UNIVERSITY OF CALIFORNIA, SAN DIEGO

Mechanisms and Threads

A dissertation submitted in partial satisfaction
of the requirements for the degree
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in
Music

by

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2012

The dissertation of Richard Snow is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Chair

University of California, San Diego

2012

DEDICATION

To my family for their love and support.

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Stereo Recording of Singing Sweetly from a Spider's Web on file at the Mandeville Special Collections Library.

ACKNOWLEDGEMENT

This dissertation would not have been possible without the community of Composers and Computer Musicians in the UCSD Music Department and more specifically those working at the Center for Research in Computing and the Arts. The ideas and techniques refined in *Labyrinth*, *Old Windows, New Worlds,* and *KnownUnknown* came to fruition in large part because of feedback from this community of composers and researchers. In particular I'd like to thank Ben Hackbarth, Joachim Gossmann, and Adam Wilson for their comraderie and advice during the creation of these pieces.

I would also like to thank my composition teachers at UCSD, Philippe Manoury and Chaya Czernowin, for all their wisdom as well as their patience with my projects over the course of their completion.

Each of the pieces outlined in this dissertation was created with intense use of the Pure Data programming environment. I wish to express my deep gratitude to Miller Puckette and the rest of the Pure Data community for providing and maintaining such a special artistic tool.

Finally, and most importantly I must thank Katalin Lukács for her love, support, and virtuosity which inspire me every day.

VITA

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ABSTRACT OF THE DISSERTATION

Mechanisms and Threads

by

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Doctor of Philosophy in Music

University of California, San Diego, 2012

Professor Philippe Manoury, Chair

Mechanisms and Threads is a series of four related compositions. The first project, titled *Labyrinth,* is a surround sound computer playback composition. The second project, titled *Old Windows, New Worlds*, is a notated composition for custom midi keyboard controlled surround synthesis instrument. The third project, titled *KnownUnknown*, is a quasi improvisatory composition for custom audio/video instrument. The fourth project is a notated three movement work for piano solo titled *Singing Sweetly from a Spider's Web.*

The project as a whole represents a large portion of my recent compositional output. Each individual piece in the series represents a new approach to the use of technology in my compositional practice. The use of subtractive synthesis, microtonality, parametrically controlled stochastically generated musical behaviors and surround sound trajectories are explored in *Labyrinth*. Live control over a surround sound synthesis paradigm combining granular/sampling techniques with spectrally tuned subtractive synthesis is the primary focus of *Old Windows, New Worlds*. *KnownUnkown* is an improvisational performance piece for custom audio/visual instrument where sound and sight combine in direct and parametrically controlled behaviors of tightly coordinated live generated audio and animation.

Finally, *Singing Sweetly from a Spider's Web* is a piano solo composed using techniques for audio analysis and transcription similar to those used in *Old Windows, New Worlds* combined with stochastic behaviour controls similar to those employed in *Labyrinth, and KnownUnknown.*

Labyrinth

The composition of Labyrinth resulted from an intuitive blend of metaphor and process. In terms of metaphor I initially took inspiration from the graphic arts and the sounds of clockwork. For me the delicate smudging and shading employed when using charcoal and the crosshatching and elegant calligraphy common among work made with pen and ink offer near limitless inspiration. Likewise the malleable qualities of a texture made from a hyper clockwork of tuned clicks shifting speeds and layered into surreal densities and trajectories offer similar possibilities. In terms of process I spent a great deal of time refining a means of control over a texture of 8 voices. Each voice was a doubly enveloped and spatialized iterative stream of subtractive synthesis (and its reverberation shadow). These materials were then layered or set against one another with consistently shifting relationships. While composing the form of the piece it struck me that these materials do push and pull the listener into unique musical places while maintaining a high degree of self similarity. I feel there is also a stress that pervades the experience of listening to the piece- a feeling similar to a kind of "finding one's way" but without ever managing an escape. This experience might be likened to walking through a labyrinth like that of the Minotaur's only for it to transform into a meditation labyrinth whose only confines are self imposed by the walker.

Sounds:

The sounds in Labyrinth are created entirely through the use of subtractive synthesis and reverberation. 90% of the iterated "clicks" heard in the piece were created by filtering white noise with three specifically tuned bandpass filters. Some of the tunings are taken from the harmonic series, others use stretched or compressed harmonic intervals, and others were tuned intuitively. An individual amplitude envelope with an exponential attack and decay shape (each slightly different from the other) is then applied to each bandpassed signal. Afterward the three signals are added back together creating the sharp attack and slightly longer decay for each click. The tuning of the bandpass filters relative to one another provides the timbral aspect of each of these sounds. To my ear this synthesis paradigm does a good job of approximating real world percussive sounds and gives the composer the ability to "tweak" them into nearly any real or surreal situation imagineable. The other 10% of the iterated clicks are combinations of between 6 and 24 tuned bandpass filters with each set of 3 given its own fundamental and fine tuning characteristics. These combinations result particularly in the more "wooden" timbres heard in the piece. Unique spatialization of the individual combinations that make up the composite timbre was meant to create a feeling as if one is listening from "inside" the sound. However, the effect achieved is more figurative than literal.

Behaviors:

In composing Labyrinth I worked toward refining the harmonic, rhythmic, and spatial potentials of iterative streams of the above described sounds with an ear toward creating complex, evocative sonic behaviors. Harmonically speaking the material in Labyrinth consists of microtonally tuned clusters/scales based on perfect harmonic ratios tuned above fundamentals found throughout the tessitura. A typical collection of 8 might be created by setting a fundamental of 100 Hz and then tuning each iterative stream successively to intervals 60/20, 61/20, 63/20, 64/20, 66/20, 67/20, 69/20, and 70/20. Another collection might have a fundamental set at 1000 Hz with each iterative stream tuned successively to intervals 18/25, 20/25, 22/25, 24/25, 26/25, 28/25, 30/25 32/25. Hundreds of such collections were employed in creating the source material for the final composition.

Each iterative stream is triggered with a set millisecond delay between triggered envelopes. This delay usually varies slightly over time but there are also many moments when the variation is set to be more dynamic and chaotic. Variation of the speed of iteration around the length of the envelope creates a liminal state of hearing a stream of iteration become a sustained tone. This behavior is used frequently in the composition.

Specific examples of this use iteration moving to sustained tone occur at 0:20, 1:13, and 8:00 but a listener can hear many more.

These iterative streams are further enveloped with generally longer attack and decay shapes (1000-5000 ms) triggered with a variable delay between successive envelopes. When applied to eight streams at once this serves to create a parametrically controlled undulating texture. The variations possible in this texture are then used to delineate identifiable (and to varying degrees suggestive) behaviors. Certain of these behaviors are meant to be more “field” or “texture” and others are meant to be more defined “gestures” or “utterances”. This essentially boils down to the difference between environmental, slow changing large scale behaviors and faster more expressive physical gestures and expressive cadenced utterances. Frequently, field like behaviors are allowed to undulate in the background while more active, physical gestures are layered over the top of these “fields” cutting them off or causing them to react in various ways.

A few examples in the music of field vs. gesture behaviors can be found at the following points:

“field” 2:20
“undulation” 3:00

gestures:
“utterance” 0:24
“beetles” 5:26
“swamp” 3:30
“dance” 6:26 and 8:45

Spatialization:

Each iterative stream is spatialized individually in stochastically controlled behavior types. This control is essentially over the location of the stream in the eight speakers surrounding the audience. “Panning” in 8 channels is achieved through Vector Based Amplitude Panning which offers an angle to the composer as a parameter of control. Behaviors such as circles, movement around an angle, specific angle to angle movement, or movement clockwise or counter away from a particular point are employed along with purely random movement. All spatialization behaviors were configured to have independent timing or timing linked to the larger scale iterative stream envelope times. Additional stochastic control over speed and distance were also built into the spatialization behaviors.

The opening of the piece combines several of the spatialization types in the first 20 seconds. A listener can hear circles, from a point, completely random trajectories, and random points within a spread in this short excerpt.

The "Beetles" example from above at 5:26 is an example of "away from a point" spatialization.

Creating the Material:

The raw "source" material in the piece was created by "dialing in" the parameters for control over the synthesis paradigm, then pressing "record" and finally controlling certain aspects of the paradigm live while others were set to change on their own. Many "takes" were recorded both for the direct iterative sounds as well as for a channel of reverberation. Each take consisted of two 8-channel soundfiles – one consiting of spatialized iterative material and the other spatialized reverberation.

The final step in the creation of Labyrinth consisted of layering/cutting/splicing these materials together. A great deal of time was spent further balancing and enveloping the materials to create more suggestive feelings of interaction between the layers as well as tweaking the ebb and flow/ perceived momentum of the overall material. Strategies employed while working with the material included layering similar vs. dissimilar materials, creating envelope shapes that cause a material to sound like it is building up to the introduction of a different behavior, cutting quickly between dissimilar materials to create composite behaviors, as well as typical level balancing and the creation of long fade ins/outs on otherwise much longer samples.

Extreme examples of layering and cutting to create composite gestures from disparate material include moments at 0:52 and 6:25.

Examples of layering between similar materials are found frequently and one obvious example is found at 2:30.

Labyrinth Form:

Looking at the form specifically, the piece divides into six sections, though it can be somewhat confusing to attempt such a division of the piece on first listen because each of these larger sections contain many sub-phrases and the ends of many of the sections elide into the next sections. This was a strategy I consciously employed both in order to create continuity but also to play with expectation derived from perceived beginnings and endings.

Overall formal design:

Section 1	0:00 – 1:09	-introduction
Section 2	1:09 – 2:20	-expansion
Section 3	2:20 – 5:27	-drop in tension build slowly
Section 4	5:27 – 6:25	-interjection building to most dramatic section
Section 5	6:25 – 8:22	-peak and dissipation
Section 6	8:22 – 10:17	-double coda “tensionless”

Old Windows, New Worlds

Please allow the following colorful metaphor: imagine a stained glass window high above you. A trio of voices rehearses in the recesses of a cathedral. Sunlight filters through the window and lights the dust in the air and the floor below. Suddenly, the window shatters inward. Just after this moment time slows nearly to a standstill. Voices, glass, and dust hang in the air. Sight and sound intermingle impossibly. The falling shards glint in the sunlight as they float slowly toward the floor. Perspectives shift and these shards are stretched like rubber and rise in waves back into the air where they are allowed to swoop like fantastic gargoyles calling to one another from the reaches of the cathedral's spires.

Old Windows, New Worlds is the latest composition for an ever changing surround synthesis live performance engine interfaced with via a standard midi keyboard. This series of compositions is dedicated to my wife, pianist Katalin Lukács whose virtuosity (among other things) inspire the long term project of creating a synthesis engine and collection of compositions worthy of her technique and interpretive prowess.

Project Notes:

After composing Labyrinth I went about trying to bring the level of detail I felt I had achieved in the synthesis paradigm, material, and spatial behavioral realms to a live performance situation. In particular, I sought to create an instrument that could be performed by a trained pianist reading somewhat traditional notation.

In a sense, this piece is a musing on technology, music, history, and performance. I have taken it upon myself to create a new instrument using the standard midi keyboard controller. It is typical these days to think of the midi keyboard as a hindrance or a holdover from the past to be improved upon or even forgotten. Miller Puckette, a hero of most current electronic music practitioners proudly and defiantly once claimed: "We must undo the midi revolution." I have witnessed this quote used as a rallying cry many times over among the many developers and composers I am lucky enough to call friends. Why did I decide to do this? Part of my desire is to open up the the world of basic and virtuosic keyboard technique to more contemporary applications of sound synthesis and, in particular, immersive/surround audio. I am definitely not convinced that the commercial midi controller or this instrument in particular is the future of computer music but as long as there are pianists learning traditional technique and reading traditional notation there will be a place for new instruments that draw on this tradition of performance.

Another of my desires in this project is to stretch our ability to notate using the standard musical staff which is so tied to the keyboard's white and black keys. It is my hope that in doing this more musicians with varying degrees of keyboard skills can both easily read, write and improvise using my instrument. The instrument in its current state is more like a percussion instrument than even the original piano. A five octave midi keyboard is used. The lowest octave is reserved for triggering global settings changes. Playing any white key within the upper 4 octaves will trigger a sound to move from outside of the listening space into the space. The velocity of the note determines several things: how long this movement takes, the overall loudness of the sound, and the relative highness/lowness of the harmony/timbre set for the particular octave in which the note was played. The spatialization is conceived as a plain (not a circle) extending forward and backward and left and right from the center of the hall. In the settings used in Old Windows, New Worlds all sounds originate from beyond the front of the audience. The left/right position of the triggered sound in the surround sound space is determined by which key in the octave was pressed. Sounds come from the front left when the C is pressed and move progressive to the right as you move up the octave to B. For instance, when F is pressed a sound enters the space from the middle. The triggered sound moves to the center of the space (relative to forward/backward) relative to the left/right position from which it began and remains in the space until the key is released. The velocity of the triggered key determines how quickly the sound moves toward the center of the space. When a key is released the sound moves to the back of the hall at a speed relative to the initial velocity and the duration for which the key is held.

Synthesis:

At its core the synthesis engine is a combination of concatenative synthesis filtered by banks of spectrally tuned bandpass filters. The parameters for this synthesis are many and most are set using preset cues. The black keys f#, g#, a# control direct glissando/bending in pitch space of the collections of filters while the c# and d# keys allow for cued interpolation between collections of frequencies/amplitudes for bandpass filter banks relative to each octave.

More specifically, the sounds are either concatenative synthesis based on fragments of vocal sounds filtered with band pass filters tuned to frequencies/amplitudes derived from analyses of unpitched, noisy sounds or the opposite (concatenative synthesis using noisy source samples then filtered at frequencies/amplitudes derived from the analyses of vocal source material). Other notable parameters include means of working with the density, speed, transposition, and level of the concatenative synthesis. Notable parameters used in the bandpass filter banks include the level balance, switching between direct use of the saved frequencies or shifting the frequencies according to a new fundamental frequency. Though the spatialization in the piece varies little from what has been described the instrument has the ability to move sounds along any predefined trajectories the composer wishes.

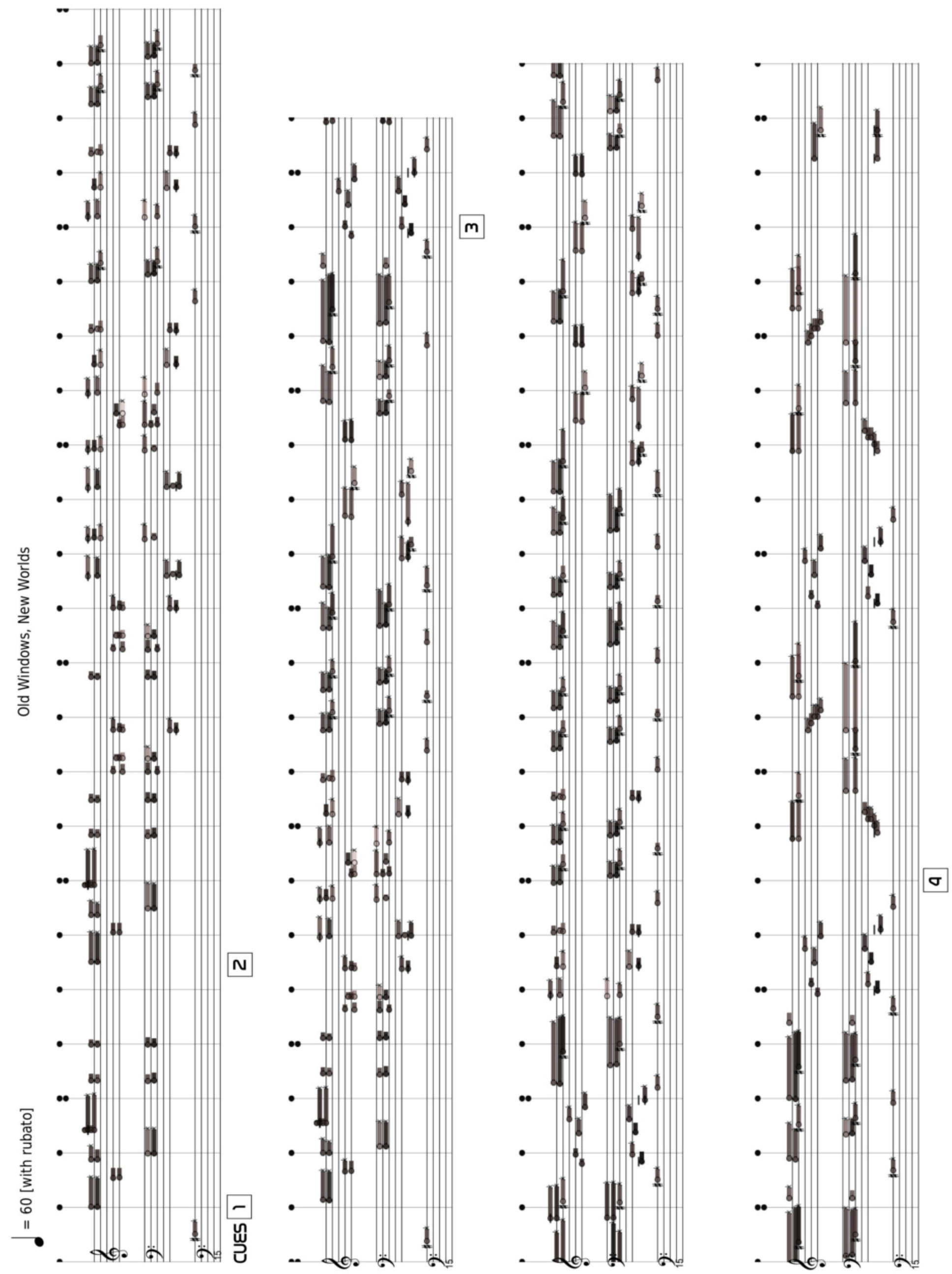
Notes about the score:

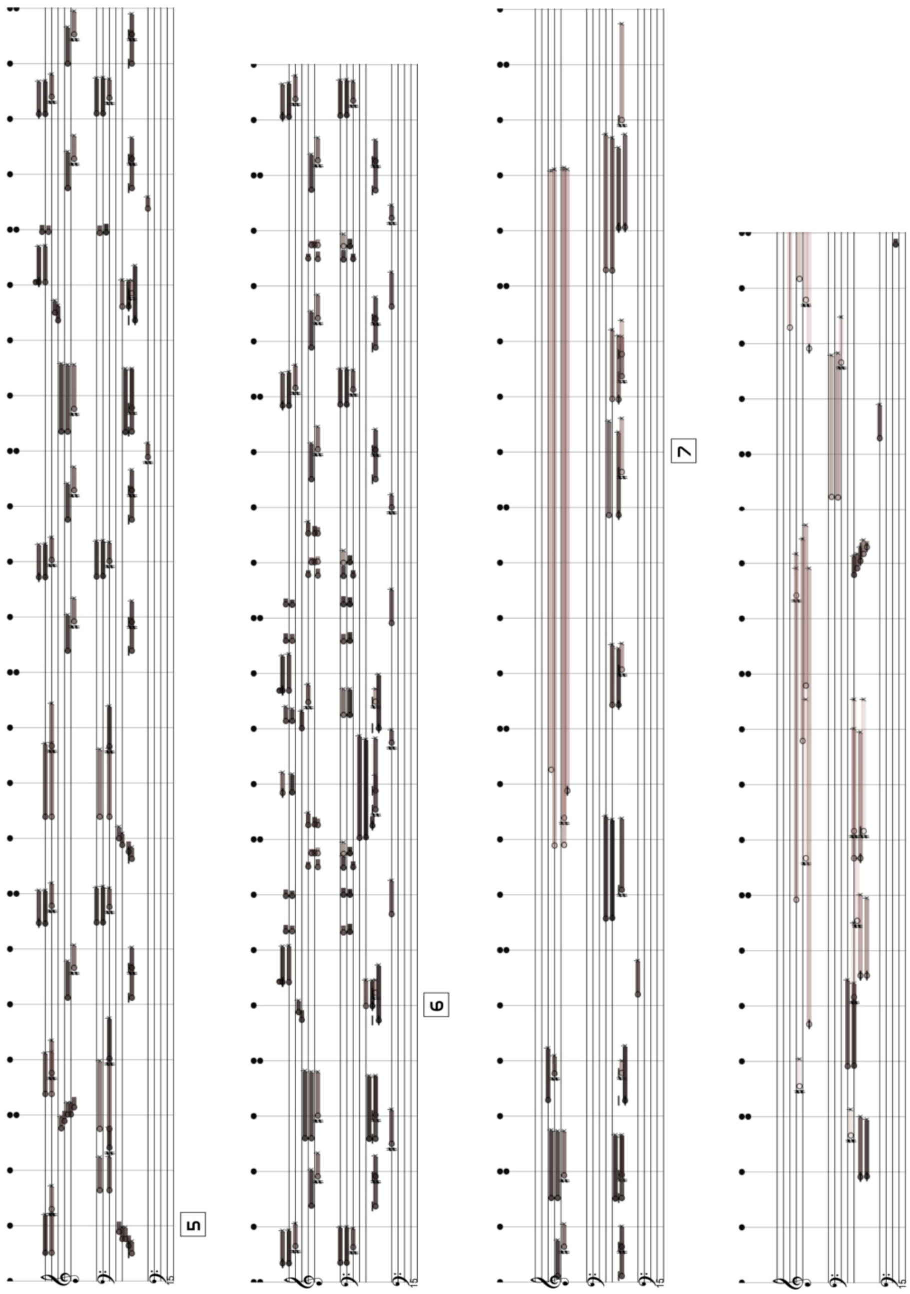
Since the performer's velocities and durations control nearly all aspects of the synthesis engine a new mode of notation was required. The score is to be played with some rubato but relationships with regard to attack and release points are to be closely observed. The duration is very specific and is notated based on the length of the color block relative to each key on the keyboard. Velocities are notated in a range approximating pppp to fff on a piano and are notated in color from light pink to dark grey.

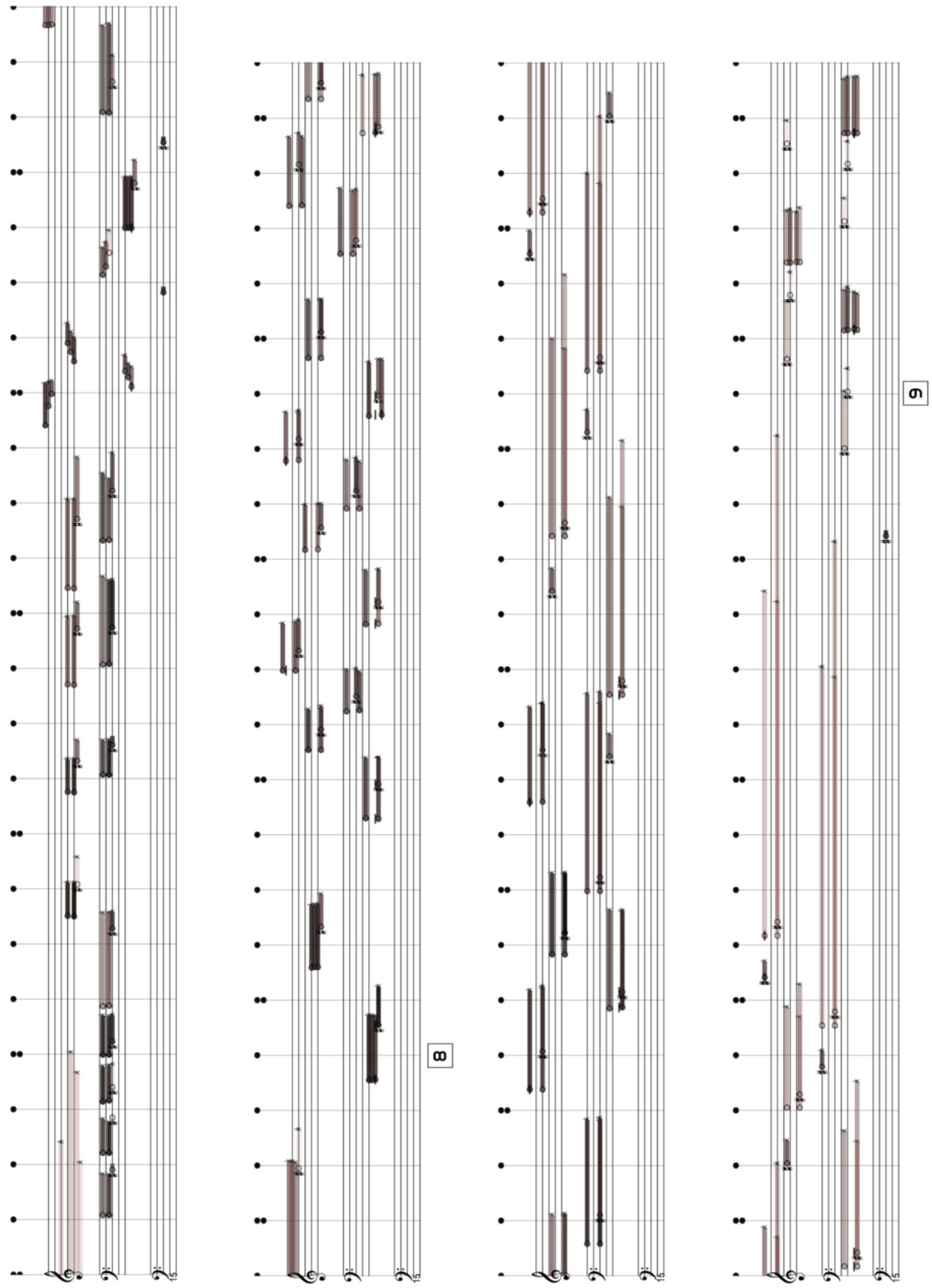
Material:

The material employed in the composition generally consists of simple patterns of rich sweeps of synthesis. Given the long attack/decay shape of any given note-event the instrument is not particularly suited to preceise contrapuntal or intensely rhythmic material. Instead, degrees of variations in pattern length, velocity and appearance serve as potentials for suggestive if subtle sonic behaviors. The title of the piece figuratively refers to “old windows”. These windows can be interpreted both as the envelopes opening on the synthesis material and those of the cathedral in which the source material for the vocal samples might have been originally performed. The old windows might be those of the cathedral or the sounds created (with a shart attack and long decay) by traditional piano technique on a traditional instrument or a singer's mouth opening as it performs traditional repetoir. Hopefully, this piece opens these ideas to “new worlds”.

The following is a scaled sample of the score. Performance materials are on 11x17 inch sized paper.


Old Windows, New Worlds
= 60 [with rubato]
CUES
1
2
3
4


5
6
7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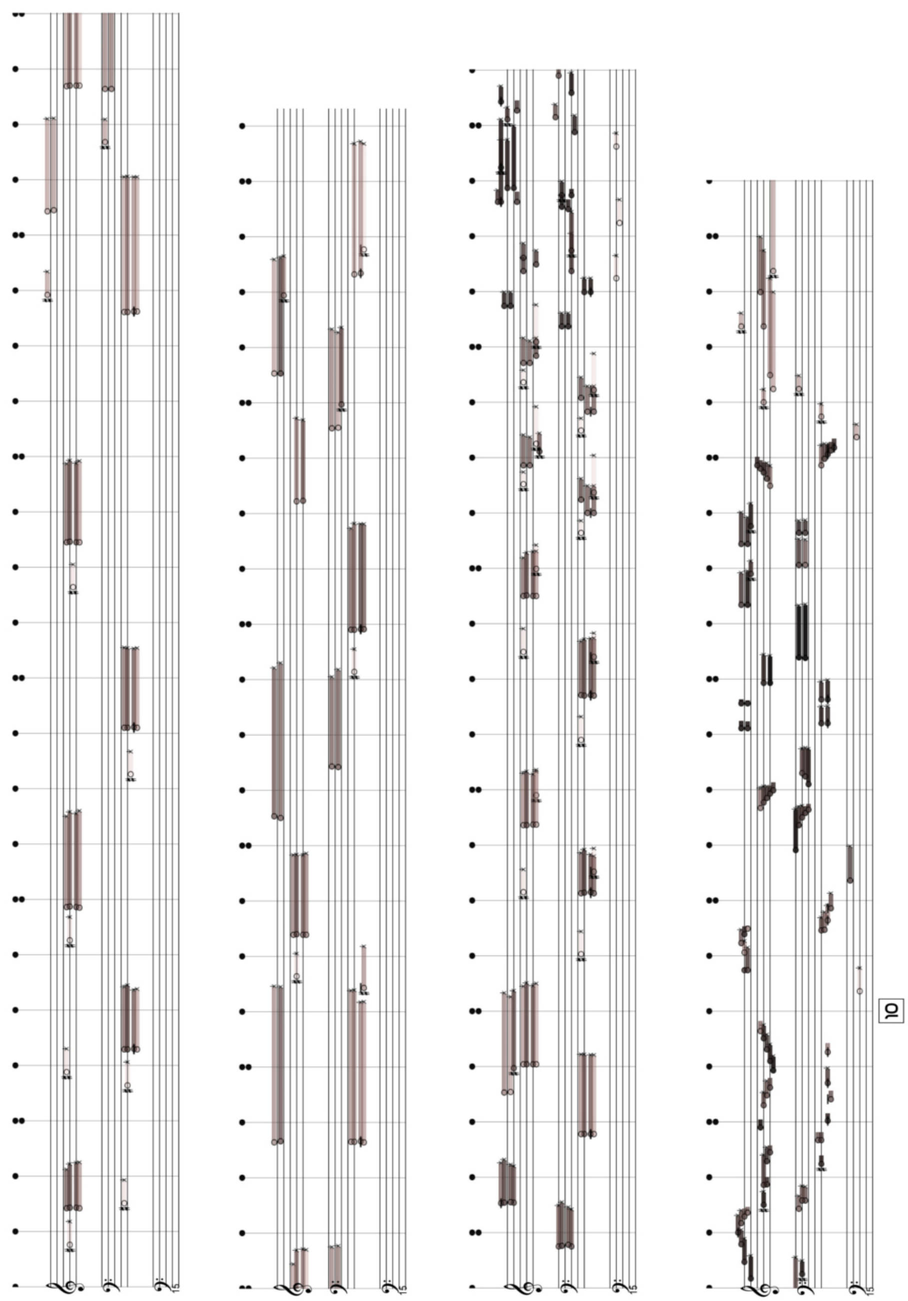
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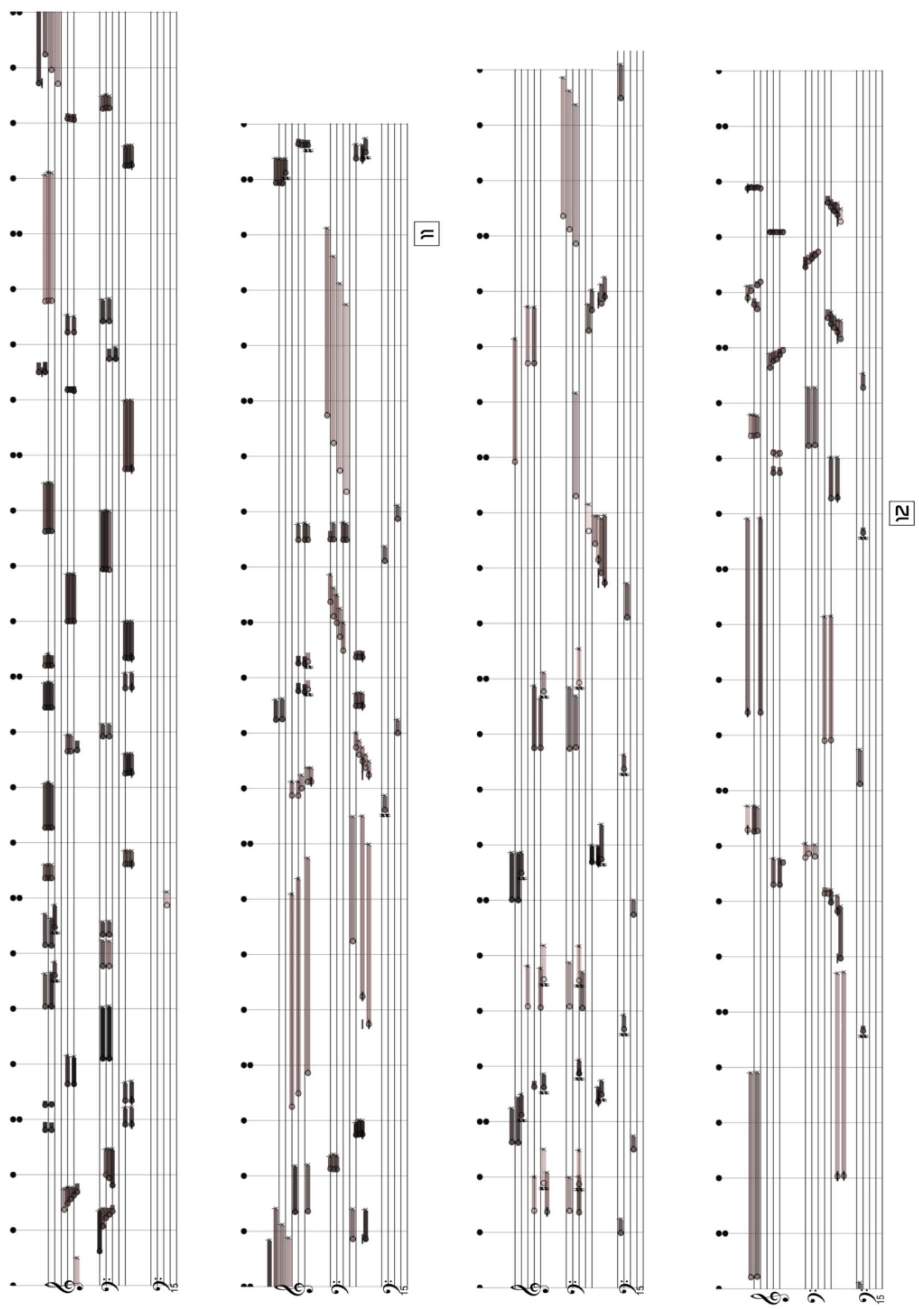
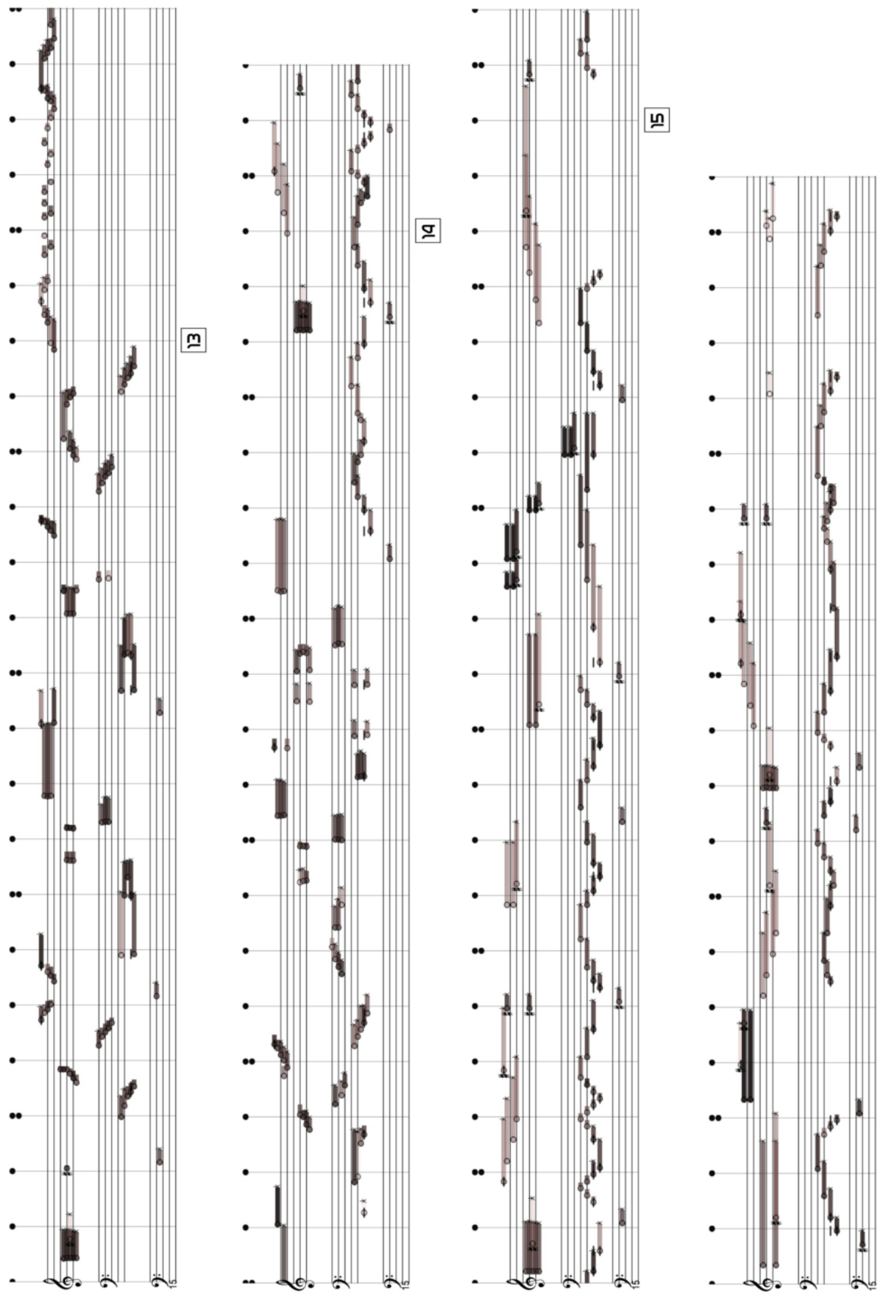
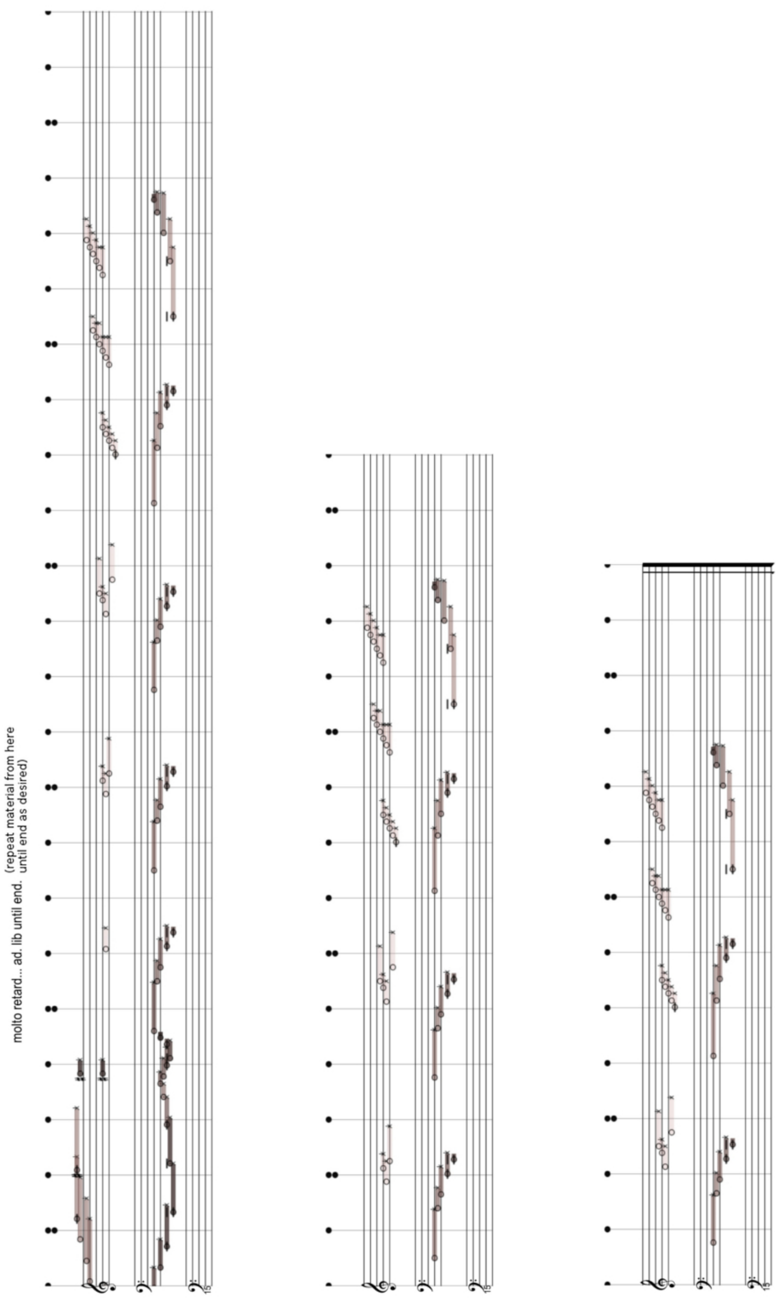

11
12




molto retard... ad. lib until end.
(repeat material from here until end as desired)
15
15
15

KnownUnkown

KnownUnkown is an improvisational performance piece for custom audio/visual instrument where sound and sight combine in parametrically controlled behaviors of tightly coordinated live generated audio and animation. The instrument offers both stochastic and direct control over several parameters.

The performer most directly controls a virtual iris represented visually as an opening and closing window and aurally (most obviously) as a direct volume control. While many other control mechanisms are realized during the performance of the piece an attempt has been made to create a visual analog for each change in the aural synthesis. Accompanying each opening window is a new collection of both preset and stochastically determined pitches and noises. These sounds are represented visually in two ways. The 3D structure is created by an analysis of the composite sound using a form of the Lissajous visualization of harmonic relationships. The general shape of the visualization is determined by three primary frequencies' relationship to one another. The colors of the Lissajous visualization are determined by the 3 primary frequencies' relationship to a fundamental frequency. Psychological and dramatic behaviors and scenes are created, allowed to morph, and then destroyed as the performer manipulates the mechanisms of the instrument. Though the relationships between the sound and visualization are fairly direct there are elements of both that are allowed to "blur". This, coupled with the additional stochastically controlled frequency choices and a set of "stochastic behaviours" insure that an entirely new performance will be created each time the instrument is used. This places the performer in a situation where he must negotiate with and respond to a kind of "knownUnknown".

Technical:

The instrument exists as 2 PD/GEM patches running simultaneously. A 4 octave USB midi keyboard (with 8 knobs+8 sliders+modulation wheel) is used to control the instrument. The patches communicate via the [netsend] object. It is crucial that the patches are running on different instances of PD on two different processors of the computer for performance without CPU issues.

Primary control:

The modulation wheel is used for direct control over a lowpass filter frequency and an overall amplitude control. This movement is represented visually by an opening and closing iris/frame, the growing and shrinking Lissajous representation, and some generally subtle color shifts.

The primary keys used are middle C, C#, and D. When pressed C pulls the iris closed (and pulls the lowpass filter frequency and overall amplitude down) from whatever degree of openness the iris currently found itself. When released the iris pops back to the point determined by the mod wheel. C# does something similar in that it pulls the iris nearly closed (and moves the lopass filter frequency and overall amplitude accordingly). The D key does the opposite. It pulls the iris open and moves the lopass filter frequency and overall amplitude to their max values. When released these values go back to their previous positions.

Whenever the iris reaches 0 a new collection of 3 frequencies are triggered for the primary synthesis (lower sawtooth wave synthesis). These frequencies are determined by selecting from a stochastically ordered set of collections of 3 ratios which are then multiplied against a similarly determined fundamental frequency. The fundamental frequency used for the frequencies determined by the ratio collections is itself chosen from a collection of ratios based on a fundamental frequency of 32Hz.

For example:

First a fundamental of 32Hz is multiplied against a stored ratio 3/2. This gives a fundamental frequency for the primary triad of 48Hz. Then the three heard frequencies are determined by recalling a collection of 3 stored ratios: 32/20, 14/20, 24/20. This yields a fundamental triad of 76.8Hz, 33.6Hz, and 57.6Hz .

The primary shape of the visualization is determined by these three frequencies using the Lissajous visualization of harmonic motion. This curve is represented in triple with each version of the curve colored according to the ratio relationships against the fundemental on which they are based.

Up to six voices of additional synthesis in addition to distortion may be layered on top of each of the 3 primary frequencies. The voices of additional synthesis are always determined via stochastically chosen ratio relationships to each of the 3 primary frequencies in a given “chord”. These frequencies are always above the fundamental triad and are represented visually as additional wave/noise added to the primary Lissajous representation. This means that these additional frequencies will be filtered out first as the iris closes leading to a more simple audio/visual object the closer the iris is to being closed.

The upper octave of the keyboard triggers preset parametrically definied stochastic “behaviors” for the instrument.

C: behaviors off
C#: random movement of iris
D: iris opens repeatedly to a set point then closes completely
D#: iris moves between two set points
E: iris moves between two set points with a % chance to close completely
F: iris moves between two set points with a % chance to open or close completely

The faders determine characteristics of these behaviors like overall speed and variation amounts for each of the parameters needed in the above behaviors.

The knobs on the keyboard control a granular synthesis/sampler instrument as well as levels for each type of synthesis in the instrument as well as a global reverberation level.

The lowest octave of the keyboard allows control over the fundamental frequency for the primary triad. This does not effect the other upper frequencies that might be present in the chord. The effect is that of parallel motion in the lower triad while the upper frequencies remain static.

There are three color effects applied to the visualization. The first is a shift in the iris color. This is triggered on a count of new primary triads. The second is a "world light" tint change that effects the entire scene. This is coupled to a delay effect in the sonification. The third effect is that of a "washing out" of the color/transparency. This is mapped to a filter sweep in the sonification.

Singing Sweetly from a Spider's Web

The backbone of this piece is a series of 160 vertical sonorities derived from a spectral analysis of a “ghost” musique concrete composition. In creating the ghost composition I used many digital audio techniques to bend, stretch, filter, layer and otherwise distort many types of prerecorded material. The vertical sonorities were taken from intuitively chosen moments in the ghost composition.

Each movement of Singing Sweetly from a Spider's Web takes a different intensely process oriented but intuitively informed approach to presenting a subset of these vertical sonorities. The first movement is the most simple. Each sonority is presented as a rising line. The timing and dynamics of each phrase are determined via collections of rotating and intersecting number series. The movement's title, *Capturing an Evaporating Map*, refers to a psychological state similar to attempting to document a memory that comes back in fragments and at varying speeds. In the second movement several object like behaviors are also defined via collections of rotating parameters. These objects continue to return under transformation. The movement's title, *Turning and Returning*, both refers to this technique and is an omage to its compositional, music box like mechanisms. The third movement was created initially in a similar fashion. Its title, *A Prismatic Disquiet,* references the harmonically colorful yet anxious collected objects and phrases which undergo processes of assembly and/or reconfiguration.

The following is a scaled sample of the performance score for Singing Sweetly from a Spider's Web. The actual performance materials are 11x17 inches.

1. Capturing an Evaporating Map

Rick Snow

1. Capturing An Evaporating Map

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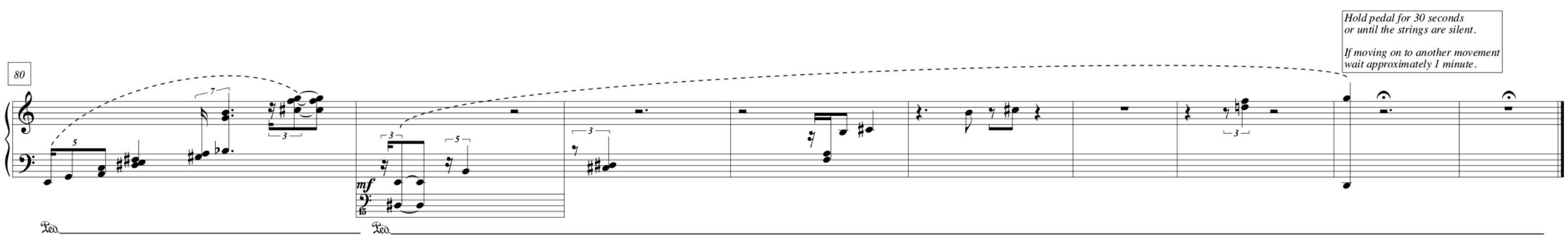

2. Turning and Returning

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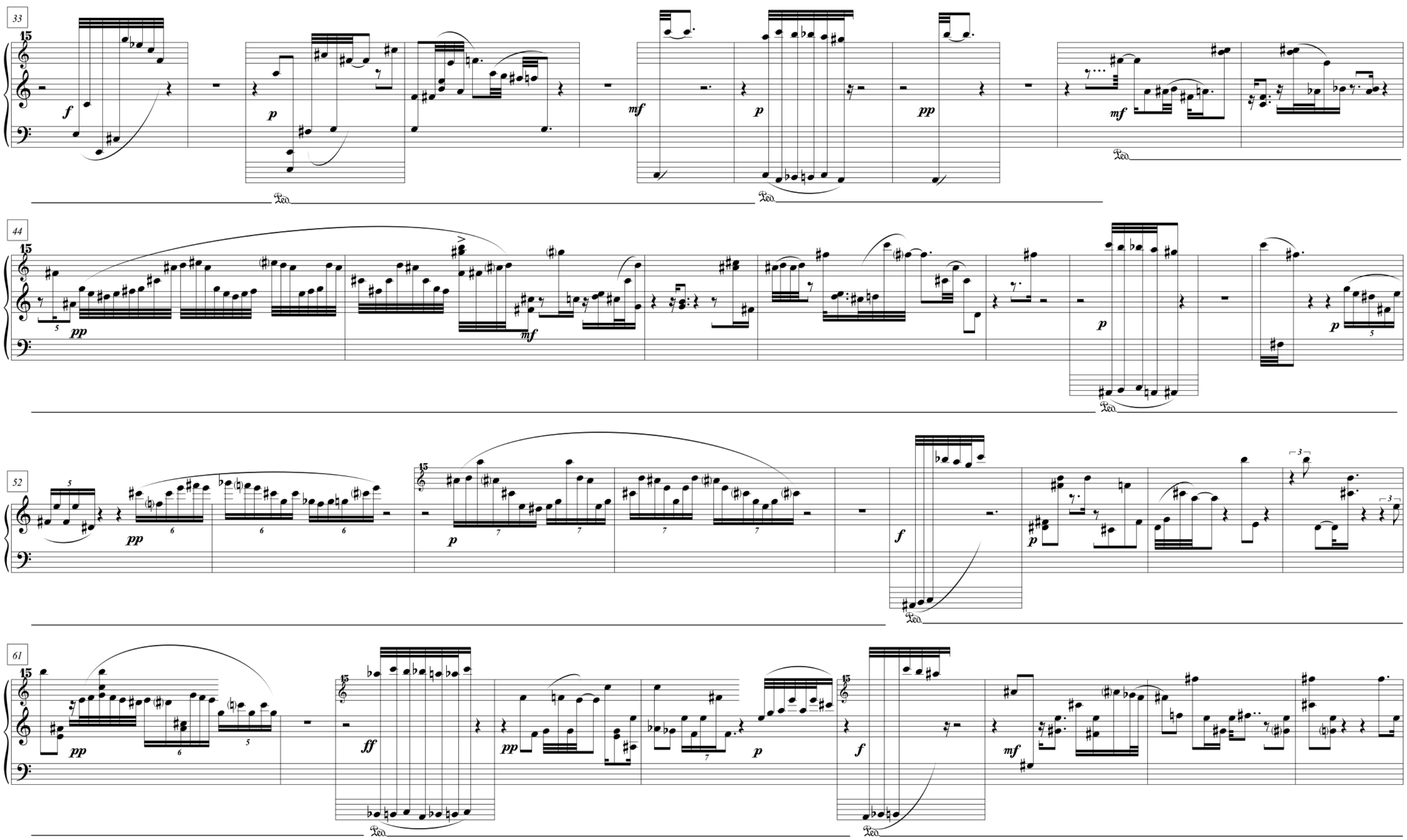

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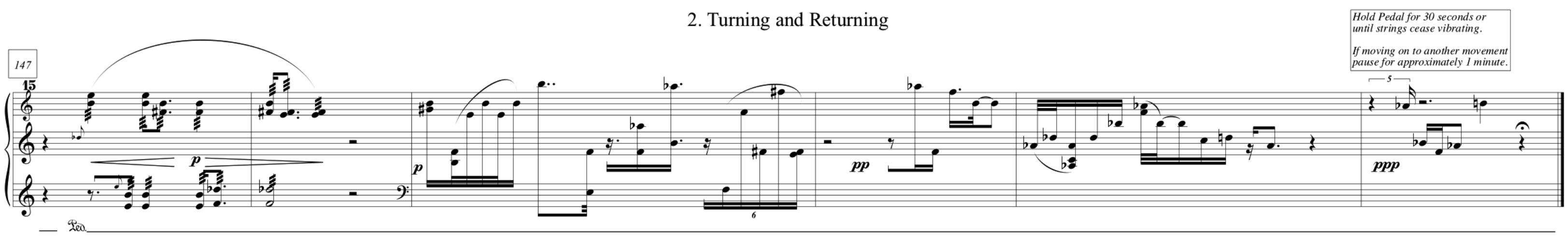
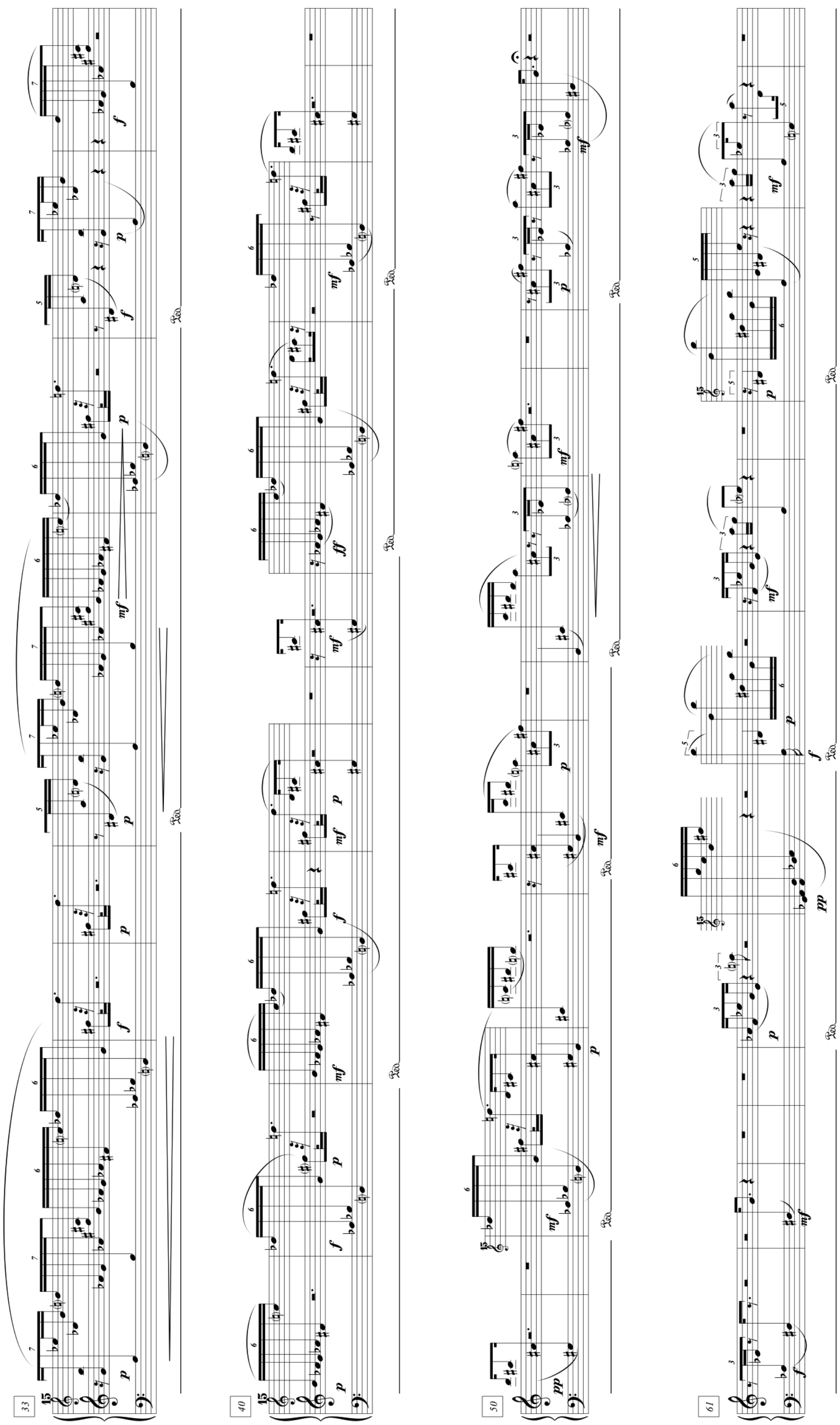


3. A Prismatic Disquiet

3. A Prismatic Disquiet



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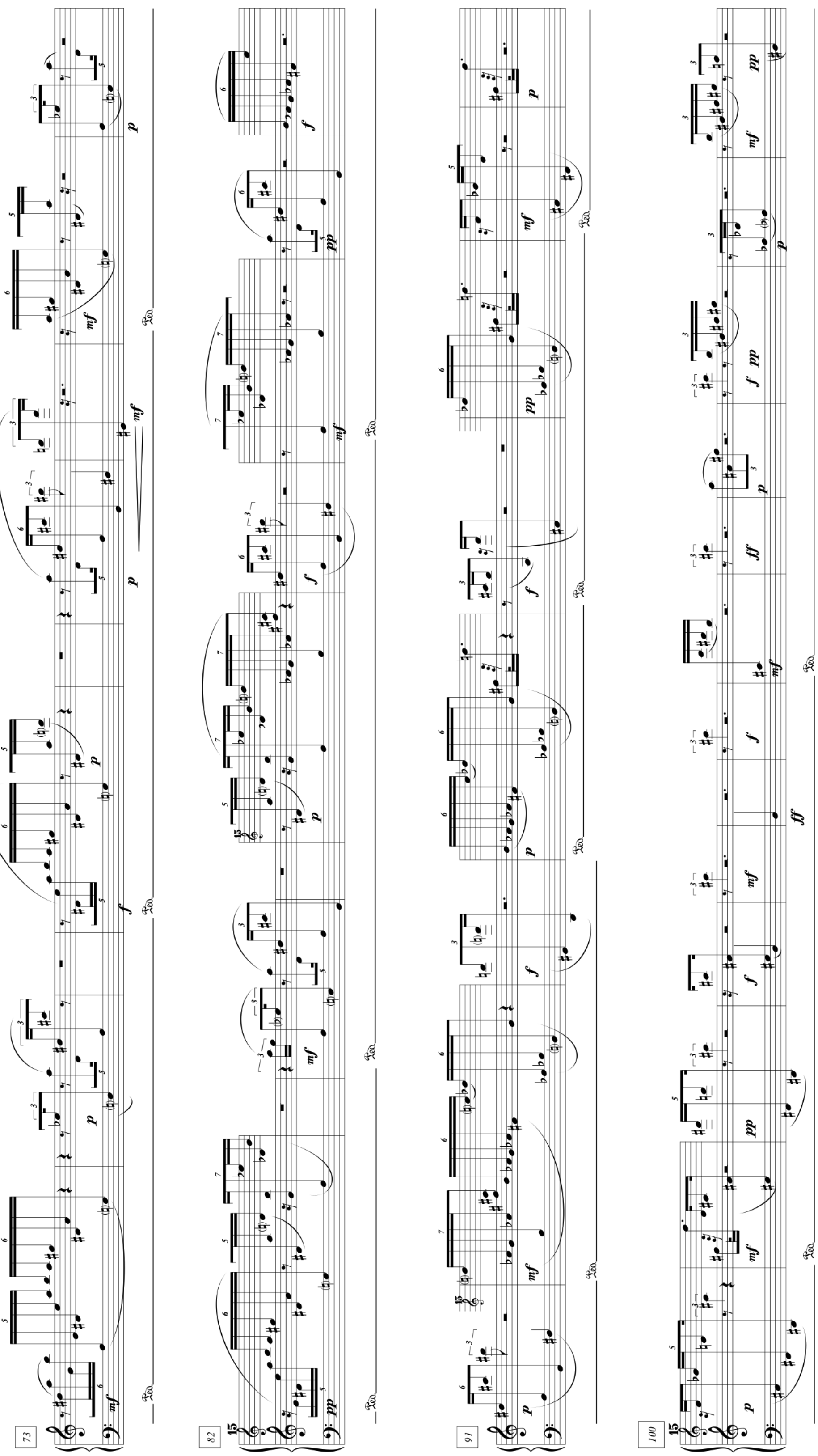

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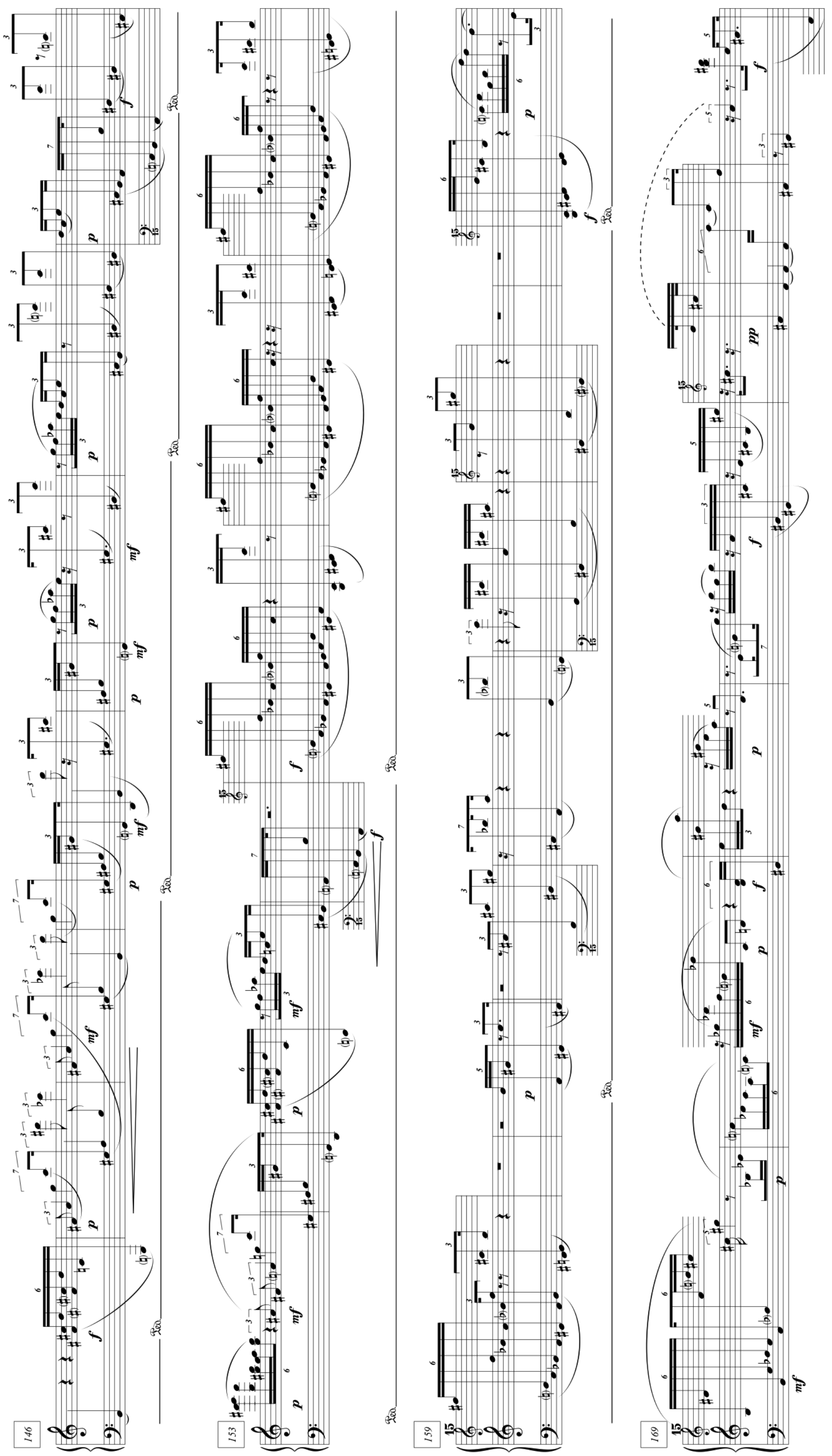

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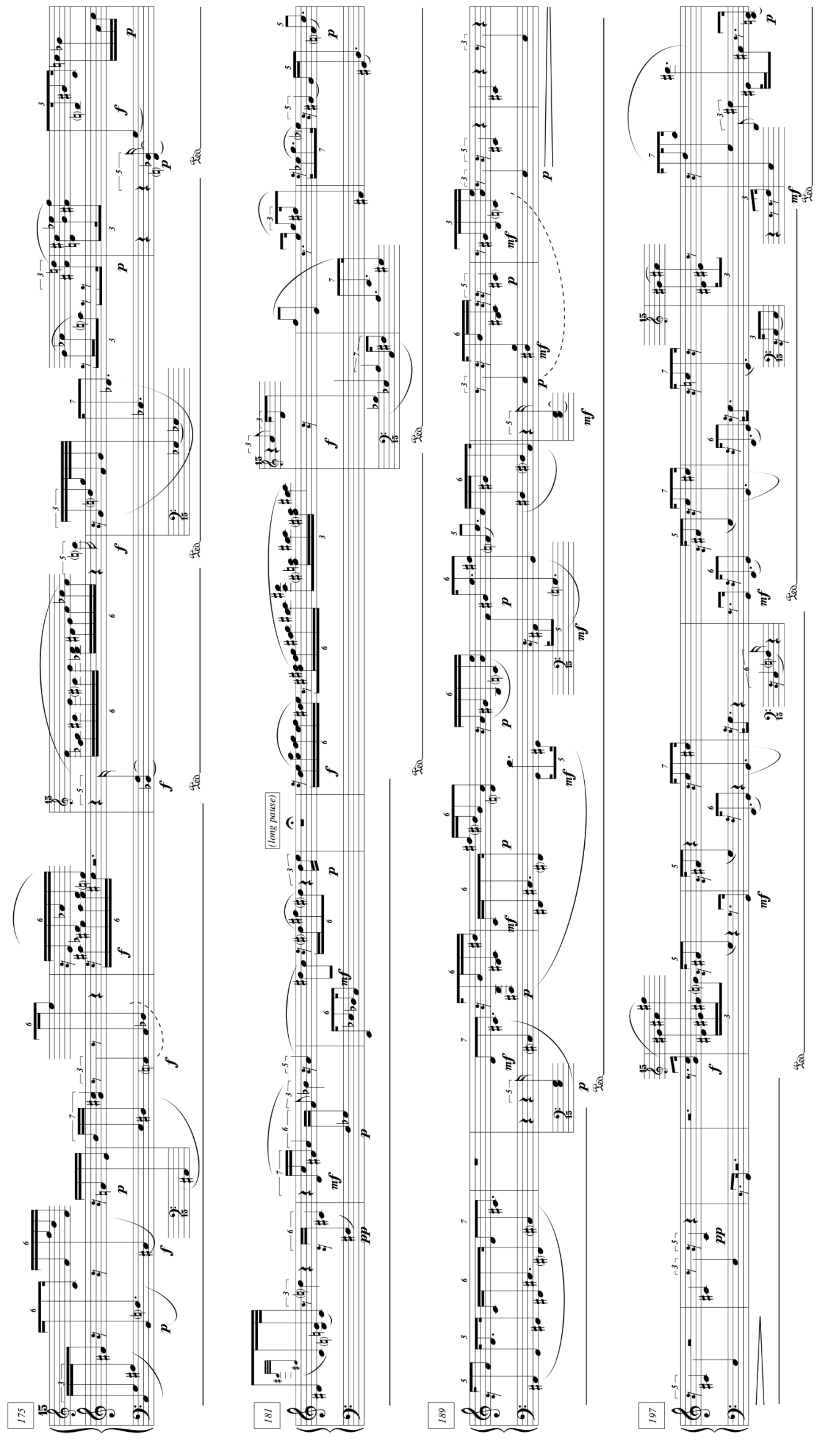

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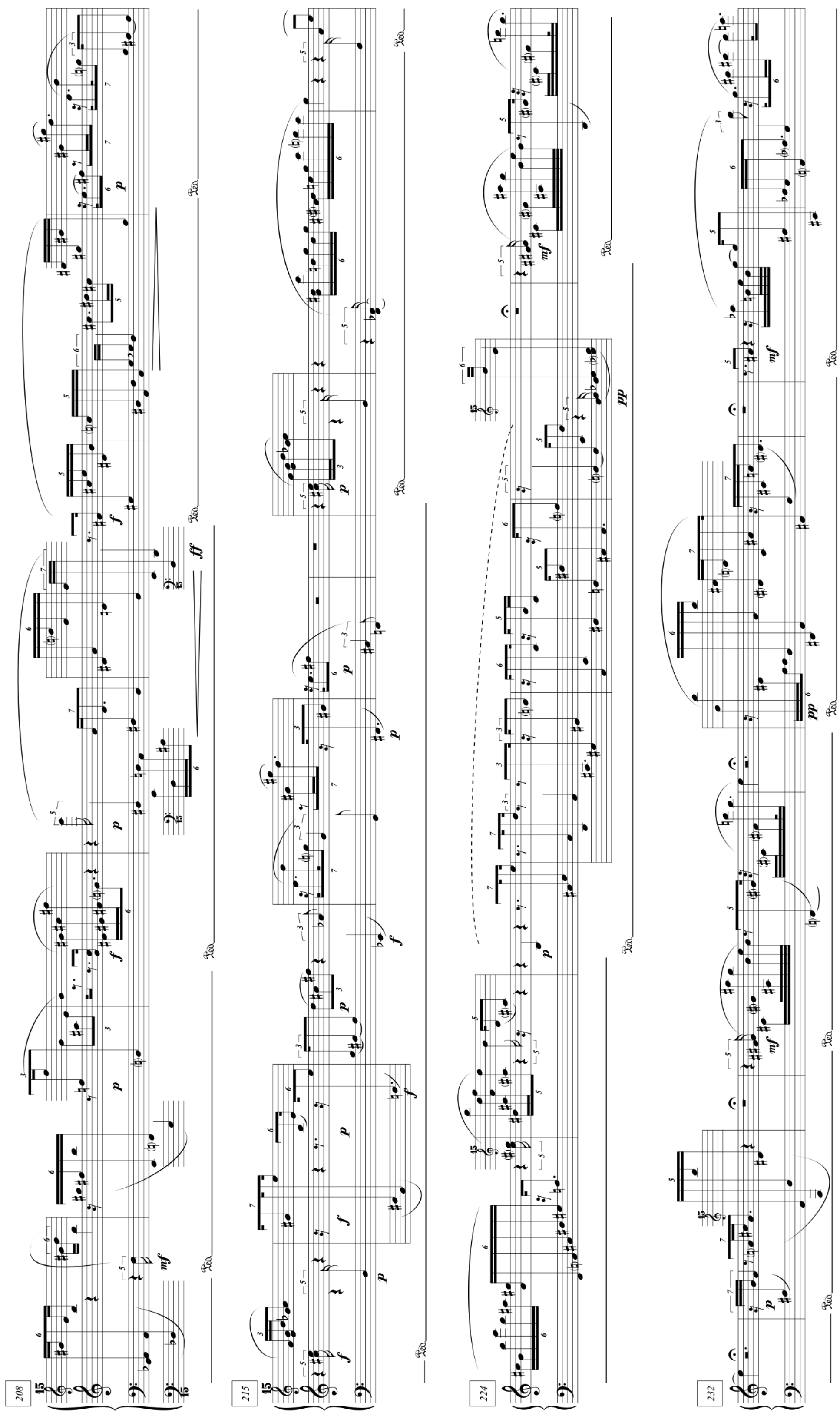

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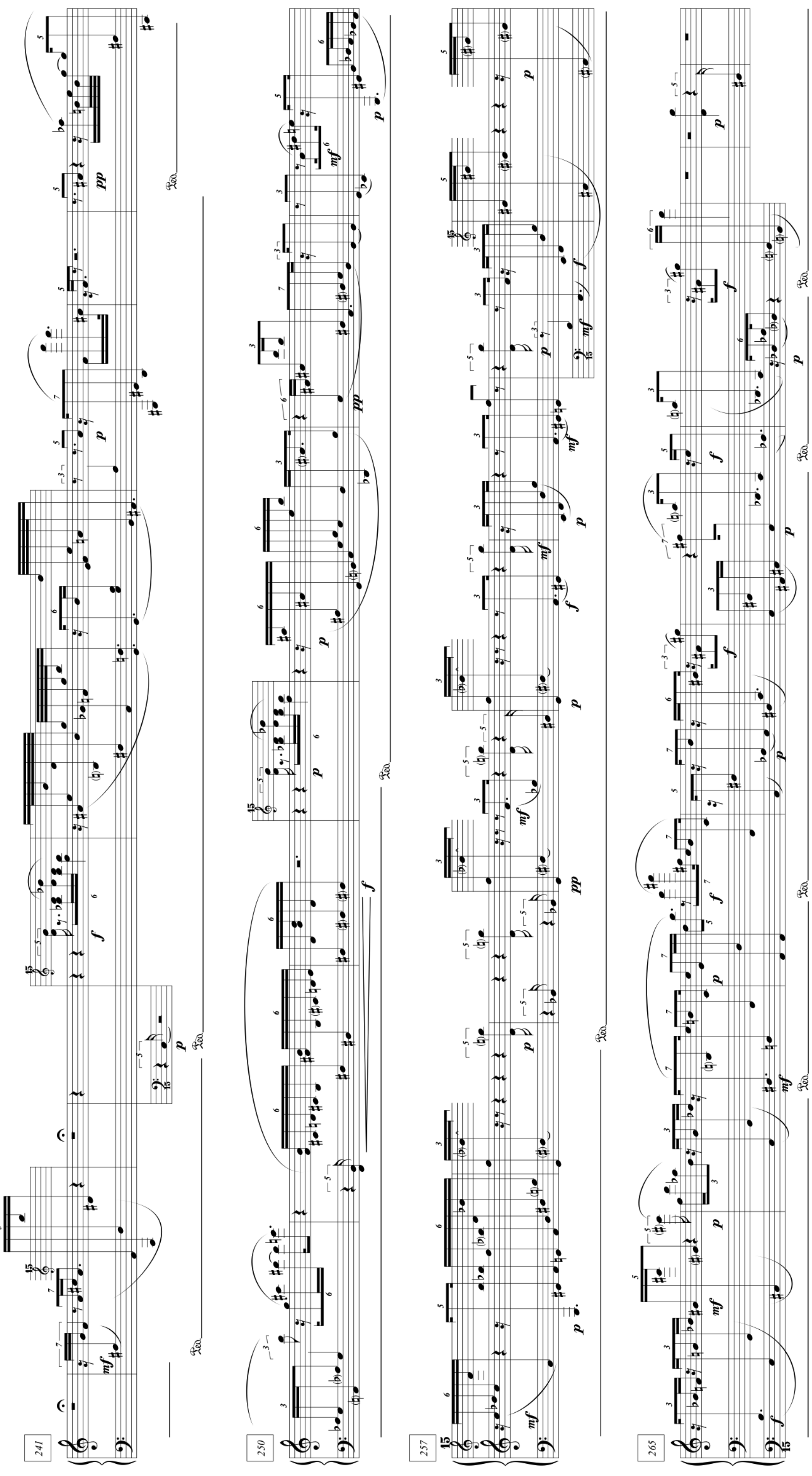
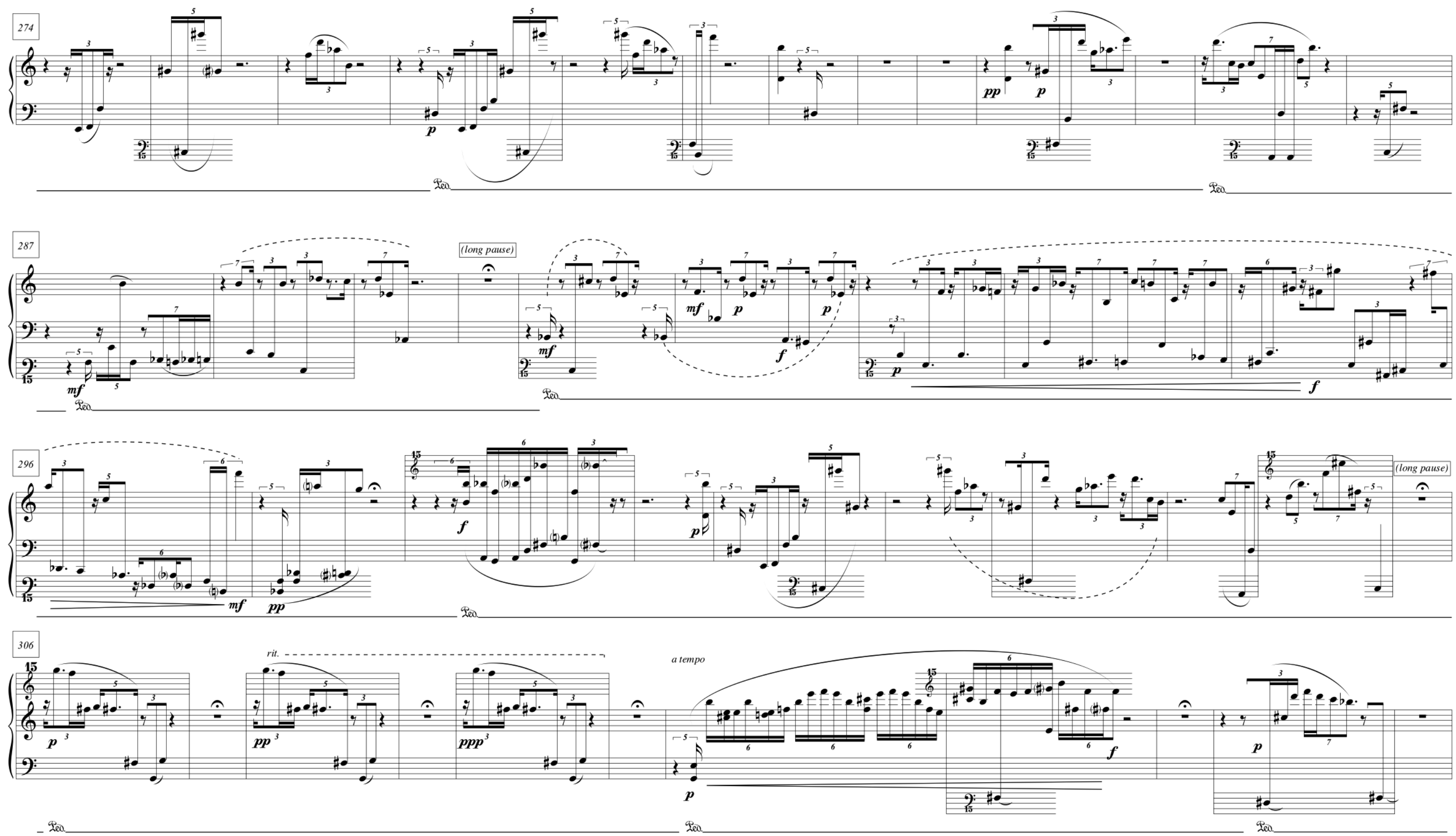


3. A Prismatic Disquiet



3. A Prismatic Disquiet

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