Codecs

(Volume I of II: Analysis)

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Abstract

This thesis contains two volumes. The first is a written text that describes my compositional techniques in the context of an analysis of *Codecs*. The second volume is the score of this work. Volume one is divided into six sections: Introduction, harmony, rhythm and time, melodic materials, form, live electronics and future directions. Each section describes techniques and processes I developed throughout the compositional process.

Codecs was inspired by the subversive proliferation musical materials though the use of audio codecs. I developed compositional tools based on encryption and compression in order to explore the audio codec metaphor.

Volume two is the full score of *Codecs*, a work for large ensemble and live electronics. It is comprised of three sections and has a duration of approximately 14 minutes. The work is scored for flute (doubling on piccolo), oboe, clarinet in Bb (doubling on bass clarinet), bassoon, horn in F, trumpet, trombone, tuba, string quintet and percussion. Electronic drum pads and captured live sounds are used to control the live electronic elements.

Ce mémoire est en deux volumes. Le premier volume est un texte décrivant mes techniques de composition dans le contexte d'analyse de Codecs. Le second volume est la partition de cette oeuvre. Le premier volume est divisé en six sections: introduction, harmonie, rythme et mesure, matériaux mélodiques, hiérarchie formelle, musique électronique en direct et recherches futures. Chaque section décrit des techniques et processus que j'ai développés tout au long du processus de composition. Codecs était inspirée par des matériaux musicaux à prolifération subversive. Les outils de composition ont été développés à base d'encryptage et de compression afin d'explorer la métaphore audio codec.

Le second volume est la partition d'orchestre de Codecs, oeuvre pour grand ensemble et instruments électroniques en direct. Elle est composée de trois sections et a une durée d'environ 14 minutes. L'oeuvre est arrangée pour flute (secondée par le piccolo), hautbois, clarinette en Sib (secondée par la clarinette basse), basson, cor en Fa, trompette, trombone, tuba, quintette à cordes et percussions. Des pads de batterie électronique et des sons captés en direct servent au contrôle des instruments électroniques.

Acknowledgements

Codecs was made possible though the McGill Contemporary Music Ensemble (CME) and Digital Composition Studio's (DCS) composer in residence program. Funding was provided by Social Sciences and Humanities Research of Canada (SSHRC). I would like to express my gratitude to the following people: to Marcelo Wanderley for giving me access to the V-Drums, to Denys Boulaine, for his hard work in rehearsal and performance, to Chris Paul Harman for giving orchestration advice, to Chris Johns for helping me plan the speaker placement for the final performance, to Richard McKenzie for his constant support during setup and tear down for all rehearsals, as well as the speaker hanging before and after the performance, to Kari Anderson (Oboe) and Vicky Shin (Percussion) for extra time in the studio recording and calibrating the electronics and finally Sean Ferguson whose role as composition teacher and mentor was invaluable during the creation of *Codecs*, as well as the writing of this thesis.

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Chapter 1: Introduction

1.1 Description

Codecs is a work for large ensemble and live electronics. It is comprised of three sections and has a duration of approximately 14 minutes. The work is scored for flute (doubling on piccolo), oboe, clarinet in Bb (doubling on bass clarinet), bassoon, horn in F, trumpet, trombone, tuba, string quintet and percussion. Electronic drum pads and captured live sounds are used to control the live electronic elements.

1.2 Objectives

My primary objectives in the composition of *Codecs* were to: a) to control live electronics in an expressive and musically meaningful way from within the ensemble without a click track, and, b) to obscure and reveal musical materials using techniques and processes inspired by contemporary electronic music, production methods and culture. To accomplish this goal I created a system for organizing musical materials called *Harmonic Encryption*. The following section offers an introduction to concepts that will be covered in detail in the following chapters.

1.3 Materials

1.3.1 Harmonic Encryption

Harmonic encryption draws on literal and metaphorical uses of the terms "encryption" and "decryption". Like the standard use of the term encryption, *harmonic* encryption transforms and obscures musical information using a compression algorithm and a pseudo cipher. Through the encryption process, the musical materials are encrypted into a single chord, which I have called the *cipher chord* in keeping with the encryption metaphor.

Although the metaphors of data compression and encryption are cultivated in all layers of *Codecs*, the harmonic encryption system is not a functional

encryption process. It does not encode and decode information the same way as is done using computers. The harmonic encryption system was created to produce aesthetically pleasing self-referential harmonic materials.

1.3.2 Harmony

Harmonic structures in *Codecs* are created by transforming and repeating a single chord progression. This progression is called the "Source Progression" and it is explained in detail in section 2.2. The source progression used in *Codecs* is an incomplete fragment of the chorale *Christ lag in Todesbanden* (BWV 227) by J.S Bach. The use of a J.S Bach chorale helped strengthen the concept of revealing and obscuring musical materials. As a familiar sound object, *Christ lag in Todesbanden* can maintain recognizable characteristics despite a great deal of obfuscation.

1.3.3 Form

Codecs' form is like a tree that grows out from the source progression. Branches are created by expanding the source progression using harmonic encryption and decryption. The expanded source progressions are superimposed, aligned and transformed to create larger structures. On the highest level *Codecs* is split into three continuous sections, each drawing on different genres of electronica[1].

1.3.3 Melody

Monophonic, contrapuntal and homophonic melodic materials are sculpted and distilled from the source progression by manipulating various parameters of harmonic encryption and decryption.

1.4 Live Electronics

Codecs takes a sample-based approach to live electronics. The manipulation of pre-composed sound materials in conjunction with the sounds

[1] Electronica is a blanket term for all subgenres that have grown from electronic dance music.

being made by the performers gives freedom to the instrumentalists, conductor and composer. When designing the software system that allows *Codecs* to run, I chose to focus on sound quality, composer-friendly features and work flow as opposed to real time signal capture and processing.

I used Max/MSP[2] to connect and control external software and hardware devices in real time. The software and hardware being connected and controlled could be anything, but I chose to use a fully featured software sampler called Kontakt[3]. High quality electronic drum pads called V-Drums[4] control both Max/MSP and Kontakt. The Max/MSP interface was created with an emphasis on usability, stability and composer-friendly features.

1.4.1 Spatialization

The role of sound and space in *Codecs* is to broaden the stereo image and keep the majority of the sound sources on the stage. Despite the complete elimination of any rear speakers, side speakers achieve a similar result as surround sound. It was my hope to expand the size of the so-called "sweet spot"[5] and provide a focused and enjoyable experience for all audience members as opposed to the few in the centre of the hall.

1.5 Codecs

The title of this piece encapsulates many ideas at the heart of this composition. A codec is a software or hardware device that encodes /decodes a digital stream or signal. This process is related to the transformation processes used throughout the piece. The term *Codecs* ties these ideas into the greater musical and cultural context of the work. Though the use of audio codecs, compression and encryption have triggered a change in the way music is shared

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[2] Max/MSP is a visual programming language for digital media. http://www.cycling74.com/products/max5
[3] Software developed by the Native Instruments corporation. It specializes in retriggering audio files. http://www.native-instruments.com/index.php?id=kontakt3
[4] http://www.roland.com/V-Drums/
[5] The position in the hall where optimum balance is achieved between all sound sources. In this case, balance between instruments and speakers

and appreciated the world over. Torrents, file sharing, the dark web[6], mp3s and iPods demonstrate the battle for control of digital objects and intellectual property, which is won and lost though data encryption. Obscuring and revealing data has become an integral part of the way data moves around the globe. Artists, corporations, listeners and users all have their own agendas and their own reasons for manipulating codecs and encryption algorithms.

Audio codecs are important not only because they revolutionized the distribution of music but also because they colour, distort and degrade sound to varying degrees. Destructive audio codecs like the MPEG Layer 3 Codec or ".mp3" imbue a distinctive sound quality to the music they compress. Many people are not aware that when they load a CD into a computer, the software automatically goes to work degrading sound quality for efficient storage. Increased use of portable music players and ear bud head phones has slowly altered people's expectations of sound quality.

Codecs explores these issues metaphorically as is the case with the harmonic encryption system and, literally, with the use of sound samples suffering from exaggerated quality loss due to excessive encoding and decoding.

1.6 Organization

Each chapter begins with an introduction then explores techniques and concepts though explanations, diagrams, reductions and score excerpts. Some of the processes create materials too large or complex for reductions. In these cases measure numbers are provided for in score examples.

[6] The dark web refers to unreachable network hosts on the internet

Chapter 2: Harmony

2.1 Introduction

I create the harmonic structures in *Codecs* by applying transformational techniques to a short fragment of musical material. This initial fragment is called the "source progression". The transformation techniques applied to the source progression include intervallic compression and expansion, as well as a procedure I have developed for harmonic encryption and decryption.

2.2 Source Progression

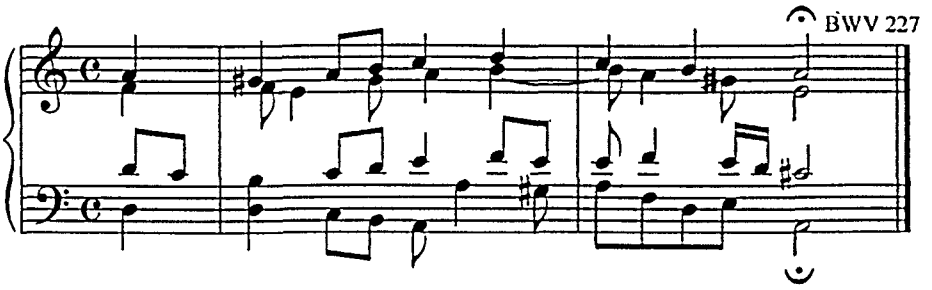


Figure 2.1 Bach Source Progression

I chose the first phrase of J.S Bach's *Christ lag in Todesbanden* (BWV 227) as the source progression for *Codecs*. Figure 2.1 is the original form of the piece. In the figure below, the progression has been stripped down to facilitate harmonic encryption. Every chord represents a change in harmony.

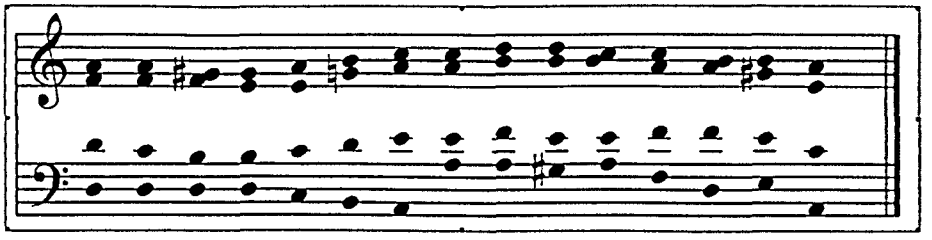


Figure 2.2 Stripped Source Progression

I chose this particular chorale fragment because it has intervallic and voice leading properties that make it suitable for the types of transformations used in *Codecs*. The progression has a balance of repetition and change, a variety of chord qualities, consistent close-position voicing in the upper voices, an independent bass contour and mainly conjunct voice leading in the upper voices. The G in the sixth chord of the stripped source progression was altered for

aesthetic reasons. In general, this progression retains its identity well even as it is being subjected to the harmonic transformations that I use in the piece.

2.3 Transformational Techniques

2.3.1 Harmonic Encryption

Harmonic encryption transforms the source progression into a cipher chord though a series of repetitions with gradual modifications. Harmonic decryption is a similar process in which the cipher chord is used to reconstruct the source progression.

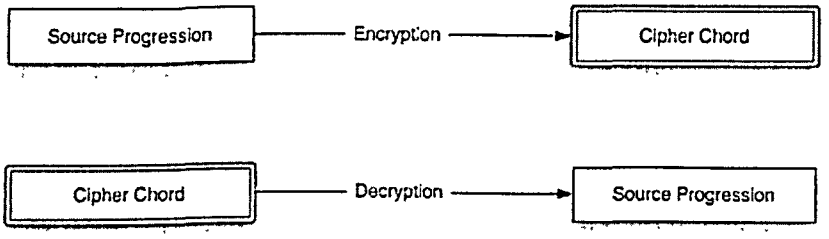


Figure 2.3 Cipher Role

I developed the harmonic encryption process in an attempt to bring together techniques used in the production of electronica and instrumental composition. By transforming and repeating fragments of the source progression as though it was an audio sample, I found that I was able to create musical effects reminiscent of encryption and decryption. A modest source progression can generate large, intricate, flexible and unified structures though harmonic encryption. The material created during the encryption and decryption process varies greatly, depending on the type of transformation used.

2.3.2 The Encryption Process

Throughout the piece a number of different processes are applied to harmonic material that are analogous to the encoding and decoding of information that takes place within an audio codec[7]. During these processes a large amount of varied pitch material is generated from a limited number of chords. As in the encoding process of a codec, large streams of these chords are compressed into

[7] An audio codec is a hardware device or a computer program that compresses/decompresses digital audio data.

"lossless"[8] states through the application of transformational techniques. These transformations involve the freezing of specific voices of a harmonic progression while other voices continue with their intervallic content adjusted to accommodate these fixed voices. That is, the intervals of the harmonic progression are maintained, but rather than moving in relation to the previously changing pitches of the frozen voice, the notes of the chords are transposed to maintain the same intervallic relationship to the fixed pitch of the frozen voice.

For example, in the following figure a structural progression of fifteen chords is gradually encrypted as the upper chord tones lock into place. In each section marked "Encryption Phase" another voice becomes fixed. In this case, the order is from highest to lowest. In compression phase 1, for example, the soprano voice becomes fixed and we can see that the alto voice maintains the same intervals below this frozen voice as in the original progression. With each additional compression phase, the highest moving note joins the static tones, transforming the remaining voices of the progression. After the 3rd compression phase, all the voices have become fixed and the fifteen-chord progression has been reduced to a single repeating harmonic entity. This chord is called the "cipher" since it can be understood metaphorically as containing hidden within itself, all of the material from the source progression. In this case, this is the first chord of the initial progression.

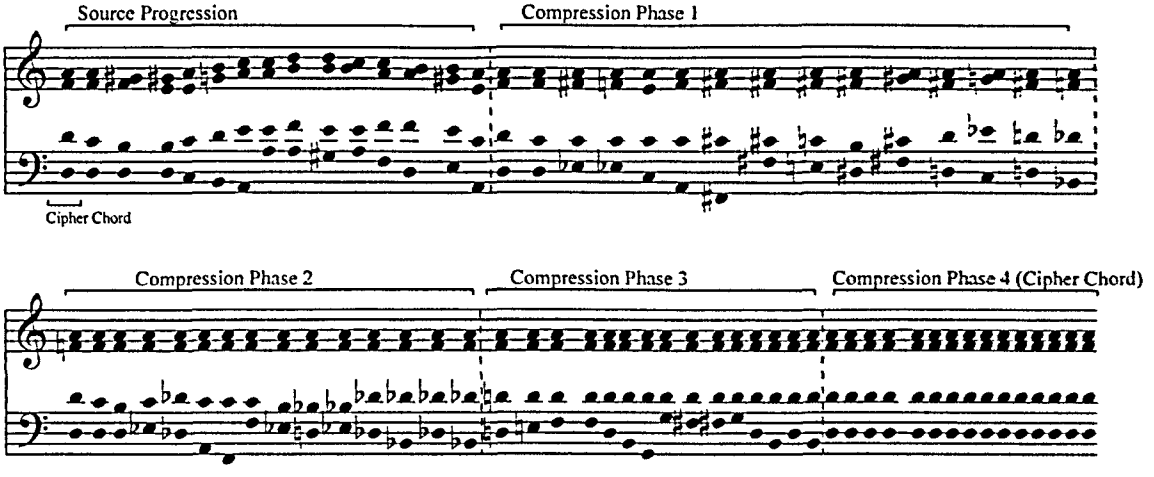


Figure 2.4 Harmonic Encryption

[8] A lossless encryption can be decrypted without compromising the data in any way.

2.3.3 The Decryption Process

The decryption process is the reconstruction of the source progression from the cipher chord. A true decryption of the source progression isn't possible but reverse transformations of harmonic encryptions can be used to achieve the same result. If we reverse the process shown in figure 2.4, we begin with the cipher and rebuild the source progression though three decryption phases.

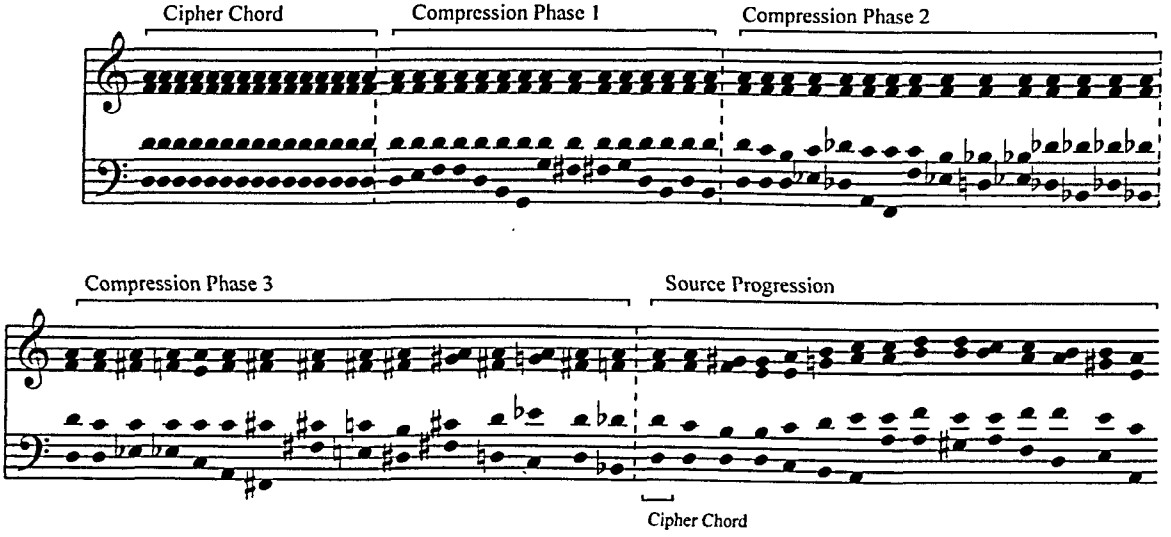


Figure 2.5 Harmonic Decryption

There are many possible variations of harmonic encryption and decryption. In figure 2.5 a different chord from the source progression is used as a cipher chord. Also, the ordering of fixed voices begins in the bass and moves to the soprano. Fixed voices can begin anywhere in the chord. A harmonic encryption and decryption beginning with internal voices can be observed in measures 319 to 330 of the score.

Figure 2.6 is an example of a harmonic decryption with altered parameters. The cipher chord is the twelfth in the source progression as opposed to the first in figure 2.5. Also, the source progression dissipates in reverse order.

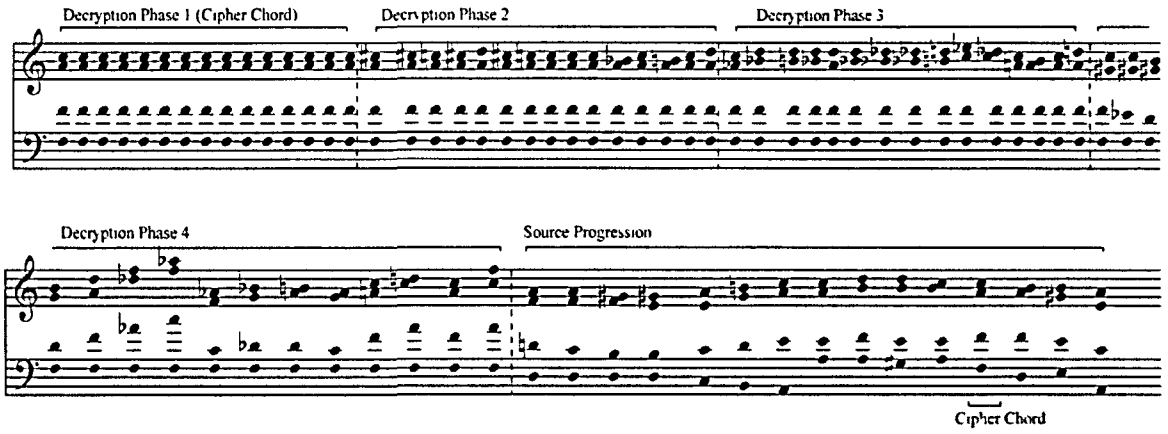


Figure 2.6 Harmonic Decryption

This process can be clarified visually with the use of piano roll notation[9].

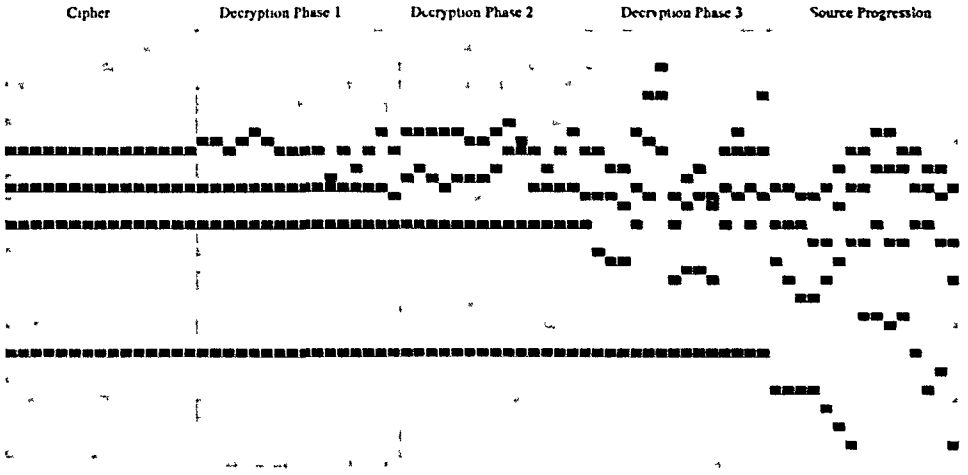


Figure 2.7 Harmonic Decryption in Piano Roll

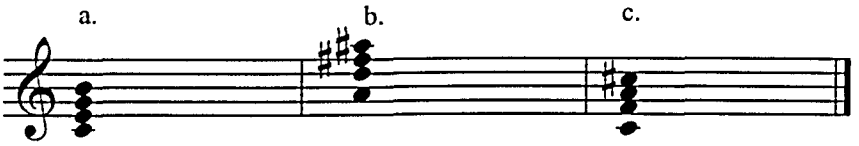
2.4 Intervallic Expansion and Compression of the Source Progression

In *Codecs*, harmonic materials are expanded though a process of multiplication. This transformation technique increases or decreases the interval space between chord voices according to a given ratio. MIDI note values[10] are used to allow notes to be transformed using numerical processes. Multiplying and

[9] Piano roll notation represents pitch on the y axis and time on the x axis The darker horizontal lines indicate black keys on a keyboard

[10] Midi assigns notes a numerical value between 0 and 127, with middle C being given the value 48 (or 60, depending on the system) The increase of one midi value represents the increase of a semi tone

dividing midi values increases or decreases the distance between notes. For example, multiplying a chord by 1.2 will increase the space between notes, where multiplying by 0.8 will make them closer together. The following figure shows a chord being multiplied buy 1.2.



a	b	c
B3 / 59	A#4 / 70	C#4 / 61
G3 / 55	F#4 / 66	A3 / 57
E3 / 52	D4 / 62	F3 / 53
C3 / 48	A3 / 57	C3 / 48

Figure 2.8 Expansion Diagram

After a chord has been multiplied it is normally transposed so that the bass voice returns to its original pitch level.

Ratio multiplication allows the harmony to be altered for musical purposes, while maintaining approximate contour and voice leading.

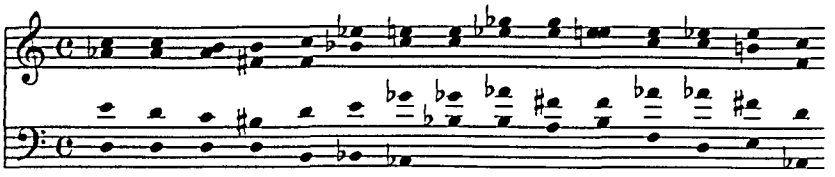


Figure 2.9 Harmonic expansion of source progression at 1.2 ratio

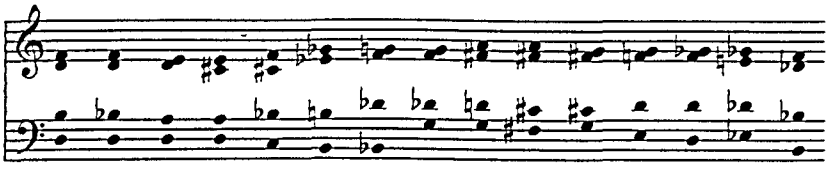


Figure 2.10 Harmonic compression of source progression at 0.8 ratio

When taken to extremes, these techniques can obscure and reveal musical information in a similar way to harmonic encryption. Chords can be crushed together with progressively extreme ratios until they become a single pitch. This

is the case in 241 to 246, except the process is happening in reverse. A single pitch expands into a chord progression.

2.5 Dynamically Changing Ratios

In some cases the ratio applied to harmonic materials changes very quickly and yields interesting results. This occurs in the passage starting at measure 154. In figure 2.8 the number used to modify the harmony is shown above the brackets on the top staff. Common notes between successive chords are tied together. In measure 355 the characteristic leap from the source progression is exaggerated.

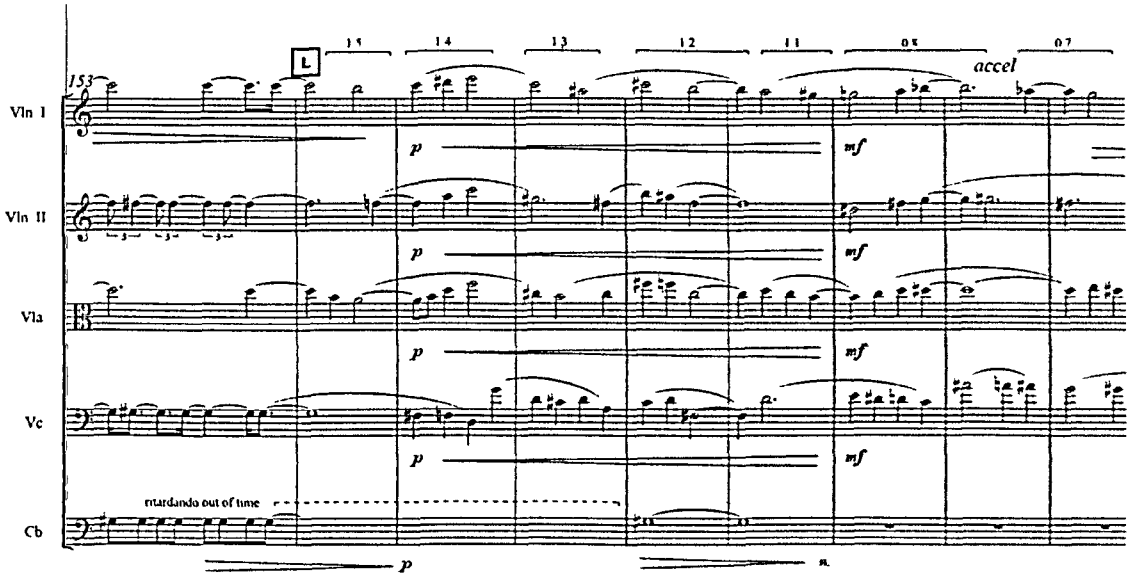


Figure 2.11 Changing Ratios

Chapter 3: Rhythm and Time

3.1 Introduction

The rhythmic processes used in the composition of *Codecs* are inspired by electronic music production techniques. The manipulation of audio loops and samples from electronica production is metaphorically mapped onto instrumental writing idioms.

The harmonic encryption process relies on the transformation over time of repeating materials. Repeating and transforming the source progression creates a shifting rhythmic profile that follows metaphors similar to harmonic encryption and decryption.

3.2 Rhythm as a Function of Harmony

Despite its uniform rhythmic values, the source progression develops a distinct rhythmic profile when repeated at high speeds. As the harmonies change through transformation processes, so does the rhythmic profile. Rhythmic interest as a function of repeating harmony is a technique heavily exploited by electronica producers. From an instrumental perspective, composers like Stravinsky and minimalist composers like Terry Riley and Steve Reich exploit a similar technique.

As shown in figure 2.3, harmonies flatten out as they approach the cipher chord. So does the rhythmic profile. Provided notes are being played at the same volume, a series of quickly repeating sixteenth note chords has a flat rhythmic profile. As the source progression is reconstructed during the decryption process, so is the shifting rhythmic profile associated with the transformation. This process can be clearly observed in the strings between measures 109 and 133.

3.3 Rhythmic Expansion

The process illustrated below is a way of generating rhythmic interest from the rhythmically static materials generated by harmonic encryption. It relies

on the principal that modifying phrase lengths can create rhythmic contrast. This process works by isolating fragments of the source progression. As fragments are selected, their start and end points move across the progression while changing the size of the selection. After fragments with complementary rhythmic profiles are selected I connected them together to create a larger pattern.

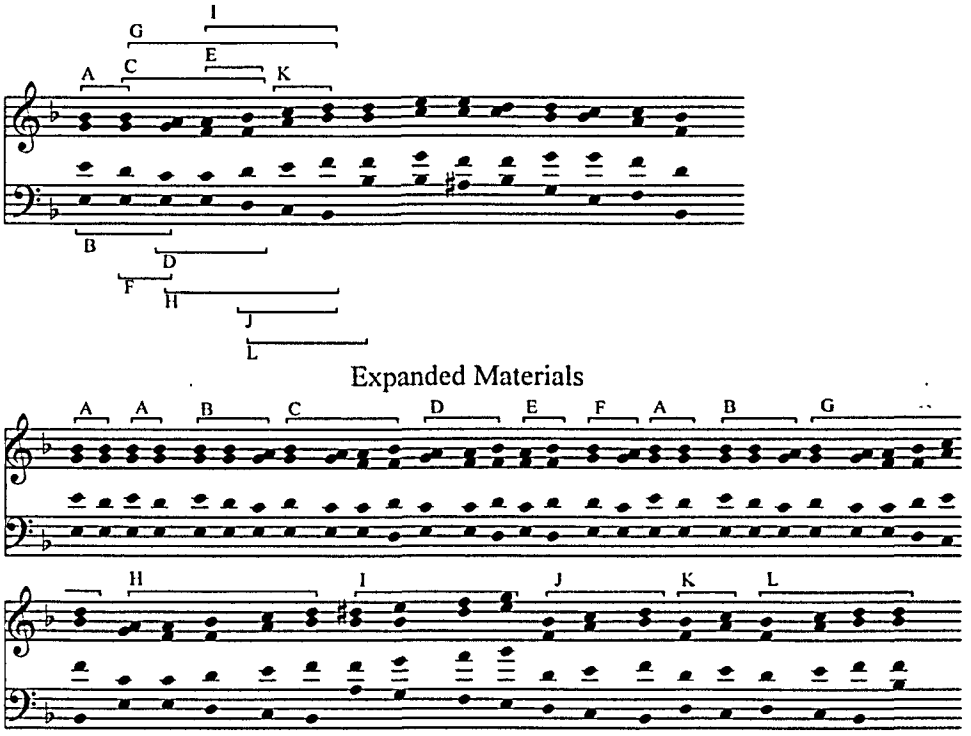


Figure 3.1 Rhythmic Expansion * letter I is transposed up a Perfect 4th

The above diagram shows the source progression with brackets that correspond with sections of the expanded materials. Figure 3.1 is a fragment of a larger rhythmic expansion that is found in many transpositions and expanded forms throughout the piece. See Measures 301 to 319 for examples in the score.

A similar technique is used in electronica production by carefully cutting up audio samples and loading them into a sampler. Stress patterns are altered as the borders of a repeating pattern are expanded and contracted. The repeating region moves across the source progression, re-contextualizing familiar patterns with each change. Like a spotlight moving across a darkened room, the beam reveals what is in the path of the flashlight but the rest remains obscured. In this way I was able to play with the listener's expectations by increasing and

decreasing the length of recognizable fragments.

3.4 Time Expansion and Time Compression

Time expansion and compression are process I used to create written out shifts in tempo rather than an imprecise accelerando. These shifts are achieved though a numerical process similar to those described in section 2.4. For example, a half note multiplied by 0.5 will result in a quarter note. When notes are multiplied by dynamic or complex ratios, the results change over time and are rounded to the nearest sixteenth or triplet. The numbers in figure 3.2 represent the number of sixteenth notes within the brackets.

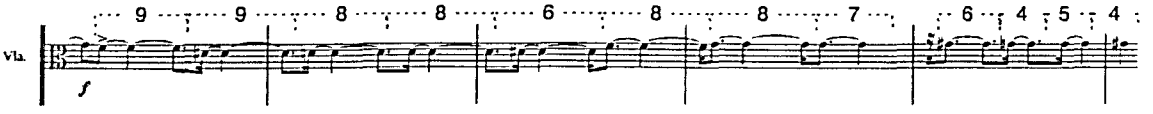


Figure 3.2 (mm.193 - 199)

This process has not been applied rigidity. I have allowed myself to make changes to my rhythmic structures in order to avoid simultaneous attacks. Figure 3.2 comes from a section of *Codecs* where lines with different rates of rhythmic compression slowly align to form the source progression. In this section the source progression acts as a point of rhythmic stability, just as the cipher chord acts as a point of harmonic stability during a harmonic encryption.

To create variety and slower changes in tempo I used a process based on addition and subtraction combined with ratio multiplication. After rounding to the nearest sixteenth note the results are similar.

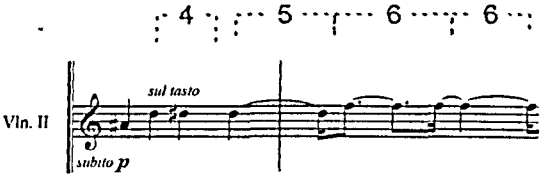


Figure 3.3 (mm.199-198)

Of course, some rhythmic materials in *Codecs* are simply freely composed gestures that are applied to melodic lines drawn from transformations of the source progression. The rhythmic profile of the clarinet solo at the beginning of the piece is an example of this.

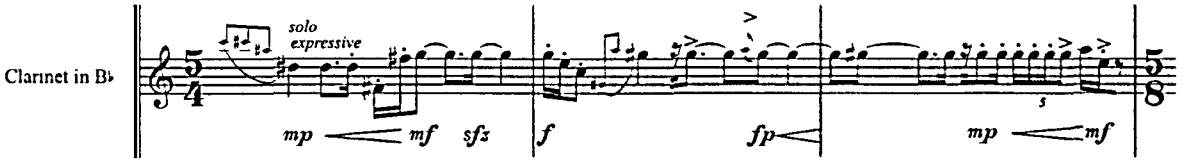


Figure 3.4 (mm. 1-3)

3.5 Negative Space

The relentless pulsing in the fast sections of *Codecs* makes even the smallest gap a dramatic moment. By taking notes out of a repeating pattern, I created rhythmic interest and contrast.

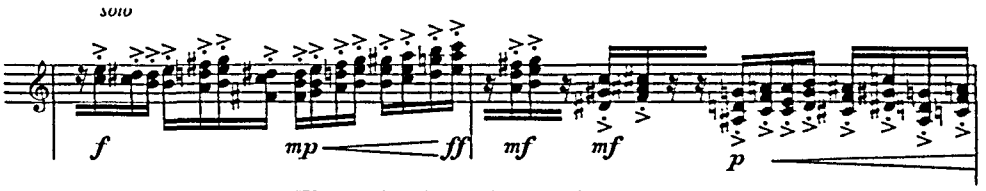


Figure 3.5 (mm. 371-373)

As the size of the space increases, so does the tension built by the lack of sound. A more dramatic use of negative space can be observed in the score at measure 386.

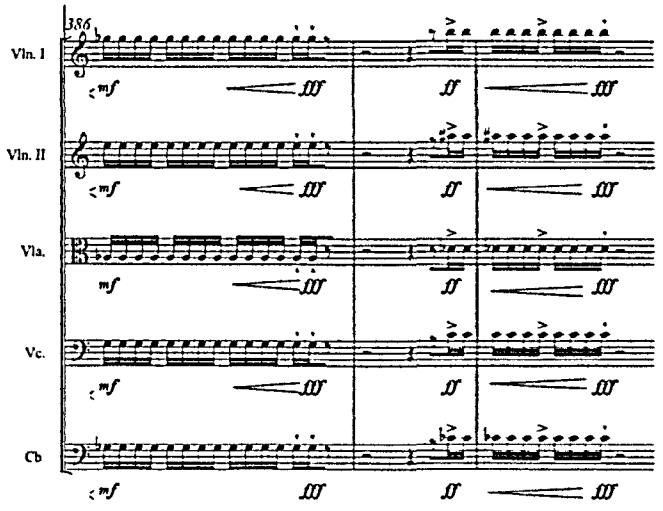


Figure 3.6 (mm. 386-388)

Chapter 4: Melodic Materials

4.1 Introduction

The melodies in *Codecs* are derived from materials generated by the transformation processes explained in chapters 2 and 3. Harmonic encryption and decryption varies the intervallic relationships between notes in the source progression. Melodic materials are a natural by-product of the chordal shifts that occur during this process. Melodic contours collapse or expand as they are repeated, obscuring and revealing melodic content. This means that there is a shifting hierarchy of melodic interest. As voices lock into their fixed position they fade into the background, making way for previously obscured voices. Many of these melodic lines are left as is and enhanced though orchestration and doubling. Others are transformed with rhythmic processes discussed in chapter 3 and harmonic ratios as discussed in 2.4.

4.2 Melodic Extraction:

4.2.1 Melodic Encryption and Decryption

Once a source progression has been unfolded through various processes, splitting apart voices and examining their contours can reveal interesting melodies. Changes in processing yield melodic materials with different characteristics. For example, harmonic encryption begins with melodic materials that are easily recognizable but gradually flatten out as they merge with the cipher chord. The oboe line at measure 57 is an example.

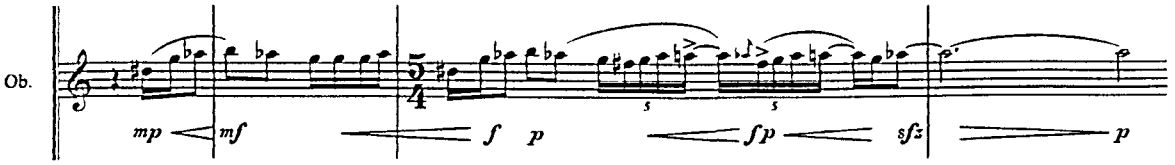


Figure 4.1 Melodic Encryption (mm. 57 – 60)

Melodic decryption is the same process in reverse. It begins with a single pitch and slowly reveals melodies. In both of these contexts, familiar melodic materials

are obscured and revealed through time.

4.2.2 Tying Common Notes

Contrast and melodic variation can be created by substituting repeated notes with held pitches. Not only does this soften the severity of the repeating metric units, it blends sections together, softens entries and creates rhythmic variety.

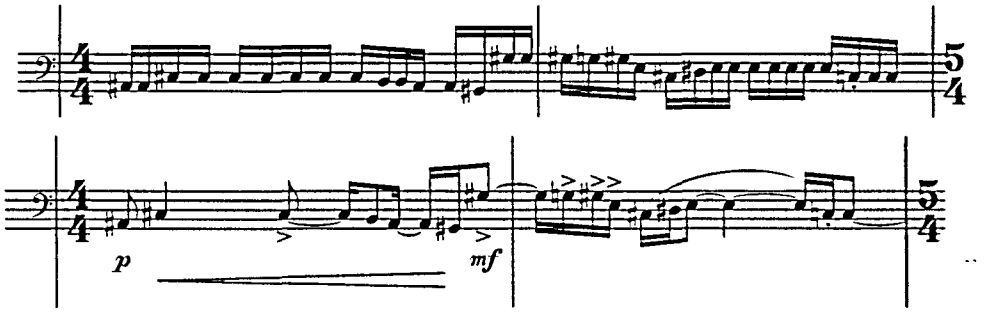


Figure 4.2 before/after tied common notes (20-21)

4.2.3 Counterpoint

The logical continuation of the technique explained in 4.2.2 is to create counterpoint by tying common notes of multiple voices simultaneously. The resulting materials are similar in texture and rhythmic profile to decorated vocal homophony. (Horton 26). The careful selection of tied notes creates pseudo tension release events similar to traditional cadences and suspensions. This works because the contours and voice leading of the source progression are partially preserved during different phases of the harmonic encryption process.

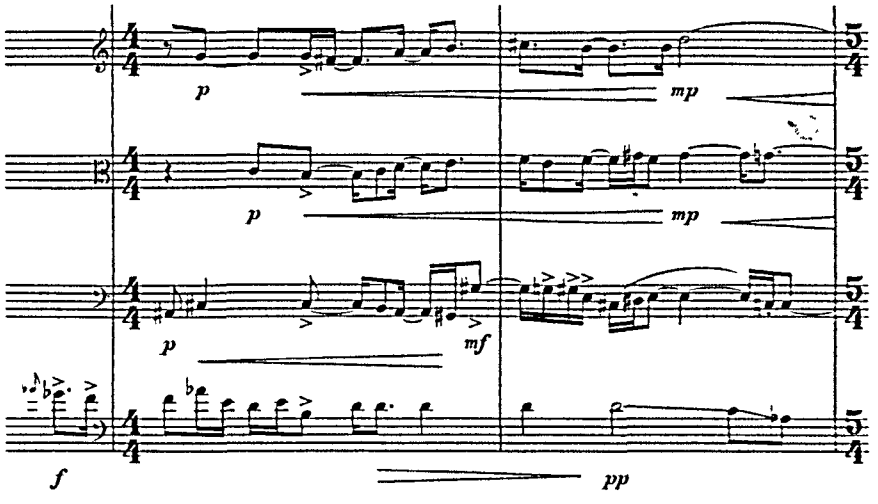


Figure 4.3 counterpoint (Measure 19-21)

4.2.4 Free Rhythmic Composition

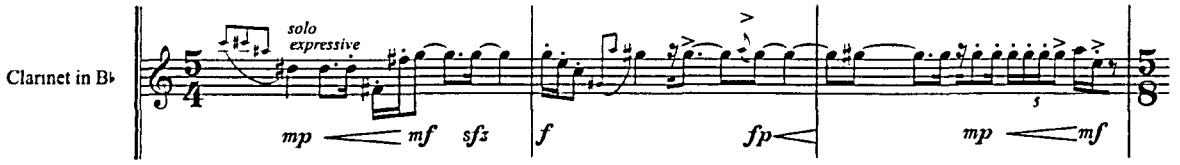


Figure 4.4 Clarinet Solo (Measures 1-3)

Taking the source progression or decrypted materials and composing a unique rhythmic profile creates the melodic materials shown above. Contrasting rhythms and decorative figures help melodies stand out in rhythmically homogenous sections.

4.3 Melodic Arpeggiation

Not all melodic materials used in *Codecs* are limited to single lines extracted from the source progression and its transformed states. Some melodic materials are created though arpeggiation. That is to say, they drift between the voices of a chord progression. The first part of the following diagram is a fragment of a harmonic encryption in its raw form. The second part is the arpeggiated version.

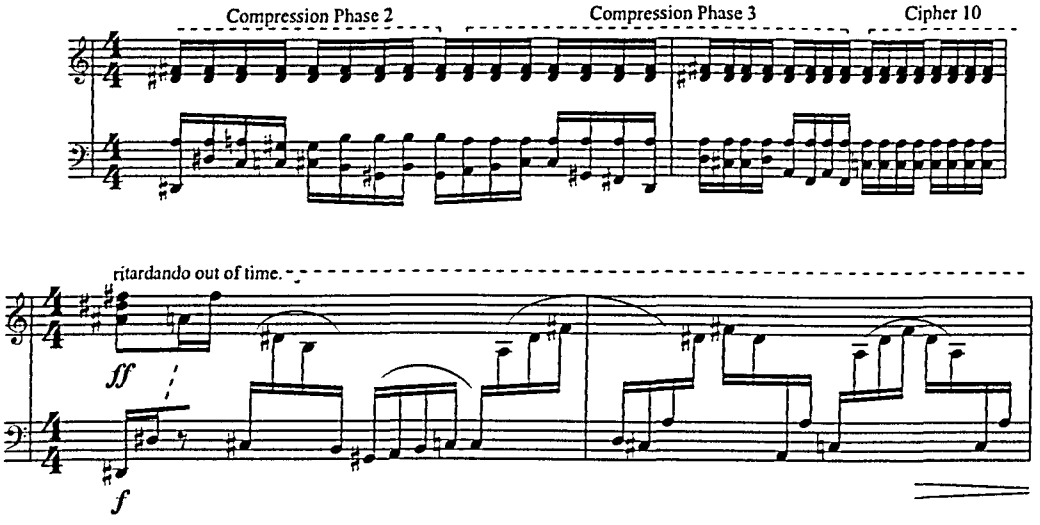


Figure 4.5 arpeggiation (measure 289-290)

Chapter 5: Form

5.1 Introduction

Formal structures in *Codecs* exist on three hierarchical levels. The first structural level is divided into three sections: "glitch", "ambient" and "gabber". These three sections are based on sub-genres of electronica. This relationship to electronica genres is not achieved though quotation but though the use of similar processing techniques, sound materials, tempo, orchestration, gesture and rhythmic materials.

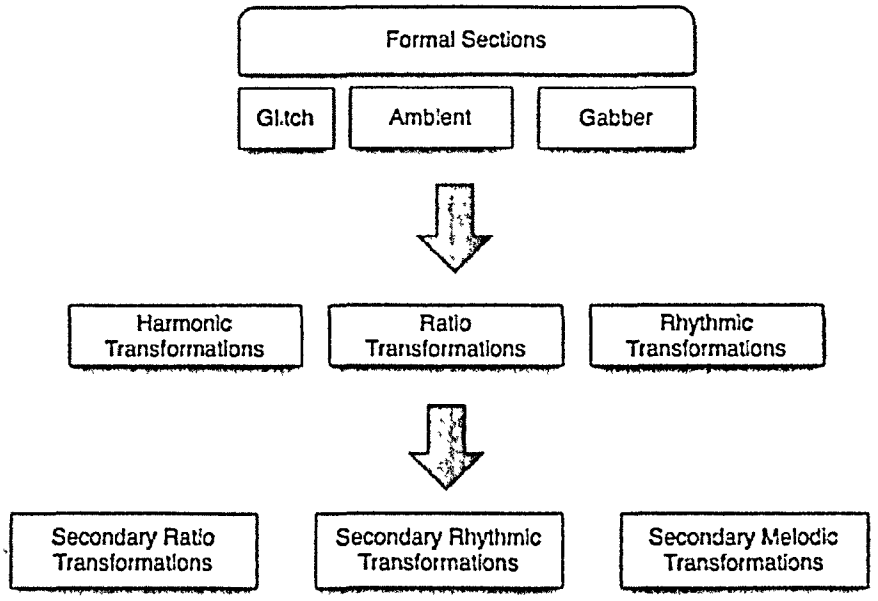


Figure 5.1 Hierarchical formal processes

The second structural layer is marked by the obscuring and revealing of the source progression using the transformational techniques described in chapter 2 and 3. This structural level is illustrated in appendix A, and will be referenced throughout the section. The diagram in Appendix A is a formal outline that was used during the planning of the piece and doesn't reflect the finished score. It shows the second level structural blocks that form the backbone of *Codecs*. Each structural block represents a harmonic process of encryption or decryption. Rhythmic transformations are indicated below the timeline using dotted brackets.

The third and most detailed structural level of *Codecs* is made up of

secondary transformations of materials from level 2. These third level transformations expand and vary materials on a gestureral basis. These smaller intricate structures are created using the same processes that are applied to level 2. This is the final level of processing and the result is the final score.

5.2 Formal Sections

5.2.1 Section 1: Glitch

Measures 1 to 149 are based on Glitch[11] music. This post digital music aesthetic emphasizes errors created by modern digital technology. This style of electronica zooms in on, and combines sounds created by, digital hardware or software failure (Cascone 24).

This formal section of *Codecs* is constructed from electronic glitch samples made from processed instrumental as well as electronic sounds. The instrumental part uses comparatively unstable rhythmic gestures, rubato, jagged contours and surprising punctuations. These elements create similarities in texture and feel to the glitch aesthetic. Stylistically characteristic and "glitchy" percussive sounds based on errors caused by the Mp3 encoding process are triggered using live electronics to punctuate and blend musical events.

5.2.2 Section 2: Ambient

Measures 149 to 241 are related to the Ambient electronica aesthetic[12] which is often characterized by long, drawn-out gestures and washes of sound. Stretching out audio samples until they lose all recognizable relationship to the original materials is a technique often used to create ambient electronic music. This section of *Codecs* was created using time expansion techniques to stretch out a harmonic encryption in a similar way. Instead of a recognizable chord progression, the source progression is transformed into a textural layer of varying attack density.

---

[11] A Glitch is a short lived fault in a system. In "Glitch Music" this is referring to digital glitches in software and hardware systems. For audio examples go to: http://www.allmusic.com/cg/amg.dll?p=amg&sql=77:11635

[12] Ambient electronica is a wide genre with many sub genres. For information and audio examples go to: http://www.ambientmusicguide.com/

5.2.3 Section 3: Gabber

Measures 241 to 390 make up the gabber section of the work. Gabber is a sub genre of electronica characterized by high speeds and audio samples that are distorted beyond the point of recognition. These samples often reflected themes of violence, drugs or profanity. Gabber was a rejection of the "elitist" attitude associated with electronica in Detroit and Amsterdam in the mid to late 90s. Relentless rhythmic pulse, harsh noises and extreme volumes in both the electronics and orchestration tie this section to the gabber aesthetic[13].

5.3 Connecting Materials

This section covers the second level of formal structures and how they interact. Sculpting and modifying the way transformed source progressions connect is the key to creating beauty, unity and interesting musical gestures in *Codecs*. Transitioning between materials can be done in many ways. The following are examples of how encryptions and decryptions are connected.

5.3.1 Palindrome

When harmonic encryptions and decryptions connect they form a palindrome shape like the one shown below. Note that the palindromic design of this example is based on the phrase structure, not on a chord by chord mirror image.

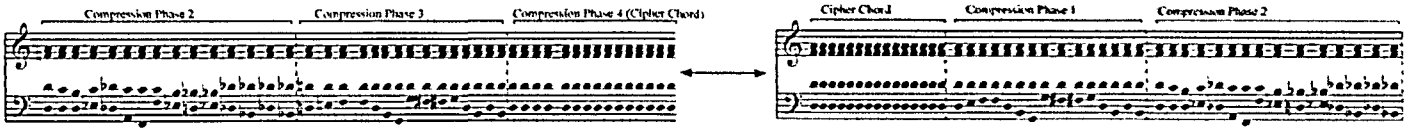


Figure 5.2 Palindrome Shape

The palindrome can be exact or modified (as in the case of the above example), depending on the type of transformations used. An exact palindrome requires its second half to be a mirror image of its first half. Each half of a modified palindrome has the same start and end points as in an exact palindrome,

[13] For examples of gabber go to: http://www.enzyme.nl (turn down your speakers)

but different transformations are used in the second half. The smoothest way to connect encryptions and decryptions is by using a common cipher chord. This is because shared rhythmic and harmonic materials blur the edges of the structural blocks like the ones shown in Appendix A.

The second section of *Codecs* (mm. 149 – 241) is an example of a large palindrome that is connected by the source progression.

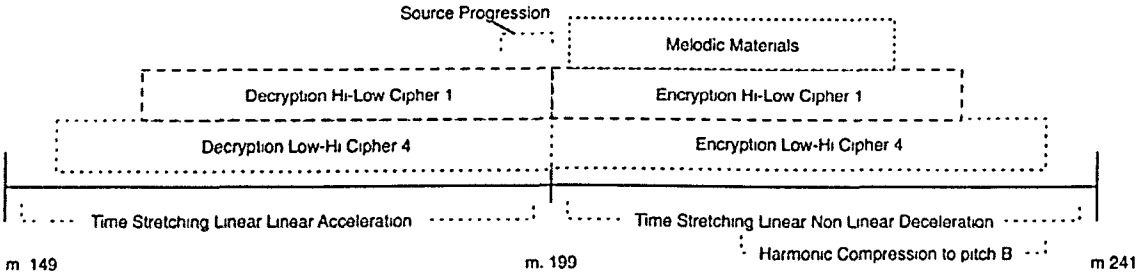


Figure 5.3 Palindrome Structural Back-bone

Modified palindromes are structurally interesting because each side is transforming the source progression in a different way. These alterations are archived though subtle or drastic modifications to the transformation processes. Imperfect palindromes serve two purposes. Firstly, it increases structural variety by not limiting symmetrically related materials to perfect palindromes; secondly, a false palindrome works well for introducing new materials. Measures 150 to 199 to 230 are an example of this type of formal structure. See Appendix A section 2.

5.3.2 Forced Splice

Warping harmonic encryptions by using free compositional techniques or ratio multiplication can splice two structural blocks together in a convincing way. This is done when two sections cannot be connected through any available harmonic encryption or rhythmic expansion process. An example can be found in the score at mm. 241 – 250. In the score excerpt below, the pitch B is harmonically expanded to connect with an encryption with a harmonic ratio of 0.5.

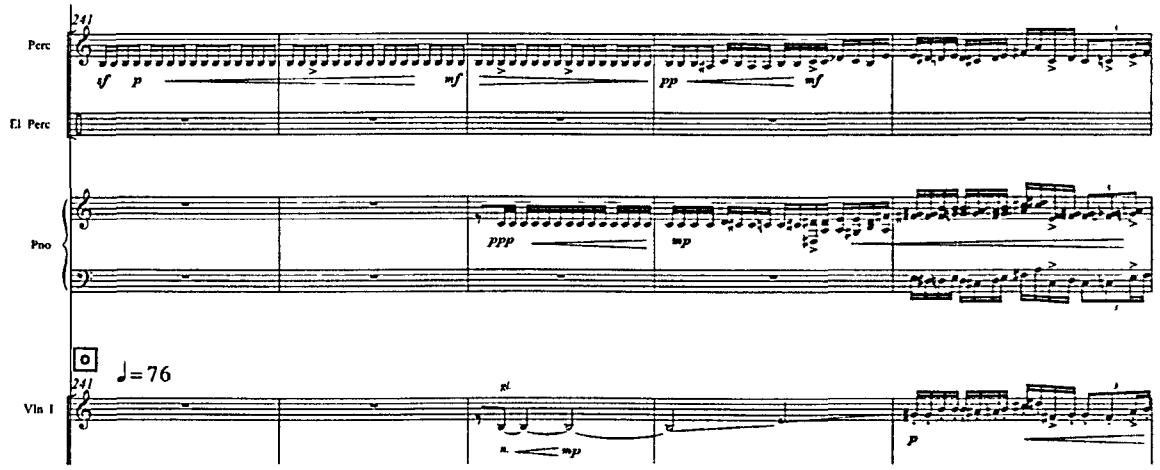


Figure 5.4 Forced Splice

5.4 Overlaying Multiple Encryptions

The cipher chord acts as a point of rest for harmonic encryptions. When two different harmonic encryptions share a cipher chord, and are superimposed, the result is a more harmonically dense structure with a shared point of rest. The same phenomenon occurs during harmonic decryption, except the role of the cipher and the source progression is reversed. For examples see mm. 149 to199 Appendix A, section 2.

5.5 Secondary Transformations

The majority of *Codecs* has been subjected at least three levels of transformation. Rhythmic, harmonic and melodic transformations stack and create complexity and variety. These transformations affect one another and the result is an expansion of the formal outline seen in Appendix A. The dotted brackets underneath the timelines give a rough approximation of secondary processing.

Chapter 6: Electronics

6.1 Introduction

The electronic component of *Codecs* consists of pre-composed electronic materials that are broken down into discreet events and triggered according to strictly ordered, overlapping multi-track sound cues[14]. Sounds are triggered using Roland V-drums[15], which are connected to a software sampler called Kontakt[16]. This connection is made via Max/MSP[17]. The triggered sounds are processed using envelopes and amplitude data derived from a real-time analysis of the audio from the live ensemble. Once the materials have been processed they are spatialized though a ten-speaker setup.

6.1.1 Working Methods

I chose to focus on triggering and filtering pre-composed sound files, as opposed to working with the live sound of instruments, because this working method eliminates many risks that are out of the performer's hands. After working with performers I have realized that a great deal of anxiety is associated with musical systems where the performer feels a lack of control.

The hardware and software setup from *Codecs* combines the stability of commercial software with the flexibility and control of Max/MSP. The sound quality and complexity of pre-composed sounds combined with the responsiveness of real time filtering, triggering and spatialization create musically convincing results. The following diagram illustrates the Codecs performance setup:

---

[14] A sound cue is a sound file that is played back though the speaker setup at a given point in time

[15] A velocity sensitive virtual drum kit designed by the Roland company http //www roland com/products/en/TD-20K/index html

[16] Software developed by the Native Instruments corporation It specializes in retriggering audio files http //www native-instruments com/index php?id=kontakt3

[17] A visual development environment for music and multimedia http //www cycling74 com/

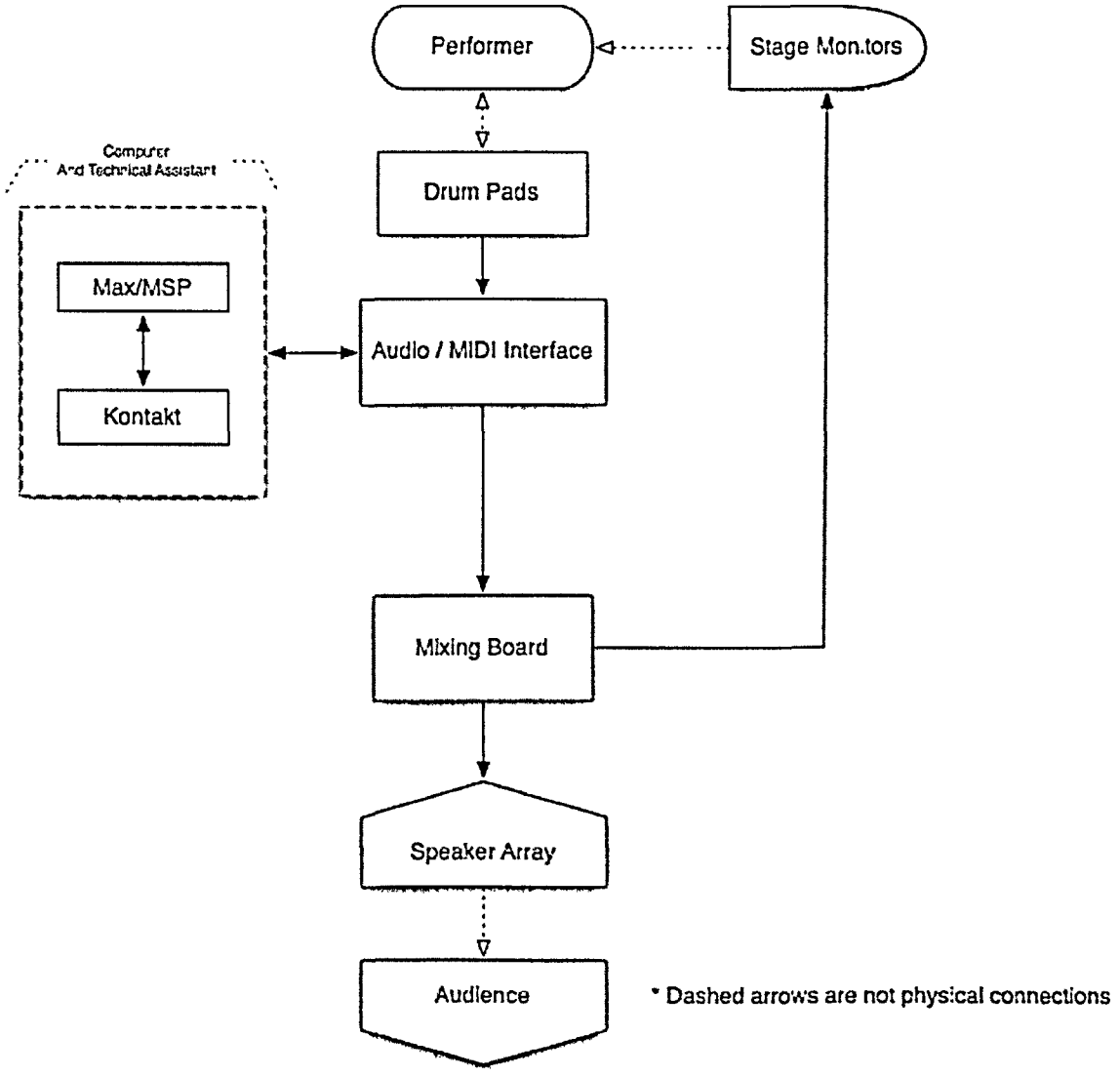


Figure 6.1 Codecs Setup Diagram

6.2 Creating a Gesture

6.2.1 Selecting Sound Files

The process of creating an electronic gesture begins with selecting, trimming and cleaning up raw audio materials. Sound materials used in *Codecs'* electronic component come from a variety of sources. These sources are related to the poetics of the piece to varying degrees and in different ways. For example, some sounds are related to the source progression, others to electronica genres mentioned in chapter 5. Some sounds are related because the methods in which

they are processed mirror processes outlined in chapter 2, 3 and 5. This type of process based relationship is an electronic extension of ideas explained in section 5.1. Some sounds have no obvious relationship, but are used for the sole purpose of adding specific attack characteristics to related sounds, or to fill out the harmonic spectrum.

Thematically related sound sources include:

- Instrumental recordings from rehearsals as well as individual recording sections with the oboe.
- Source progression being performed on harpsichord, organ, piano and analog synthesizer.
- V-I cadences from selected J.S Bach works performed by Canadian artists.
- Isolated artifacts[18] from the Mp3 Codec.
- Fragments of electronic music related to the three large formal structures of *Codecs*.
- Digital communication technology. (Cell phones, modems, fax machines)

Unrelated sound sources:

- Analog and digitally synthesized sounds
- Skateboard clattering on pavement
- Power tools
- Yelling
- Factory Machines

6.2.2 Montage

After the selection process, sounds were loaded into a digital audio workstation for mixing, sequencing and processing. These sounds were manipulated in such a way as to obscure and reveal their relationships to the source progression. Sounds are overlaid and combined to create larger gestures

[18] Artifacts are a type of noise created when processing a sound. In this case, the mp3 codec creates a distinctive noise pattern during the compression process.

that integrate into the instrumental part.

In order to keep track of which sound is associated with which drum pad, I routed audio files in the DAW[19] though three separate outputs. This allowed me to work quickly and efficiently with large gestures created from layers of samples triggered by multiple drum pads. Working with separate outputs helps me break down complex sound events. I can quickly switch between groups of sounds; from an individual drum pad, to how it relates to the larger soundscape.

6.2.3 Timelines

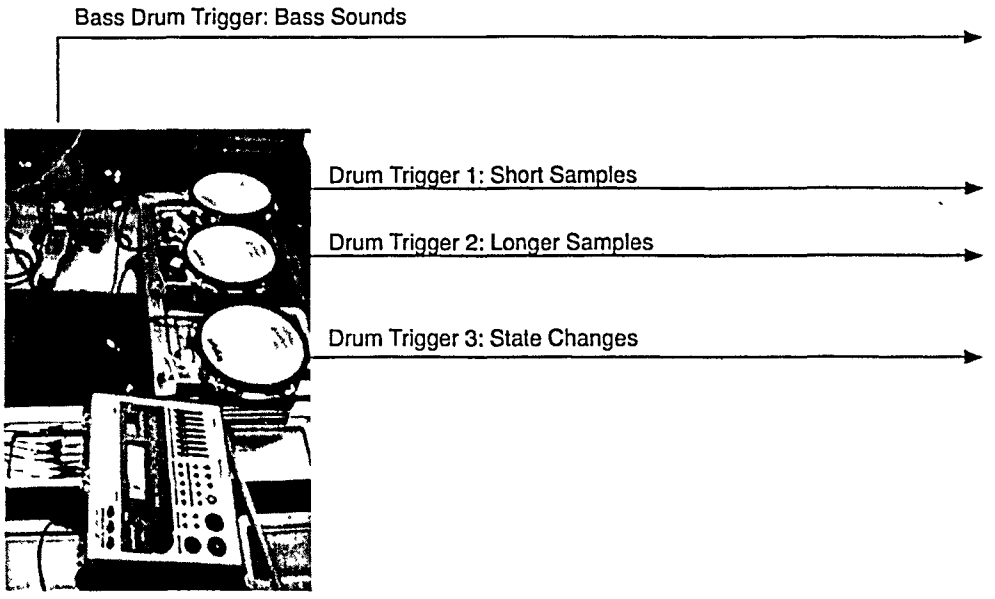


Figure 6.2 Trigger Time Line

The Max/MSP patch used in *Codecs* communicates with four drum controllers (shown above), which are three velocity sensitive drum pads and one foot-operated drum controller. Drum pad 1 primarily controls shorter sounds on timeline one. Drum pad 2 controls long sounds on timeline two. Drum pad 3 sends state changes to Max/MSP. And the bass drum pedal triggers bass sounds on the third timeline. A state is a collection of timing and processing parameters that control the samples being triggered by the drum pads. This configuration allows for three timelines of multi-channel samples; each being triggered, filtered and spatialized independently. The sounds that are triggered on each timeline can be changed at any time using the third drum trigger. I built the Max/MSP patch to

[19] Digital Audio Workstation

be scalable so more or fewer triggers may be added for different performance situations.

6.2.4 Simulation

During the compositional process, large complex events can be quickly integrated into a mock-up simulation by exporting the material from the three outputs mentioned in 6.2.2 and loading them into Kontakt. Once the sounds are loaded into Kontakt, they are further divided using transient and zero crossing detection[20]. This interface illustrated by figure 6.2. The three timelines can then be triggered and manipulated along with a mock-up of the instrumental score. Additional automation can be entered along with the audio to simulate the data coming from the ensemble.

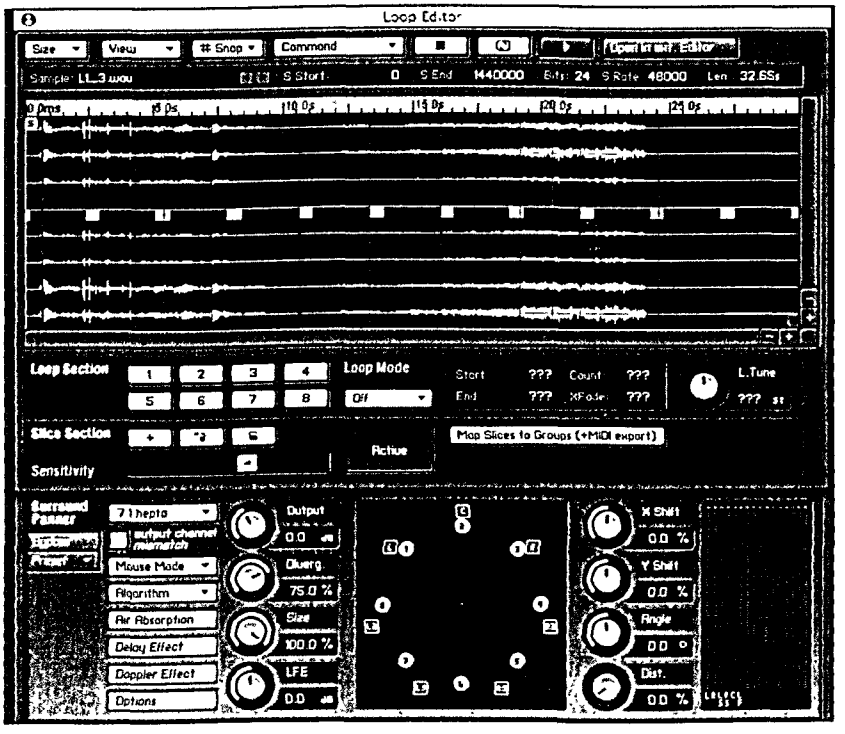


Figure 6.3 Kontakt

Working this way allows for a great deal of speed, experimentation and flexibility while manipulating a staggering amount of audio material. Proper simulation is very important as it identifies many problems without wasting rehearsal time.

[20] Kontakt searches for logical places to split a sound without causing undesired pops and clicks.

6.5 User Interface

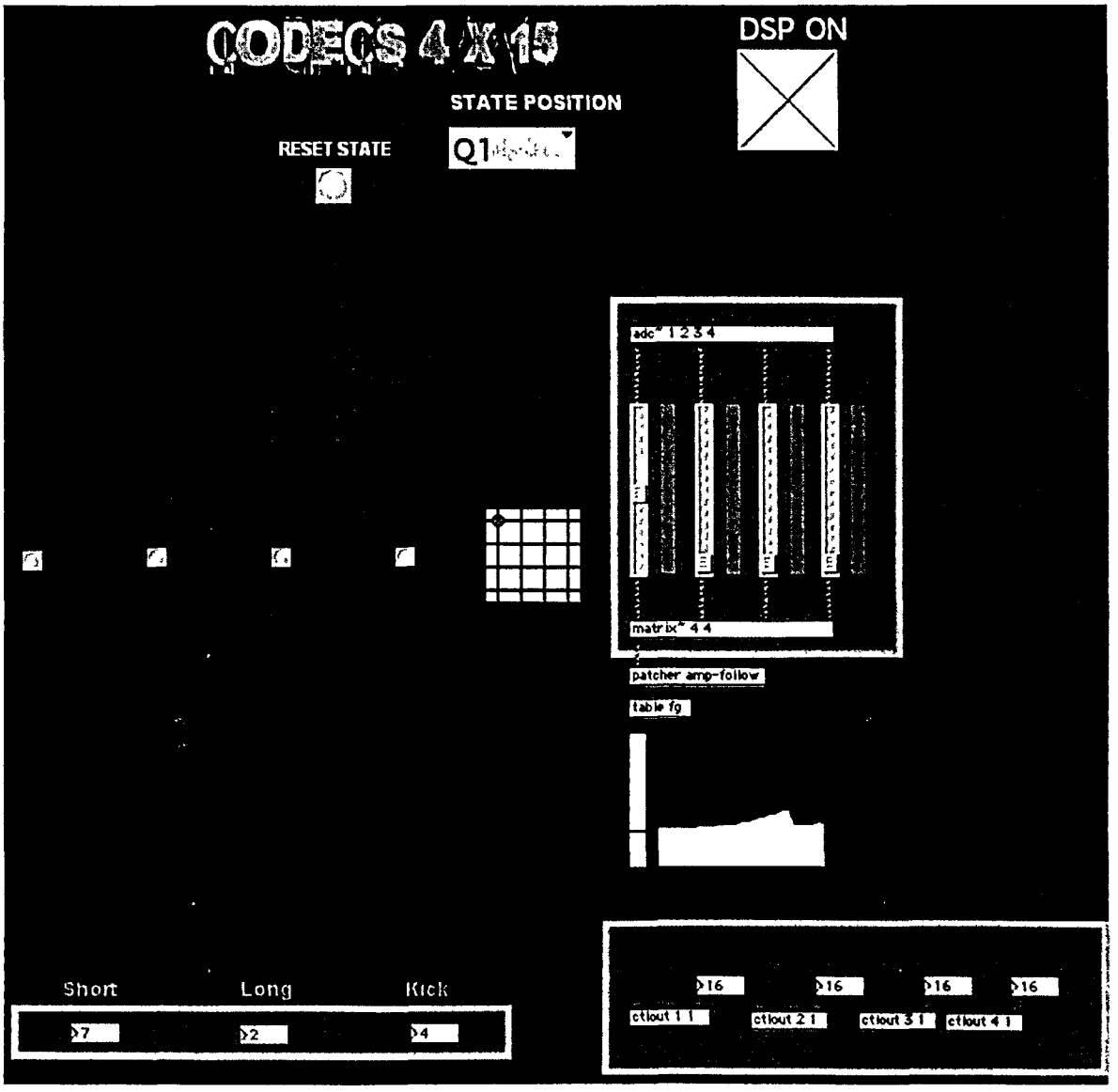


Figure 6.4 Patch Interface

6.5.1 Composer Interface

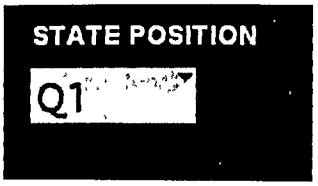
Once the desired gestures are broken down into appropriate components and loaded into Kontakt, the triggering process gets passed from the DAW[21] to the V-Drums via Max/MSP patch (Shown above). The patch I created connects the V-Drums to Kontakt and manages the ordering of audio events. When the musical gestures are performed on the v-drums, the composer can quickly make

[21] Digital Audio Workstation

changes and revisions in order to make gestures more musically convincing. Event sequencing, voice count, filtering and spatialization can be further refined from within the patch. It is helpful that Kontakt contains many audio shaping and filtering tools. Most importantly, if a gesture needs to be replaced altogether, it can be altered and quickly re-loaded.

6.5.2 Hierarchical Triggering

The timeline of audio events for each drum pad is controlled by a dynamic 2D array. This means that a list of audio events is assigned to each drum pad at any given moment during the piece. As the performer strikes a pad, Max/MSP triggers a sound and checks the list for the next event. Triggering audio in a list means that if the performer makes a mistake, he or she will be out of sync with the ensemble. To combat this problem, I devised a hierarchical triggering and error-compensation system. Infrequent but critical audio events are assigned to the left drum pad while shorter and more frequently occurring sounds are assigned to the right drum pad. If the order of events on the right pad's timeline is shifted, the sounds are similar enough that the effect will be negligible. Also, the lists of audio events associated with a drum pad are updated when the third drum pad is triggered. The third drum pad resets the lists of events for the next section of the piece. Constantly re-setting lists of events as the player progresses though the piece allows every section to begin at the right point. The list can be seen under "state position" in figure 6.4.



6.5.3 Rehearsal

In rehearsal, cue numbers associated with measure numbers are used to move the Max/MSP patch to different sections of the piece. As the conductor repeats and changes sections, the technical assistant or performer has to select the appropriate state position. A stereo version of the setup for *Codecs* is compact and streamlined enough that it can be setup in ten minutes before rehearsal. Not having live processing means there are no levels that need to be checked.

6.5.4 Performance

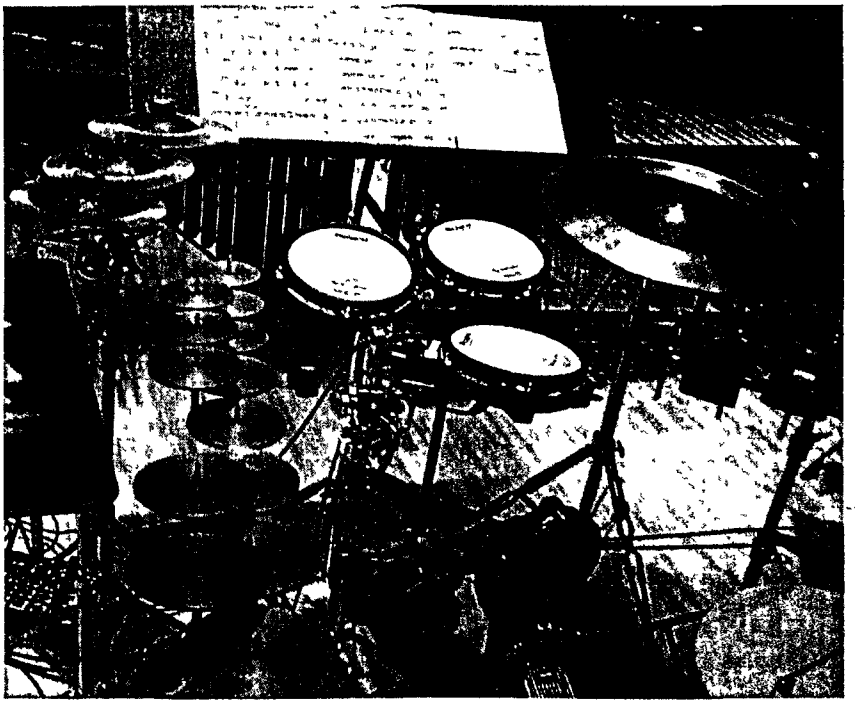


Figure 6.5 Stage Setup

The drum pad interface for *Codecs* has a very small physical and visual footprint on stage. There are no computers, tangles of wires or midi cables. This minimizes distractions and helps the audience to focus on the music. The connection between the v-drum pads and the v-drum module helps to make this possible. This connection is analog and can be fed though built-in stage inputs that can be connected to the mixing desk. The drum pads are seamlessly integrated into the percussion section of the ensemble so there are no visual distractions. There are stage speakers behind the percussion section that serve as monitors for the percussionists, as well as a localized logical sound source for the majority of the electronic sounds.

6.6 Spatialization

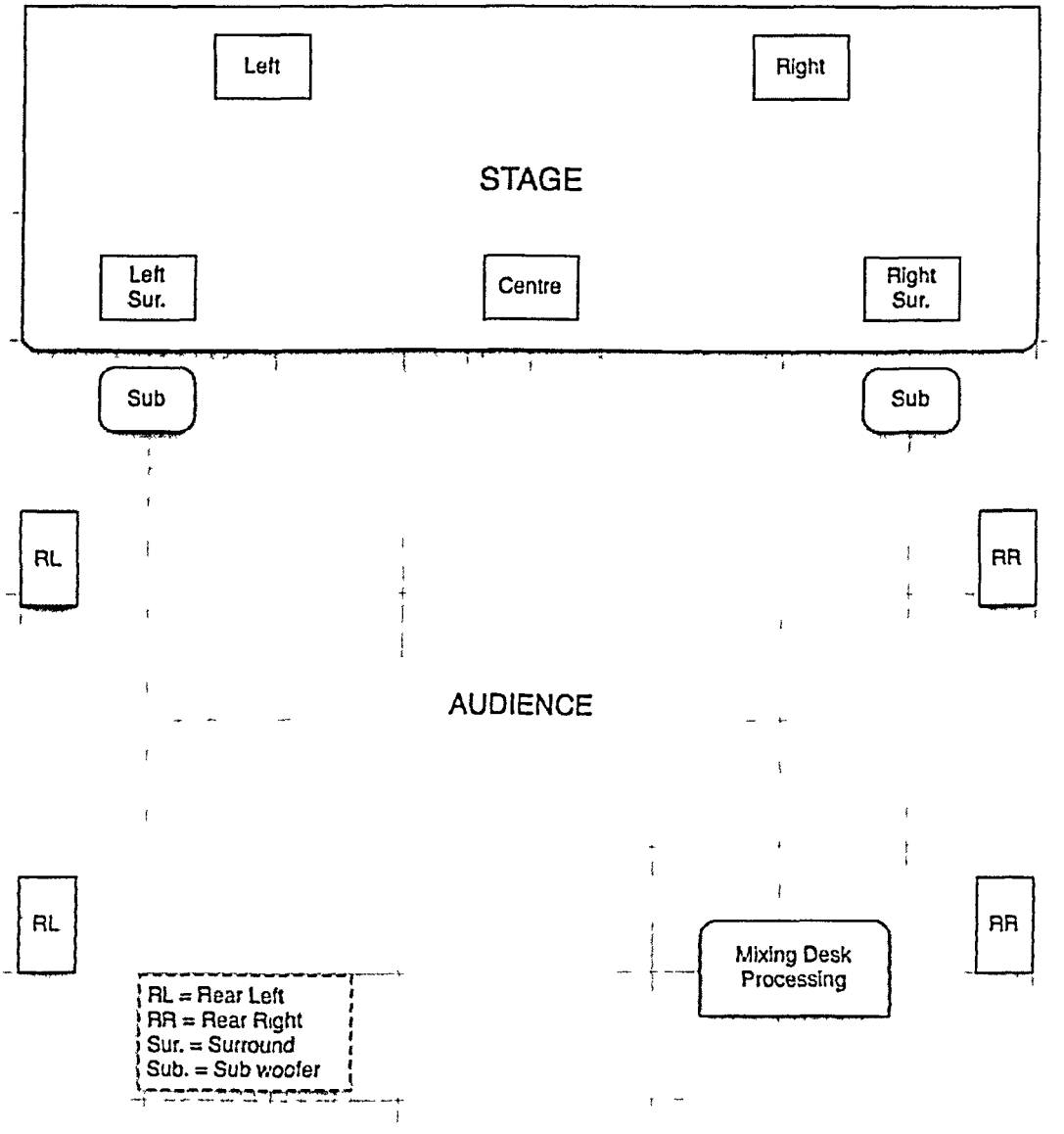


Figure 6.6 Speaker Placement

I chose a non-standard "big stereo" speaker setup as opposed to the more common circular[22] setup. By placing the main speakers behind the ensemble, I was able to blend sounds convincingly without amplifying the live instruments. Sounds perceived as coming from the same place in physical space are naturally grouped together by the brain. This is called grouping by common fate. By not amplifying instruments, I also avoid issues with sound quality loss and feedback.

[22] A circular speaker setup surrounds the audience with equally spaced speakers

The centre speaker is reserved for particularly subtle and delicate sounds. It is not used often because of the proximity to the audience and the way it collapses the stereo image. The additional speakers are be used to broaden the stereo image to the point of surround sound. For example, sounds can begin behind the ensemble and move out as an ultra wide stereo until they fragment into a series of spatialized sounds.

The side speakers were suspended on metal cables. By raising the speakers I sacrificed some clarity for an increase of the sweet spot[23]. Keeping the side speakers higher on the wall reduces the problem of sitting on the side, and having a single speaker blaring in one ear.

With the speaker setup illustrated in figure 6.6, true surround sound is not possible because of the lack of rear speakers. This was an aesthetic decision as I find sounds positioned behind the audience to be distracting.

6.7 Spatialization Types:

There are different ways that I used the surround speakers during the performance. The following sections explain these techniques.

6.7.1 Stereo Swell

At different points during the piece the panning of the audio materials is controlled by the volume of the instrumentalists. This means that as instruments got louder, the sound source of the electronic elements moved out into the hall. Panning sounds off the stage creates a sense of energy and excitement that builds with the volume of the performers. This technique was used in the middle section. At measure 147 the stereo swell is triggered by the bass drum.

6.7.2 Individual Sources

I used Kontakt's built in surround panner to place certain sounds within the surround space. Depending on where the sounds were placed, this could give the impression of a larger than life drum kit, or a natural localized sound. This technique was used in the introduction. mm. 1-5

[23] The sweet spot is the point in the hall where all audio elements are well balanced from a listening perspective

6.7.3 Moving Sources

There are many ways to control the placement of sounds in real time using Kontakt. Each sound file can be given a unique path though space like in M.M. Or, as was the case in the final section, triggered sound can be randomly panned all over the hall. This effect was particularly dramatic.

Chapter 7: Future Directions

7.1 Introduction

During the pre-compositional processes of *Codecs* I anticipated technical problems and developed solutions, often in the form of added features in my patch that I programmed for Max/MSP. When *Codecs* was performed my working method and Max/MSP patch were tested in rehearsal and concert settings. These experiences gave me the opportunity to create a list of changes that would improve the functionality and the musicality of my working method. The following section outlines possible improvements to my working method.

7.2 Improvements in the Electronics

7.2.1 Improved Panic Functions

In rehearsal it was sometimes necessary to stop all electronic sounds and processes instantly. A feature that allows for a full stop in processing to occur with one click is called a "panic" function. A panic function is a useful feature in many musical situations. For example, during a false start the conductor cuts off the ensemble and quickly restarts. The electronics need to be able to start and stop just as quickly. Usually implementing this feature is not an issue because audio is handled within Max/MSP where it is easy to stop all outputs. I chose to use Kontakt as my primary audio source, and panic functions are not as straightforward in this software. Although, believe it is possible to send mute functions to Kontakt from Max/MSP.

7.2.2 Start Anywhere

I structured my Max/MSP patch in such a way that the electronics could start at many different places in the score. These places included rehearsal letters and beginnings of gestures. In rehearsal I realized that conductors want to be able to start anywhere, no exceptions. More often than not, they want to start just before a gesture, never right on it.

In order to solve this problem, I would need to create a program that calculates approximate positioning within a sound file according to a given measure number. This would require a complete overhaul of my max patch and the possible elimination of the Kontakt from the framework.

7.2.3 Visual Feedback:

A screen with a simplified interface could help the performer recover from missed cues during performance. Not knowing the state of the electronics is a source of stress for the performer. The problems with a lack of visual feedback became apparent when both the performer and technician compensated for an error simultaneously, canceling out both of their efforts. A straightforward diagram with cue number, rehearsal letter, and upcoming cue would be enough. Fixing this problem would involve a secondary monitor, which would unfortunately add clutter and complexity to an already complex setup.

7.3 Customized Software Tools

7.3.1 Open Music

It would be a straightforward process to create a set of Open Music[24] tools that can transform a source progression in the ways outlined in chapters 2, 3 and 4. These tools would save a lot of time during the pre-compositional process and allow for more experimentation with complex materials.

7.3.2 Harmonic Simulations

I would like to create a software tool that takes any musical material and calculates possible source progressions and cipher chords. This would require simulations and brute force computation. The result would be a piece of software that reverses the working order that I used in the creation of *Codecs*. Being able to invert diagram 2.2 would be exciting and would expand the possibilities of my system.

[24] Open music is a visual programming language for music. http://sourceforge.net/projects/ircam-openmusic/

7.4 Practical Considerations

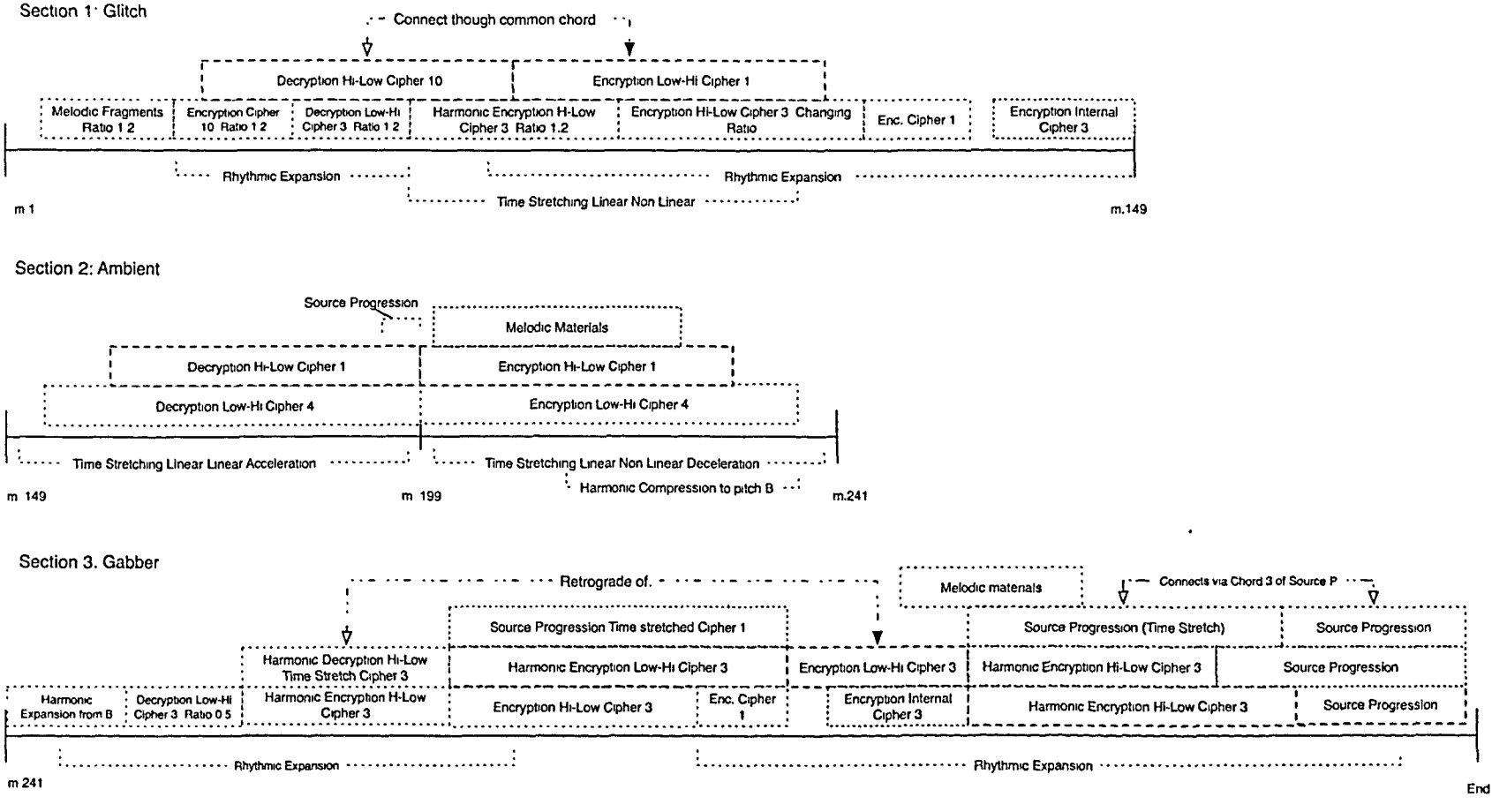
7.4.1 Mallets

The V-Drums shown in figure 6.4 emit an audible clicking sound when struck with wooden drumsticks. This is not a problem during loud sections. However, during softer sections of the performance, some clicking was audible. Softer mallets and adjusting the sensitivity of the V-Drums could rectify this problem although not entirely solve it. This is because of the minimum physical impact required for a trigger.

7.4.2 Numbering

Separating cue numbers and measure numbers was a mistake. It added a level of abstraction that made it difficult for the technician to reset the patch quickly and to follow the conductor during rehearsal. This problem is easy to fix but would require modifying and re-printing the score and parts.

Appendix A: Formal Sketch



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Eliot Britton

for 16 instruments and Live Electronics

Eliot Britton

Codecs (2008)

Instrumentation:

Flute/Piccolo
Oboe
Bassoon
Clarinet in Bb / Bass Clarinet

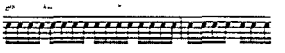
Horn in F
Trumpet in C
Trombone
Tuba

Piano
Percussion x 2

2 violins
Viola
Cello
Bass

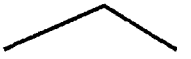
Instructions:

-(==>) Represents a gradual change in timbre example: (air ==> pitched) would be a transition as slow as possible from blowing through the instrument to playing clear notes. The transition covers the length of the dotted line. Molto sul tasto ==> molto sul point represents slowly sliding the bow to the bridge.



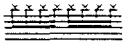
-Hairpin dynamic levels should be gradual, even over several measures

-All pitch bends are approximate. Continue the bend for the duration of the thick line If the line moves to a second note head, bend the first pitch to that of the second.



* Strings.
Stay on the same string when possible When not possible, switch smoothly

-X notation·
Horn/Winds: Air blown through the instrument.
Strings Bow on the wood of the bridge, creating a dry rasping sound.
Accortion: Blow air through the air release valve.



Blocks Notation:
Cluster chords: Play all chromatic pitches that fall under the hand.
Button Cluster: Press many buttons with the palm.

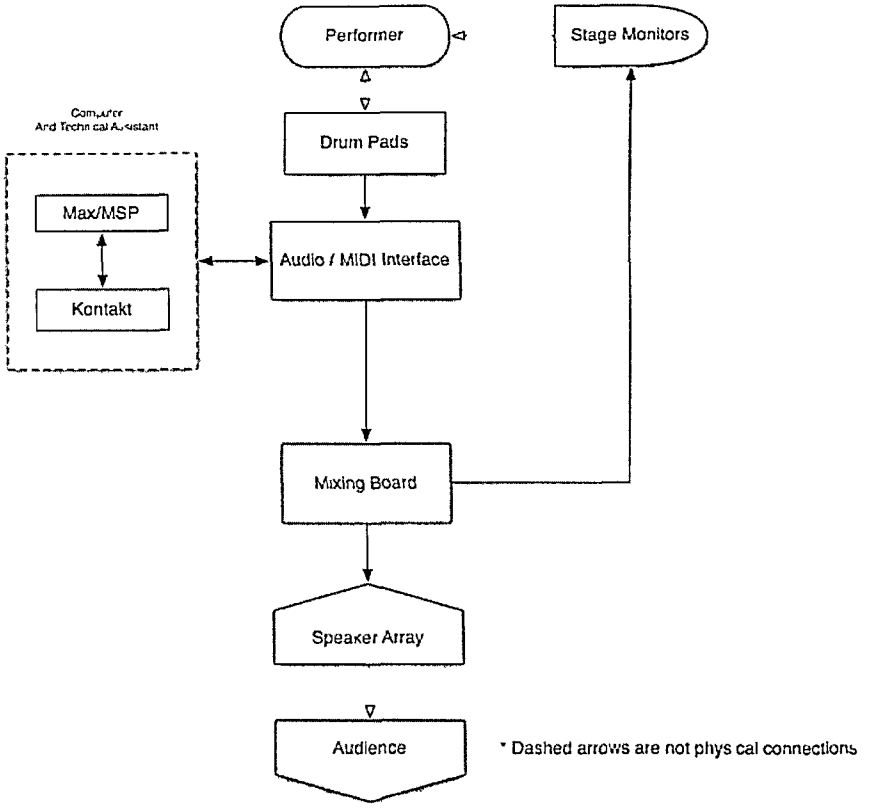
Courtesy accidentals have been added for the convince of the performers.
Conventional accidental rules still apply.

-Duration: 13 - 14 minutes
-Score notated in C
-Instruments at sounding pitch. (Except basses and piccolo)
-Almglocken and gongs are relative pitches.

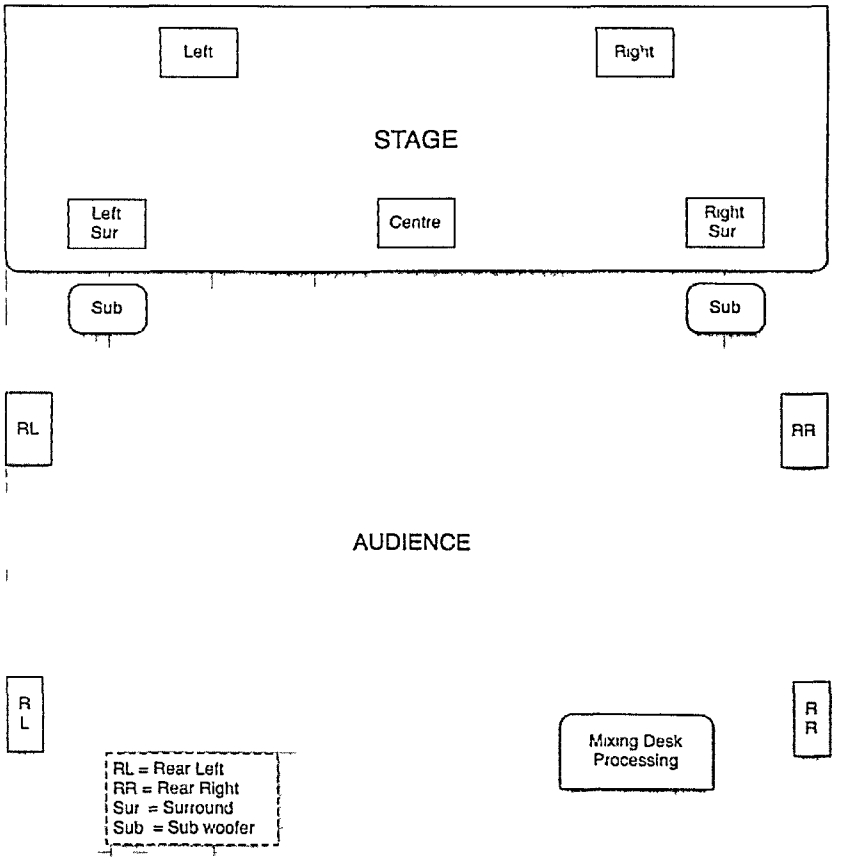
Percussion 1: piccolo snare, vibraphone, bass drum, Large Tam, Toms 1 tubular Bell, 2 Toms, Piccolo woodblocks

Percussion 2: 3 Drum Pads, 5 low cow bells, 3 resonant metals, ride cymbal. glockenspiel.

Signal Path



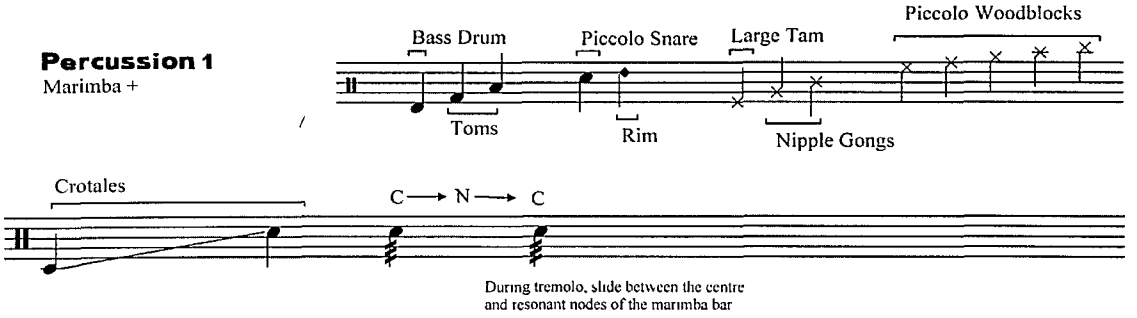
Speaker Placement



CODEX Percussion Key

Percussion 1

Marimba +



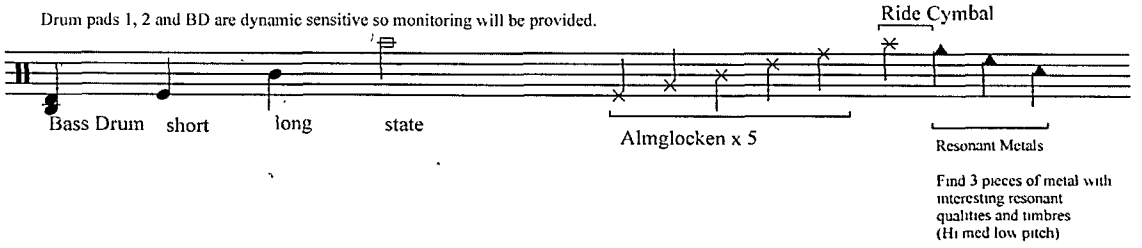
Percussion 2

Glockenspiel +

Electronic Drum Pads:

Bass Drum Pad triggers bass drum sounds and longer samples.
Drum pad 1 (Short). This drum pad triggers shorter dynamic sound files.
Drum pad 2 (Long). This drum pad triggers longer sound files.
Drum pad 3 (State): This drum pad triggers patch changes in the electronics.

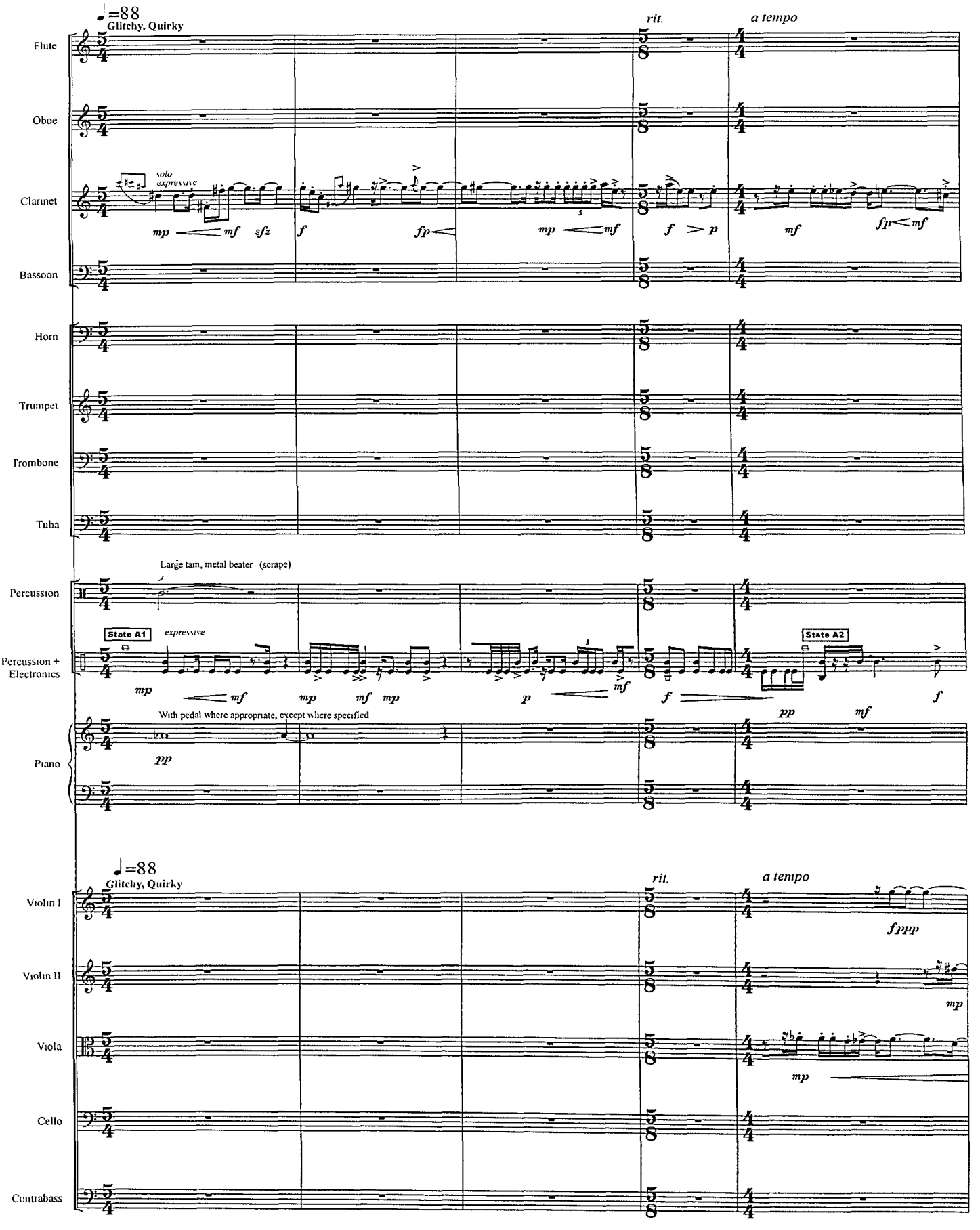
Drum pads 1, 2 and BD are dynamic sensitive so monitoring will be provided.

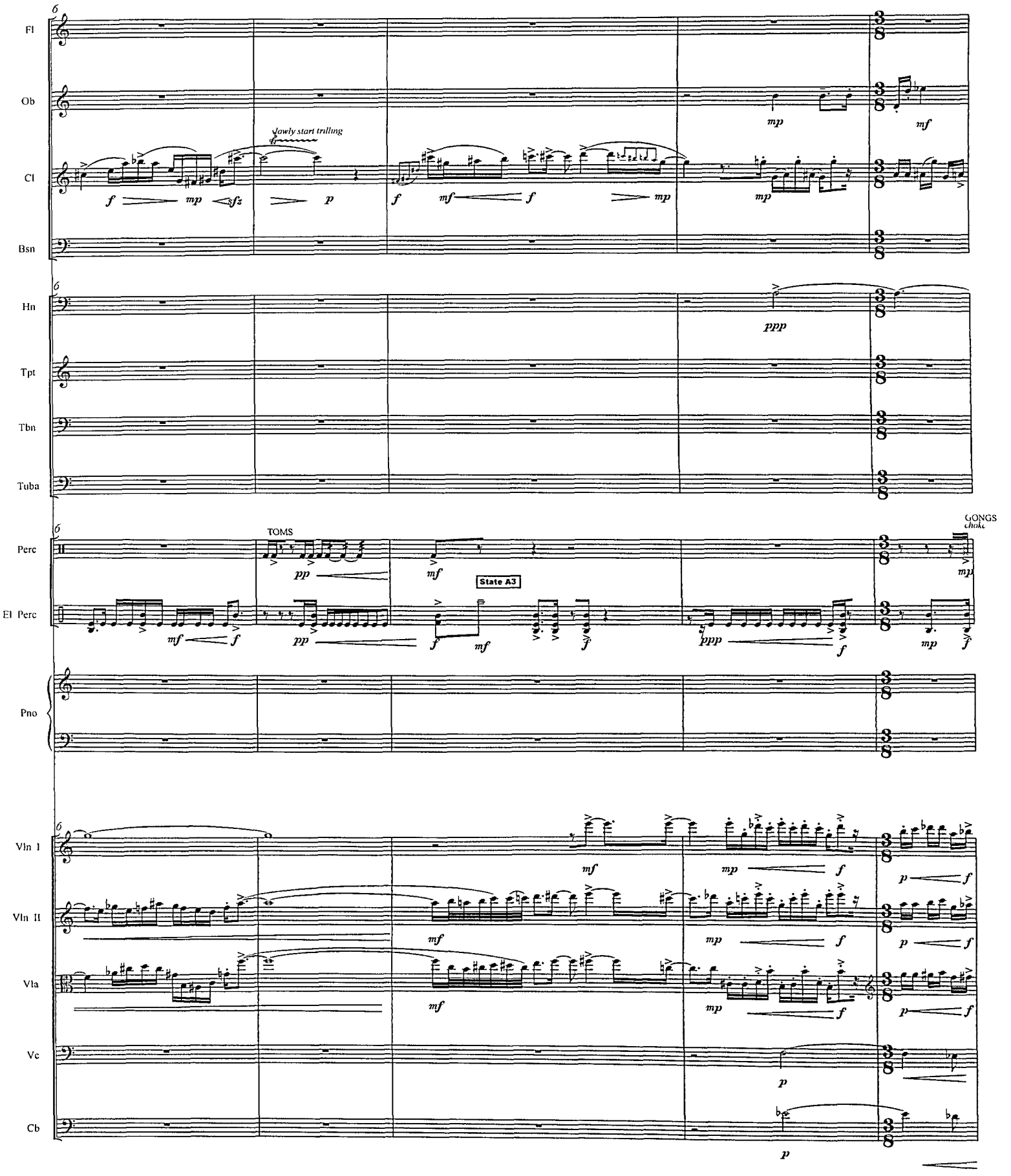


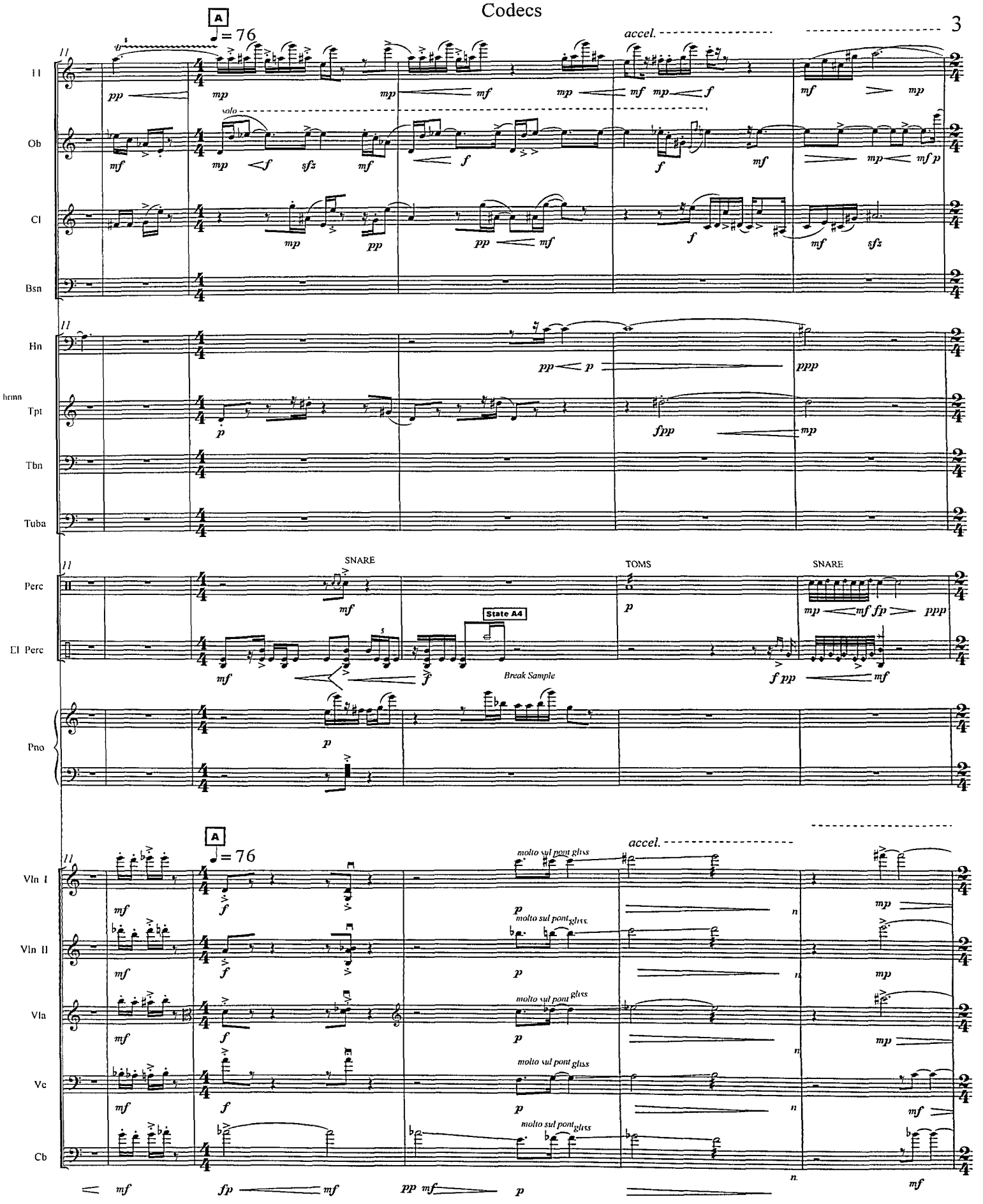
N.B. There is one section where perc 2 is asked to play the bass drum

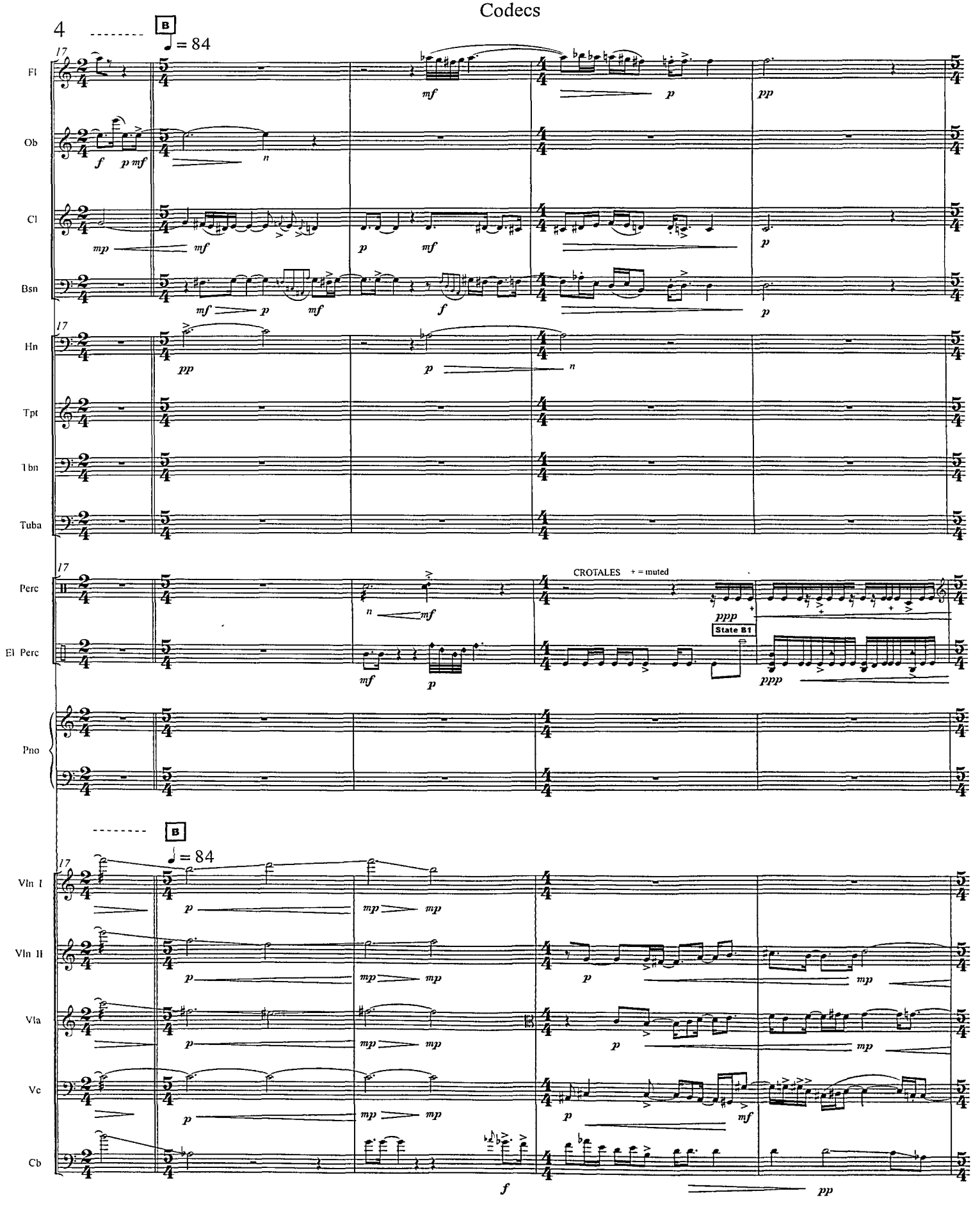
CODECS

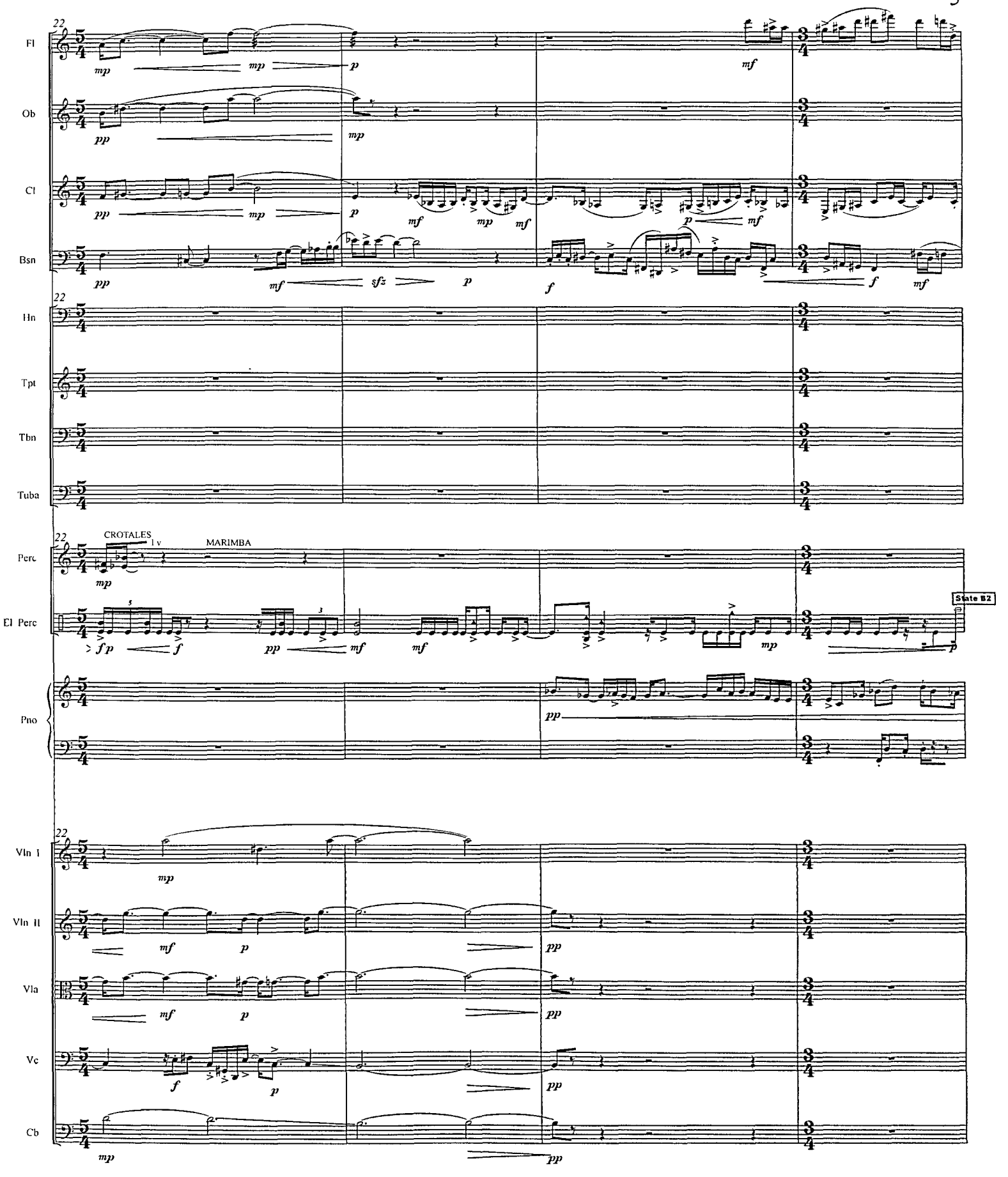
Eliot Britton

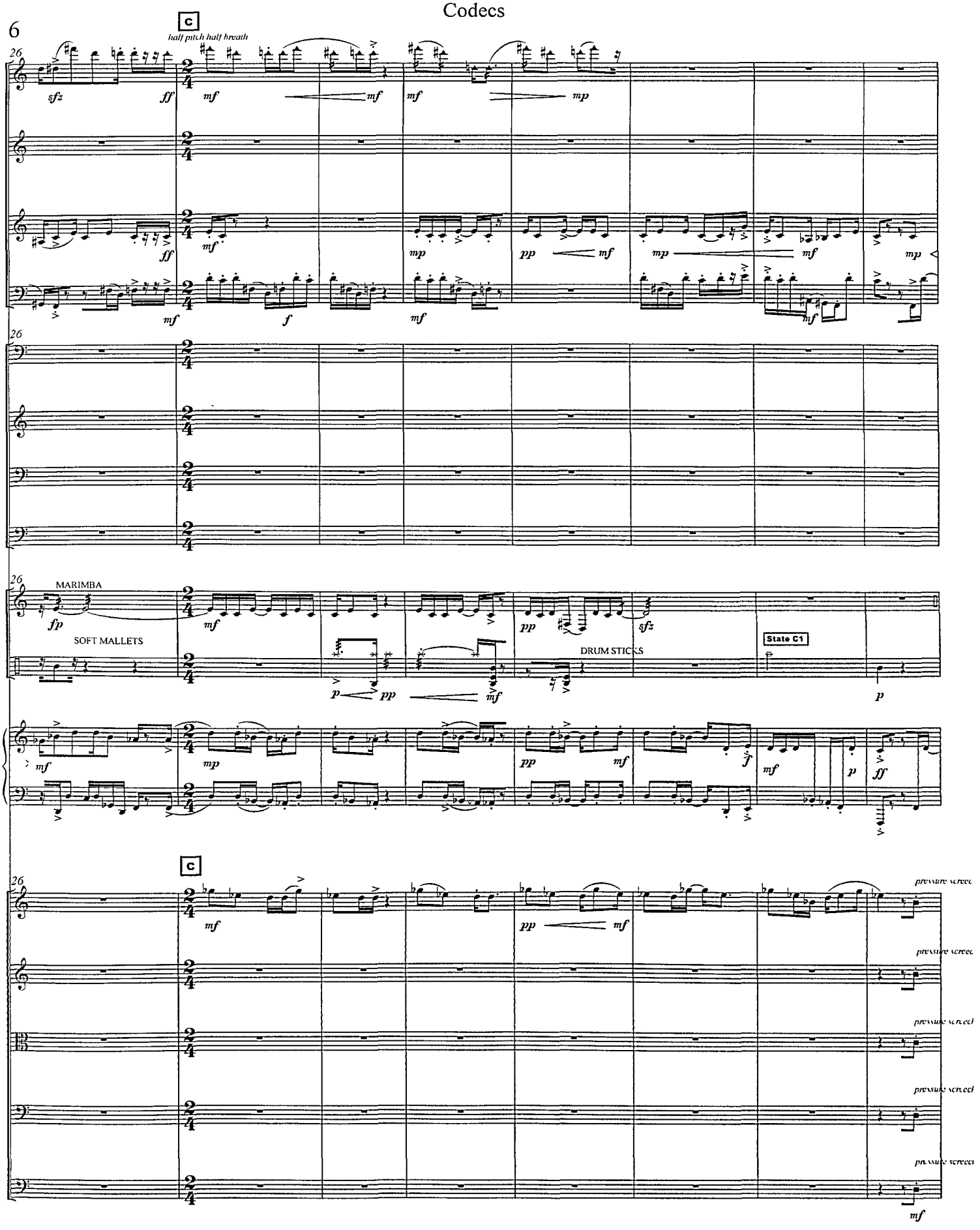


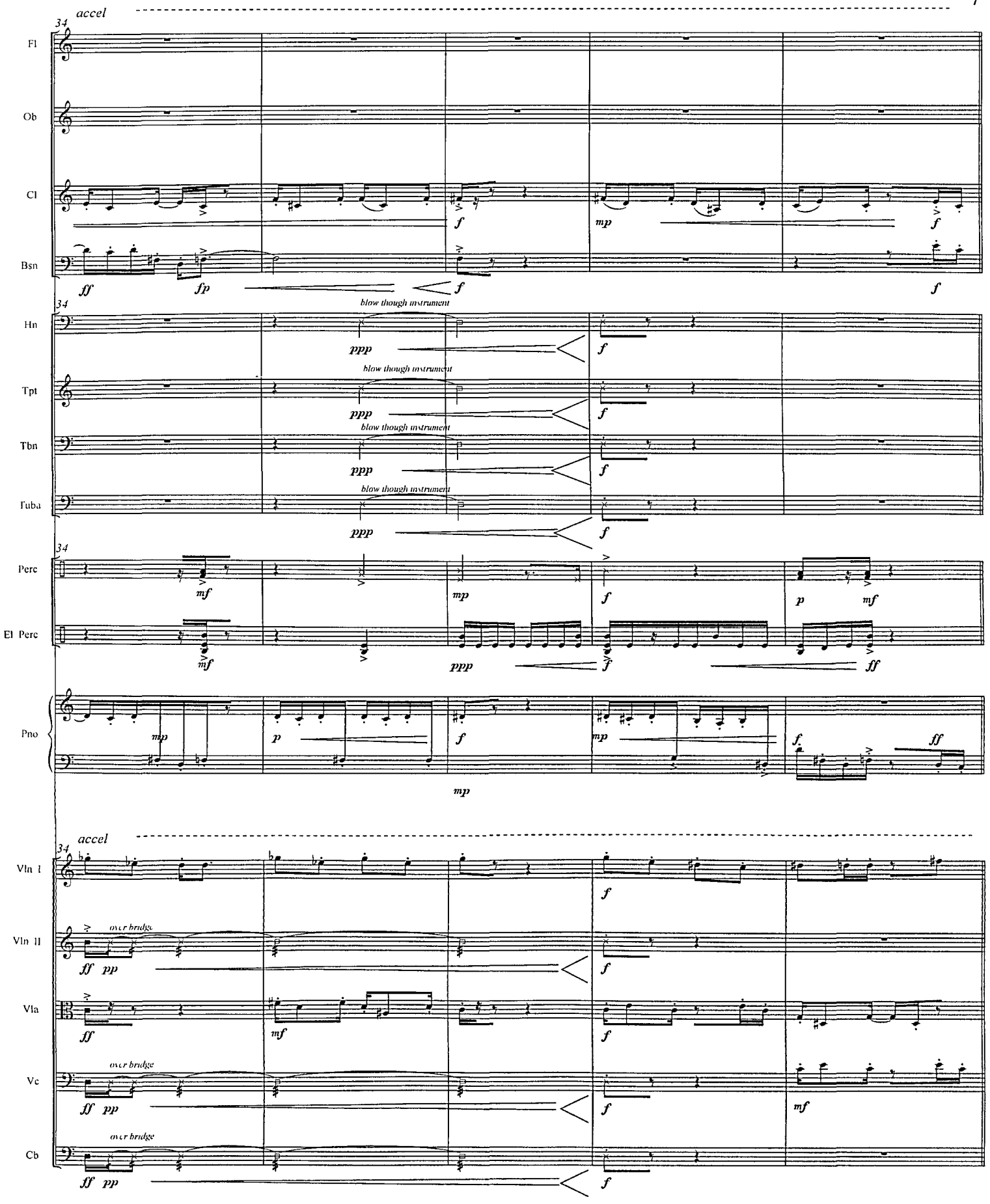

Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
Slowly start trilling
TOMS
State A3
GONGS
choke

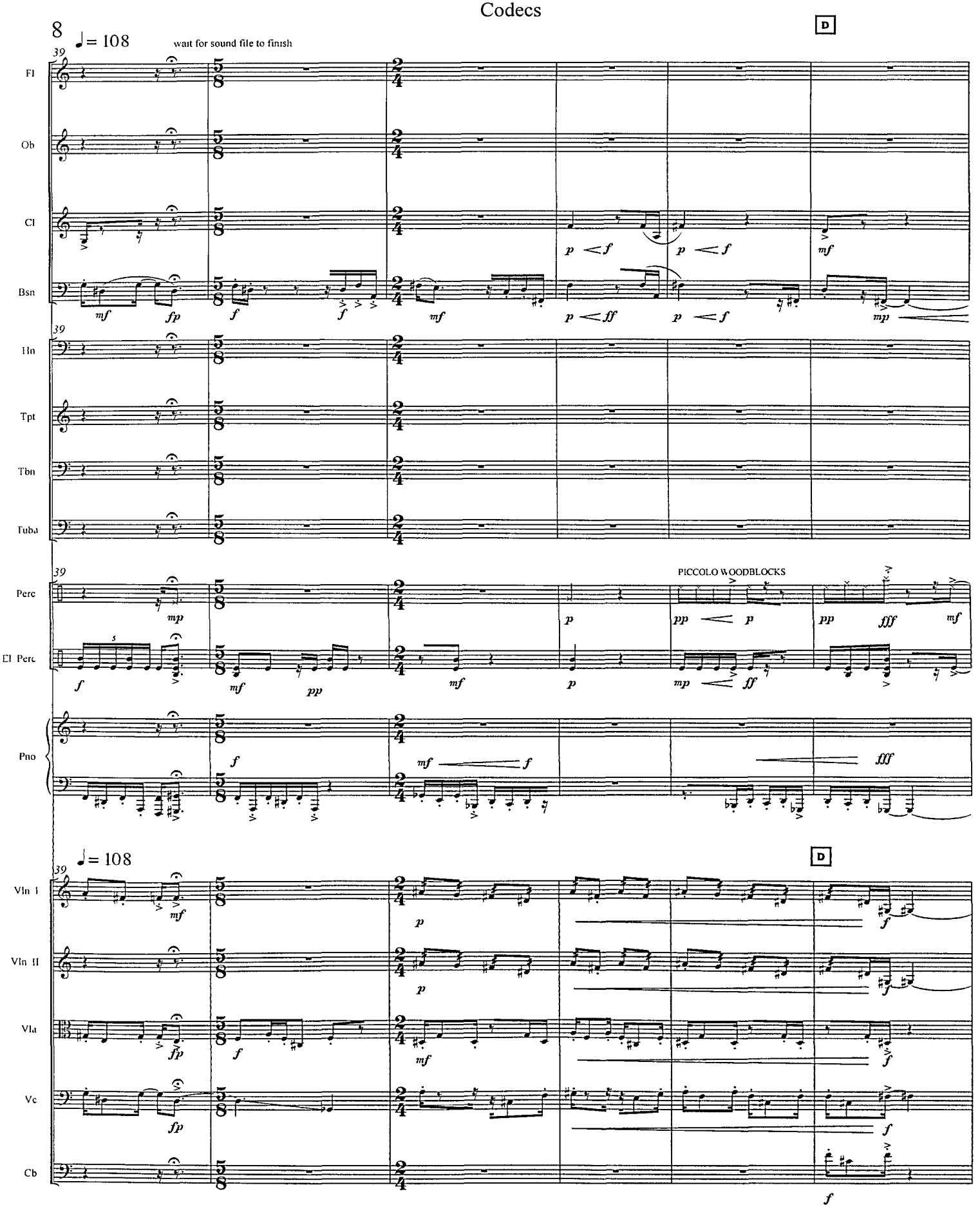

A
♩= 76
accel.
Fl
Ob
Cl
Bsn
Hn
hmn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
SNARE
TOMS
SNARE
State A4
Break Sample
A
♩= 76
accel.
Vln I
Vln II
Vla
Vc
Cb
molto sul pont gliss

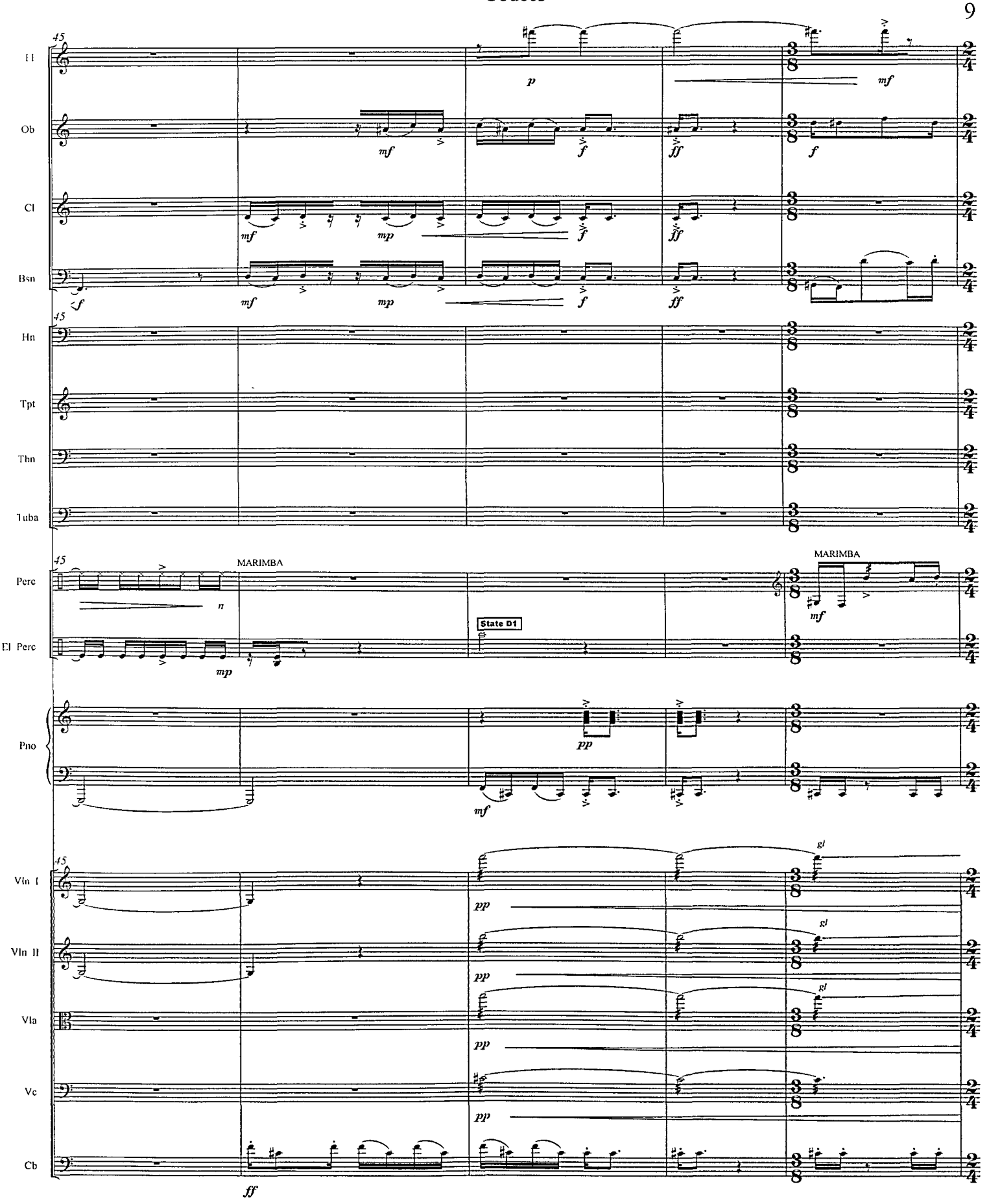

4
B
♩ = 84
17
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
CROTALES + = muted
State 81
B
♩ = 84
Vln I
Vln II
Vla
Vc
Cb

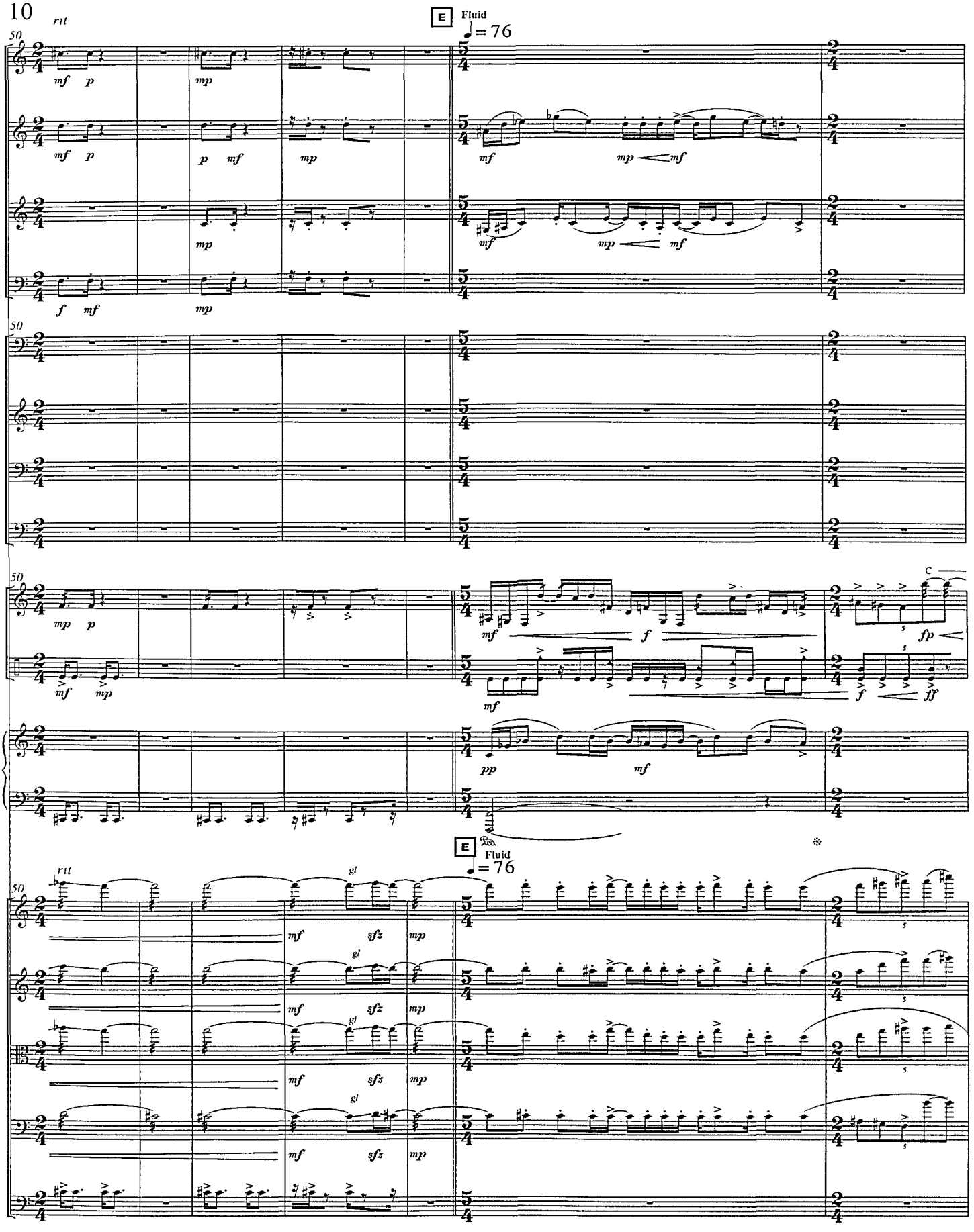

22
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
CROTALES
MARIMBA
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
State 82

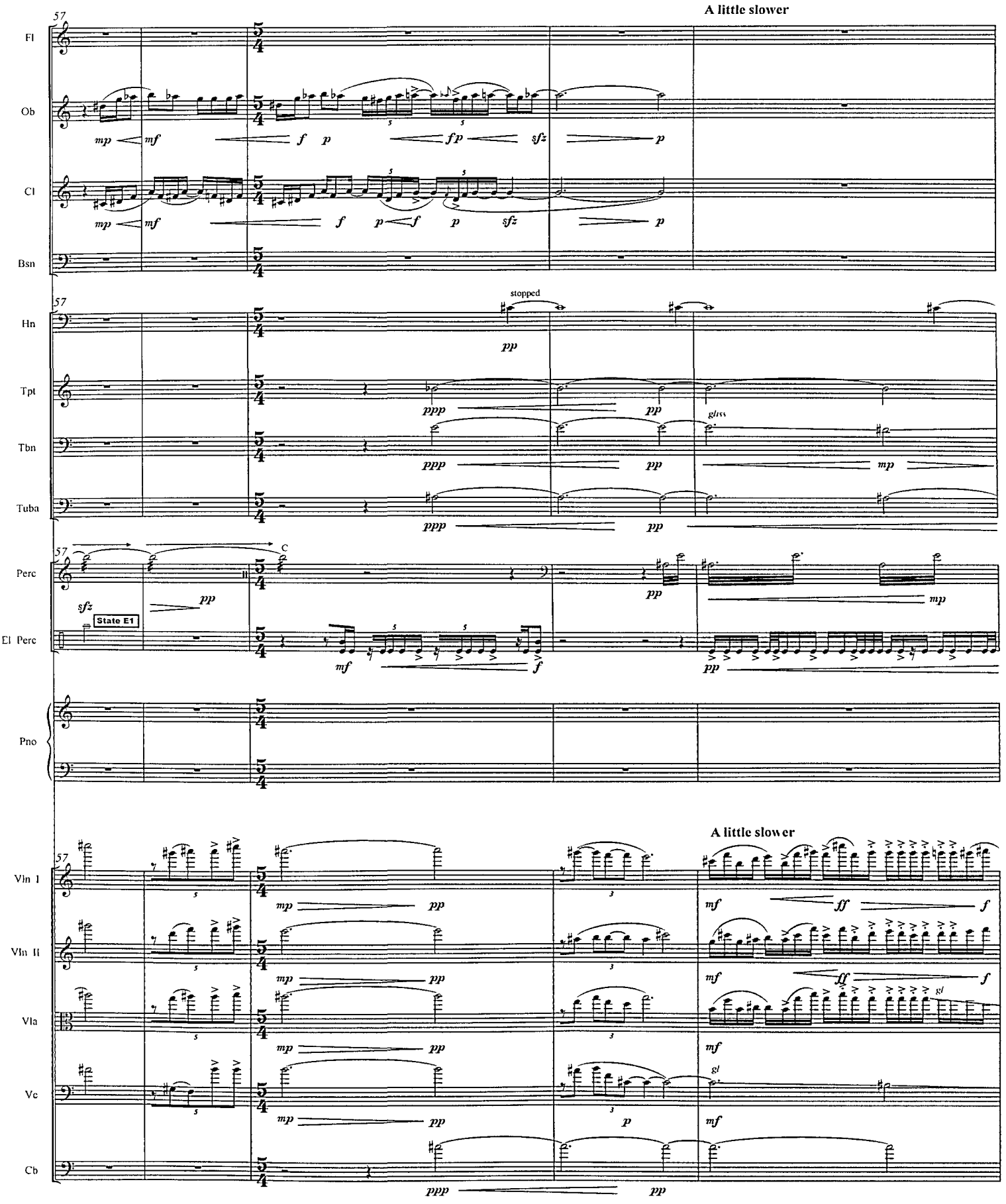

C
half pitch half breath
26
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
MARIMBA
SOFT MALLETS
El Perc
DRUM STICKS
State C1
Pno
C
Vln I
Vln II
Vla
Vc
Cb
pressure screech


accel
34
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
blow though instrument
over bridge


8
♩= 108
wait for sound file to finish
D
39
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
PICCOLO WOODBLOCKS
Pno
♩= 108
D
Vln I
Vln II
Vla
Vc
Cb


45
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
MARIMBA
MARIMBA
State D1
p
mf
f
ff
mp
pp
gl


10
rit
E
Fluid
♩ = 76
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
Fl Perc
Pno
C
rit
E
Fluid
♩ = 76
Vln I
Vln II
Vla
Vc
Cb


A little slower
Fl
Ob
Cl
Bsn
Hn
stopped
Tpt
Tbn
Tuba
Perc
El Perc
State E1
Pno
A little slower
Vln I
Vln II
Vla
Vc
Cb

Codecs

wait for sound file to finish **F** ♩=88

62 rit

Except electronics

Fl

Ob

Cl

Bsn

Hn

Tpt

Tbn

Tuba

Perc

El Perc

Keep steady tempo repeat pattern until fermata

State F1

Pno

♩=88

F

Vln I

Vln II

Vla

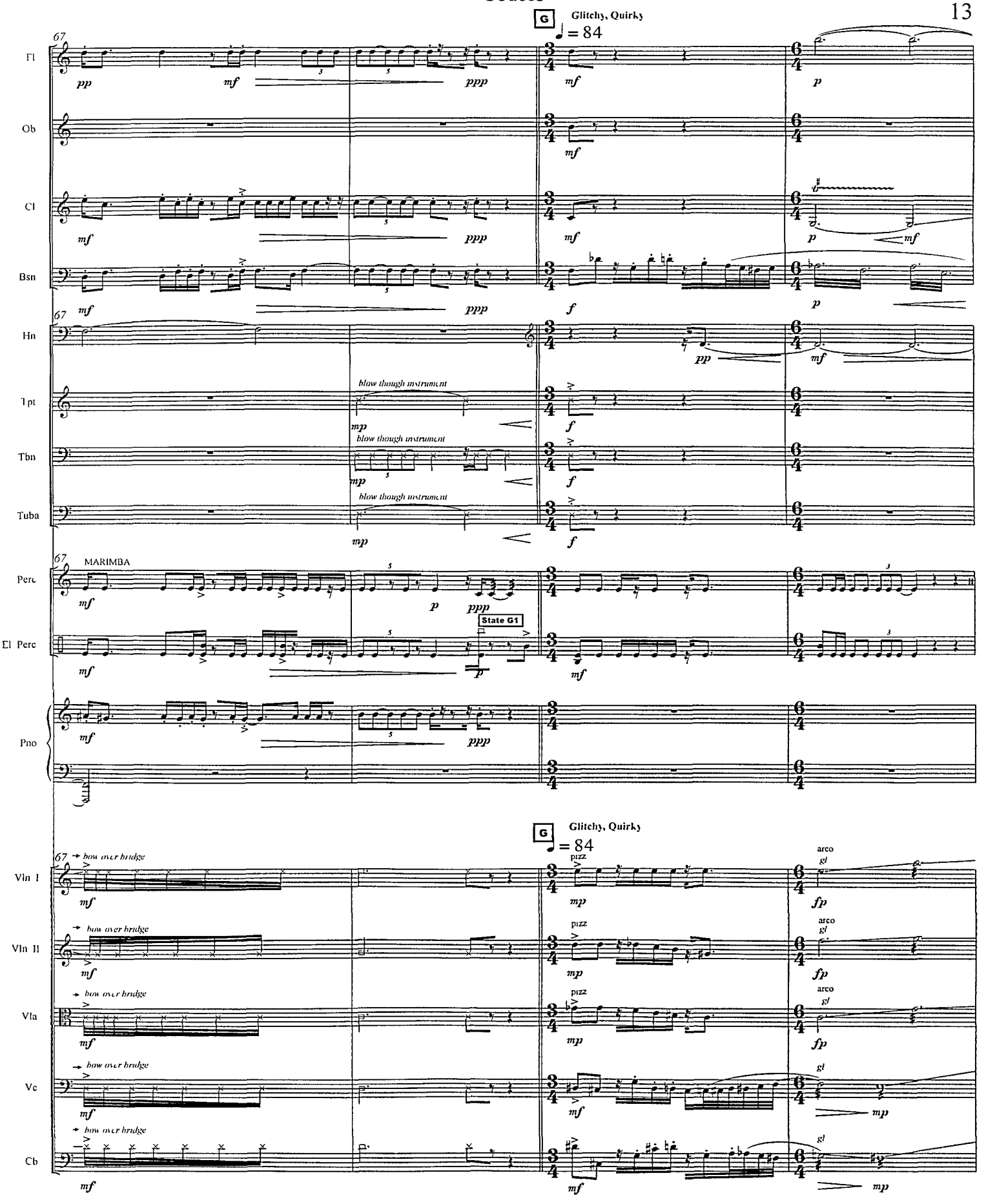
Vc

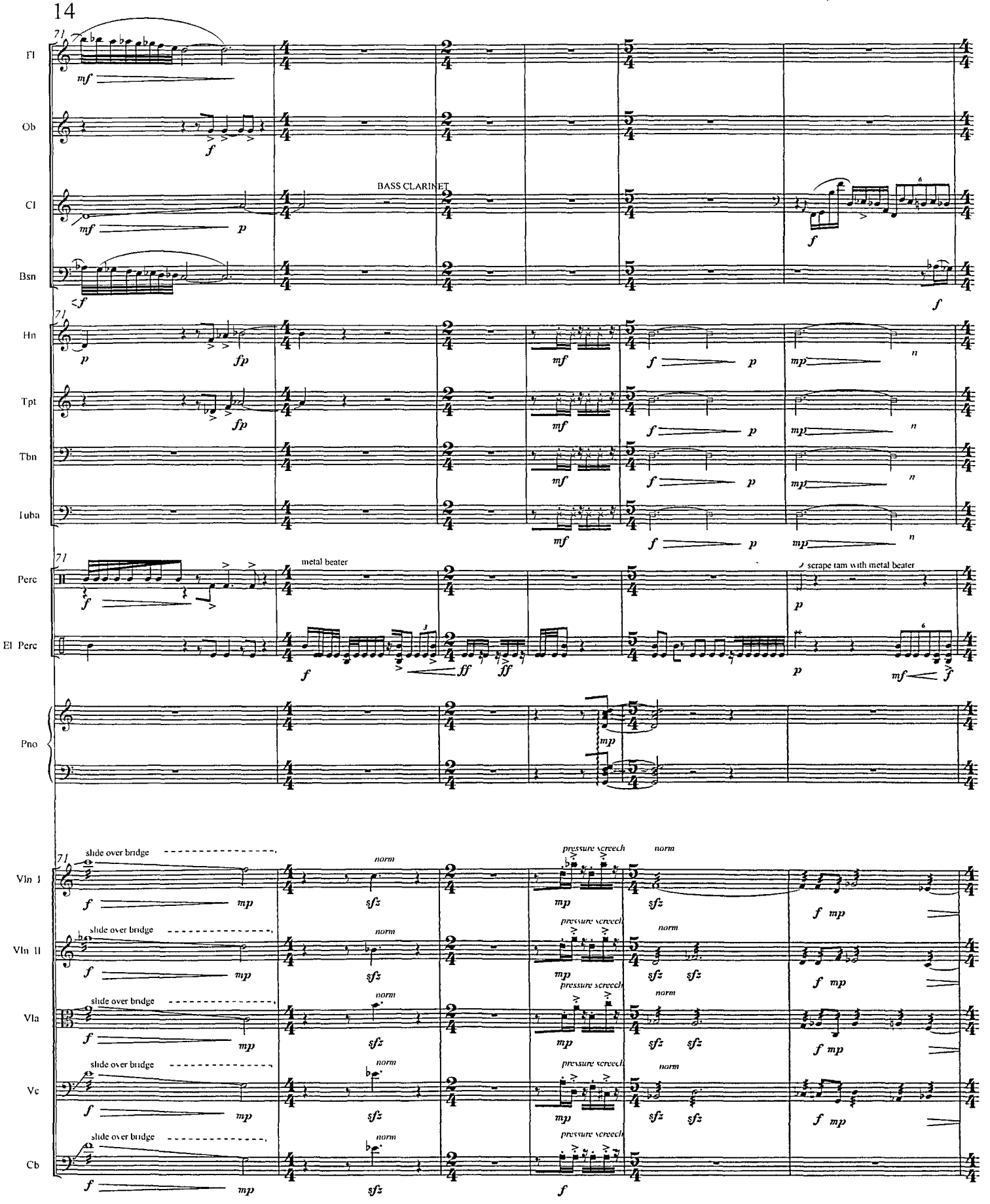
Cb

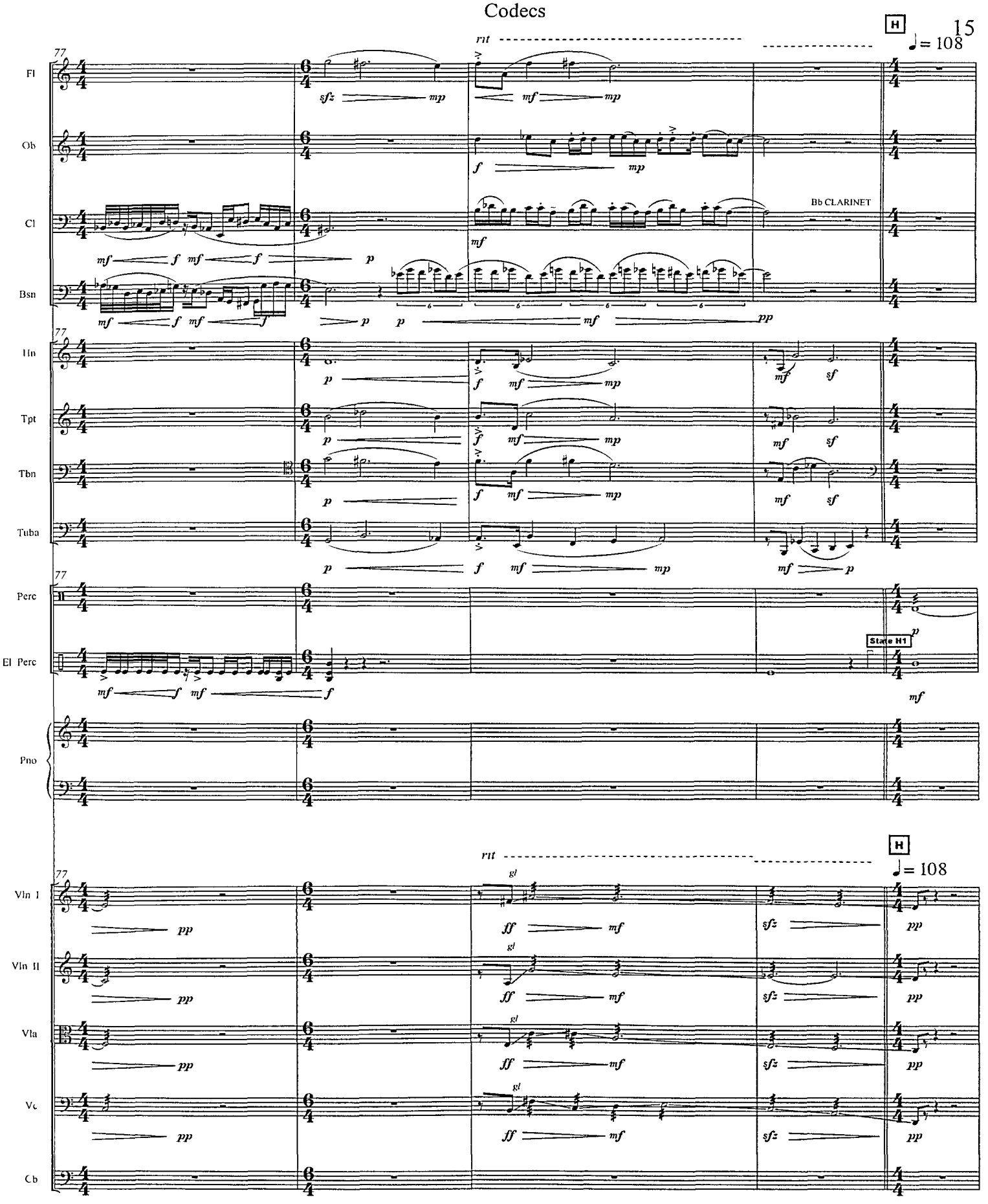
sul tasto

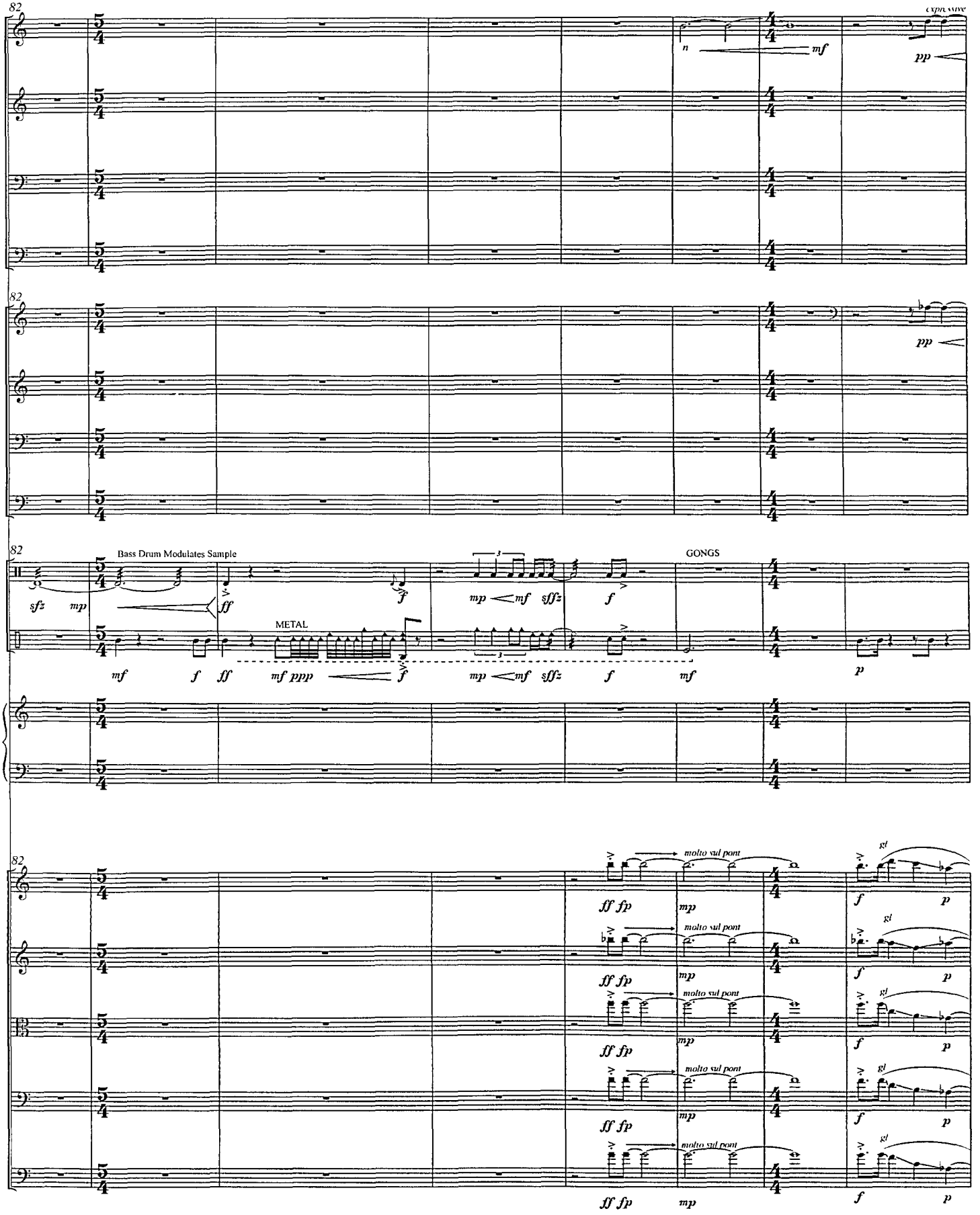
molto sul pont

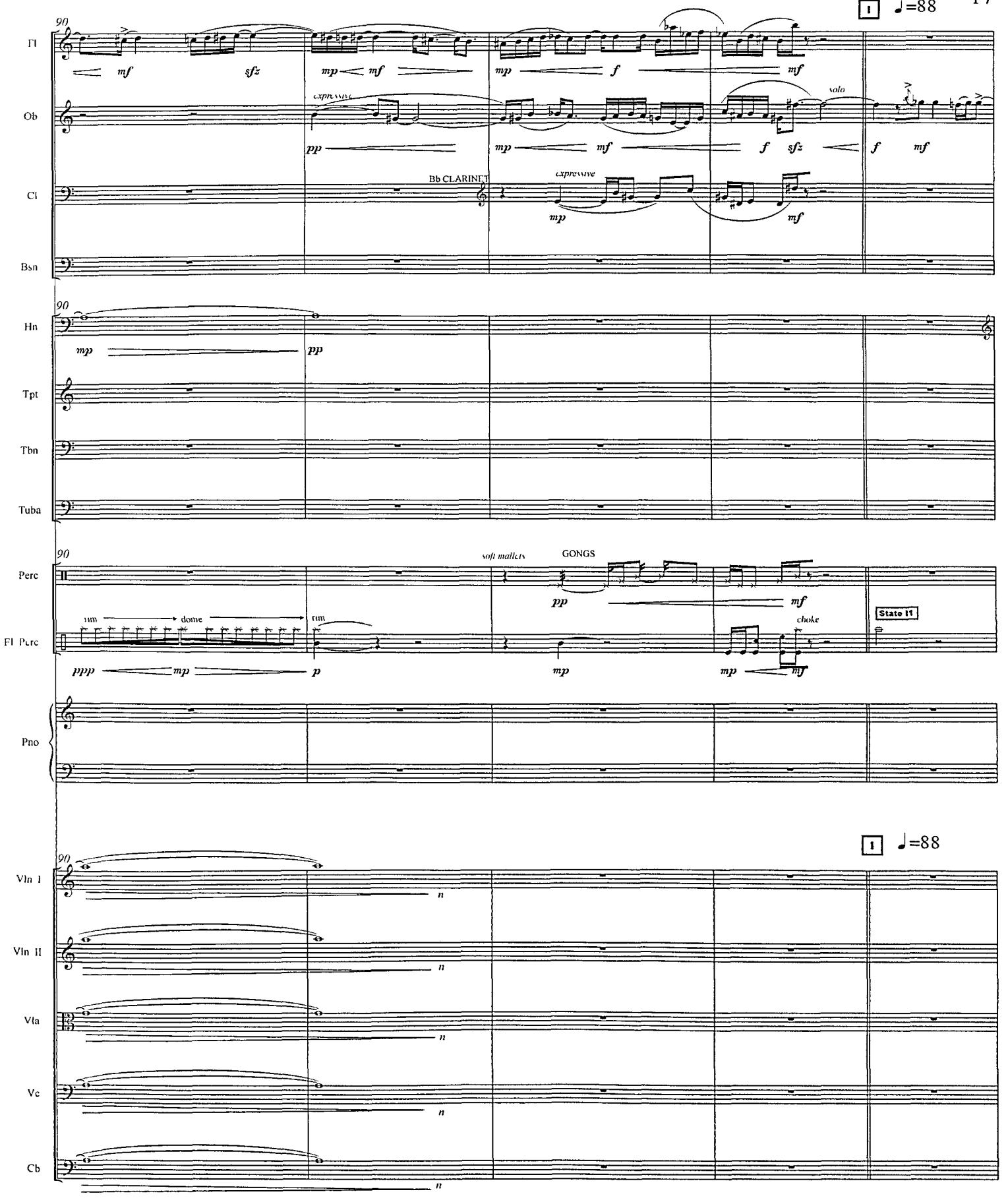
gl

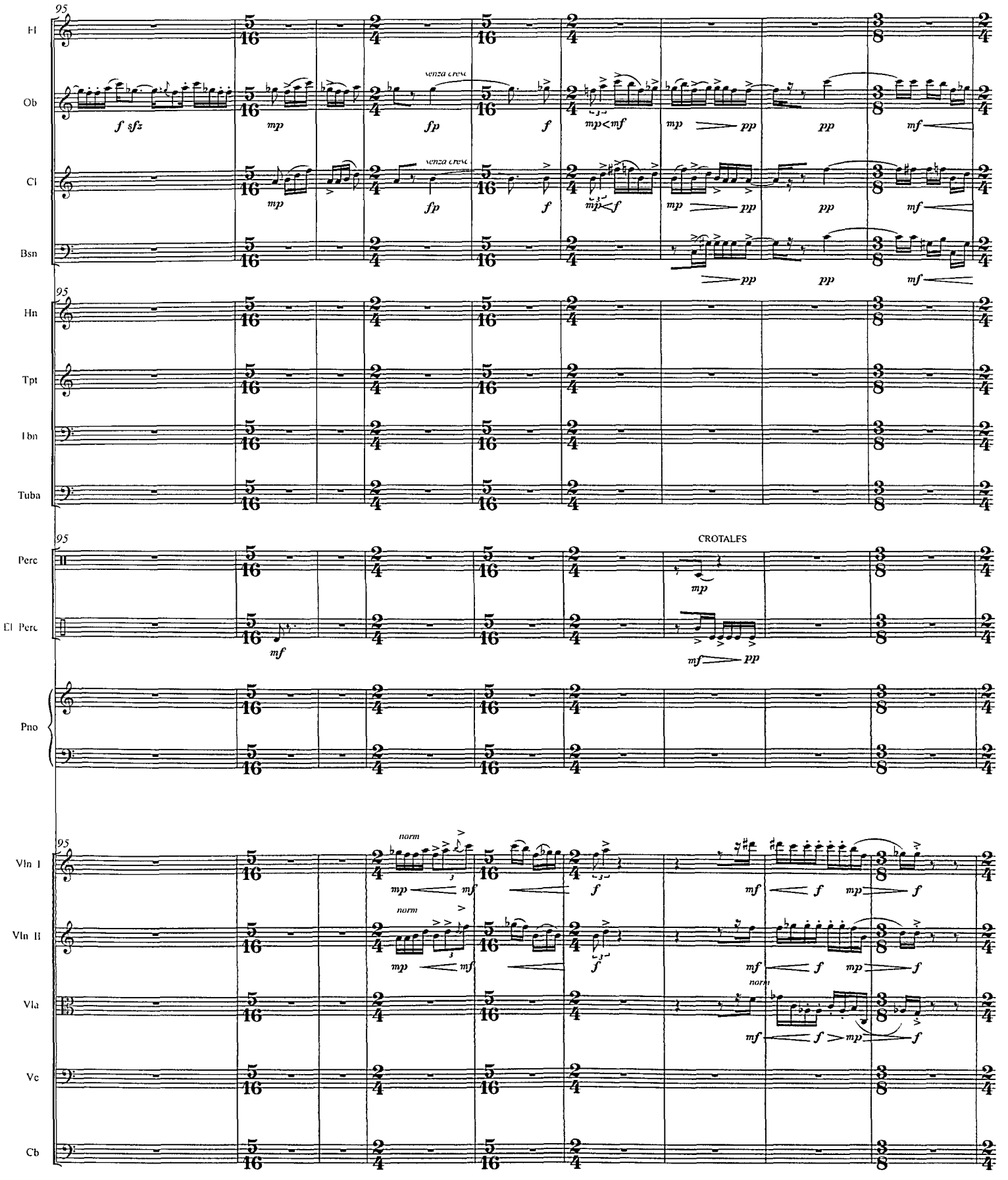

G
Glitchy, Quirky
♩ = 84
67
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
MARIMBA
State G1
blow though instrument
Vln I
Vln II
Vla
Vc
Cb
bow over bridge
pizz
arco
gl

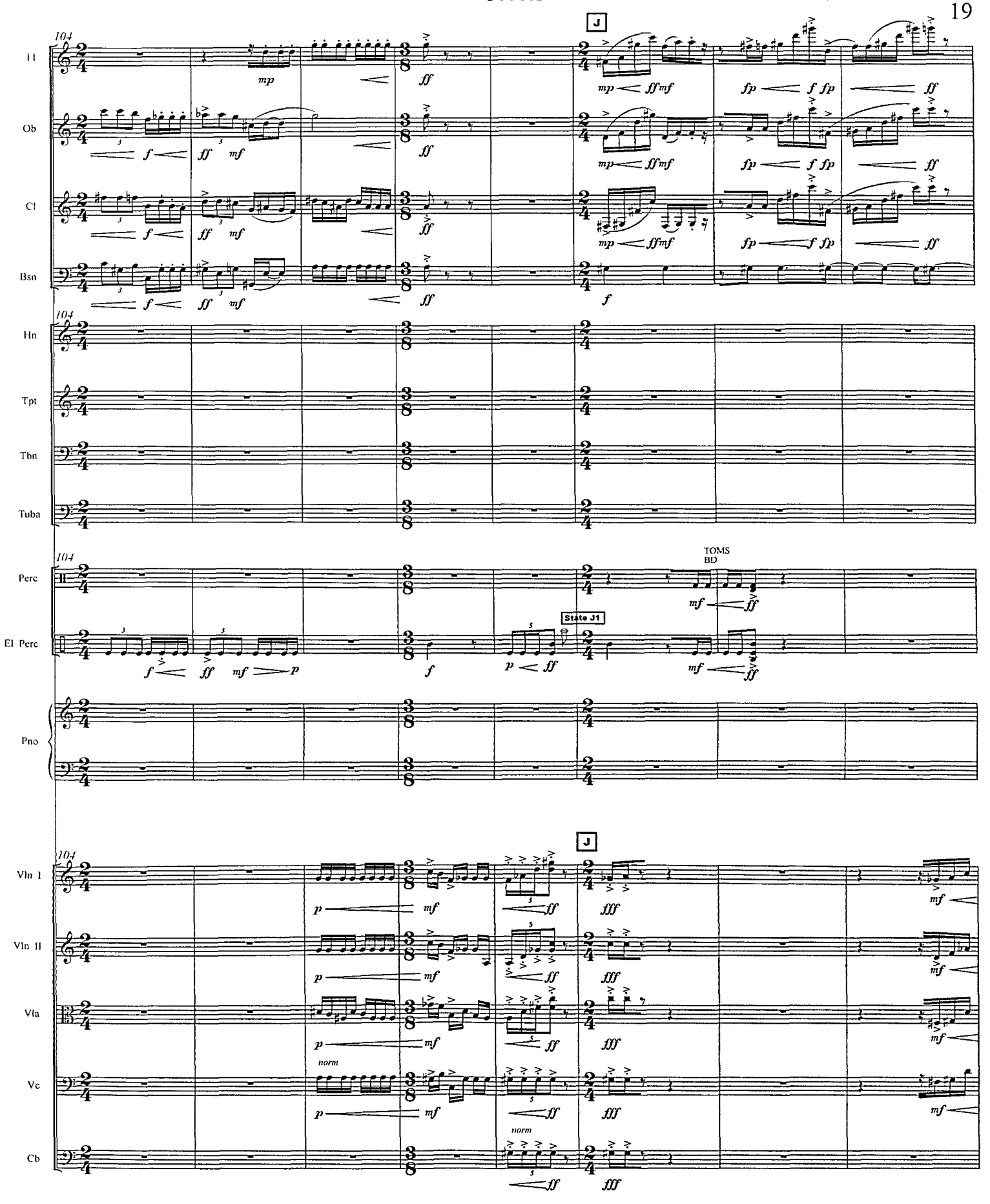

Fl
Ob
Cl
BASS CLARINET
Bsn
Hn
Tpt
Tbn
Tuba
Perc
metal beater
scrape tam with metal beater
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
slide over bridge
norm
pressure screech

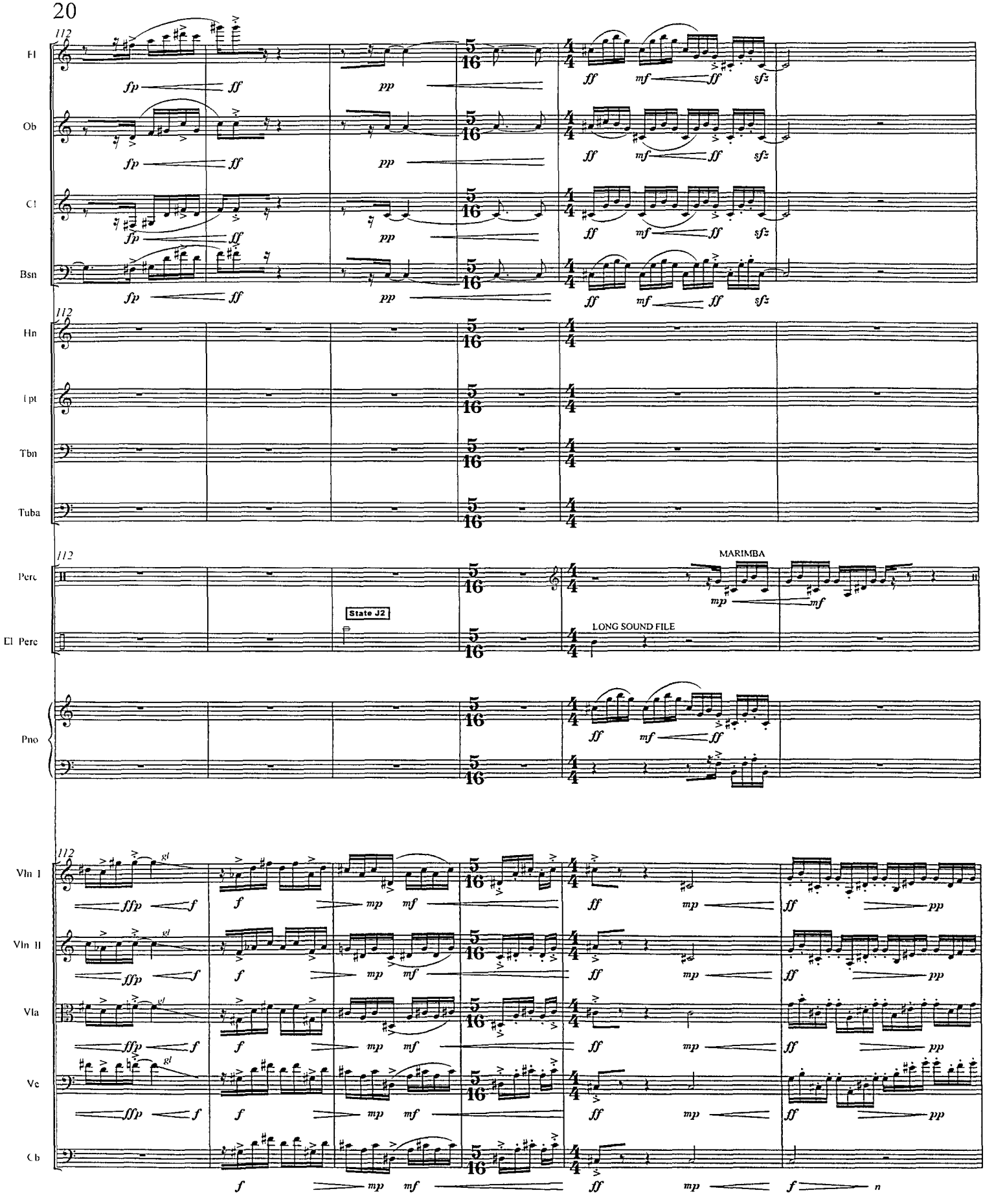

H
♩= 108
rit
77
Fl
Ob
Cl
Bb CLARINET
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Start H1
Pno
H
♩= 108
rit
gl
Vln I
Vln II
Vla
Vc
Cb

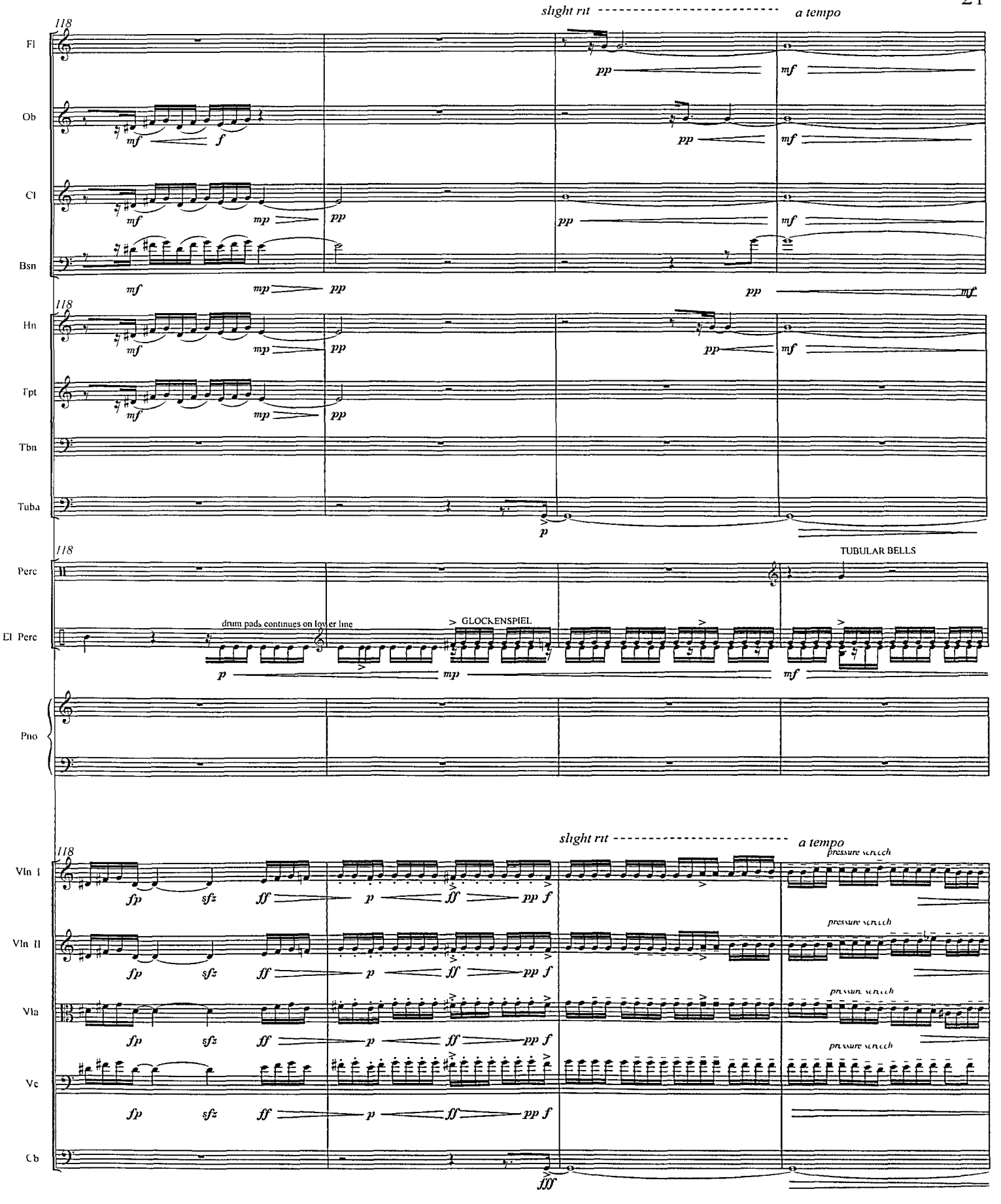

82
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
Bass Drum Modulates Sample
METAL
GONGS
molto sul pont
gl

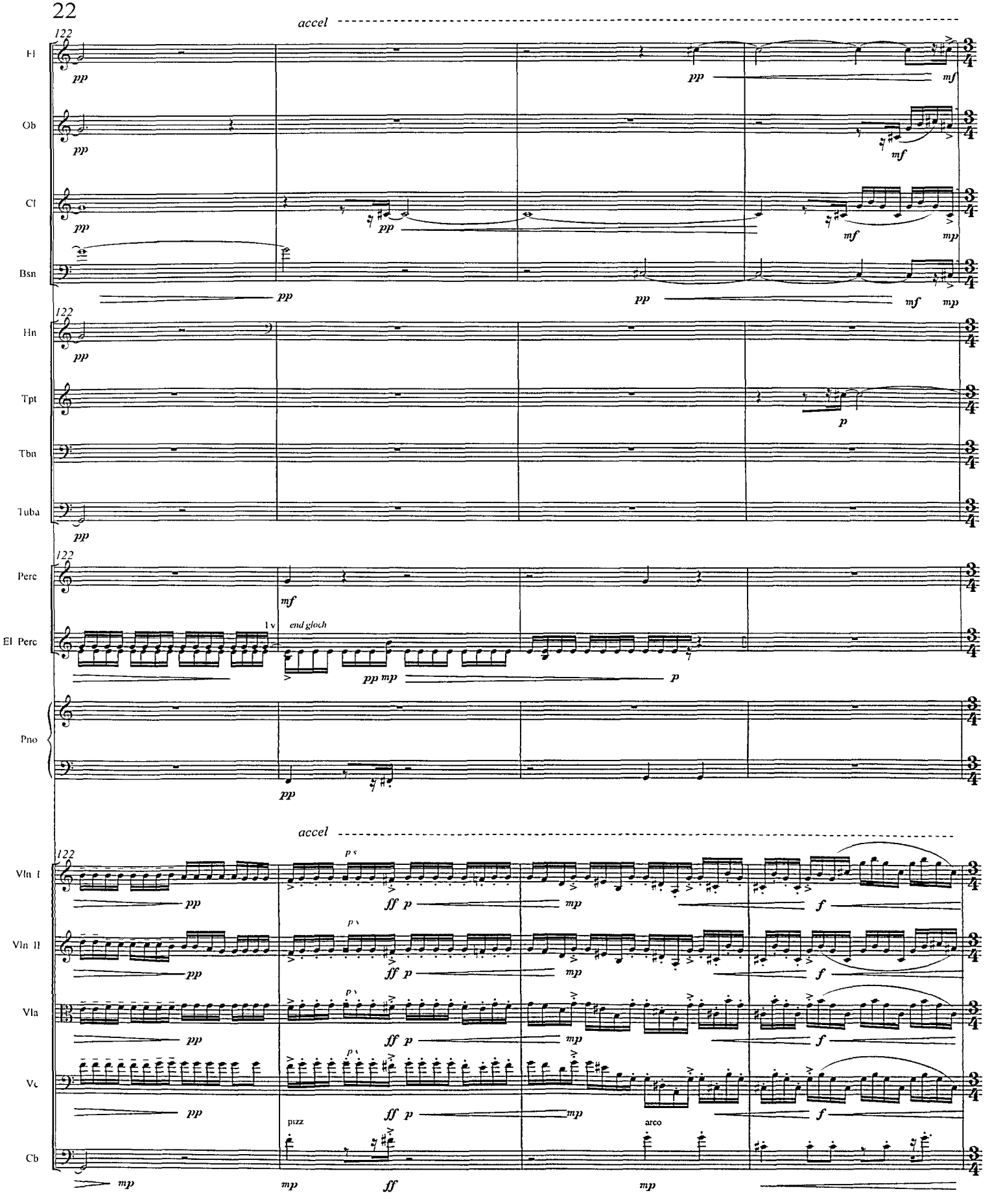

1
♩=88
90
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
Fl Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
mf
sfz
mp
f
pp
ppp
expressive
solo
Bb CLARINET
soft mallets
GONGS
rim
dome
choke
State 11
n

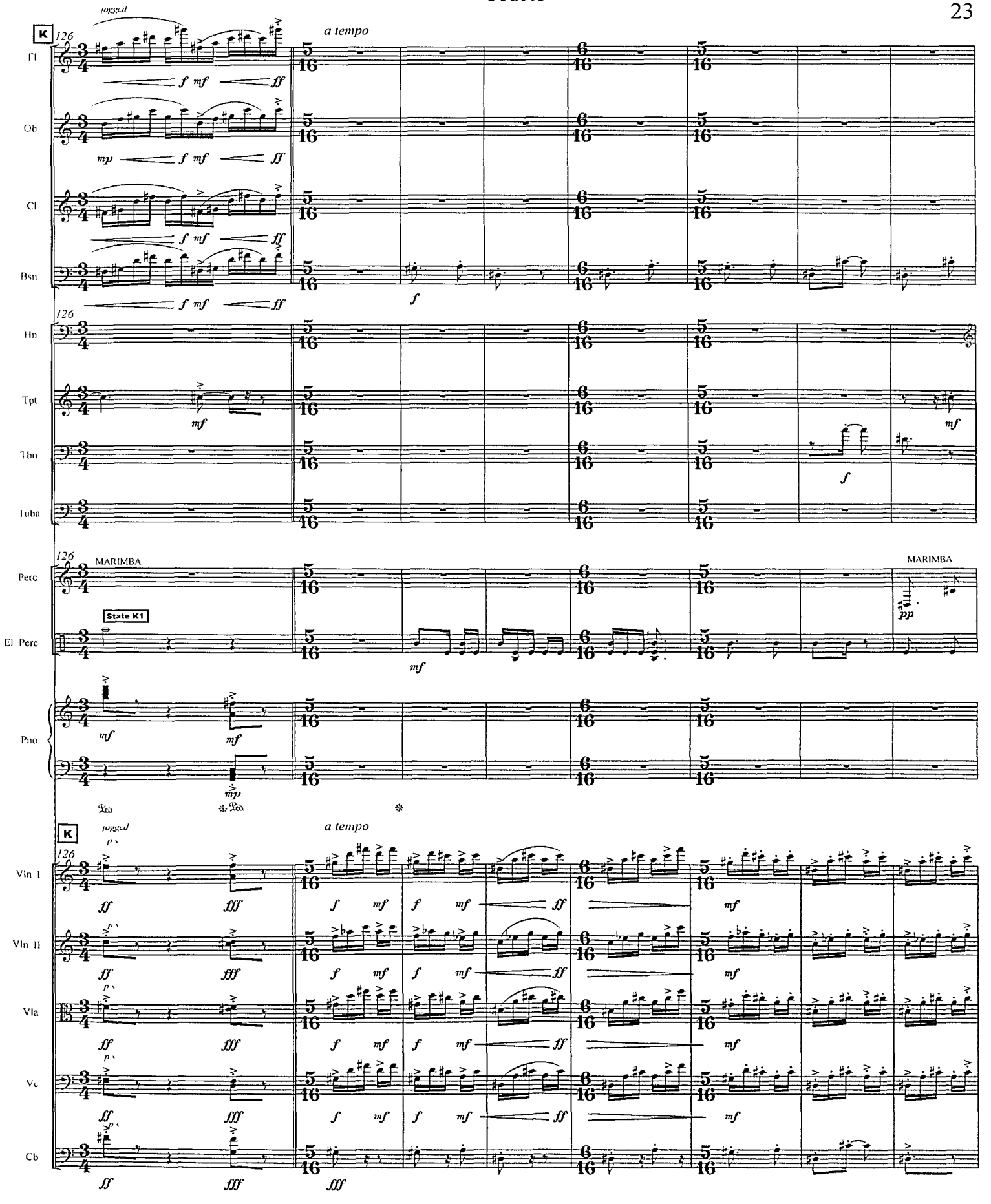

95
Fl
Ob
Cl
Bsn
senza cresc
CROTALES
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
norm
Vln I
Vln II
Vla
Vc
Cb

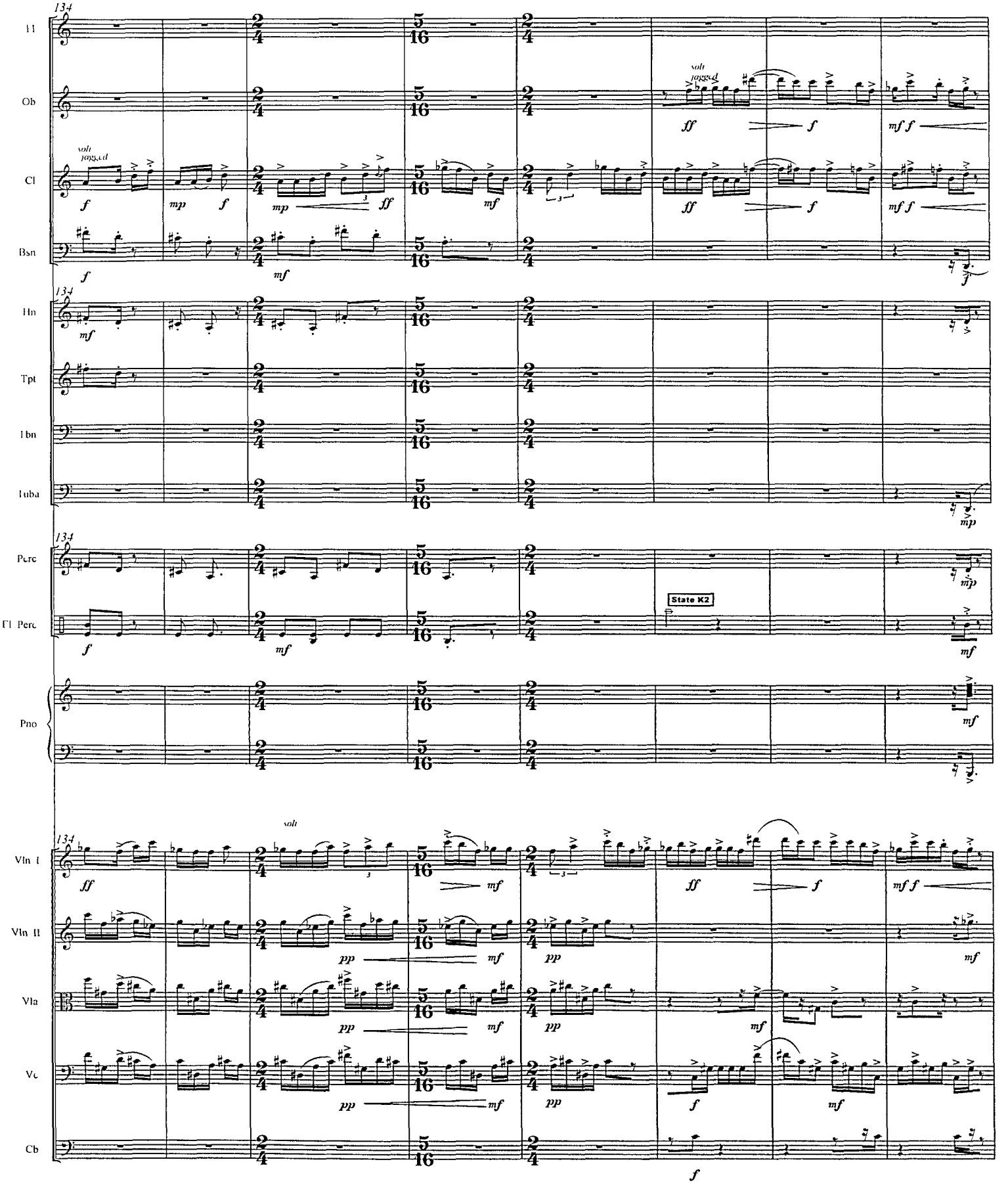

104
J
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
TOMS
BD
Stick J1
Pno
Vln I
Vln II
Vla
Vc
Cb
norm

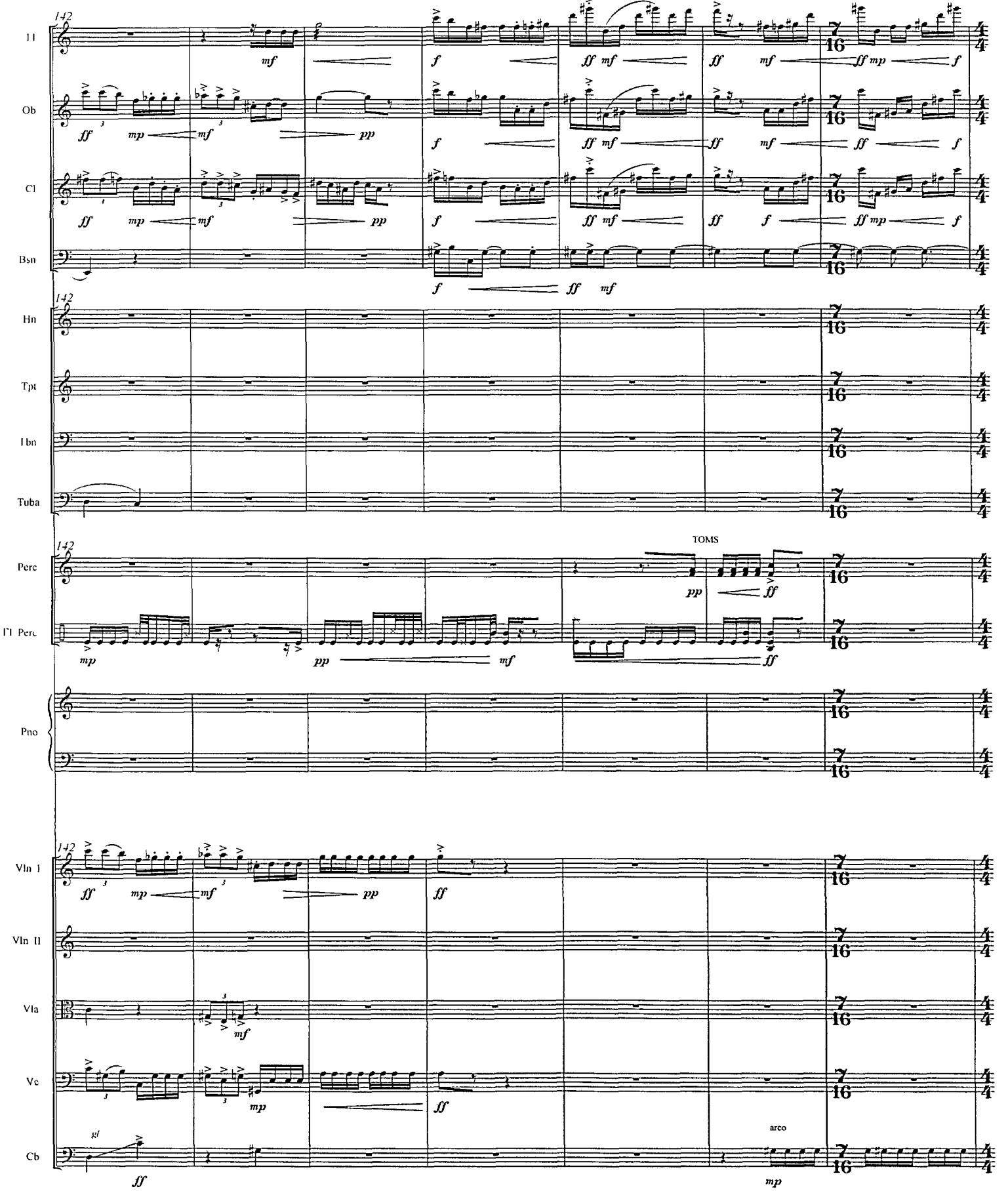

112
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
MARIMBA
State J2
LONG SOUND FILE

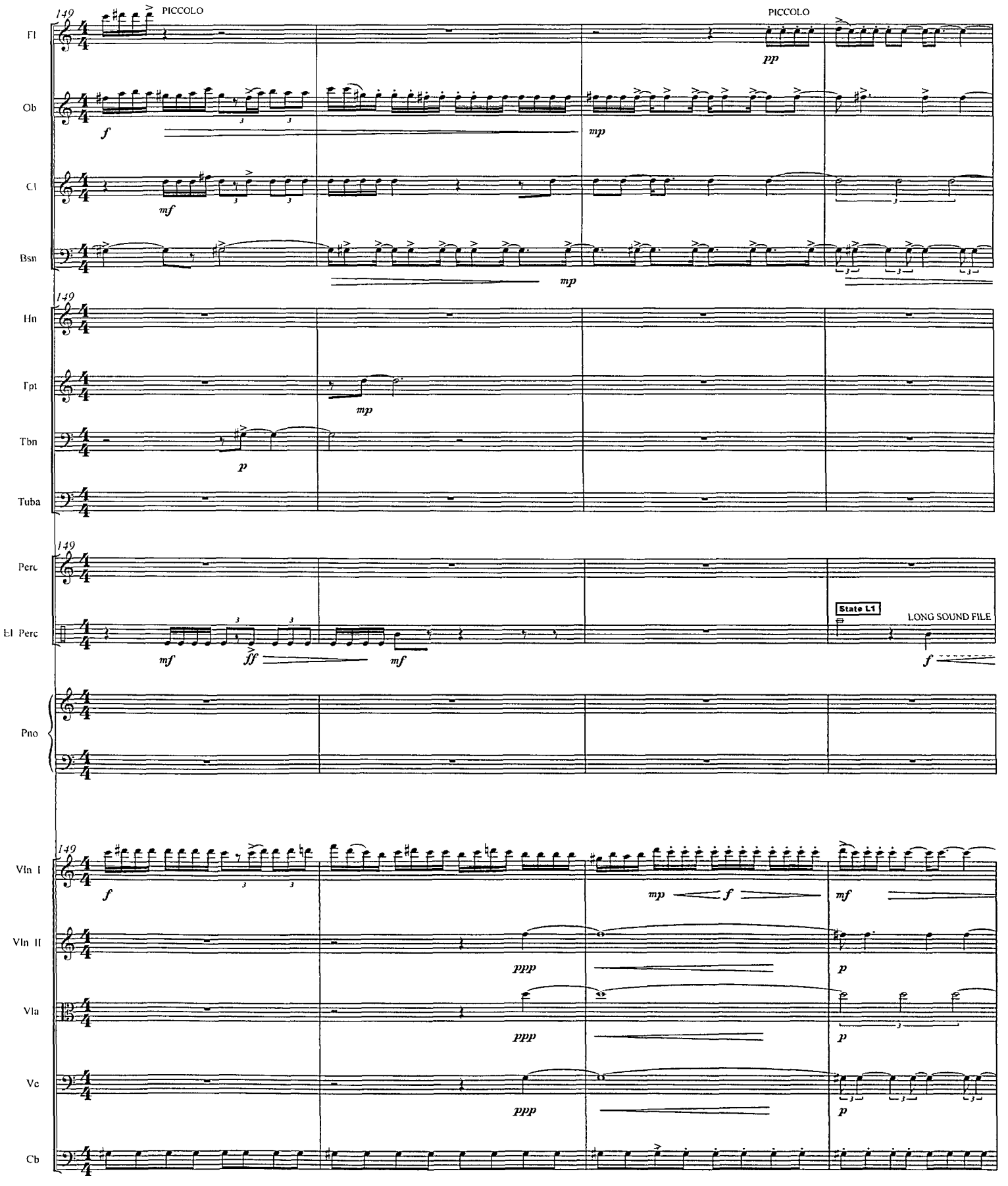

slight rit
a tempo
118
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
TUBULAR BELLS
El Perc
drum pads continues on lower line
GLOCKENSPIEL
Pno
Vln I
Vln II
Vla
Vc
Cb
pressure screech

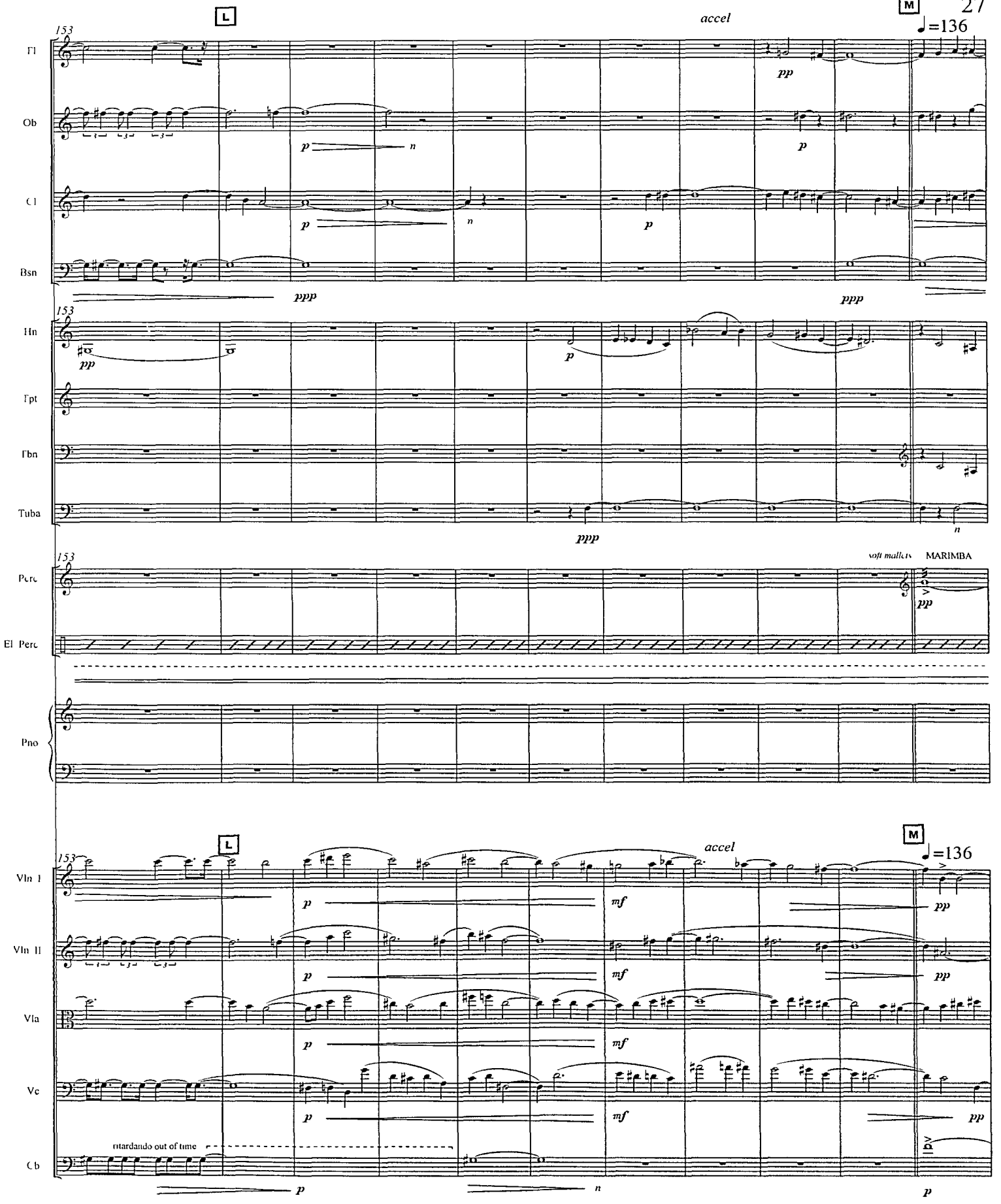

accel
122
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
pp
mf
mp
p
ff
end gloch
pizz
arco

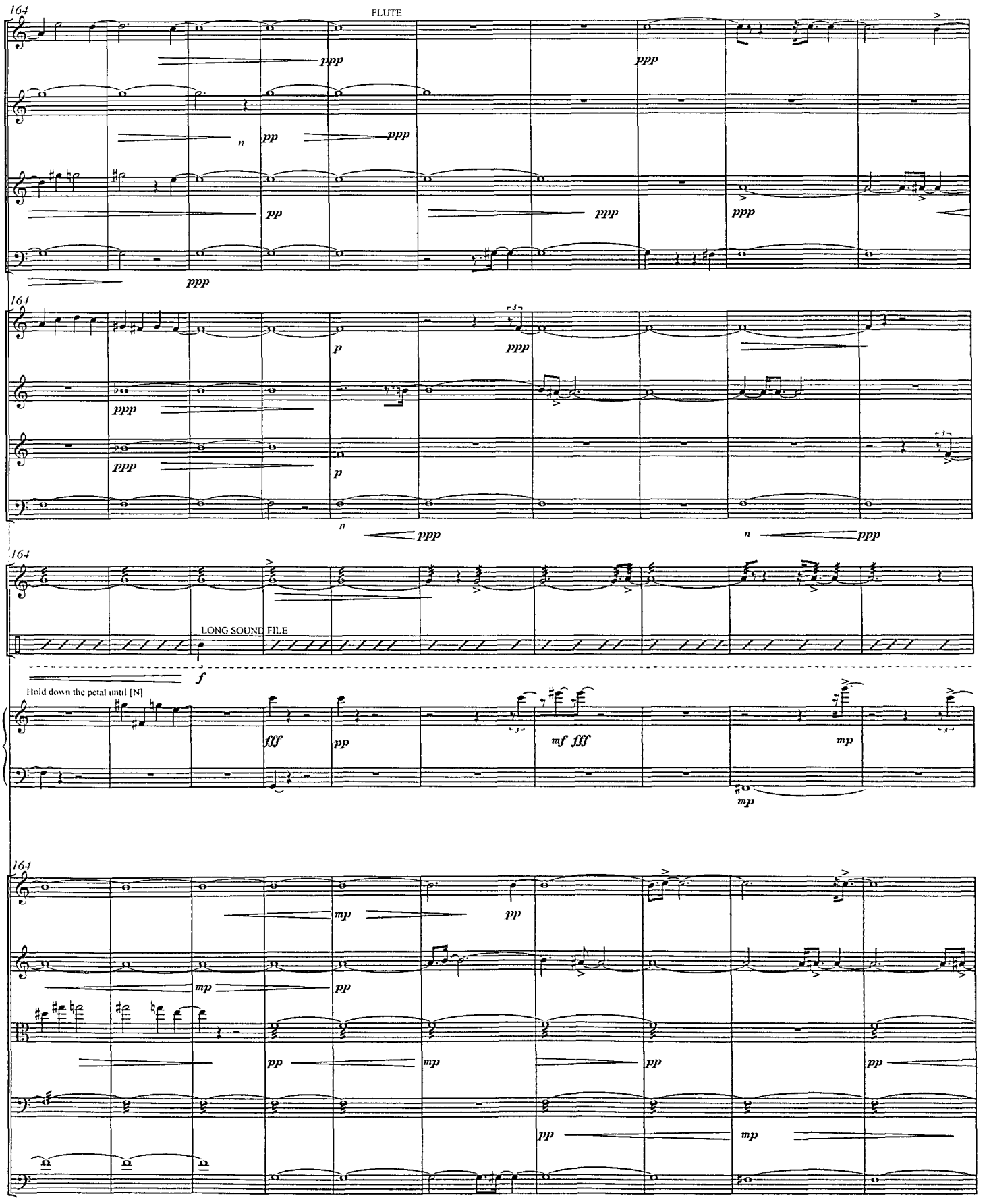

K
126
jagged
a tempo
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
MARIMBA
State K1
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb

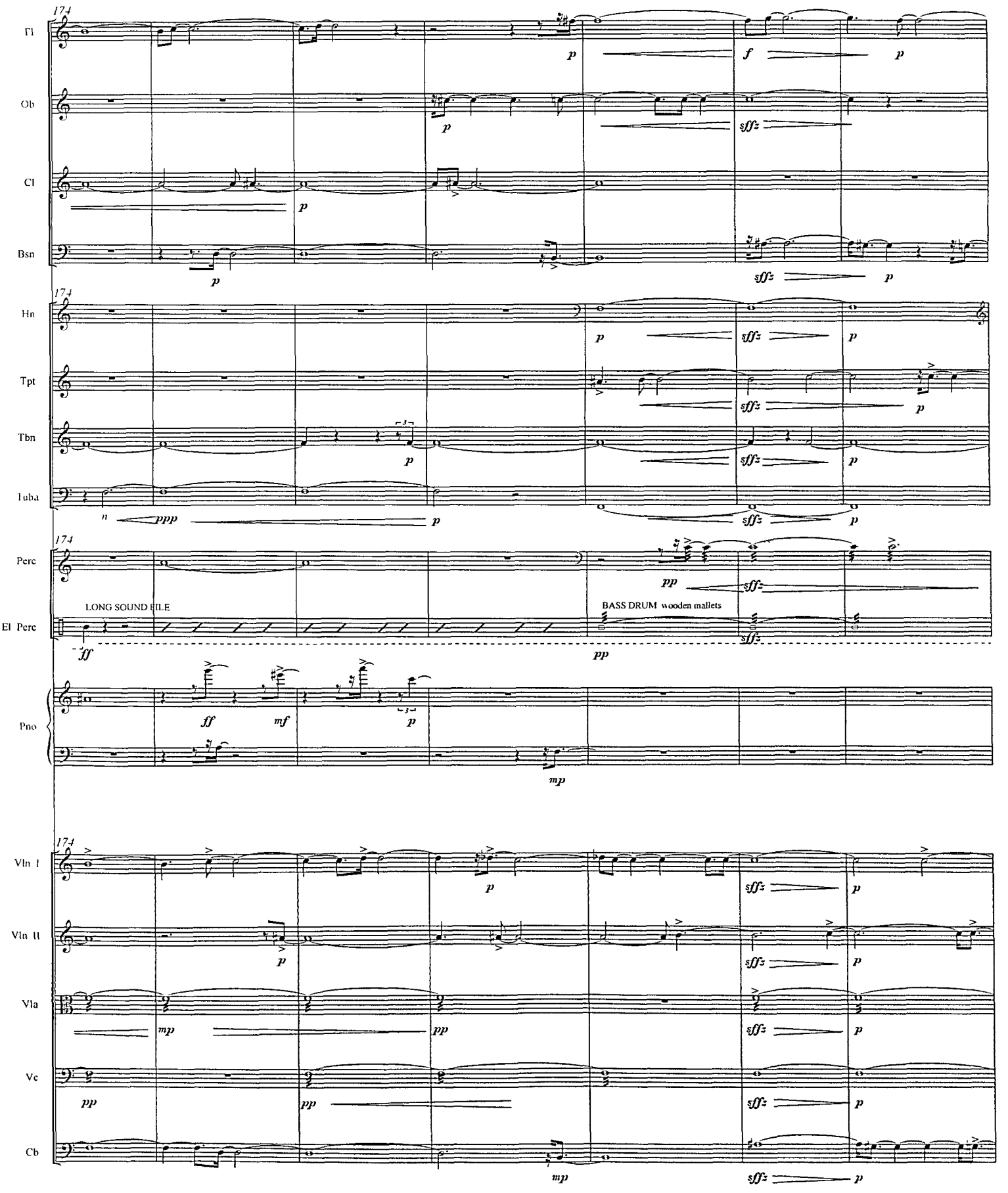

134
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
Fl Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
soli
jagged
State K2

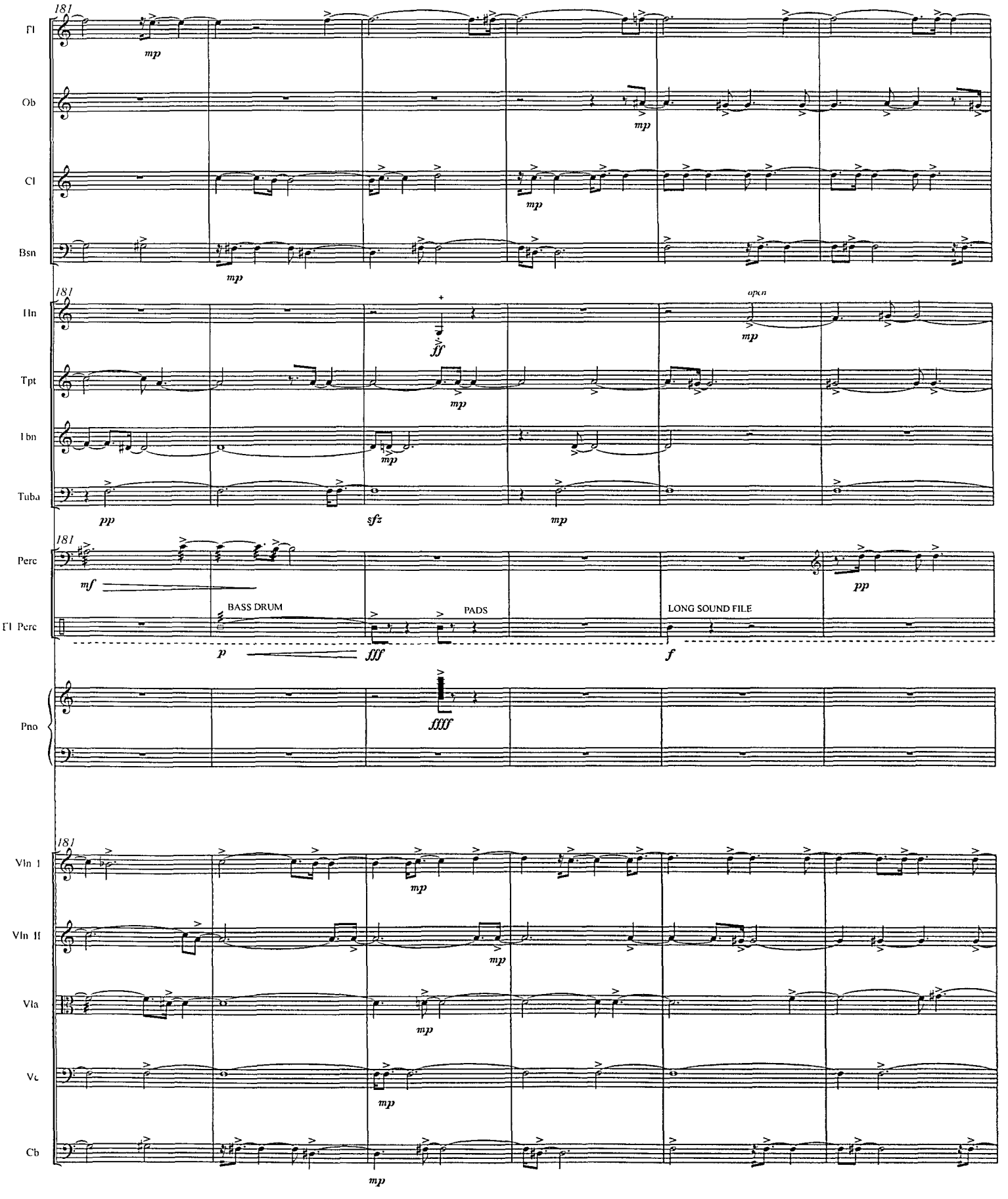

142
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
TOMS
Fl Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
arco

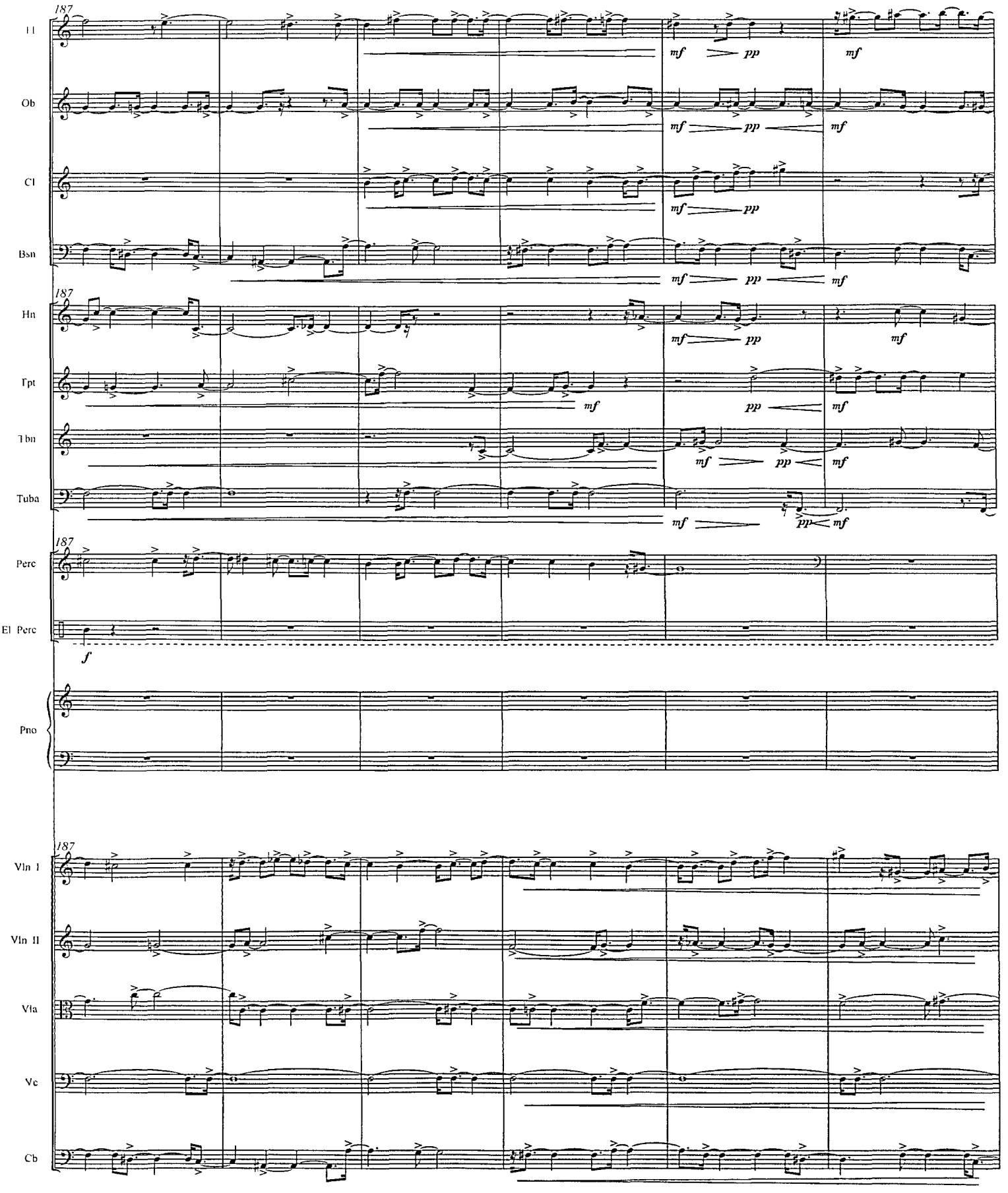

149
PICCOLO
PICCOLO
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
State L1
LONG SOUND FILE
Pno
Vln I
Vln II
Vla
Vc
Cb

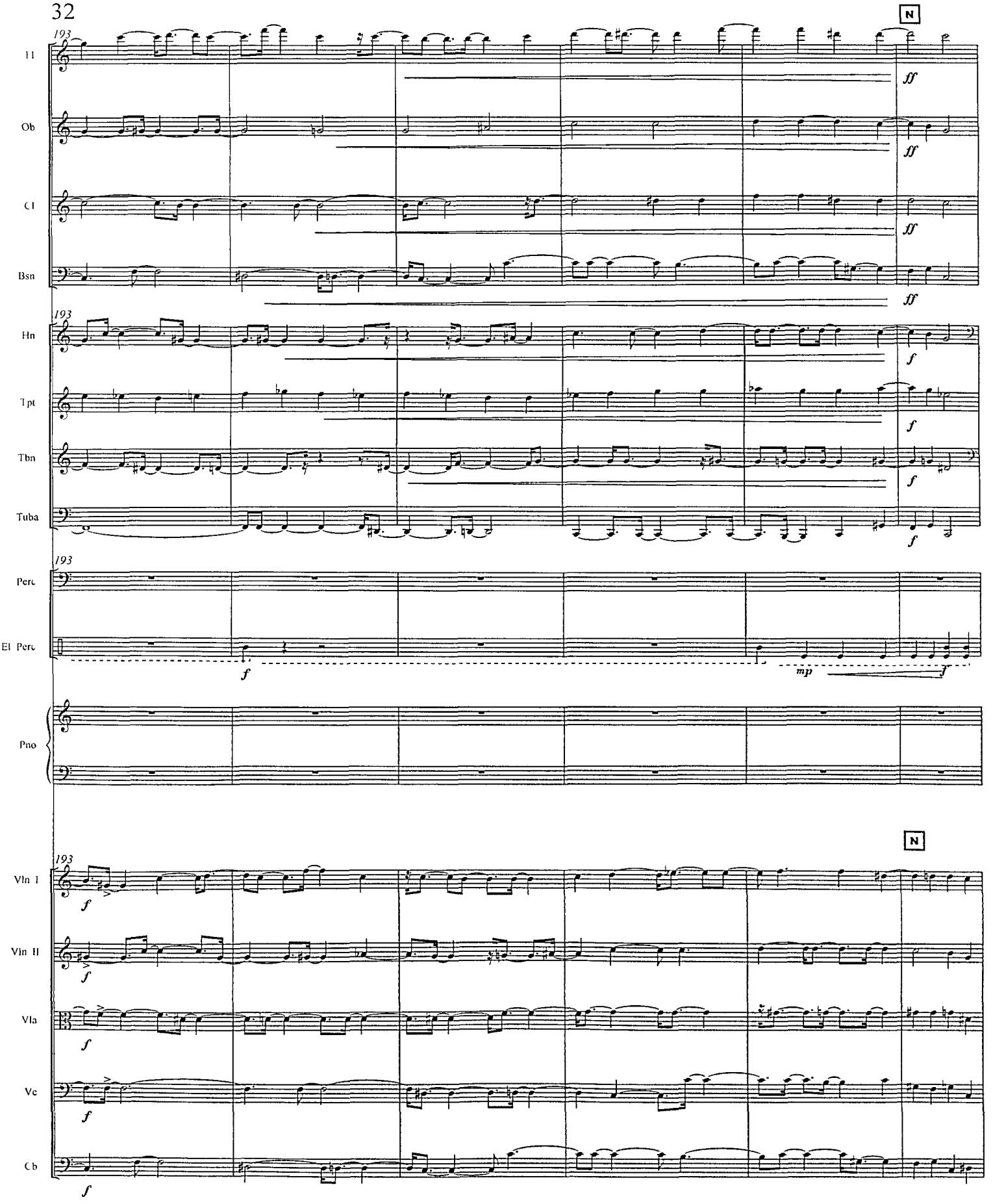

L
M
accel
=136
153
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
soft mallets
MARIMBA
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
ritardando out of time
pp
p
n
mf
ppp

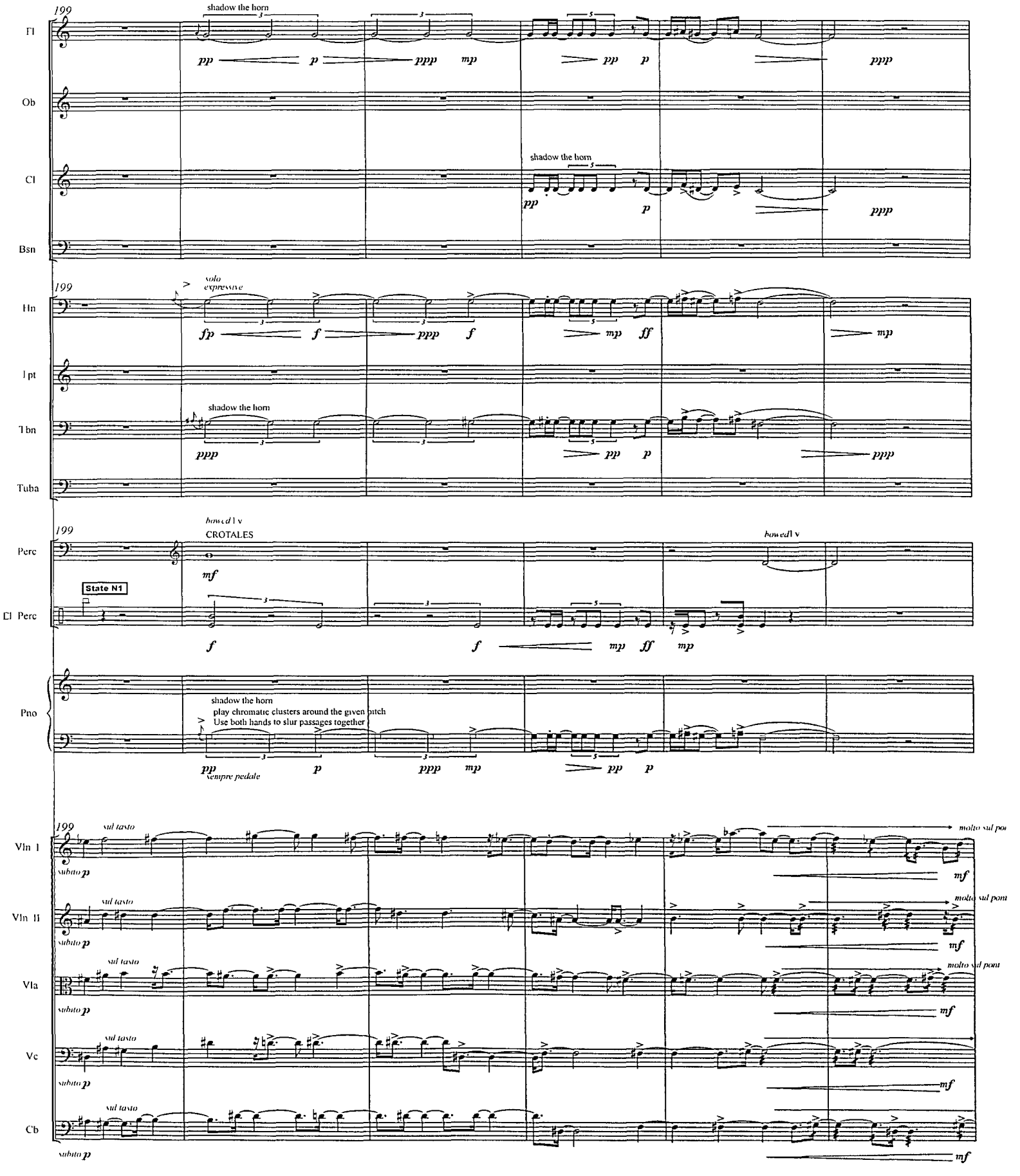

164
FLUTE
Fl
Ob
Cl
Bsn
164
Hn
Tpt
Tbn
Tuba
164
Perc
El Perc
LONG SOUND FILE
Hold down the petal until [N]
Pno
164
Vln I
Vln II
Vla
Vc
Cb

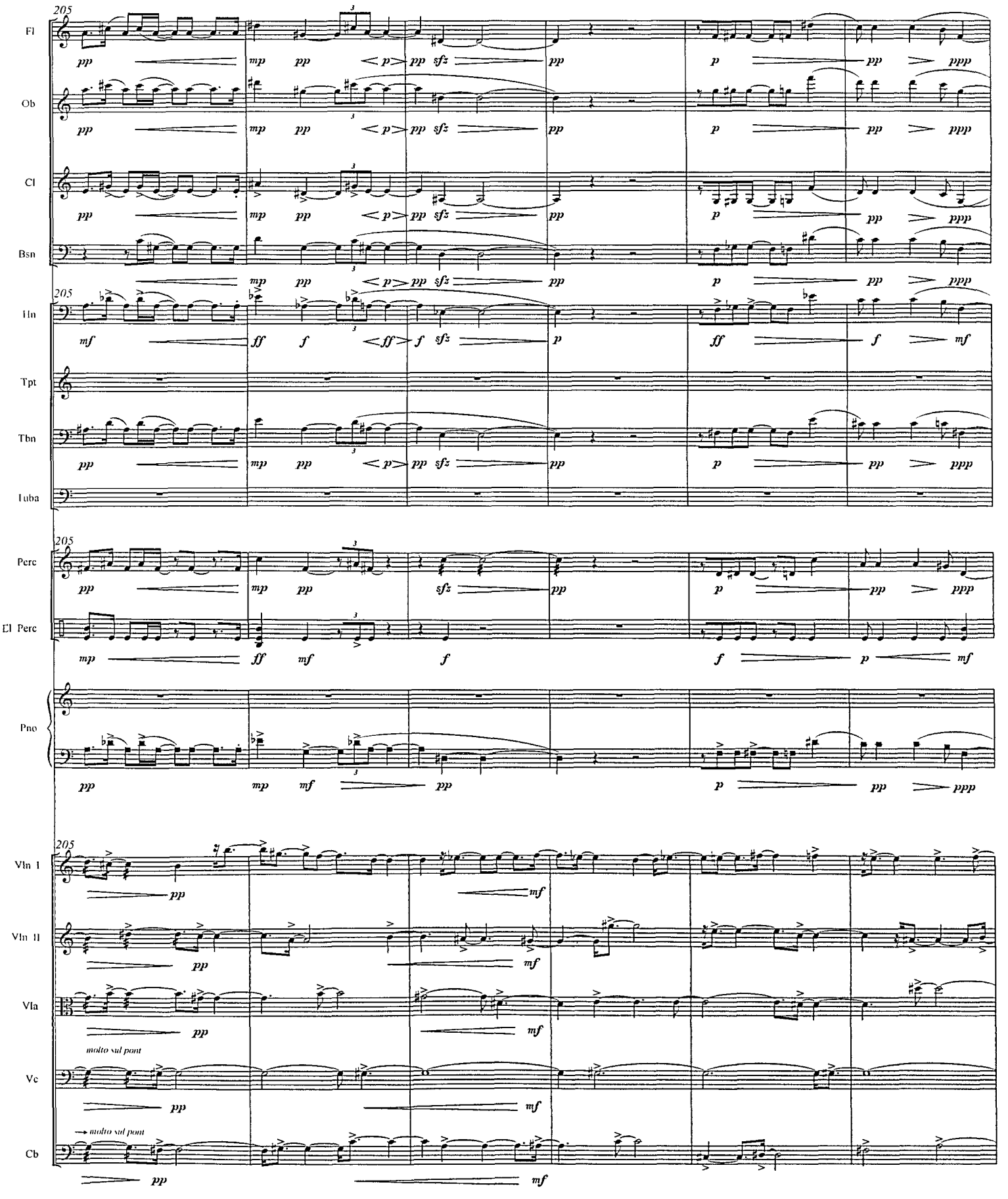

174
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
LONG SOUND FILE
BASS DRUM wooden mallets
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb

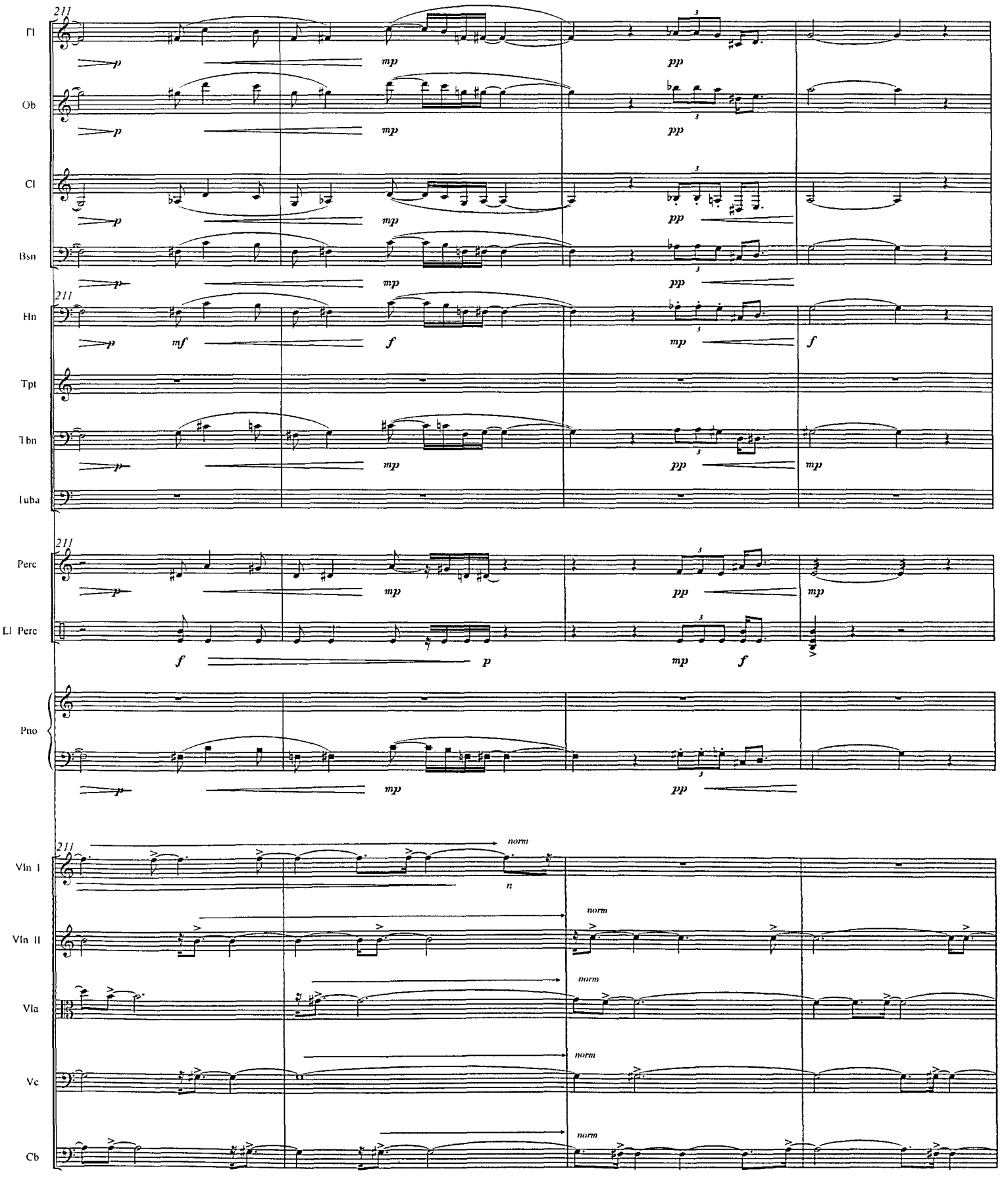

181
Fl
Ob
Cl
Bsn
mp
181
Hn
Tpt
Tbn
Tuba
open
mp
ff
sfz
pp
181
Perc
Fl Perc
mf
BASS DRUM
PADS
LONG SOUND FILE
p
fff
f
pp
Pno
ffff
181
Vln I
Vln II
Vla
Vc
Cb

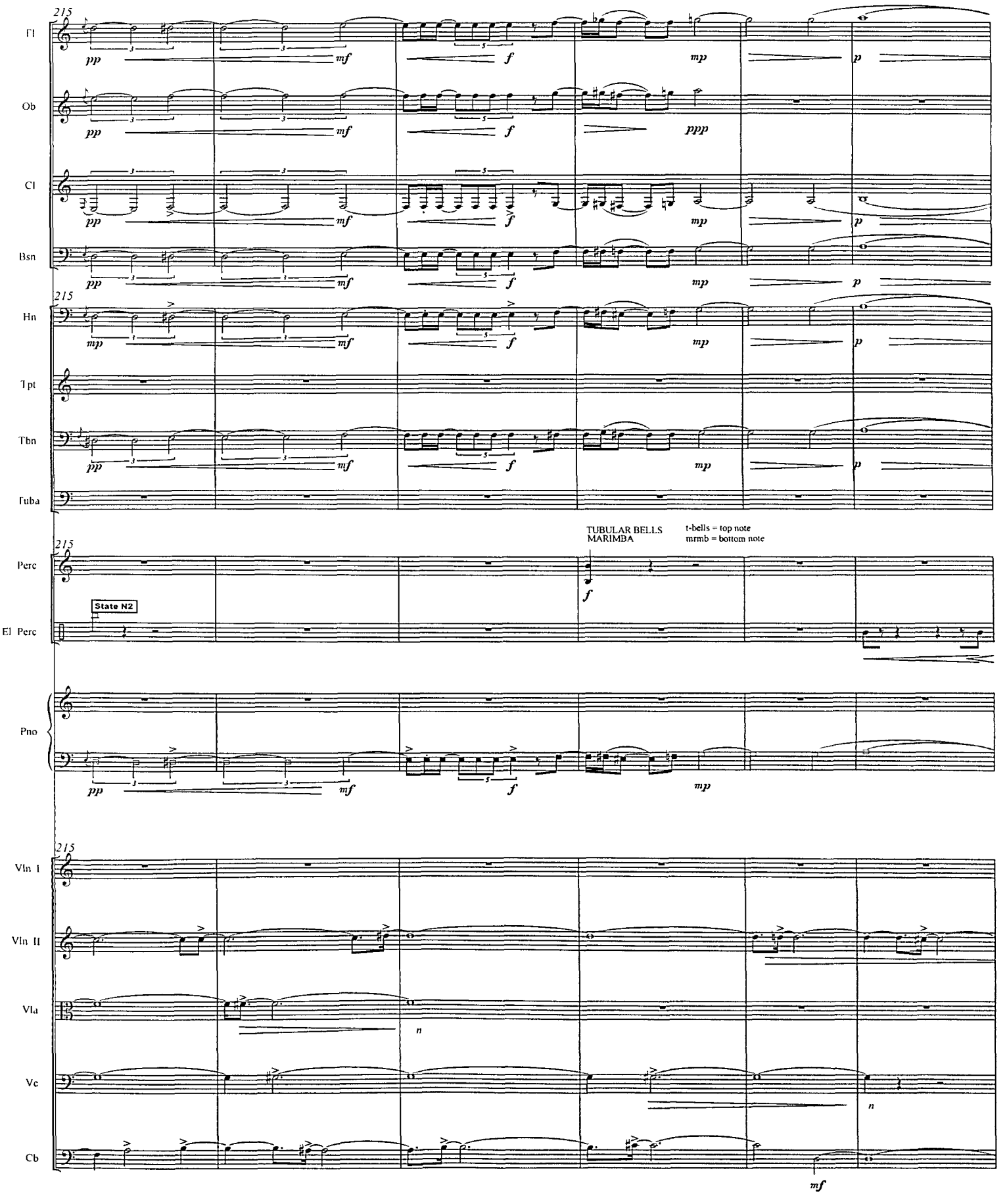

187
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
mf
pp
f

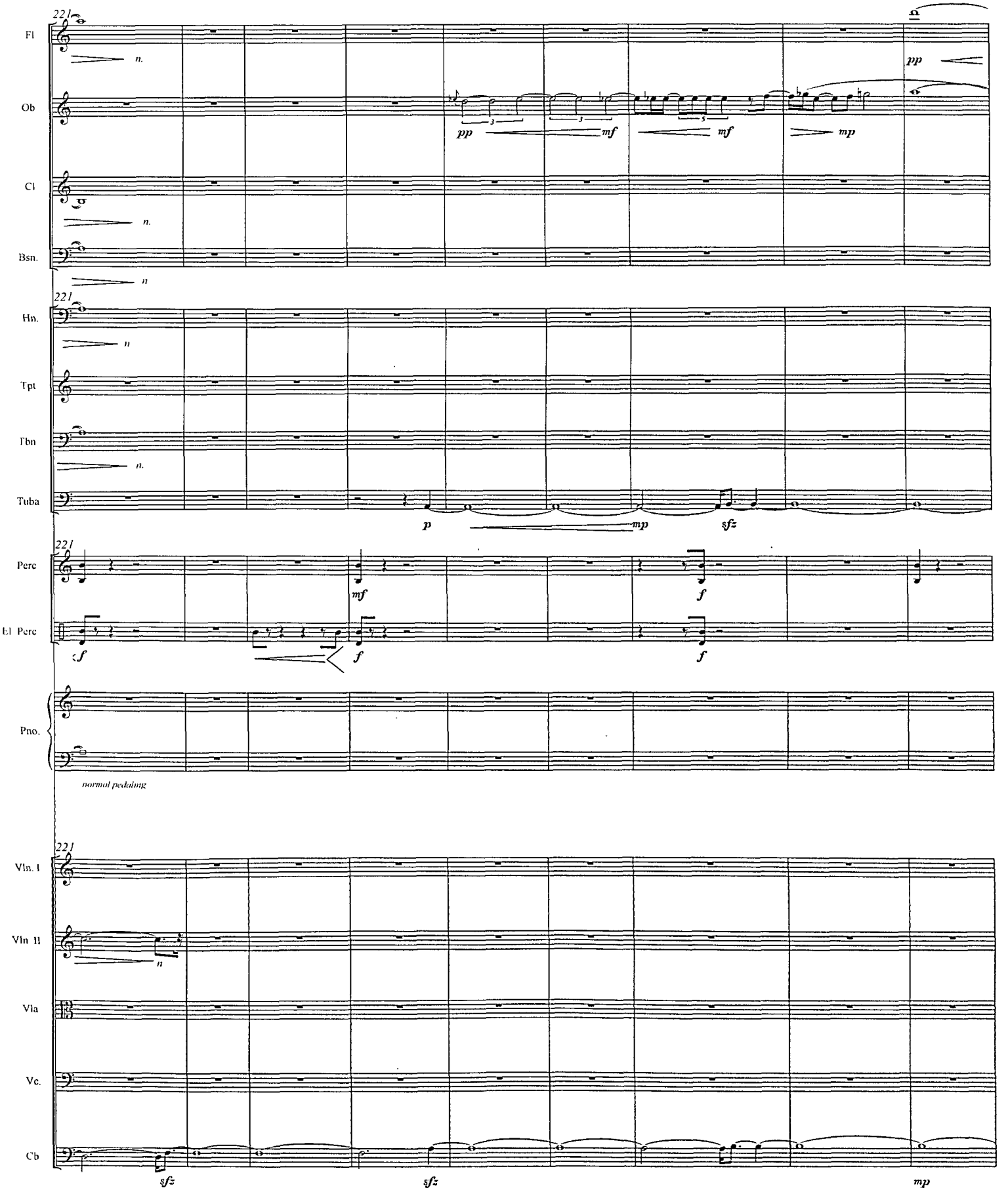

193
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
N
ff
f
mp

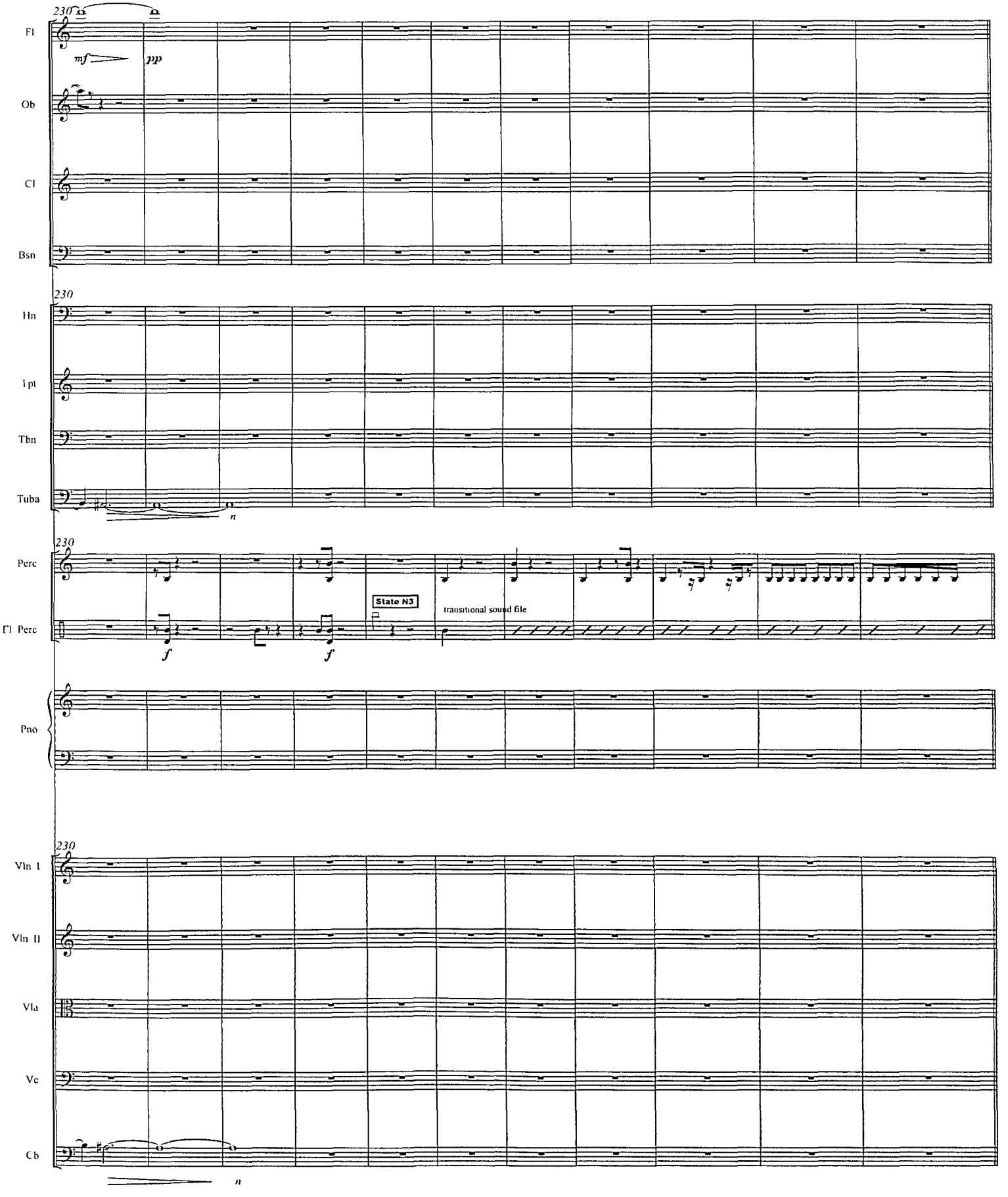

199
Fl
Ob
Cl
Bsn
shadow the horn
shadow the horn
Hn
Tpt
Tbn
Tuba
solo
expressive
shadow the horn
Perc
El Perc
bowed l v
CROTALES
bowed l v
State N1
Pno
shadow the horn
play chromatic clusters around the given pitch
Use both hands to slur passages together
sempre pedale
Vln I
Vln II
Vla
Vc
Cb
sul tasto
molto sul pon
subito p
mf

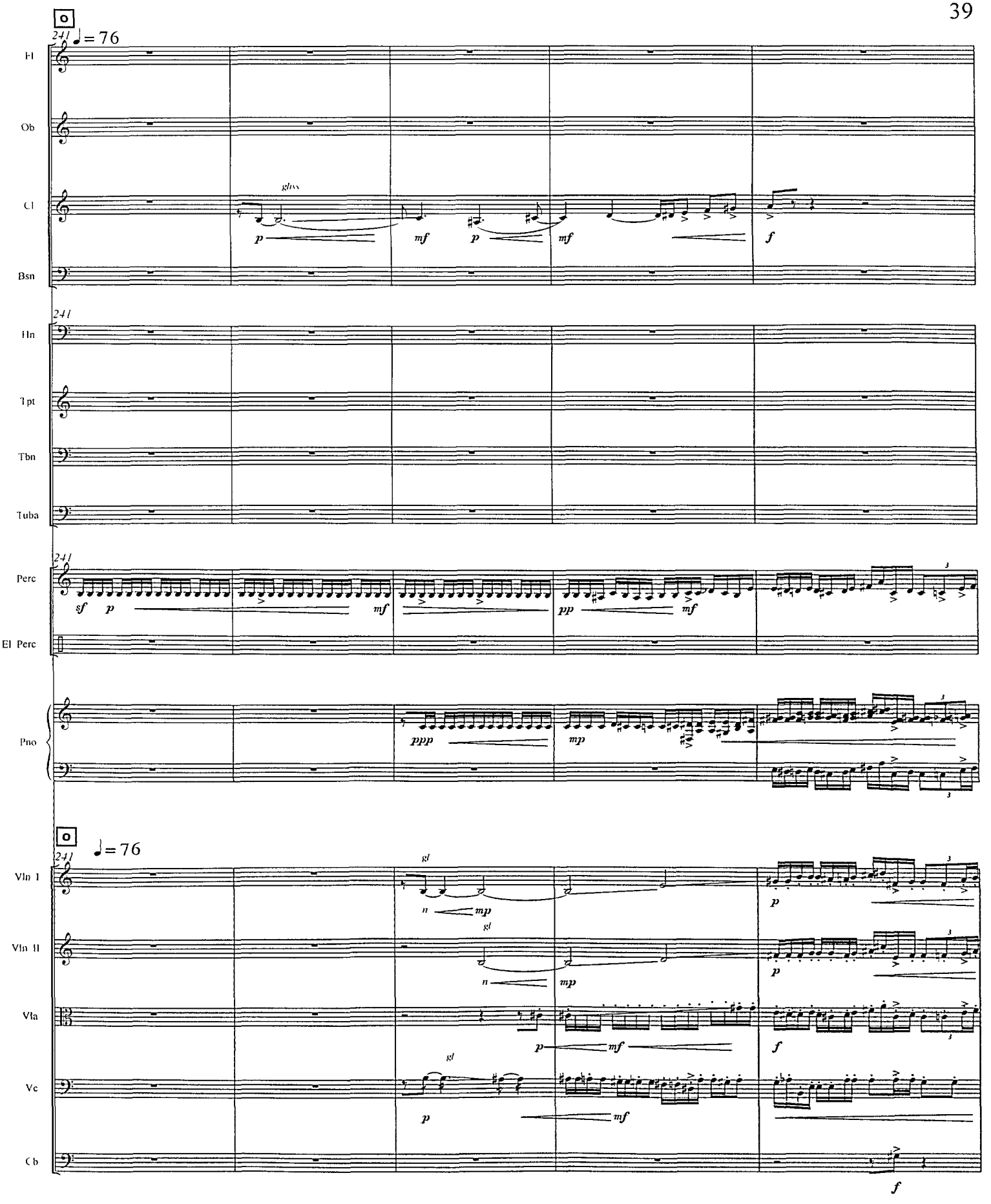

205
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
molto sul pont
molto sul pont

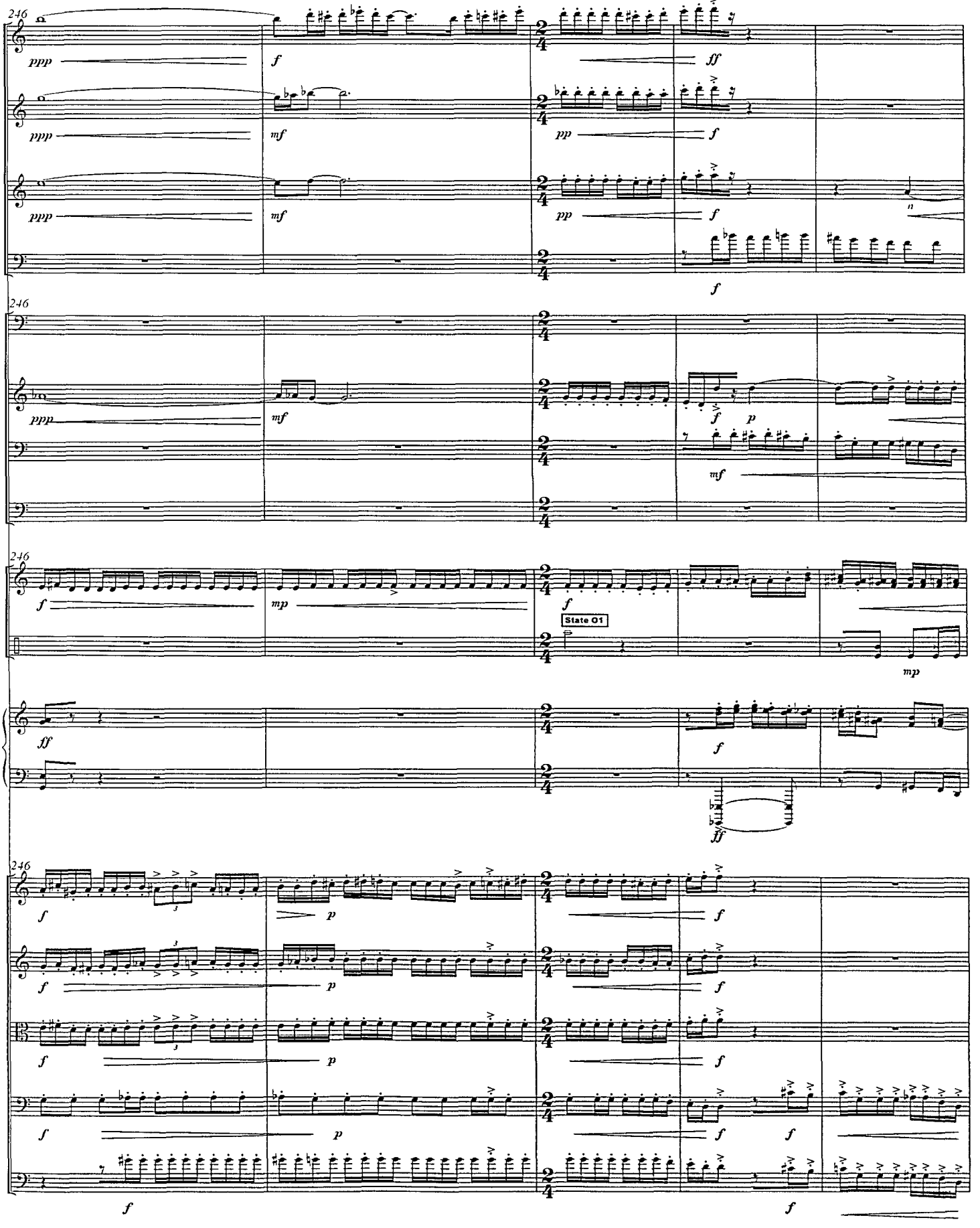

211
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
norm

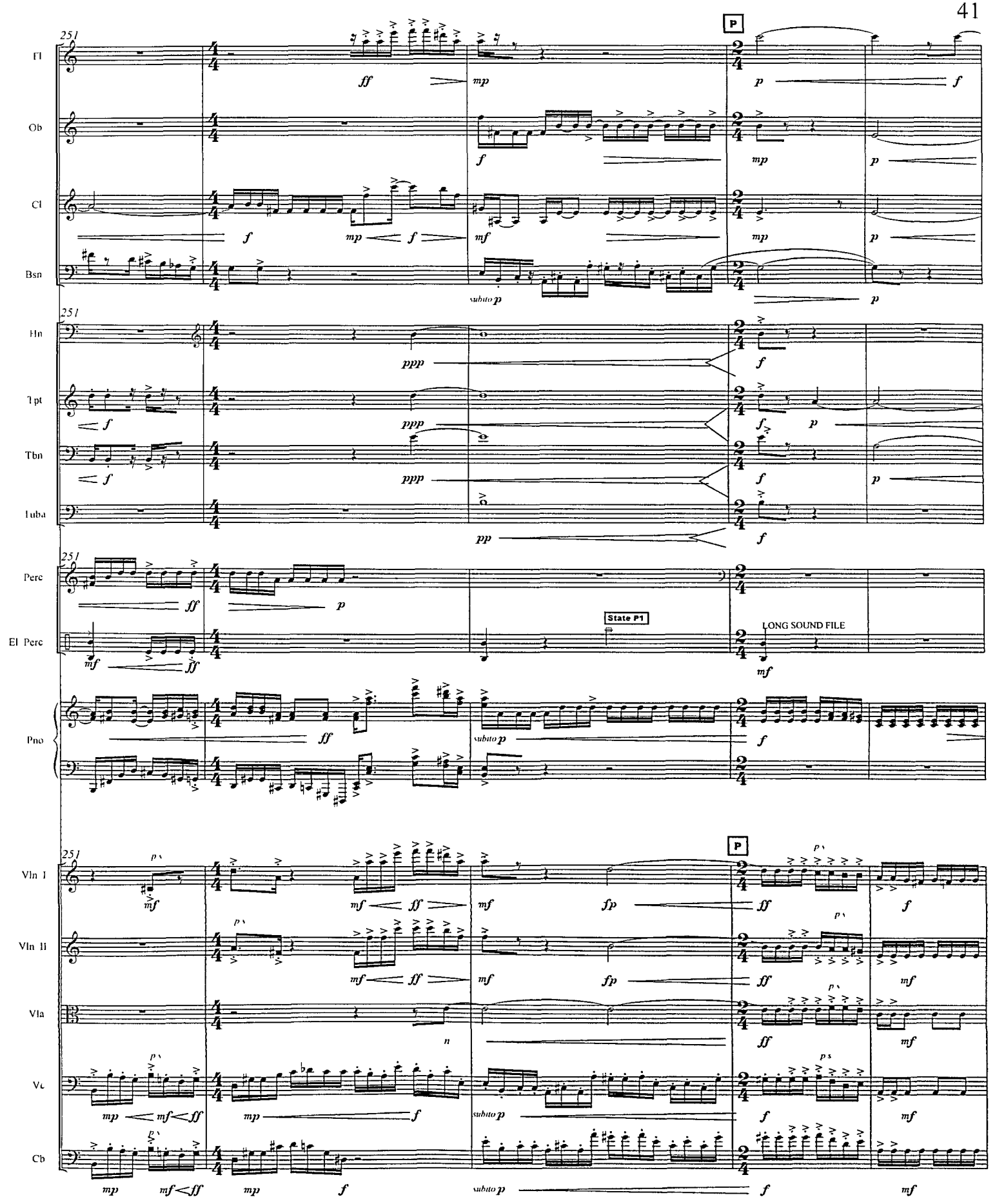

215
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
TUBULAR BELLS
MARIMBA
t-bells = top note
mrmb = bottom note
State N2
pp
mf
f
mp
p
ppp

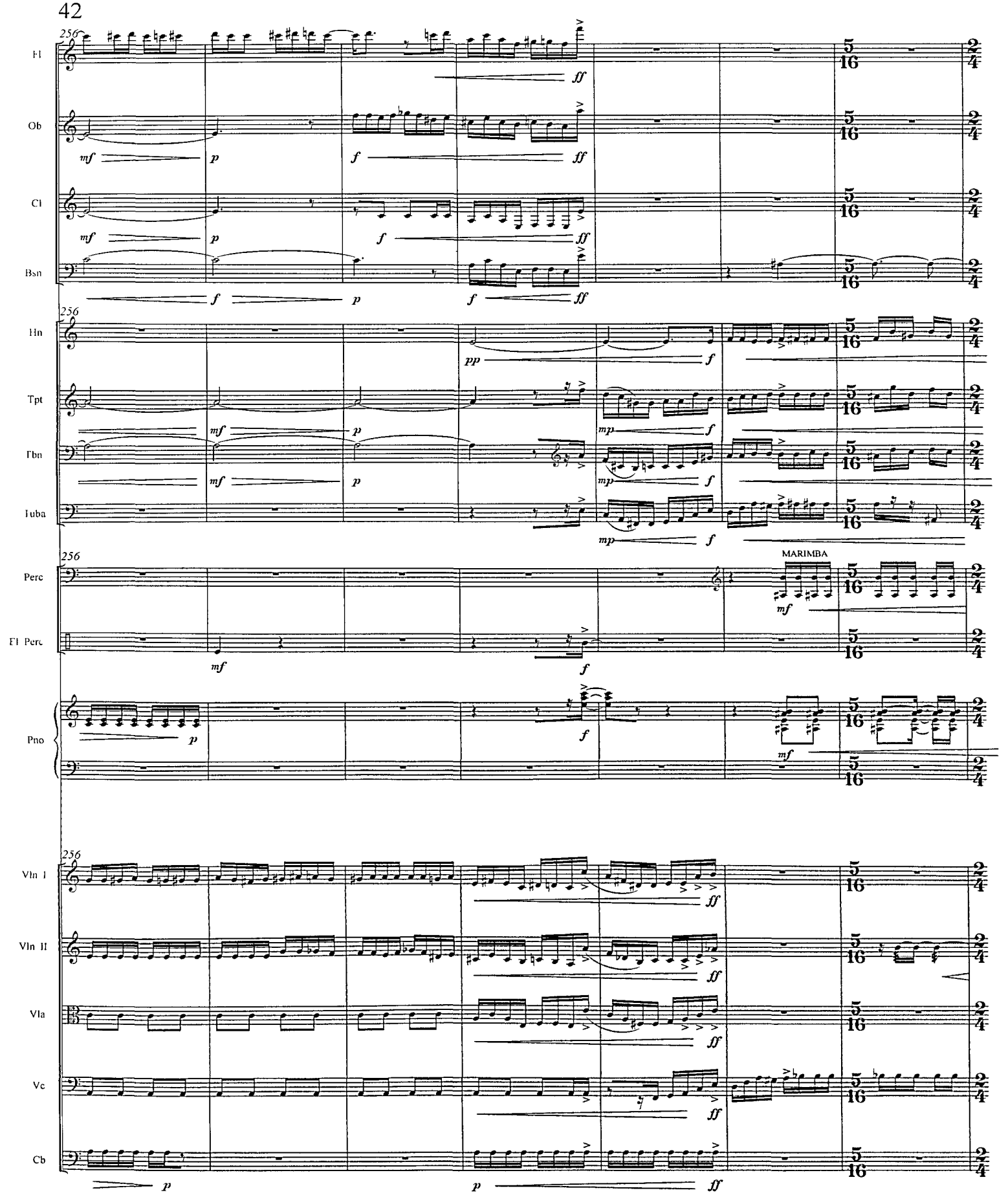

221
Fl
Ob
Cl
Bsn.
Hn.
Tpt
Tbn
Tuba
Perc
El Perc
Pno.
normal pedaling
Vln. I
Vln II
Vla
Vc.
Cb
pp
mf
mp
p
sfz
f

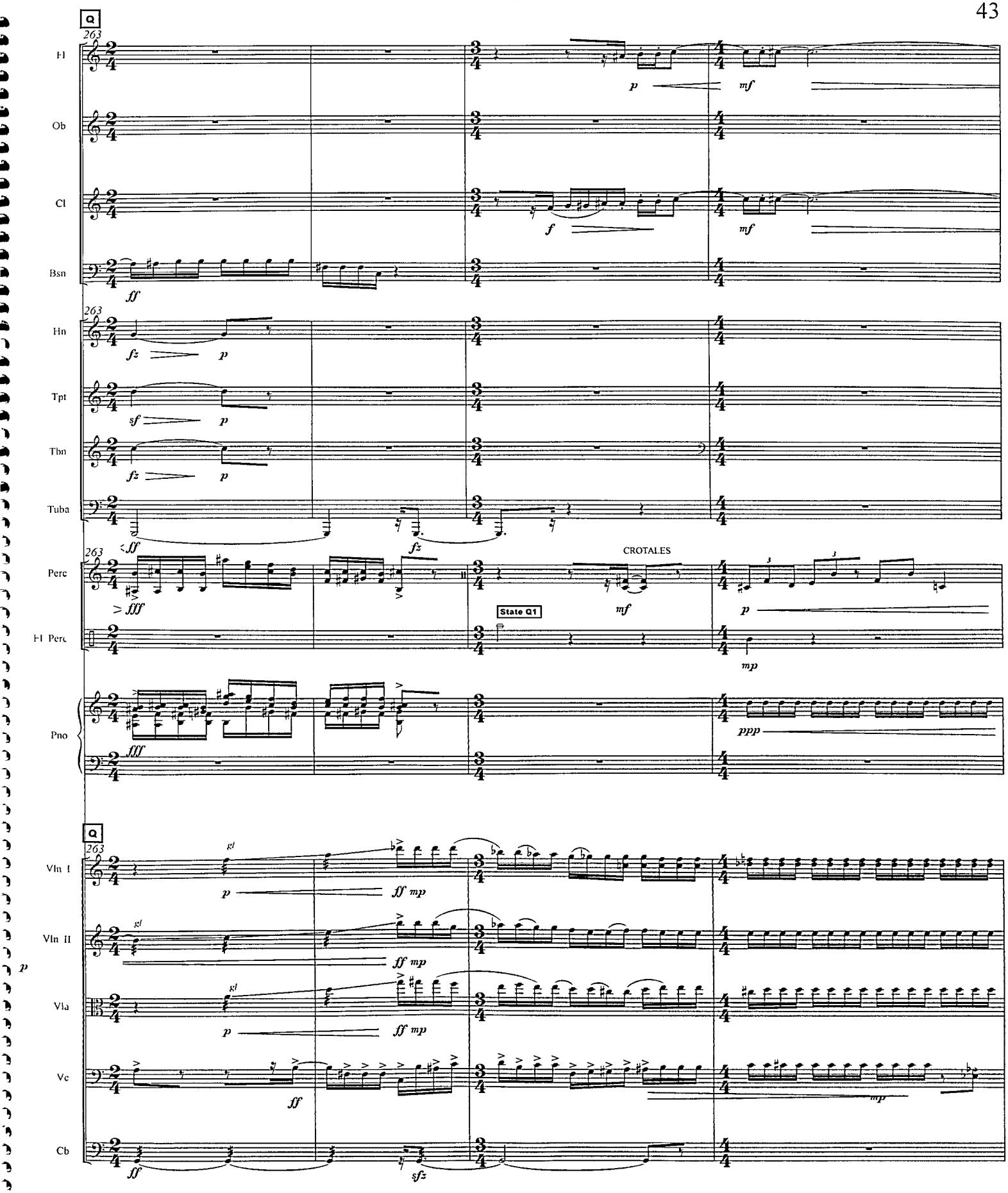

230
Fl
mf
pp
Ob
Cl
Bsn
230
Hn
Tpt
Tbn
Tuba
n
230
Perc
State N3
transitional sound file
Cl Perc
f
f
Pno
230
Vln I
Vln II
Vla
Vc
Cb
n

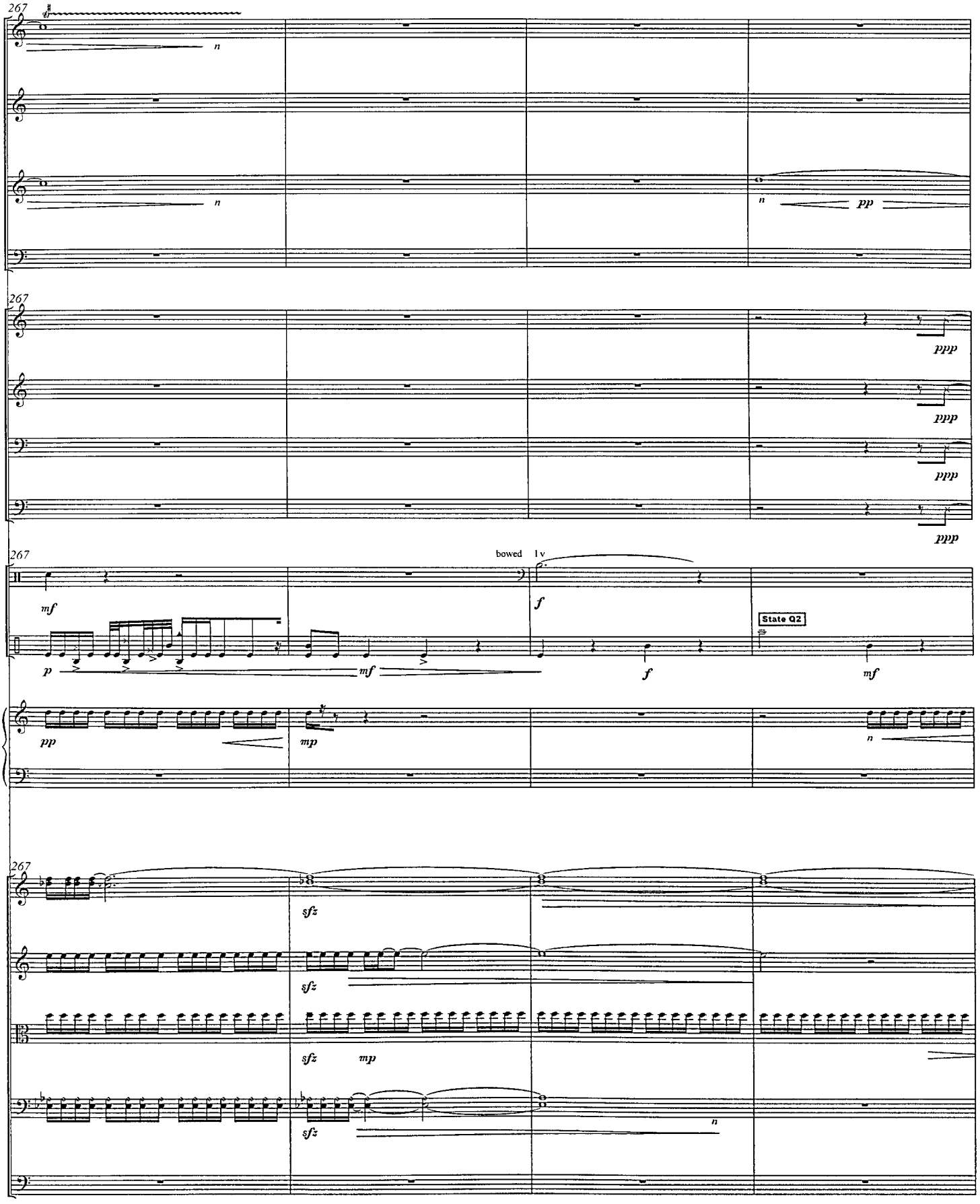

241
♩= 76
Fl
Ob
Cl
Bsn
gliss
p
mf
p
mf
f
241
Hn
Tpt
Tbn
Tuba
241
Perc
El Perc
sf
p
mf
pp
mf
Pno
ppp
mp
241
♩= 76
Vln I
Vln II
Vla
Vc
Cb
gl
n
mp
p
mf
f

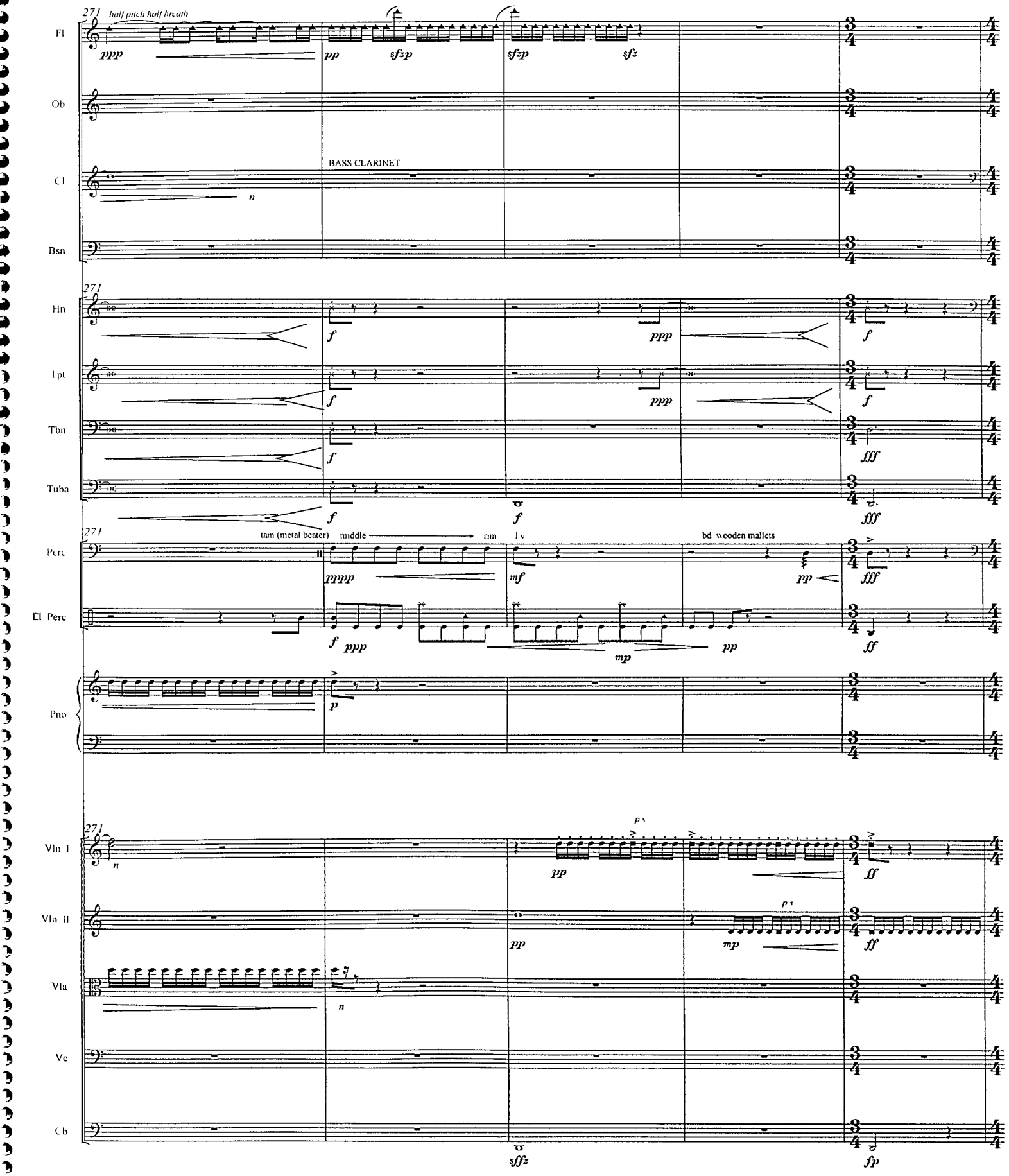

246
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
State 01
Pno
Vln I
Vln II
Vla
Vc
Cb

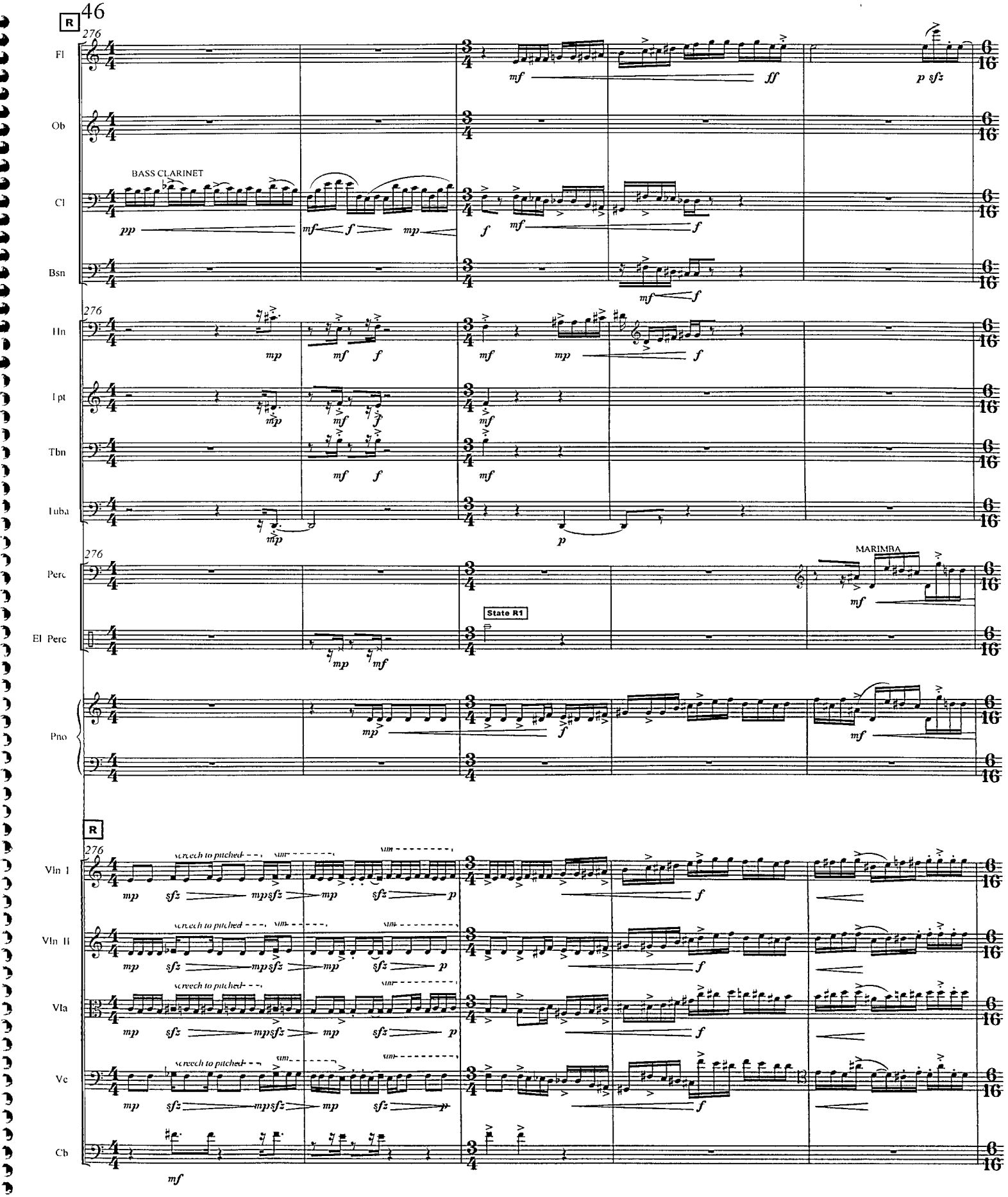

251
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
P
State P1
LONG SOUND FILE

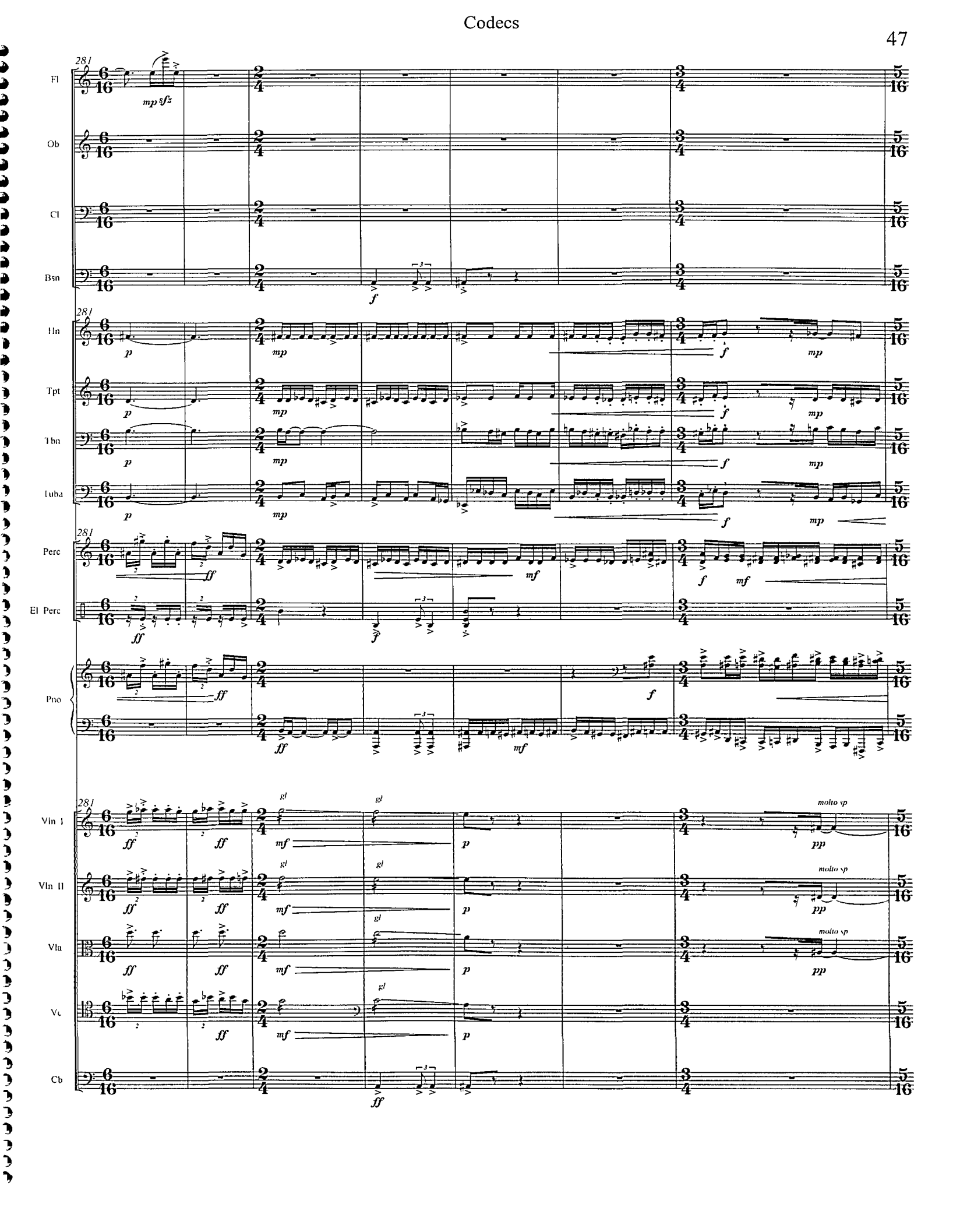

Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
MARIMBA
Pno
Vln I
Vln II
Vla
Vc
Cb

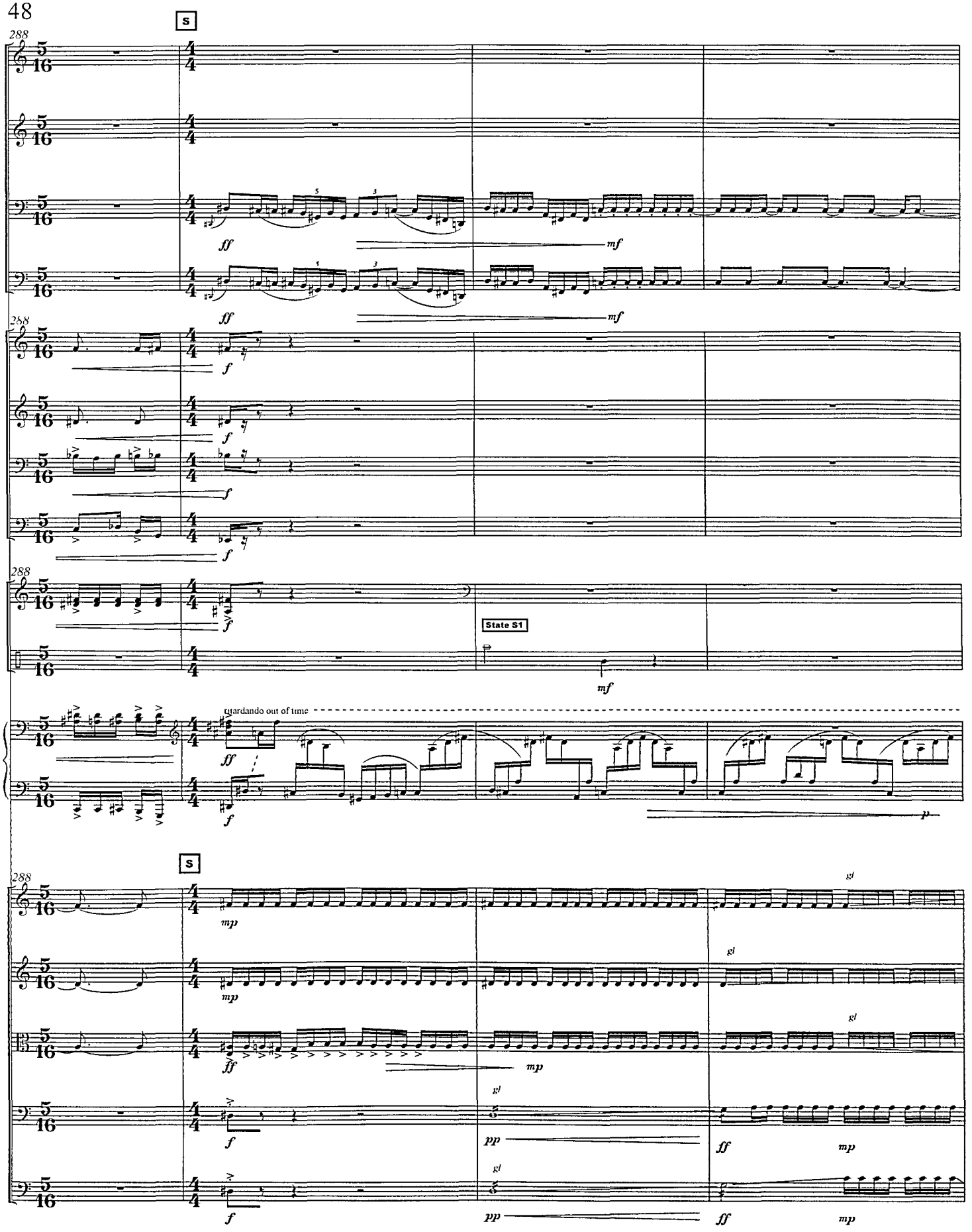

Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
Fl Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
263
CROTALES
State Q1

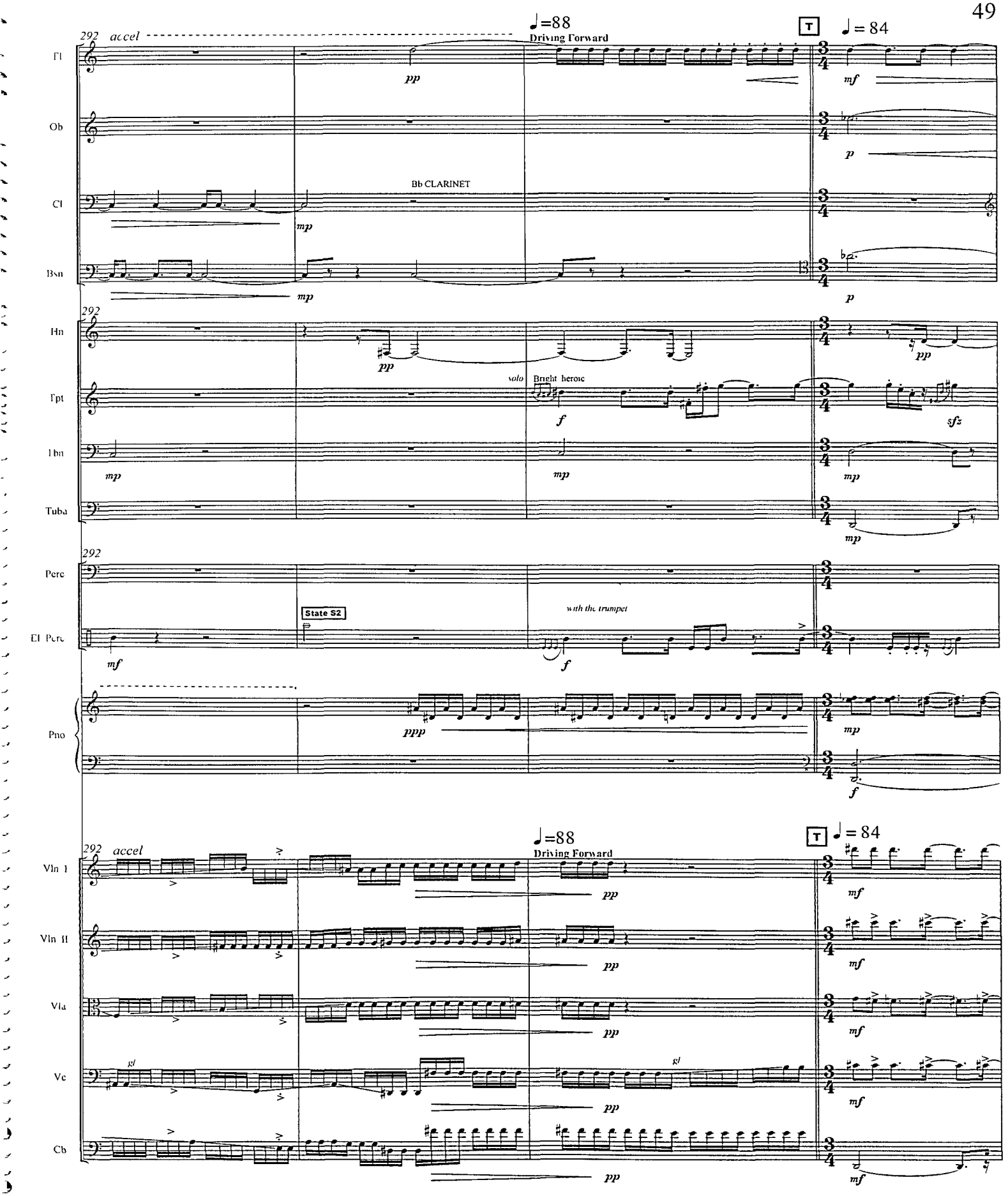

267
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
bowed
State Q2

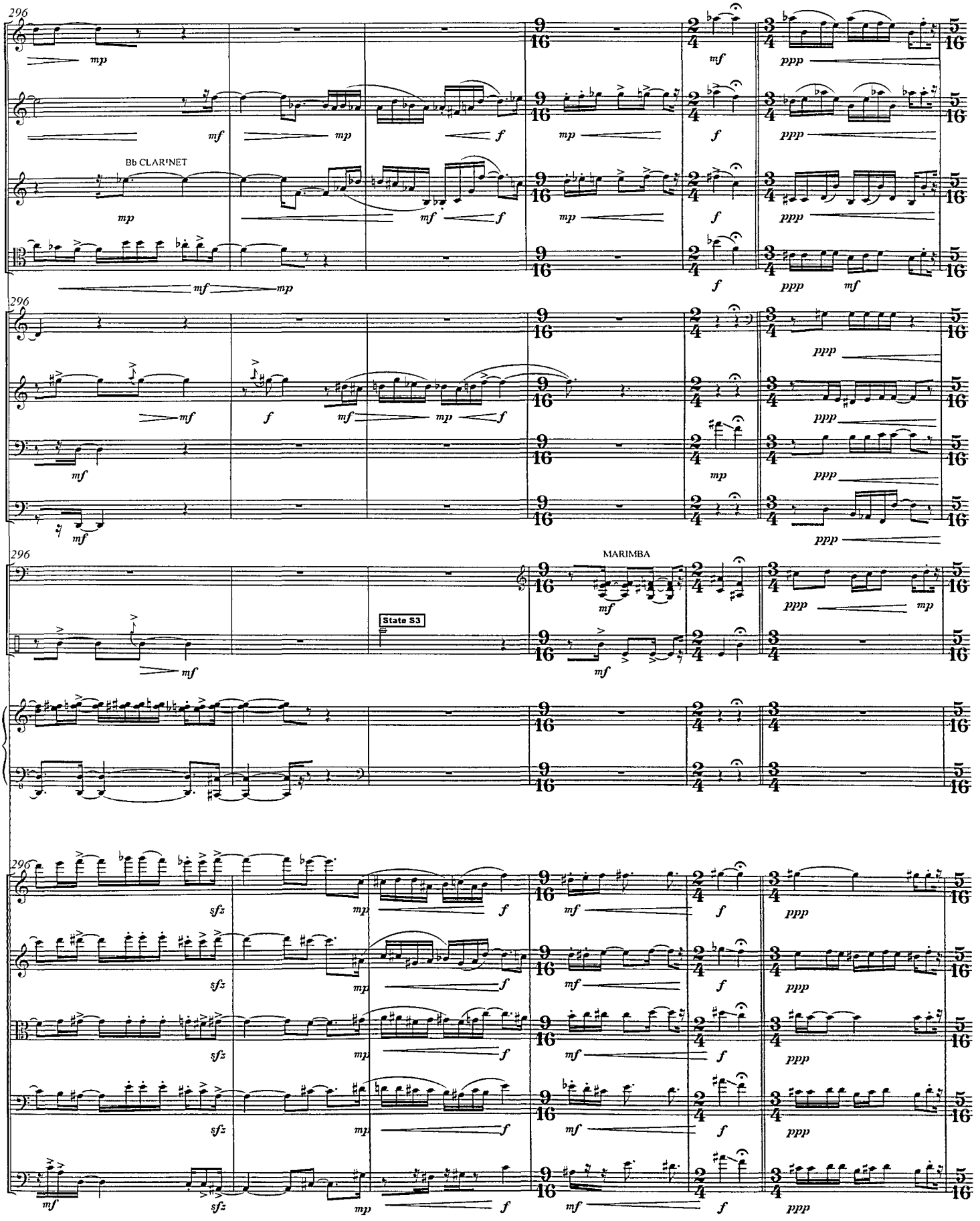

271
half pitch half breath
Fl
Ob
Cl
BASS CLARINET
Bsn
Hn
Tpt
Tbn
Tuba
tam (metal beater)
middle
rim
l.v
bd wooden mallets
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb

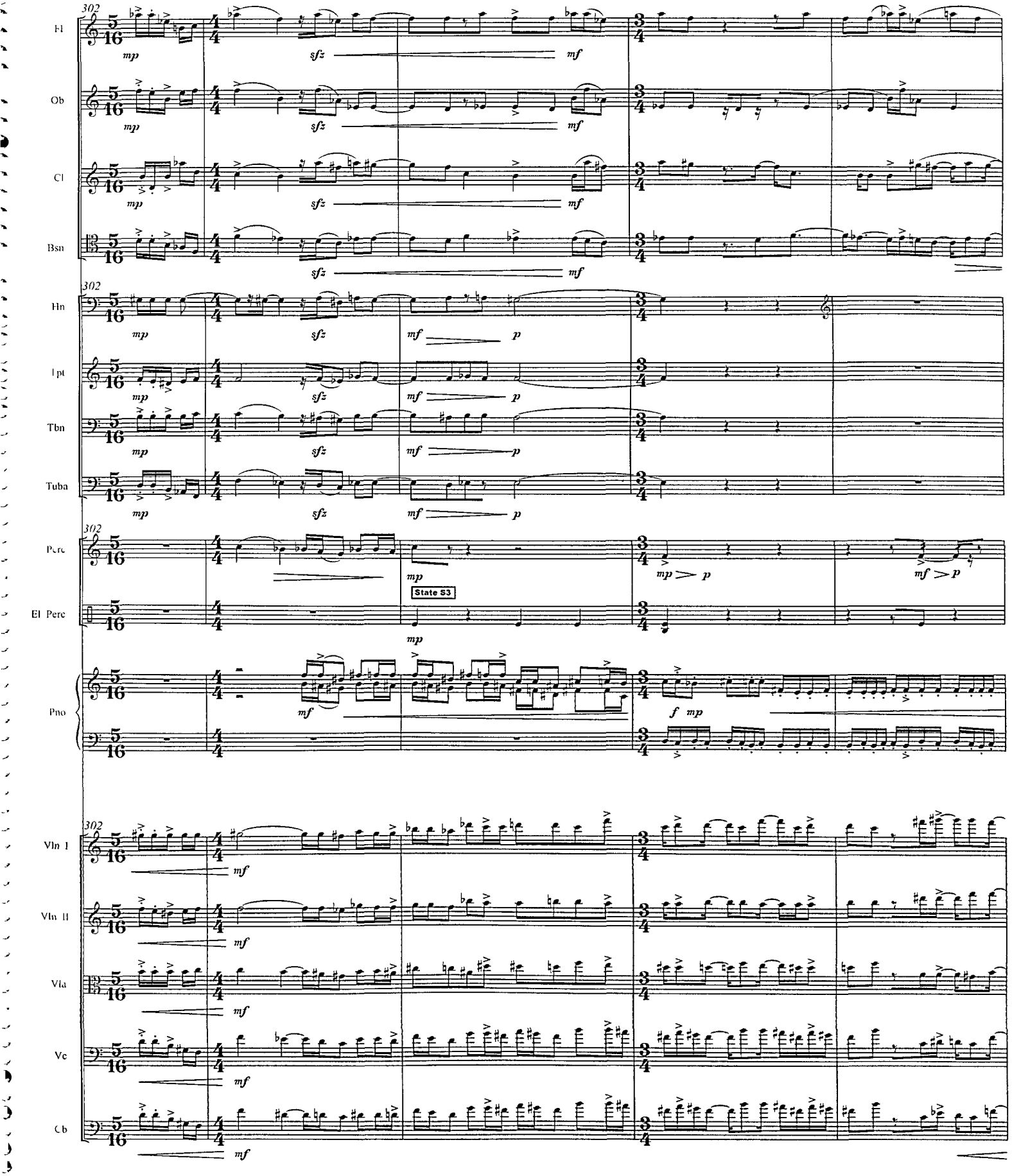

46
R
276
Fl
Ob
BASS CLARINET
Cl
Bsn
276
Hn
Tpt
Tbn
Tuba
276
Perc
MARIMBA
State R1
El Perc
Pno
R
276
Vln I
Vln II
Vla
Vc
Cb
screech to pitched

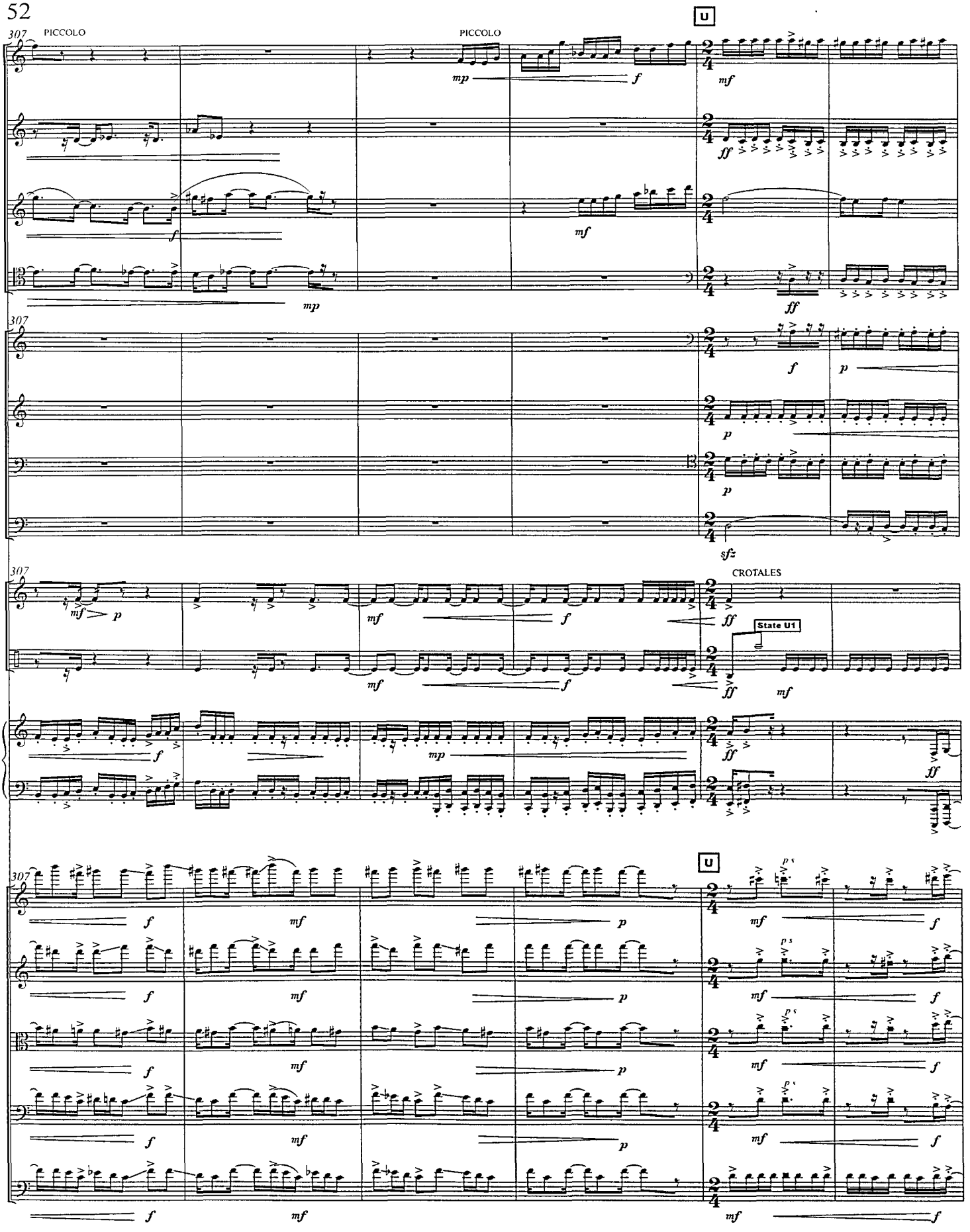

281
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
mp sfz
molto sp
gl

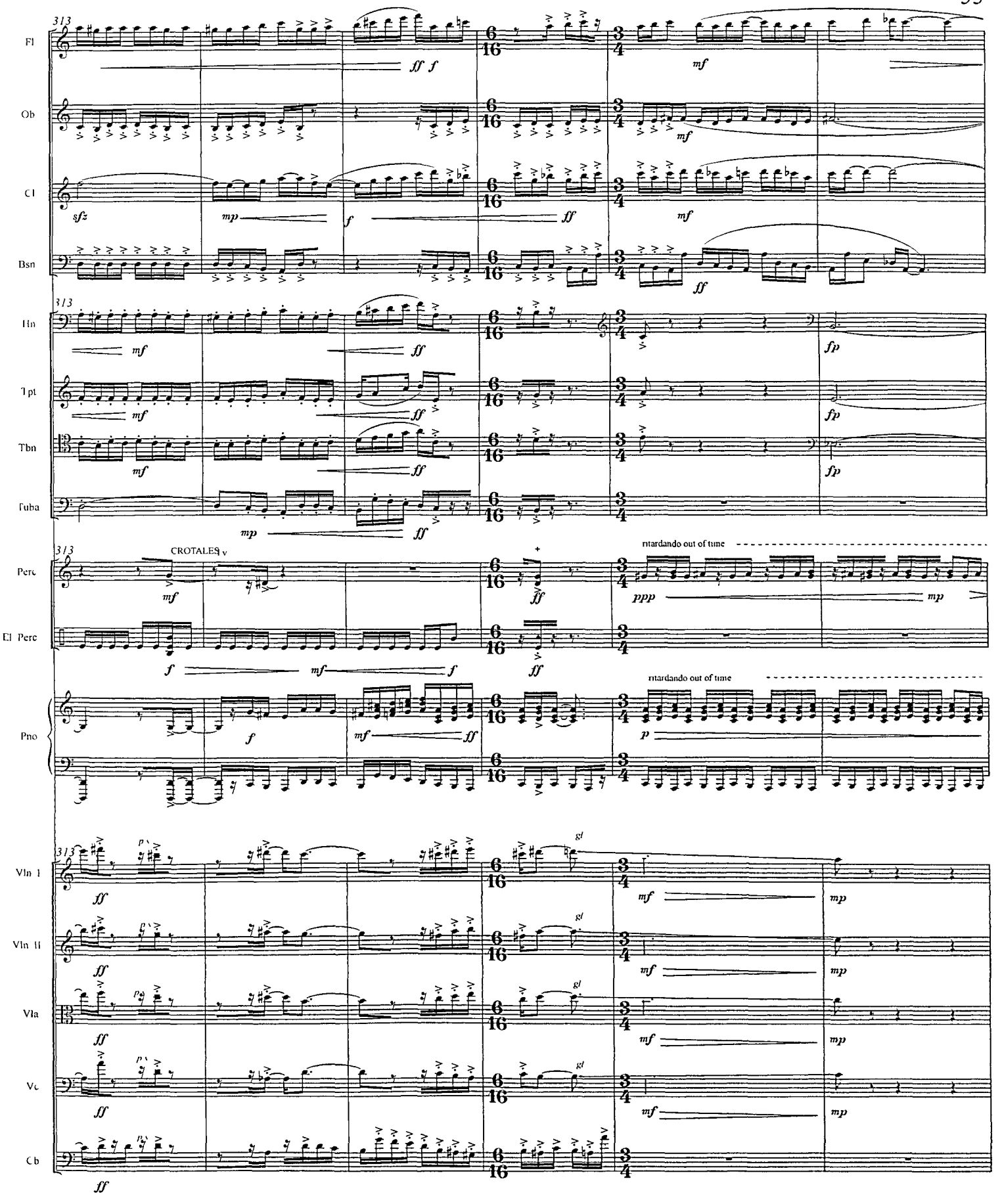

S
288
Fl
Ob
Cl
Bsn
ff
mf
288
Hn
Tpt
Tbn
Tuba
f
288
Perc
El Perc
State S1
mf
Pno
guardando out of time
ff
f
p
S
288
Vln I
Vln II
Vla
Vc
Cb
mp
gl
ff
pp
f

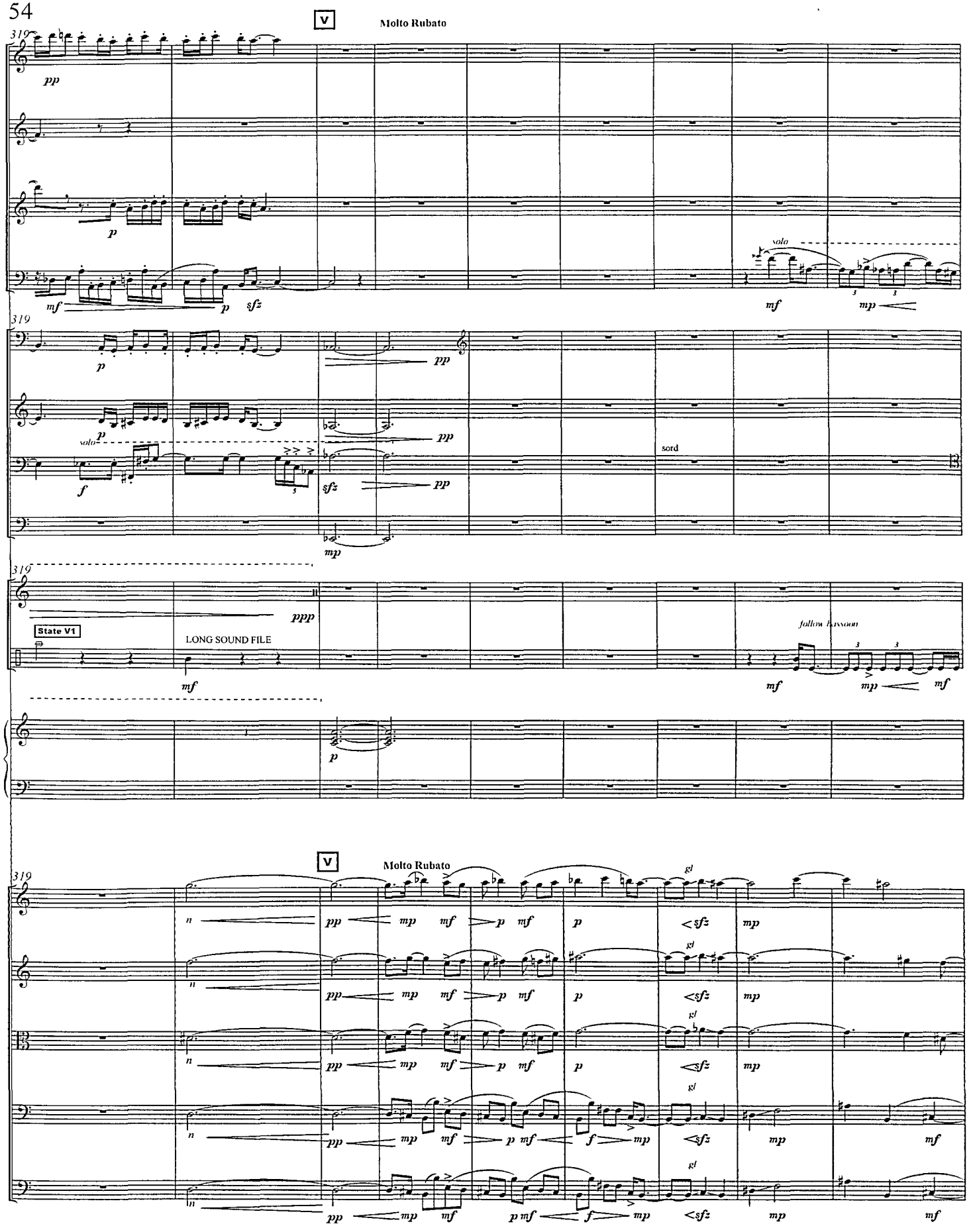

292 accel
♩=88
Driving Forward
T
♩= 84
Fl
Ob
Cl
Bb CLARINET
Bsn
Hn
Tpt
solo
Bright heroic
Tbn
Tuba
Perc
State S2
with the trumpet
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
gl

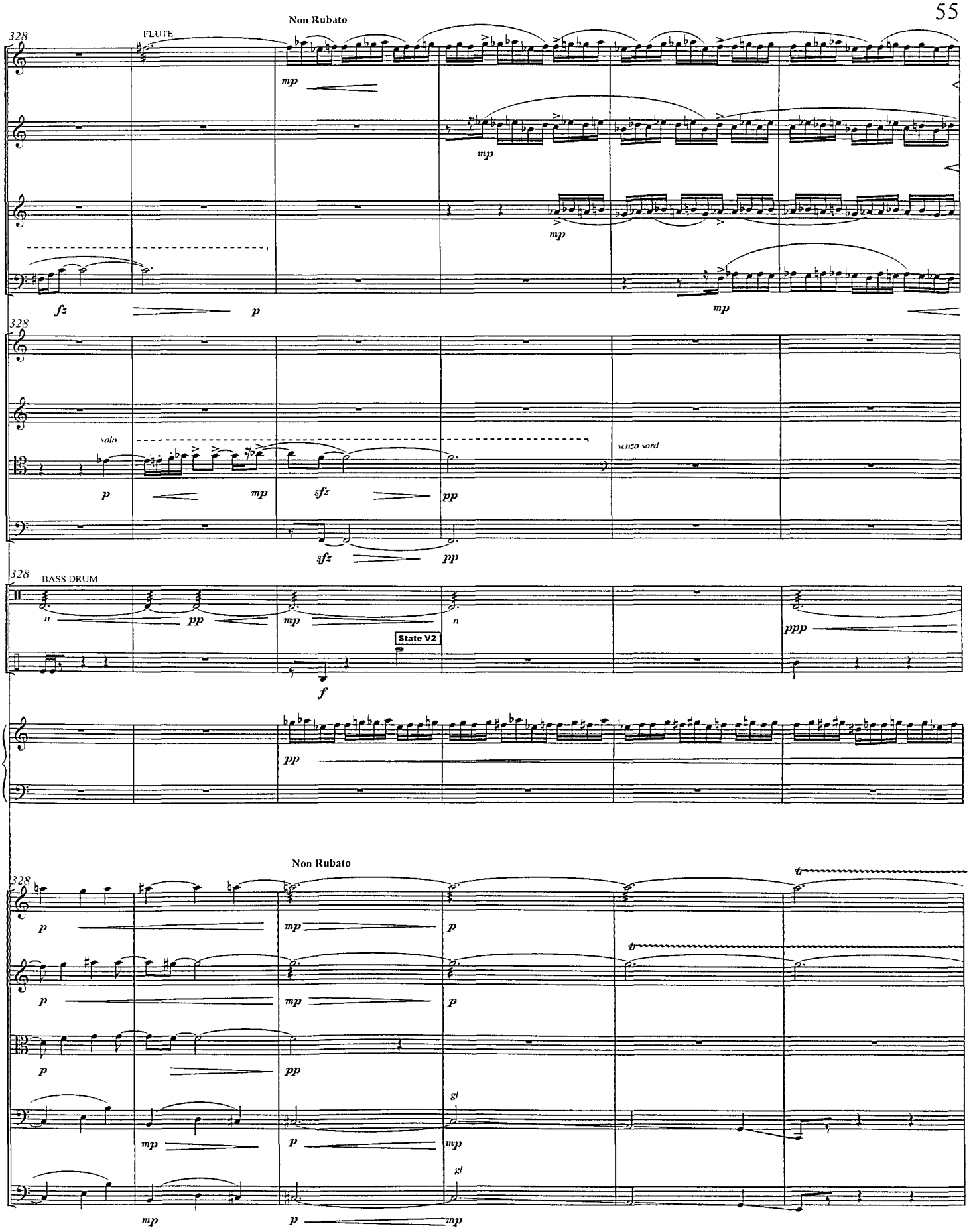

296
Fl
Ob
Bb CLARINET
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
MARIMBA
State S3
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb

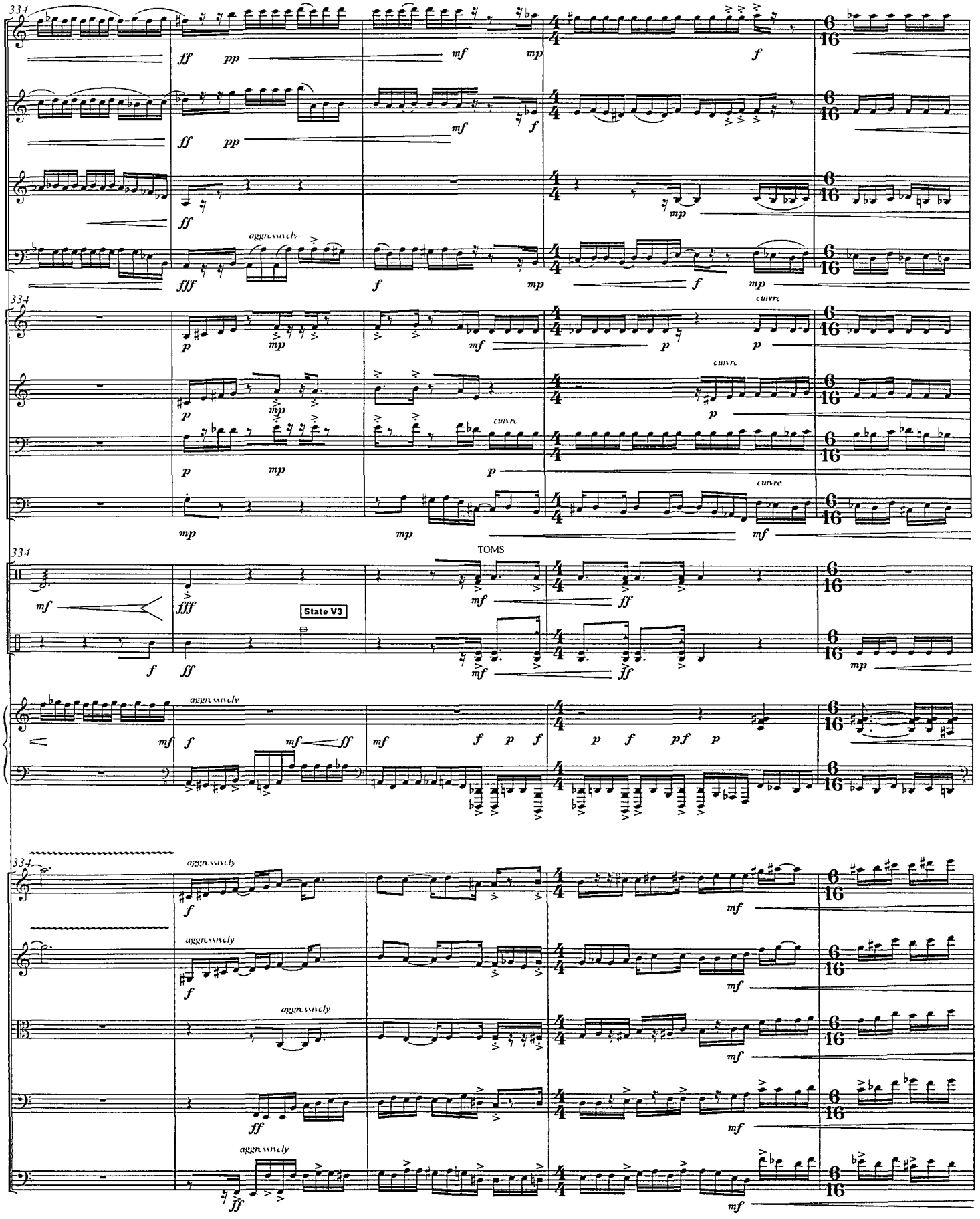

302
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
mp
sfz
mf
p
State S3

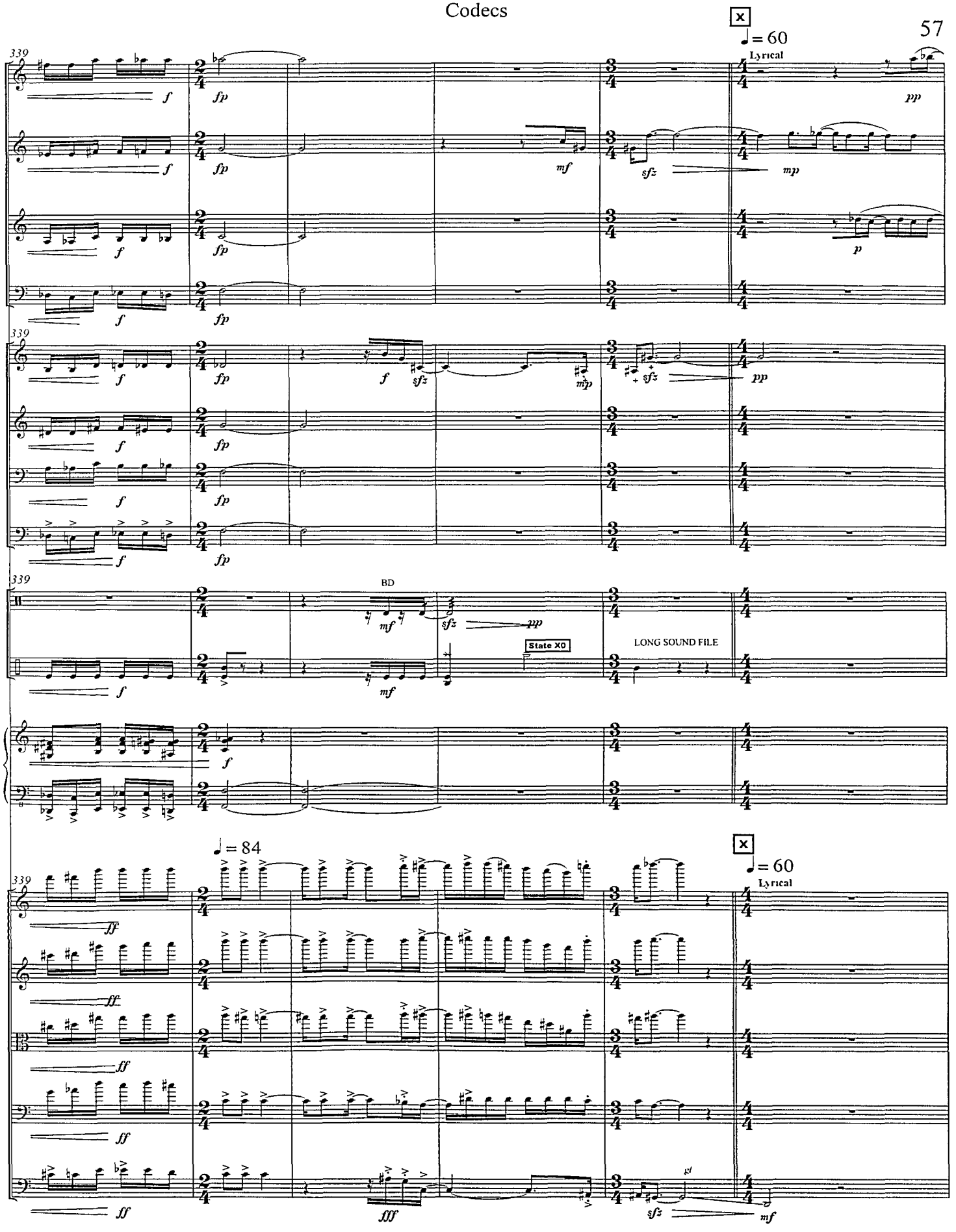

307
PICCOLO
PICCOLO
U
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
CROTALES
El Perc
State U1
Pno
Vln I
Vln II
Vla
Vc
Cb

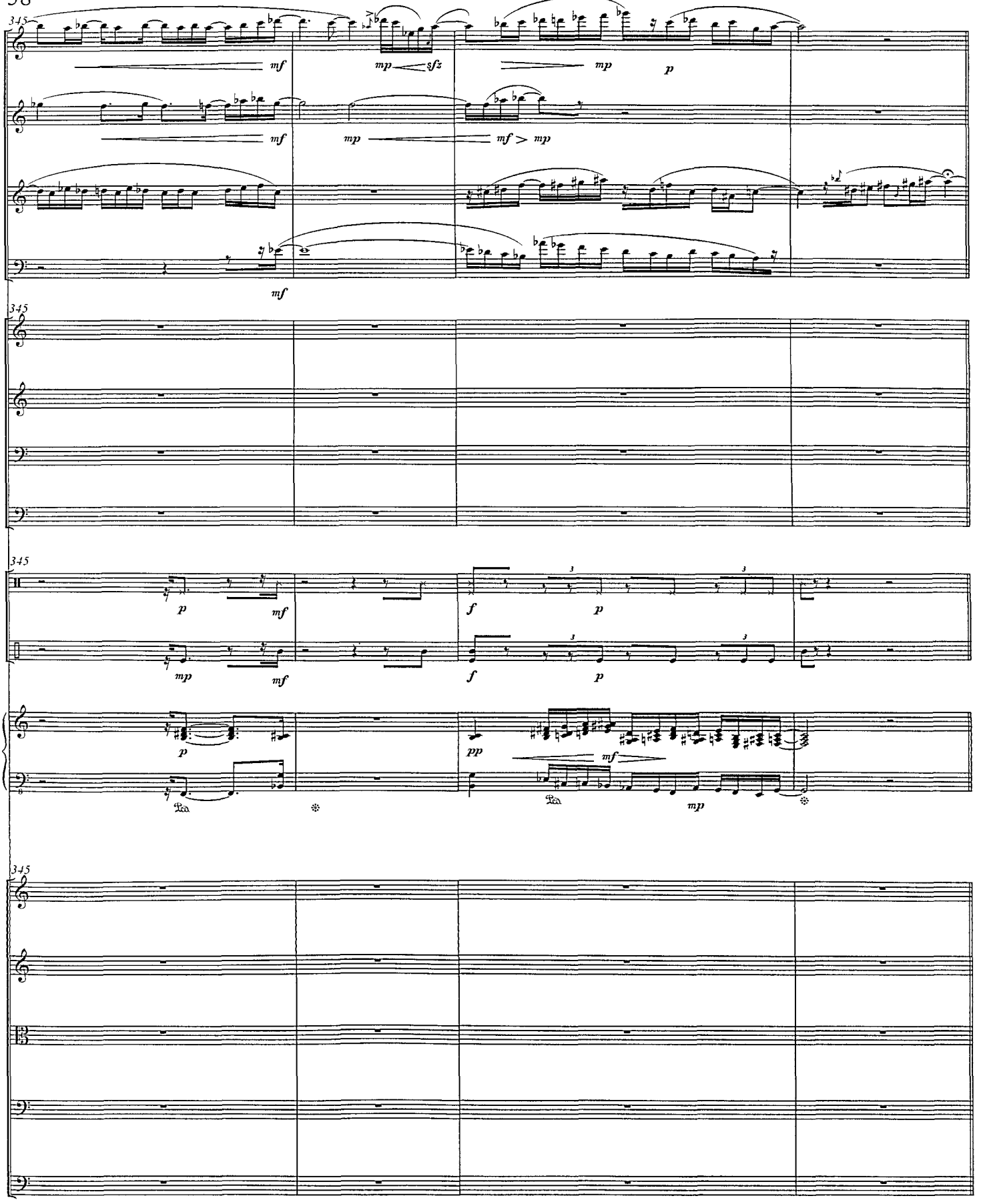

313
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
CROTALES
El Perc
Pno
ritardando out of time
Vln I
Vln II
Vla
Vc
Cb

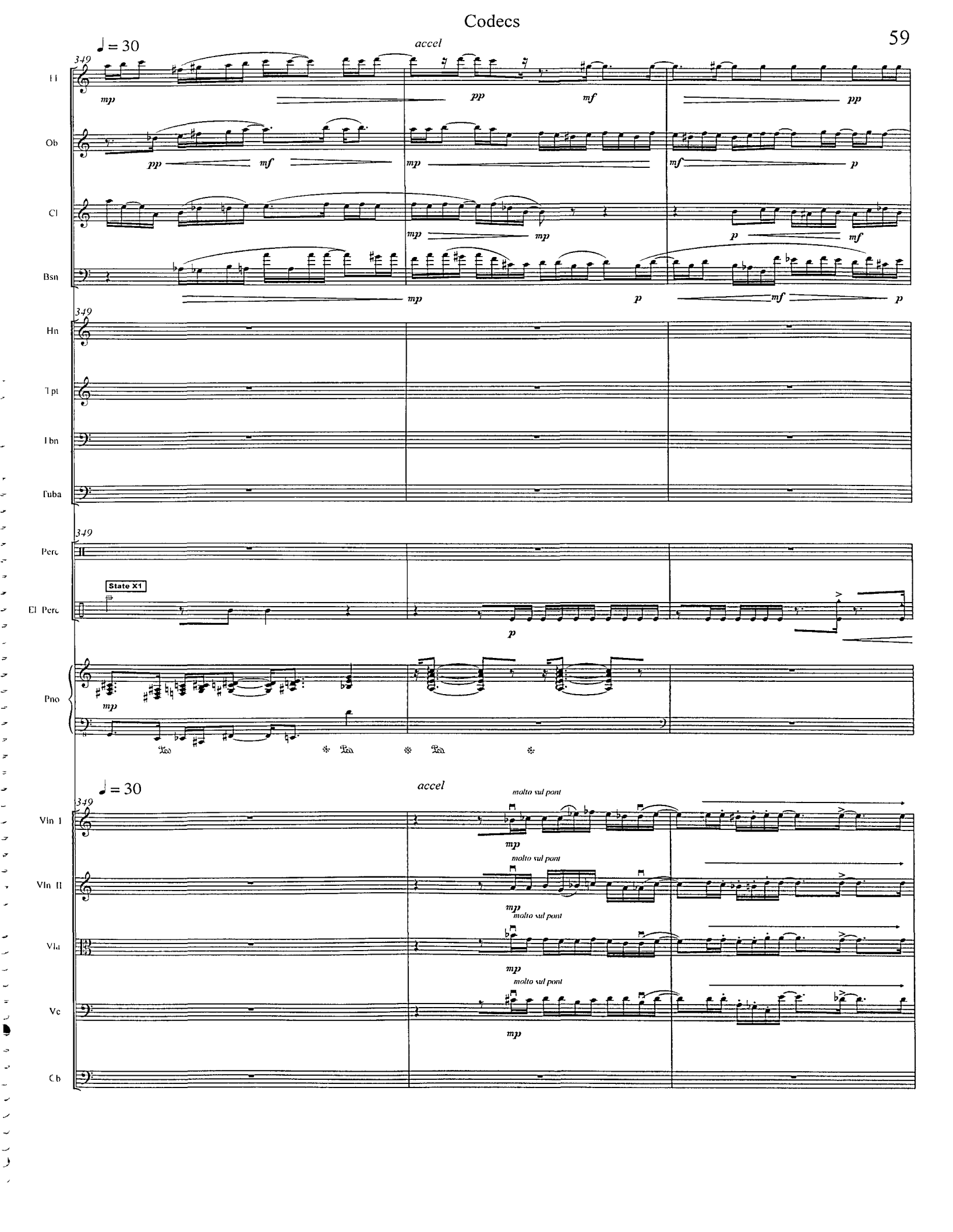

V
Molto Rubato
319
Fl
Ob
Cl
Bsn
solo
Hn
Tpt
Tbn
sord
Tuba
Perc
State V1
LONG SOUND FILE
El Perc
follow bassoon
Pno
V
Molto Rubato
Vln I
Vln II
Vla
Vc
Cb
gl


Non Rubato
328
FLUTE
Fl
Ob
Cl
Bsn
Hn
Tpt
solo
senza sord
Tbn
Tuba
BASS DRUM
Perc
State V2
Lt Perc
Pno
Non Rubato
Vln I
Vln II
Vla
Vc
Cb

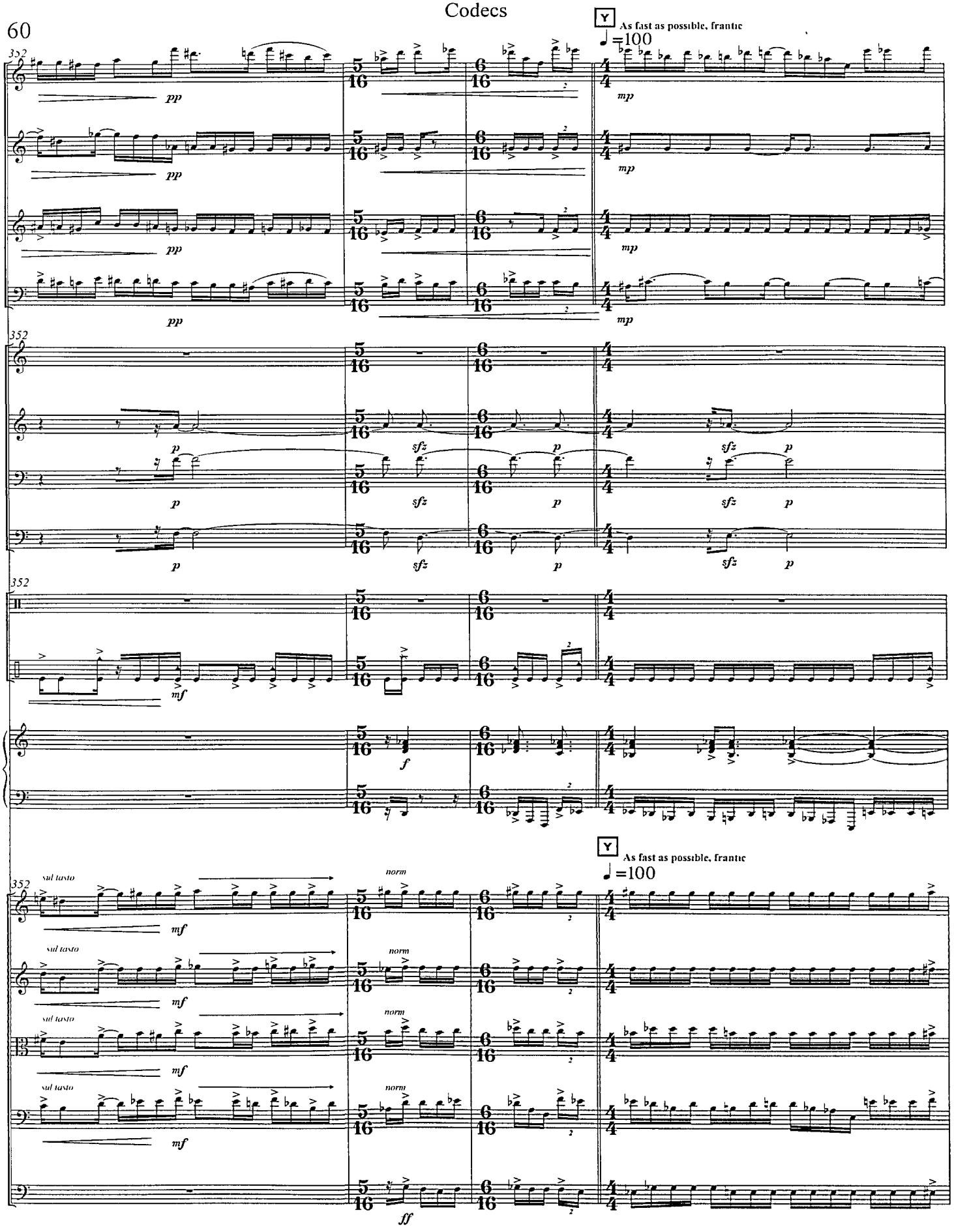

334
Fl
Ob
Cl
Bsn
aggressively
Hn
Tpt
Tbn
Tuba
curve
Perc
Fl Perc
TOMS
State V3
Pno
Vln I
Vln II
Vla
Vc
Cb

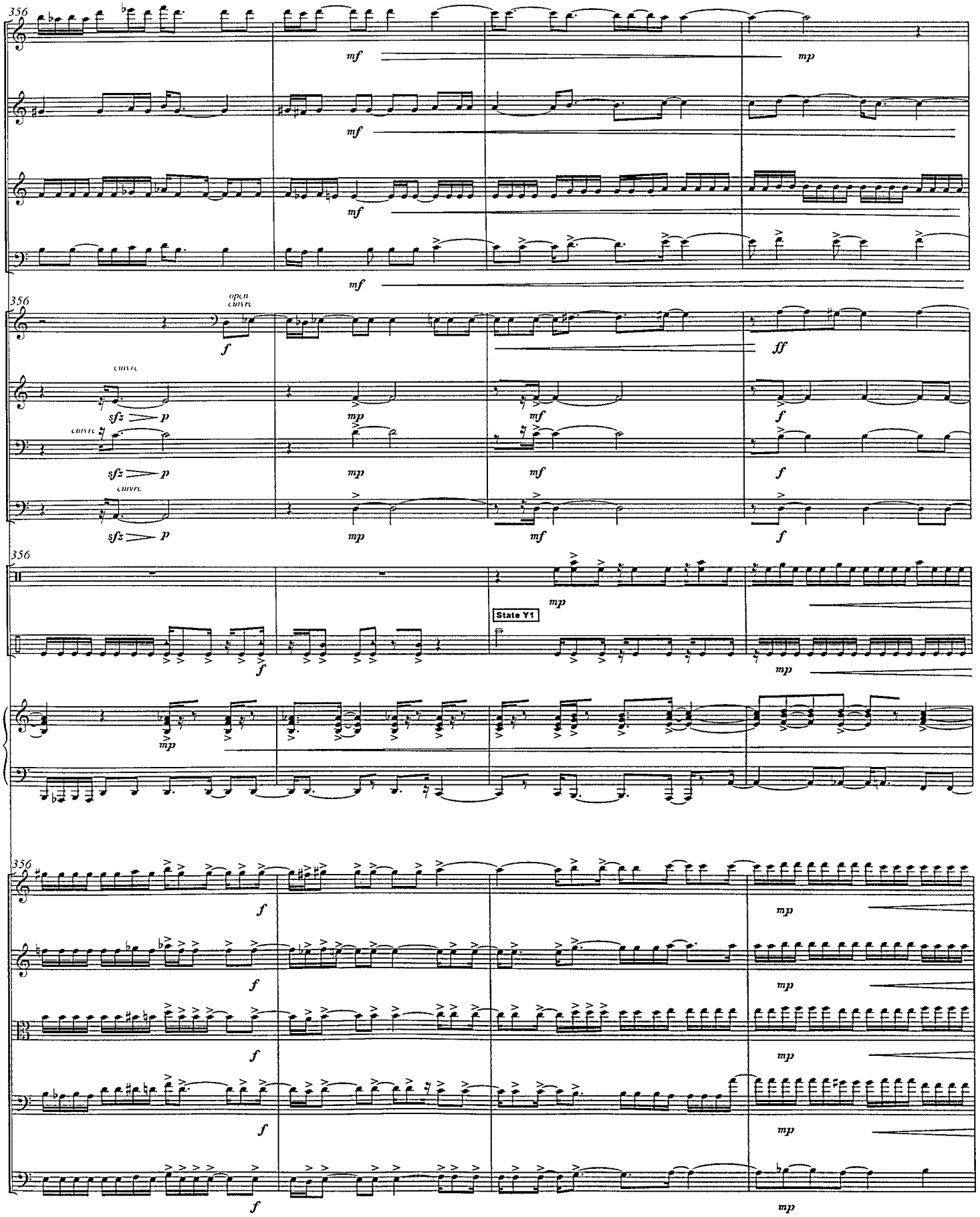

339
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
Hi Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
BD
State X0
LONG SOUND FILE
♩= 84
♩= 60
Lyrical

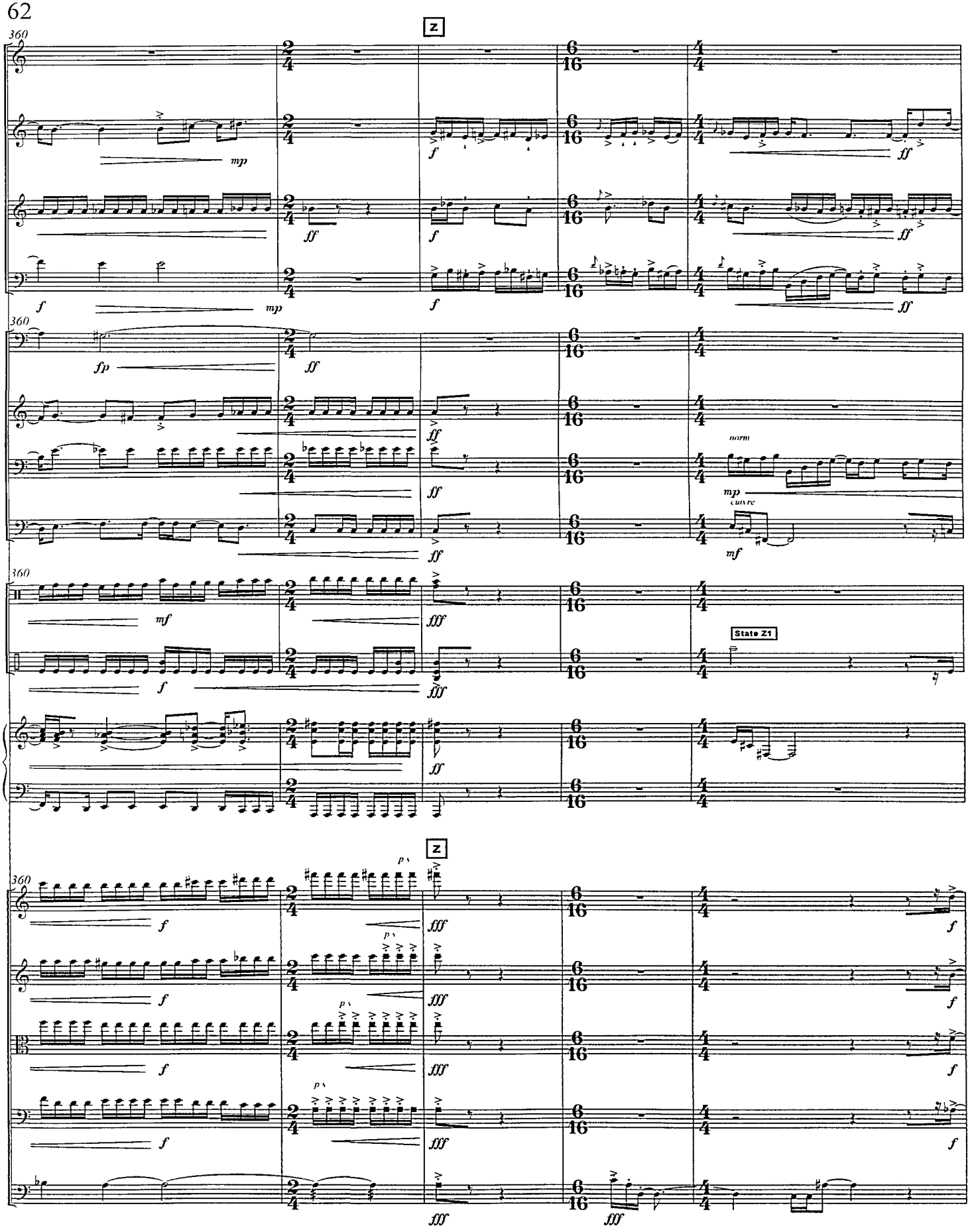

345
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
mf
mp
sfz
p
mf > mp
f
pp
Ped.

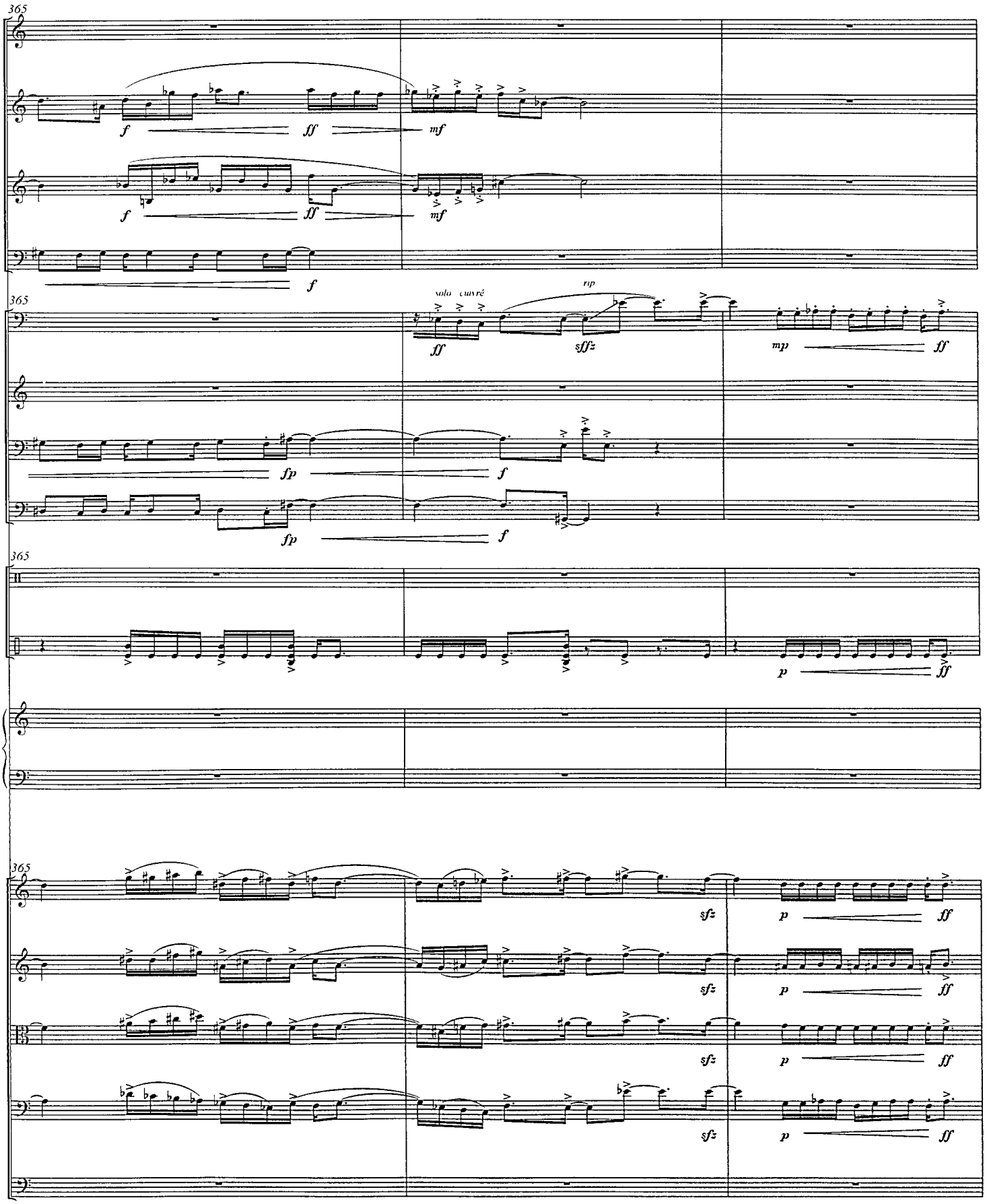

♩ = 30
accel
349
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
State X1
El Perc
Pno
♩ = 30
accel
Vln I
Vln II
Vla
Vc
Cb
molto sul pont

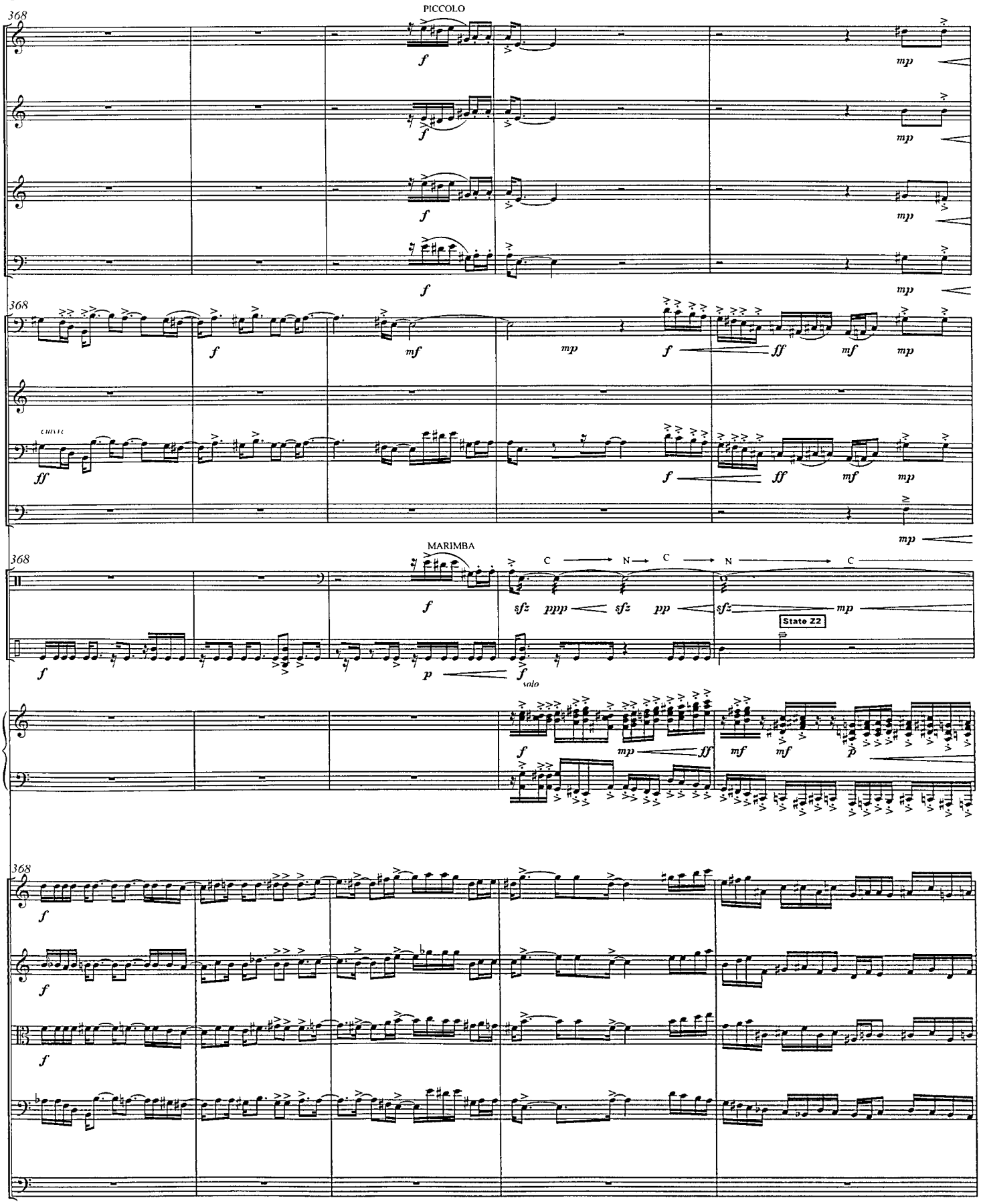
Codecs

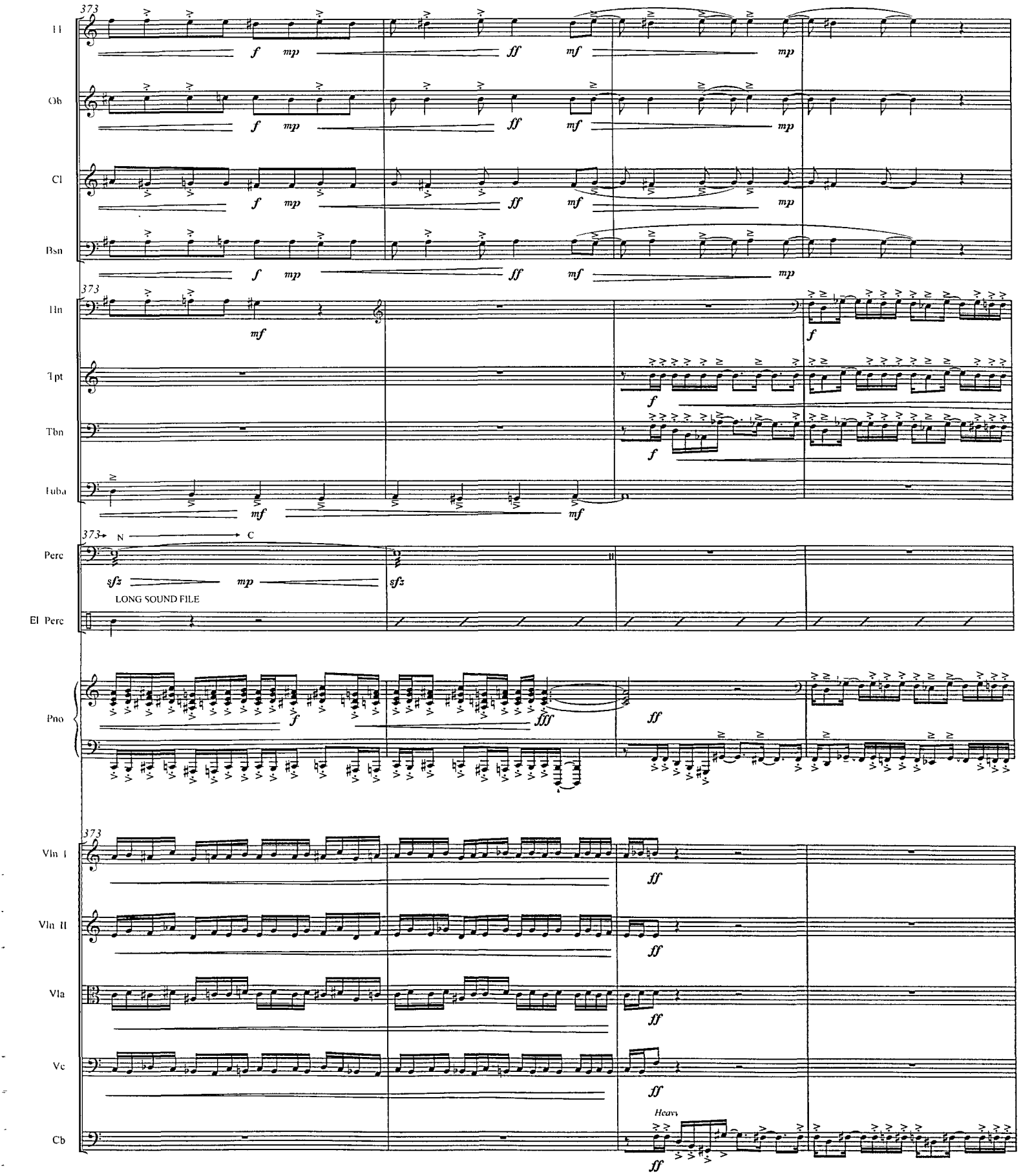

Y
As fast as possible, frantic
♩=100
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
sul tasto
norm

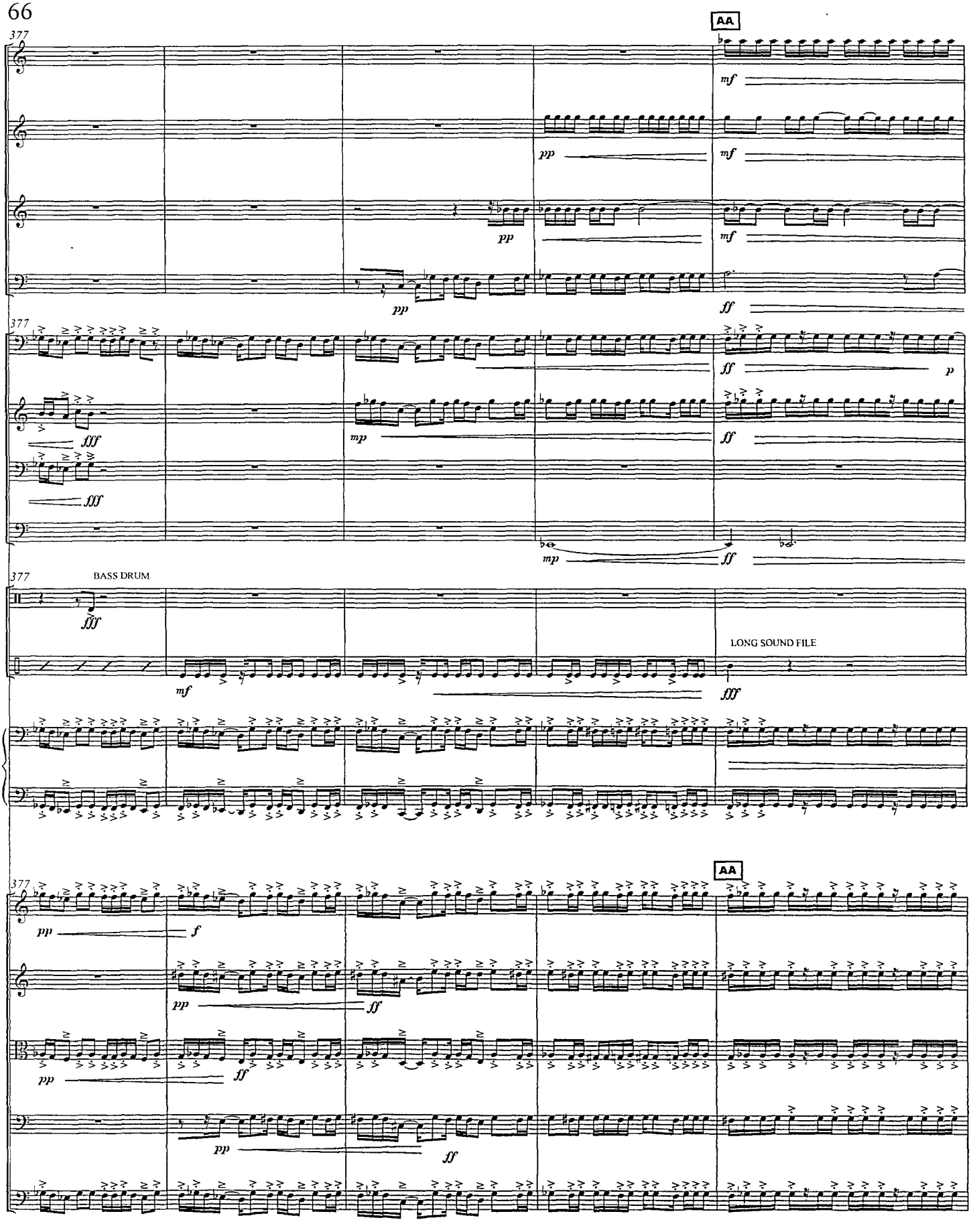

356
Fl
Ob
Cl
Bsn
Hn
open
curve
Tpt
Tbn
Tuba
Perc
State Y1
Lt Perc
Pno
Vln I
Vln II
Vla
Vc
Cb

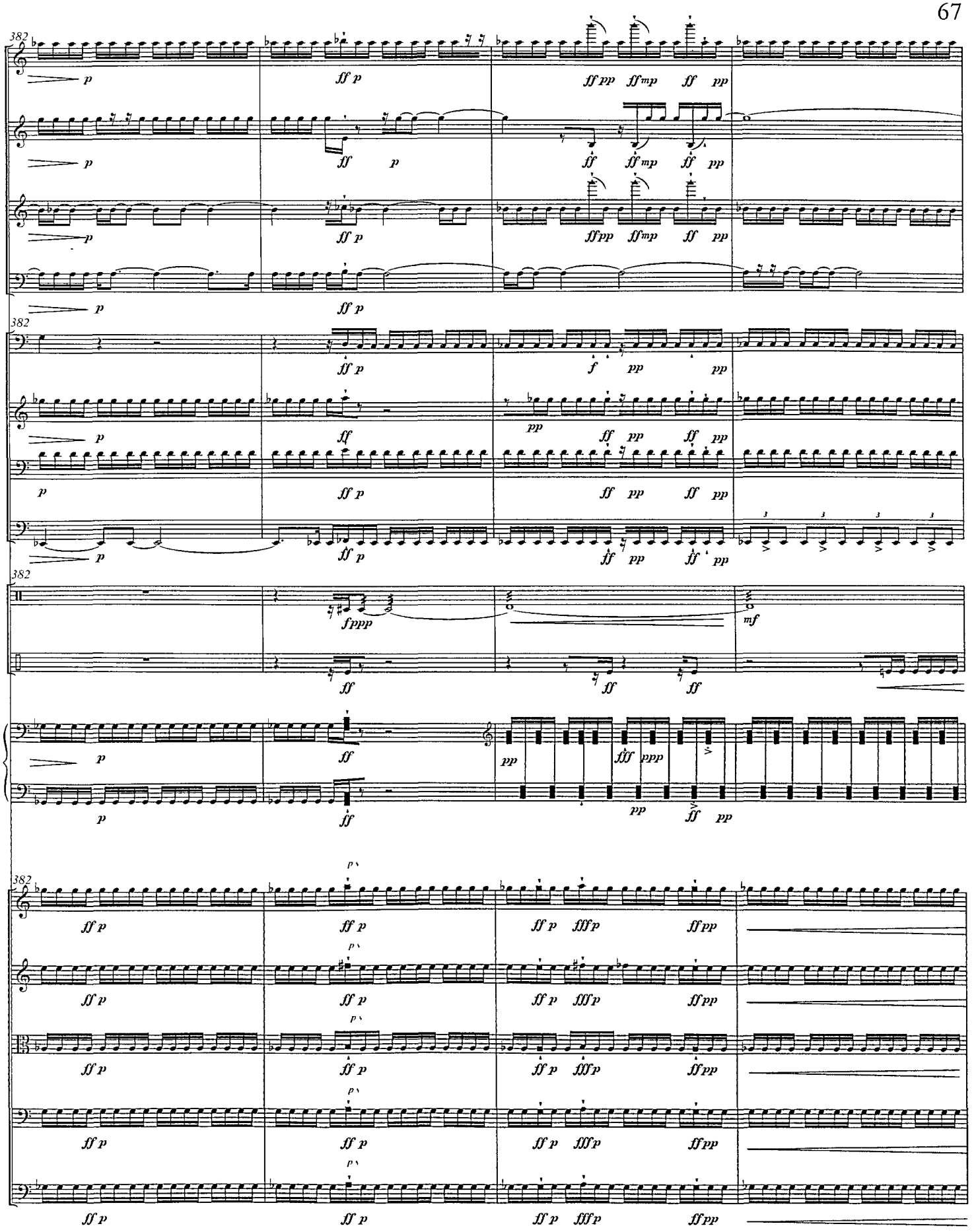

Z
360
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
mp
f
ff
fp
mf
fff
norm
cuivre
State Z1

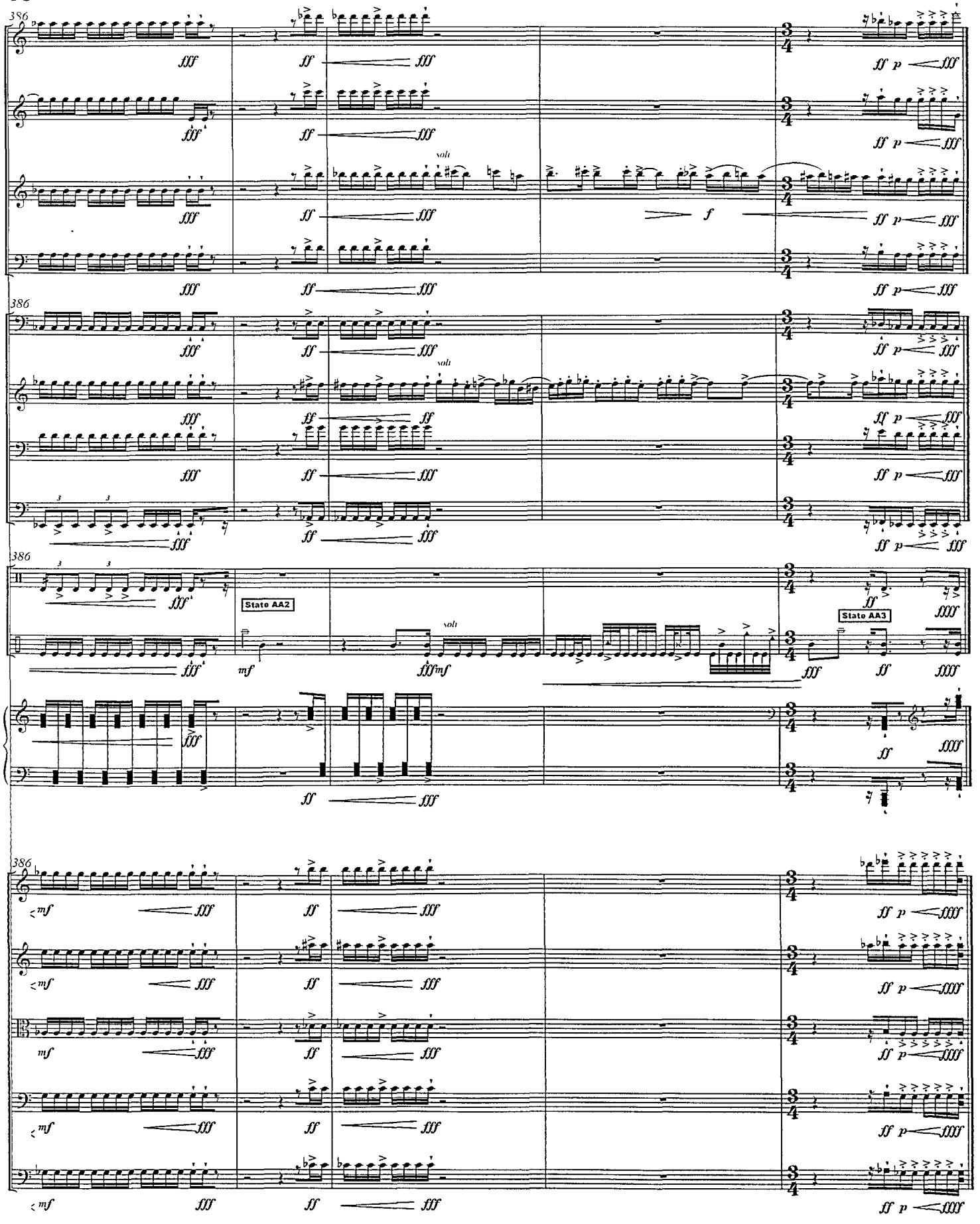

365
Fl
Ob
Cl
Bsn
365
Hn
solo cuivré
rip
Tpt
Tbn
Tuba
365
Perc
El Perc
Pno
365
Vln I
Vln II
Vla
Vc
Cb


PICCOLO
368
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
MARIMBA
Perc
El Perc
Pno
C
N
State 22
Vln I
Vln II
Vla
Vc
Cb


373
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
N
C
LONG SOUND FILE
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
Heavy


377
AA
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
BASS DRUM
Fl Perc
LONG SOUND FILE
Pno
Vln I
Vln II
Vla
Vc
Cb
mf
pp
ff
fff
mp
p
f


382
Fl
Ob
Cl
Bsn
382
Hn
Tpt
Tbn
Tuba
382
Perc
El Perc
Pno
382
Vln I
Vln II
Vla
Vc
Cb


386
Fl
Ob
Cl
Bsn
Hn
Tpt
Tbn
Tuba
Perc
State AA2
State AA3
El Perc
Pno
Vln I
Vln II
Vla
Vc
Cb
volt