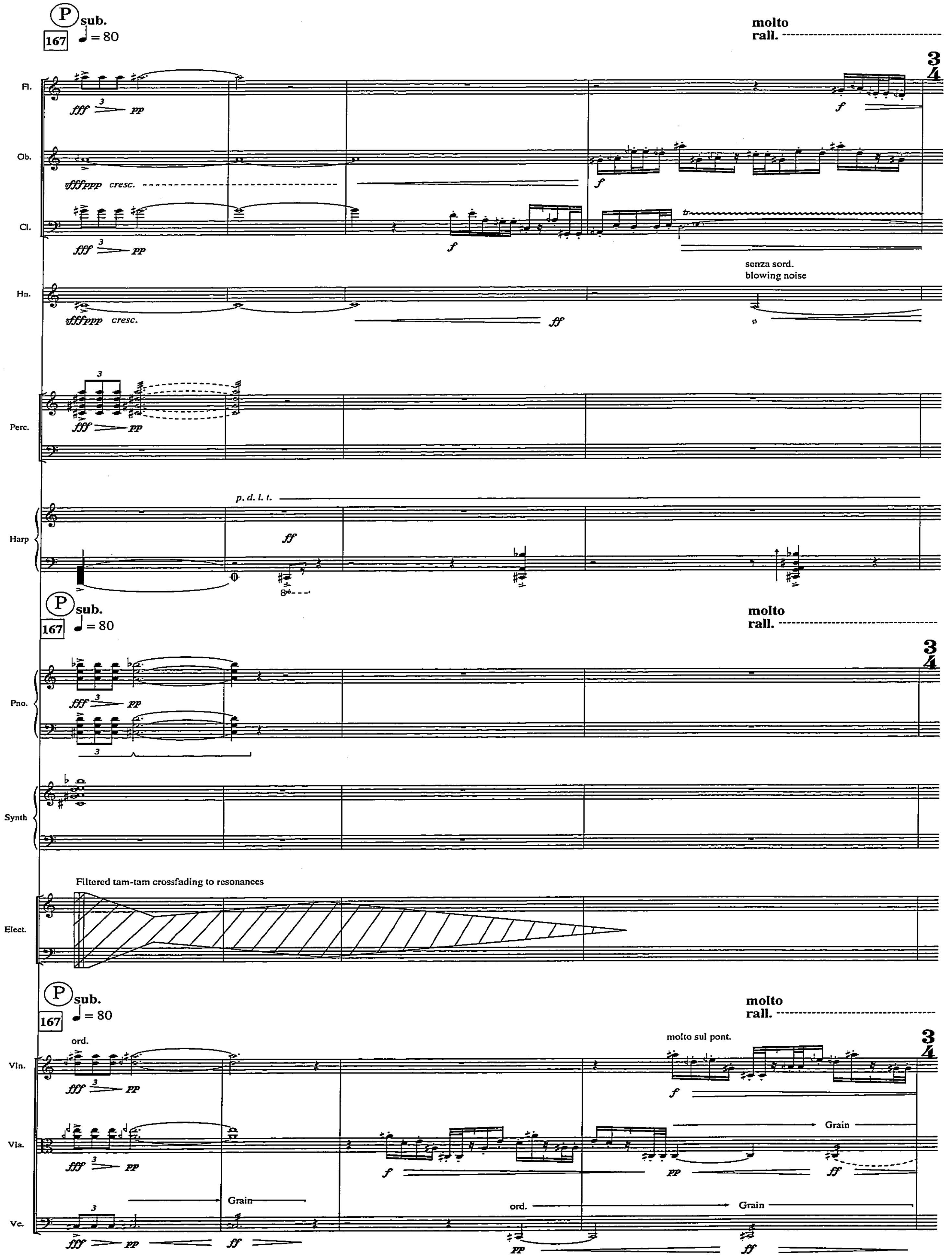

150
molto accel.
= 80
Alto Flute
Fl.
Ob.
blowing noise
Tongue Slap
ord.
Bass Clarinet
Cl.
senza sord.
blowing noise
sordina
Hn.
Perc.
scrape rim
Harp
Pno.
Synth
Dying phantom bell breezes
Elect.
gliss.
sub. p
Vln.
Vla.
Vc.

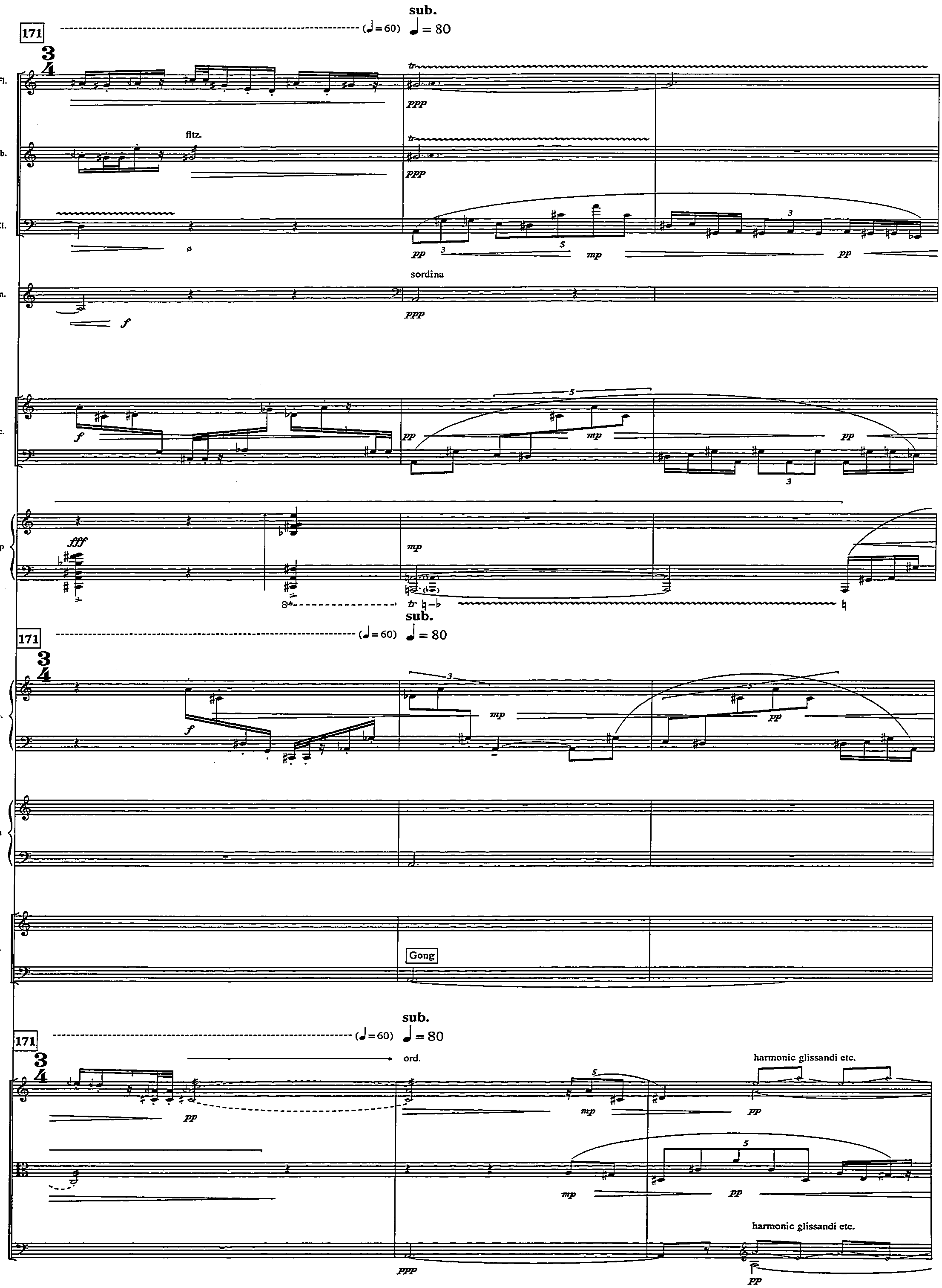

O
molto accel. (♩=107)
sub. ♩=80
154
Fl.
Ob.
fltz.
Cl.
Hn.
Marimba
Perc.
Harp
C♯ D♯ E♮ F♮ G♯ A♮ B♭
Pno.
Synth
Elect.
Gong
Vln.
Vla.
pizz.
arco
Vc.


158
Fl.
Ob.
Cl.
fltz.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Gong
Vln.
Vla.
Vc.


161
molto rall.
(♩= 60)
sub. ♩= 80
Fl.
Ob.
fltz.
Cl.
Hn.
Perc.
Harp
p. d. l. t.
B♮
C♮ D♯ E♮ F♮ G♭ A♮ B♭
Pno.
Synth
Elect.
Gong
Vln.
irregular trem.
Vla.
Vc.

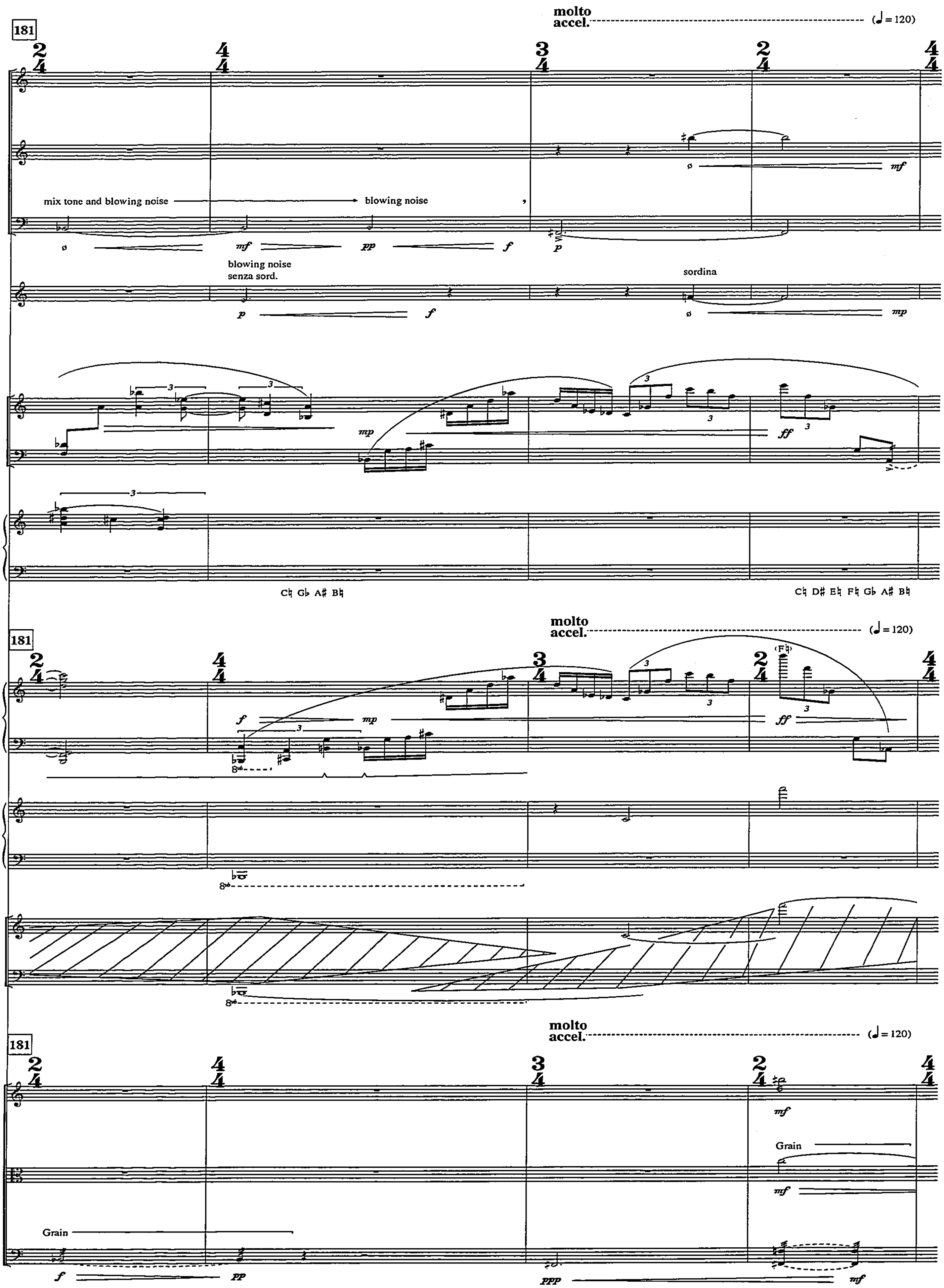

164
molto accel.
(♩= 120)
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
C♯ D♯ G♮ B♭
Pno.
Synth
High granularization
Elect.
molto sul pont.
sul pont.
ord.
Vln.
Vla.
Vc.

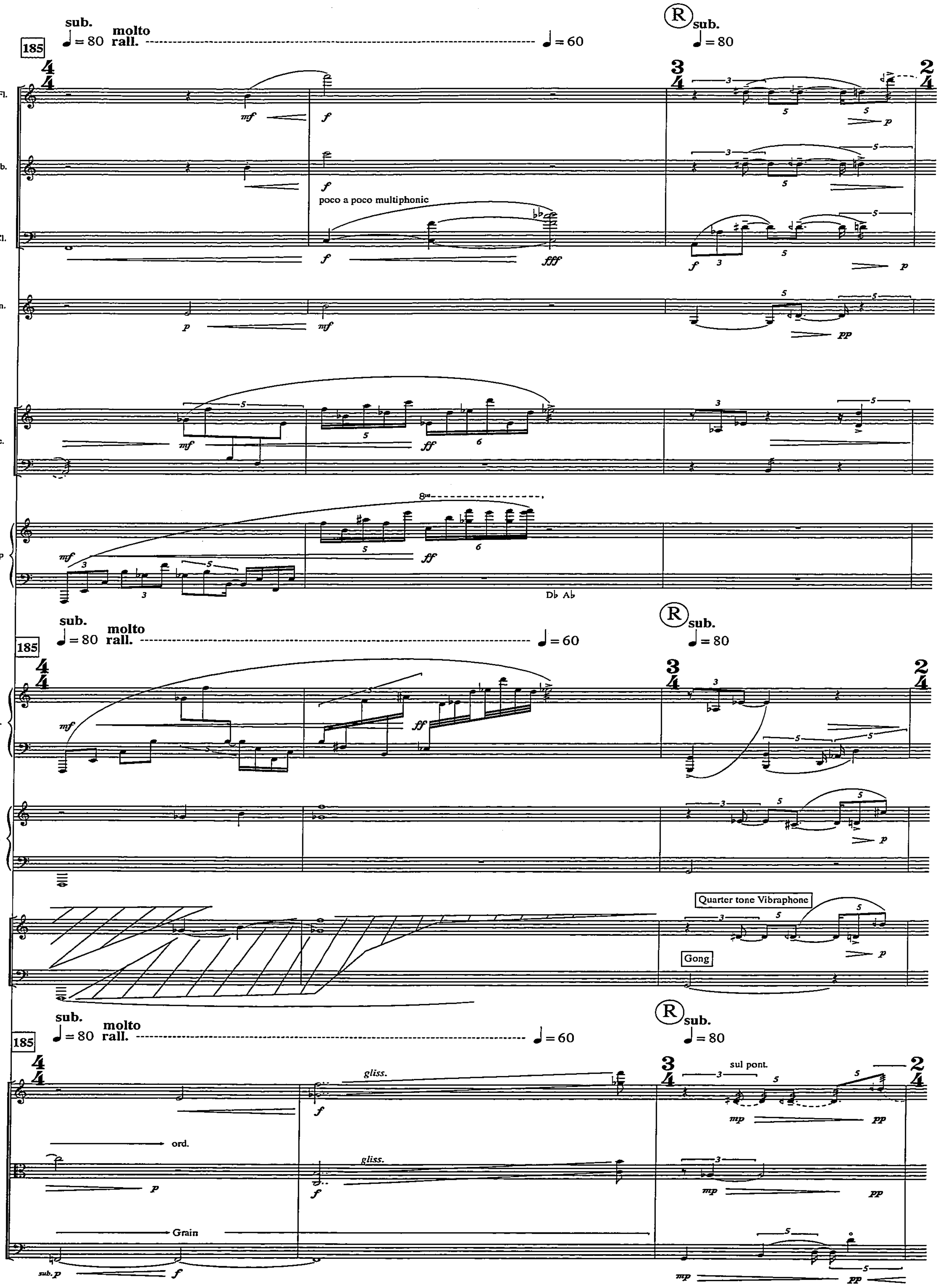

P sub.
167
♩ = 80
molto rall.
3/4
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fff pp
sfffppp cresc.
f
ff
senza sord.
blowing noise
p. d. l. t.
Filtered tam-tam crossfading to resonances
ord.
molto sul pont.
Grain
pp


171
(♩= 60) sub. ♩= 80
Fl.
Ob.
fltz.
Cl.
Hn.
sordina
Perc.
Harp
Pno.
Synth
Elect.
Gong
Vln.
ord.
harmonic glissandi etc.
Vla.
Vc.
harmonic glissandi etc.


molto accel.
174
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
mf
ppp
p
pp
mp
ff
8va


177
(♩ = 100)
Q sub.
♩ = 80
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
fltz.
C♯ D♯ E♮ F♮ G♮ A♮ B♭
Filtered tam-tam crossfading to resonances
irregular trem.
irregular trem.
gliss.

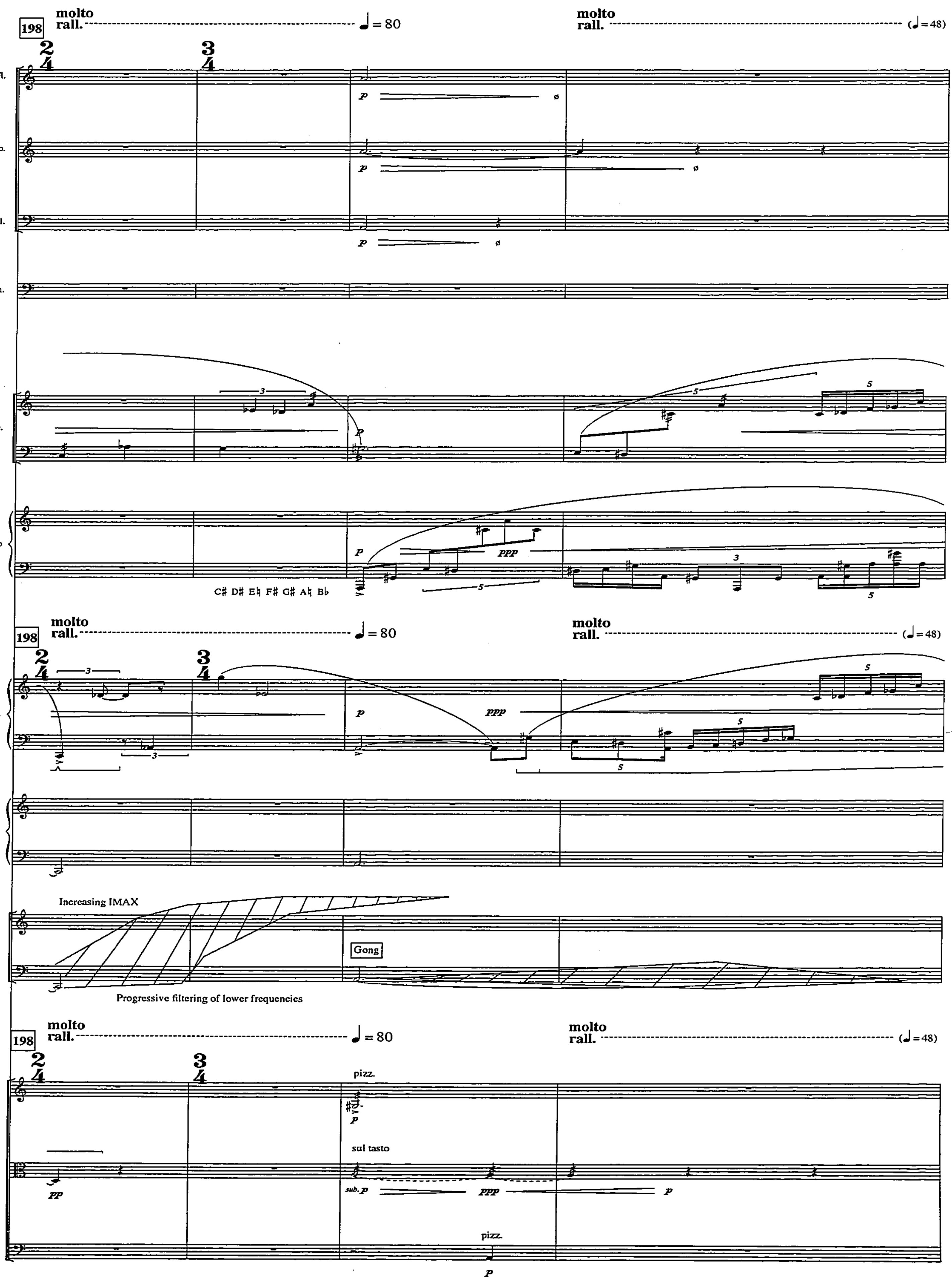

molto accel.
(♩ = 120)
181
Fl.
Ob.
Cl.
mix tone and blowing noise
blowing noise
Hn.
blowing noise
senza sord.
sordina
Perc.
Harp
C♮ G♭ A♯ B♮
C♮ D♯ E♮ F♮ G♭ A♯ B♮
Pno.
Synth
Elect.
Vln.
Vla.
Grain
Vc.
Grain

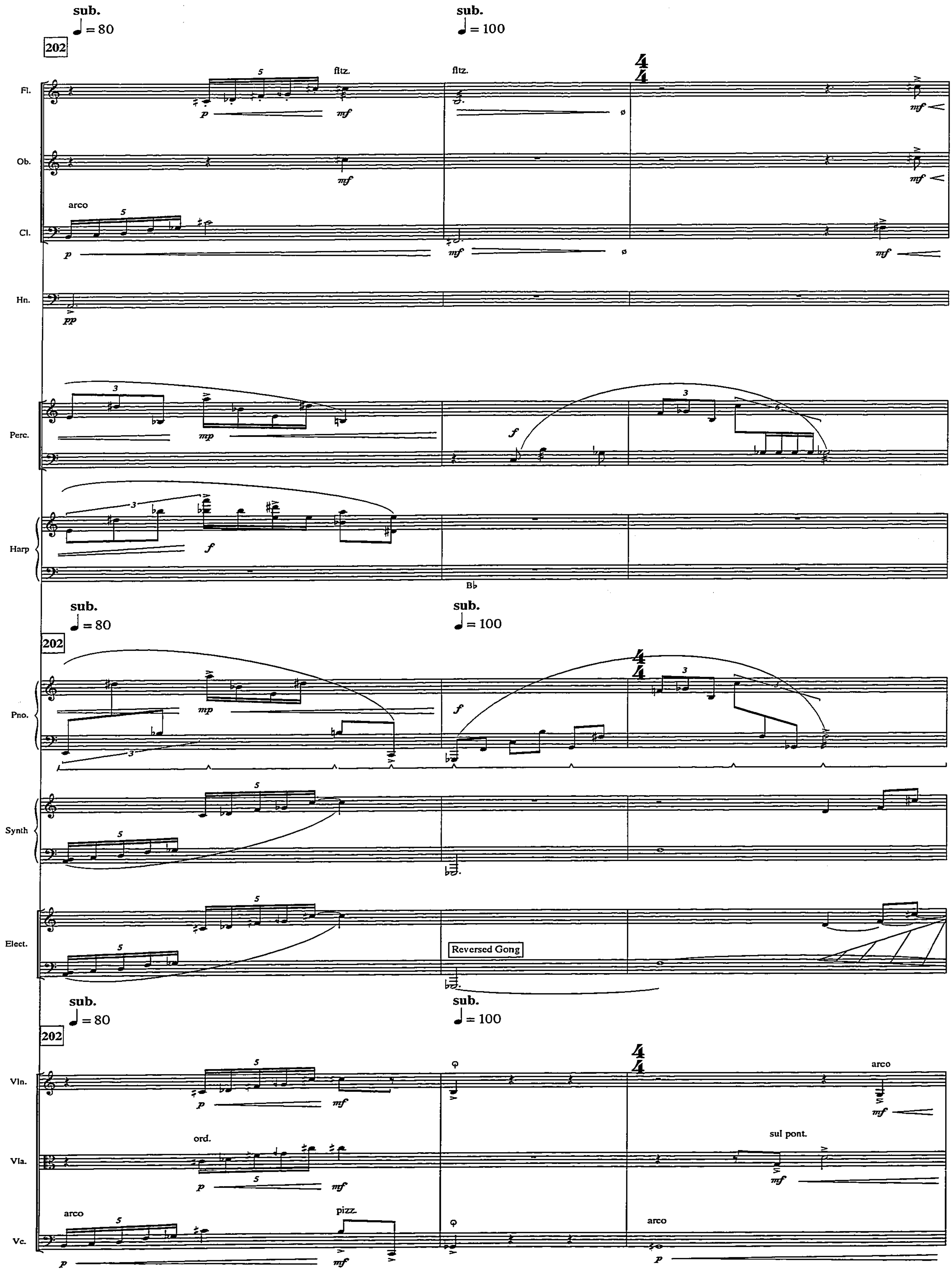

185
sub.
molto rall.
R
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
poco a poco multiphonic
Db Ab
Pno.
Synth
Elect.
Quarter tone Vibraphone
Gong
Vln.
Vla.
Vc.
gliss.
sul pont.
ord.
Grain


188
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Eb F# G♮
188
Pno.
Synth
Elect.
188
ord.
Vln.
pizz.
arco
Vla.
Vc.


191
molto rall.
(♩= 66.7)
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
gliss.
Grain
C♮ D♭ E♭ F♯ G♮ A♭ B♮
G♯ A♮

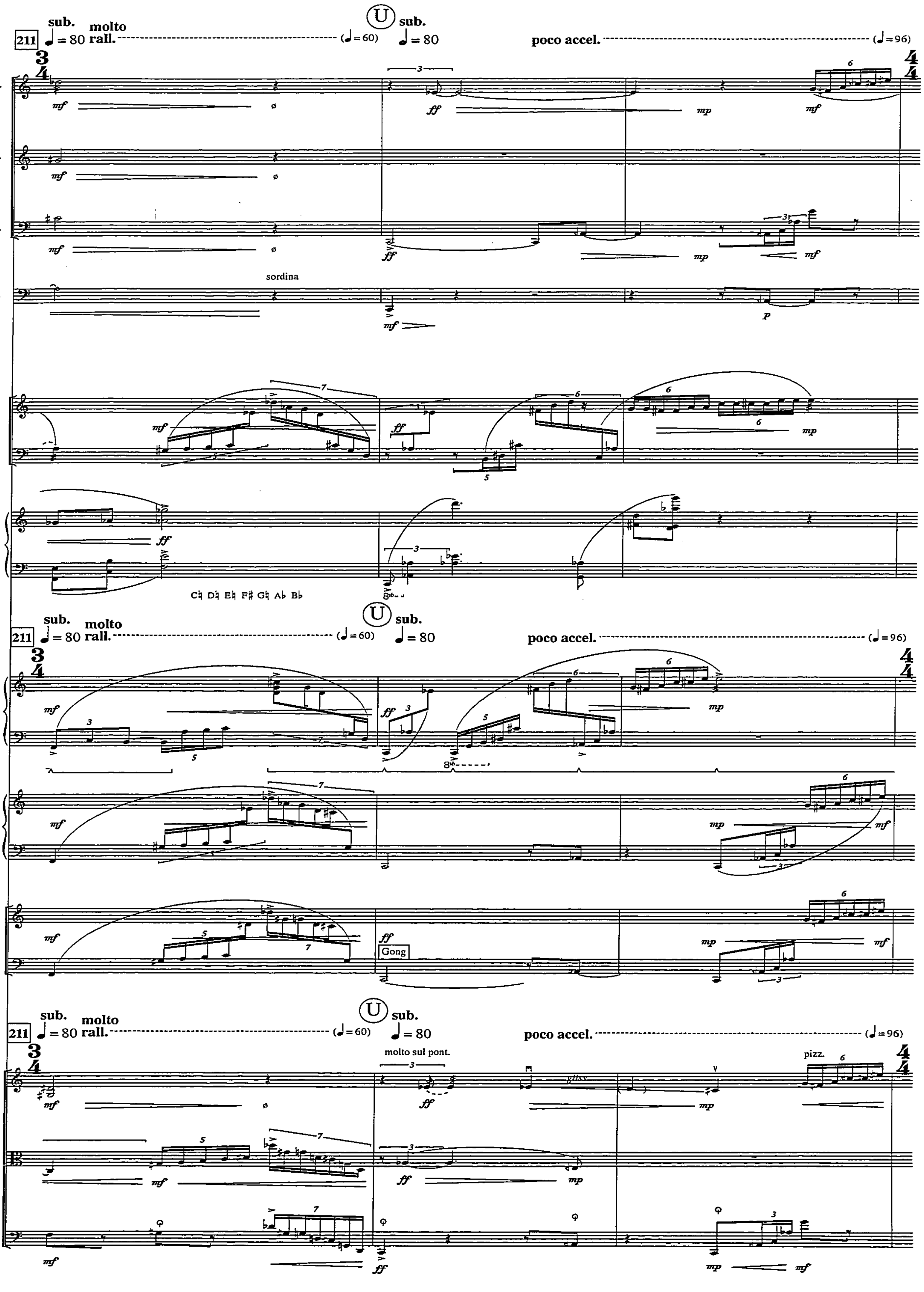

S
sub.
♩ = 100
194
pizz.
Fl.
Ob.
Tongue Slap
Cl.
blowing noise
senza sord.
blowing noise
Hn.
sordina
Perc.
Harp
C♯ D♯ E♮ B♭
Pno.
Synth
Increasing IMAX
Elect.
Frequency Modulation Timbre
Progressive filtering of lower frequencies
Vln.
arco
Grain
Vla.
Vc.

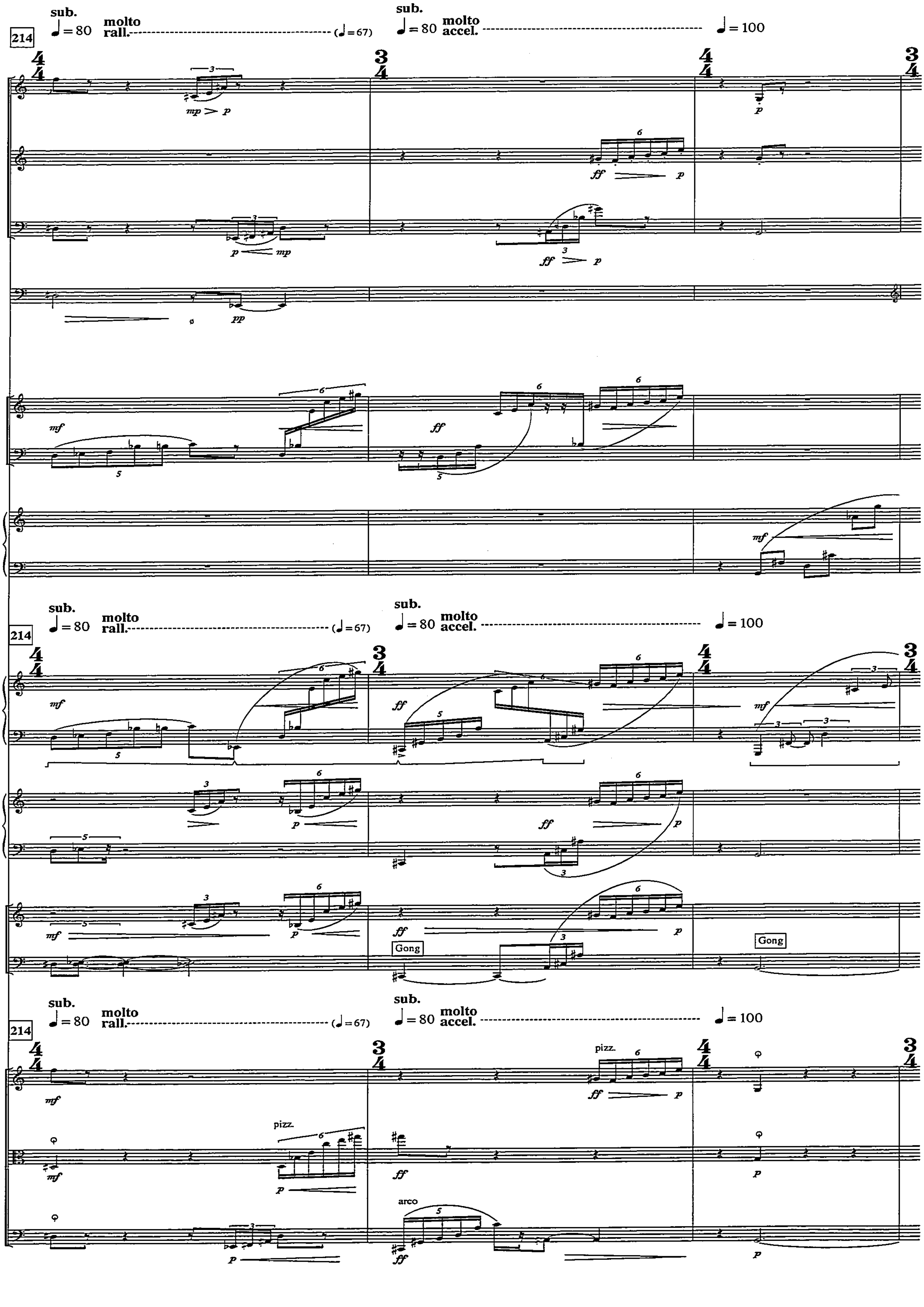

198
molto rall.
♩ = 80
molto rall.
(♩ = 48)
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
C# D# E♮ F# G# A♮ B♭
Pno.
Synth
Increasing IMAX
Elect.
Gong
Progressive filtering of lower frequencies
Vln.
pizz.
Vla.
sul tasto
Vc.
pizz.

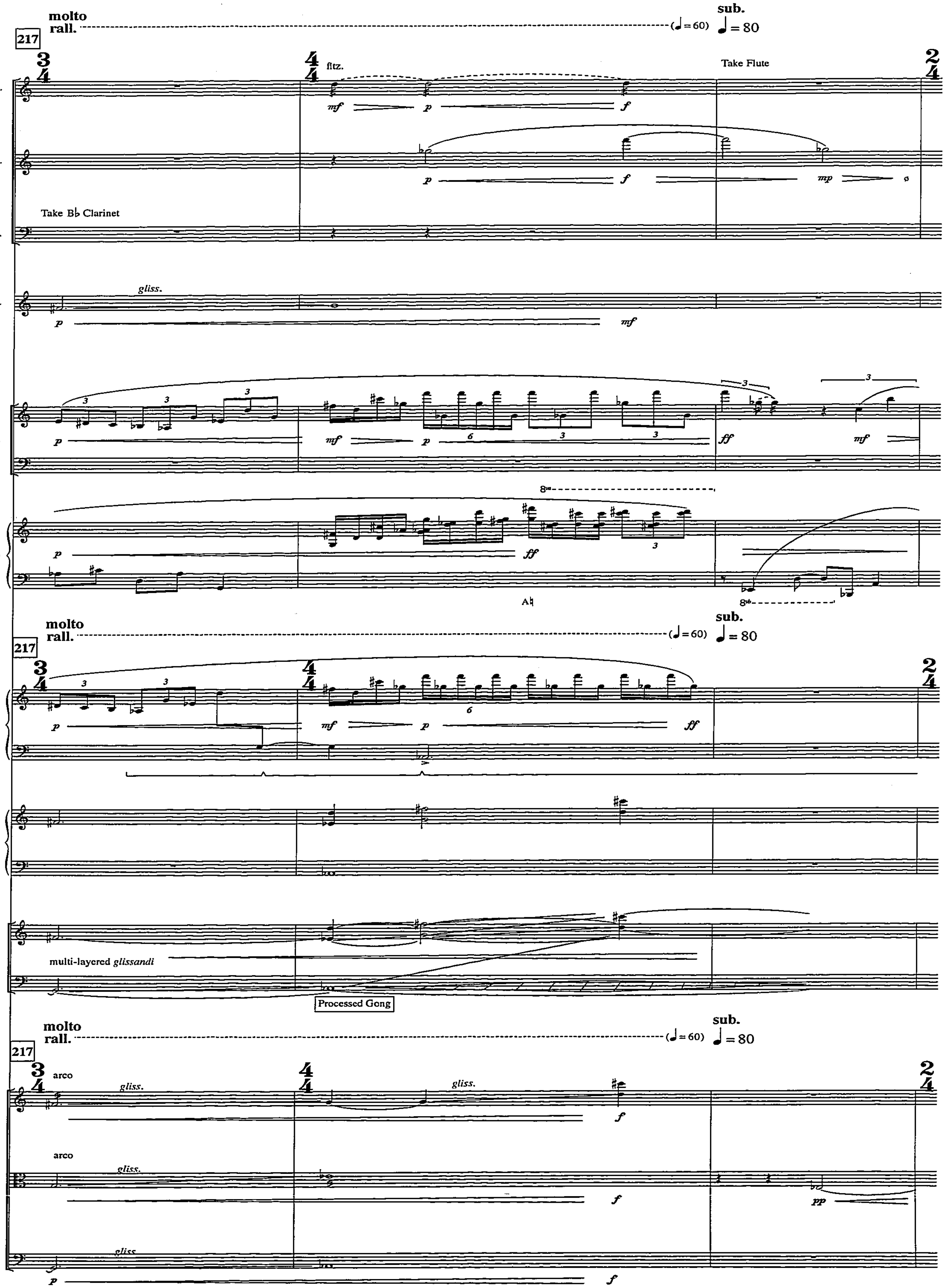

sub.
♩ = 80
202
sub.
♩ = 100
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
arco
Bb
Reversed Gong
ord.
pizz.
sul pont.

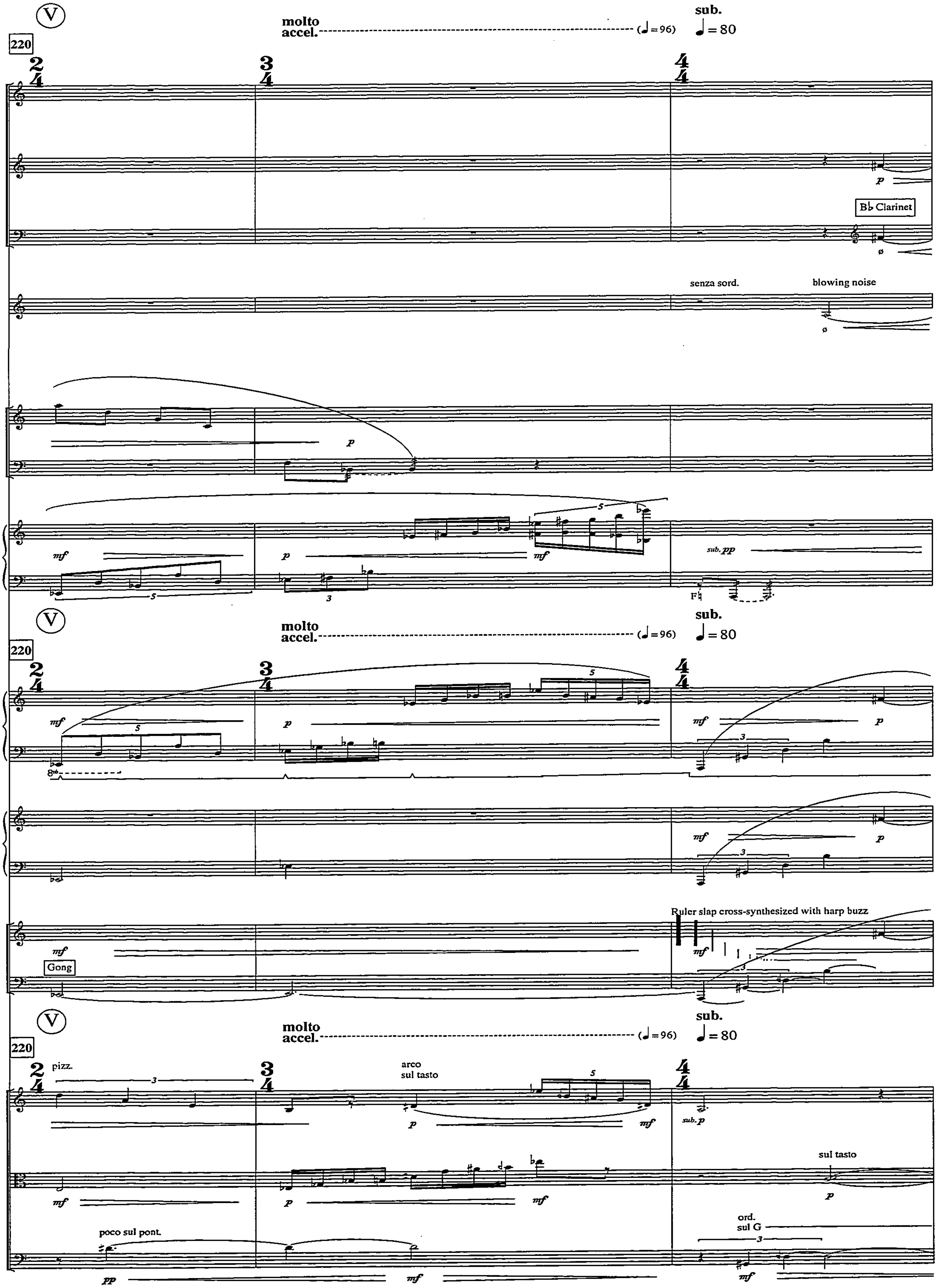

molto rall.
T
♩ = 80 poco accel.
(♩ = 96)
molto rall.
(♩ = 60)
205
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
fltz.
Crossfade of twisting resonances
Quarter tone Vibraphone
Gong
sul pont.
ord.
ord. arco
Grain


sub. ♩= 80 molto accel. (♩= 114) sub. ♩= 80 molto accel. (♩= 107)
208
Fl.
Ob.
Cl.
Hn.
senza sord.
blowing noise
Perc.
Harp
F♮ G♭ A♭
Pno.
Synth
Elect.
Gong
Reversed Gong
Vln.
Vla.
pizz.
arco
Grain
Vc.
pizz.

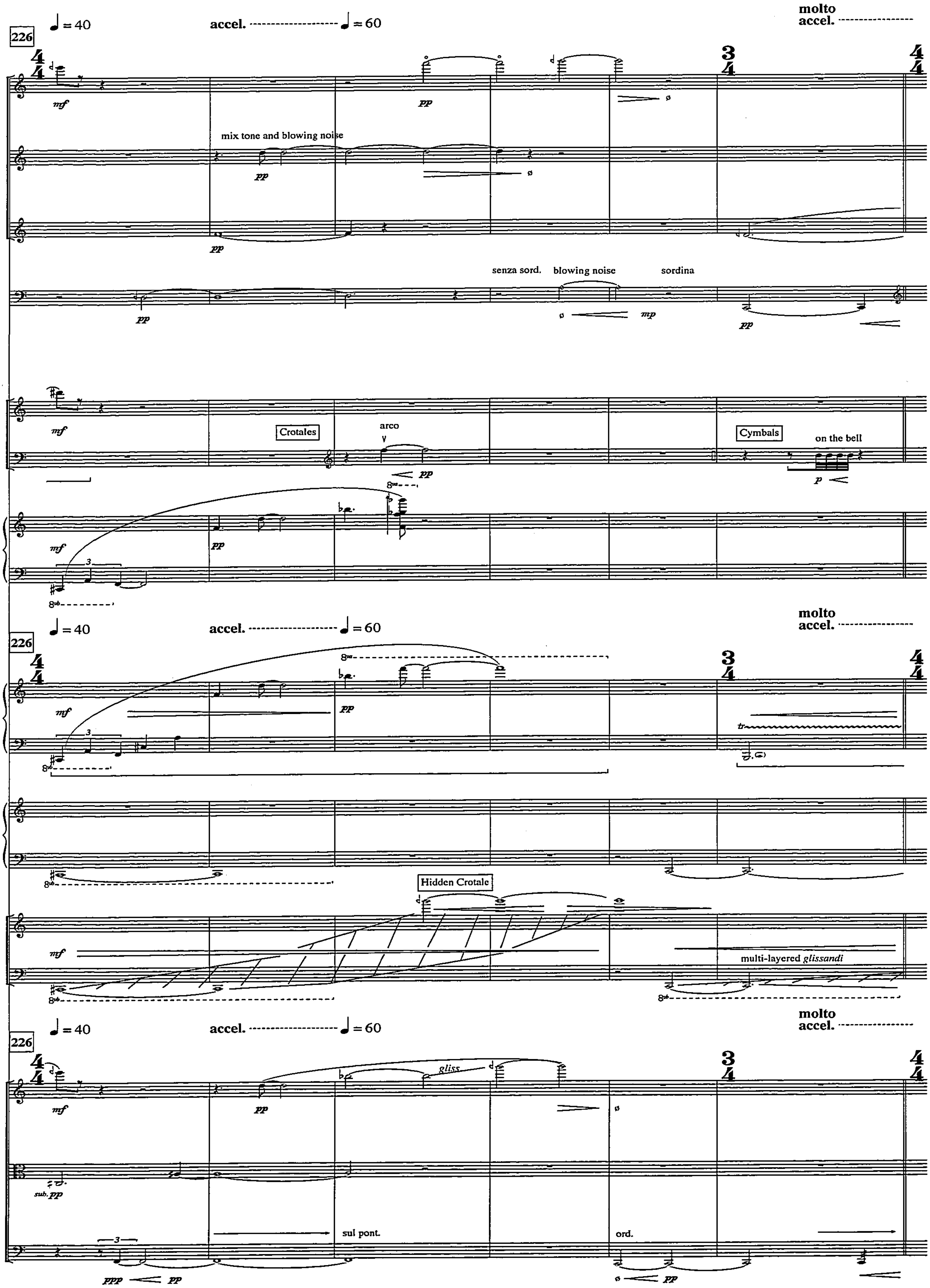

211
sub. ♩= 80 molto rall. (♩= 60)
U sub. ♩= 80
poco accel. (♩= 96)
Fl.
Ob.
Cl.
Hn.
sordina
Perc.
Harp
C♮ D♮ E♮ F♯ G♮ A♭ B♭
Pno.
Synth
Elect.
Gong
Vln.
molto sul pont.
gliss.
pizz.
Vla.
Vc.

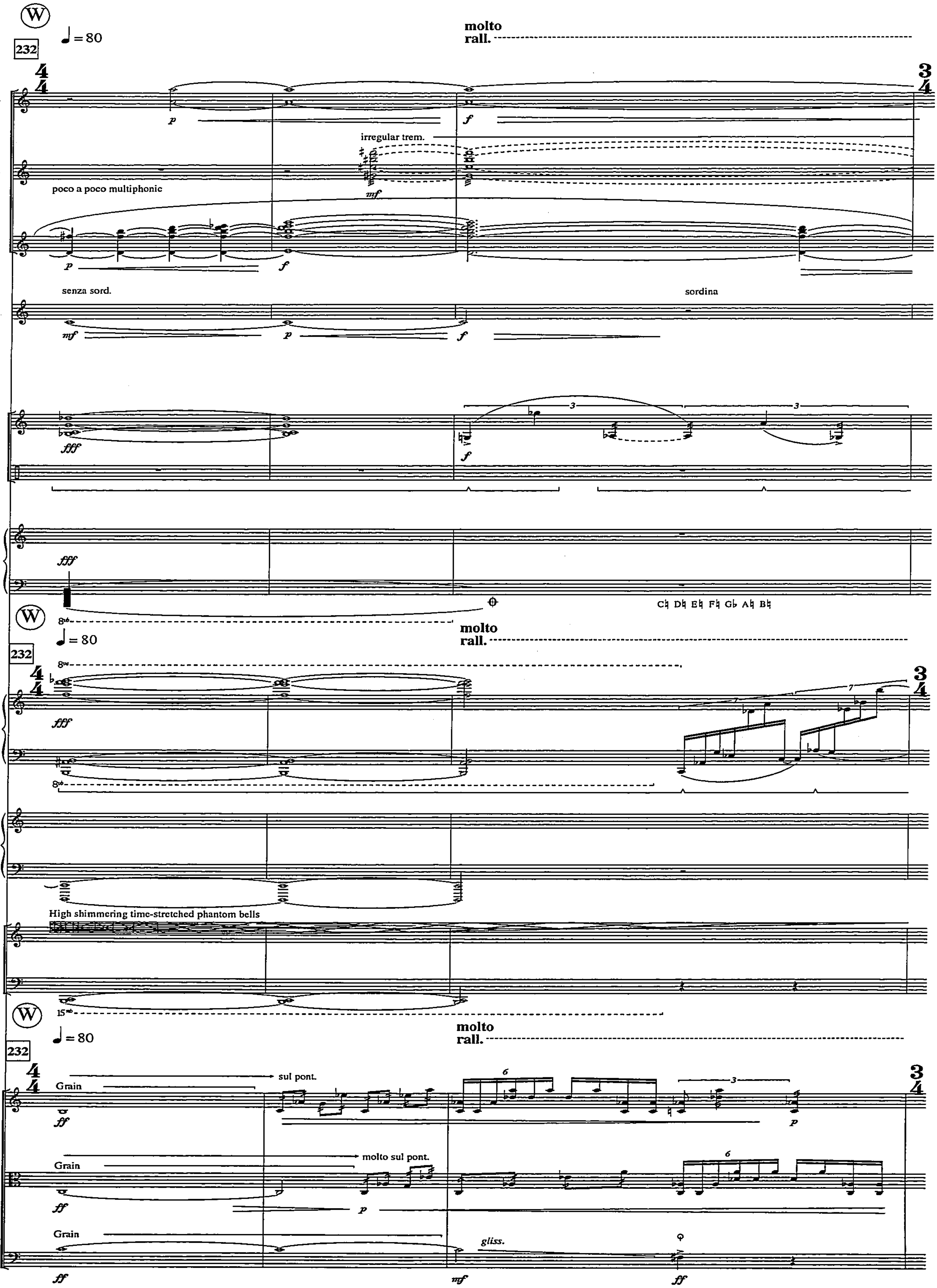

214
sub.
♩= 80 molto rall. (♩= 67)
sub.
♩= 80 molto accel. ♩= 100
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Gong
Gong
Vln.
pizz.
Vla.
pizz.
Vc.
arco

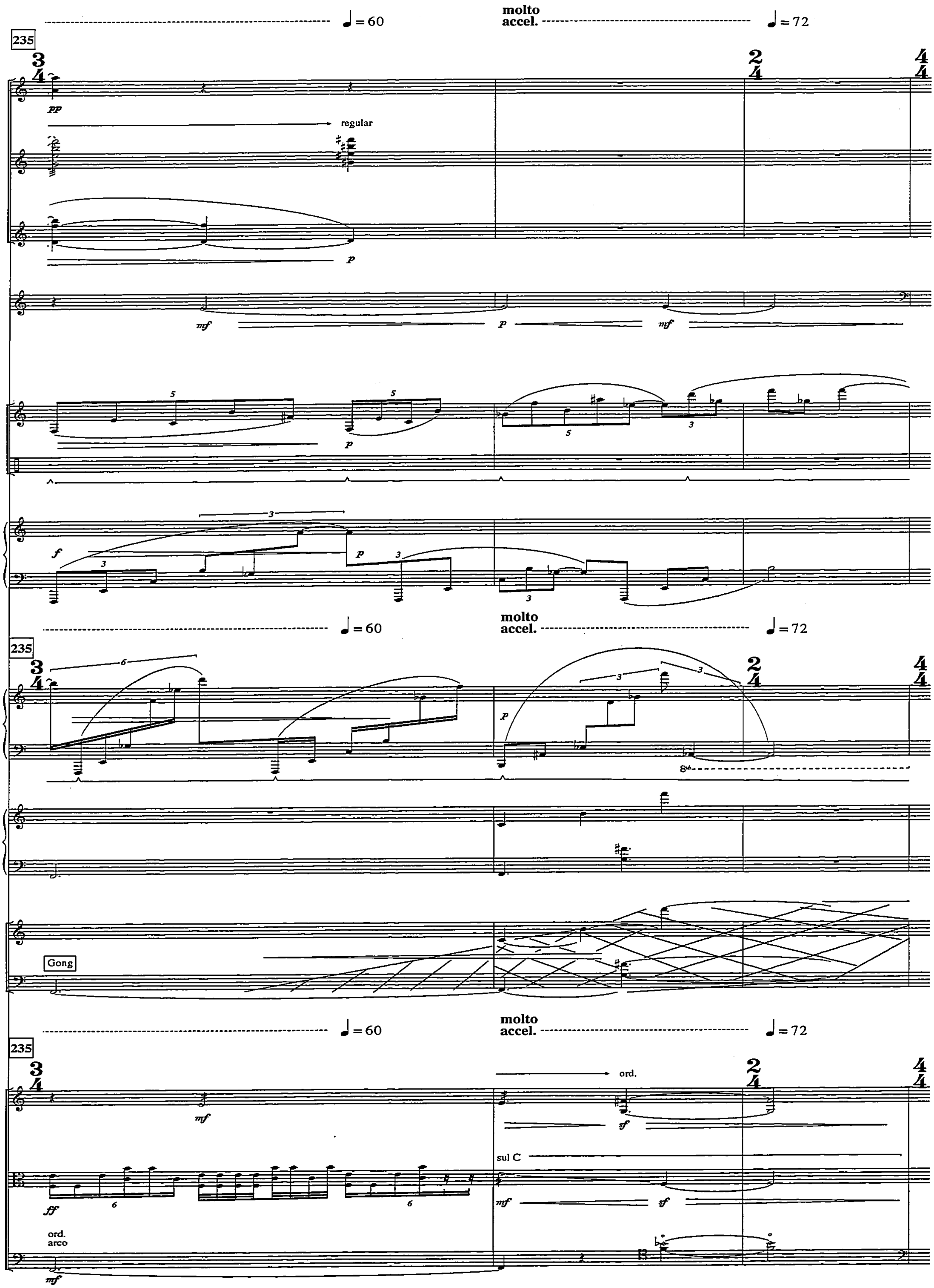

molto rall.
(♩= 60)
sub. ♩= 80
217
flz.
Take Flute
Take B♭ Clarinet
gliss.
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
A♮
Pno.
Synth
Elect.
multi-layered glissandi
Processed Gong
arco
Vln.
Vla.
Vc.


V
220
molto accel.
(♩=96)
sub. ♩=80
Fl.
Ob.
B♭ Clarinet
Cl.
senza sord.
blowing noise
Hn.
Perc.
Harp
sub. pp
F♮
Pno.
8vb
Synth
Ruler slap cross-synthesized with harp buzz
Gong
Elect.
pizz.
arco
sul tasto
Vln.
sub. p
sul tasto
Vla.
poco sul pont.
ord.
sul G
Vc.

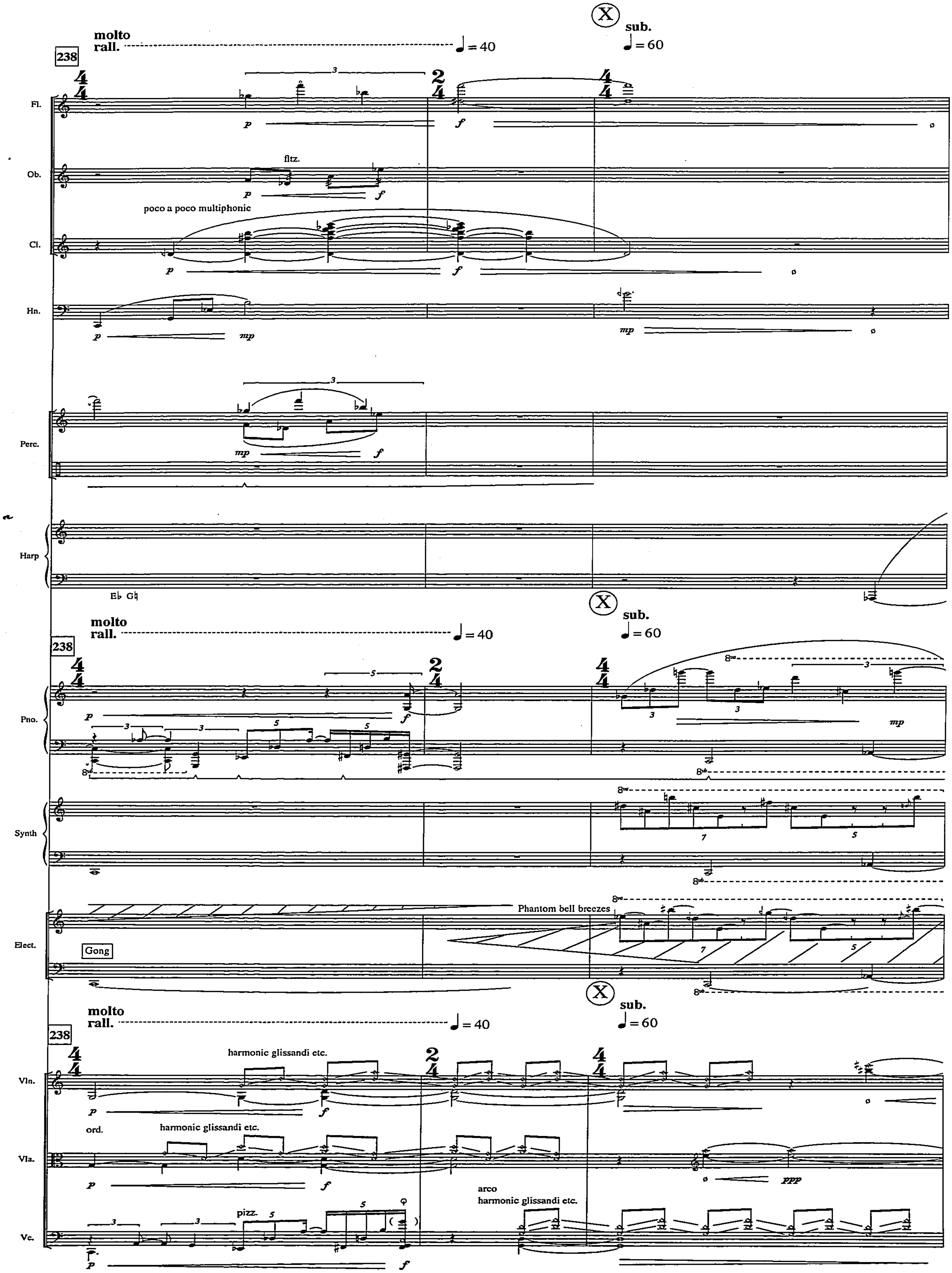

223
molto rall.
sub. ♩= 80
molto accel.
sub. ♩= 80
molto rall.
Flute
Fl.
Ob.
Cl.
Hn.
fltz.
sordina
Vibes
Perc.
Harp
C♯ D♮ E♮ F♮ G♭ A♮ B♮
Pno.
Synth
Elect.
Vln.
Vla.
Vc.
ord.


226
♩ = 40
accel.
♩ = 60
molto accel.
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
mix tone and blowing noise
senza sord.
blowing noise
sordina
Crotales
arco
Cymbals
on the bell
Pno.
Synth
Elect.
Hidden Crotale
multi-layered glissandi
Vln.
Vla.
Vc.
gliss
sul pont.
ord.

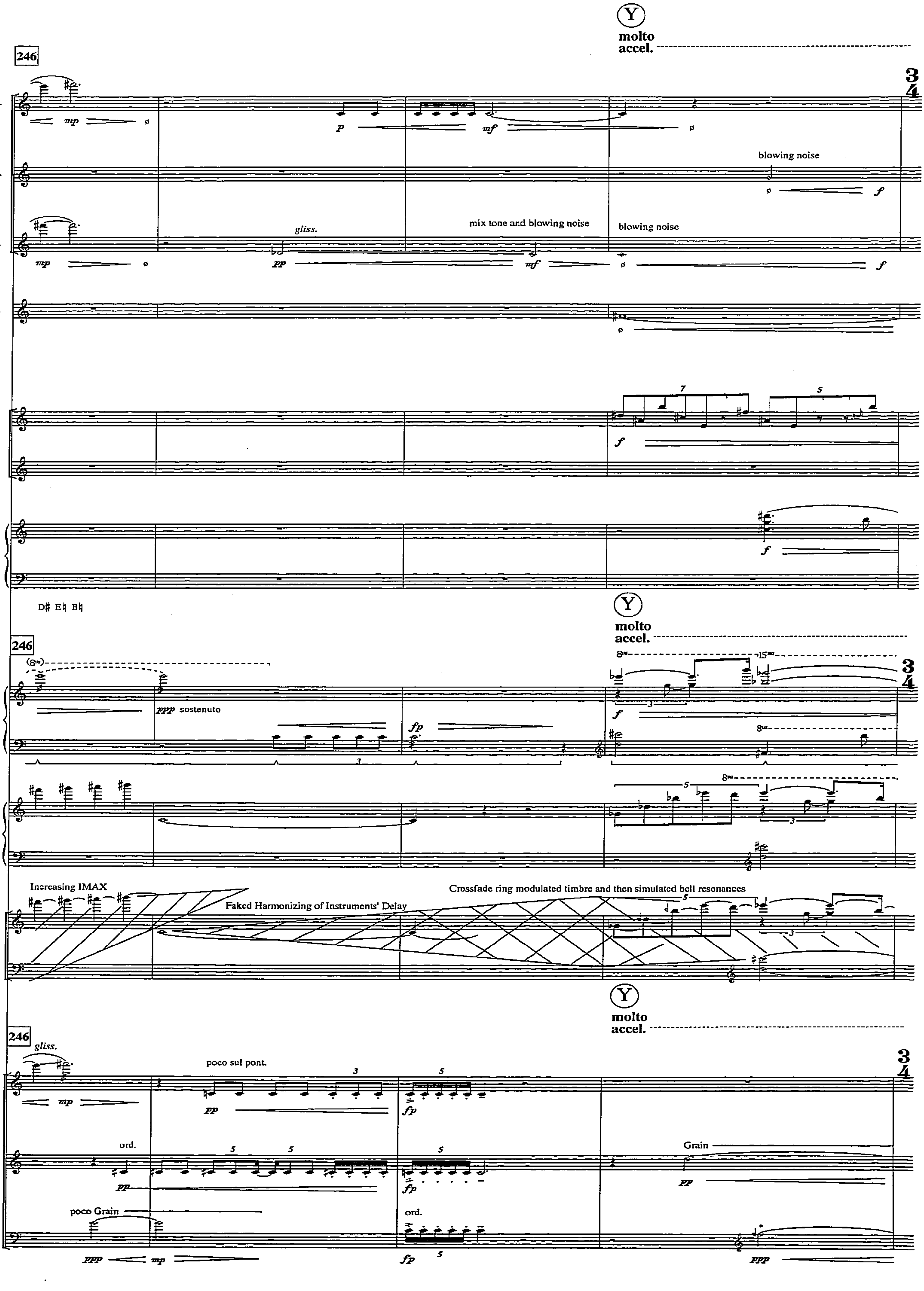

W
232
♩ = 80
molto rall.
Fl.
Ob.
poco a poco multiphonic
irregular trem.
Cl.
Hn.
senza sord.
sordina
Perc.
Harp
C♮ D♮ E♮ F♮ G♭ A♮ B♮
Pno.
Synth
High shimmering time-stretched phantom bells
Elect.
Vln.
Grain
sul pont.
Vla.
molto sul pont.
Vc.
gliss.

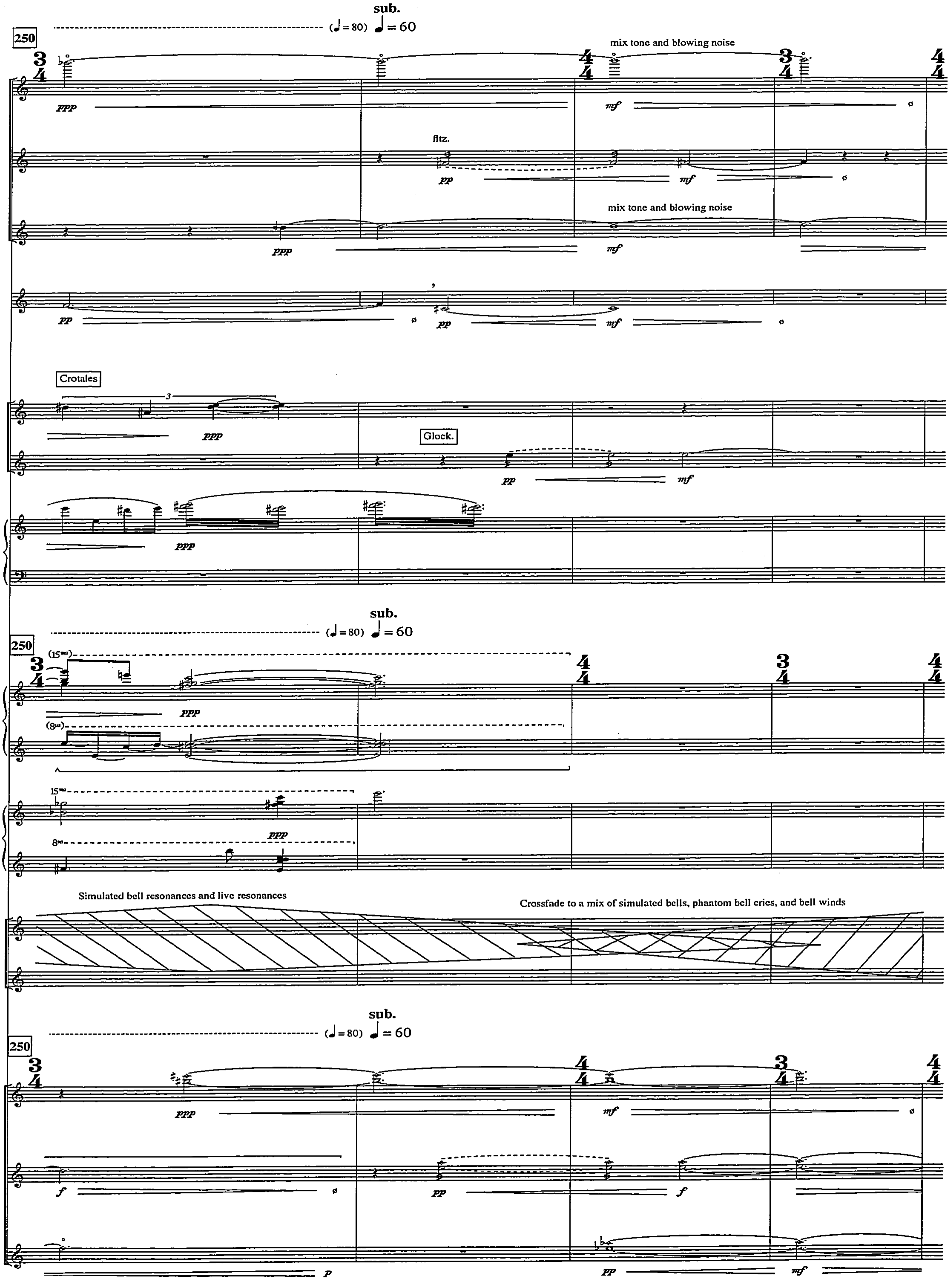


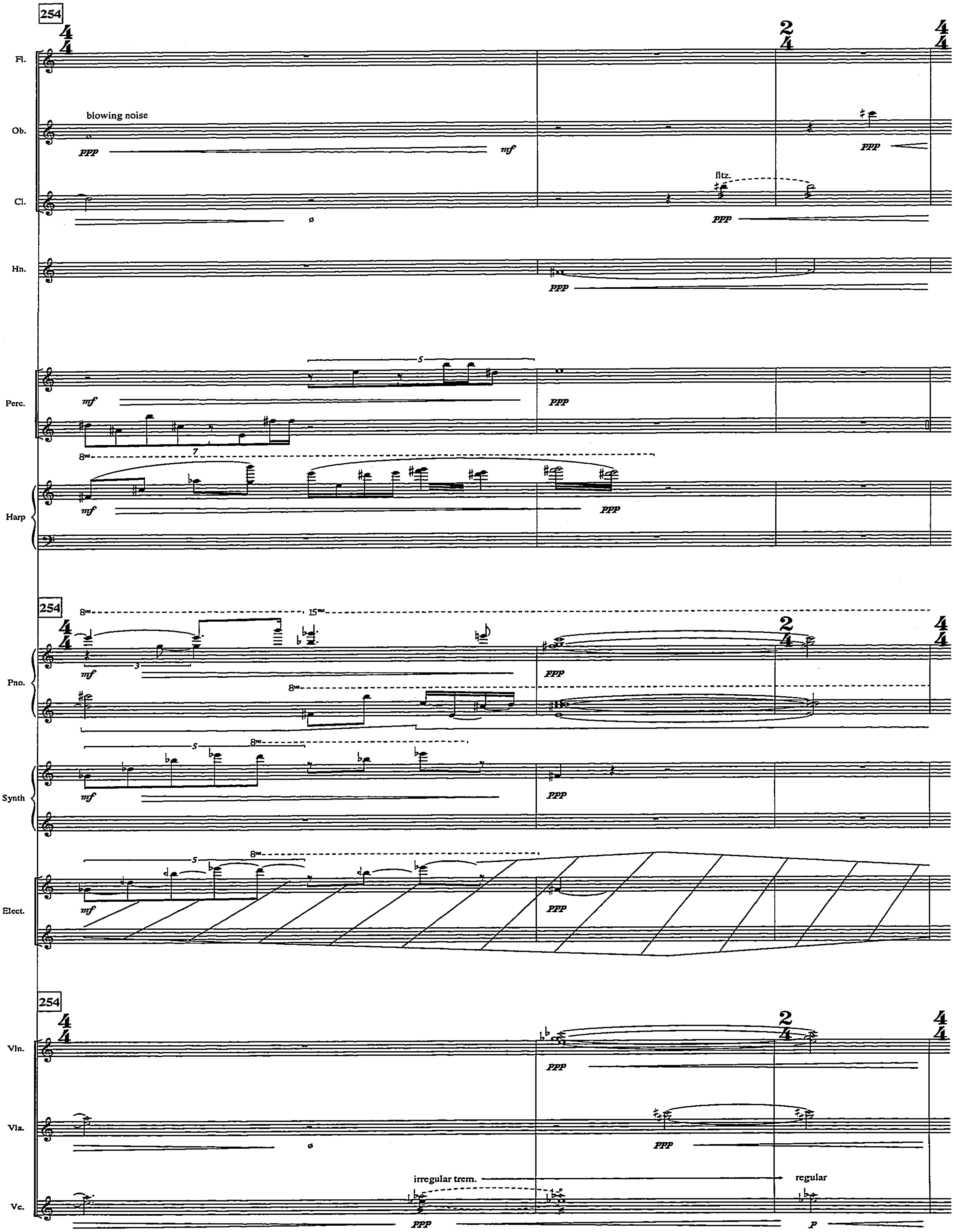
♩= 60
molto accel.
♩= 72
235
Fl.
Ob.
regular
Cl.
Hn.
Perc.
Harp
Pno.
Synth
Elect.
Gong
Vln.
ord.
Vla.
sul C
Vc.
ord. arco

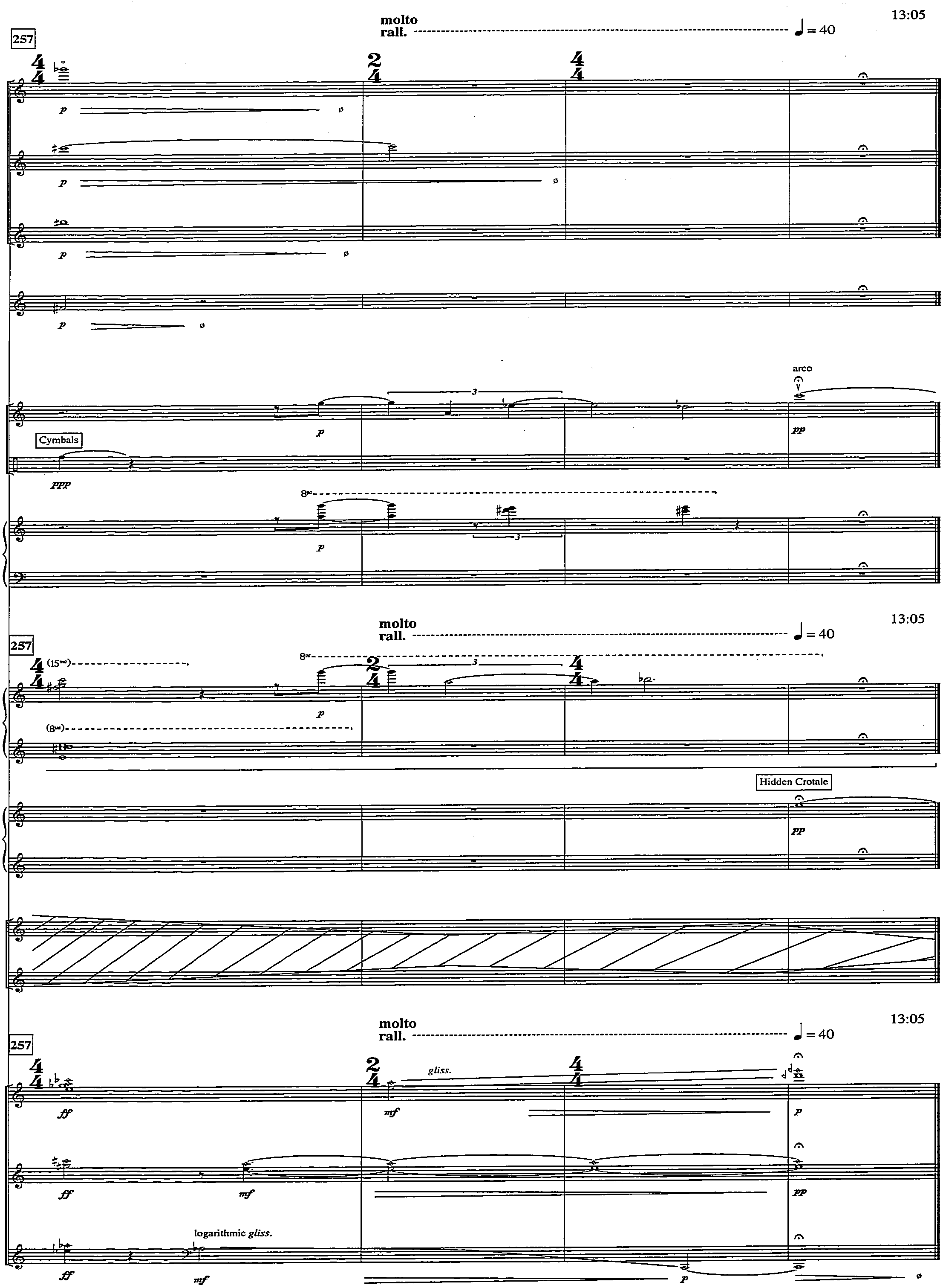

molto rall.
♩= 40
X
sub. ♩= 60
238
Fl.
Ob.
fltz.
poco a poco multiphonic
Cl.
Hn.
Perc.
Harp
E♭ G♮
Pno.
Synth
Phantom bell breezes
Gong
Elect.
Vln.
harmonic glissandi etc.
ord.
Vla.
arco
pizz.
Vc.


241
Fl.
Ob.
Cl.
Hn.
Perc.
Glock.
Crotales
arco
Harp
Pno.
Synth
Elect.
Frequency Modulation Timbre
Vln.
Vla.
sul tasto
Vc.
pizz.


Y
molto accel.
246
Fl.
Ob.
Cl.
Hn.
Perc.
Harp
blowing noise
gliss.
mix tone and blowing noise
blowing noise
D♯ E♮ B♮
Pno.
Synth
Elect.
ppp sostenuto
Increasing IMAX
Faked Harmonizing of Instruments' Delay
Crossfade ring modulated timbre and then simulated bell resonances
Vln.
Vla.
Vc.
poco sul pont.
ord.
Grain
poco Grain


sub.
(♩=80) ♩=60
250
mix tone and blowing noise
Fl.
ppp
mf
fltz.
Ob.
pp
mf
mix tone and blowing noise
Cl.
ppp
mf
Hn.
pp
pp
mf
Crotales
Perc.
ppp
Glock.
pp
mf
Harp
ppp
sub.
(♩=80) ♩=60
250
(15ma)
Pno.
ppp
(8va)
15ma
Synth
ppp
8va
Simulated bell resonances and live resonances
Crossfade to a mix of simulated bells, phantom bell cries, and bell winds
Elect.
sub.
(♩=80) ♩=60
250
Vln.
ppp
mf
Vla.
f
pp
f
Vc.
p
pp
mf


254
Fl.
Ob.
blowing noise
ppp
mf
Cl.
fltz.
ppp
Hn.
ppp
Perc.
mf
5
7
ppp
Harp
mf
ppp
254
Pno.
3
mf
ppp
Synth
5
mf
ppp
Elect.
5
mf
ppp
254
Vln.
ppp
Vla.
ppp
Vc.
irregular trem.
regular
ppp
p



257
molto rall.
♩ = 40
13:05
Fl.
Ob.
Cl.
Hn.
Perc.
Cymbals
arco
Harp
Pno.
Synth
Hidden Crotale
Elect.
Vln.
gliss.
Vla.
Vc.
logarithmic gliss.