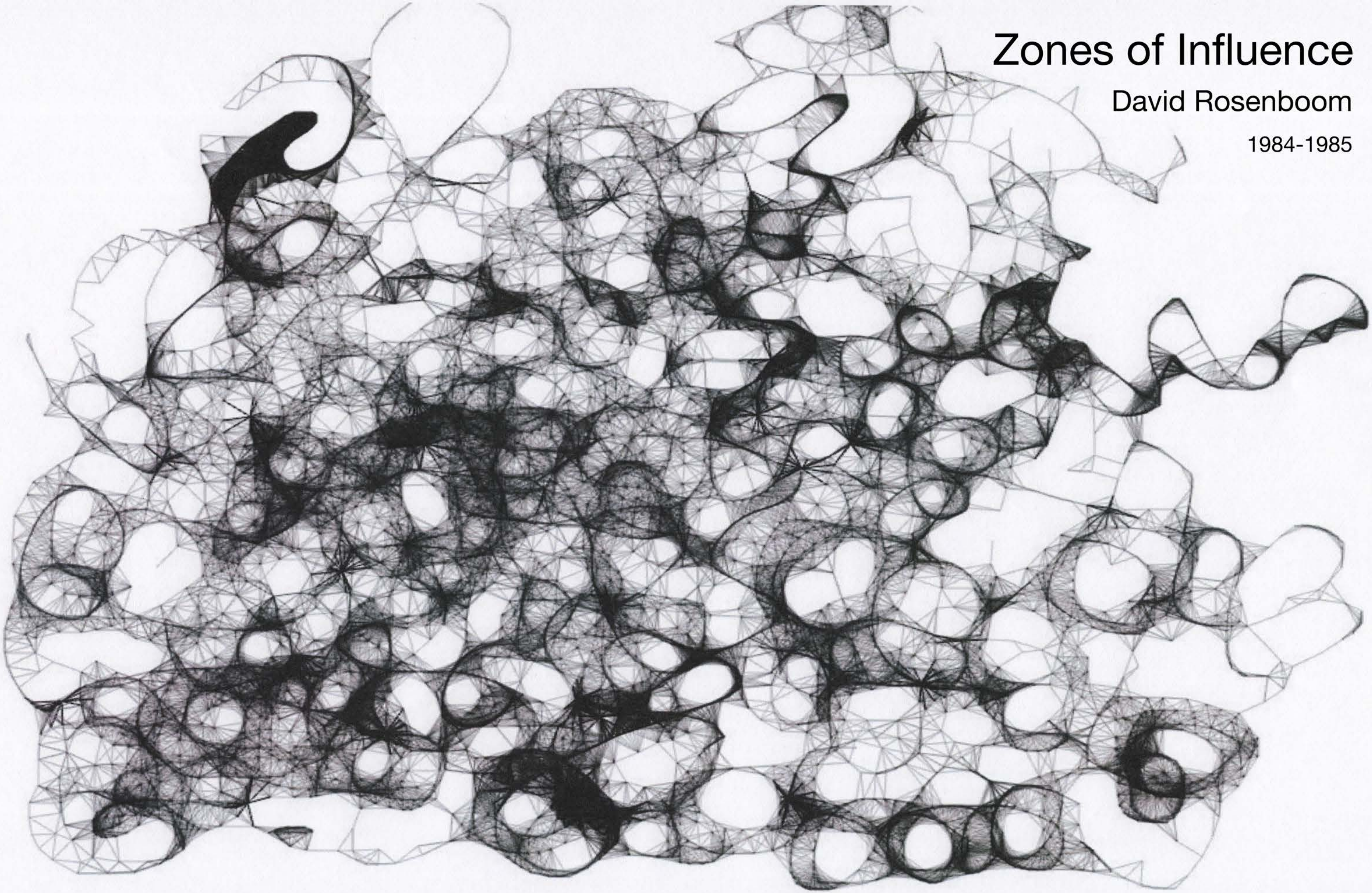
Zones of Influence

David Rosenboom

1984-1985



five movements for percussion soloist,
interactive electronics-computer music systems,
auxiliary melody and continuous glissando parts

written for

Willian Winant
percussionist

Jinku Kim
cover image and
live video interpretations for
Zones of Influence performances

score revisions and updates
2013-2014 and 2021

David Rosenboom Publishing (BMI)

Print date: February 20, 2021

– Blank Page –

Program Notes

Zones of Influence is a propositional cosmology activated in music. It is an example of *propositional music*, a point of view about composing in which composers might build proposed models of worlds, universes, evolution, brains, consciousness or whole domains of thought and life, and then proceed to make dynamical musical embodiments of these models, inviting us to experience them in spontaneously emerging sonic forms. My process for composing *Zones of Influence* in the early 1980s involved building such models with the idea that once built, they would be activated by the gloriously unpredictable virtuosity of a master performer. Everything was to be energized in vigorous live performance. So, *the models became instruments*.

Performers in such paradigms often interact with these models via compositional algorithms that generate musical materials, the forms of which result from the *way* they play and *what* they play. The algorithms may also restructure themselves in response to *how* the performer plays. The *what*, in the case of *Zones of Influence*, may include notes, rhythmic structures, melody shapes, melismas and other patterns detected via sensors attached to acoustic percussion instruments.

The propositional models in *Zones of Influence* explore ideas about evolution and morphogenesis, thresholds of perception crossed when *things* transform themselves into other *things*, the nature of predictability and what it means to *know* something about a physical system and the dynamical nature of catastrophic change. *Zones of influence* is also a term used to describe a region of space surrounding a structure for morphological dynamics, known as a *chreod*. Inside this *zone of influence*, that structure can directly affect other structures, as it might do inside an embryo. Outside the *zone*, it does not.[1]

Among the many elements of musical language heard in the dynamical models of *Zones of Influence*, musical *shapes* are always prominent: shapes heard as melodies, shapes describing changes in speed, space and time, shapes in the microcosms of sound waves and the macro-forms of whole movements, the shapes of transforming functions that bend sound waves and musical forms into new sounds and forms, the shapes of *probability rhythms* that govern likelihoods for things happening and the shapes of glissando gestures swirling in a counterpoint matrix. All these shapes are related to each other. Most are derived from transformations of just two, freely-composed, 60-note melodies, called the *Origin Melody* and *Target Melody*, which act as musical DNA for the entirety of *Zones of Influence*. All in all, 306 interrelated melodies appear, and every one results from some way of transforming the contours of the *Origin Melody* into those of the *Target* and vice versa. These ways of transforming produce mutated melodies, which are mapped in a multi-dimensional, *concept space* showing how *close* (similar) or *far away* (dissimilar) each is perceived to be from the *Origin* and the *Target*. Sets of mutated melodies emerging from particular ways of transforming lie along pathways in this space, called *trajectories*. These trajectories are then treated as higher level shapes in the counterpoint structures of *Zones of Influence*. Shapes upon shapes emerge and intertwine up and down a *holarchy* of musical forms.[2] At the time, I called this process, *morphological mutation*, a new way of making variations.

Some of these trajectories are smooth, with only subtle changes appearing from melody to melody and shape to shape. Some are jagged, with mutated shapes moving far away from and bearing only distant, perceived relatedness to either the *Origin* or *Target*. Eventually, however, they move closer and closer again, exhibiting increasing similarity to one or the other. Finally, this world of shapes led me to construct a *system of counterpoint*, within which the shapes are combined and recombined, like vines or veins intertwining, sharing features that refer to one another or to the *Origin* and *Target*. This sonic recombination produces newly emerging musical entities. I hope that joyful musical explorers, active creative listeners, will find endless discoveries awaiting them in the fabric of this musical space. *Zones of Influence* is, most of all, an invitation to enjoy listening like a pioneer.

Part I: *The Winding of a Spring*, a) ***The Stochastic Part*** and b) ***The Tripartite Structure***
The Winding of a Spring explores evolutionary pathways between order and disorder expressed in rhythmic patterns and melodic relationships. Along these pathways, our listening space may become warped by perceptual singularities, or musical centers of gravity, around which more and more energy is wound until full capacity is reached.

I had been fascinated for many years by the vast and rich musical language of Scottish rudimental drumming. Today we encounter a greatly simplified descendent in American parade drumming. The source, however, is extraordinary in its complexity and extensive repertoire. *The Winding of a Spring* includes a fixed score for three snare drums (low, medium and high), in which a selection of traditional drumming rudiments appears in endlessly varied forms. The components of these forms are superimposed over one another, like the transparent layers of a "visible human," showing bones, muscles, organs, veins, nerves, and so on. They include the rudiment patterns and their variations, the placement of drumming accents, assignments of the performer's left and right hands to the three snare drums, the number of drum strokes played during each metric unit, dynamics and a *Just* (whole-number ratio) scale of tempo variations for what I call *speed melodies*. In *The Stochastic Part*, the methods for transforming these materials employ probabilities to organize disorder. In *The Tripartite Structure*, a musical scaffolding is built by imbedding patterns inside groups of three within groups of powers of

---

[1] I have often been inspired French mathematician and thinker, René Thom's writings about form, change and catastrophe theory, as in his book, Structural Stability and Morphogenesis.
[2] The term *holarchy* is used to refer to structures regarded as processes that have both top-down and bottom-up dynamical aspects.

three—(from 3^0 to 3^7 yielding a macro-pattern of 2,187 elements). This ordering is reminiscent of the *mora* in South Indian drumming or the *tehai* in North Indian drumming, which also employ tripartite forms. Here they are carried to extreme in combination with other contemporary percussion techniques.

Each stroke played by the percussionist triggers the propositional model to emit a sound in a three-part counterpoint (with multi-voice polyphony) paralleling the three snare drums. Each part is composed from a set of eleven melodies slowly transforming between the *Origin* and *Target*. The three melody sets differ in the smoothness or jaggedness of their trajectories. The one attached to the lowest drum is the smoothest, and that attached to the highest drum is the most complex. Endless cross-references result from recombining fragments of the 33 melodies with each other. Changes in the sound synthesis engines are activated at specific points in the score and are determined as an aspect of creative orchestration.

Part II: *Closed Attracting Trajectories*, a) ***Melody Set 1*** and b) ***Melody Set 2***

In *Melody Set 1*, I wanted to make a marimba and its rigid bars of wood appear to be singing and to be able to bend and re-shape its phrases and melismas. My solution was real-time signal processing, and this is the only place in *Zones of Influence* where that technique is applied to the acoustic emanations of the percussion. It is intended that the processing capture resonances in the marimba's melodic intoning and spin off subtle pitch-shifted swirls from its notes. A key thing to know is that in *Melody Set 1* we hear the smoothest trajectory possible of 21 melodies slowly bending from the shapes of the *Origin* into the shapes of the *Target*. We also hear the *Origin* at the beginning and the *Target* at the end, played simply on the unprocessed, solo marimba. The score is written in proportional notation with ornaments and without meter. Here is our most direct experience with the melodic DNA of *Zones of Influence*.

Closed Attracting Trajectories also explores catastrophic changes of state, like those we encounter in nature when one aspect of a phenomenon is gradually varied, like water turning suddenly to ice when its temperature is gradually and continuously lowered. The musical analogy derives from a theory of musical perception that treats melodies strictly as contours or shape morphologies. The compositional process is sensitive to sudden changes in perception occurring when one thing stops sounding like where it came from and starts sounding like where it's going. While *Melody Set 1* presents the smoothest possible trajectory of one melody bending into the forms of another, *Melody Set 2* contrasts this with some of the most complex. Sudden melodic transitions are common. To complement this, it is intended that changes in the electronic synthesis engines are less frequent.

The counterpoint system of *Melody Set 2* is also thicker and more tangled than *Melody Set 1*. Eight lines of electronic counterpoint are generated from four trajectories of 6 melodies each (24 melodies in all). A solo marimba and xylophone articulate a fifth trajectory. The score employs a technique I call *window improvisation*. A small window scans through each 60-note melody at pre-determined, varying rates. The player improvises patterns with the notes appearing inside the window, maintaining their ordering. The size of the moving window may vary from two to ten notes. Dynamics, tempi, and all pitches are specified. The marimba and xylophone are treated as one large instrument, and their acoustic signal is parsed into eight frequency ranges. Activity in these ranges is analyzed, and the results drive the propositional model, which in turn drives the sound synthesis engines. In addition to generating single notes, the model also generates bursts of notes at specific speeds, complementing the *window improvisation* of the player.

Part III: *Given the Senses the Real Pregeometry*

Part III explores in musical metaphor a process through which the universe may learn to perceive its own existence. Its score is largely imbedded in the software of the propositional model. The percussionist uses their senses, with some help from graphic diagrams, to discover the form of this algorithmic score, which is analogous to the *pregeometry* or the given order of the universe. They do this by initiating actions with their instruments, which may or may not trigger responses in electronic sound. Their actions can also modify the score, just as an observer imparts influences on that which is observed. This model assumes that reality (the order of the piece) is the product of a consciousness (the percussionist) interacting with its environment (the electronic sounds); that the currency of reality is information flowing in both directions between the consciousness and the environment; and that theories or assumptions about reality reflect as much the characteristics of consciousness as their relevance to the nature of the universe, to the process of consciousness perceiving itself, and ultimately, to the universe perceiving its own existence.

Principles from quantum mechanics guide the musical structure as well. A set of *probability waves* expresses the likelihood of the percussionist's actions being followed by sonic responses. These *probability waves* influence the potential match between that *given by the senses* and that *given by the pregeometry*. A kind of "harmonic" series of probability waves makes a *stochastic key*. The musical experience involves the audience observing the percussionist learning to play *in tune* with this probabilistic key in order to establish a close binding between their sounds and the electronic sounds. These probability waves are scanned cyclically.[3] When the percussionist activates a sensor, the value of a corresponding probability wave at the current point in its cycle is retrieved. If the activation coincides with a peak or relative high point in the wave, the likelihood of the percussionist's action generating a change in the sound synthesis algorithms is high. Otherwise, it is low. The percussionist learns to feel the probability rhythms imbedded inside the software-based score and interacts with them. This is reminiscent of how, in the quantum world, the positions of charged particles can only be described with probabilities that *collapse* into *knowable* outcomes only when an experimenter interacts with them by taking measurements. In *Zones of Influence*, the percussionist can only come to *know* the system by

[3] The shapes of these probability waves, considered as *eigenfunctions*, are made with Laguerre polynomials.

initiating actions with their instruments.

An auxiliary performer provides additional musical material affected by the percussionist's actions. The score gives eight trajectories of pitch material, again, all derived from transformations of the *Origin* and *Target Melodies*. The trajectories vary in length from two melodies to four, making 20 melodies in all. The auxiliary player works their way through them in a manner similar to the *window improvisation* of Part II, with somewhat more freedom, but with general directions for speed, temporal density and the lengths of note groups. These notes are further parsed into eight ranges. Activity in these ranges drives another eight-part counterpoint texture generated from eight additional trajectories of mutated melodies, producing 19 more. That makes 39 melodies in Part III. Bursts of notes from the melodies may also emerge as a result of the auxiliary player interacting with the same probability rhythms. Though the auxiliary player performs music from the score, they never know what the resulting sounds will be. That is because the percussionist's interaction with the probability rhythms determines which synthesis algorithms will be activated at any time, and these can change rapidly.

Several other ideas from quantum theory also inspired musical analogies in Part III. The *indistinguishability principle* leads to the idea that entities with contrasting vectors (particles with anti-parallel spins) form the tightest bonds with each other. This binding of contrasting phenomena is considered to be a basic principle of nature and also guides the musical metaphor. The idea of a *continuum* in this music is considered to be an illusion and is dependent on one's scale of observation. Consequently, it is assumed that there must be discrete states in macroscopic as well as microscopic phenomena, which are experienced as large-scale *catastrophes*. The assumption follows that changes in morphologies tend to be sudden and are followed by periods of tendency toward stability. The *indeterminacy principle* guides the formation of *musical complementarities* between the percussion and electronic sounds. The more musical states become defined by probability functions of short wavelengths, the more illusive their complements become, as the wavelengths of their probability functions become longer and smoother.

Part IV: *Epigenesis, Ontogenesis, Phylogenesis, Parthenogenesis*
Part IV is inspired by ideas about evolution and self-replication, on genetic, individual, and group levels. These play out in rhythmic patterns and melodic shapes articulated across a drum tarang, a group of drums of graduated pitch. Transformation algorithms are applied to rhythmic patterns and the contours of movement across the drum tarang. The percussionist's part is completely notated. An auxiliary performer is called for again, this time to play a very simple *pulse melody* made of two sets of eight pitch sequences with four to six notes. To create these, the 60-note Origin and target Melodies were reduced to 20 pitches that are particularly important in how their internal phrases move. The keyboardist's task is to keep the beat while the initially simple drum tarang and electronic parts become progressively more complex.

Sensors are attached to the eight drums of the tarang. These drive another eight-voice counterpoint matrix, this time made with transformations applied to the reduced and transposed melody modules, which are compressed further by mapping them into a quarter-tone (24 pitch-class) space. Each resulting melody trajectory contains nine mutated melodies, making 72 short melodies driven by the percussionist and sixteen played by the auxiliary performer, 88 in all.

Finally, the score specifies locations where the software begins storing pulses from the drum sensors in an accumulation loop that grows more and more complex as patterns replicate and recombine. Independently, these are recalled and played back through the synthesis engines. This buildup occurs twice, and everything ends in coordination.

Part V: *The Buckling of a Spring*
Poetically, the spring that was wound up in Part I buckles in Part V, releasing a swarm of swirling shapes. All are derived from curves in the probability waves of Part III. In Part V they are applied to every aspect of the synthesis algorithms, in long, short, fast and slow forms, and are notated precisely in a score for two glissando instruments, a continuously-gliding tympani roll and swooping pitches on a higher pitched, continuous glissando instrument.[4] The higher instrument's sound is parsed into eight frequency ranges. Each time it enters into one of these ranges, as it swoops up and down, it triggers a sliding electronic sound in an eight-part counterpoint matrix. The starting pitches for these glides come from more transformation trajectories made with the short melody modules heard in Part IV. This time, there are eleven melodies in each trajectory (88 in all), and they are optionally mapped in both quarter-tone (24 pitch class) and half-tone (12 pitch class) scale arrangements. They may also be transposed up and down by octaves freely. The starting pitches for each high-range glissando also articulate a trajectory of seven melodies. (Optionally, these may be doubled by an extra electronic voice to reinforce them, as long as it remains in synch with the glissando instrument.) Ten synthesis algorithms, all based on non-linear wave shaping with time-varying parameters derived from the probability waves, are grouped into two cycles of five. Alternate voices in the counterpoint matrix trigger changes around these two cycles, creating a constantly shifting sonic cosmos. At least two algorithms, one from each cycle, always sound at once. A scale of speeds from very slow to very fast is also specified. To ground and restart our perceptions, two contrasting elements punctuate this cosmos. First, knocks and clangs of wood and metal slice unpredictably through the gliding swarms, like whacks from a Zen master's stick, lest mindfulness escape us into open sonic space. Second, the glissando instrument and percussion interrupt half way through, injecting brief bursts of notes scurrying around the set of melody modules originally heard in the pulse-keeping line of Part IV. After that, the swarming sonic cosmos returns for a while before eventually swirling off into distant space.

---

[4] The score calls for any instrument capable of making continuous glissandi over the pitch ranges shown. An example could be a violin.

Zones of Influence

Performance Instructions

General Notes

Zones of Influence offers a propositional musical world expressed in musical structures and data from morphological, musical shape transformations implemented with algorithms operating on freely composed, human-generated starting materials. As shapes transform and intertwine, they act as agents enabling unfolding structures to function as environments for interaction. Shapes on the scale of microsounds up to macro-shapes articulating the forms of entire movements comprise principal components in the vocabulary of the *Zones of Influence* musical world. Shapes may also become elements enabling a kind of syntax for gesture sentences to be composed. Tools for measuring similarities and differences among shapes are also part of the composition toolkit. These also aid in traversing scales of complexity and simplicity among the agents of *Zones of Influence* environments.

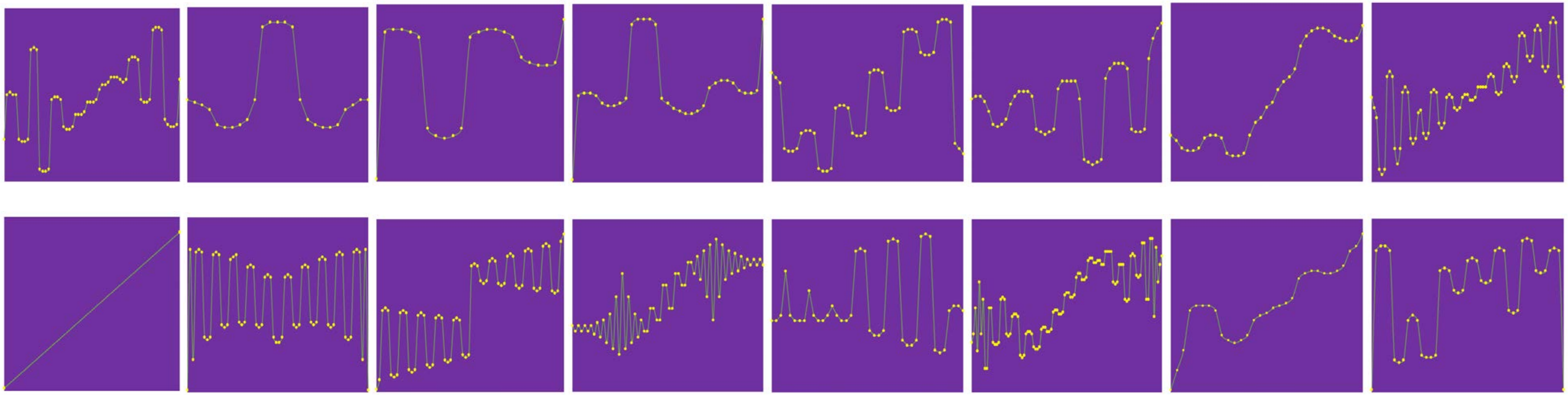
This is also a world inviting creative interpretation in how a solo percussionist interacts with and directs electronics-computer systems linked to the percussion instruments via sensors and operating with those sensor data in response. The electronics-computer systems are to be operated and played by an accompanying performer. In collaboration, the two performers may creatively develop *instrument definitions* to imbed in polyphonic, bi-timbral synthesis units within general guidelines.

Specific instructions for interpreting notations are attached to each Part of the *Zones of Influence* score. Special notes on the electronics-computer setups for each Part are also included. The electronics-computer setups for each Part are shown in simple block diagrams, based on prior realizations. It is presumed that the electronics-computer performer will use hardware and software most effective and available at the time a realization is undertaken. Some general notes on the synthesis techniques follow here.

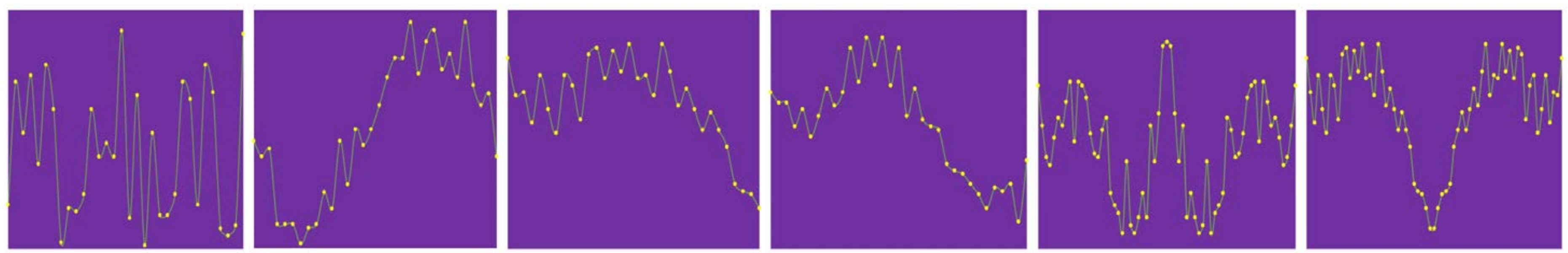
Three, bi-timbral, polyphonic, bi-timbral synthesis units are necessary for a complete performance. Parts Ia, Ib, IIb and IV require three units. Parts III and V require two. Part IIa uses a different approach. The term bi-timbral is used in the following way. In previous realizations, non-linear wave-shaping was the primary synthesis technique employed. Each *instrument definition* could have two wave-shaping transformation tables active at the same time with a means to dynamically cross fade among them. In addition, each wave-shaping transformation table would be associated with its own set of envelope functions—with usually 6 to 8 segments—attached to several synthesis parameters: Pitch, Timbre (width of a window into a transformation table being scanned by a sine function), Timbre Modulation (modulation of the window size via amplitude modulation of the sine function), Frequency or Phase Modulation, and Level or Gate (linked amplitude and low pass filter function). Actions and Alternate Actions could be associated with each breakpoint in each envelope, facilitating stopping, advancing or jumping to another segment based on input stimulus conditions (switches, keys, controller conditions, etc.). Sources for biasing, controlling, or modulating the key synthesis parameters were also available. It must be emphasized that the contents of a pair of wave-shaping transformation tables defines the timbral universe for individual instrument definitions. Having two in each instrument definition, along with their control functions, enables mixing and cross-fading between the two tables. In this way, smooth or not so smooth transitions can be enacted dynamically within a single instrument definition. The electronics performer uses their creative ingenuity to program appropriate *instrument definitions*. A flexible controller setup is needed to initiate *instrument definitions* and control their synthesis parameters in expressive ways. This general concept of synthesis is part of the composer's intention.

In early realizations, a Buchla Touché digital keyboard instrument, based on non-linear wave-shaping synthesis, and a set of Buchla 200 and 300 Series modules were used. A custom interface, Black Box Sensor Interface (Rosenboom and Tomita), was built to enable sensors placed on percussion instruments to be connected to the Touché. The composer's software, FOIL (Far Out Instrument Language), metaFOIL (a metacompiler implementation of FOIL), programs written in TI9900 Assembly Language and an early experimental version of HMSL (Hierarchical Music Specification Language) were employed, all running on the central processor of the Touché. A second-generation version created later with a more developed version of HMSL (Burk, Polansky and Rosenboom) enabled the use of MIDI instruments. The most recent realization—as of the date of this writing—was created using greatly expanded instrument inspired by the original Touché, also based on non-linear wave-shaping synthesis, created with Reaktor CORE software (Rosenboom and Zwartjes), called Touché II. This version can be heard on a double-CD, *Zones of Influence* (Pogus Productions, 2014). Each version had its particular characteristics. As music technology advances in the future, new tools may be brought to bear on future realizations of *Zones of Influence* that may be created anew each time.

The following images show the non-linear wave-shaping transformation tables used for realizations of *Zones of Influence* in which the Touché and Touché II instruments were used. The yellow dots show data points for functions that are interpolated in practice. The idea is to give a visual presentation that might be informative and inspire future realizations. The precise data is not as important as the idea of the *shapes*. Each one defines a particular domain of possible timbres. Each *instrument definition* contains two wave-shaping transformation tables, which can be loaded with any combination of the shapes shown. The last five shapes are specially designed for and used only in Parts V and III. The original Touché, its Black Box Sensor Interface device, and the Touché II Graphic User Interface (GUI) are also shown. Both the Touché and Touché II offered quad-space outputs with parameters that could be modulated.



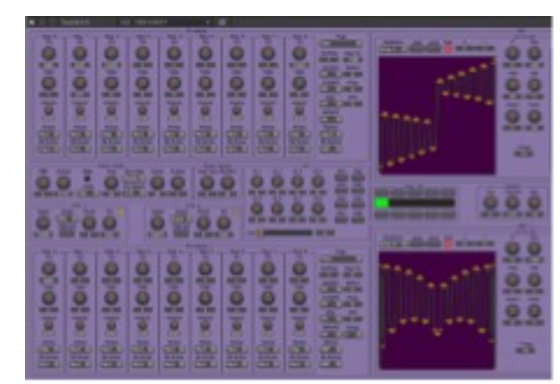
(also for initializing)



III & V III & V III & V III & V III & V

Touché

Black Box Sensor Interface



Touché II GUI

Part I:
The Winding of a Spring
a) *The Stochastic Part* and b) *The Tripartite Structure*

Score
The percussionist uses three snare drums of **Low**, **Medium** and **High** pitch. The pitch ranges of the drums should be well differentiated from each other. Examples could include a Field Drum, Medium Snare Drum and Piccolo Snare Drum. Standard snare drum sticks are used throughout with weight and feel determined according to the performer's preference. Snares are engaged throughout. The score indicates how the left and right hands play on each drum, thus:

LL = both hands on **Low** drum
LM = left hand on **Low** drum, right hand on **Medium** drum
LH = left hand on **Low** drum, right hand on **High** drum
MM = both hands on **Medium** drum
MH = left hand on **Medium** drum, right hand on **High** drum
HH = both hands on **High** drum

Right **R** and Left **L** sticking indications must be followed. The percussionist may recognize some of the sticking patters being drawn from traditional Scottish rudiments, here permuted, varied and overlapped with combinations of rhythmic groupings; flam, ruff, and normal strokes; open and closed rolls and accent structures. In addition to articulating the form of this snare drum solo, these elements are also important in how they drive the electronic parts triggered through sensors attached to each of the three snare drums.

Tempo markings change often. A *Just* scale of tempi is used to articulate the sense of speeding up and slowing down, meant to enable a kind of *tempo melody* to be felt within a tuned *tempo scale*. The ratios listed with the tempo markings are a guide for the performer. They indicate proportions that show how a change from one tempo to another can be thought of as a *metric modulation*. For example, the ratio 5/6 corresponds to a tempo shift from quarter-note equals 75 beats per minute to quarter-note equals 90 beats per minute. The performer should try to play these changes as accurately as possible, within human reason. For practicing purposes, it can be helpful to work with a computer-generated click track, in order to get used to the speed changes. After practicing in this way, the percussionist should proceed according to their own internalized sensitivities for speeds.

In the *Tripartite Structure*, small letters above each bar outline groupings in the tripartite form. They may be useful for analyzing the tripartite form, but the percussionist does not need to follow them in performance. The *Stochastic Part* and the *Tripartite Structure* may be considered sub-movements in *The Winding of a Spring* and may be separated in performance by a brief pause. The electronics-computer performer may need to reinitialize software and equipment during this pause, but its length should remain brief.

Zones of Influence is conceived as a work integrating solo percussion performance with electronics and algorithmic systems. However, it has been possible on occasion to perform Part I as a percussion solo for multiple snare drums to good effect, without including the electronics parts. In such a realization, performers should play expressively and brilliantly. *The Stochastic Part* is wild and unpredictable. *The Tripartite Structure* is a completely determined pattern of elements grouped hierarchically in threes, i.e., threes within larger threes, within larger threes, etc., up to several powers of three. The score shows blocks of nine-bar phrases, separated by brief rests in time. These nine-bar phrases are, in turn, grouped in sets of three, making 27-bar sections, and so on.

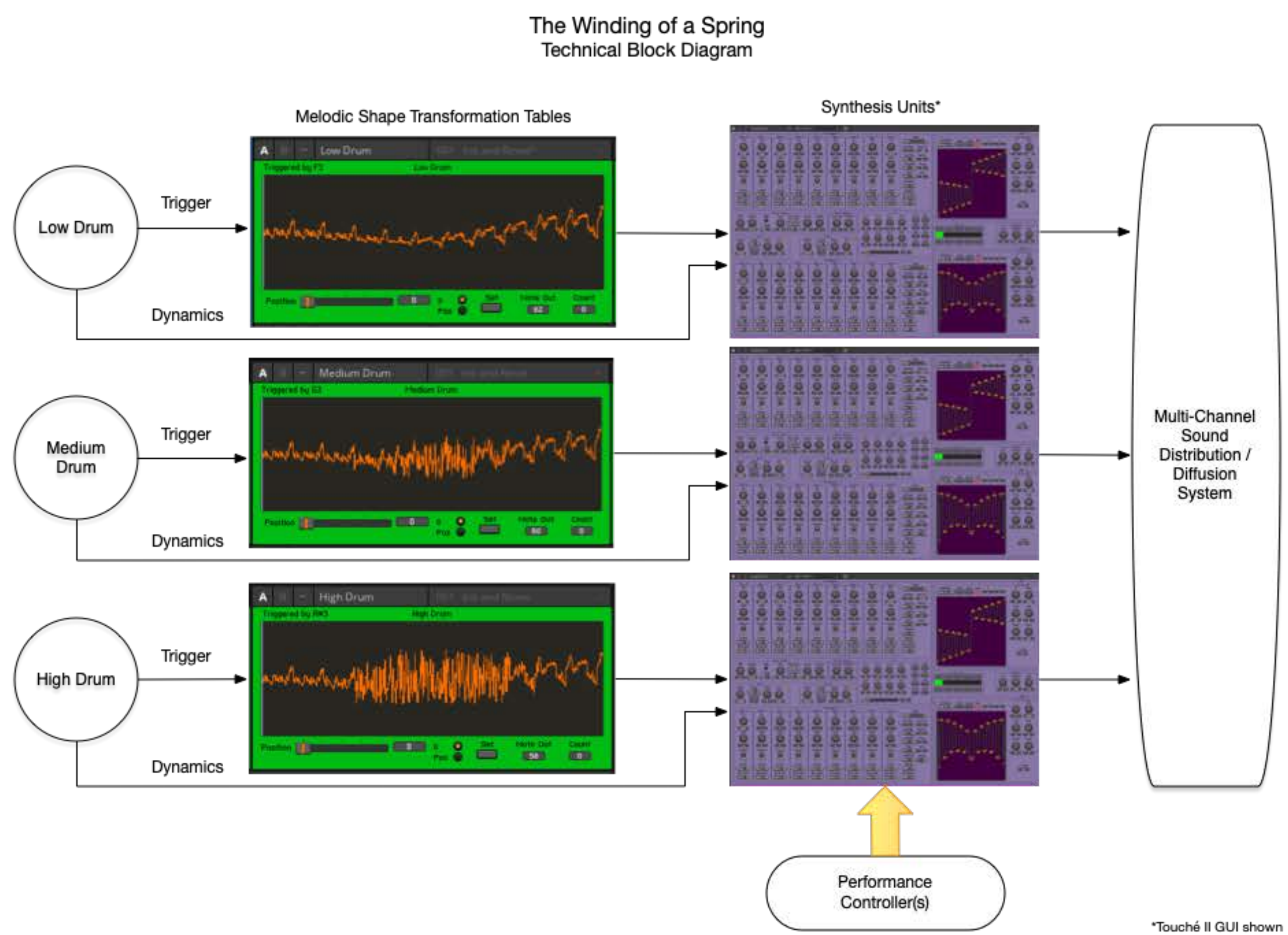
The entirety of the percussion part for *The Winding of a Spring* is a layering of independent compositions: a rudiment patterns composition, a sticking pattern composition, a notes-per-beat composition, a left-right hand and drum pitch composition, a tempo composition, and an accent composition. Each composition plays itself out in two larger frameworks, one based on probabilities and one based on cyclical patterns. It should be fun, subtle, bright, rich, and energetic.

Electronics-Computer Part
The intended function of the electronics-computer setup is to capture drum strokes and use that data to play a set of melodic shapes that entwine each other in a complex emerging counterpoint, the dynamic subtleties of which are influenced by the percussionist's articulation of the written score. For this purpose, an array of melodic lines was created by transforming the *melodic shapes* of two freely composed, sixty-note lines: *Origin Melody* and *Target Melody*. These two melodies help form the structural DNA in all of *Zones of Influence*. One technique employed extensively involves bending an

Origin Shape iteratively, aided by semi-stochastic and semi-deterministic algorithms, so that they pass through various perceptual domains, called trajectories, until finally arriving at the *Target Shape*. The contrapuntal arboretum that emerges in each part of the composition results from the ways in which the transformed shapes are combined, which may vary somewhat from performance to performance.

Data for the array of pre-generated melodic shapes must be entered into the electronics-computer system for each part of the work. Tables for these data are shown below, along with graphs that display a visual gestalt for each array. The data shown in the arrays are in standard MIDI pitch values. One way to enter these data into a computer system is to copy the tables from a digital version of this score and paste them into simple text files that can be imported into the software used to realize performances.

Sensors attached to each snare drum must extract trigger and dynamics data to be sent to the electronics-computer setup. This system must be tuned so that it can capture individual high-speed drum strokes as accurately as possible. Readouts from the data tables are triggered by each stroke from corresponding drums. When a table reaches its end, it wraps around back to its beginning and continues. Each of three synthesis units is driven by the data elements in a corresponding table of data for melodic shapes and receives dynamics information from a corresponding drum. Dynamics data can be used to shape synthesis parameters. The following diagram shows snare drums, data tables, and polyphonic, bi-timbral synthesis units. (Images of the composer's Reaktor modules are shown to serve as conceptual examples.) The performer may also develop their own means for real-time algorithmic responses to performed dynamics.



Melody Transformation Shape Trajectory Data for *The Winding of a Spring*

The following tables show MIDI pitch numbers for the *Origin Melody*, *Target Melody*, and melody transformation trajectory shape data sequences that are to be entered into the data tables activated by each drum. The *Origin* and *Target Melody* tables are shown for reference. They are also included in each of the three drum tables. Graphs of the shapes are provided to give a visual feel for the forms of these shapes. Note that the *Origin* and *Target Melodies* can be seen in more traditional notation in Part II: *Closed Attracting Trajectories*, *Melody Set 1*.

Origin Melody Shape Data—Begins Each Set of Melody Transformation Trajectories

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77

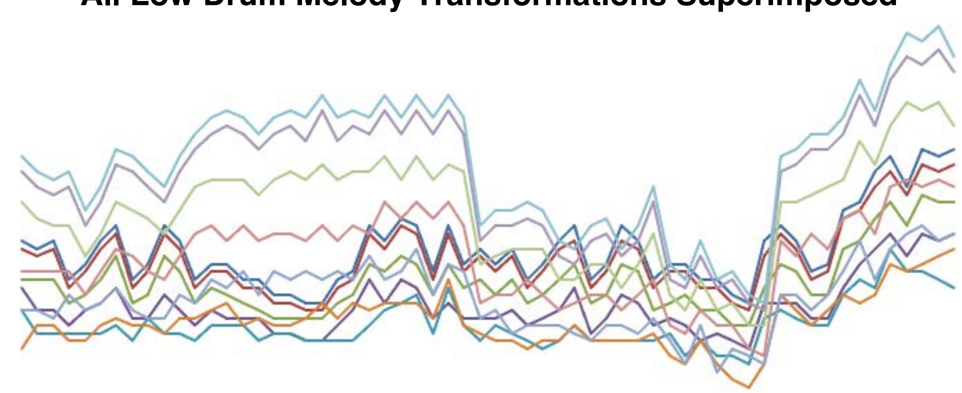
Target Melody Shape Data—Concludes Each Set of Melody Transformation Trajectories

76 74 73 74 69 72 77 76 74 72 76 79 81 82 81 79 81 82 81 84 81 82 81 84 81 84 81 84 81 67 69 69 70 69 65 64 67 68 64 67 72 62 60 65 60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

Low Drum Shape Data—Trajectory of 11 Melodies Transformed from *Origin* to *Target* in Sequence (660 notes)

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 64 63 64 59 61 64 66 59 61 66 64 59 61 61 59 59 57 57 56 56 59 60 66 64 67 66 60 66 61 63 61 63 59 61 64 65 59 61 65 64 59 61 61 59 59 57 56 63 66 64 60 61 68 69 72 74 71 75 74 75 60 60 60 57 58 60 63 57 58 63 61 57 59 58 57 56 55 55 55 55 57 58 62 61 63 62 58 62 59 60 58 60 57 58 60 62 57 58 62 61 56 57 58 56 56 54 54 59 62 61 58 58 64 65 68 70 67 71 70 70 59 56 56 54 56 57 59 55 55 58 56 54 56 55 55 55 53 53 52 52 54 56 60 57 60 59 55 57 55 55 55 56 54 55 56 59 53 55 58 57 54 55 54 52 53 52 51 57 57 57 55 55 59 62 64 66 63 66 65 66 56 53 53 53 53 53 54 52 55 53 53 52 54 54 54 52 53 53 52 52 52 52 54 56 57 58 53 59 54 52 54 53 52 51 52 54 52 52 52 52 52 53 50 52 50 50 49 55 56 55 54 54 58 60 59 64 61 61 60 59 51 54 54 52 52 54 55 54 54 53 55 55 56 57 54 55 54 54 55 57 55 57 56 57 57 57 55 60 54 53 52 52 51 52 52 54 52 52 52 52 53 50 49 52 49 47 46 49 58 56 54 56 58 57 58 62 61 62 63 64 56 56 55 58 56 57 59 56 55 55 58 57 60 59 61 58 61 60 61 60 61 60 63 60 61 64 58 62 61 55 56 53 54 54 54 53 52 54 54 53 55 52 49 54 48 51 50 49 58 58 56 58 61 65 60 64 66 67 65 66 61 61 61 61 58 61 64 63 61 60 63 66 67 65 67 65 66 66 65 67 65 67 66 70 68 70 68 70 67 57 58 58 60 58 56 57 58 58 56 58 60 54 53 56 54 54 51 50 65 63 66 64 68 69 66 72 73 72 73 72 70 68 67 67 63 66 70 69 68 66 69 72 73 73 73 71 73 74 73 75 73 74 74 76 73 76 73 75 74 62 63 64 64 64 60 60 62 62 59 62 66 58 56 60 56 57 54 54 70 70 71 72 73 78 75 80 83 82 83 80 74 72 71 72 67 70 75 74 72 70 74 77 79 80 79 77 79 80 78 82 78 80 79 82 79 82 79 82 79 65 67 67 68 67 63 62 65 66 63 65 70 60 59 63 59 60 57 56 74 75 77 77 79 84 80 86 89 88 90 87 76 74 73 74 69 72 77 76 74 72 76 79 81 82 81 79 81 82 81 84 81 82 81 84 81 84 81 84 81 67 69 69 70 69 65 64 67 68 64 67 72 62 60 65 60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

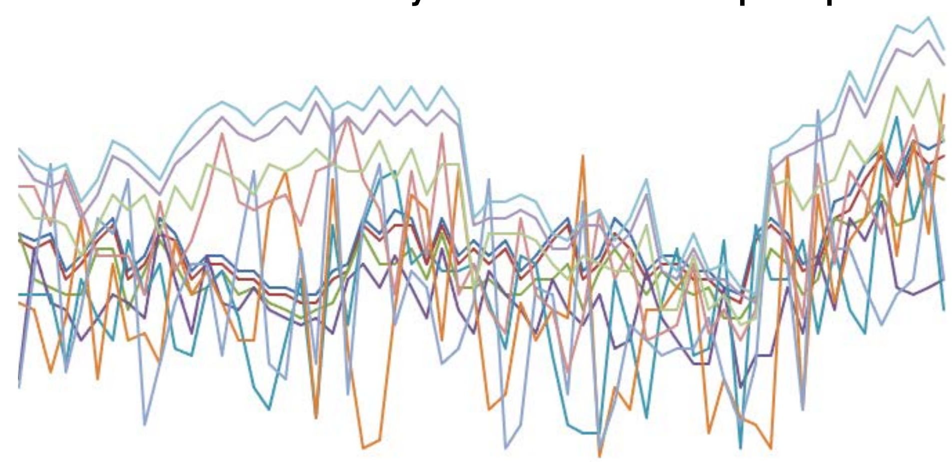
All Low Drum Melody Transformations Superimposed



Medium Drum Shape Data—Trajectory of 11 Melodies Transformed from *Origin* to *Target* in Sequence (660 notes)

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 64 63 64 59 61 64 66 59 61 65 64 59 61 61 59 59 57 57 56 56 59 60 66 64 66 66
61 66 61 63 61 63 59 61 64 66 59 61 65 63 59 61 61 59 59 57 56 64 66 64 60 61 67 68 72 75 71 76 74 75 65 59 58 57 57 63 63 55 60 64 61 57 58 60 57 58 56 55 54 55 56 60 65 61 61 63 59 65 58 58 59 57 57 59 59 61 55 60 63 60 57 60 58 57 58 54 54 57 63 61 57 59
67 66 67 70 66 67 73 72 46 63 56 55 51 54 57 56 54 66 59 52 62 56 55 58 55 54 53 54 52 59 61 58 62 58 54 63 55 52 60 57 55 52 59 55 53 57 50 51 60 54 51 48 48 58 45 49 49 58 52 62 55 67 64 69 58 57 58 59 57 57 57 48 59 54 51 64 57 61 50 49 58 60 54 45 42 51
59 41 66 53 66 72 73 61 63 60 60 61 56 50 62 61 49 40 39 39 59 52 41 56 63 49 50 64 37 66 59 59 64 52 63 55 52 73 80 67 74 55 56 55 47 54 67 46 61 51 52 48 64 57 60 56 51 51 68 73 62 41 72 50 37 38 55 70 68 51 73 58 42 44 56 51 55 54 75 36 45 42 55 55 58 61
39 46 41 40 37 75 42 70 56 64 67 77 62 77 65 83 45 60 74 47 55 67 65 72 40 48 56 61 61 49 63 73 48 46 63 48 81 44 67 74 53 60 58 48 50 56 72 37 40 58 57 44 69 37 43 53 51 49 50 50 54 46 40 48 73 61 42 81 63 63 58 53 57 59 73 59 71 71 66 73 68 62 62 62 57 69
60 64 70 78 69 68 69 70 66 73 74 80 72 68 57 73 62 78 57 61 55 52 67 57 55 47 54 68 59 63 51 52 53 61 52 55 51 55 74 62 54 74 61 73 70 65 73 79 71 79 70 67 67 66 62 66 70 68 70 65 71 68 74 73 72 70 74 73 74 76 74 73 73 77 72 76 70 74 74 58 65 65 65 64 61 59
62 61 60 60 66 55 55 62 55 57 53 54 71 72 68 71 72 77 74 77 84 80 85 77 75 72 71 72 67 70 75 74 72 70 74 76 78 80 78 77 78 80 78 82 78 80 78 81 79 81 79 81 79 66 67 67 68 67 63 63 66 66 63 65 70 60 59 63 59 59 57 56 73 75 76 77 78 84 80 85 89 88 90 87 76 74
73 74 69 72 77 76 74 72 76 79 81 82 81 79 81 82 81 84 81 82 81 84 81 84 81 84 81 67 69 69 70 69 65 64 67 68 64 67 72 62 60 65 60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

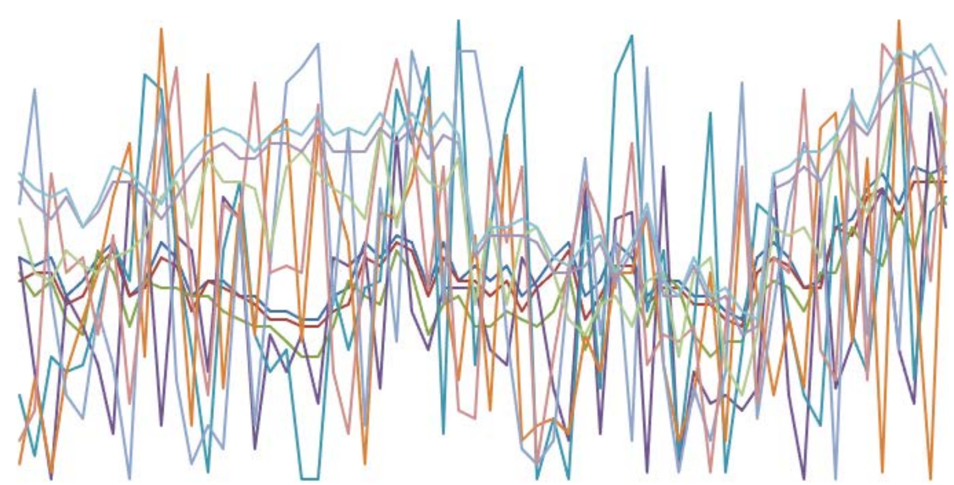
All Medium Drum Melody Transformations Superimposed



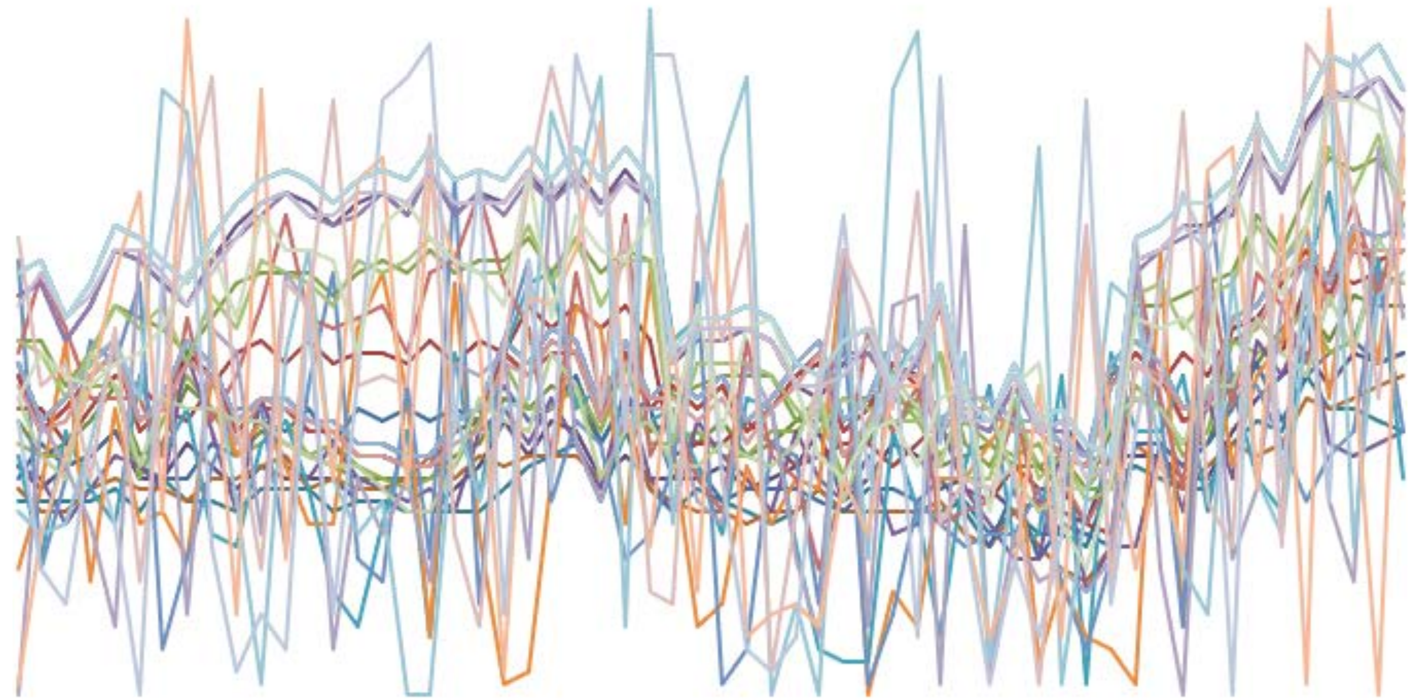
High Drum Shape Data—Trajectory of 11 Melodies Transformed from *Origin* to *Target* in Sequence (660 notes)

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 62 63 63 59 60 64 66 60 61 65 64 58 62 61 60 59 57 57 56 56 58 59 65 64 67 66
60 65 62 62 60 62 58 61 63 66 57 60 64 64 59 61 61 59 59 57 56 63 65 64 61 61 69 68 73 74 70 75 75 75 63 60 62 57 55 66 63 56 62 61 61 60 60 58 57 56 56 54 52 52 56 62 60 59 66 63 55 59 60 56 56 58 57 56 58 63 53 59 64 61 56 63 61 55 52 54 54 60 62 61 58 63
63 69 66 64 71 66 76 72 65 50 36 60 56 51 42 75 73 43 68 66 50 73 70 40 55 50 55 46 65 64 66 48 81 58 53 61 61 61 53 51 65 61 48 41 74 42 70 71 37 77 38 50 46 47 45 48 76 47 36 73 48 54 70 74 53 46 84 69 47 39 52 50 51 58 67 62 89 87 66 53 37 66 75 55 50 53
36 36 61 53 61 62 87 80 90 42 96 51 69 83 90 36 44 36 71 48 89 94 58 66 39 56 84 37 53 72 70 57 47 43 73 55 50 68 92 49 71 73 38 49 37 50 57 63 73 80 52 95 69 43 89 48 72 55 81 83 54 81 74 67 38 71 70 75 86 62 49 68 45 81 41 43 44 42 55 50 63 63 71 51 41 47
63 41 75 60 47 57 48 82 84 54 78 37 96 65 36 85 72 87 60 47 44 58 51 36 73 85 49 38 43 40 70 43 64 88 90 93 59 82 43 74 54 92 84 59 92 92 80 55 40 38 41 62 78 55 68 41 90 51 37 48 41 50 88 44 59 72 80 75 36 87 55 73 53 92 88 76 41 45 76 63 65 55 68 46 63 79
90 60 47 72 70 88 63 64 63 85 50 42 66 81 91 82 61 77 45 44 78 67 77 38 52 64 75 70 61 80 51 55 54 56 37 56 77 46 65 63 87 53 49 86 49 93 90 79 62 87 70 63 62 66 64 63 65 66 68 73 75 69 78 75 75 74 66 77 79 76 74 73 70 82 69 78 75 74 78 59 70 59 68 69 63 57
55 59 60 56 62 63 52 63 65 51 47 55 69 68 69 65 81 74 71 77 88 88 87 80 75 72 70 73 69 71 75 75 73 70 73 76 79 80 78 78 80 80 79 82 79 79 79 82 80 82 78 81 80 65 68 68 68 67 63 63 64 67 62 66 71 60 60 64 59 60 55 56 74 75 77 75 79 83 81 85 88 89 90 85 76 74
73 74 69 72 77 76 74 72 76 79 81 82 81 79 81 82 81 84 81 82 81 84 81 84 81 84 81 66 69 69 70 69 65 64 67 68 63 67 72 62 60 65 60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

All High Drum Melody Transformations Superimposed



All 33 Melody Transformations used in *The Winding of a Spring* Superimposed



In practice, instrument definitions for the three polyphonic, bi-timbral synthesis units are to be developed by the electronics-computer performer according to their creative responses to the score and the percussionist's interpretation. In general, it is most effect to call up new *instrument definitions* or make alterations in their controllable parameters at points where the percussionist's Left/Right sticking patterns change, i.e., **LM** to **MH** to **LH** and so on. It is recommended to select some, not all, of these points in the score at which to make changes in synchrony with the percussionist. They may be initiated quickly for abrupt synchronized changes or slowly to make gradual transitions.

Part II:
Closed Attracting Trajectories
a) *Melody Set 1* and b) *Melody Set 2*

General Note
Closed Attracting Trajectories requires a five-octave marimba and a xylophone that is used to extend the upper range of the marimba in *Melody Set 2*. *Melody Set 1* and *Melody Set 2* may be considered sub-movements of *Closed Attracting Trajectories* and may be separated in performance by a brief pause. The electronics performer may need to reinitialize software and equipment during this pause, but its length should remain brief.

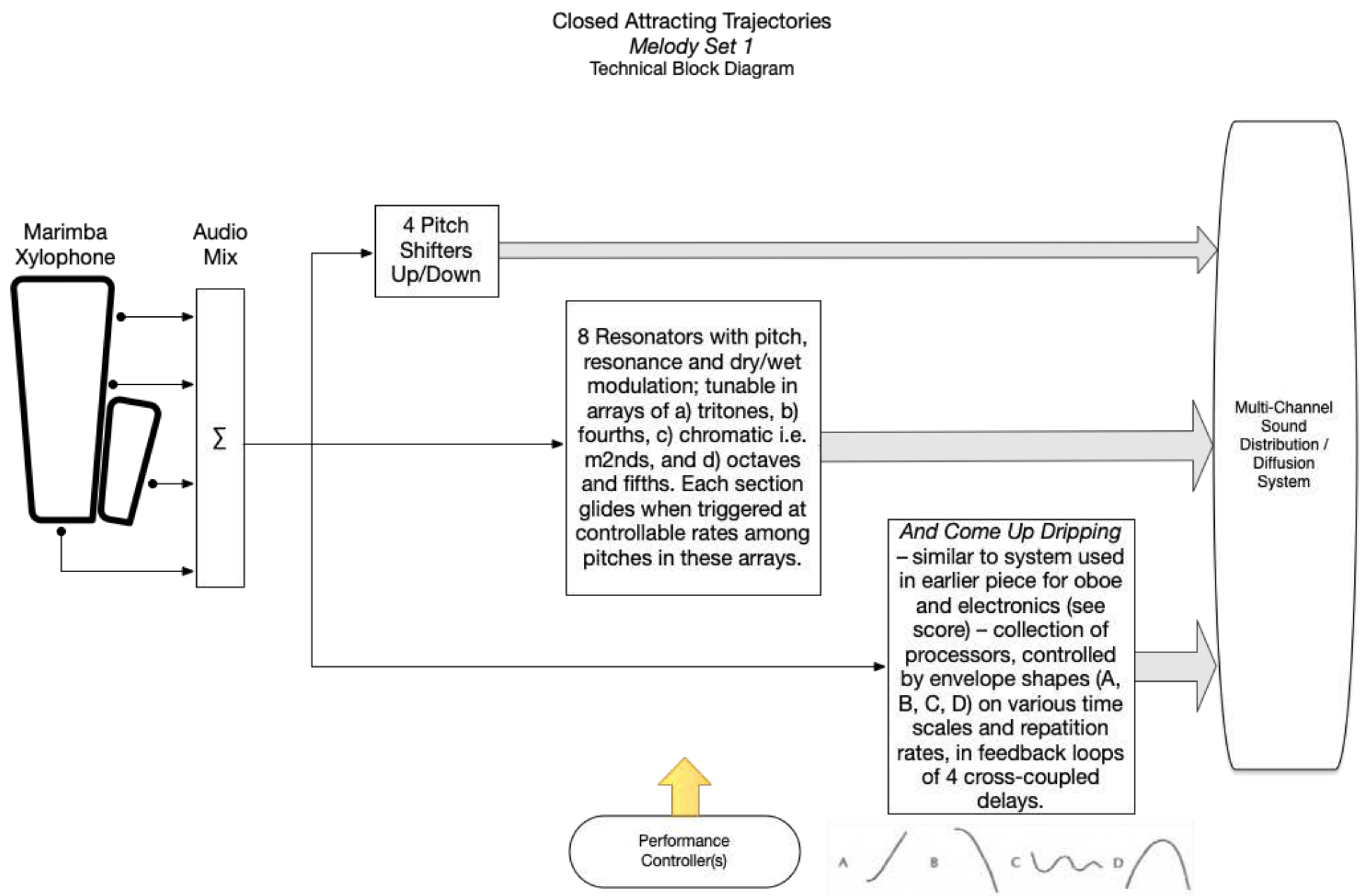
Melody Set 1

Score
The notations for *Melody Set 1* are contained within a series of twenty-one boxes. Each box contains a melody that is notated without meter. The percussionist is to use their best sense of melodic shaping and phrasing to freely interpret these notations. This sub-movement should be relatively soft and subtle. The first box contains the *Origin Melody*, and the last box contains the *Target Melody*. These melodies permeate the entire *Zones of Influence* world. The intervening nineteen boxes contain melodies derived by transforming the *Origin Melody* into the *Target Melody* in a way that creates the smoothest transformation trajectory heard in *Zones of Influence*.

Only the marimba is used in *Melody Set I*. Accidentals apply only to the notes they precede. Lines extending out from some note heads are proportional, indicating that those notes should be sustained with soft rolls. The approach should be to make the marimba sing softly.

Electronics-Computer Part
The electronics-computer performer is invited to follow the percussionist, accompanying them with very subtle processing of the marimba sound. The intention is to try to give the illusion that the marimba is able to bend its pitches as in singing a raga. The effects should be very subtle. They may also place the marimba sound inside a sonically luminescent, soft cloud. In previous performances, processes illustrated below were used. These are provided here to give context and illustrate the intention. The electronics-computer performer is free to develop their own processes in a creative response to the percussionist's interpretation.

It is generally effective to allow the percussionist to play the *Origin Melody* without processing, and then slowly add it until around the middle of the sub-movement and reduce it as the percussionist approaches the *Target Melody*.


Closed Attracting Trajectories
Melody Set 1
Technical Block Diagram
Marimba Xylophone
Audio Mix
Σ
4 Pitch Shifters Up/Down
8 Resonators with pitch, resonance and dry/wet modulation; tunable in arrays of a) tritones, b) fourths, c) chromatic i.e. m2nds, and d) octaves and fifths. Each section glides when triggered at controllable rates among pitches in these arrays.
And Come Up Dripping – similar to system used in earlier piece for oboe and electronics (see score) – collection of processors, controlled by envelope shapes (A, B, C, D) on various time scales and repatition rates, in feedback loops of 4 cross-coupled delays.
Multi-Channel Sound Distribution / Diffusion System
Performance Controller(s)
A
B
C
D

Melody Set 2

Score
While *Melody Set 1* presents the smoothest trajectory of melody transformations from *Origin* to *Target*, *Melody Set 2* presents the most wildly jagged and complex. The score begins with a reminder of the *Origin Melody*, as presented in *Melody Set 1*, without electronics. The interpretation, however, does not have to be the same. This is immediately followed by the main section of *Melody Set 2* with electronics-computer parts added.

The notation for this part presents material for a *moving window improvisation*. Each bar, separated by dashed bar lines, contains one twenty-note melody shape along a trajectory of thirty-three transformed shapes toward the *Target Melody* at the end. Tick marks inside each bar separate groups of four notes. These marks are for visual convenience and to help the player keep track of their position. Below each bar, two numbers are shown, one at the beginning and one in the middle. These numbers define the current width of the window in the moving improvisation. For example, in the first bar, the window begins five notes wide. This means that the percussionist is to improvise with groups of five notes at a time, starting with the first five, then dropping the first note and adding the sixth, then dropping the second and adding the seventh, moving in this way through the bar until the middle. At the middle, the window size drops to two notes at a time. The percussionist is to improvise in this way, moving through the melody streams at their own pace.

Next, each bar has its own tempo marking. These range from very fast to quite slow. The improvisation should be guided by these speeds, which are constantly changing, articulating *tempo melodies*. Finally, each bar also shows dynamic markings. Sometimes, there is one marking. Sometimes there are two markings with a back slash. In these instances, the percussionist is to integrate sudden shifts in dynamics while improvising inside the bar. For instance, if the dynamics indication is ***pp/f*** , the percussionist should include sudden shifts between pianissimo and forte at will in their improvisation. When brackets appear above notes or groups of notes, these pitches are intended to sound an octave higher, and usually require use of the xylophone. The xylophone must be placed within easy reach of the percussionist, enabling switching to appropriate mallets and making a seamless extension of the marimba parts to the xylophone. If this is not possible, because of limitations of range with the instruments available, they may be sounded as written. The brackets are there, because the combination of balanced stochastic and deterministic processes in the compositional algorithms call for the higher pitches to preserve the form of the melody transformations. Pitches in the counterpoint melodies articulated by the electronics-computer parts will be able to sound its intended pitches.

After the final bar of the moving window improvisation, and after a breath, the *Target Melody* should be sounded without electronics-computer interaction to conclude *Closed Attracting Trajectories*.

The percussionist should choose mallets that are not too soft and provide well-articulated lines.

Electronics-Computer Part
An eight-voice counterpoint of transformed melody shapes is to be added by the electronics-computer part. Microphones focused on the low, middle and high ranges of the marimba and the xylophone should be set up. These should be adjusted so that their responses delineate the four ranges and areas of the instruments. However, a bit of overlap in the pickup regions, depending also on the performer's dynamics, is acceptable.

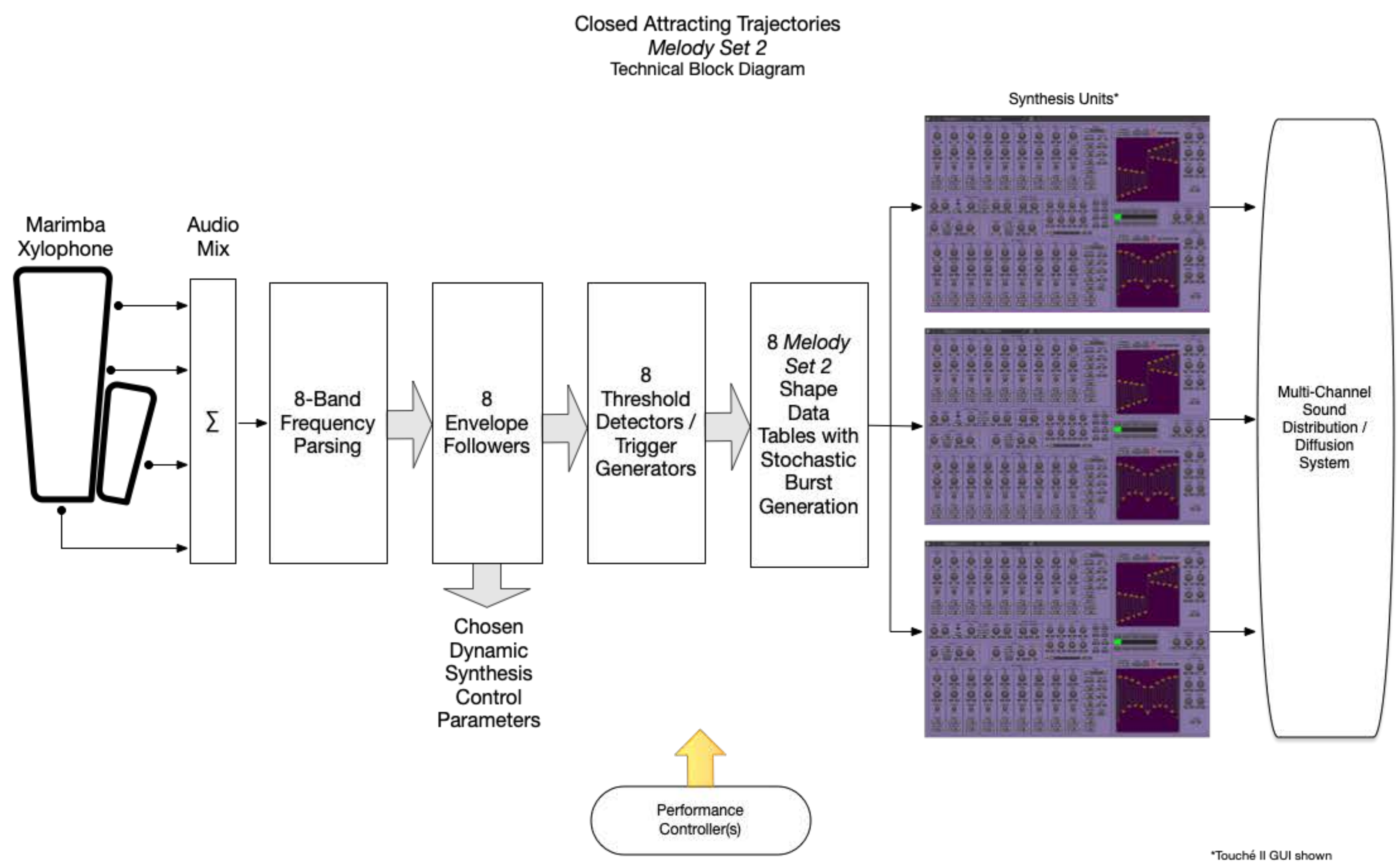
The mixed mike signals are sent to a set of bandpass filters that parse the frequencies in the acoustic signal into eight differentiated frequency bands, covering the range of the instruments. It is intended that there be a dynamic interaction of the percussionist with the responses of the bandpass filters. Perfect differentiation is not as good as excellent differentiation with some overlap and dynamical, push-pull responses.

The outputs of the eight filters are connected to eight envelope followers followed by eight threshold detectors. The envelope follower outputs are available to apply to synthesis algorithm parameters, to create dynamic effects following the percussionist's dynamics, at the discretion of the electronics-computer performer. The threshold detectors are tuned to transmit triggers reliably in response to marimba and xylophone strokes to eight data table units containing a set of melodic transformation shapes. This is in a similar manner to Part I, *The Winding of a Spring*. In this case, however, each trigger advances the system through its corresponding data table, which outputs its note values to all three of the polyphonic, bi-timbral synthesis units. These data table units also have Enable switches, which the electronics-computer performer can use to turn on and off each of the eight table outputs.

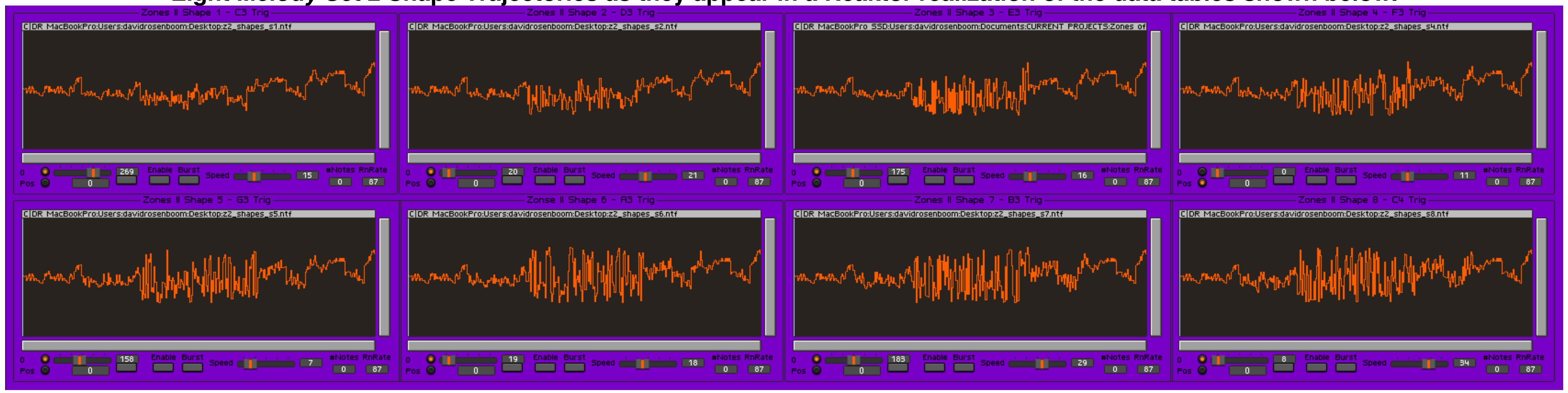
Each table has an Enable switch. It is generally effective to turn on several of the data table outputs at the beginning, add others individually, and then disable some as the movement progresses toward its end. The polyphonic, bi-timbral synthesis units used in the past were also based on non-linear wave-shaping, as has been described in the instructions for Part I, *The Winding of a Spring*.

Data for the array of pre-generated, melodic transformation shapes must be entered into the electronics-computer system. Tables for these data are shown below. The numbers shown in the arrays are in standard MIDI pitch values. These can be copied and pasted into text files that can be imported into software used to realize the score in performance. An image of eight data table units implemented in Reaktor software is shown below.

These data table units also have a feature for generating bursts of notes. When this is enabled, a trigger signal generates not just one note, but a burst of notes at a speed set by the operator. Setting each table with its own speed value can create a rich array of readouts, as the progress of the performance moves the melody transformation tables through their shape data. The number of notes in any given burst is also determined stochastically so that they are constantly varying. This adds an element of uncertainty and surprise and is particularly effective when the percussionist is performing bars in the score with very slow tempi. When a data table reaches its end, it loops back to its beginning and continues.



Eight *Melody Set 2* Shape Trajectories as they appear in a Reaktor realization of the data tables shown below.



Melody Set 2 Shape Trajectory 1

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 59 59 60 57 58 62 61 57 58 62 60 57 58 60 57 56 56 54 54 53 56 59 61 61 62 62
57 64 59 58 57 59 57 58 59 63 56 57 63 60 56 59 58 56 55 54 53 59 64 61 57 59 63 64 67 72 67 69 69 71 52 55 57 52 47 63 57 53 47 58 55 55 51 52 60 47 57 54 52 56 52 61 56 53 58 57 53 55 51 51 46 62 51 56 49 57 51 57 58 49 51 58 50 50 43 51 47 42 62 56 56 60
53 61 55 65 62 70 63 61 48 56 58 50 53 53 60 53 62 62 60 58 65 55 65 65 58 54 57 59 61 61 67 67 59 64 68 67 64 47 55 51 55 55 50 50 53 53 51 57 52 55 57 54 48 46 49 41 64 67 62 62 62 67 62 62 65 70 75 75 68 68 68 68 62 66 70 70 67 67 70 71 73 76 74 73 73 76
75 77 72 75 72 75 73 76 75 74 74 62 64 62 66 65 62 61 63 62 58 61 67 58 56 60 57 56 53 53 69 69 71 72 74 78 73 80 85 84 85 81 76 74 73 74 69 72 77 76 74 72 76 79 81 82 81 79 81 82 81 84 81 82 81 84 81 84 81 84 81 67 69 69 70 69 65 64 67 68 64 67 72 62 60 65
60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

Melody Set 2 Shape Trajectory 2

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 60 59 61 56 58 59 61 57 58 65 61 57 59 59 56 56 55 54 54 53 59 56 64 60 65 62
58 64 58 59 58 59 56 56 63 60 56 59 60 61 56 59 56 58 55 55 53 58 64 60 58 57 67 67 69 68 67 71 69 72 66 48 68 38 37 43 58 52 55 48 68 45 41 40 40 68 45 62 60 46 53 49 46 67 58 59 58 47 46 58 51 53 53 57 64 60 42 53 59 55 52 43 42 50 56 52 44 37 40 40 62 52
52 73 60 51 75 69 63 60 56 52 68 59 41 55 53 55 56 50 59 63 60 54 44 76 43 66 63 56 63 65 49 44 54 63 65 61 59 55 58 58 54 61 54 60 44 53 43 46 46 56 55 54 54 52 46 50 57 57 56 63 50 74 67 63 63 69 75 76 67 68 67 68 60 67 70 71 67 66 69 69 75 77 77 71 74 72
75 77 71 73 71 79 73 76 73 75 75 61 62 63 63 64 58 61 59 61 56 64 67 60 58 59 58 58 52 53 68 71 74 73 77 77 76 77 80 82 85 78 76 74 73 74 69 72 77 76 74 72 76 79 81 82 81 79 81 82 81 84 81 82 81 84 81 84 81 84 81 67 69 69 70 69 65 64 67 68 64 67 72 62 60 65
60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

Melody Set 2 Shape Trajectory 3

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 59 62 61 57 56 59 63 58 58 63 61 57 61 58 56 58 55 56 54 53 57 59 61 62 63 61
58 60 57 62 58 58 58 56 63 60 56 57 60 58 57 57 59 57 57 54 54 62 61 62 57 57 65 62 71 71 67 72 71 70 53 47 56 45 55 45 46 67 48 76 46 52 63 62 41 46 48 40 47 40 73 37 71 38 73 54 56 63 49 51 55 49 38 39 78 40 41 65 44 61 40 64 38 71 39 60 42 37 69 38 62 47
77 79 67 49 62 62 47 76 71 45 73 39 36 45 59 56 59 45 63 47 41 40 55 75 46 69 75 46 60 44 44 71 62 66 76 43 51 55 53 54 58 67 72 72 43 55 62 55 61 44 42 50 61 54 41 39 36 51 68 53 53 87 62 48 84 83 93 63 69 66 69 68 59 65 68 67 67 64 69 73 73 72 69 74 69 74
73 74 75 76 70 74 72 76 73 76 73 64 65 65 64 65 61 62 59 62 59 61 65 61 58 61 56 57 53 54 69 70 71 74 70 80 76 79 82 82 86 84 76 74 73 74 69 72 77 76 74 72 76 79 81 82 81 79 81 82 81 84 81 82 81 84 81 84 81 84 81 67 69 69 70 69 65 64 67 68 64 67 72 62 60 65
60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

Melody Set 2 Shape Trajectory 4

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 57 63 61 56 61 63 62 57 57 66 62 59 61 58 56 58 55 57 55 55 54 58 66 62 63 61
58 58 59 61 57 58 54 61 61 60 57 61 64 61 58 58 58 54 57 55 52 62 65 61 57 58 62 63 72 72 67 74 70 73 44 46 50 64 51 76 61 45 74 57 57 58 60 62 65 60 40 67 59 59 63 38 48 67 56 44 72 63 64 48 61 45 51 58 40 36 75 60 47 37 39 76 45 37 47 51 44 74 41 73 73 67
41 41 37 41 64 67 73 60 75 58 44 80 62 65 50 50 63 71 59 54 49 58 76 36 70 59 60 65 68 66 78 85 76 80 72 53 80 71 43 43 37 36 57 50 38 62 78 50 60 77 42 66 55 63 69 46 69 53 44 76 94 71 86 52 67 68 54 67 75 66 69 67 63 65 75 70 71 66 68 71 77 78 74 68 74 73
68 73 73 77 74 74 75 77 70 73 74 62 66 64 70 60 60 57 67 64 62 64 64 54 52 57 55 60 52 56 69 75 74 74 74 80 75 85 79 83 89 78 76 74 73 74 69 72 77 76 74 72 76 79 81 82 81 79 81 82 81 84 81 82 81 84 81 84 81 84 81 67 69 69 70 69 65 64 67 68 64 67 72 62 60 65
60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

Melody Set 2 Shape Trajectory 5

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 70 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 64 67 65 61 62 69 70 74 76 72 77 76 77 65 58 62 55 62 63 64 53 59 62 58 58 60 58 59 56 53 53 55 54 57 56 67 59 59 58
55 68 56 63 59 58 56 55 57 66 57 59 66 58 55 59 56 56 57 55 55 64 59 61 58 59 65 63 65 70 68 74 68 66 49 39 74 45 41 88 56 41 83 80 89 48 52 47 75 58 37 47 36 36 45 41 58 58 57 53 41 93 50 65 60 50 63 60 41 55 46 56 69 52 52 61 59 56 50 70 55 69 42 52 36 37
44 80 70 62 73 65 58 64 56 55 47 64 43 84 71 54 48 66 83 87 36 60 48 69 46 62 62 85 47 58 60 50 80 85 88 51 62 42 85 79 40 40 47 75 50 59 56 49 64 46 48 48 43 62 45 82 54 49 42 75 73 84 88 44 92 91 41 46 63 69 73 70 71 63 72 63 61 66 74 66 75 73 76 72 68 78
75 74 80 71 74 82 74 74 74 74 75 56 59 60 63 71 55 57 64 63 56 60 67 51 55 59 58 56 52 55 69 72 75 72 73 83 78 76 77 82 87 80 76 74 73 74 69 72 77 75 74 72 76 79 81 82 80 79 81 82 80 84 81 82 81 84 81 84 81 84 81 66 69 69 70 69 65 64 67 68 64 67 72 62 60 65
60 61 58 57 76 77 79 79 81 86 82 88 92 91 93 89

***Melody Set 2* Shape Trajectory 6**

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 67 58 65 60 57 55 60 57 59 68 64 59 58 61 58 58 55 53 55 53 60 58 60 60 63 62
57 66 57 62 59 61 56 54 62 57 58 62 64 62 57 62 58 55 54 56 54 66 61 62 58 59 59 65 66 74 66 75 71 69 59 59 69 84 48 82 93 85 43 92 46 41 55 50 80 57 58 54 56 41 92 88 92 96 86 47 37 45 75 53 58 58 64 36 43 49 45 48 45 56 54 53 37 70 88 96 95 80 53 84 44 61
65 58 71 54 49 37 93 89 50 79 87 59 82 56 85 91 51 53 37 43 46 79 69 70 58 59 76 44 57 66 38 92 71 42 77 87 58 55 47 81 86 92 95 47 44 63 36 89 92 65 55 57 87 70 43 50 66 51 63 66 57 58 44 90 87 38 85 90 73 70 74 67 64 61 72 73 61 68 78 75 68 74 71 71 79 79
71 81 72 76 64 73 73 81 73 84 75 58 69 64 65 70 64 67 67 64 53 67 68 59 58 58 54 60 54 51 74 72 75 69 76 73 74 81 78 76 92 82 75 74 73 74 68 72 77 76 73 72 76 79 81 82 80 78 81 82 81 84 81 82 81 84 81 84 81 84 81 67 69 69 70 69 65 64 67 68 64 67 72 62 60 65
60 61 58 57 76 77 79 79 81 85 81 88 92 91 93 89

***Melody Set 2* Shape Trajectory 7**

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 64 67 65 61 62 69 70 74 76 72 77 76 77 71 66 61 58 63 62 65 60 57 68 63 55 52 51 53 58 55 53 56 57 56 59 69 58 69 63
61 67 57 63 57 57 59 62 61 66 54 58 64 59 57 63 57 57 55 54 52 67 62 64 60 57 63 69 72 72 67 75 70 65 59 52 81 84 36 86 70 52 41 63 54 54 56 79 44 43 42 86 83 76 76 38 58 52 43 46 83 40 87 50 81 71 88 55 80 64 86 50 62 72 37 52 69 70 83 60 40 46 76 71 48 72
86 48 39 73 45 89 45 84 83 39 52 51 56 38 66 85 60 43 66 76 49 93 59 39 58 53 51 60 53 70 50 50 40 86 69 49 87 60 54 41 48 36 37 75 39 89 89 93 94 93 76 44 43 36 71 37 38 90 92 76 83 78 80 65 90 89 96 88 68 59 73 64 69 59 76 66 64 74 68 67 65 71 80 74 79 65
69 76 81 73 76 75 81 81 72 67 81 56 65 65 59 63 66 56 67 63 53 66 58 48 66 58 52 64 50 61 60 74 68 68 68 81 74 82 89 85 78 84 76 74 73 73 69 72 77 76 74 72 76 79 81 82 81 79 81 82 80 84 81 82 81 84 81 84 81 83 81 67 69 69 69 69 65 64 66 68 64 67 72 62 60 65
60 60 58 57 76 77 79 78 81 86 82 88 92 91 93 89

***Melody Set 2* Shape Trajectory 8**

65 64 65 60 62 65 67 60 62 67 65 60 62 62 60 60 58 58 57 57 60 61 67 65 68 67 61 67 62 64 62 64 60 62 65 67 60 62 67 65 60 62 62 60 60 58 57 65 67 65 61 62 69 70 74 76 72 77 76 77 67 56 56 54 64 60 64 57 57 67 60 56 57 55 59 54 60 52 49 47 64 59 69 66 61 69
62 57 55 52 61 63 59 62 58 65 50 50 63 63 52 60 57 58 57 53 58 63 61 65 55 59 71 66 67 71 66 74 68 66 45 47 93 61 44 81 67 48 37 76 66 37 39 71 39 39 59 39 62 76 95 37 93 87 41 60 54 69 54 50 57 60 64 48 82 45 52 67 45 87 96 70 39 73 62 54 40 65 82 87 67 73
70 49 86 95 55 66 45 78 37 82 88 90 57 85 55 49 61 92 80 53 44 95 84 69 43 89 45 83 91 68 85 47 56 43 48 45 45 80 43 64 60 45 37 65 81 59 63 85 57 49 52 45 71 47 69 58 76 89 88 74 68 58 75 86 57 48 76 44 68 60 66 63 65 75 75 80 65 78 69 80 82 84 73 70 62 78
72 82 83 68 78 73 75 87 70 77 83 65 64 63 63 70 59 53 63 67 58 64 70 53 55 55 55 64 60 56 75 60 84 65 72 86 73 67 77 91 88 73 76 74 72 74 69 72 77 76 73 72 76 78 80 82 80 78 81 82 81 84 81 82 81 84 81 84 81 84 81 67 68 69 70 69 65 64 67 68 63 67 72 62 60 65
59 60 58 57 76 77 79 78 81 86 81 88 92 91 93 89

The Burst speed values shown in the above example are chosen to have no repetitions: 15, 21,16, 11, 7, 18, 29, and 34 for Shapes 1 through 8 respectively. These values represent the frequencies in Hz of clock oscillators controlling burst rates in each module.

Part III:
Given the Senses the Real Pregeometry

General Notes

Part III is an environment in which the percussionist and an auxiliary performer are closely linked in an interactive improvisation scheme that depends on probabilistic synchronies. The percussionist selects a group of metal instruments with which to improvise freely. All the instruments must be metallophones. Seven of these metallophones are to be chosen as objects to which sensors will be attached. The auxiliary performer must use an instrument (typically a keyboard) that can send pitch, dynamics and sustain signals to two processes. One of these processes plays a polyphonic, bi-timbral synthesis unit loaded with a collection of *instrument definitions*. Again, non-linear wave-shaping synthesis has been used in prior realizations. The second process invokes an algorithmic procedure that uses *probability rhythm cycles* to determine whether *instrument definitions* active in the synthesis units that are being played by the auxiliary performer will be changed. The result is that while the auxiliary performer improvises with the score materials, the sounds the synthesis units produce in response might be altered at any time by the percussionist's interactions with the *probability rhythms*.

Seven *Probability Rhythm Shapes* were calculated using Laguerre polynomials, which also appear in some aspects of quantum mechanics. The data for these shapes are listed below and should be loaded into data tables that can read them out in free running, continuous cycles. The seven tables correspond to the seven metallophone sensors setup by the percussionist.

When one of these sensors is activated, a value from a free-running random number generator is retrieved and tested to see if it lies above the current value being read out from a corresponding *Probability Rhythm Shape*. If it does, the system sends out a signal to change the *instrument definition*—also referred to as program change signal or preset—for both synthesis units. It is intended that the percussionist learns through practice to *feel* the rhythm and shape of each of the *Probability Rhythm Shapes*. They determine whether or not striking an instrument with a sensor attached will change the sounds the auxiliary player is making. Striking in synchrony with a peak will almost certainly result in a change. Striking in synchrony with a low point results in a low probability of triggering a change. Striking at places in the contour between high and low will have various likelihoods of triggering changes.

The cycling readout rates for each table are to be set individually. This will establish a range of cycles from slow to fast. The percussionist then gains a feeling for how instruments placed at strategic locations in the setup might or might not initiate changes. Meanwhile, the auxiliary performer continues to play, without knowing if and when the sound of their instrument will change, rapidly or slowly, intermittently or continuously. In prior realizations a cycle of five presets, *instrument definitions*, was programmed to be associated with each *Probability Rhythm Shape*.

Next, a set of eight *Melodic Shape Transformation Tables* are programmed to be activated as follows. The outputs of these tables are played by another synthesis unit. Readouts from these tables are activated whenever the auxiliary performer plays pitches that fall within certain ranges. These ranges can be freely set for each table. It is usually most effective to divide the available pitch range of the instrument being used into eight non-overlapping regions. Each region will then activate one corresponding table. The performer may choose which pitch ranges will activate which tables. In Part III, the lengths of these tables differ, and their pitch contours exhibit different variance characteristics. In general, the shorter shapes show low variance and the longer ones show higher variance. These are mirrored in the score the auxiliary performer plays from as well. Still, they are all based on transformations of the *Origin* and *Target Melodies* that guide musical forms throughout *Zones of Influence*.

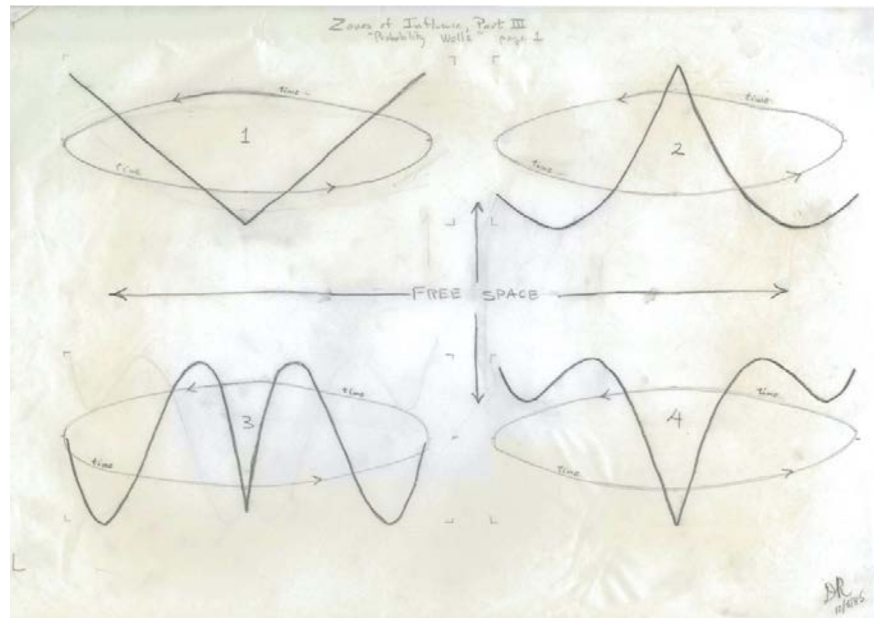
The melodic shape tables also have a Burst function that can be enabled and disabled at will. If it is enabled, then when a pitch arrives that falls inside the trigger range, the system will readout a burst of notes at speeds that can be individually set for each table. The number of notes in a particular burst is determined by obtaining the current value of a particular, free-running *Probability Rhythm Shape* cycle associated with the given *Melodic Shape Transformation Table*. The burst will continue until its length is reached or the note that triggered the burst is released, i.e., the end of a sustain. This function is particularly useful in expressive performance when a keyboard is used. The performer may choose which *Probability Rhythm Shapes* to assign to each *Melodic Shape Transformation Table*. Readout from the tables always wraps around to the beginning when the end is reached.

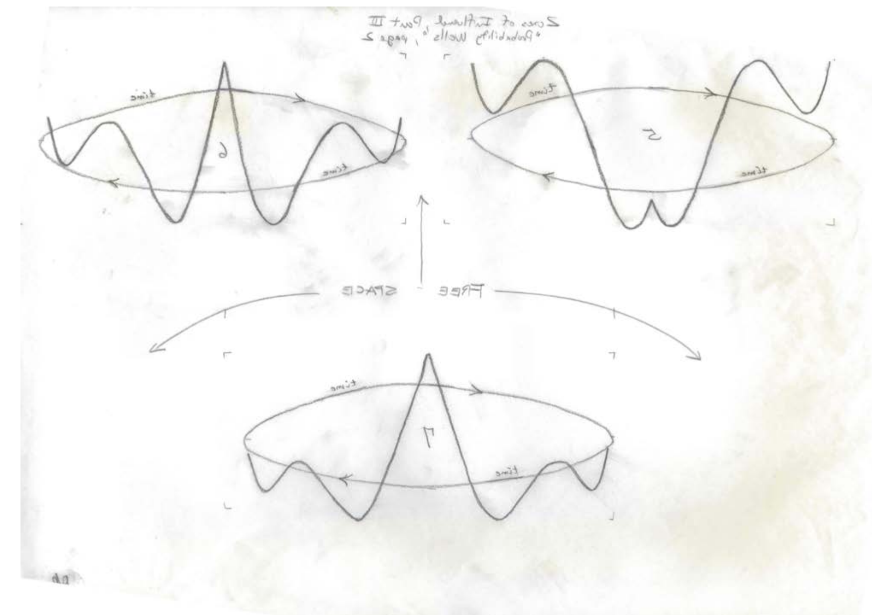
The shape tables also have master Enable switches, so that the performer can turn them on and off as desired during a performance. Triggering may begin with Box 1 in the score. Shapes and Burst functions may be turned on and off according to the dynamics of an emerging improvisation. Foot controllers may be desirable to enable the auxiliary performer to keep their hands free.

Given the Senses the Real Pregeometry provides an interaction model in which the components of the model can be explored and adapted through performers' choices. In this way, part of the performance paradigm includes customizing the model itself as an instrument, within its framework of restrictions, to fuel the creativity of the musicians.

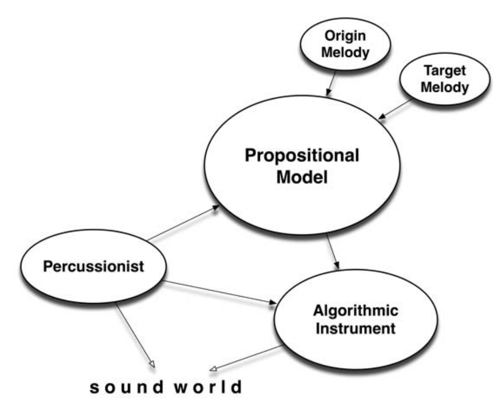
Score

The percussionist's score consists of seven curves depicting the Probability Rhythm Shapes. Each is associated with a region in the metallophone setup where a sensor or sensors are located. Manuscript sketches below show shapes created from Laguerre polynomials that have been rescaled and doubled in mirror images along their horizontal axes. They become the Probability Rhythm Shapes of *Melody Set 2*, and are sometimes also referred to as "probability wells." Circles around the shapes labeled "time" help show how they reside in a field of multiple, independent, cyclical times. "FREE SPACE" surrounds them, where metallophones without sensors might exist. These shapes also reappear in Part V of *Zones of Influence*, *The Buckling of a Spring*.



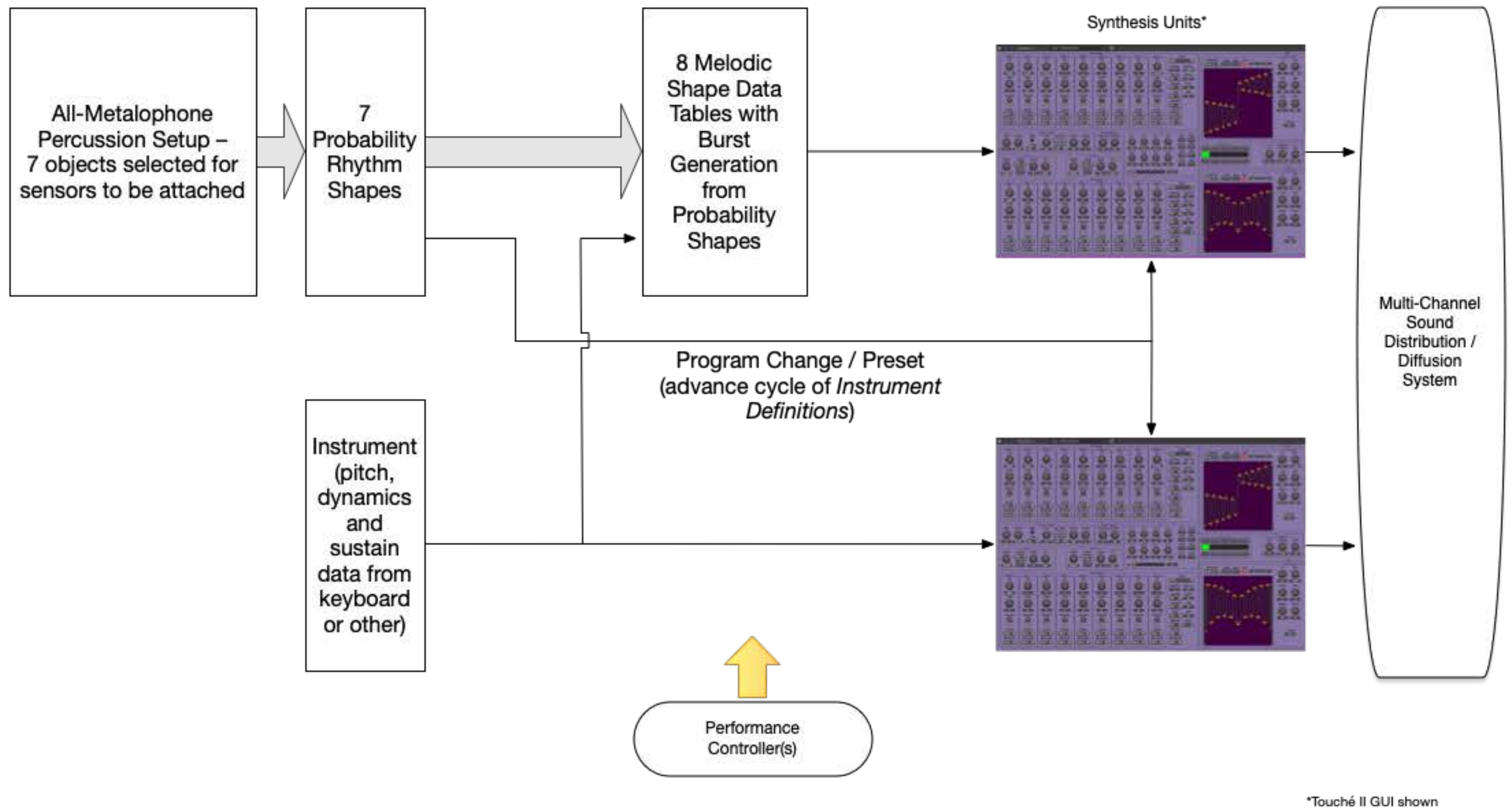


The primarily elements of the auxiliary performer's score are eight boxes containing monophonic lines. The auxiliary performer is to improvise with the notes of these lines, employing a *moving window improvisation* technique. See the instructions for Part IIb for a description of moving window improvisation. Unlike Part IIb, however, the size or width, of the moving window is left unspecified and is up to the free choices of the performer. For reference, the lines move from being relatively smooth with low variance in Box 1 to high variance in Boxes 4 and 5 and back to low variance in Box 8. Box 1 and 8 contain a single, sixty-note line. In the other boxes, a dashed line separates sets of sixty-note lines for visual reference. These are to be played in the sequence shown. All in all, there are nineteen sixty-note lines, all of which are derived from transformations of the *Origin Melody* and *Target Melody*, the melodic DNA of *Zones of Influence*. Part III begins with the repeated note F and ends with repeated high Fs. Markings suggesting things like speeds, types of grouping, temporal density, etc. should be followed. The two players in Part III are meant to create an improvisation with the materials of the score and the interactive, probabilistic linking defined by the propositional model of Part III. This is called *playing the propositional model*.

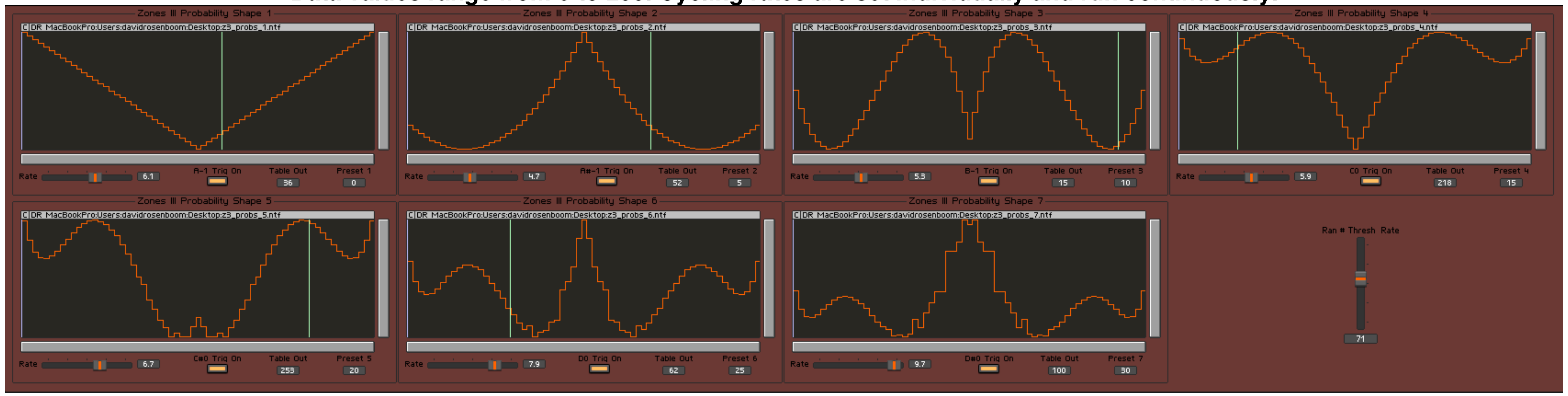


Playing the Propositional Model in *Zones of Influence*

Given the Senses the Real Pregeometry
Technical Block Diagram



Seven Probability Rhythm Shapes as they appear in a Reaktor realization of the data tables shown below. Data values range from 0 to 255. Cycling rates are set individually and run continuously.



Probability Rhythm Shape 1
231 223 216 209 202 195 187 180 173 166 159 151 144 137 130 123 115 108 101 94 87 79 72 65 58 51 43 36 29 22 15 7 0 7 15 22 29 36 43 51 58 65 72 79 87 94 101 108 115 123 130 137 144 151 159 166 173 180 187 195 202 209 216 223 231

Probability Rhythm Shape 2
52 42 33 25 18 13 8 4 2 0 0 0 2 4 8 13 18 25 33 42 52 62 75 87 101 117 133 150 168 187 208 229 251

Probability Rhythm Shape 3
125 86 55 31 15 5 0 1 6 16 29 44 63 82 103 125 146 167 187 205 221 233 244 248 249 244 234 217 196 164 124 78 21

Probability Rhythm Shape 4
239 217 202 193 188 188 190 195 202 210 218 226 235 242 247 251 253 254 251 246 239 229 219 202 186 166 145 122 101 74 48 24 0

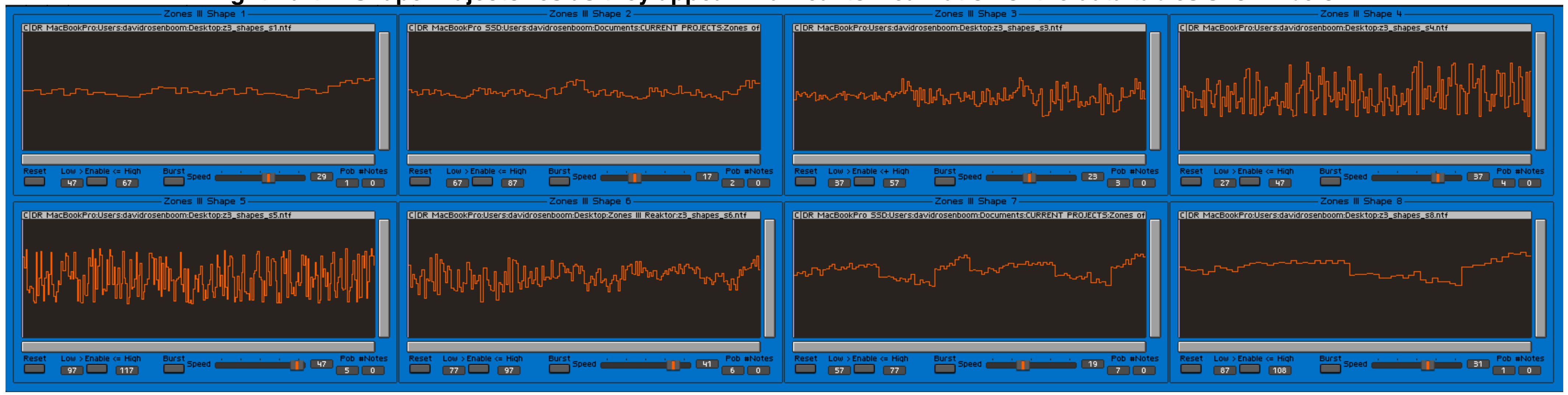
Probability Rhythm Shape 5
252 210 185 173 171 177 187 200 213 226 238 247 253 255 251 244 233 220 200 180 157 131 114 80 60 37 20 1 9 0 1 22 43

Probability Rhythm Shape 6
165 121 99 92 95 105 118 132 143 151 157 157 153 146 132 117 100 85 62 48 31 17 24 0 10 15 32 37 102 120 152 215 255

Probability Rhythm Shape 7
100 61 44 42 49 60 71 81 87 88 87 80 72 62 47 32 23 17 3 4 0 7 38 21 53 74 99 99 186 187 206 255 245

The Probability Rhythm Shape cycling rates in this example are: 6.1, 4.7, 5.3, 5.9, 6.7, 7.9 and 9.7 for Shapes 1 through 7 respectively. Ignoring the decimal points, these would be all prime numbers with no repetitions. These values represent the frequencies in Hz of clock oscillators cycling the functions in each module.

Eight Part III Shape Trajectories as they appear in a Reaktor realization of the data tables shown below.



Melodic Shape Trajectory 1

64 64 65 60 61 65 66 59 61 66 65 60 62 62 60 60 58 58 57 57 60 61 66 68 67 67 61 67 62 63 61 63 59 61 65 66 60
61 67 65 60 61 61 60 59 57 56 65 66 65 61 62 69 69 73 75 72 77 75 77

Melodic Shape Trajectory 2

62 63 59 60 65 65 60 61 65 64 59 60 61 59 59 57 57 56 56 58 60 65 64 67 66 60 66 61 63 61 62 58 61 64 65 60 61
65 63 58 60 60 59 59 57 56 65 66 67 60 61 67 68 73 74 70 76 75 75 65 62 63 58 60 64 65 59 59 62 64 57 62 59 58
58 56 57 55 55 56 58 67 63 67 63 58 65 62 61 60 61 69 61 62 62 59 59 65 62 57 59 60 57 58 56 54 63 63 61 60 60
65 69 69 75 67 75 72 72

Melodic Shape Trajectory 3

54 63 60 58 61 62 60 57 59 61 62 53 54 59 55 59 57 55 54 55 56 57 60 61 59 63 54 60 60 59 59 58 56 60 62 61 55
57 58 59 54 62 55 58 56 55 53 61 63 60 57 59 62 61 63 77 61 64 74 69 64 54 64 47 67 54 65 51 50 66 51 57 54 64
66 59 49 55 53 50 60 60 60 62 56 52 53 62 57 59 55 63 49 47 47 50 63 52 66 64 49 56 53 49 61 55 53 67 54 54 59
56 62 64 67 78 75 58 69 69 65 61 50 48 53 60 66 36 37 37 41 65 52 50 74 54 43 70 67 73 52 54 54 69 62 46 52 48
47 52 49 57 58 56 51 51 71 38 67 60 50 61 59 41 41 43 53 67 57 57 57 58 64 61 77 66 73 55 64 55

Melodic Shape Trajectory 4

66 42 69 64 57 63 62 45 55 54 54 46 64 37 77 64 50 46 60 71 75 36 57 47 69 41 63 60 72 45 52 56 39 78 87 88 39
55 37 84 75 38 40 46 68 48 54 57 55 62 48 38 52 46 72 45 92 43 36 37 61 67 70 75 40 95 83 64 37 54 56 80 71 89
38 74 58 52 54 84 46 62 54 67 60 43 90 75 51 75 36 54 82 63 45 57 40 66 48 47 41 49 82 52 37 67 56 48 42 69 59
38 47 61 49 52 66 38 65 84 90 38 96 95 44 66 55 69 53 52 57 62 90 45 76 44 59 78 69 92 94 71 38 70 66 63 39 61
93 93 67 72 77 36 87 91 62 53 42 60 47 60 86 83 58 83 45 46 58 94 73 49 50 90 79 54 41 84 36 85

Melodic Shape Trajectory 5

87 75 95 51 48 55 53 39 37 92 45 64 93 56 39 64 71 46 68 92 57 44 38 49 61 57 82 72 72 91 88 66 63 71 63 92 64
39 62 38 37 67 46 45 58 86 77 95 38 85 52 77 96 89 46 52 50 84 57 95 88 57 76 42 57 75 42 58 93 64 58 36 43 84
52 54 63 92 44 67 80 41 49 57 57 63 91 91 86 57 85 62 51 87 44 80 52 87 76 50 74 61 62 39 61 63 65 92 57 49 74
38 74 37 40 36 52 67 63 49 68 77 57 40 51 42 57 62 79 49 43 54 89 76 55 67 45 94 54 41 77 88 86 65 38 43 66 51
39 70 89 49 47 47 40 64 40 69 72 90 93 65 62 38 61 45 87 71 56 84 85 82 61 37 48 37 87 93 69 85 43 94 59 47 54
45 60 70 56 59 89 78 88 44 85 41 65 54 63 81 67 37 40 88 65 74 55 70 40 58 80 92 50 43 59 65 85 53 51 52 96 38
50 54 68 83 62 38 90 42 43 88 75 93 42 60 88 96 88 78

Melodic Shape Trajectory 6

78 54 68 63 58 46 66 73 42 63 61 86 60 50 90 46 84 80 71 59 77 73 53 51 50 73 54 49 59 58 81 73 52 67 58 61 67
38 75 75 62 56 51 50 71 40 59 57 49 71 57 86 49 84 83 80 59 52 61 77 54 64 71 58 62 75 57 55 77 62 65 65 63 83
65 64 66 80 80 77 70 74 70 61 77 79 77 69 77 72 58 50 59 66 63 56 70 74 59 61 63 55 49 58 62 67 61 50 63 77 62
73 77 79 69 68 82 67 82 70 75 72 65 70 66 72 72 63 62 66 69 72 68 74 72 76 71 69 79 74 69 77 79 75 75 73 69 76
74 64 64 58 65 64 62 57 60 69 66 66 69 60 61 57 51 63 57 51 65 73 67 76 73 74 75 80 84 77 88 73

Melodic Shape Trajectory 7

67 70 69 71 66 68 75 75 73 67 73 74 77 79 74 73 76 74 76 80 74 76 78 78 76 79 78 79 76 65 65 65 66 65 63 61 64
63 60 63 68 57 57 62 59 60 56 55 74 73 77 74 77 80 78 84 87 86 89 86 72 73 72 72 68 70 75 74 72 70 75 77 78 80
80 76 79 79 79 82 78 80 79 81 78 81 79 81 78 66 67 67 69 67 64 63 65 66 63 65 70 59 59 63 59 60 56 56 76 75 77
76 79 84 79 85 90 88 90 87

Melodic Shape Trajectory 8

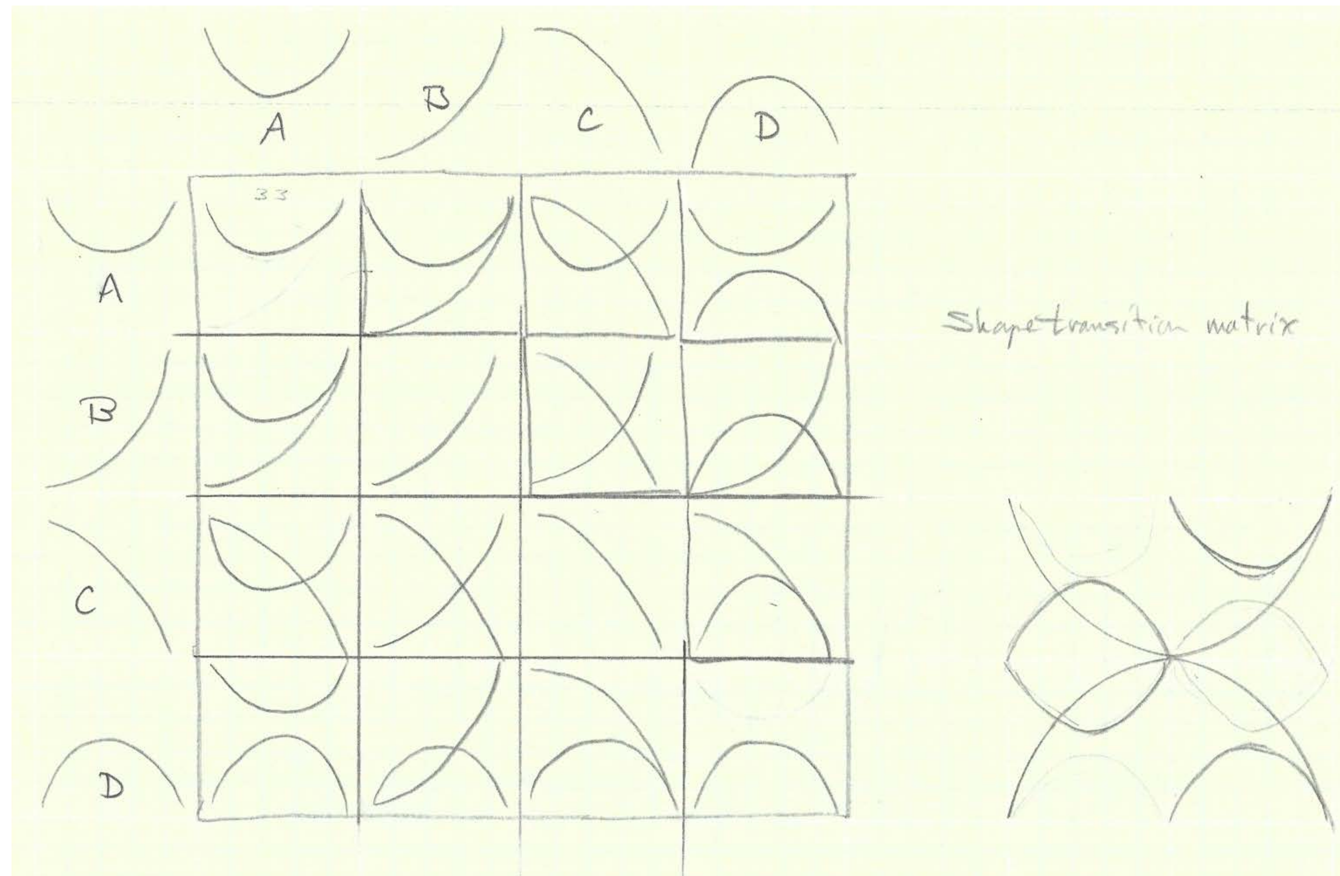
76 73 72 73 68 71 77 75 73 71 76 78 80 81 80 78 80 81 80 83 80 81 80 83 80 83 80 83 80 67 68 68 69 68 64 64 66
67 64 67 71 62 59 64 60 60 58 56 76 76 78 78 80 85 82 87 91 90 92 88

In this example, Probability Rhythm Shape 1 is assigned to both Melodic Shape Trajectories 1 and 8. The remaining assignments, 2 through 7 are made with correspondingly numbered modules. Burst rates are: 29, 17, 23, 37, 47, 41, 19 and 31 for Shapes 1 through 8. These are prime numbers with no repeats. The pitch trigger ranges are set for a wide-ranging instrument in MIDI note numbers:
47 > <= 67, 67 > <= 87, 37 > <= 57, 27 > <= 47, 97 > <= 117, 77 > <= 97, 57 > <= 77 and 87 > <= 108 for Shapes 1 through 8 respectively.

Part IV:
Epigenesis, Ontogenesis, Phylogenesis, Parthenogenesis

General Notes

The conceptual terrain for Part IV includes notions about self-replication and ideas relating to evolution on genetic, individual and group levels. Four gesture shapes constitute some of the key language elements in the percussion part. The percussionist articulates these by moving across the pitch compass of a set of eight tuned drums. These gesture shapes are gradually transformed, one into another, through all combinations, using probabilistic Markov chain procedures to determine the transformation trajectories. Sets of these trajectories are used to outline a syntax for gesture statements.



Shape Transition Matrix illustration from the composer's sketches.

An eight-voice electronic counterpoint, tuned in quarter-tones, is triggered by strokes on the tuned drums with sensors attached. The elements of the counterpoint begin with melody fragments that follow key phrase landmarks in the *Origin* and *Target Melody Shapes* of *Zones of Influence*. A musical form emerges from the interactions among evolving gesture shapes, melody transformation trajectories, transitions in rhythmic groupings, elongation and masking of patterns with rests, and the injection of stochastic influences.

Score

The percussionist's part is to be realized with a set of eight tuned drums, as in a Tabla or Mrdangam Tarang. For this piece, a Tarang may also be constructed with other drums, such as Chinese Tom Toms, or other hand drums typical of Africa, Asia or the Middle East. It is desirable that they be hand drums capable of a rather definite pitch. A suggested pitch set, if appropriate drums are available, is specified in the score. The percussionist is free to choose pitches. They should be widely enough spaced to articulate a distinct scale spanning the range achievable with the drums available. The part is written in conventional notation. Notes referencing the individual drums are placed in the spaces of two staves of music. When rhythmic figures calling for six-tuples or nine-tuples are specified, groups of two or three notes are often connected by means of a tie marking. This is intended to indicate that the notes under the tie may be played using articulated, multiple-stroke techniques.

An auxiliary Lahera part is also notated in the score. The Lahera part is a melody that serves as an accompaniment and a timekeeper for the Drum Tarang part. Time must remain very constant and stable throughout Part IV. It begins in Bar 23. It is a pulse melody. It references the timekeeping function of a Lahera in Indian music; however, it is not structured in an easily recognizable melodic cycle. Instead, it is constructed like the electronic counterpoint from evolving transformations of the melody fragments referred to above. The Lahera can be played in a variety of ways, most commonly with a keyboard sending note signals to a synthesis unit.

Electronics-Computer Part
Three polyphonic synthesis units required. Two of these must be capable of quarter-tone tuning. The third is used to play the Lahera part. Previous realizations have been created using bi-timbral, non-linear wave-shaping techniques. No specifications as to the precise nature of the timbres assigned to each voice is given. This is left up to the creative discretion of the performers. In previous realizations made with the Touché and Touché II, a blend of two voices, one bright and metallic and one softer were used. The two timbres were very slightly mistuned with one another, like instrument pairs in a Balinese gamelan, to make a rich mixture with the Drum Tarang instruments. The electronics-computer performer may treat this as an opportunity to make a creative contribution to the piece, always bearing in mind that this is an accompaniment part for a percussion solo.

Each drum is assigned a *Melodic Shape Trajectory Set* tuned in quarter-tones. They are contained in shape tables made from morphological transformation trajectories on fragments of the *Origin* and *Target Melodies*. The sequences shown below are in MIDI note numbers. The pitch sequences are repeated, looped, as necessary. Readout always wraps around to the beginning when the end of a table is reached. In Part IV, the Melody Shape Data Tables are of different lengths. Each table has an adjustable note split point. This means that pitch values greater that the split point value will be sent to one synthesis unit, and values equal to or less than the split point value will be sent to the other synthesis unit. Thus, higher notes will be played with one timbre, and lower notes with another.

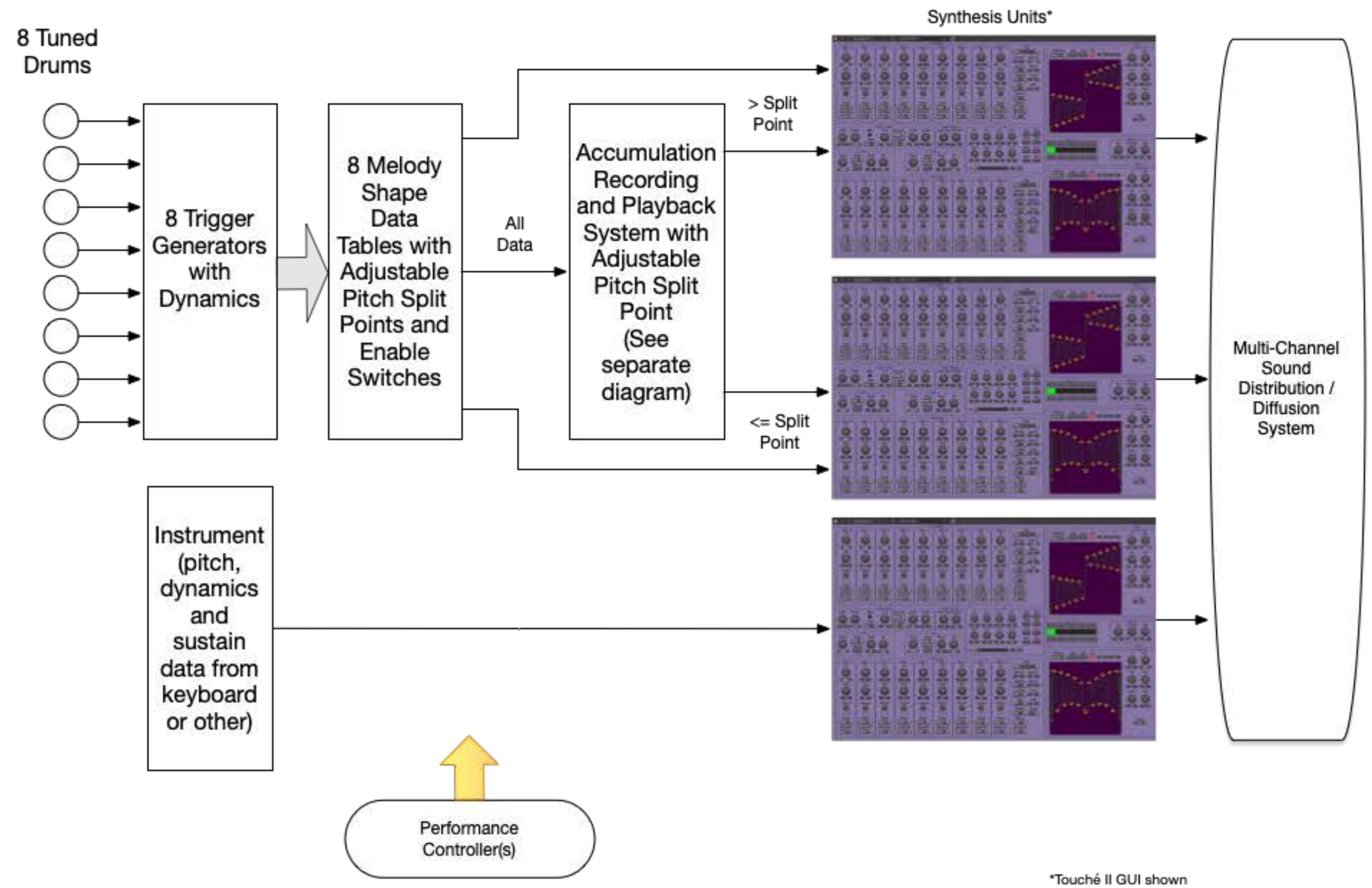
Successive strokes on a particular drum should produce stimulus triggers, causing a corresponding voice to advance through its melodic sequence. The system must have the capability of enabling or disabling this process for individual voices. The piece begins with readout from all the Shape tables disabled. On the third beat of bar 70, Shape table four is enabled, causing it to play in response to activity on fourth drum. On the third beat of bar 91, Shapes three and six are enabled in a similar manner. On the first beat of bar 114, Shapes one and eight are enabled. Finally, on the second beat of bar 136, Shapes two, five and seven are enabled. All Shapes continue from there to the end of the movement.

Lastly, the electro-acoustic part requires that the system have a sequence capture—record and playback—function, which operate as follows. When triggered by the performer, the sequence capture system records all activity produced by the computer instrument. All note events or trigger stimuli for all voices are to be recorded in some type of memory buffer. It is not necessary that trigger stimuli retain their original polyphonic voice assignments. These may be reassigned to other voices upon playback. If the sequence capture recorder is stopped and then restarted, all information previously held in the memory buffer is overwritten by new data.

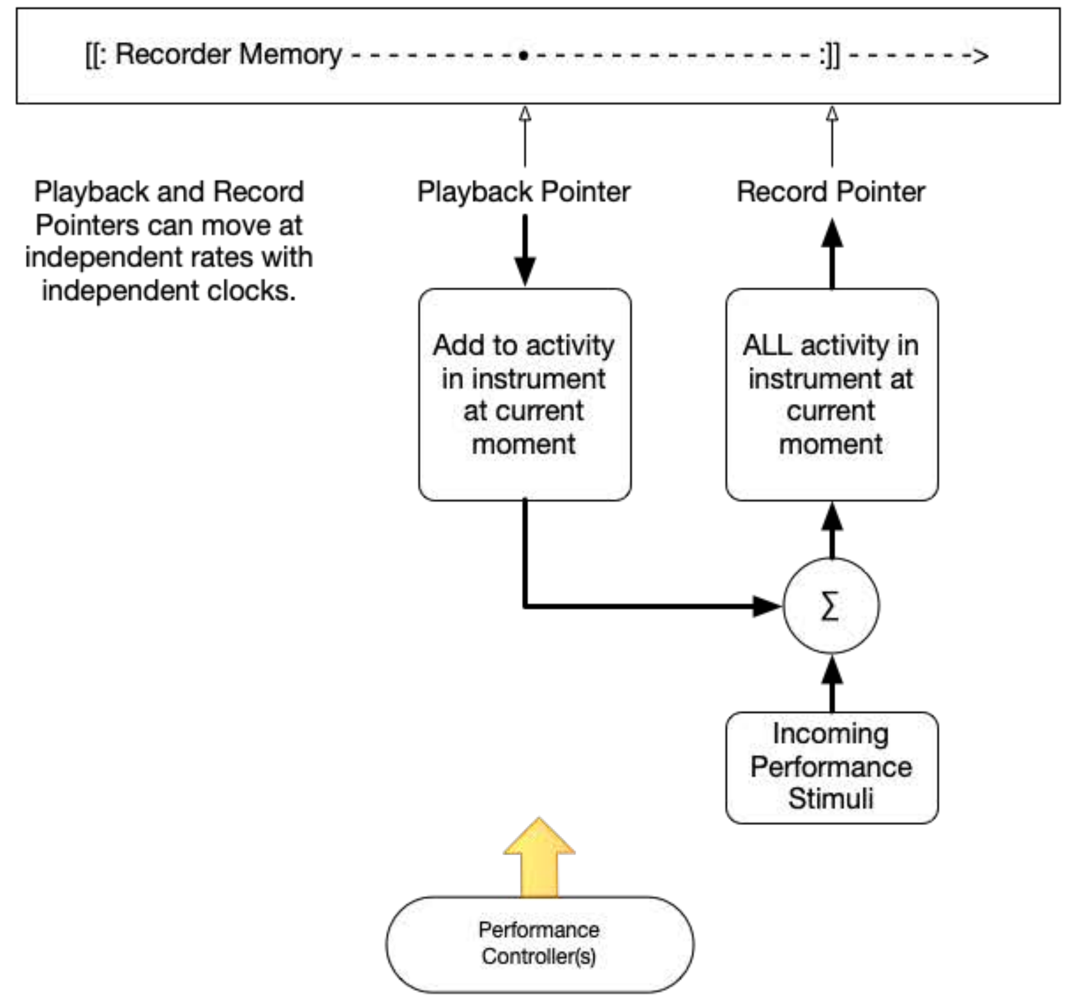
The system must also be capable of playing back the recorded information entirely independently from the sequence capturing process. The playback mechanism must maintain its own pointers into the memory buffer, separate from those used by the recording mechanism. Consequently, playback can proceed from a location in the buffer different from the location at which new data may be overwriting old data when the recording mechanism is simultaneously active. Upon reaching the end of the memory buffer, the playback system automatically loops back to its beginning and continues playing. It is important that the recorder capture all activity in the system, including that which may be being played back by the playback mechanism. This may result in a recording accumulation effect, producing sound activity which may grow in density to a considerable extreme.

On the first beat of bar 160, the recording process is to be started. On the first beat of bar 166, the playback system is started. On the second beat of bar 188, the recording system is stopped, but the playback system continues. On the third beat of bar 202, playback stops. Recording starts again on the third beat of bar 203. Playback resumes on the first beat of bar 208. All processes then end in synchrony with the last note of the percussion part on the third beat of bar 240. It is important that the performance of this movement maintain a constant tempo in order that all parts in the performance process keep at least close synchrony with the material that accumulates in the recording and playback process.

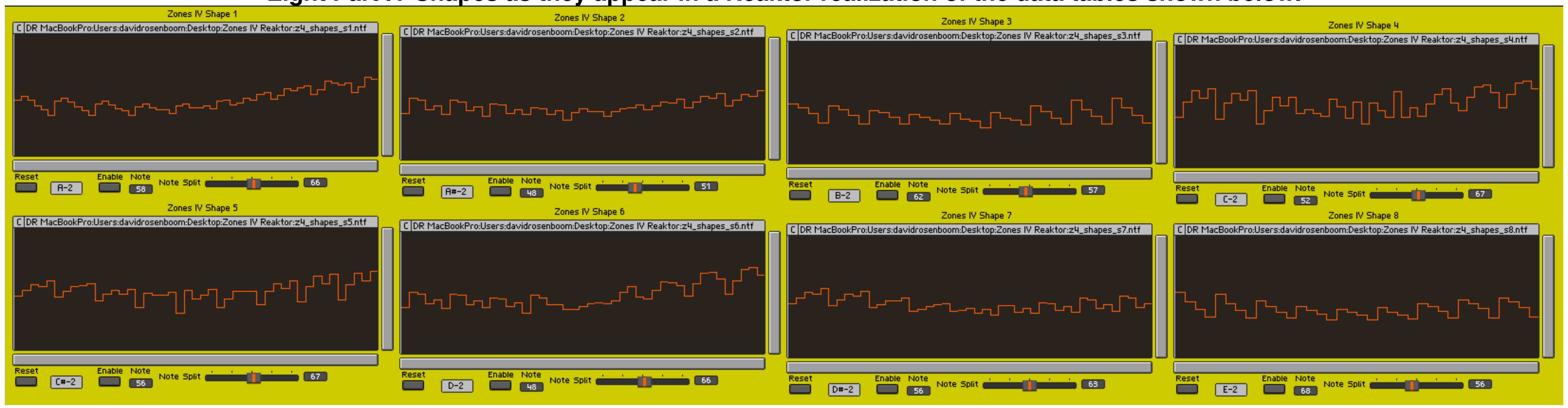
Epigenesis, Ontogenesis, Phylogenesis, Parthenogenesis
Technical Block Diagram



Epigenesis, Ontogenesis, Phylogenesis, Parthenogenesis
Accumulation Recording and Playback Process



Eight Part IV Shapes as they appear in a Reaktor realization of the data tables shown below.



Melody Shape Trajectory Set 1
58 62 58 52 48 42 57 60 56 51 47 42 54 57 53 49 47 42 51 54 50 48 48 44 52 54 50 50 52 49 57 58 53 55 60 58 64 66 59 63 70 68 71 73 64 69 78 76 74 76 66 72 82 80

Melody Shape Trajectory Set 2
48 64 62 52 56 47 62 60 51 55 45 58 57 48 52 47 54 53 47 51 41 49 53 50 50 45 50 53 54 57 52 56 60 59 63 54 60 66 64 69 56 62 68 66 72

Melody Shape Trajectory Set 3
62 58 52 42 60 56 50 41 55 53 48 41 51 48 45 41 52 46 44 37 53 47 45 40 60 54 47 41 66 56 49 41 68 58 50 42

Melody Shape Trajectory Set 4
52 68 80 72 82 50 67 77 70 80 45 59 73 64 73 56 60 56 53 71 63 51 68 45 67 59 52 79 52 62 53 66 76 82 67 59 73 84 86 78 62 76 88 90 82

Melody Shape Trajectory Set 5
56 62 68 66 72 55 61 66 67 69 51 58 62 58 63 44 59 57 57 60 38 62 53 57 63 44 53 61 61 61 47 61 69 64 72 50 66 77 69 79 52 68 80 72 82

Melody Shape Trajectory Set 6
48 64 62 52 56 47 62 61 51 55 48 58 57 49 53 42 61 58 51 51 46 46 49 52 53 52 55 64 70 59 57 66 75 74 71 60 73 84 85 78 62 76 88 90 82

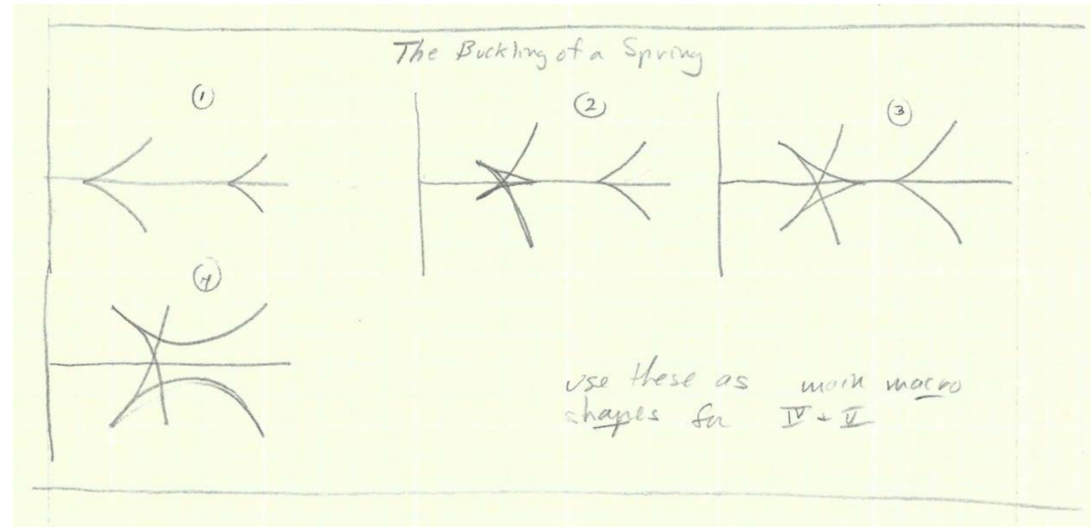
Melody Shape Trajectory Set 7
56 62 68 66 72 54 60 66 64 69 52 55 59 59 62 48 50 53 55 56 48 49 51 46 50 44 54 54 47 51 46 57 56 49 53 47 62 60 51 55 48 64 62 52 56

Melody Shape Trajectory Set 8
68 58 50 42 66 56 49 41 59 53 47 41 53 49 45 39 50 47 44 39 52 47 44 40 56 53 48 41 60 56 51 41 62 58 52 42

The quarter tone interpretation of these data works as follows. This is taken from the design of the Touché II, which provides the means to set a pitch Center and scale MIDI pitch values from 1/100th-tone resolution to half-step resolution. Values in the data tables shown above are interpreted as scaled MIDI pitch numbers. However, contiguous values represent quarter-tone steps, not half-tone steps. Thus, there are twenty-four steps per octave. First, the pitch Center is established. For example, using standard MIDI coding, MIDI value 60 maps to "Middle C," or C4. If 60 is set as the Center, with quarter-tone resolution, then C5 would show a data value of 84. If a Center value of 84 is used with quarter-tone resolution, the pitches resulting from values in the tables would sound 8va, one octave higher. Setting the Center value to 36 would result in values sounding 8vb, one octave lower. Selecting octave shifting is offered as an option for choosing sounds that work creatively with the Drum Tarang. The Lehara part is played with pitches sounding as written, not in quarter-tones.

Note that in this version Note Split points in MIDI values are: 66, 51, 57 67, 67, 66, 63 and 56 for Shapes 1 through 8 respectively. These are set to divide the pitch compass of each shape at an effective point. The Note Split value for playback from the Accumulation Recording and Playback process (not shown here) is 65.

Part V:
The Buckling of a Spring



Composer's sketch.

General Notes
The primary essence of Part V is contained in two parts for continuous glissandi instruments. One is realized with a drum capable of continuous glissando rolls, such as a pedal-timpani. The other may be realized with any higher-range instrument capable of continuous glissandi, such as a violin. The percussionist must also have two additional sounds. The first should be a clangorous, metallic sound, such as might be produced with an automobile spring coil. Other metal instruments may be used. The metal sound(s) should be strong, complex and relatively unpitched. Avoid instruments, which produce sounds that are too musical or beautiful. The second additional sound should be a strong, wooden sound, producing a thud with some resonance, like a log drum. Again, the sound should not be too beautiful; rather it should invoke the feeling of relentless knocking on a very large door.

Score
The score is organized in a series of bars of varying lengths. Each bar contains a number of equal-length, glissando figures in the melody part and one single glissando in the percussion part. Each glissando figure in the melody part may be thought of as encompassing one beat or time unit in a given bar. The pitches indicated should be established firmly as points of departure for the glissandi. Every attempt should be made to articulate the glissandi shapes as precisely as possible. Note that these shapes are all derived from a relatively small repertoire of basic shapes, which can be learned and recognized through practice. (Some shapes in this repertoire first appear above in the instructions for Part III and are described there.)

The notations of pitch ranges encompassed by each glissando figure are intended to be reproduced as accurately as possible. However, in the case of the continuous drum, some transposition is acceptable, if absolutely necessary. The drum range is normalized to span a pitch compass of one octave, from F to F, with B as the central pitch focus. The intended drum pitch compass is depicted in the score. In the case of tympani, this may expand the normal range of the drum to include low sounds produced by a rather loose drumhead to high sounds from a very tight head. Distortions may result from this extreme loosening and stretching. This is alright. The indicated pitch compass is preferred. If it is necessary to transpose the pitch center to accommodate a particular instrument, this may be done. The one-octave range should be maintained.

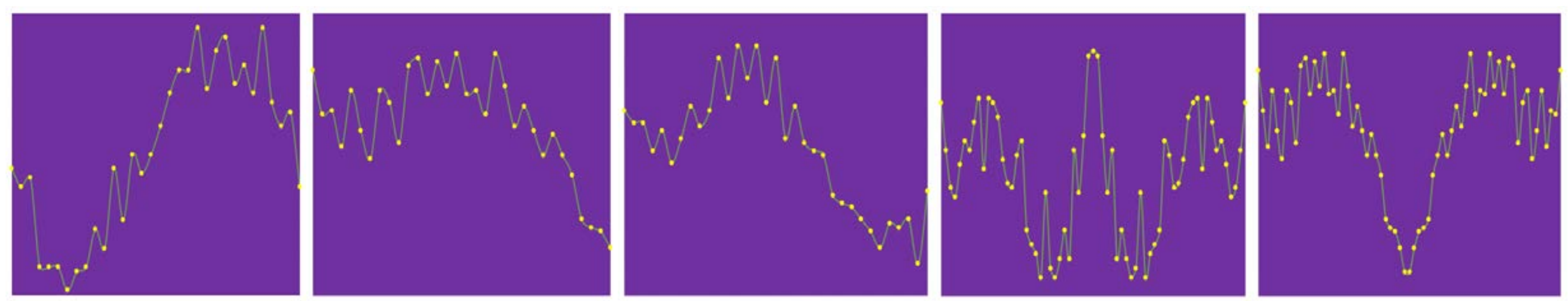
The clangorous metallic and wooden sounds must always be coordinated with the beginnings of glissandi in the melody instrument as indicated in the score. Square brackets, which sometimes appear under or over a note, specify that these notes should be played one octave below or above the indicated pitch when possible.

At the beginning of each bar a number from 1 to 12 is indicated. These numbers are *tempi coefficients*. They indicate the relative speed with which the bar should be executed. The players are asked to agree on a series of twelve tempi ranging from very, very slow for tempo coefficient 1 to very, very fast for tempo coefficient 12. This range could be as wide as from something like 15 bpm to 160 bpm. Changes of tempo occur with every bar in the piece. There is a constant sense of speeding up and slowing down, which is referred to as *tempo melody*.

In the middle of the score, the flow of the ongoing glissandi shape texture is suddenly interrupted, providing a contrasting distraction before the piece suddenly returns to the sliding glissandi world and continues on to its last half. Eight groups of melody fragments are shown. Performers should improvise very fast bursts of notes from these fragments, traveling freely and independently among them by following arrows outlining possible pathways. The pitches should be played in the order given and fragments may be repeated any number of times. Performers should, in general, emphasize synchronizing how they start each fragment. Departing from this synchrony occasionally and creatively is allowed. The dynamics of the Insert should outline one gesture from fortissimo to pianissimo and back to fortissimo. The length of this interruption is conceived as being not too long. However, it is also intended that all fragments be played. When finished with this interruption, players return immediately to the main body of the piece and continue as before.

The general dynamics for the movement as a whole are thought of as outlining a continuous crescendo from the beginning to the middle section, a decrescendo and crescendo within the interrupting melody fragments, and a continuous decrescendo from the middle to the end. This should be considered as a general directive, which may be modified to serve the purposes of intended lyricism and creative interpretation.

Electronics-Computer Part
Two polyphonic, bi-timbral, synthesis units programmed with non-linear wave-shaping techniques are required. Each is assigned a group of four voices coming from melody shape transformation trajectory tables. A set of *instrument definitions* (typically around ten) must also be programmed, half of which are assigned to one synthesis unit and the other half assigned to another synthesis unit. These will be cycled in performance according to a scheme described below. The essential components of these *instrument definitions* are drawn from a set of wave-shaping transformation functions and a set of synthesis parameter control functions (envelopes). These could be thought of as the elements with which a syntax of gesture shapes is developed. All the shapes are derived from rescaled Laguerre polynomials, with some jitter introduced from stochastic sources added to the wave-shaping functions. While the synthesis methods and the precise nature of timbres may be designed by the electronics-computer performer and may vary from performance to performance, the nature of the shapes must be maintained. Images of the five wave-shaping transformation functions used in realizations with the Touché II instrument are shown here:



These five functions are used in combinations of one or two in the bi-timbral, non-linear wave-shaping synthesis units. They were generated with rescaled, bidirectional Laguerre polynomials with some stochastic jitter added.

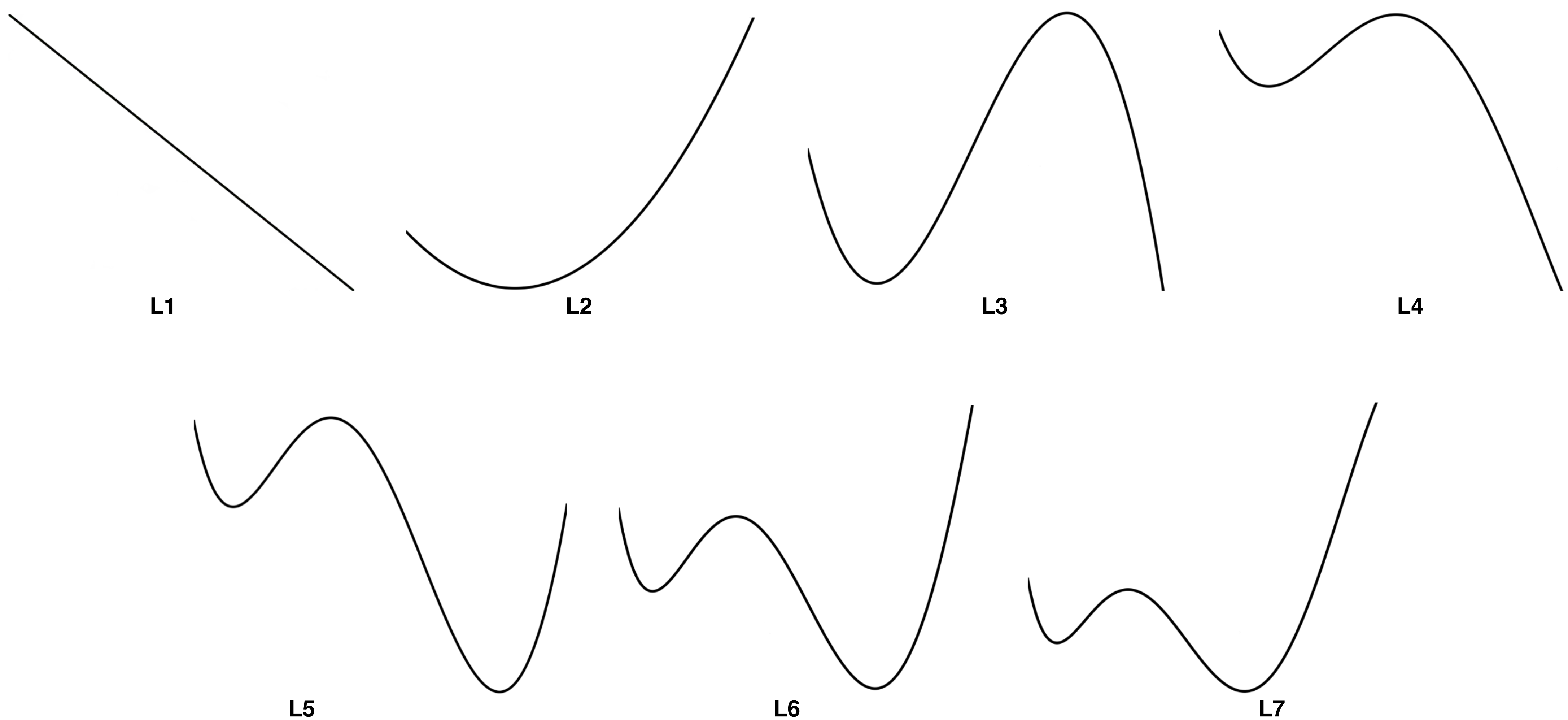
Sound from the continuous glissando melody instrument is fed into a system for pitch tracking. The derived pitch values are then parsed into bands. When a glissando from the melody instrument enters one of these bands, a trigger signal is generated. That trigger signal, in turn, advances a corresponding Shape Table, which sends an initial pitch value to one of the synthesis units and triggers a sound. For example, in the realization shown in the Technical Block Diagram below, these bands have been chosen to encompass a range appropriate for a violin. MIDI pitch values for these ranges are shown here:

Shape 1: 54 > <= 61
Shape 2: 61 > <= 67
Shape 3: 57 > <= 73
Shape 4: 73 > <= 79
Shape 5: 79 > <= 85
Shape 6: 85 > <= 91
Shape 7: 91 > <= 97
Shape 8: 97 > <= 103

When a trigger is generated, it also advances a corresponding table of program numbers for instrument definitions, which sends a Program Change message to one of the synthesis units. The diagram below shows how outputs from all these tables are mapped to the two synthesis units. In this example, ten instrument definitions are in use, five of which are sent to each synthesis unit. The sequencing of the program changes may be freely designed by the electronics-computer performer.

The center frequencies of the eight pitch ranges should be approximately equally spaced across the full pitch (log frequency) range of the glissando instrument used. The ranges should be distinct and non-overlapping. Only one trigger should be generated when the glissando instrument's pitch enters a pitch band. It must leave that band and reenter it to generate another trigger corresponding to that specific band. When the melody instrument plays a continuous glissando over its full range, it should generate successive triggers as it crosses successive pitch ranges. This should cause the continuous glissando to have an effect analogous to the strumming of multi-stringed, electronic harp, the activation of each string corresponding to an individual pitch-band detection and stimulus for the computer instrument.

In addition to the wave-shaping functions shown above, the design of instrument definitions must also include a specific set of seven parametric control functions (envelopes). These are also critical in manifesting the musical structure in this work. Whatever synthesis resources are used, the fundamental structure of these continuous control functions must be maintained. They are shown here, labeled **L1 . . . L7**:



In realizing Part V, the values (vertical axes) of these shapes are scaled so that they range from 0% to 100% of the control range of particular synthesis parameters. Three time-scales (horizontal axes) for each shape are programmed as well, resulting in three sets of seven, or twenty-one shapes in all. All shapes in the first set are to be approximately two seconds long, approximately four seconds in the second set, and approximately nine seconds in the third. (In the Touché version, the functions were realized with thirty-two data points, each separated by 72 milliseconds in the first set, yielding lengths of 2.304 seconds; 144 milliseconds in the second set, yielding lengths of 4.608 seconds; and 288 milliseconds in the third set, yielding lengths of 9.216 seconds. A longer version in which the data points were separated by 576 milliseconds, yielding lengths of 18.432 seconds were also calculated and used in some rare instances. It is acceptable to use fewer data points to program envelop break points that approximate these shapes and rely on interpolation to smooth them out when necessary. The important thing is to maintain the feeling of each shape in how it is realized.

It is intended that the twenty-one shapes be applied in a rotation/permutation scheme to synthesis parameters that may be devised by the electronics-computer performer. This scheme can assign time length scales, function shapes, and synthesis parameters to each other according to the following rules. First, one of the specific time length values described above must be chosen for each instrument definition, and all the shapes used in that definition will be of the same length. Then, the shapes are to be applied to the following five, primary synthesis parameters, assuming a non-linear wave-shaping scheme. Shapes L1, L3 and L4 are only used for the Gate Level function, shapes L2, L5, L6 and L7 are used for the other parameters, and no two functions are assigned the same shape in any given instrument definition.

Pitch	fundamental pitch of a sound	**L2**, **L5**, **L6** and **L7** in rotation/permutation scheme
Timbre	size of a lookup window into a waveform transformation function determined by the amplitude of a sine wave driving function	**L2**, **L5**, **L6** and **L7** in rotation/permutation scheme
T.M. Index	timbre modulation index, depth with which a sine wave driving function is amplitude modulated	**L2**, **L5**, **L6** and **L7** in rotation/permutation scheme
F.M. Index	frequency modulation index	**L2**, **L5**, **L6** and **L7** in rotation/permutation scheme
Gate Level	final amplitude and low-pass filtering stage through which all voices pass before being output from the system	**L1**, **L3** and **L4** in rotation/permutation scheme

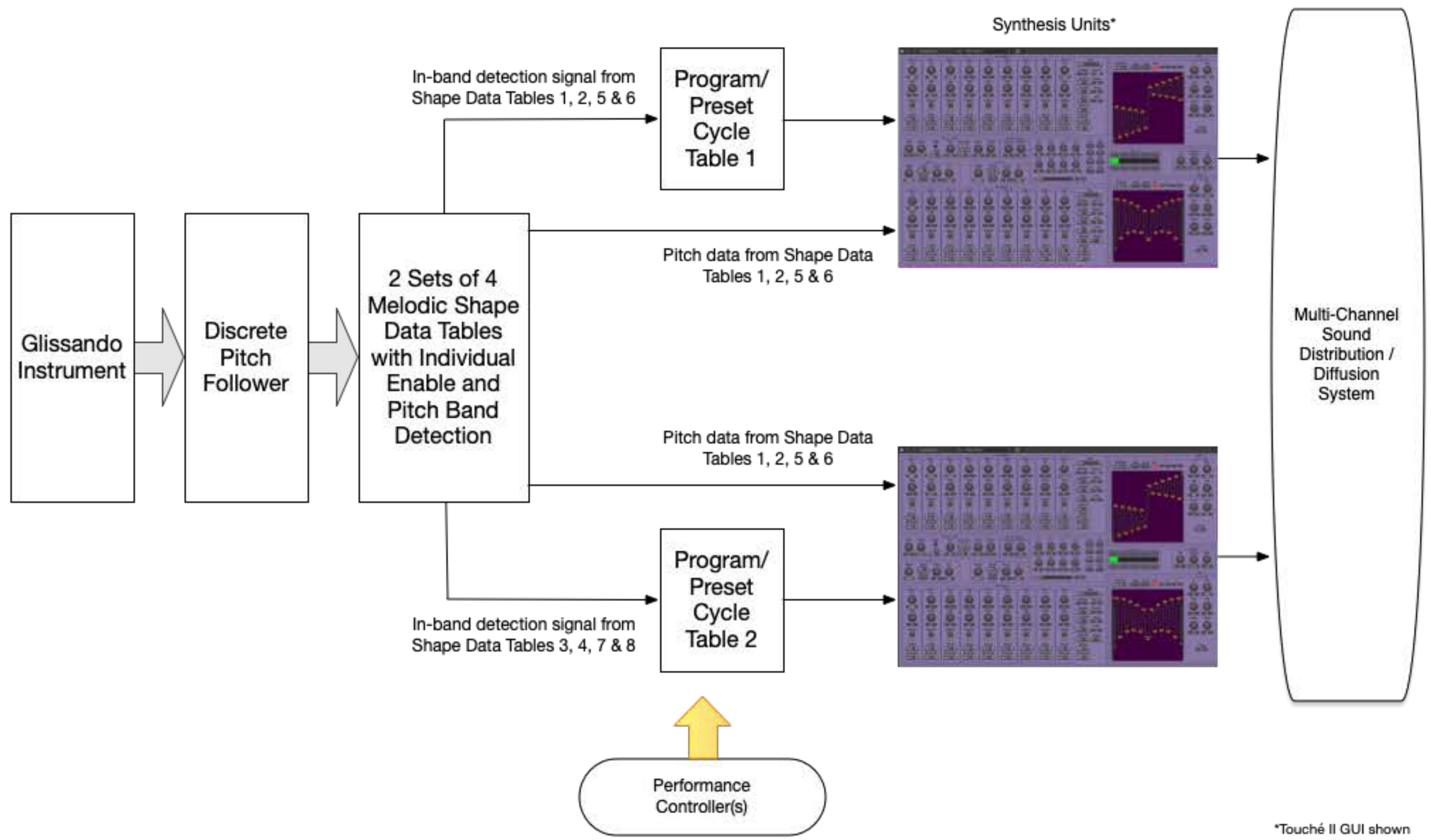
In most instances, the remaining parameters, F.M. Frequency (frequency of a modulating waveform) and T.M. Frequency (frequency with which the sine wave driving function is modulated by another sine wave) are either left fixed or, more often, set to be derived from a fixed ratio of carrier frequencies (primary pitch) to modulating frequencies. These may be freely designed by the synthesist. If another synthesis method is used to realize this piece, the synthesist should at least be familiar with the techniques of non-linear wave-shaping in order to understand the kinds of timbre evolution effects that can be created with this method. The most important quality to comprehend is the way in which waveforms can be made more complex or simple under continuous dynamic control. This defines a timbre domain. It is the way in which this timbre domain is traversed and the qualities of particular paths through this timbre space that should be most carefully preserved.

Note that at times it may be necessary to scale the parameter values to suite a particular synthesis method. For instance, in the Touché wave-shaping instrument, the index values for frequency and timbre modulation were often scaled down a bit. This was necessitated because of the extreme effect that high modulation indices for these particular parameters can have on a sound, as compared with other parameters. Such rescaling is possible. However, it should always be carefully applied for good reasons. The form of the envelope shapes should always be preserved.

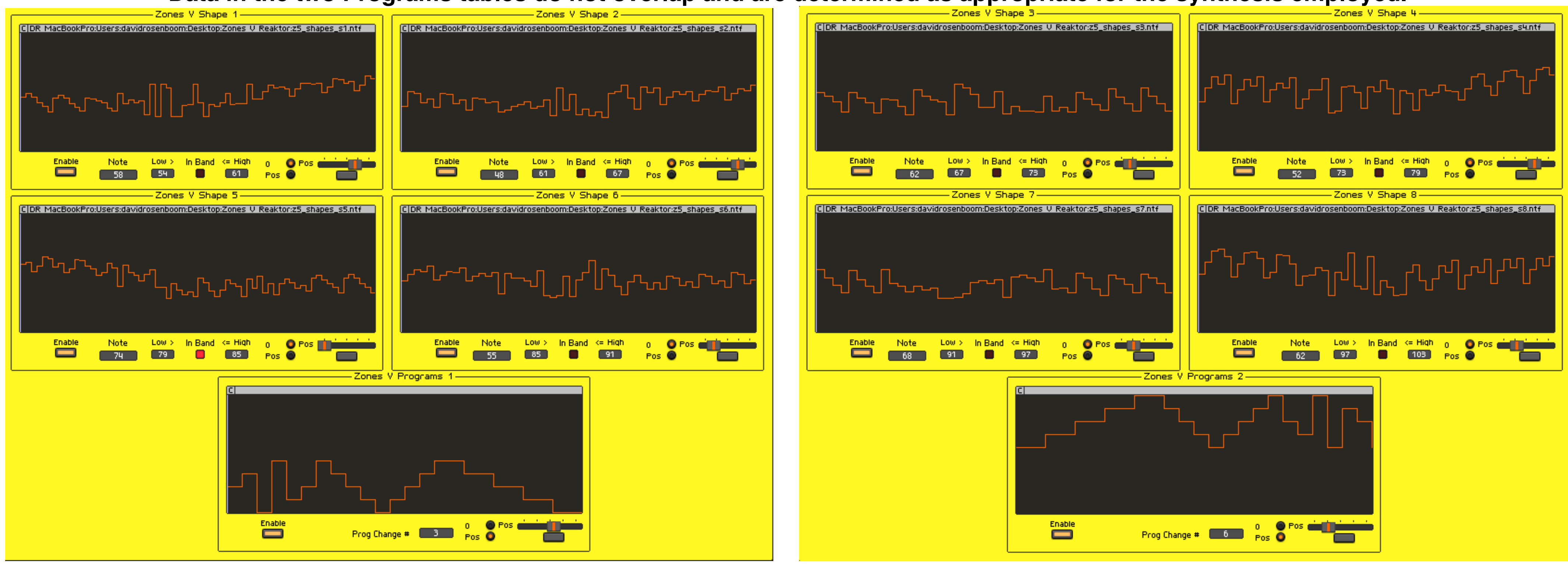
In Touché and Touché II realizations, a spatial distribution effect was also applied by means of subtle phasing or slow modulation of an all-pass filter network. This or other spatialization schemes should be applied with taste and care, so as not to be too noticeable, but to broaden and enrich the sound space. All other unspecified parameters may be freely created to suite the performers' desires and instrument capabilities.

Readout from all the tables always wraps around to the beginning when the end is reached.

The Buckling of a Spring
Technical Block Diagram



Two sets of Part V Shapes as they appear in a Reaktor realization of the data tables shown below.
Data in the two Programs tables do not overlap and are determined as appropriate for the synthesis employed.



Shape 1
58 62 58 52 48 42 57 60 57 51 47 43 57 56 54 52 46 43 62 51 55 52 54 39 73 37 73 69 37 37 49 50 73 52 37 50 48 52 62 50 51 51 73 56 56 65 72 69 70 68 59 68 74 74 73 74 63 70 79 78 74 76 66 72 82 79

Shape 2
48 64 62 52 56 47 62 61 51 55 44 57 56 52 53 42 44 48 50 53 46 48 55 38 69 44 61 39 45 38 42 36 62 65 72 57 45 70 63 69 50 58 65 61 64 54 61 66 64 70 55 62 68 66 72

Shape 3
62 58 52 41 62 56 51 40 55 54 47 38 66 58 54 52 38 72 68 60 46 46 63 39 47 42 42 41 58 42 46 41 62 55 49 43 67 57 50 42 68 58 50 42

Shape 4
52 68 80 72 82 50 66 77 70 80 52 66 73 68 79 45 55 66 66 78 40 42 69 70 62 45 69 63 76 67 39 65 61 43 66 59 62 71 64 63 54 67 80 83 70 59 75 86 87 80 61 76 88 90 82

Shape 5
74 76 66 72 82 80 71 75 65 69 79 78 72 69 61 65 75 70 49 73 64 61 55 62 68 48 48 36 52 45 40 43 38 58 53 44 38 45 56 52 49 38 57 47 60 42 52 40 52 57 53 47 50 44 58 61 56 52 48 42 58 62 58 52 48 42

Shape 6
55 62 68 66 72 56 61 66 64 70 55 60 63 60 64 41 63 58 58 55 49 67 39 37 39 60 38 56 64 78 46 69 61 49 40 54 61 53 46 53 46 60 58 50 54 48 62 60 52 55 48 64 62 52 56

Shape 7
68 58 50 42 67 56 49 42 68 52 49 43 49 45 47 36 36 37 41 53 55 52 56 37 59 61 58 54 68 46 47 42 63 58 46 39 61 57 51 42 62 58 52 42

Shape 8
62 76 88 90 82 59 74 86 87 80 58 65 84 83 74 50 60 61 70 67 39 64 56 86 49 46 82 40 55 48 39 40 65 73 55 45 57 72 64 78 46 61 71 65 79 52 67 79 70 80 52 68 80 72 82

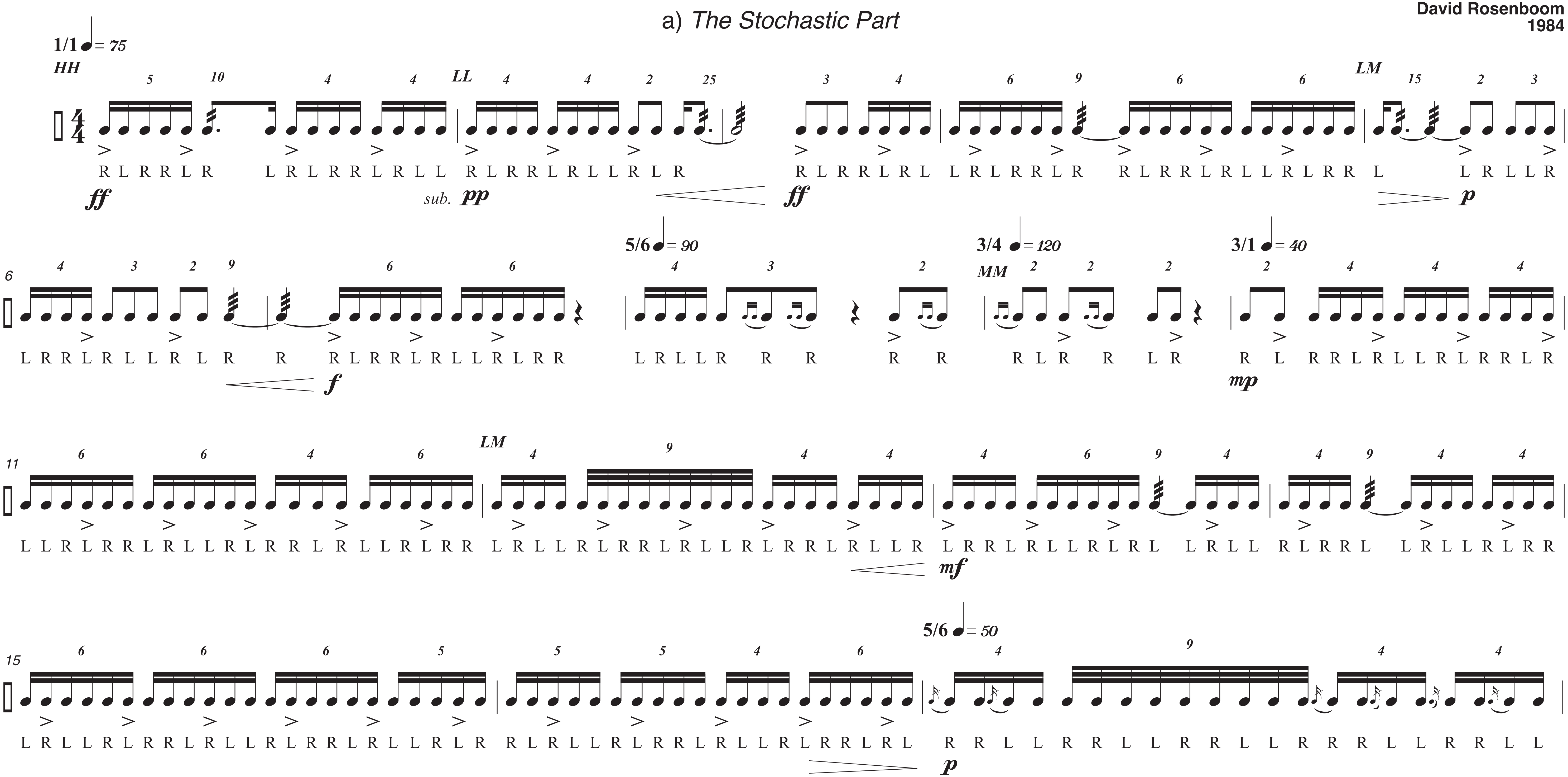
It is intended that these pitch data be interpreted as quarter-tone representations in the same way as in Part IV. Refer to that section of these instructions for details. In Part V, however, the electronics-computer performer may experiment with both octave-shifting and interpretating the data as half-tone or quarter-tone pitch representations. Again, the shapes are what matter most. As in Part IV, the shape transformation trajectories are produced with melodic fragments following phrasing landmarks in the *Origin* and *Target Melodies*. In Part V, a greater degree of stochastic influence is injected into the transformation functions. Enable switches are all turned on at the beginning of the movement, are turned off during the middle contrasting section, and back on when the glissando parts resume.

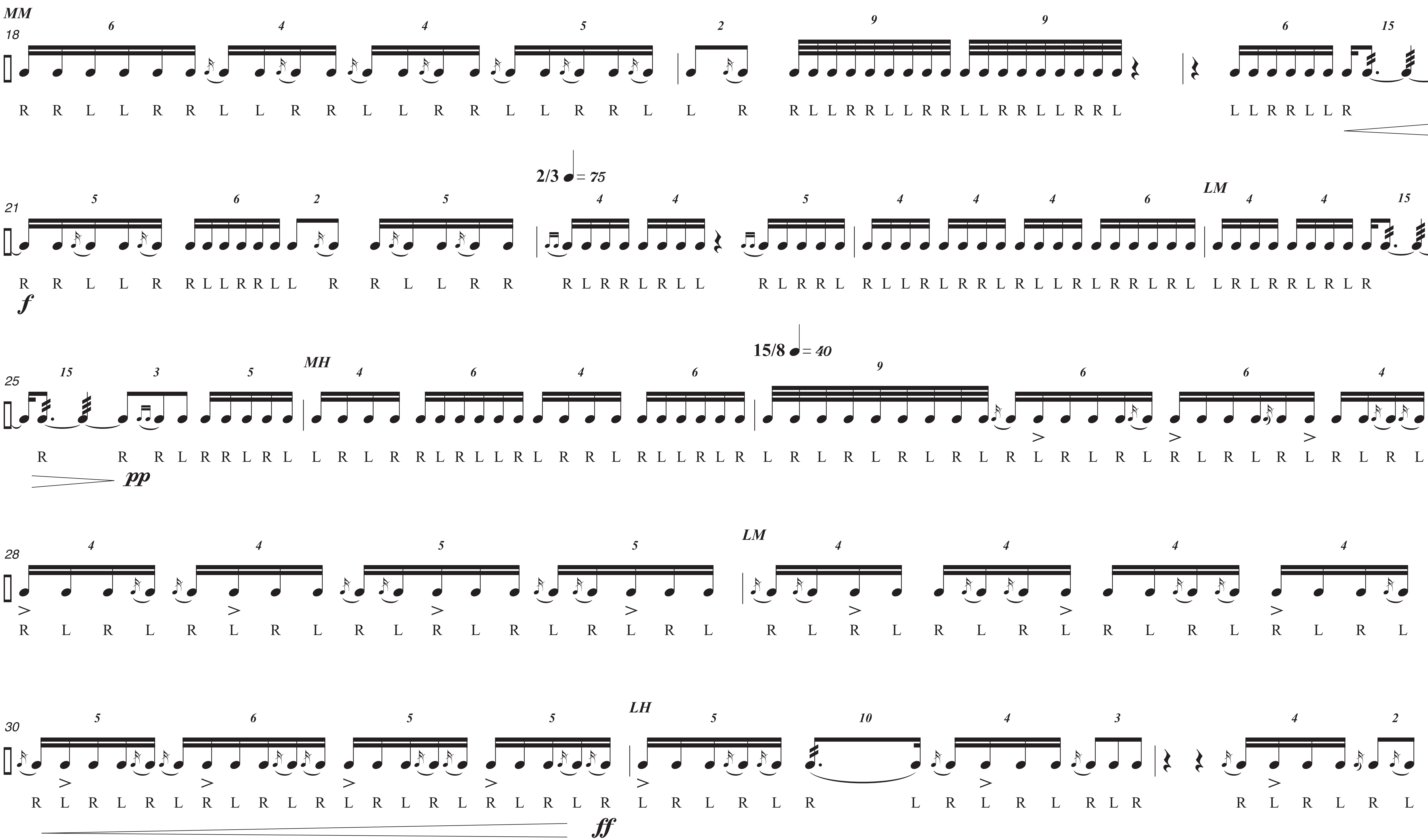
Zones of Influence

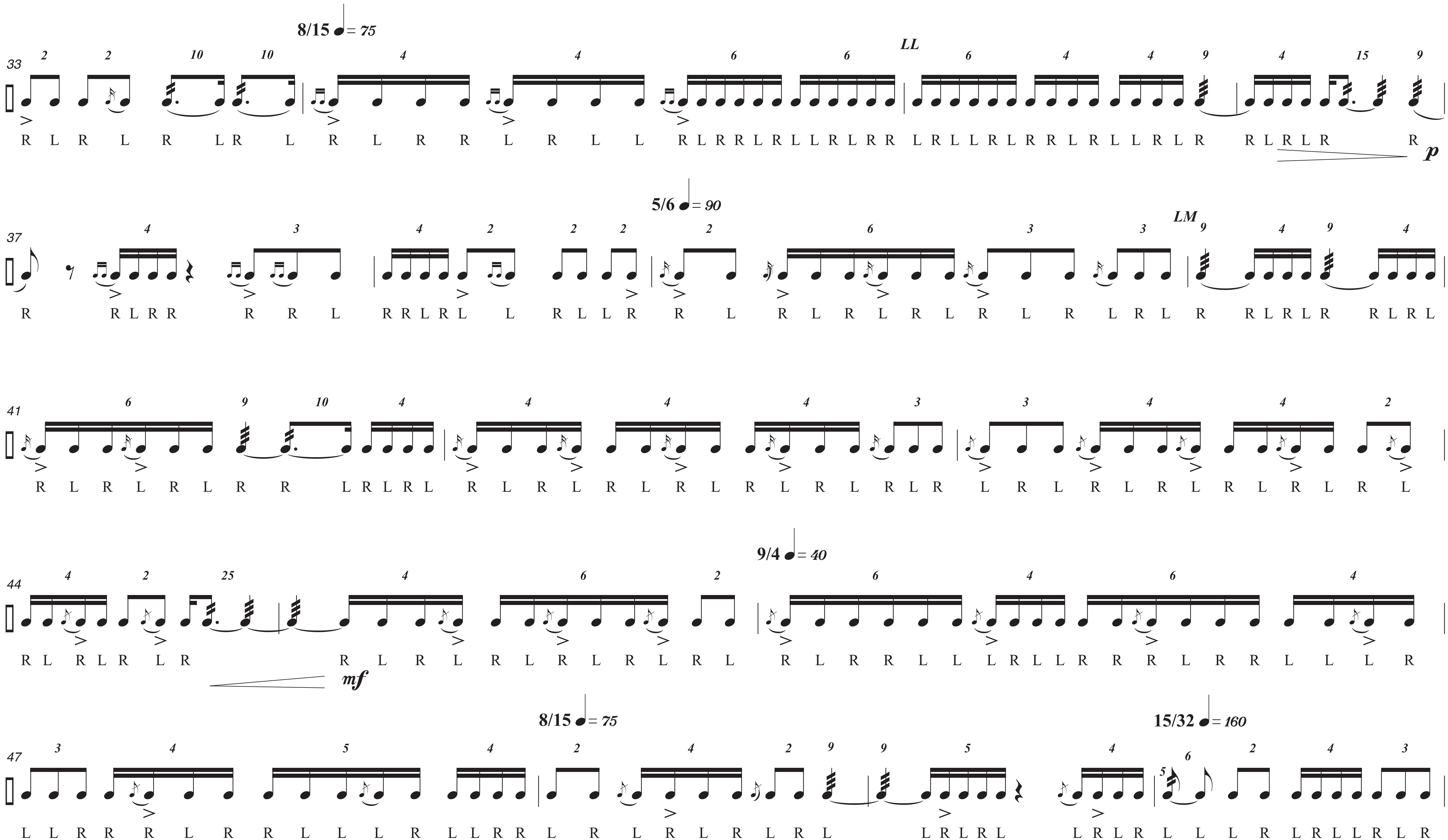
Part I: *The Winding of a Spring*

a) *The Stochastic Part*

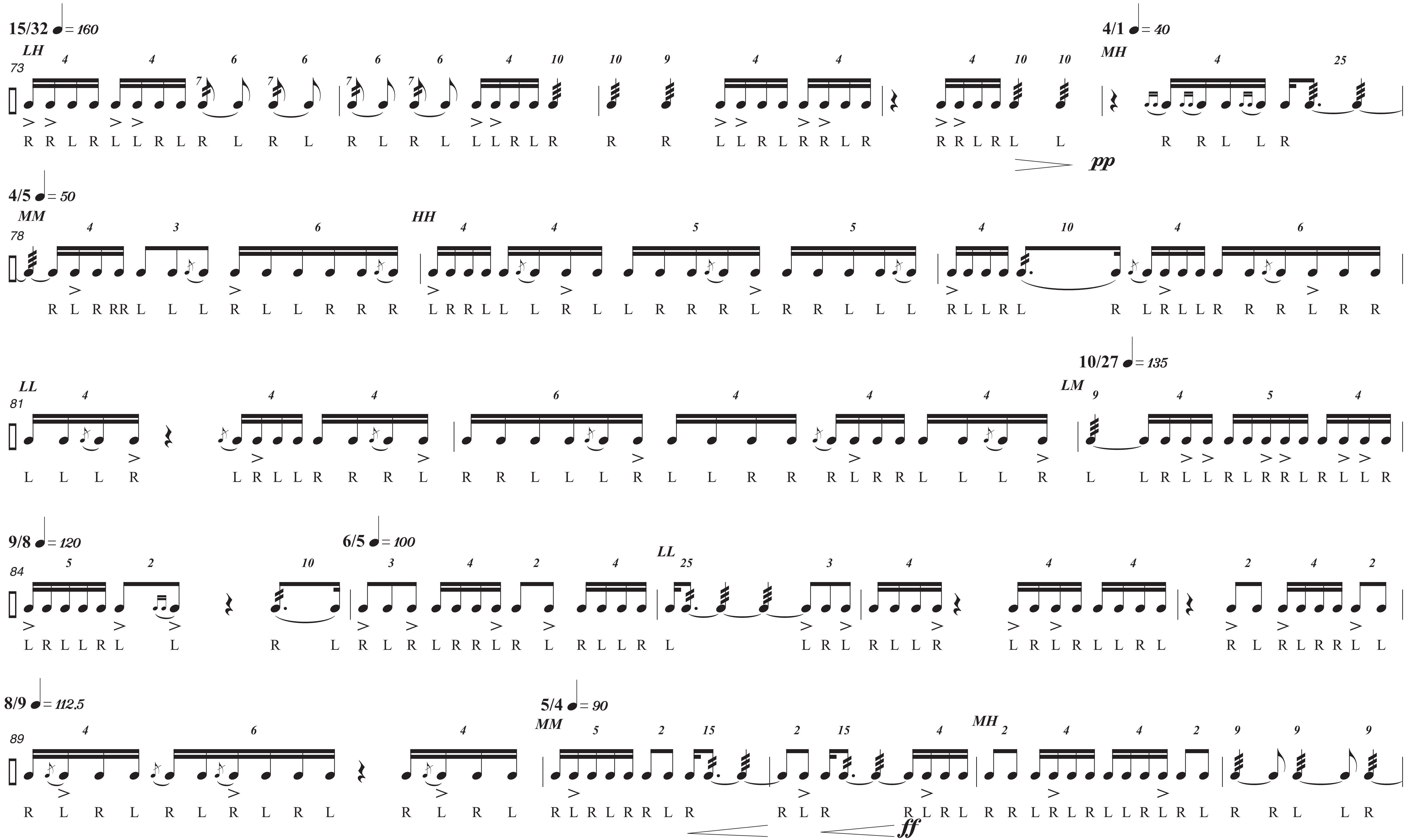
David Rosenboom
1984

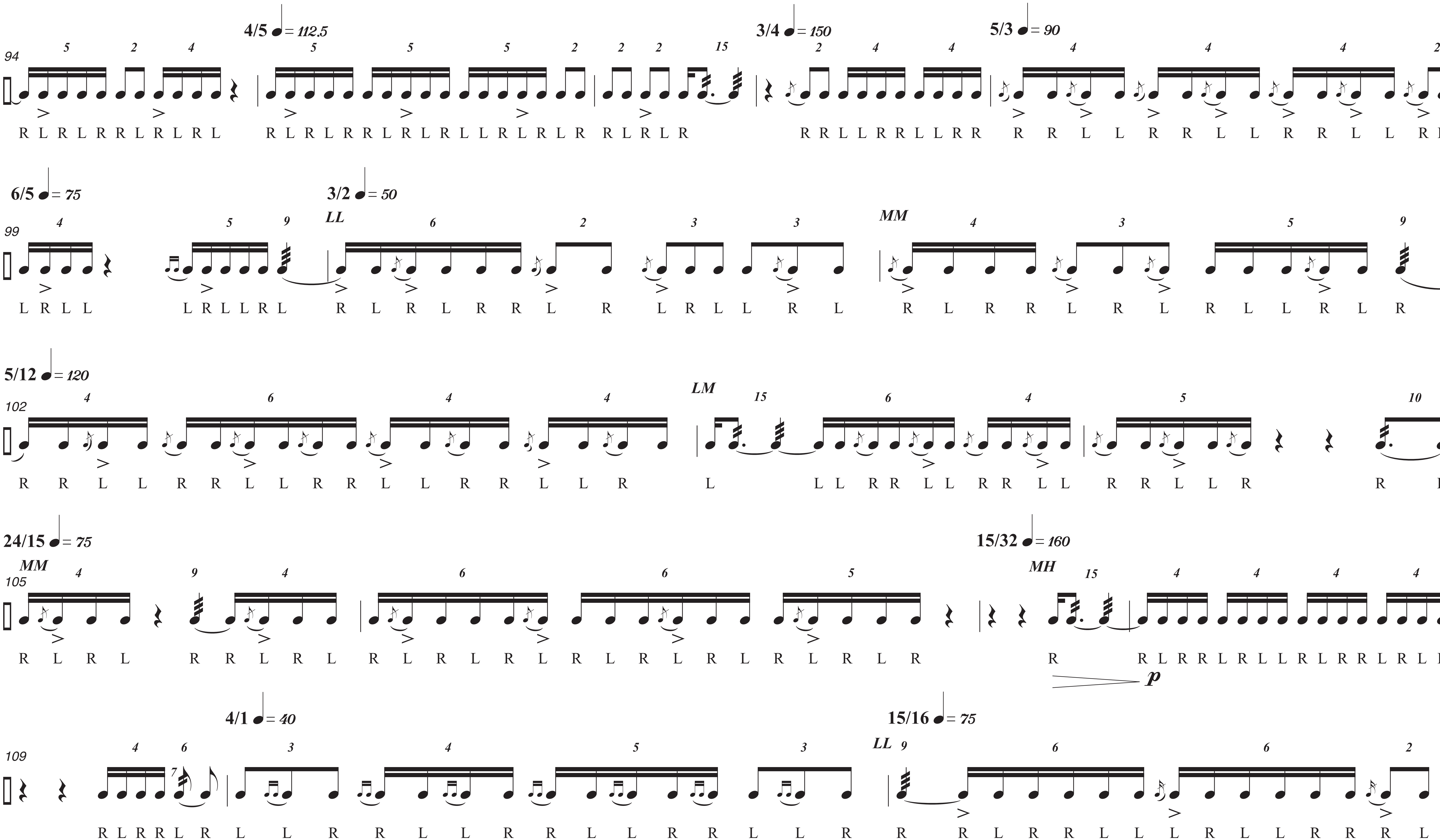


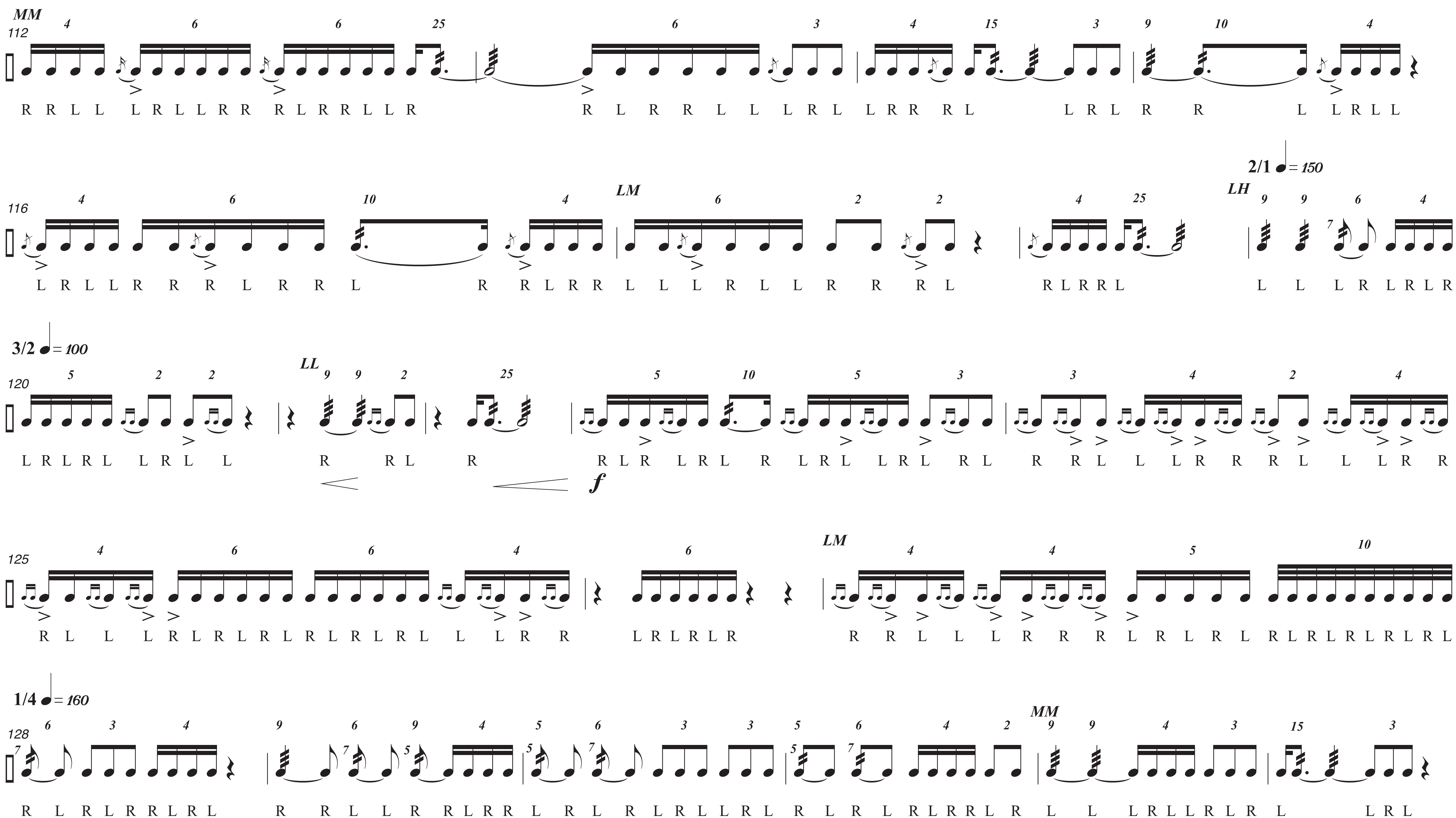

MM
LM
MH
LH
2/3 ♩ = 75
15/8 ♩ = 40
f
pp
ff
R R L L R R L L R R L L R R L L R R L L R
R L L R R L L R R L L R R L L R R L
L L R R L L R
R R L L R R L L R R L L R R L L R R
R L R R L R L L
R L R R L R L L R L R R L R R L R L L R L R R L R L
L R L R R L R L R
R R L R R L R L L R L R L L R L R R L R L L R L R
L R L R L R L R L R L R L R L R L R L R L R L R L R L
R L R L R L R L R L R L R L R L R L R L R L R L R L R L R L R L
R L R L R L R L R L R L R L R L R L R L R L L R L R L R L R L R L R L R L R L R L R L R L R L R L R L


33
8/15 ♩= 75
LL
p
37
5/6 ♩= 90
LM
41
44
9/4 ♩= 40
mf
47
8/15 ♩= 75
15/32 ♩= 160

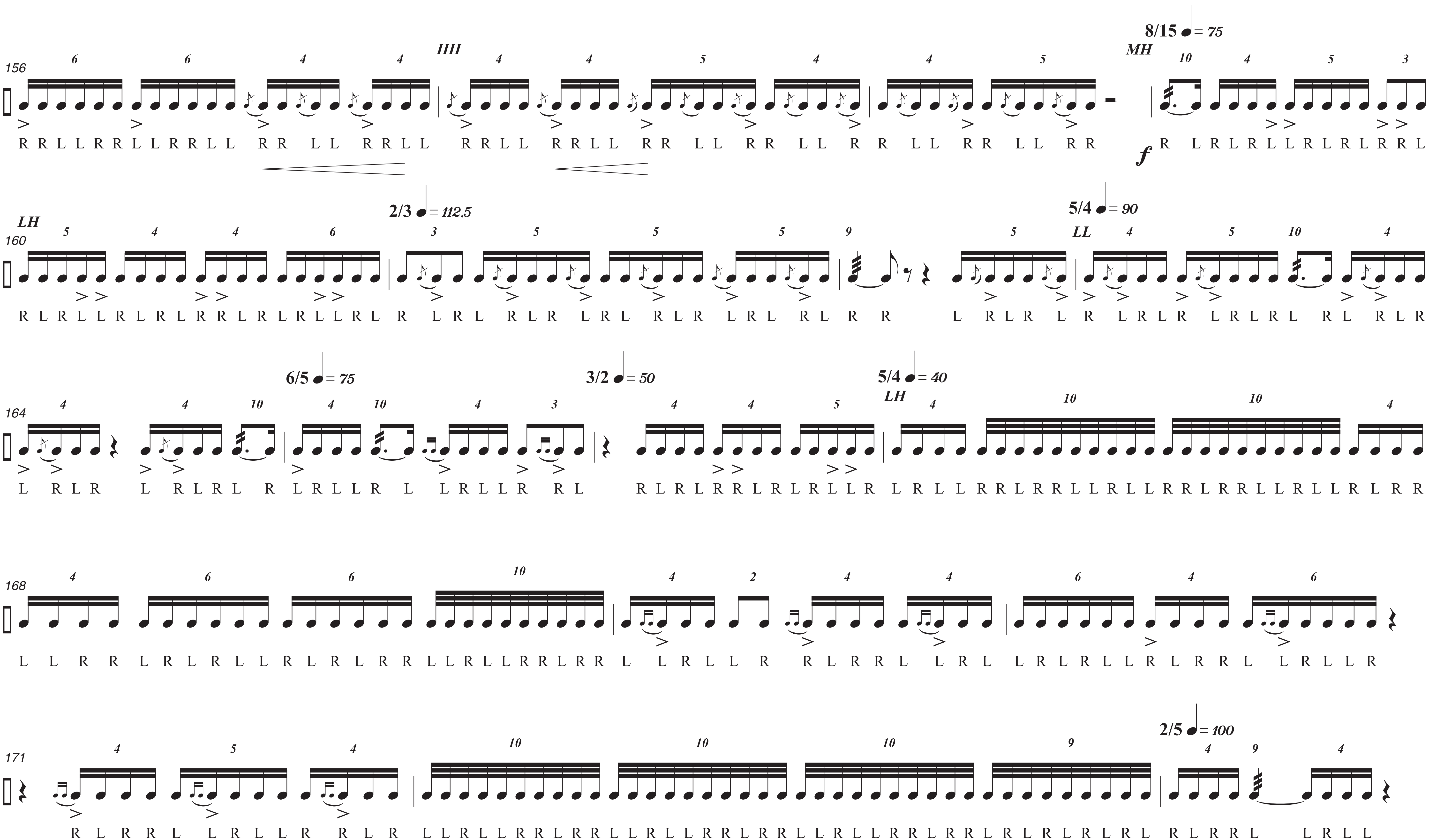

64/45 ♩= 112.5
LL
p
4/5 ♩= 180
9/5 ♩= 100
f
4/3 ♩= 75
LH
MM
MH

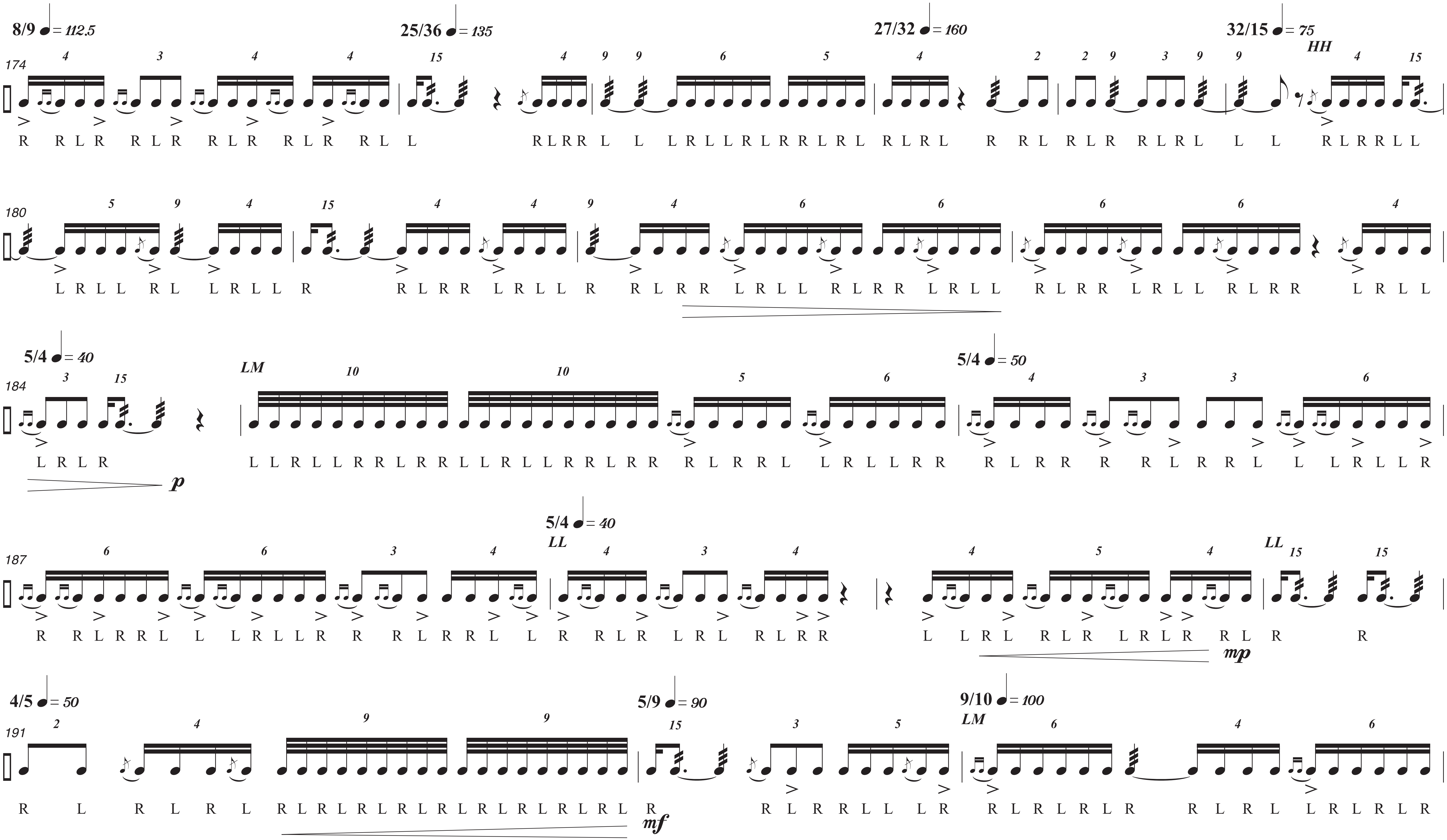

15/32 ♩= 160
LH
73
R R L R L L R L R L R L R L R L L L R L R R R L L R L R R L R R L R L L
4/1 ♩= 40
MH
pp
R R L L R
4/5 ♩= 50
MM
78
R L R RR L L L R L L R R R
HH
L R R L L L L R L L R R R L R R L L L R L L R L R L R L L R R R L R R
LL
81
L L L R L R L L R R R L R R L L L R L L R R R L R R L L L R
10/27 ♩= 135
LM
L L R L L R L R R L R L L R
9/8 ♩= 120
84
L R L L R L L
6/5 ♩= 100
R L L R L R L R R L R L R L L R L
LL
L R L R L L R L R L R L L L R L R L R R L R R L L
8/9 ♩= 112.5
89
R L R L R L R L R L R L R L
5/4 ♩= 90
MM
R L R L R R L R R L R R L R L
MH
R R L R L R L L R L R L R R L L R
ff

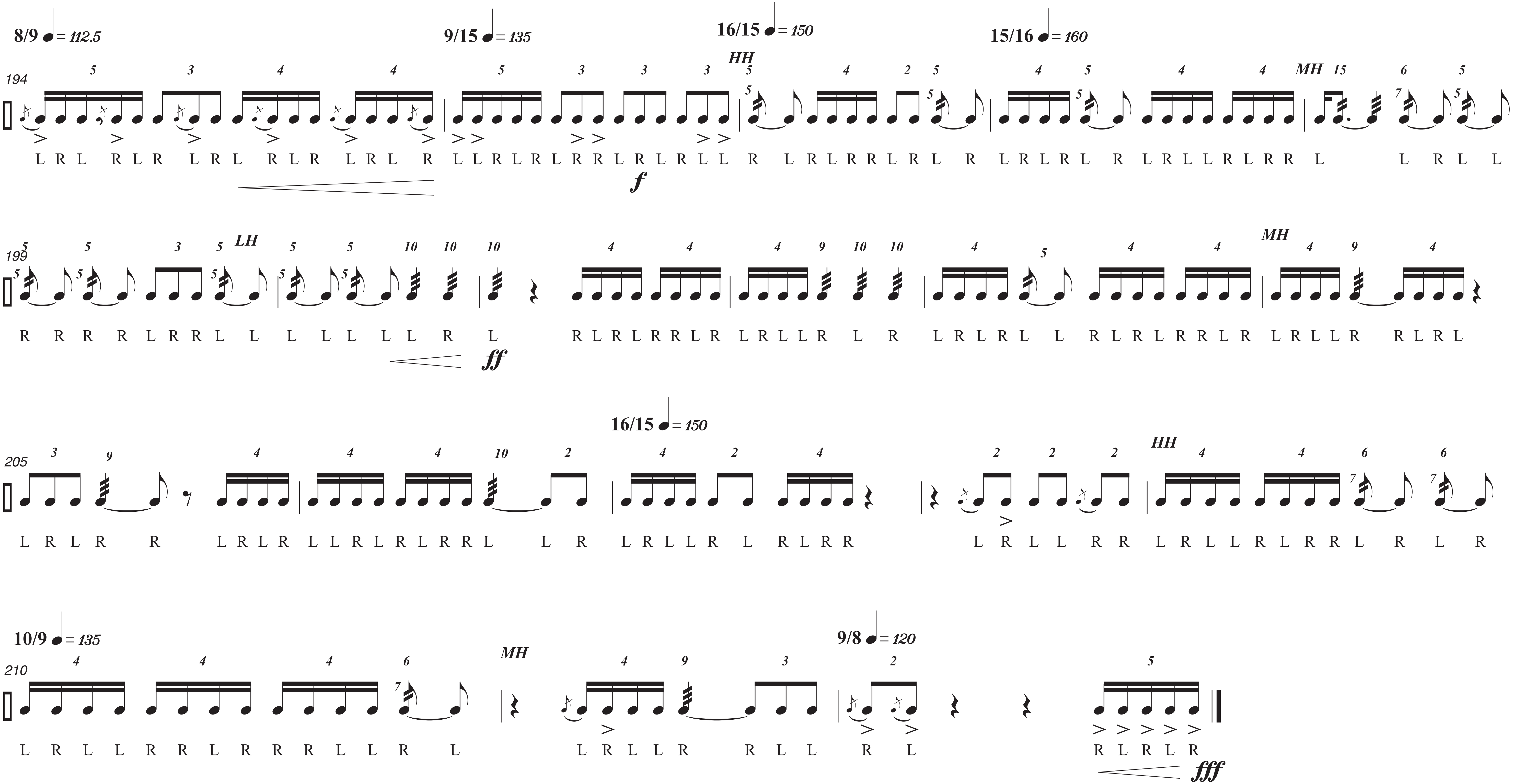

4/5 = 112.5
3/4 = 150
5/3 = 90
94
R L R L R R L R L R L R L R L R R L R L R L L R L R L R L R R L R L R R R L L R R L L R R R R L L R R L L R R L L R R
6/5 = 75
3/2 = 50
LL
MM
99
L R L L L R L L R L R L R L R R L R L R L L R L R L R R L R L R L L R L R
5/12 = 120
LM
102
R R L L R R L L R R L L R R L L R L L L R R L L R R L L R R L L R R L
24/15 = 75
15/32 = 160
MM
MH
105
R L R L R R L R L R L R L R L R L R L R L R L R L R L R L R R R L R R L R L L R L R R L R L L
p
4/1 = 40
15/16 = 75
LL
109
R L R R L R L L R R L L R R L L R R L L R R R L R R L L L R L L R R R L


MM
LM
LH
LL
2/1 ♩= 150
3/2 ♩= 100
1/4 ♩= 160
f
R R L L L R L L R R R L R R L L R R L R R L L L R L L R R R L L R L R R R L L R L L
L R L L R R R L R R L R R L R R L L L R L L R R R L R L R R L L L R L R L R L R
L R L R L L R L L R R L R R R L R L R L L R L L R L L R R L L L R R R R L L L R R
R L L L R L R L R L R L R L R L R L L L R R L R L R L R R R L L L R R R R L R L R L R L R L R L R L R L R L R L
R L R L R R L R L R R L R L R L R R R L R L R L R L L R L R R L L R L R L R L R R L R R R L R L L L R L L R L R L L R L
- 7 -


4/3 ♩= 120
LH
134
16/15 ♩= 112.5
MM
5/4 ♩= 90
LL
R R R L L R R L L R L L L R
R L L R L R L R R L R L R L R L
R R R L R L R R L R L R L R L
LM
140
9/4 ♩= 40
R R R R L R L R L R L R L R L R L R R L L L R L L R R R L R
R L L R L R R L L R L R R L L R L R R L L
mp
4/9 ♩= 90
144
9/10 ♩= 100
R R L R R L R R L R R L R L R R L R R L R R L R R L R L R R L R R L R R L L
R L R L R L R L R L R L R L R L R L
LH
148
5/8 ♩= 160
LL
16/9 ♩= 90
MH
R L R L R R R L R R L L R L L R L R L R L R R L R
L R L L L R L R R L R L L R L R L L R R R L R L L
153
9/4 ♩= 40
LL
R R R L R L R R L L L R L R L L L R R R L R L
R L R R L R L R L R L L L R R R L
R R L L R R L L R R L L R R L L R R L L R R L L

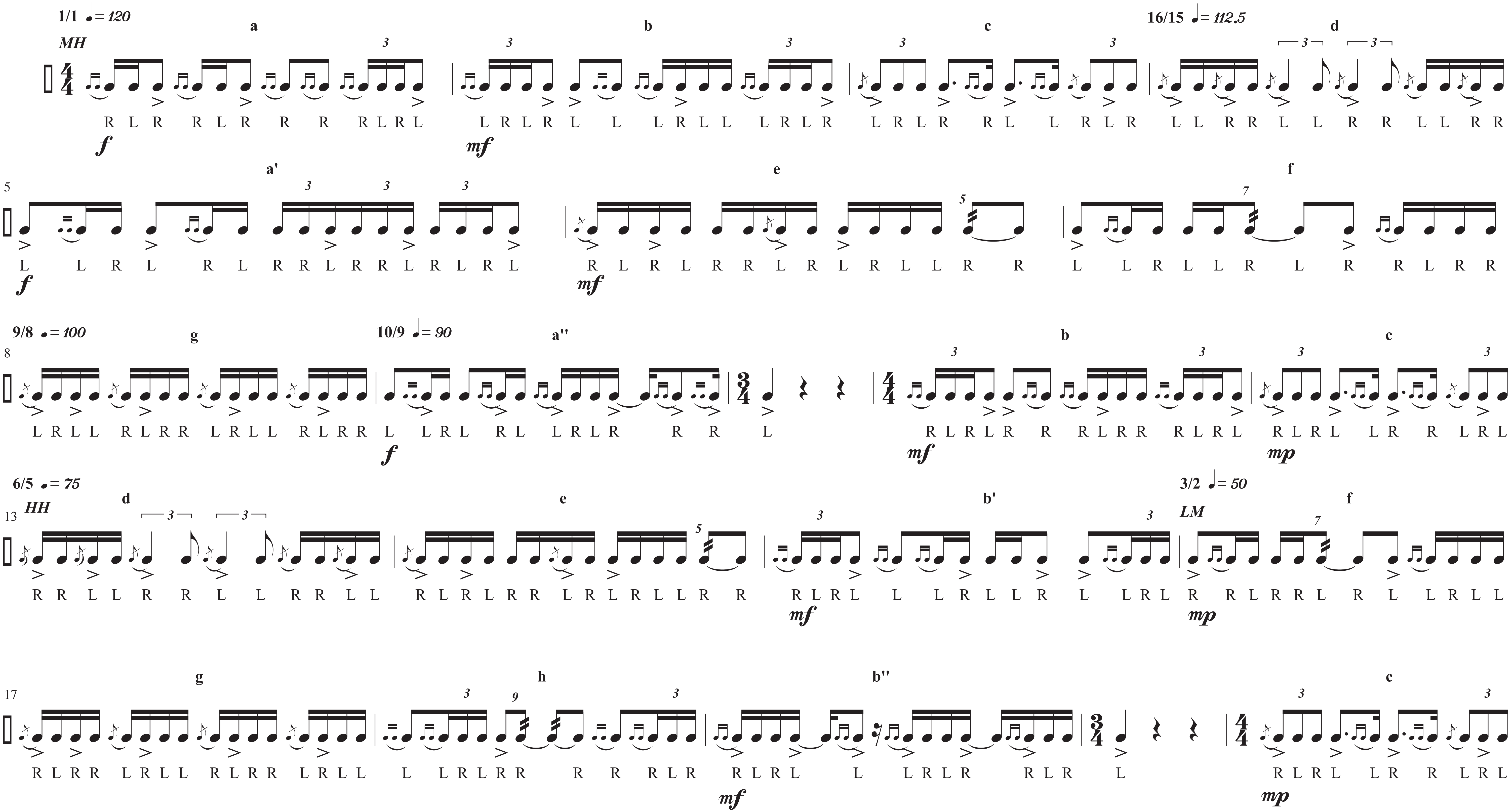

156
HH
MH
8/15 ♩= 75
R R L L R R L L R R L L R R L L R R L L R R L L R R L L R R L L R R L L R R L L R R L L R R
f
R L R L R L L R L R L R R L
160
LH
2/3 ♩= 112.5
5/4 ♩= 90
LL
R L R L L R L R L R R L R L R L L R L R L R L R L R L R R L R L R L R L R R L R L R L R L R L R L R L R L R L R L R L R R L R
164
6/5 ♩= 75
3/2 ♩= 50
5/4 ♩= 40
LH
L R L R L R L R L R L R L L R L L R L L R R L R L R R L R L R L R L L R L R L L R R L R R L L R L L R R L R R L L R L L L R L R R
168
L L R R L R L R L L R L R L R R L L R L L R R L R R L L R L L R R L R R L R L R L L R L R L R L R L L R L R R L L R L L R
171
2/5 ♩= 100
R L R R L L R L L R R L R L L R L L R R L R R L L R L L R R L R R L L R L L R R L R R L R L R L R L R L R L R R L L R L L


8/9 = 112.5
25/36 = 135
27/32 = 160
32/15 = 75
HH
174
R R L R R L R R L R R L R R L L
R L R R L L L R L L R L R R L R L R L R L R R L R L R L R L R L R L L L R L R R L L
180
L R L L R L L R L L R R L R R L R L L R R L R R L R L L R L R R L R L L R L R R L R L L R L R R L R L L
184
5/4 = 40
LM
5/4 = 50
L R L R
p
L L R L L R R L R R L L R L L R R L R R R L R R L L R L L R R R L R R R R L R R L L R L L R
187
5/4 = 40
LL
LL
R R L R R L L L R L L R R R L R R L L R R L R L R L R R R
L L R L R L R L R L R R L R
mp
191
4/5 = 50
5/9 = 90
9/10 = 100
LM
R L R L R L R L R L R L R L R L R L R L R L R L R L
mf
R L R R L L L R R L R L R L R R L R L L R L R L R


8/9 = 112.5
9/15 = 135
16/15 = 150
15/16 = 160
194
HH
MH
f
199
LH
MH
ff
205
16/15 = 150
HH
210
10/9 = 135
MH
9/8 = 120
fff

– Blank Page –

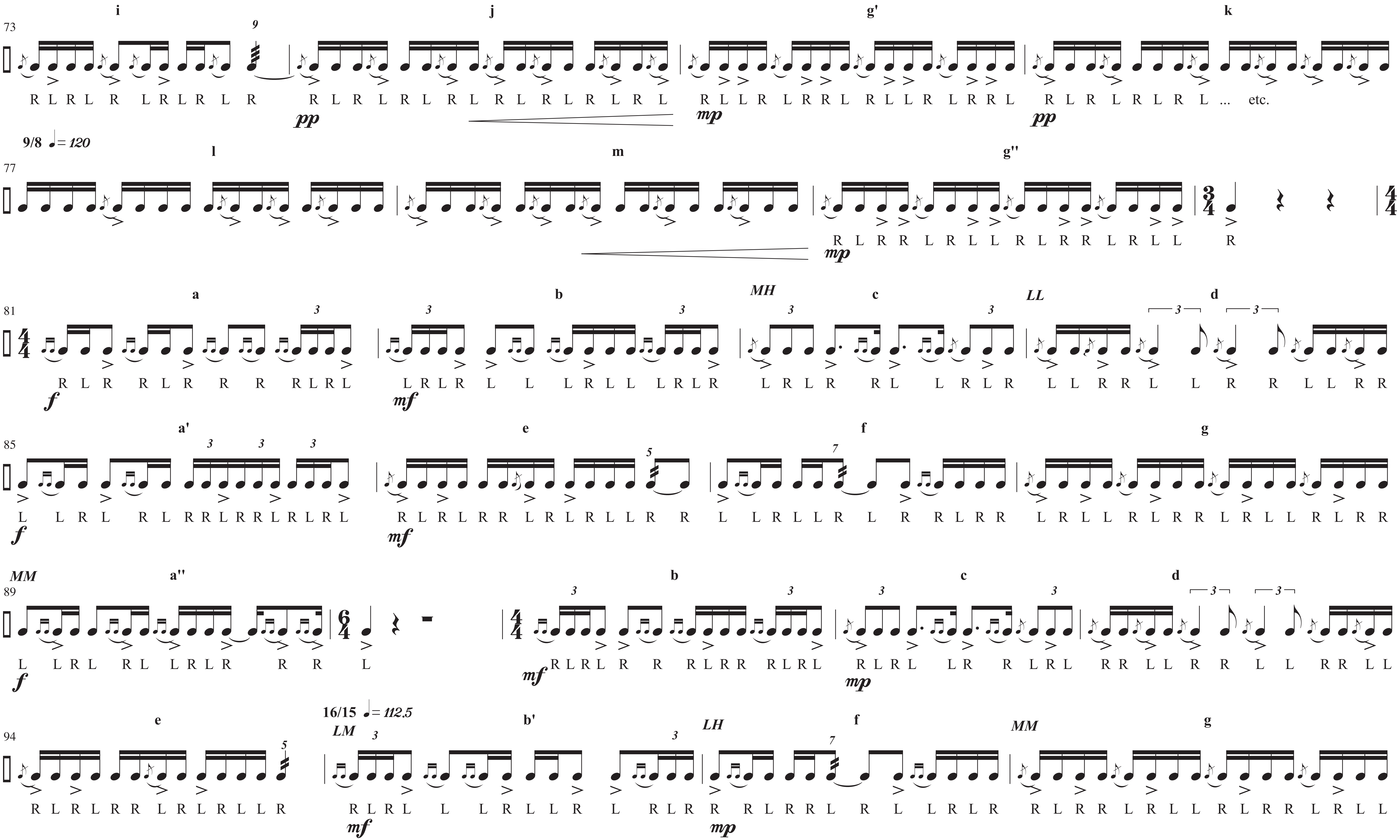
b) *Tripartite Structure*

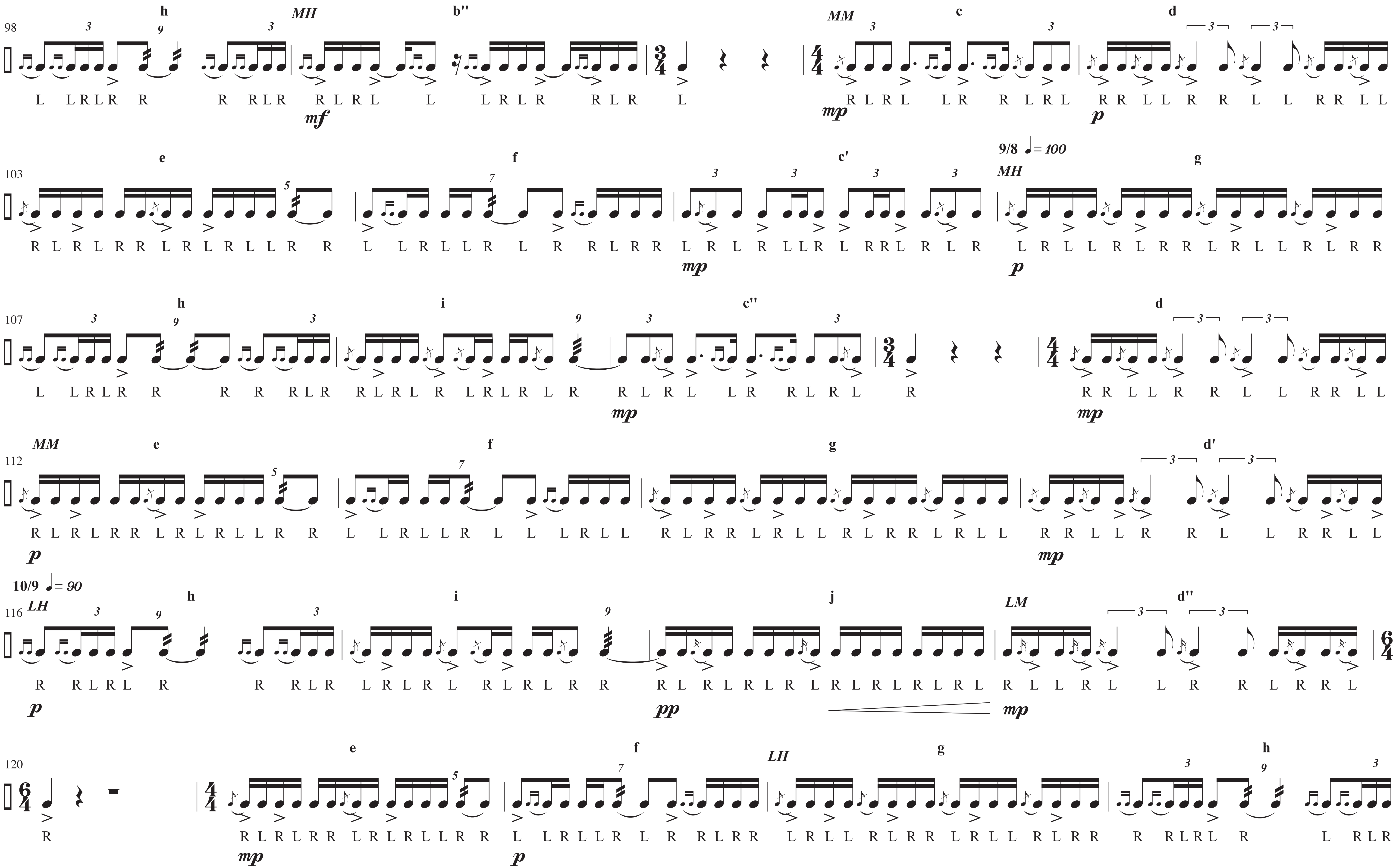


Print date: 2/18/21

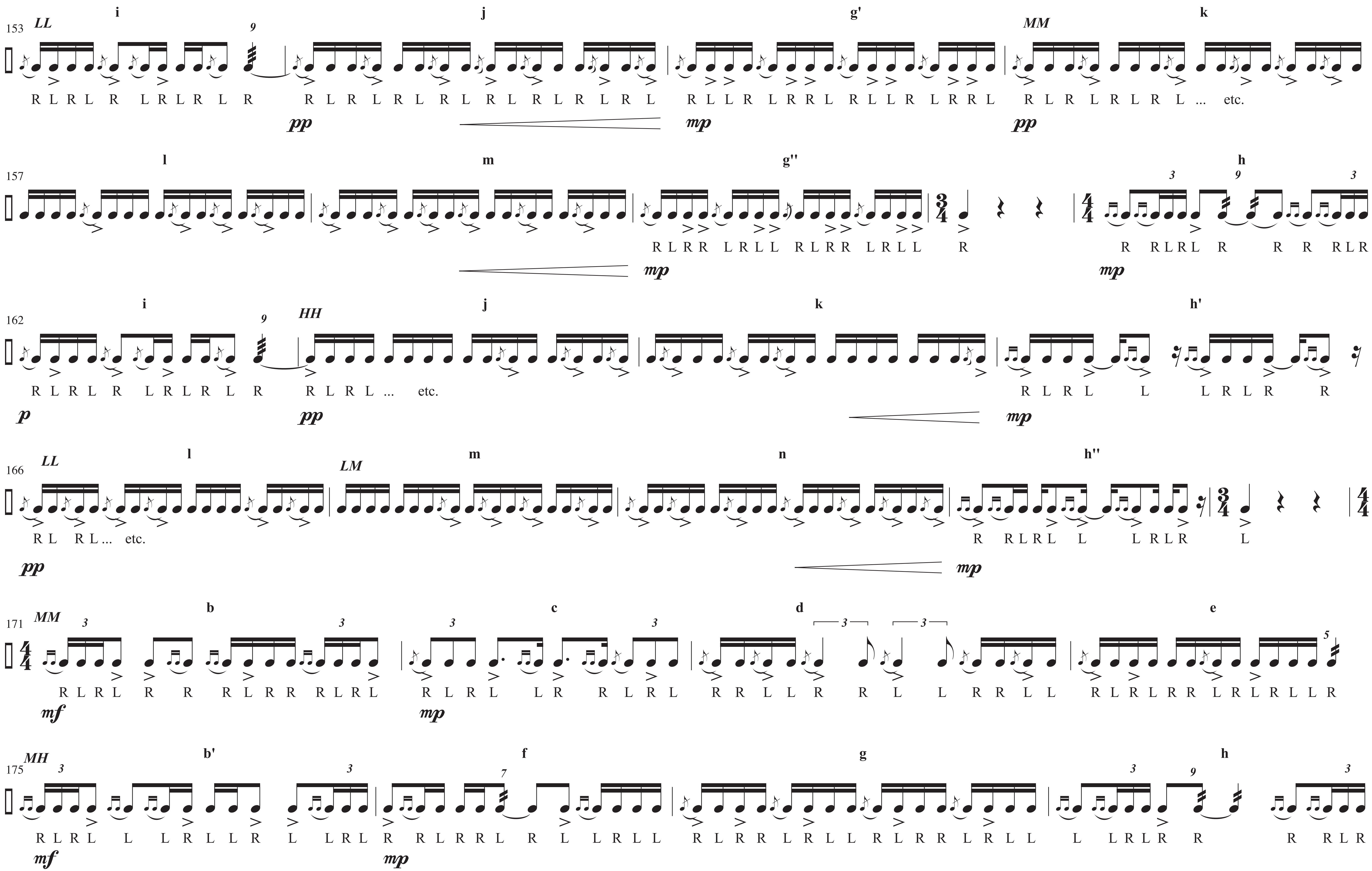

22 LH
d
e
HH
f
c'
p
mp
26 2/3 ♩= 75
g
h
MM
i
c''
p
mp
30
d
5/6 ♩= 90
LH
e
9/10 ♩= 100
f
MH
g
mp
p
35
d'
h
5/6 ♩= 120
i
j
mp
p
pp
39
d''
a
8/9 ♩= 135
MM
b
mp
f
mf
43
c
d
a'
27/32 ♩= 160
LL
e
f
mf

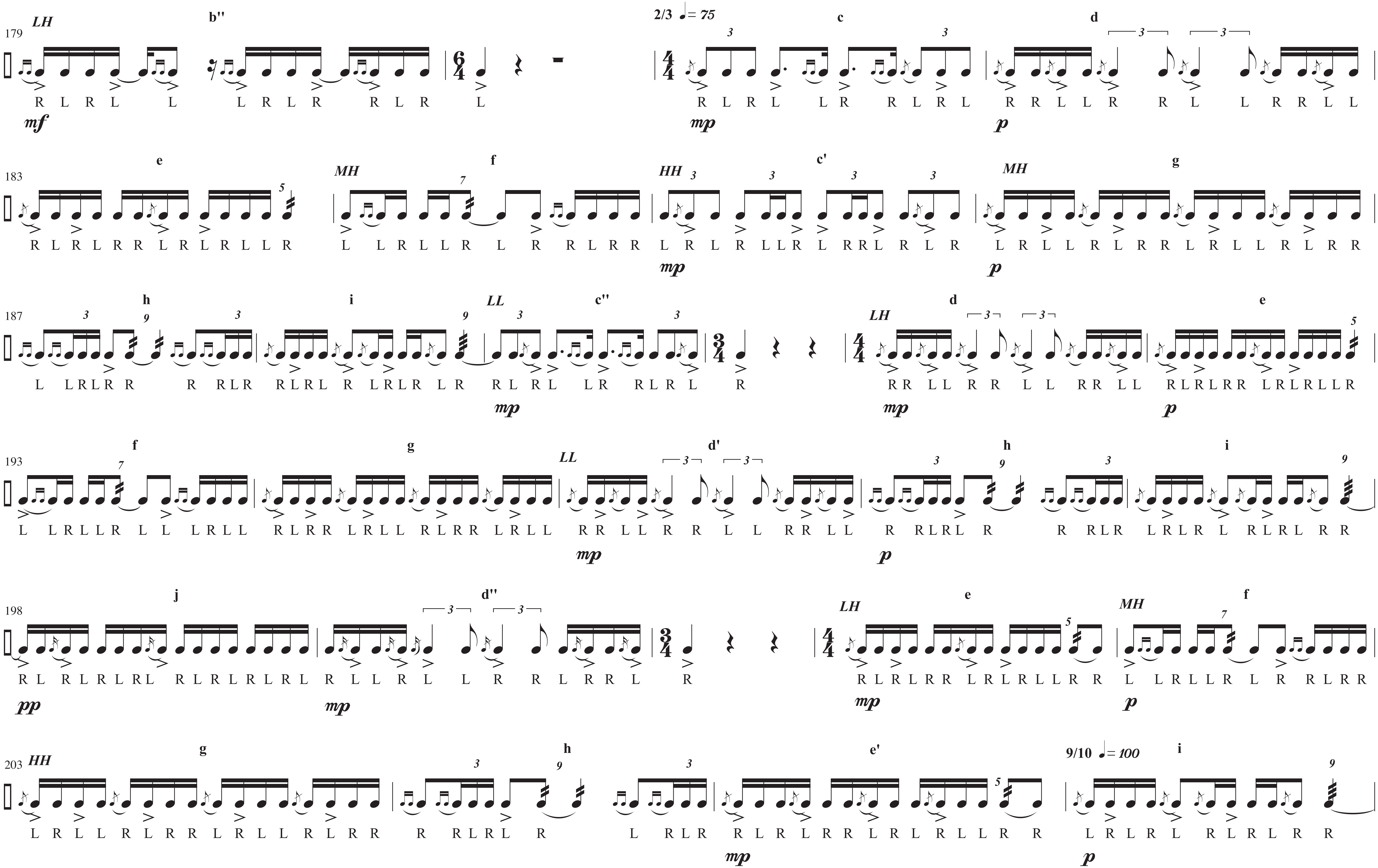

47
f
7
g
MH
a''
e
5
L L R L L R L R R L R R L R L L R L R R L R L L R L R R L L R L R L L R L R R R L
R L R L R R L R L R L L R R
f
mp
52
LH
f
7
g
h
3
9
3
e'
5
L L R L L R L R R L R R L R L L R L R R L R L L R L R R R R L R L R R L L R L R L R L R L R R L R L R L L R R
p
mp
56
HH
i
9
j
k
L R L R L R L R L R R R L R L R L R L R L R L R L R L R L R L R L R L R L R L R L R L R L R L
p
pp
59
MH
e''
5
R R L R L R L L R L R L R R L R R L R R L R L L R L L L R L L R L R R L R L L R L R R R R L R L R R R R L R
mp
mp
p
64
HH
i
9
f'
j
k
R L R L R L R L R L R R L R R L L R L L R R L R L R L R L R L R L R L R L R L R L R L ... etc.
mp
pp
10/9
= 135
68
l
f''
LL
g
h
3
9
3
R L R R L L R L L R L R R L R L R R L R L L R L R R L R L L R R L R L R R R R L R
mp
mp
p


73
i
j
g'
k
9
R L R L R L R L R L R
R L R L R L R L R L R L R L R L
R L L R L R R L R L L R L R R L
R L R L R L R L ... etc.
pp
mp
pp
9/8 ♩= 120
77
l
m
g''
R L R R L R L L R L R R L R L L
R
mp
81
a
b
MH
c
LL
d
R L R R L R R R R L R L
L R L R L L L R L L L R L R
L R L R R L L R L R
L L R R L L R R L L R R
f
mf
85
a'
e
f
g
5
7
L L R L R L R R L R R L R L R L
R L R L R R L R L R L L R R
L L R L L R L R R L R R
L R L L R L R R L R L L R L R R
f
mf
89
MM
a''
b
c
d
L L R L R L L R L R R R L
mf
R L R L R R R L R R R L R L
R L R L L R R L R L
R R L L R R L L R R L L
mp
94
e
16/15 ♩= 112.5
LM
b'
LH
f
MM
g
5
7
R L R L R R L R L R L L R
R L R L L L R L L R L R L R
R R L R R L R L L R L R
R L R R L R L L R L R R L R L L
mf
mp


98
h
MH
b''
mf
MM
c
d
mp
p
103
e
f
c'
9/8 ♩= 100
MH
g
mp
p
107
h
i
c''
d
mp
mp
112
MM
e
f
g
d'
p
mp
10/9 ♩= 90
116
LH
h
i
j
LM
d''
p
pp
mp
120
e
f
LH
g
h
mp
p

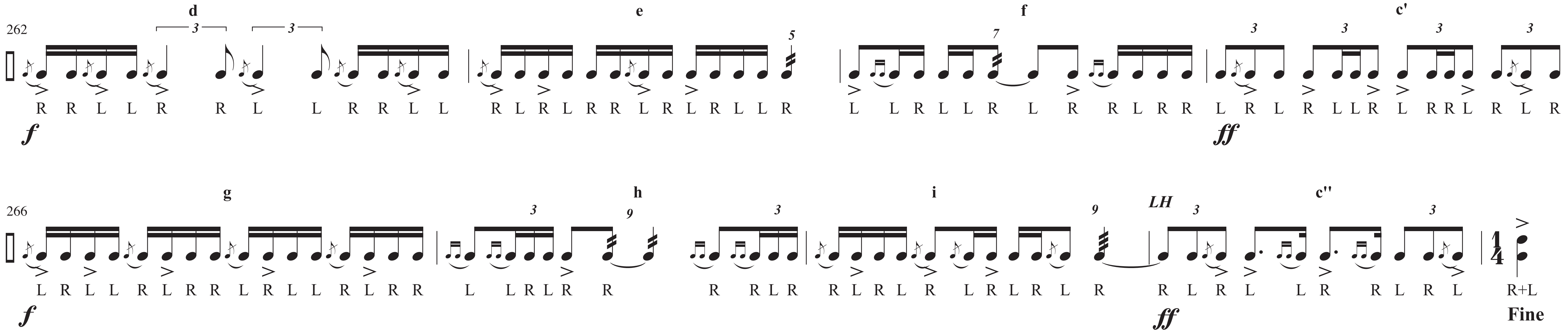

125 LM
e'
i
j
k
5
9
R L R L R R L R L R L L R R
L R L R L R L R L R L
R L R L R L R L ... etc.
mp
p
pp
129 LL
e''
b
c
LH
d
3/4
4/4
R R L R L R L L R L R L R R
L
R L R L R R R L R R L R L R
R L R L L R R L R L
R R L L R R L L R R L L
mp
mf
mp
134
e
b'
f
g
R L R L R R L R L R L L R
R L R L L L R L L R L R L R
R R L R R L R L L R L
R L R R L R L L R L R R L R L L
mf
mp
138
h
b''
LM
f
3/2 ♩= 50
g
L L R L R R R R L R
R L R L L L R L R R L R
L
R R L R R L R L L R L R
R L R R L R L L R L R R L R L L
mf
mp
p
143 LL
h
MM
i
f'
MH
j
LL
k
L L R L R R R L R L
R L R L R L R L R L R
R R L R R L L R L L R R L
R L R L R L R L ... etc.
mp
pp
148
l
f''
6/4
4/4
g
LH
h
R L R R L L R L L R R L R R
L
R L R R L R L L R L R R L R L L
R R L R L R R R L R
mp
mp
p


153 LL i 9 j g' MM k
R L R L R L R L R L R
R L R L R L R L R L R L R L R L
R L L R L R R L R L L R L R R L
R L R L R L R L ... etc.
pp mp pp
157 l m g'' h 3 9 3
R L R R L R L L R L R R L R L L R
R R L R L R R R R L R
mp mp
162 i 9 HH j k h'
R L R L R L R L R L R
R L R L ... etc.
R L R L L L R L R R
p pp mp
166 LL l LM m n h''
R L R L ... etc.
R R L R L L L R L R L
pp mp
171 MM 3 b 3 3 c 3 d 3 3 e 5
R L R L R R R L R R R L R L
R L R L L R R L R L
R R L L R R L L R R L L
R L R L R R L R L R L L R
mf mp
175 MH 3 b' 3 f 7 g h 3 9 3
R L R L L L R L L R L L R L
R R L R R L R L L R L L
R L R R L R L L R L R R L R L L
L L R L R R R R L R
mf mp


179
LH
b''
2/3 ♩= 75
c
d
mf
mp
p
183
e
MH
f
HH
c'
MH
g
mp
p
187
h
i
LL
c''
LH
d
e
mp
mp
p
193
f
g
LL
d'
h
i
mp
p
198
j
d''
LH
e
MH
f
pp
mp
mp
p
203
HH
g
h
e'
9/10 ♩= 100
i
mp
p


207
j
k
e''
R L R L R L R L ... etc.
R R L R L R L L R L R L R R L
pp
mp
211
f
g
h
i
R R L R R L R L L R L L
L R L L R L R R L R L L R L R R
R R L R L R R R L R R L R L R L R L R L R L R
mp
p
215
f'
j
k
8/9 ♩= 112.5
LL
l
R R L R R L L R L L R R L
R L R L R L R L ... etc.
mp
pp
219
f''
c
d
e
f
R L R R L L R L L R R L R R L
R L R L L R R L R L
R R L L R R L L R R L L
R L R L R R L R L R L L R
L L R L L R L R R L R R
mp
mp
p
15/16 ♩= 120
225
c'
g
h
LM
i
c''
L R L R L L R L R R L R L R
L R L L R L R R L R L L R L R R
L L R L R R R R L R
R L R L R L R L R L R
R L R L L R R L R L
mp
p
f
230
g
MH
h
i
HH
j
R
R L R R L R L L R L R R L R L L
R R L R L R R R L R
R L R L R L R L R L R
R L R L R L R L R L R L R L R L
mp
p
pp


235
LH
g'
k
l
m
R L L R L R R L R L L R L R R L
R L R L R L R L ... etc.
mp
pp
239
MH
g''
6/4
4/4
h
HH
i
8/9 ♩= 135
j
R L R R L R L L R L R R L R L L R
R R L R L R R R R L R
R L R L R L R L R L R
R L R L ... etc.
mp
f
mf
mp
244
k
h'
LM
l
m
R L R L L L R L R R
R L R L ... etc.
f
mp
248
LL
n
h''
3/4
4/4
i
9/10 ♩= 150
j
R R L R L L L R L R L
R L R L R L R L R L R
R L R L ... etc.
f
f
mp
253
k
MH
l
i'
m
R L R L R L R L R L R
R L R L ... etc.
f
mp
257
n
MH
o
HH
i''
3/4
4/4
15/16 ♩= 160
c
R L R L R L R L R L R L R L R
R L R L L R R L R L
f
ff


262
d
e
f
c'
R R L L R R L L R R L L
R L R L R R L R L R L L R
L L R L L R L R R L R R
L R L R L L R L R R L R L R
f
ff
266
g
h
i
LH
c''
L R L L R L R R L R L L R L R R
L L R L R R R R L R
R L R L R L R L R L R
R L R L L R R L R L
R+L
f
ff
Fine

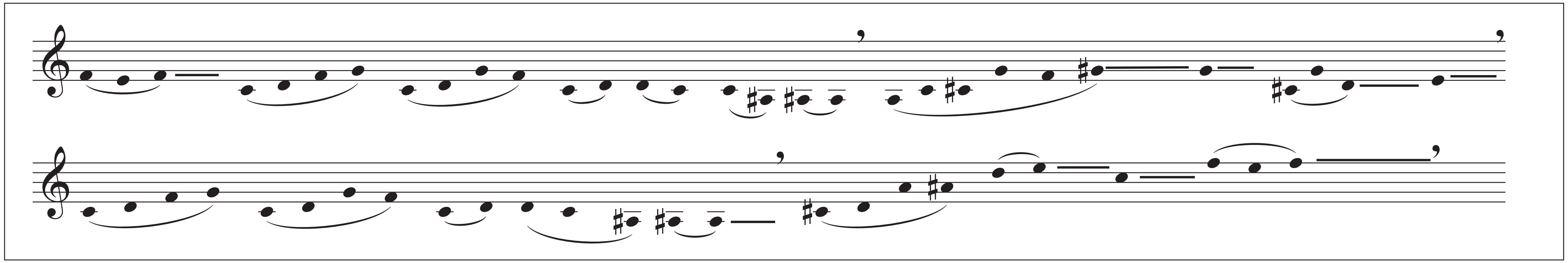
Part II: *Closed Attracting Trajectories*

a) *Melody Set 1*

Accidentals apply only to the notes they precede.

Origin Melody

1

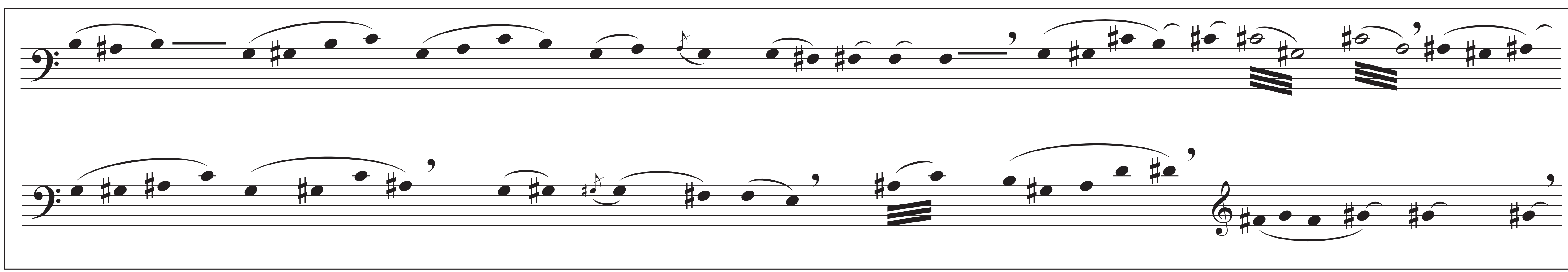


2

3

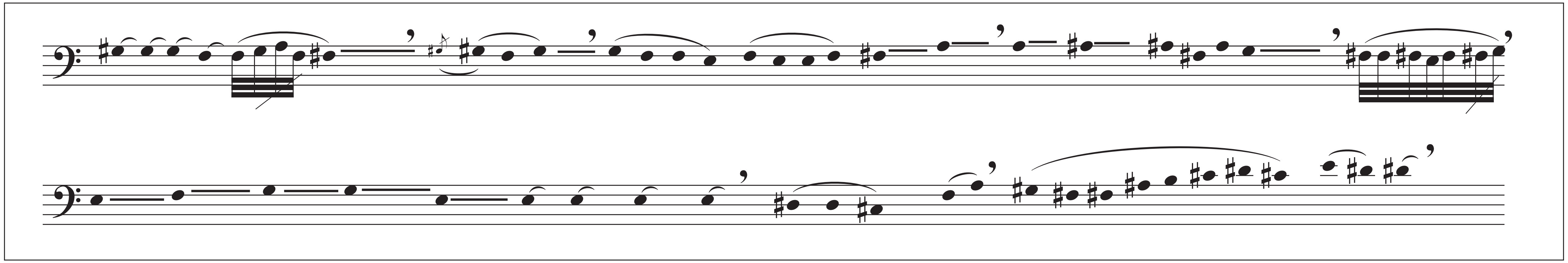
4


5

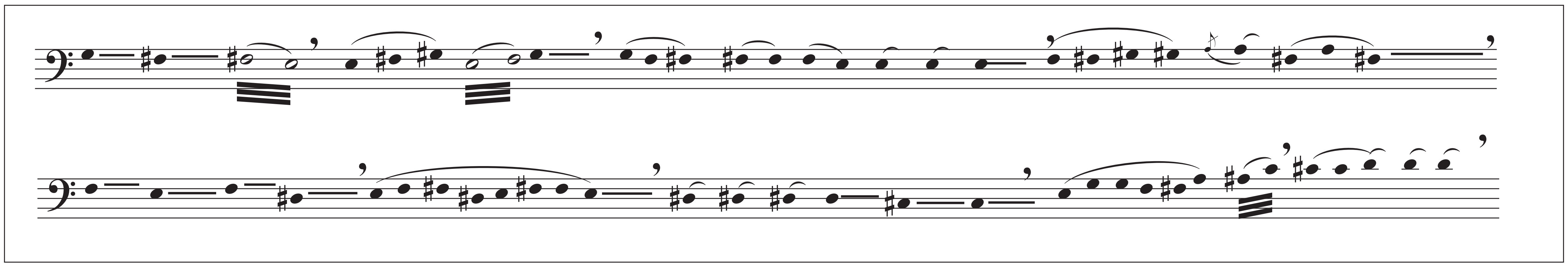

6


7


8



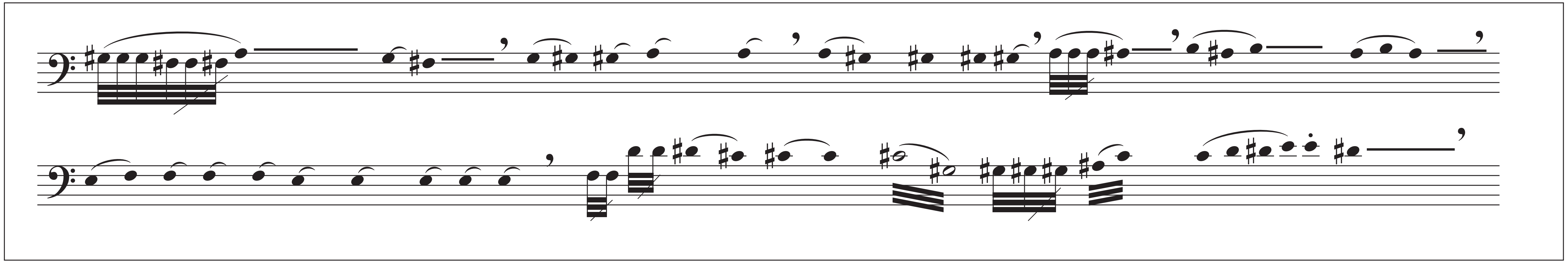
9



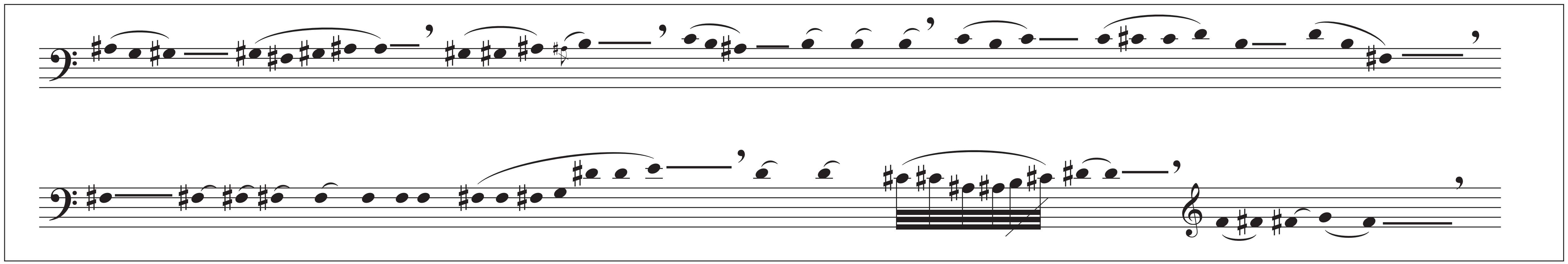
10

11

12



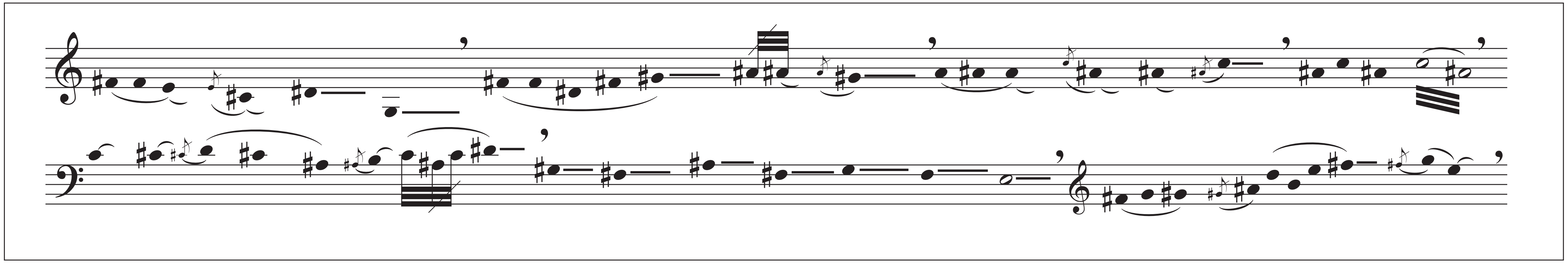
13



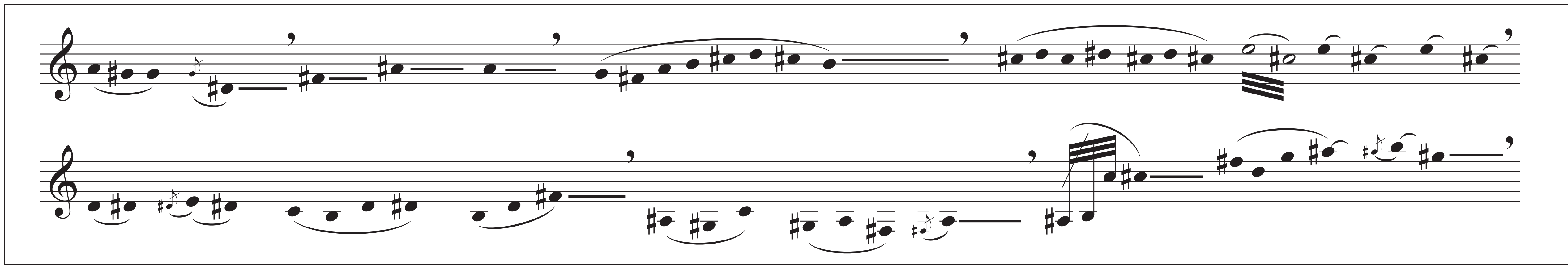
14

15

16



17



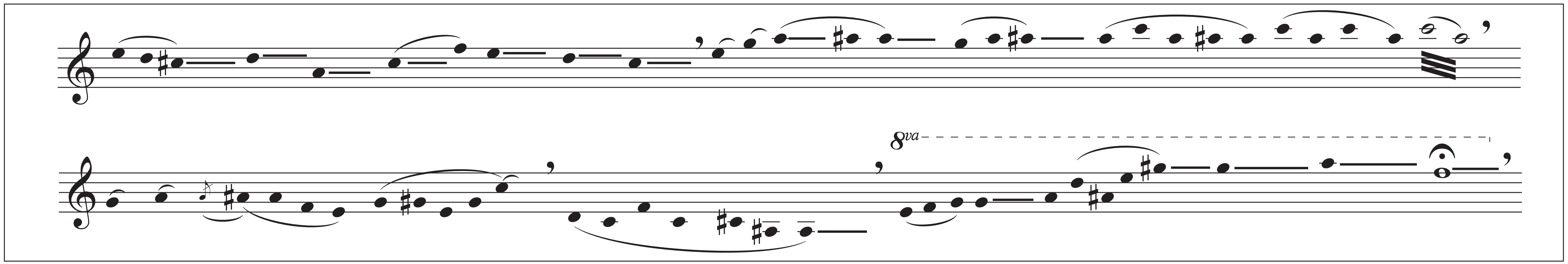
18

19

20

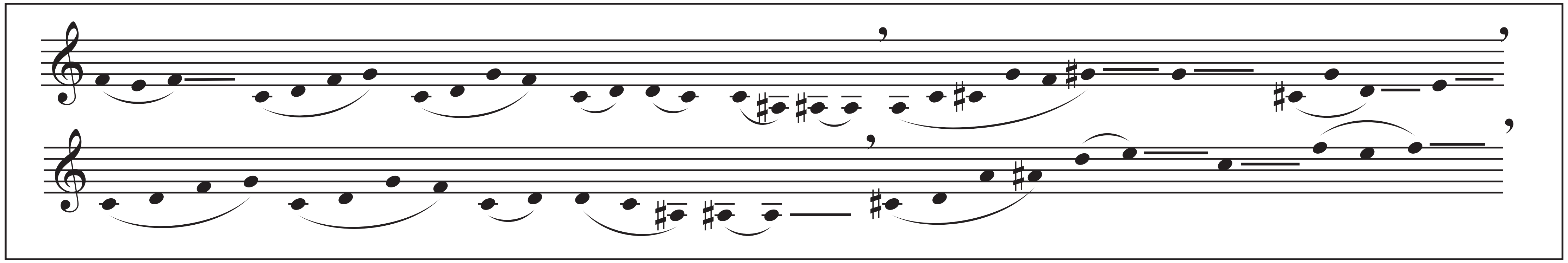
Target Melody

21



b) *Melody Set 2*

Origin Melody



Print date:2/18/21

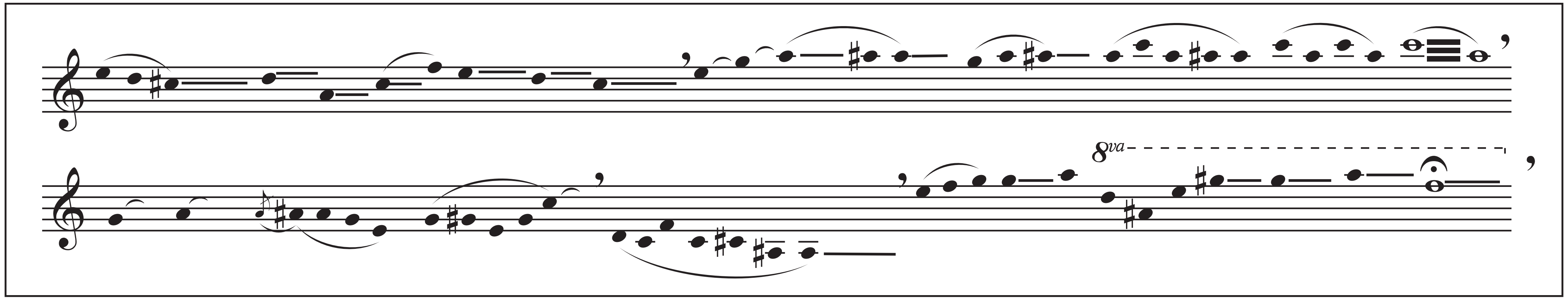
♩= 90
♩= 112.5
♩= 135
pp/mp
f
pp/mp
2 6 3 4 2 3
♩= 160
♩= 120
♩= 15
pp/mp
mp
pp/mp
2 3 4 2 4 2
♩= 90
♩= 33.75
♩= 15
pp/mp
pp/f
mp
4 2 2 4 4 2
♩= 160
♩= 50
♩= 75
pp
p/ff
p/ff
2 5 3 2 2 3


♩= 120
mf
3
9
♩= 50
p/mf
2
3
♩= 33.75
mf/ff
10
4
♩= 75
mf
9
5
♩= 90
p
2
9
♩= 75
ff
3
2
♩= 50
mf/ff
3
4
♩= 33.75
p
2
5
♩= 100
mf/ff
2
9
♩= 180
mf/ff
3
2
♩= 90
p/mf
2
5
♩= 75
p/ff
5
5


♩= 50
♩= 90
♩= 100
p/ff
p/ff
mf
2
9
2
4
3
4
♩= 50
♩= 50
♩= 50
p/ff
mf
f/fff
6
2
6
2
2
2
♩= 120
♩= 120
♩= 40
mp/f
f
mp/fff
4
2
10
2
2
5
♩= 75
♩= 160
♩= 150
f/fff
f/fff
f
3
5
3
2
2
5

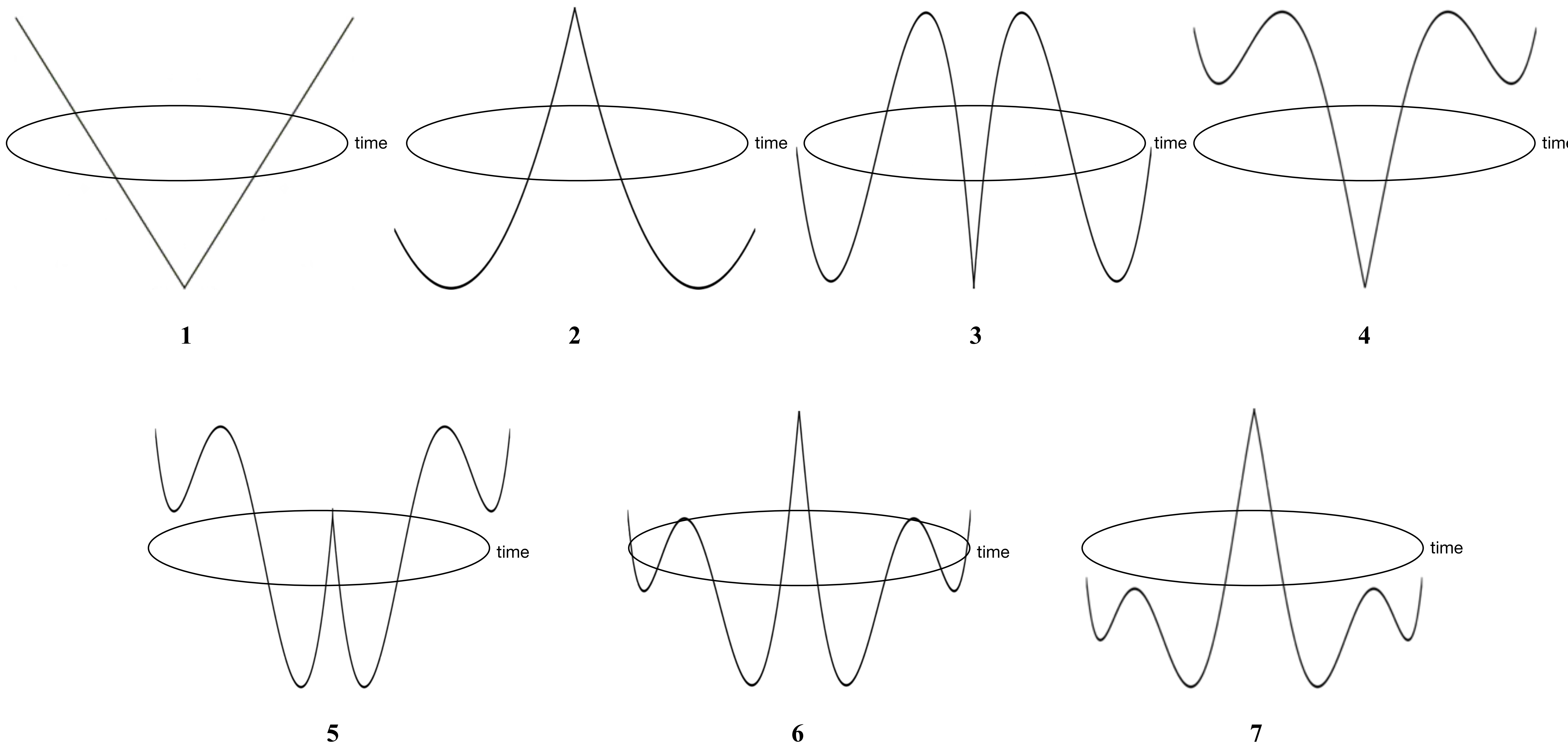

♩= 120
f
2
3
♩= 100
f
2
9
♩= 75
f
6
3
♩= 50
mp/f
5
3
♩= 33.75
f
4
2
♩= 15
f/fff
6
5
♩= 50
mp/fff
3
2
♩= 90
f
4
2
♩= 112.5
f/fff
2
5
♩= 135
f
5
3
♩= 160
mp/f
5
3
♩= 180
mp/fff
3
5

Target Melody



Part III: *Given the Senses the Real Pregeometry*

Probability Rhythm Cycles

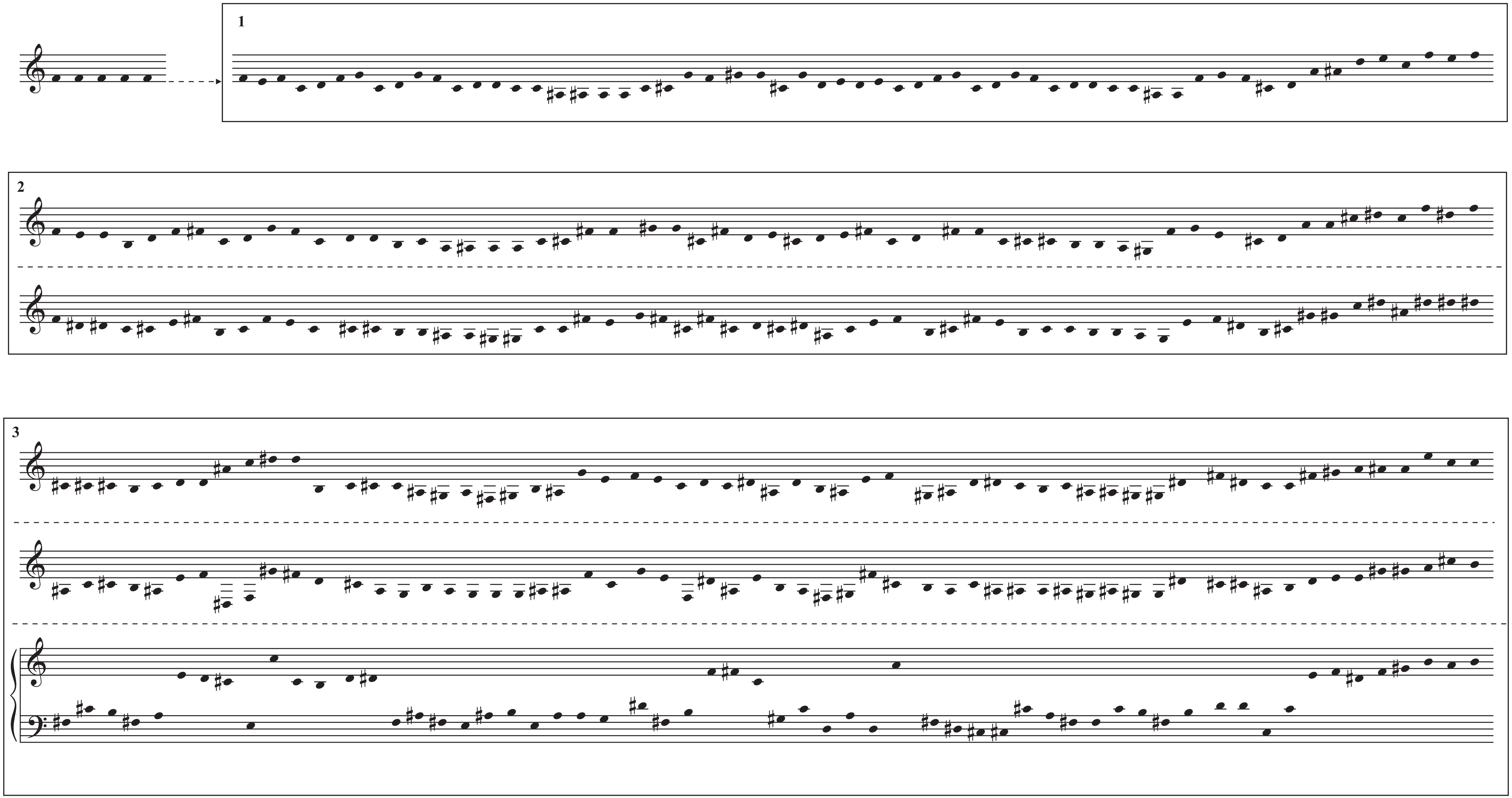


Version: 2/18/21

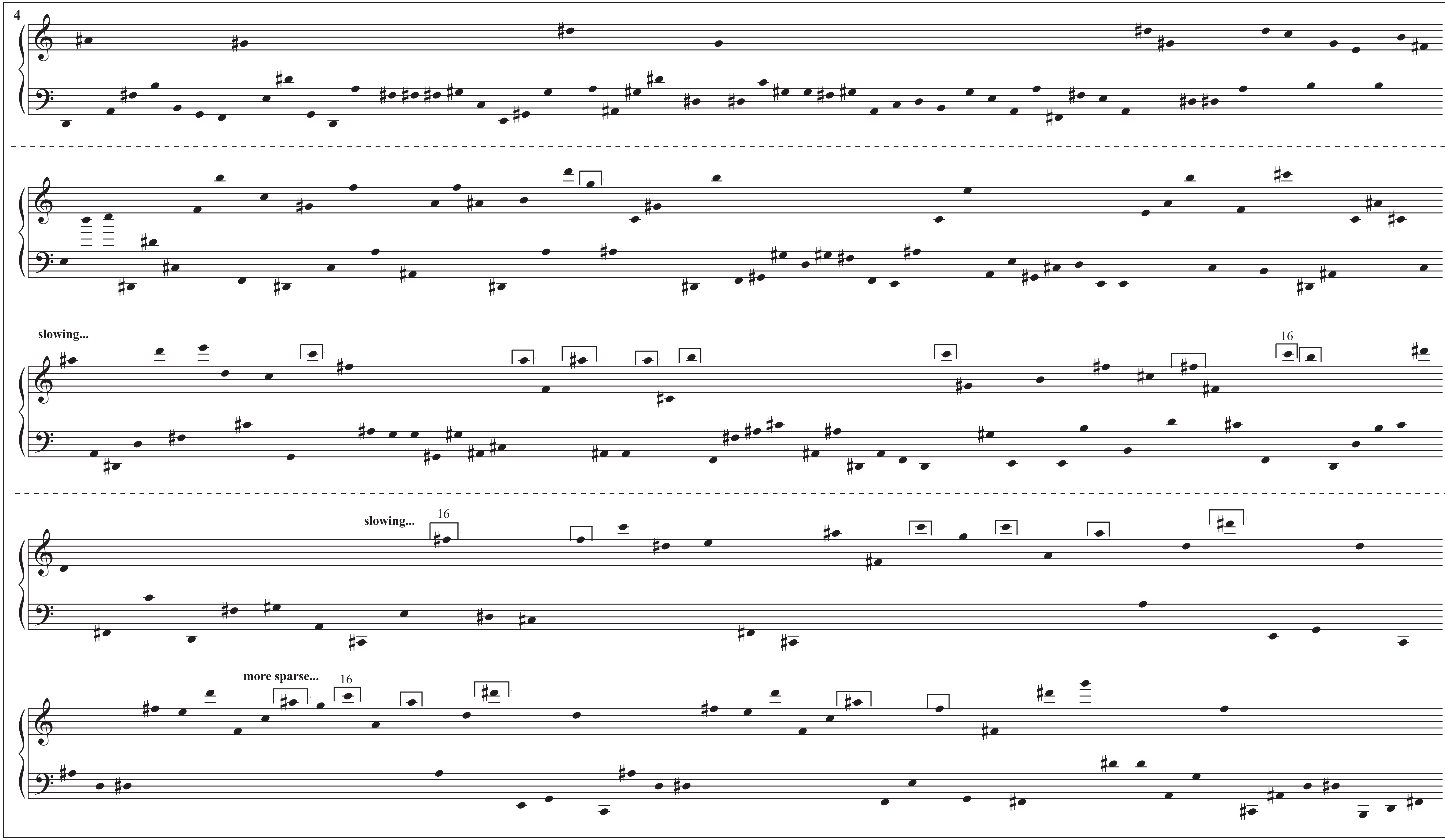
– Blank Page –

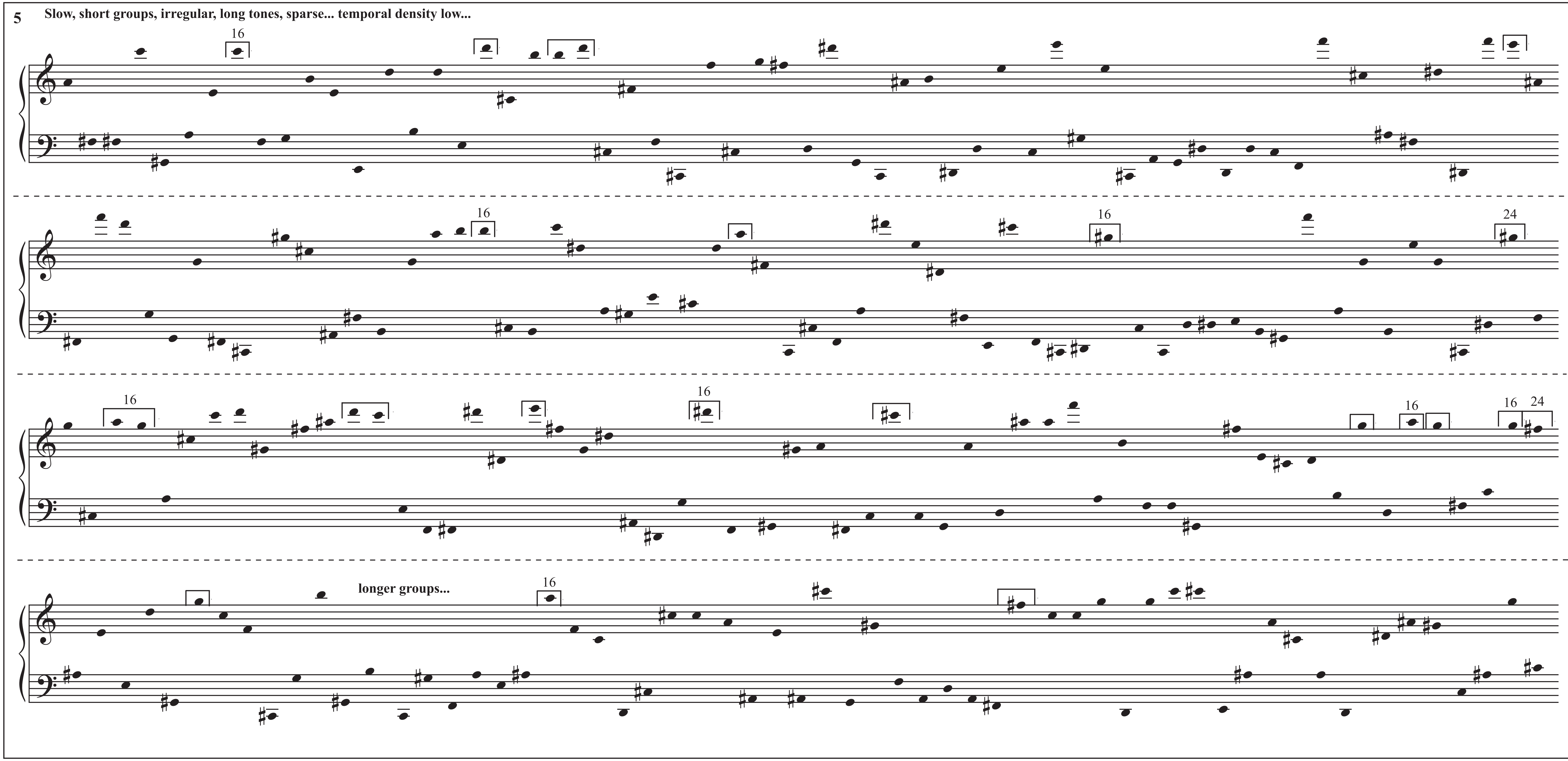
Part III: Given the Senses the Real Pregeometry

auxiliary performer

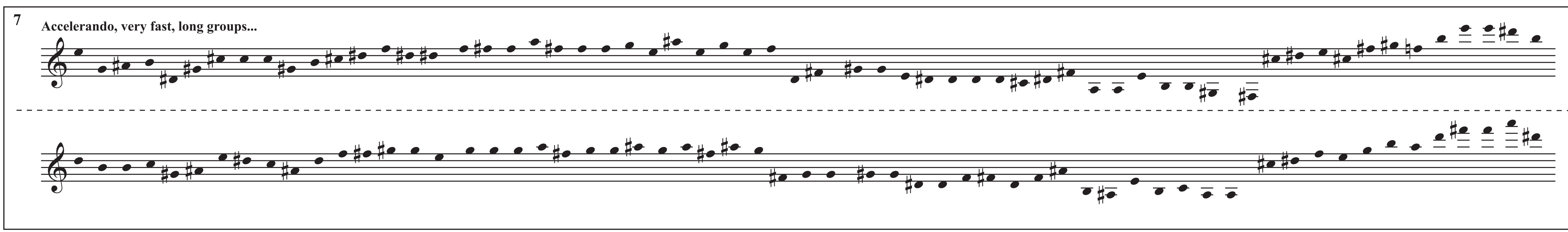


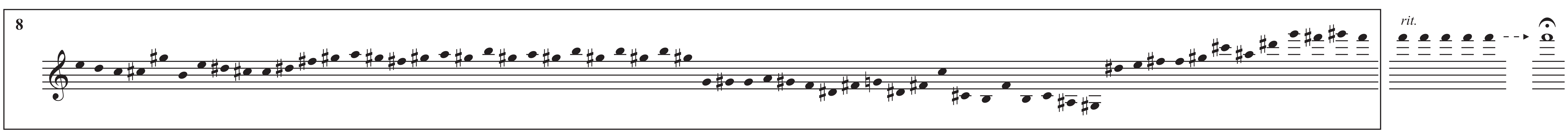
Print date: 2/18/21


4
slowing...
16
slowing...
16
more sparse...
16


5
Slow, short groups, irregular, long tones, sparse... temporal density low...
longer groups...


6
Accelerando, increasing temporal density...


7
Accelerando, very fast, long groups...


8
rit.

Notes on grand staff spaces indicate drums from low to high, not particular pitches. A suggested pitch set is: D#, F#, G#, A#, B, C#, D, E. A tabla tarang is preferred. However, the piece may also be played with other kinds of tuned drums of graduated sizes, in which case the actual pitch set used may need to be adapted to the instruments available. Dynamics are *expressivo ad libitum.*

Part IV: Epigenesis, Ontogenesis, Phylogenesis, Parthenogenesis

30
30
40
40
50
50


60
60
69
Shape 4 ON
69
79
8va
79


88
88
97
97
105
105


Shapes 1 & 8 ON
8va


Shapes 2, 5 & 7 ON
135
143
150
8va


START RECORDING
START PLAYBACK

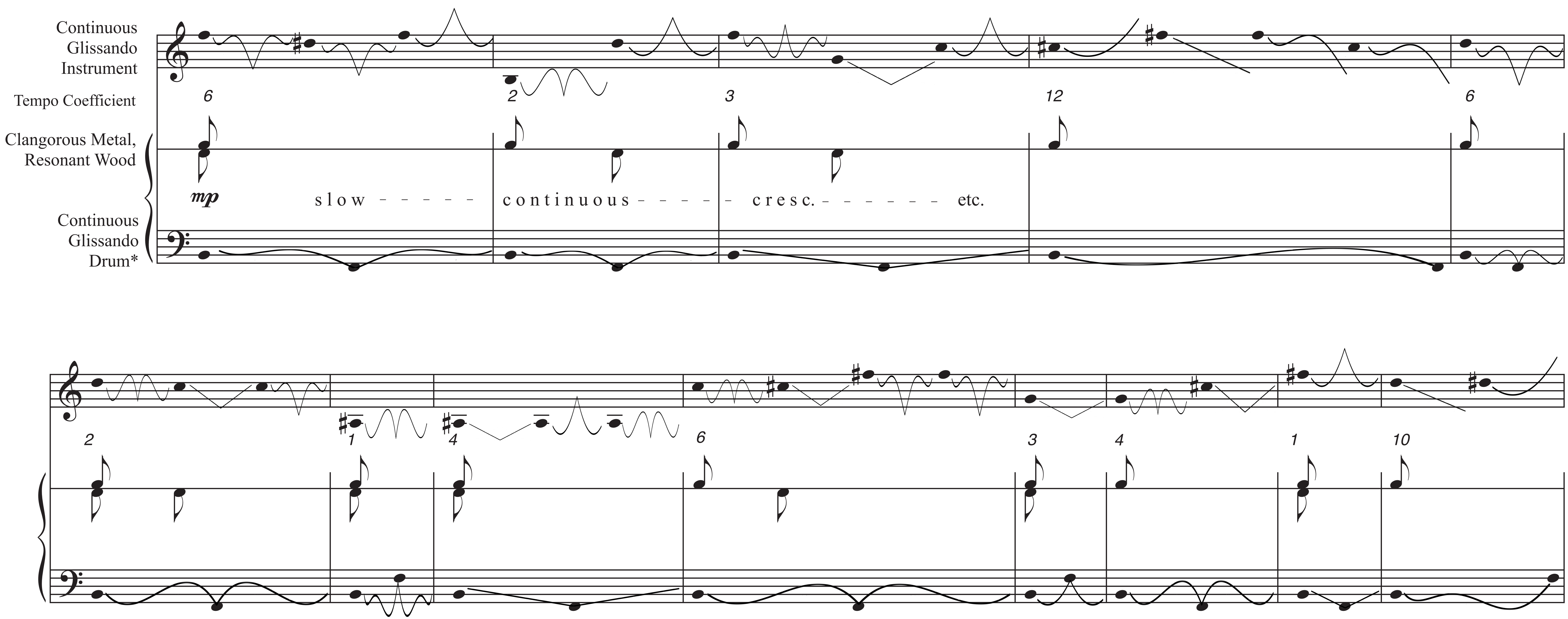

STOP RECORDING
STOP PLAYBACK
START RECORDING


START PLAYBACK
206
206
214
214
222
222

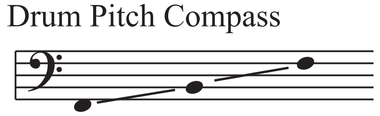

229
229
9
5
4
9
237
237
STOP PLAYBACK
9
9
9
4

Part V: The Buckling of a Spring

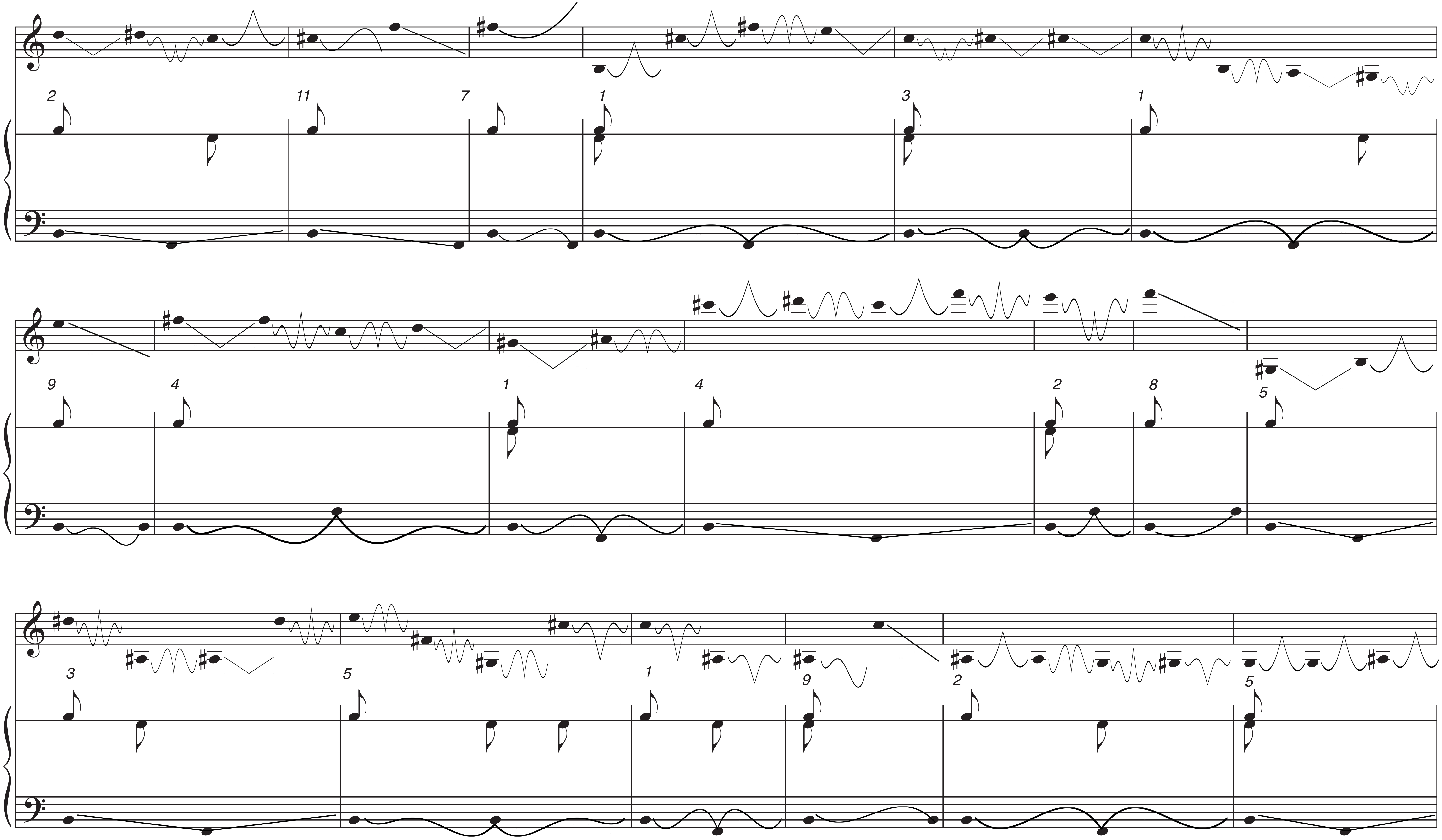
The Buckling of a Spring

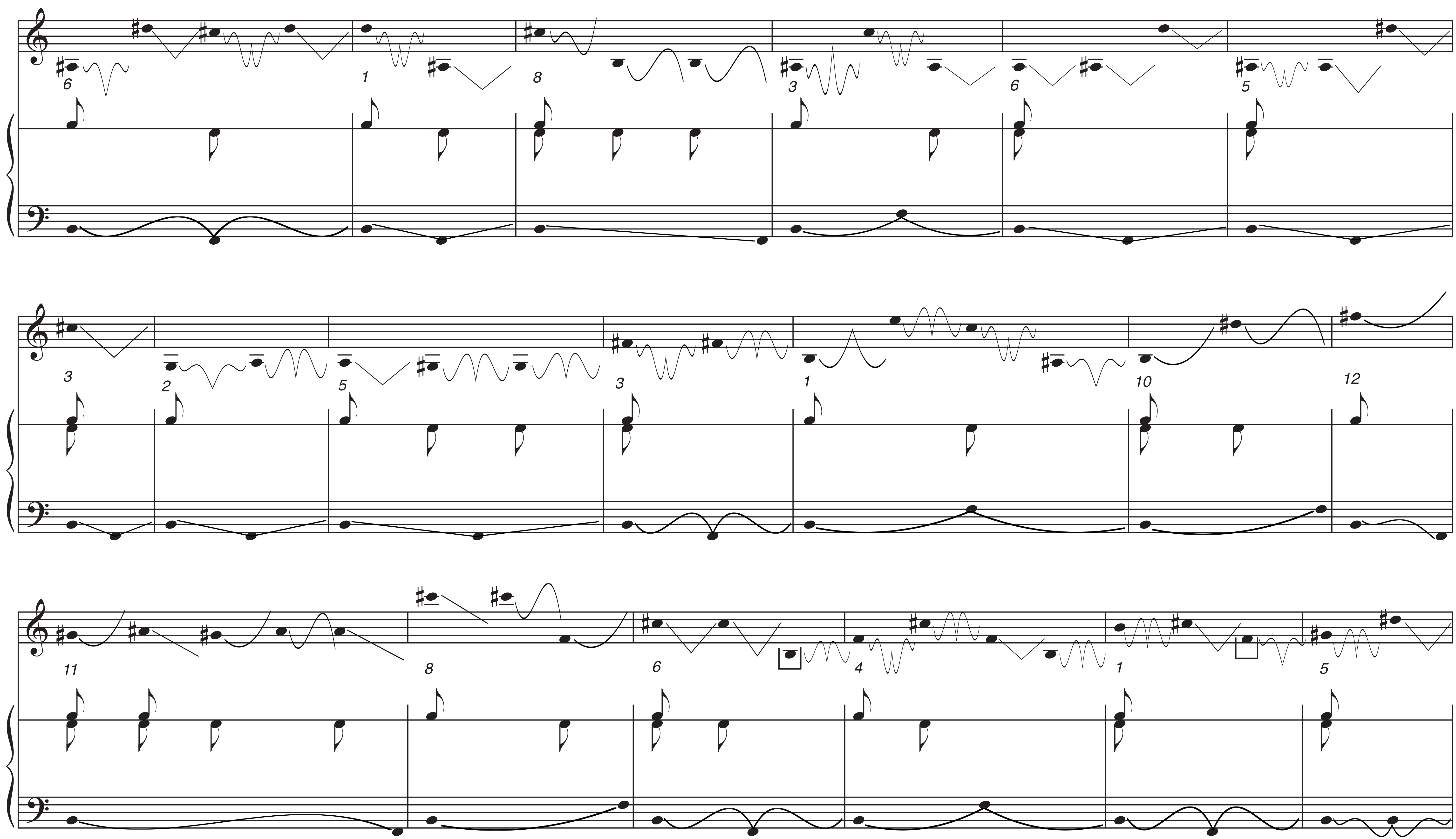


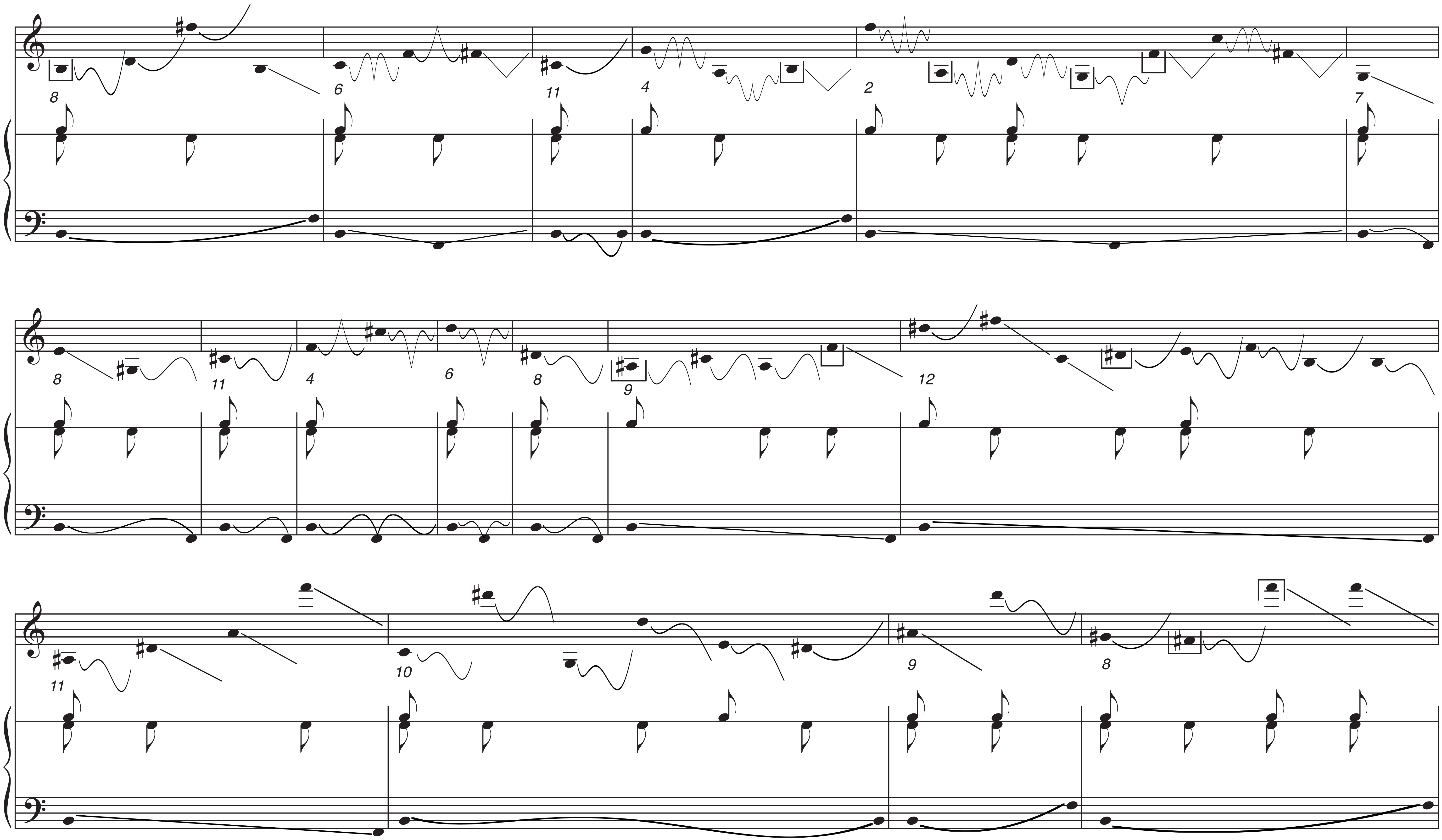
* Drum Pitch Compass



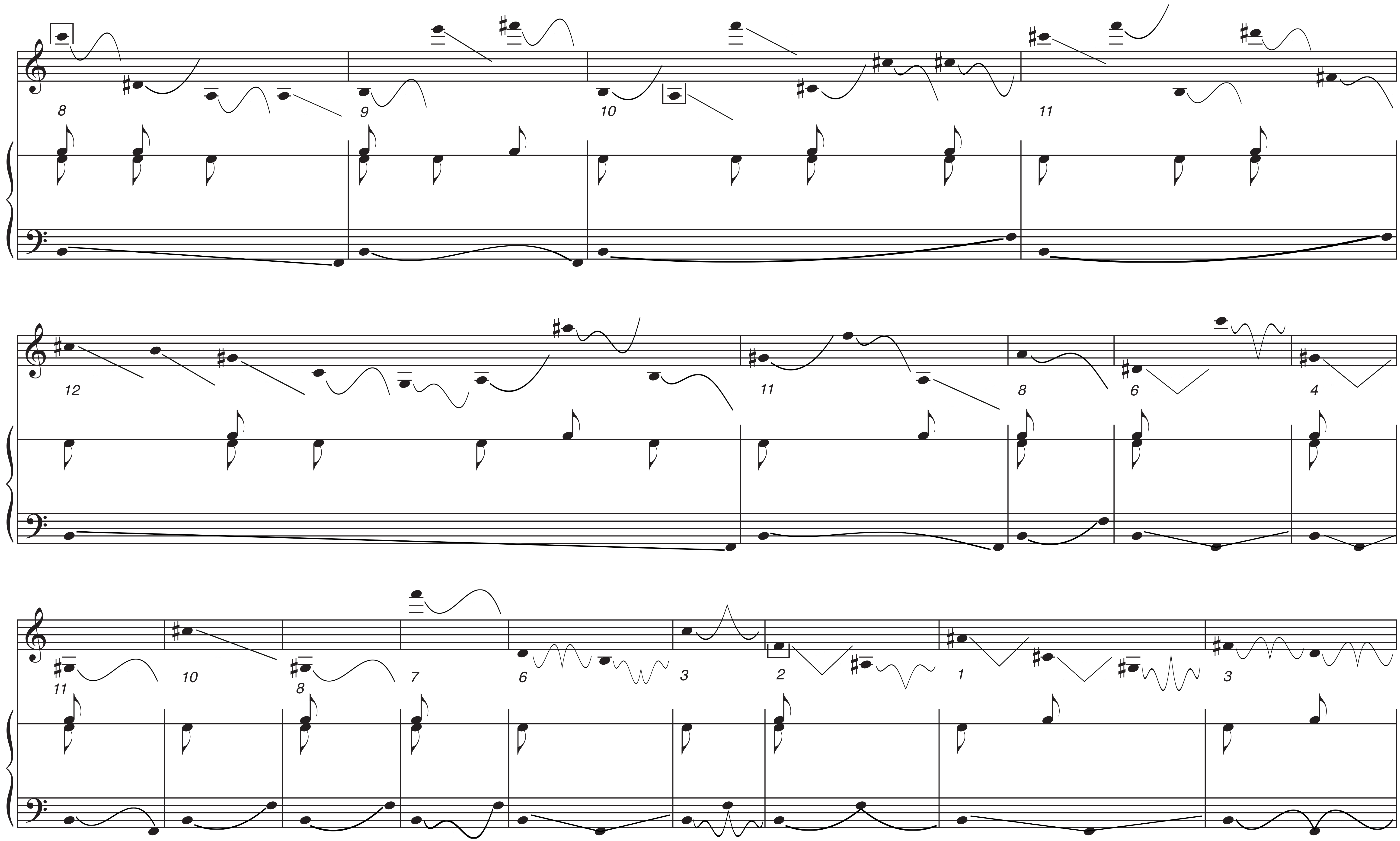
normalized to one octave;
B is central focus

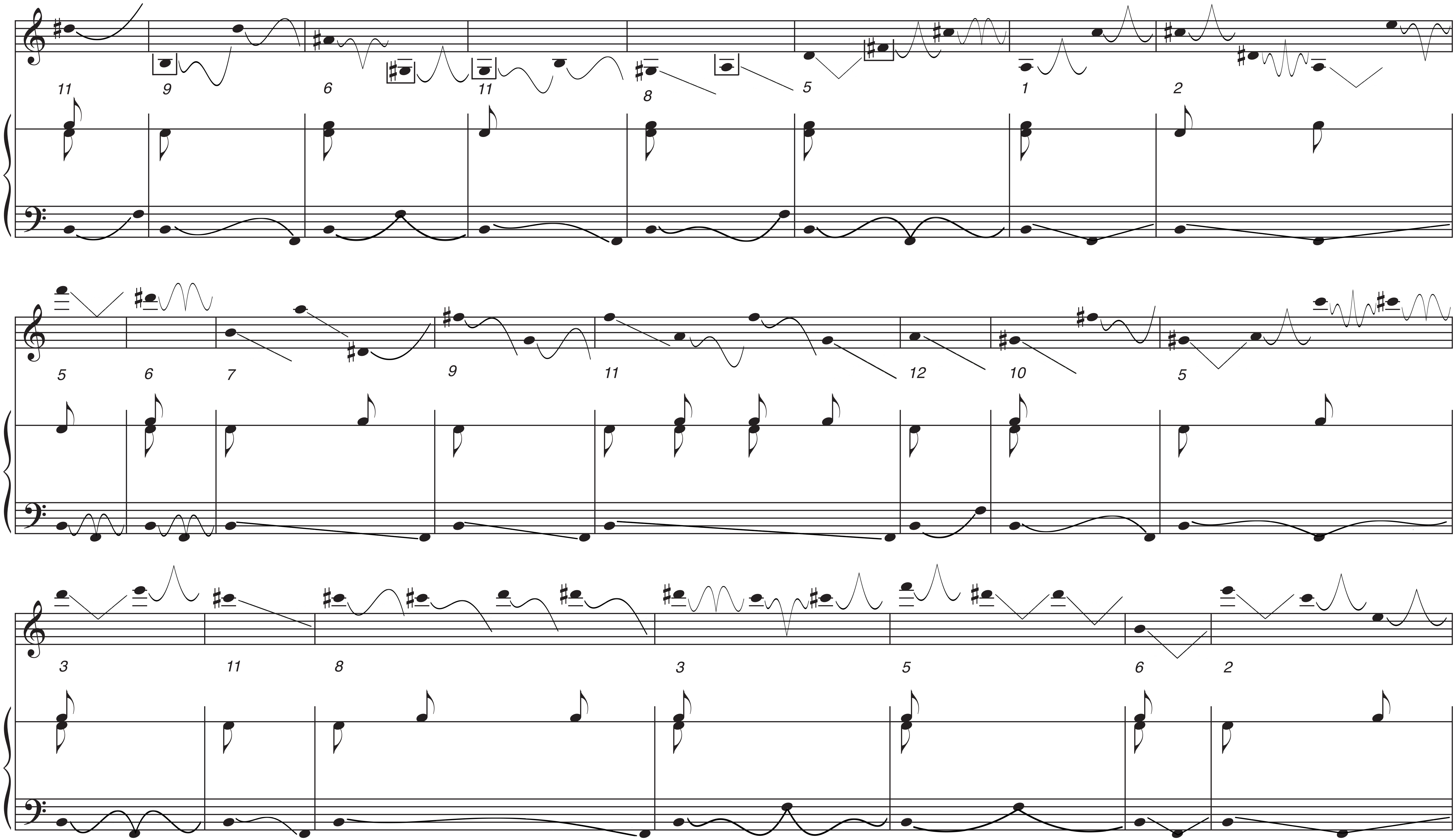

2 11 7 1 3 1
9 4 1 4 2 8 5
3 5 1 9 2 5

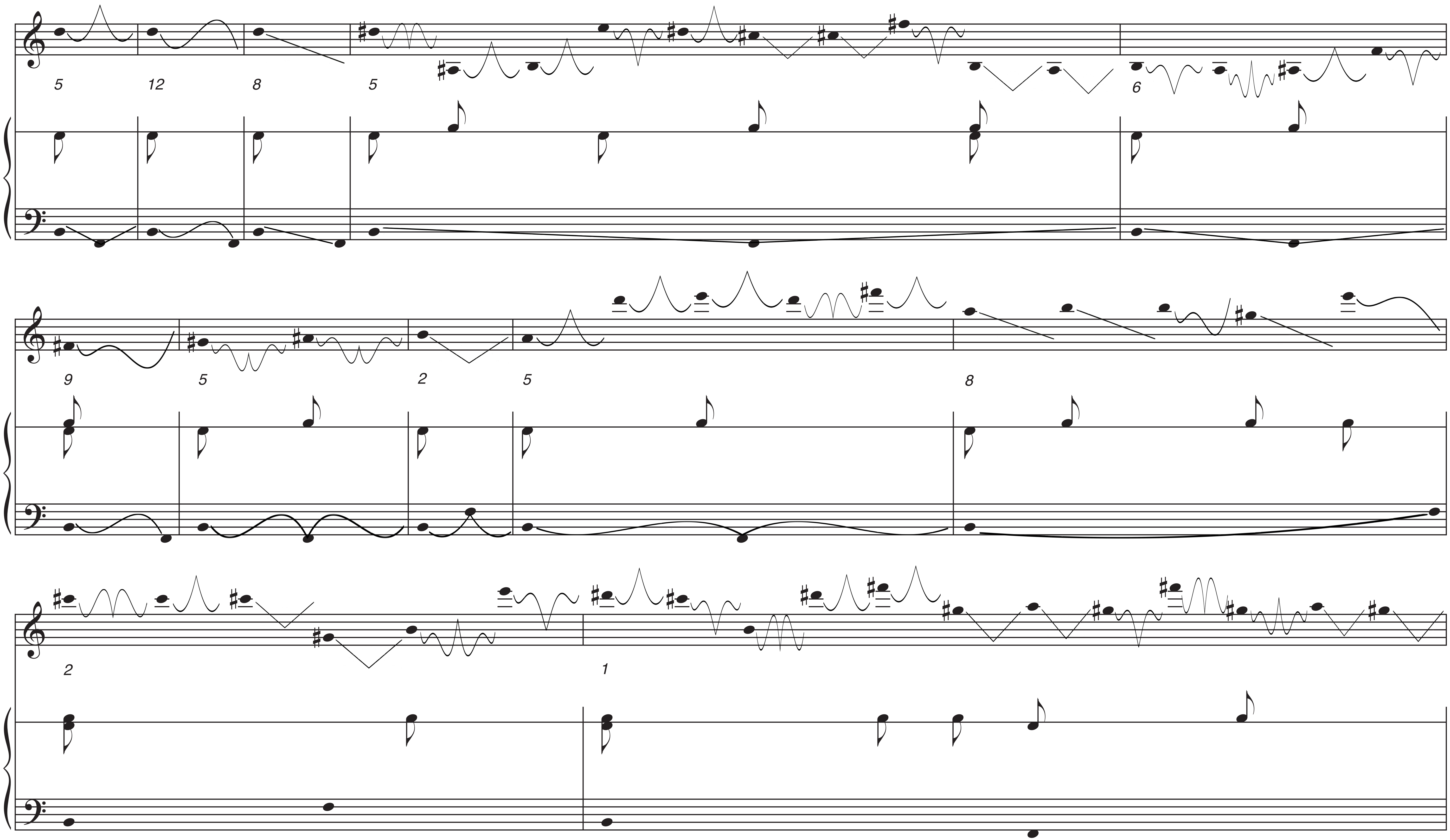

6
1
8
3
6
5
3
2
5
3
1
10
12
11
8
6
4
1
5

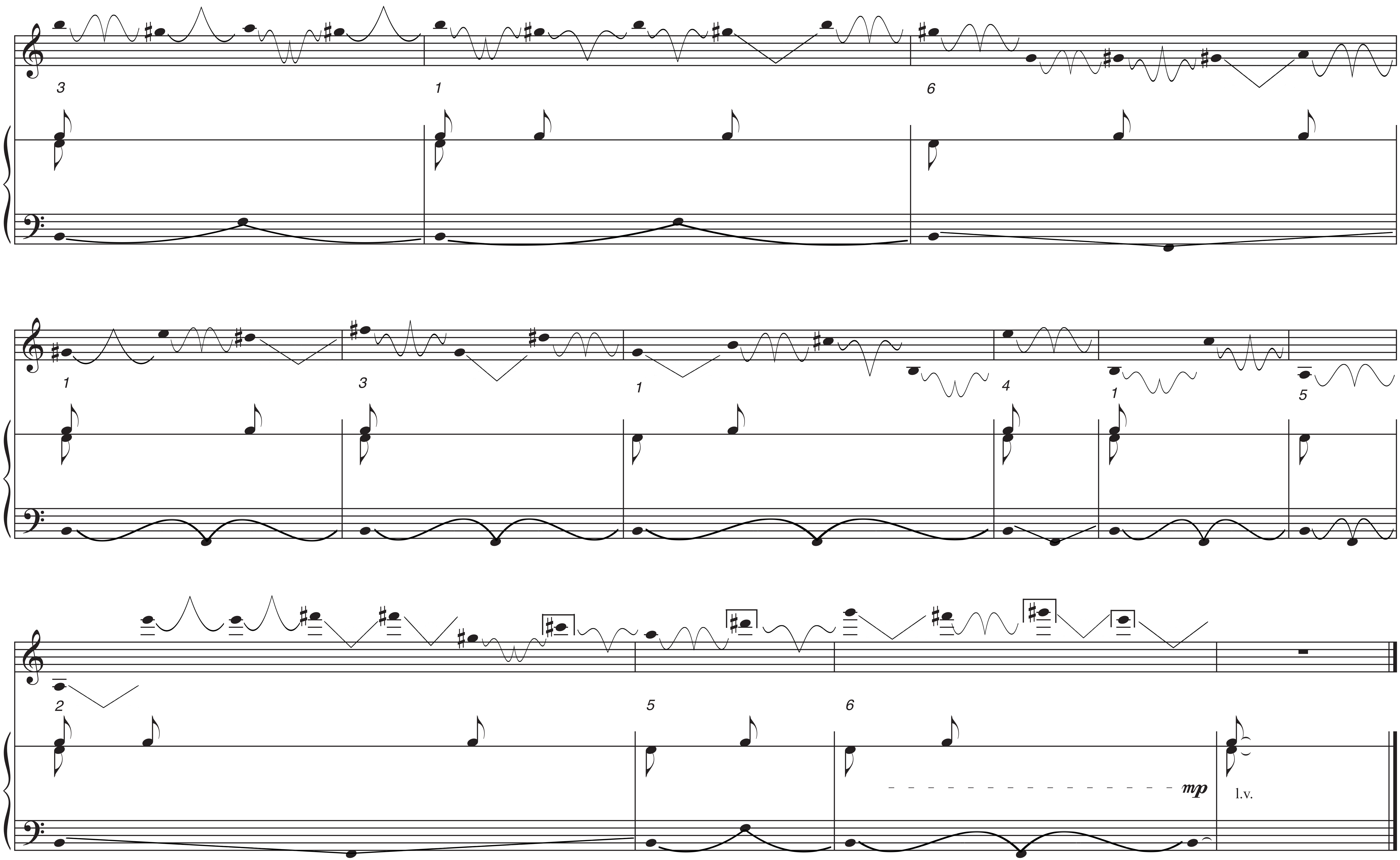

8
6
11
4
2
7
8
11
4
6
8
9
12
11
10
9
8


7
6
5
4
3
2
Fast groups; Synchronous starts ; Vary lengths
Travel freely following arrows, then return.
1
ff
ff
Make one loudness gesture: ff pp ff
2
3
4
5
6
7
slow - - - - - - continuous - - - - - dim. - - - - - - etc.


8
9
10
11
12
11
8
6
4
11
10
8
7
6
3
2
1
3


11 9 6 11 8 5 1 2
5 6 7 9 11 12 10 5
3 11 8 3 5 6 2


5
12
8
5
6
9
5
2
5
8
2
1


3
1
6
1
3
1
4
1
5
2
5
6
mp
l.v.