SYMPHONY NO. 1

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Symphony No. 1 is an orchestral composition for twenty-four instrumental groups without percussion instruments. It was composed with Algorithmic Composition System software, which gives driving forces for composition to the composer through the diverse compositional methods largely based on physical phenomena.

The symphony consists of three movements. It lasts about sixteen minutes and twenty-six seconds--five minutes and twenty-two seconds for the first movement, five minutes and forty seconds for the second movement, five minutes and twenty-four seconds for the third movement. Most musical components in the first movement of the symphony are considered embryos, which gradually begin developing through the second and third movements.

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CHAPTER ONE

BACKGROUND: ALGORITHMIC COMPOSITION

Early Compositional Algorithms

Presumably, Guido d'Arezzo started the first example of compositional algorithm in 1026.[1] *Micrologus*, one of the chapters of his treatise for singers, contains a practical scheme for composing music along with his compositional algorithm. His method was to use correspondences between the vowels of the text and the pitches of the scale. Because the algorithm was used only for melody regarding employing pitches into a Latin text, Guido took a Latin text and extracted the vowels from each word and looked up corresponding pitches from his table. His method must be an algorithm because the process includes the construction of the table and the lookup operation.[2]

In the fourteenth century, Philippe de Vitry developed a unifying device using a rhythmic formula called *isorhythm*. His motet tenors were often made of a slow repeating rhythmic pattern. This consists of *color* as the repeating series of pitches and *talea* as the long recurring rhythmic unit. De Vitry incorporated the technique into tenors of his motets, which functioned as a foundation for the entire polyphonic structure.

Other examples related to formalizable music include canons, fugues, rounds, and variations. W. A. Mozart's *Musikalischs Wurfelspiel* is a famous example of algorithmic composition, which requires dice play to assemble minuets from the prewritten measures

[1] Gareth Loy, "Composing with Computers—a Survey of Some Compositional Formalisms and Music Programming Language," in *Current Directions in Computer Music Research*, eds. Max V. Mathews and John R. Pierce (Cambridge: MIT Press, 1991), 297.

[2] Ibid., 298.

of music. Thus the order of measures is determined by a set of dice throws before a performance.

In the twentieth century, Arnold Schoenberg developed the innovative twelve-tone serial technique using a uniform distribution of the twelve pitches as a simple deterministic method, in which the original row could be transformed into three different rows. They are called inversion, retrograde and retrograde-inversion, respectively. The four rows and their forty-four transpositions yield an important structure called *set-complex*. Later, Schoenberg invented hexachordal combinatoriality to make closer relationships between two different rows possibly to provide stronger unity to the *set-complex*. However, he used only semi-combinatoriality usually from the original and fifth inversion rows through his serial compositions.

Xenakis: Stochastic Music

When the total serialism emerged, the totally controlled deterministic compositions could be little distinguished from utter randomness. By this point of view, Iannis Xenakis started developing stochastic methods[3] for his compositions while composers such as Karlheinz Stockhausen, Pierre Boulez, John Cage, Earle Brown and others experimented with aleatoric methods of composition to break out the extreme determinism of serial compositions. Xenakis' stochastic music originated from the

[3] Stochastic methods can guarantee overall trends according to the probability tables. In general stochastic procedures include the decision-making process as well as the random choice. They generate musical events according to probability tables that weight the occurrence of certain events over others. For example, a basic stochastic generator produces a random number and compares it to values associated with the probability table. If the random number belongs to a certain range of values in the probability table, the algorithm generates the event associated with that range.

principle of indeterminism, which started as a result of the impasse in serial music as well as other causes.[4] Xenakis thought that *it was necessary to replace it by a more general causality, by a probabilistic logic which would contain strict serial causality as a particular case*.[5] In the 1960s, Xenakis developed the Stochastic Music Program (SMP) with Fortran language to realize probabilistic logic to his compositions. The formulas of SMP were originally developed by scientists to describe the behavior of particles in gases.[6] To create music, Xenakis provided SMP with data such as the average duration of sections, minimum and maximum density of notes for a section, instrumental groupings for timbre classes, timbre classes for a function of density, probabilities to each instrument, longest duration for each instrument, and so forth. Xenakis created a number of important works with SMP such as *ST/10-1* and *Atrées* for ten soloists, both in 1962, and *Eonta* in 1964. In general, to complete compositions, Xenakis has rearranged and modified the raw output generated by the SMP program. Later the SMP program was improved by mathematician-composer John Myhill in 1979 and has been re-coded for personal computers since then.[7]

Lejaren Hiller

Lejaren Hiller was the first person who composed music entirely with a computer. The first work was *The Illiac Suite for String Quartet*, which was created by Hiller and his collaborator Isaacson in 1956 using the Illiac computer at the University of Illinois.

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[4] Iannis Xenakis, *Formalized music* (Bloomington: Indiana University Press, 1971), 8.

[5] Ibid., 8.

[6] Curtis Roads, *The computer music tutorial* (Cambridge: The MIT Press, 1996), 837.

[7] Ibid., 838.

Hiller and Isaacson transformed rules of various compositional styles into a great number of conditions. The composition process thus consisted in checking procedures whether the random number chosen suits all conditions. For example, if a pitch doesn't suit any condition, another number is selected and compared again. If a pitch suits all conditions, the pitch is selected as output. Hiller's approaches to *The Illiac Suite for String Quartet* differ from the stochastic or probabilistic procedures. They consist of mostly deterministic procedures. For example, if a pitch is needed, the pitch is not selected randomly but the pitch comes from the seed data that is decided by the checking process.

Soon, Hiller and Robert Baker set up a compositional programming language called MUSICOMP with assembly language in 1963, which provided basic techniques for generating original musical scores. Hiller and Baker divided the source decks into three basic parts, System Regulatory Routines, Compositional and Analytical Subroutines, and Sound Synthesis Routines. The Compositional Subroutines contain many stochastic routines to select musical elements such as rhythmic durations, pitches and pitch ranges. Since then, Hiller started to compose experimental compositions such as *Computer Cantata* (1963), *Algorithm I* (1969), and *Algorithm II* with increased stochastic procedures.

Other Composition Programs

Besides Xenakis' SMP and the MUSICOMP of Hiller and Baker, Gottfried Michael Koenig created a program named Project 1 at the Institute of Sonology, Utrecht, in 1970. Project 1 mainly consists of seven selection principles and a database for five musical parameters such as instrument, rhythm, harmony, register, and dynamics. As

input a composer provides data such as a set of chords, the total number of events to be generated, tempos, and a random number.

The MIDIDESK created by Clarence Barlow in 1989 is a recent example of an algorithmic composition program. It processes note files or digital scores using a multitude of modules, ranging from typical sequencer tools to Markov analysis / synthesis[8] and efficient N-tuplet quantization. However, the main purpose of the program is to manipulate MIDI data that is entered as input. Barlow has used the program to compose from solo piano to large orchestral compositions. The following are some of the noticeable MIDIDESK commands: VARY, RIDE, TIDY, FADE, MOCK, and PART. The VERY command consists of three modes including shift, spread, and slide. The shift mode transposes a sequence, the spread mode expands the range of the sequence, and the slide mode applies a continuous change between values in the sequence. The RIDE substitutes many notes for one note. The TIDE is used to eliminate any portion of the sequence. The FADE interpolates between two sequences. Finally the MOCK imitates a sequence using a Markov chain based on a statistical analysis of the sequence.

Phil Winsor: His Programming Examples and MusicSculptor

Phil Winsor wrote a great number of algorithmic composition programs during the 1980s. Many of them are included in his three invaluable books: *Computer Composer's Toolbox* in 1987, *Automated Music Composition* in 1989, and *ComputerMusic in C* in 1991. The programs in those three books deal with all kinds of

[8] The Markov chain is one of the stochastic processes and has been used popularly for a strategy in algorithmic compositions. It's a probability system, in which the likelihood of a future event is determined by the state of one or more events in the past.

problems including mathematical formulas and graphics functions as well as deterministic and probabilistic / stochastic processes. His focus is very clear. He teaches how to adapt them to create and modify music, and to solve problems with the computer. As well, Winsor wrote many programs that are long and complex for his own compositions or sometimes for demonstration. Soon, many of the programs he had written were merged and integrated into a larger program called MusicSculptor.

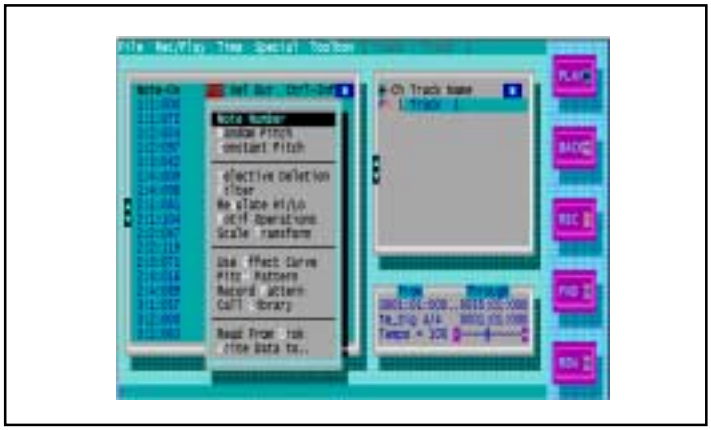

Fig. 1. A screen of MusicSculptor with menu commands for pitch. The largest box on the left side is *Note-List window*, the box in the upper right corner is *Tracks Window*, and the below is for real-time sequencer.

In 1991 Winsor developed interactive algorithmic composition software named MusicSculptor, with his assistant Kuo-Lung Chang. MusicSculptor works for any personal computer using the DOS operating system with a midi interface card. It's a real-time midi environment with integrated algorithmic composition procedures. As the name MusicSculptor implies, users cannot merely generate music, but also sculpt existing pieces using diverse algorithmic procedures such as *Motif Operations*, *Filter*, *Selective Deletion*, *Regulate Hi*/*Lo*, *Scale Transformation* and so forth.

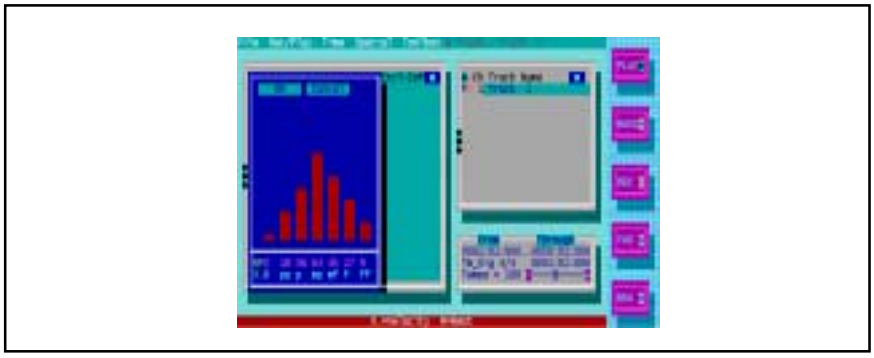

Fig. 2. A screen showing the stochastic distribution table for dynamics.

One noticeable feature of the program is that users can design contouring curves using *Design Effect Curve window*, and then they can generate new musical elements or pattern current musical elements after the contouring curves using *Use Effect Curve* command.

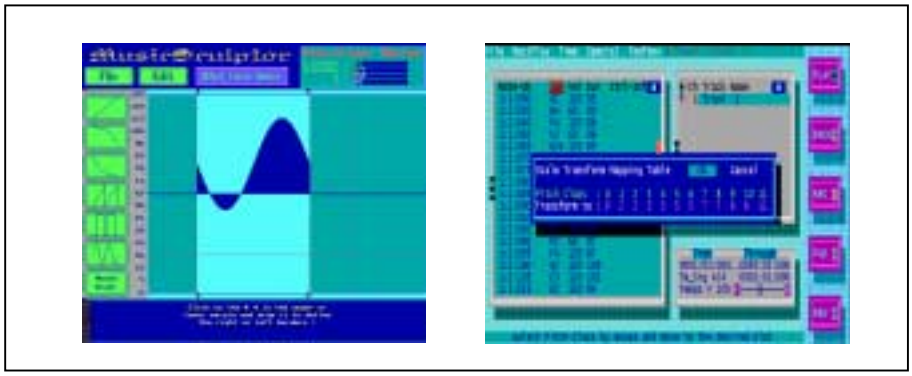

Fig. 3. *Design Effect Curve window* and *Scale Transform Mapping Table* of MusicSculptor. Users can design any contouring lines for new musical elements or for any preexisting musical elements to reshape.

CHAPTER TWO

ABOUT *SYMPHONY NO. 1*

Algorithmic Composition System v.2.2

I have been thinking and looking for a new way of composing music using microtones after composing several atonal compositions myself. I composed the first microtonal work named *Heartburning* in 1993. I chose a multichannel synthesizer as a medium for the sound. To create microtonal sounds for the composition, I had to add numerous pitchband messages to the corresponding notes and then I changed the pitchband values with the mouse and keyboard. It was a very tedious and time-consuming job. When I took Prof. Phil Winsor's second algorithmic composition class in 1994, he taught algorithmic composition with Visual Basic; during the first class he used GW basic. As a final project, I composed a tape piece named *A Life,* for which I used Visual Basic to make several short programs to generate microtonal passages and tone clusters. Both the process and the result were interesting and satisfying experiments to me. Soon after that, I started my own algorithmic composition program named ACS (Algorithmic Composition System) to experiment with other musical elements from time to time since 1995.

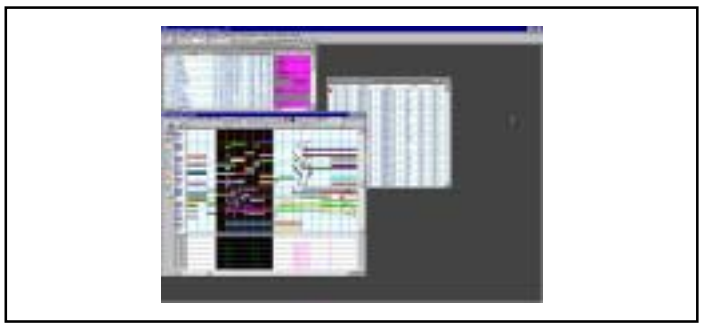

Fig. 4. An ACS screen showing *Track List*, *Event List*, and *Piano Roll* windows.

Specification of ACS

I started writing algorithmic composition programs with Visual Basic from the beginning. While programming, I faced Visual Basic's limitations, which made me dive into the C world to solve problems such as building the sound system part. After struggles, I found a way to make a MIDI sequencer with the support of DLL files that interact with the Visual Basic program. The DLL files mainly consist of functions that cannot be performed or created with Visual Basic. Examples are the timer functions, the functions sending MIDI messages directly to MIDI ports, and other time-critical calculating functions. As ACS is based on Visual Basic, it works only on 32-bit Microsoft Window systems. Fig. 5 shows a simple description of ACS.

- Algorithmic Composition Environment with a real-time MIDI sequencer.
- Provides 32 compositional tracks currently.
- Supports up to 10 MIDI devices simultaneously for playing sounds, so that the composer utilizes up to 160 channels if he combines many MIDI devices such as synthesizers and sound cards.
- Music editor that operates in real-time.
- Imports and exports standard MIDI files.

Fig. 5. Specification of ACS.

Structure of ACS

ACS consists of five basic parts: Foundation Routines, Algorithmic Composition Routines, Analysis Routines, Editing Routines, and Sound System Routines (real-time MIDI sequencing part).

Foundation Routines enable the composer to build basic musical parameters and retain data for Algorithmic Composition Routines. Algorithmic Composition Routines consist of a great number of deterministic and stochastic procedures to create music based on instructions and data the composer provides. Sound System Routines and Analysis Routines allow the composer to inspect the result. If he/she feels the output needs corrections or arrangements, he/she may use Editing Routines to correct, refine, or rearrange the raw output.

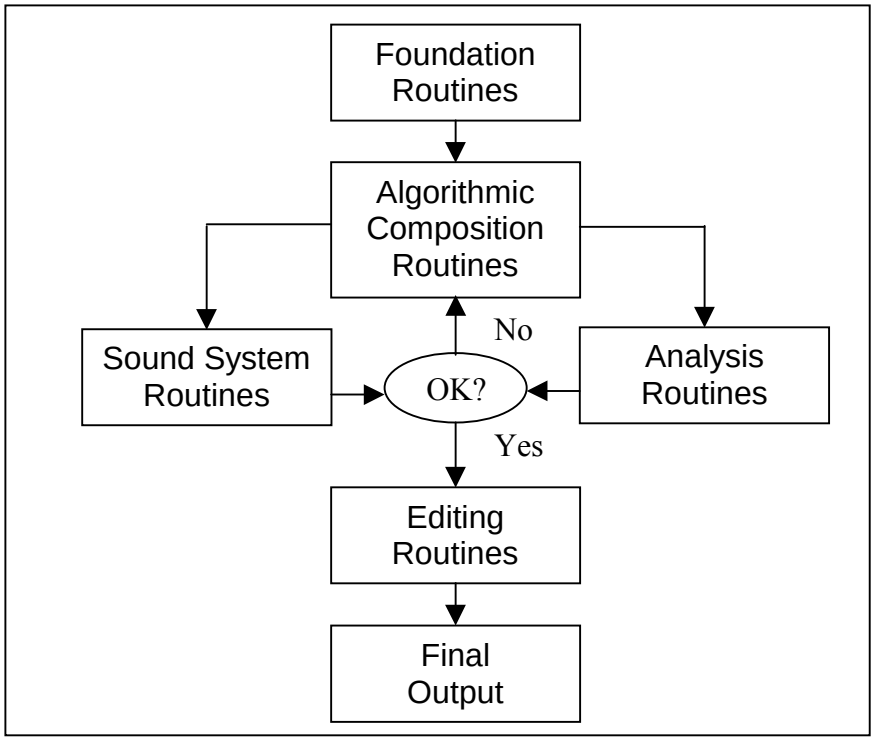

Fig. 6. Logic of five basic parts of ACS.

Functions of ACS

Foundation Routines

Foundation Routines provide the composer with tools to design common musical data, such as pitch contents, interval patterns, rhythmic elements, rhythmic patterns, rhythmic groupings, data for note distribution, and the ranges for output. Once the data are constructed, they can be called from any function in ACS.

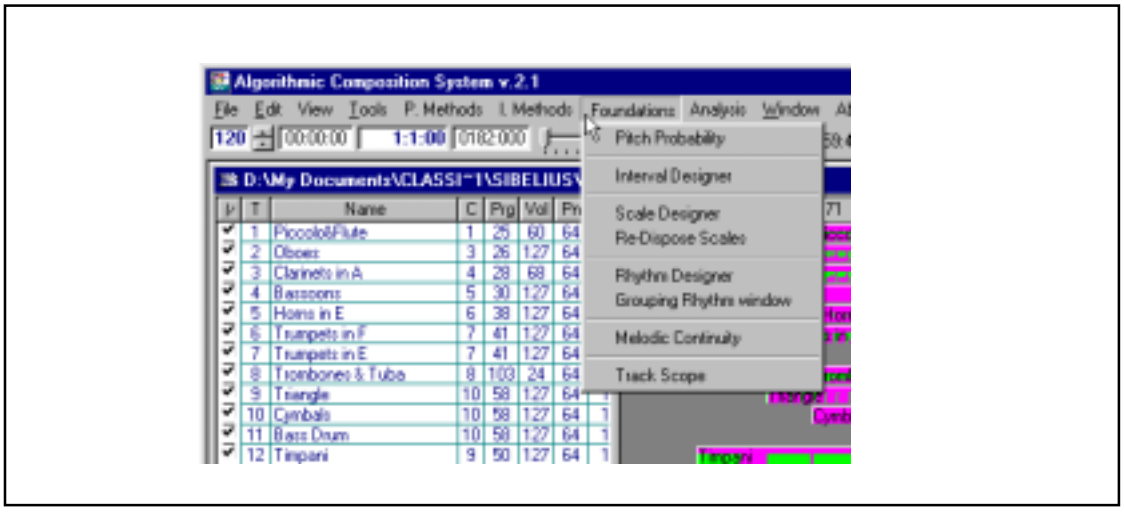

Fig. 7. *Foundations menu* commands.

Pitch Probability window provides a probability distribution table for the simple random functions based on stochastic processes, which produce random pitches.

Interval Designer window provides tools to build intervals with their probability data, which are employed exclusively for *Interval Method* that can generate multi-voice output.

Scale Designer window provides tools for the composer to build scales or pitch series. For example, when the composer designs a scale or a series, he/she can build

scales with tools to copy, paste, delete, invert, retrograde, transpose, and so forth. While building scales, he/she can play them using the sound functions.

Fig. 8. *Scale Designer window* in Foundation Routines.

Rhythm Designer window provides tools for the composer to build rhythms, rhythmic patterns, and rhythmic groupings for each individual track.

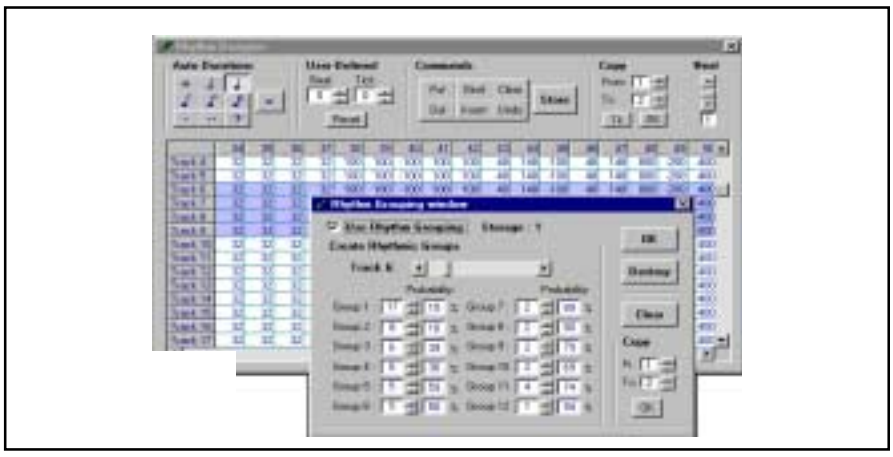

Fig. 9. *Rhythm Designer window* in Foundation Routines.

The role of *Melodic Continuity window* is to control the probability of the occurrence of notes. These settings can be distributed into many sections of output with different data for each section, which makes various distributions of notes for the output.

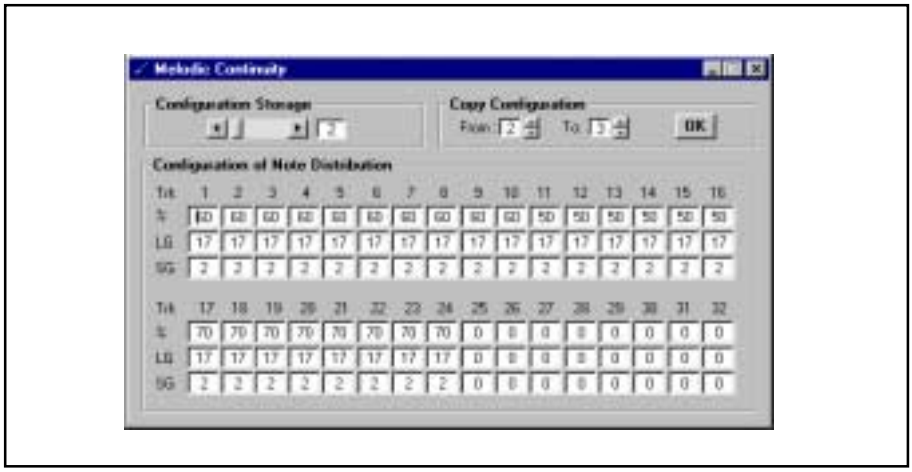

Fig. 10. *Melodic Continuity window.*

Algorithmic Composition Routines

Algorithmic Composition Routines are divided into three categories according to the processing size and their roles. They are named *Partial Methods, Integrated Methods*, and *Tools,* respectively.

Partial Methods of Version 2.2 consist of *Serialism*, *Directionism*, *Scale Transformer*, *Remodel Pitch Content*, *Linear Shaper*, and *Curvilinear Shaper*. These methods normally target a single track rather than multi-tracks of those of *Integrated Methods*. Consequently, output sizes are in general smaller than the ones from *Integrated Methods*.

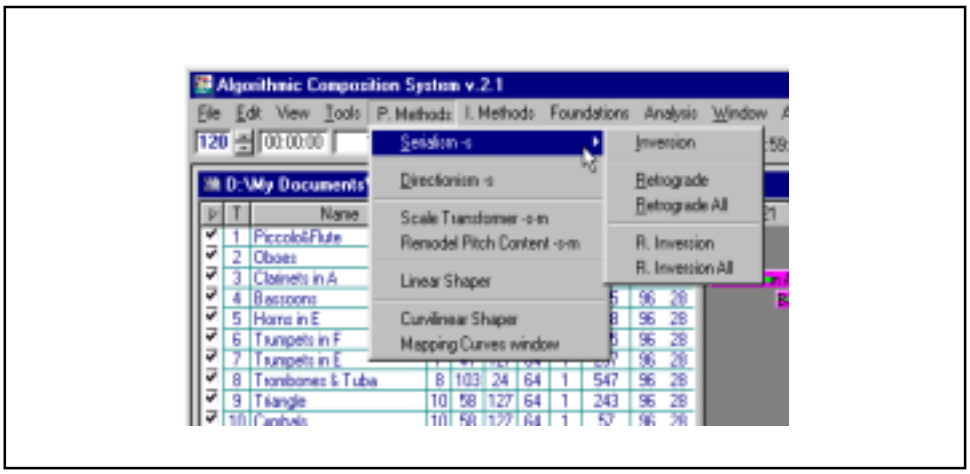

Fig. 11. The menu commands of *Partial Methods.*

The five *Serialism* commands modify what the composer selects for inversion, retrograde and retrograde inversion. They are transference of the basic twelve-tone techniques.

The second menu command *Directionism* is my own term. I discovered the directions of pitches are very notable, whether they occur in tonal or atonal music. In general, the ascending melody produces more energy and stronger tension than the descending one does, and so does the phenomenon between the skip and step motion of notes. When we have a melody, we can transform it using the directions of the pitches. As we did in the twelve-tone music, we also can transform it into a mirror motion, a backward motion, and the mirror of the backward motion. This way, the techniques of *Directionism* provide the composer with more freedom by increasing the range of the choice of pitches but still providing clear order to the composition, which drives the composer to continue the composition to the end with motivation. Whether it is a twelve-tone scale or not, it can be adapted into any style of music. I applied this concept to my

handicraft works in the past such as *Lines* (1994), *Waves* (1995), and *My Load is God* (1995).

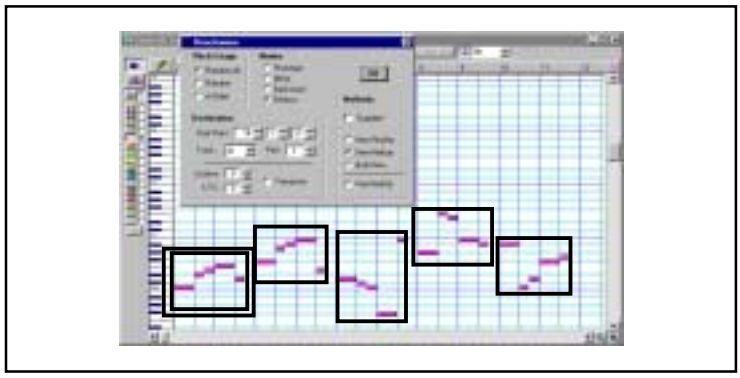

Fig. 12. An example using *Directionism* showing the original, *Prototype*, *Mirror*, *Backward*, *Backward-Mirror* starting from the left rectangle box.

Scale Transformer, *Remodel Pitch Contents,* and *Temper Pitch Range* in *Tools* menu originate with Winsor's MusicSculptor, in which most functions are suitable for any kind of music elements for transformation, modification, and altering through sculpturing functions such as filtering, congruence, mapping, and so forth.

Scale Transformer function of ACS does a similar job. It replaces current pitches with pitches in the new scale. *Remodel Pitch Contents* is a kind of filter that replaces or subtracts specific pitches.

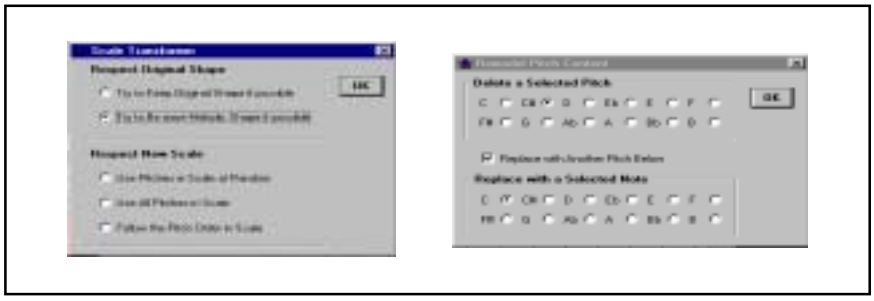

Fig. 13. *Scale Transformer* and *Remodel Pitch Contents* windows.

Linear Shaper enables the composer to pattern music after a drawing as Fig. 14 shows. The example here is a patterned fragment after a drawing. The first is without adapting pitch range congruence, and the latter adapting the 8-semitone pitch range congruent function.

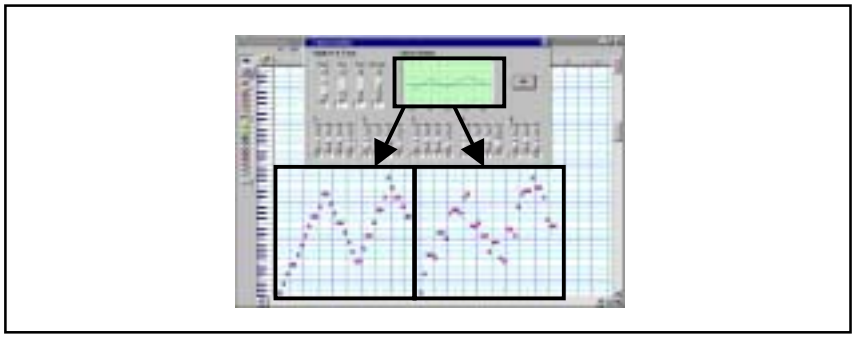

Fig. 14. An example of *Linear Shaper*.

Curvilinear Shaper enables the composer to pattern music after curvilinear motion. Then the composer can refine raw output using the mapping functions as shown in Fig. 15.

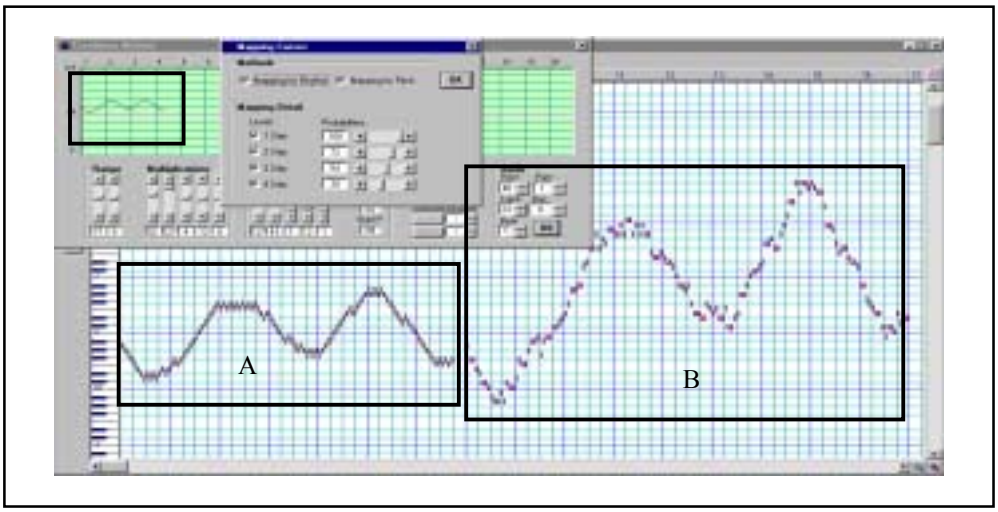

Fig. 15. The rectangle box in the upper left corner shows a curvilinear vector graphic. Rectangle box A is raw output patterned after the vector graphic, and box B is the refined one with mapping functions in *Mapping Curves* window.

Integrated Methods are comprised of *Serial, Interval*, *Harmonizing*, *Matrix & Vector*, *Extended Serial*, and *Chordal Phrasing Methods*. All of them are capable of multi-track processing up to 32 tracks simultaneously.

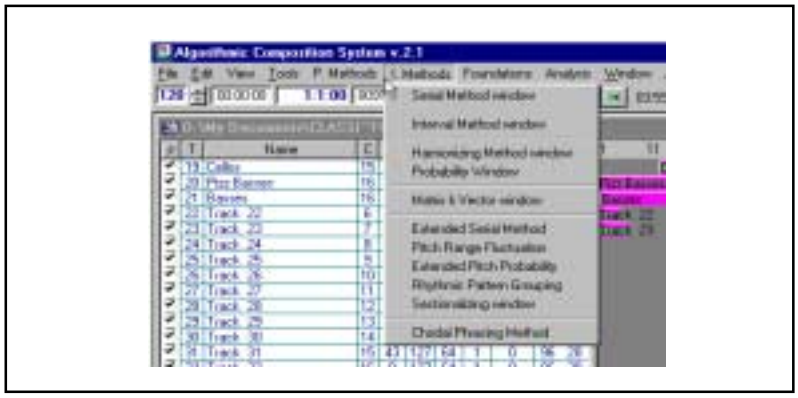

Fig. 16. *Integrated Methods* menu commands.

Serial Method is a similar transference of the twelve-tone techniques. As the method requires only a single pitch range data for the entire output, the overall result is much rawer than those from other methods.

Fig. 17. *Serial Method* window.

Interval Method is a kind of transference of the pitch set theory, in which interval relationships between pitch sets are significant while the relationships between pitches in the scale are meaningless. The following is an example of the output based on interval 0 (including the same pitches and octave equivalents), 1, 2, 3, and with *Chord Progress Generator*, which will create chords that contain the same interval contents.

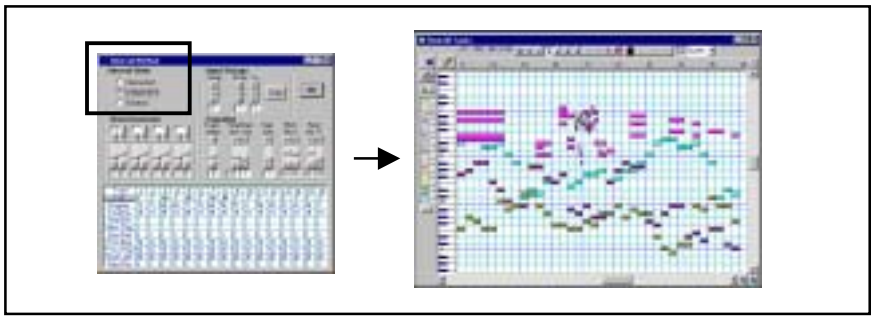

Fig. 18. An example of the output from *Interval Method.*

Harmonizing method has the capability of generating simple tonal as well as atonal output. For tonal output the composer feeds in chords, harmonic rhythms, and other basic musical data. The method includes tools controlling the overall contouring motions of the output as shown in Fig. 19.

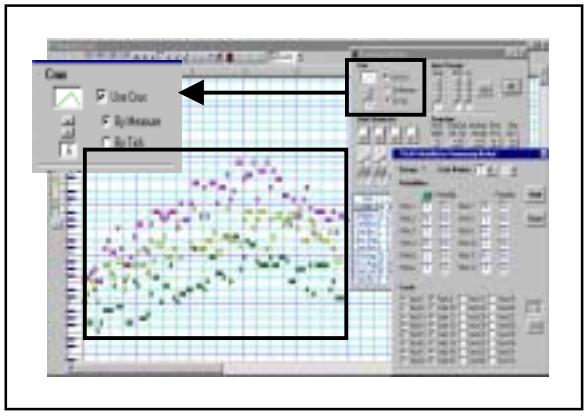

Fig. 19. An example of *Harmonizing Method*.

I devised *Matrix & Vector Method* to simulate textural music like Penderecki's *Threnody for the Victims of Hiroshima* (1960) for fifty-two string instruments, Ligeti's *Atmosphères* (1961), and the like. Although the method may look similar to *Curvilinear Method* in *Partial Methods*, *Matrix & Vector Method* originates from the two-dimensional distortion of a matrix while *Curvilinear Method* is uni-dimensional. *Matrix & Vector Method* thus creates much more diverse shapes for a multi track as well as a single track.

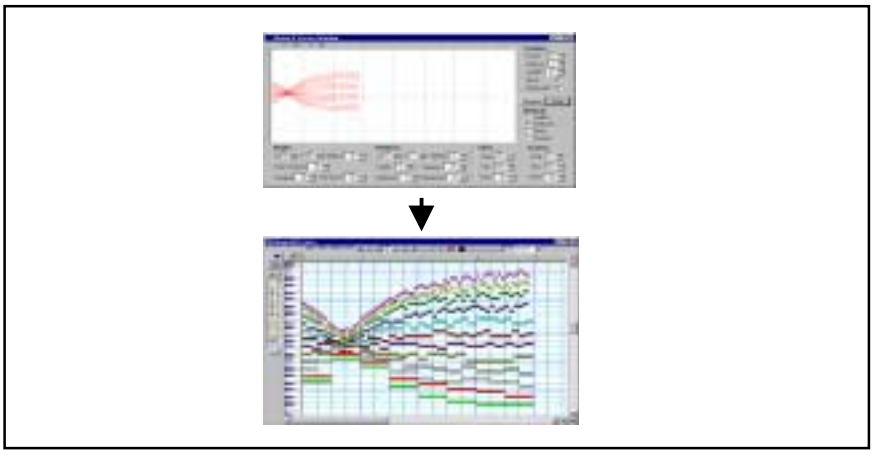

Fig. 20. An example using *Matrix & Vector Method.*

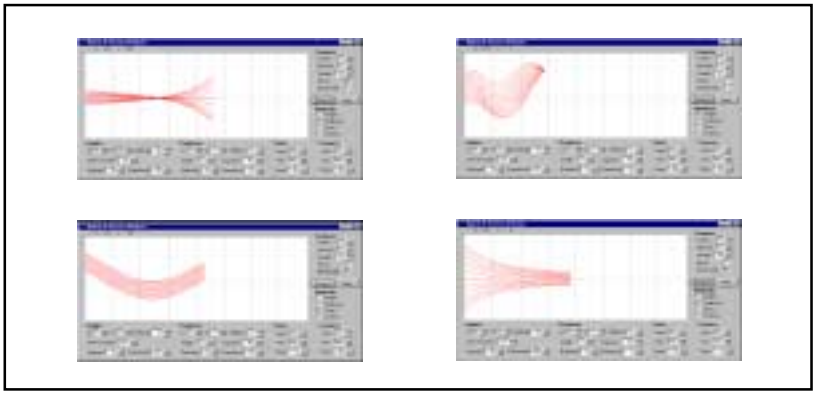

Fig. 21. Diverse vector graphics created using *Matrix & Vector Method.*

Extended Serial Method is an extension of *Serial Method* in ACS. It has increased deterministic algorithmic procedures, which allow the composer to have more control over the process. For example, *Extended Serial Method* helps the composer group tracks by rhythmic pattern so that he can apply the same rhythmic pattern to specific tracks.

The method also allows the composer to control other musical data by sections. For example, because all tracks can be divided up into 10 sections freely without time range limits, the composer can provide each section with different configurations for *Pitch Range Fluctuation*, *Extended Pitch Probability*, *Rhythmic Pattern Grouping*, and *Melodic Continuity*.

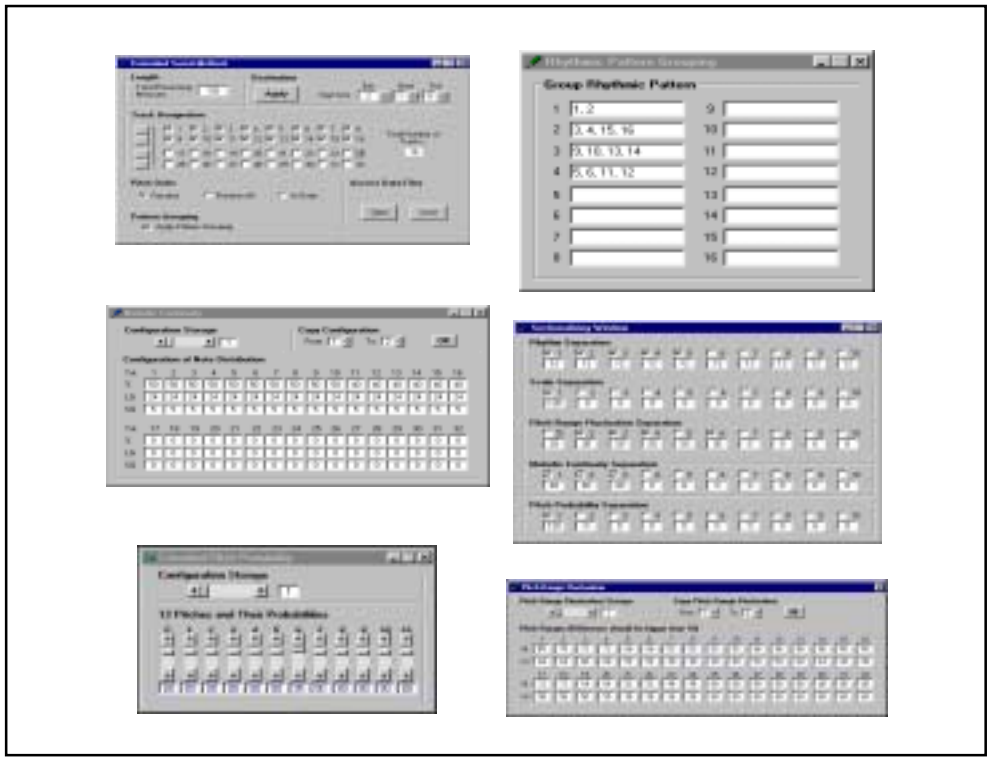

Fig. 22. The main window and other configuration windows of *Extended Serial Method*.

Chordal Phrasing Method is an algorithm using simple stochastic procedures that generate chords or static tone clusters like noises. The composer provides a rough pitch range and rhythms, and the procedure randomly selects pitches from the range.

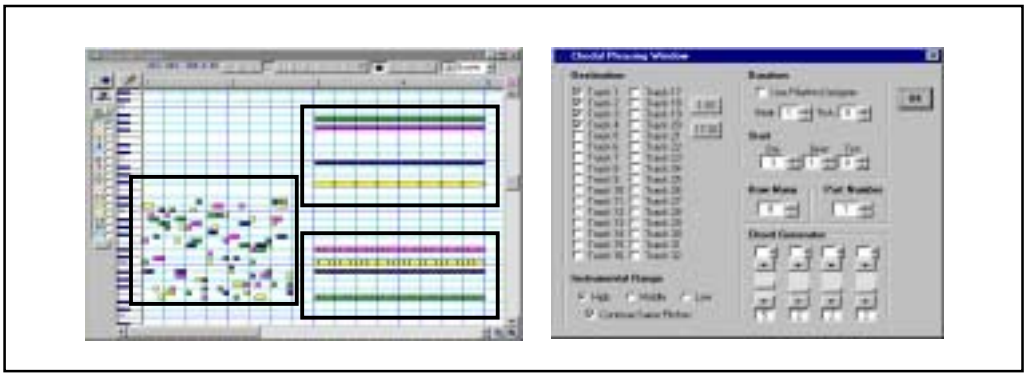

Fig. 23. An example of *Chordal Phrasing Method*.

The functions in *Tools* menu do not create any musical output but modify existing data, and some tools are used as utilities to support a better compositional environment. The modifying tools include *Transpose*, *Temper Pitch Range*, *Compress or Expand at a Note Position*, *Compress or Expand with Time Position*, *Change Durations*, *Quantization*, *Change Velocities*, and *Insert or Remove Rest*.

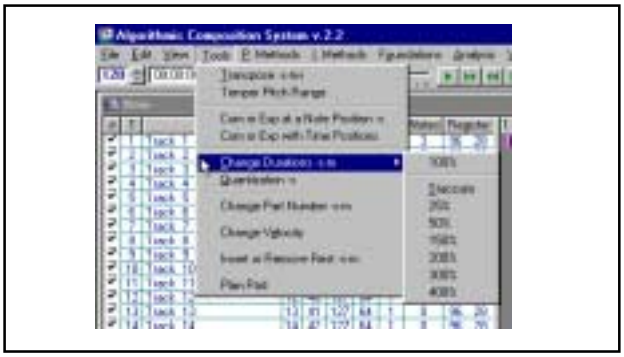

Fig. 24. *Tools* menu commands.

Temper Pitch Range changes current pitch ranges by shifting notes up or down to accommodate the selection to the new required pitch range. The two functions, *Compress or Expand at a Note Position* and *Compress or Expand with Time Position*, change the time positions of the selection. The latter changes both note-on and note-off time while the former changes only the note-on time of the selection.

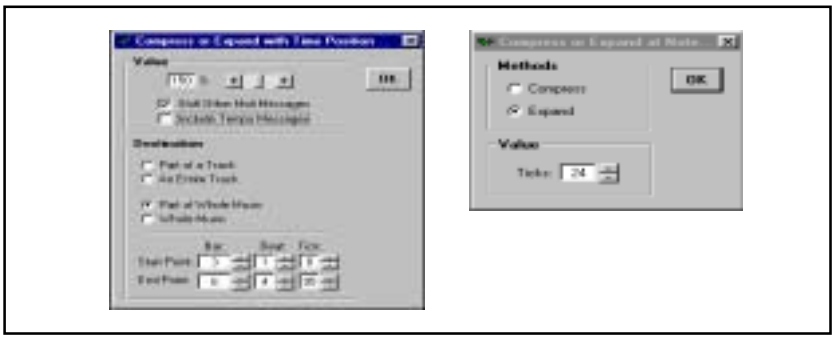

Fig. 25. *Compress or Expand at a Note Position* and *Compress or Expand with Time Position* windows.

Plan Pad window provides a simple word processor and drawing tools. It helps the composer put notes and ideas together while composing. The window saves notes as a separate file automatically, which can be opened from any word processor.

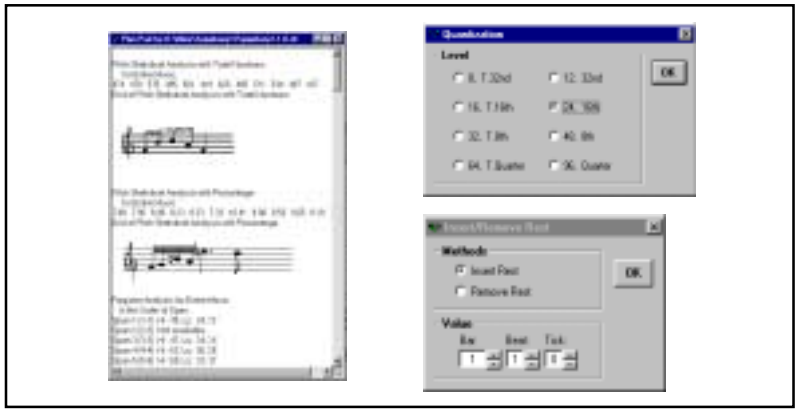

Fig. 26. *Plan Pad*, *Quantization*, and *Insert or Remove windows.*

Analysis Routines

ACS currently includes fourteen analysis functions, which can be divided into six categories such as pitch, register, rhythm, harmony, interval and dynamics analyses. Some windows use a measuring unit called *span* for better presentation, which can range from a single-measure to 100-measures at maximum.

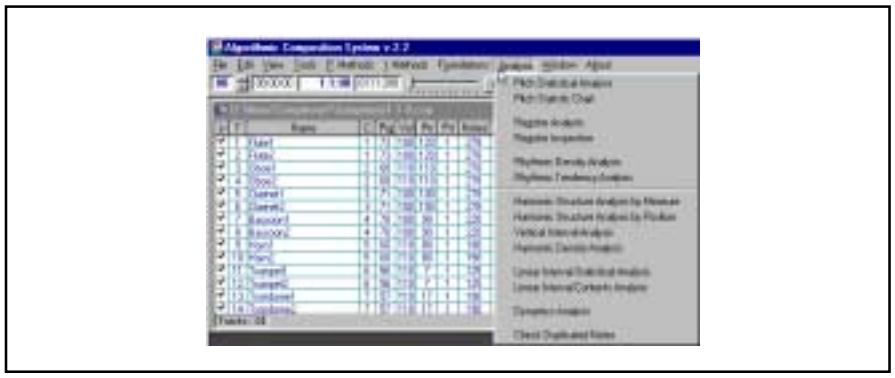

Fig. 27. *Analysis* menu functions.

Pitch Statistical Analysis shows the total frequencies of each pitch by spans or by a single-span specified, which can be done for a track as well as entire piece of music.

Fig. 28. An example of *Pitch Statistical Analysis* function.

Pitch Statistic Chart window provides the composer with information on the frequency of each pitch. This window shows the result as a graphic chart, in which the rectangular bars represent ratios between pitch numbers. The composer can compare a time range to another time range regarding pitch frequency using the analysis.

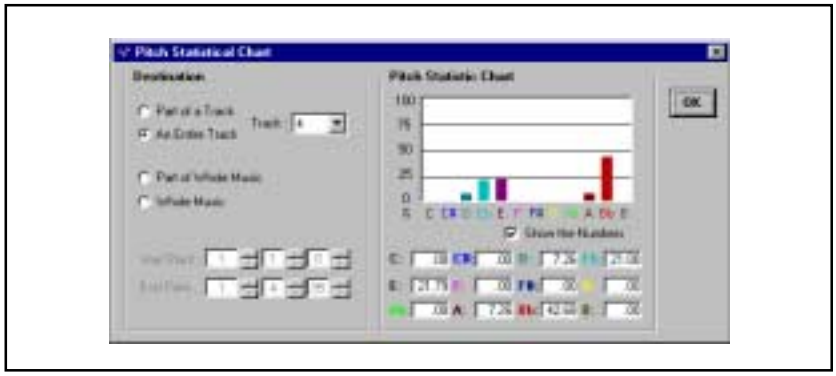

Fig. 29. An example of *Pitch Statistical Chart analysis.*

Register Analysis presents each track's pitch range or register by the following three different aspects: the measure order, the widths of the pitch ranges, and the highest and lowest pitches.

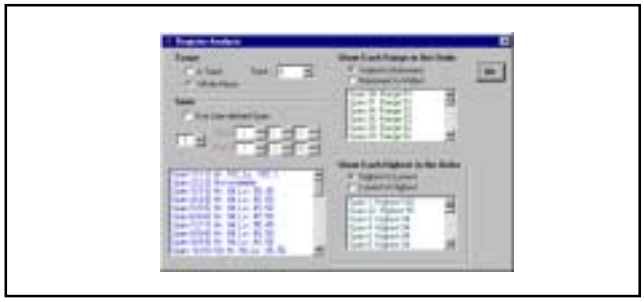

Fig. 30. An example of *Register Analysis.*

The role of *Register Inspection window* is to check if pitches are in the corresponding instrumental register. If certain pitches are out of range, the upper box shows the track number and the lower box shows the location with a measure number.

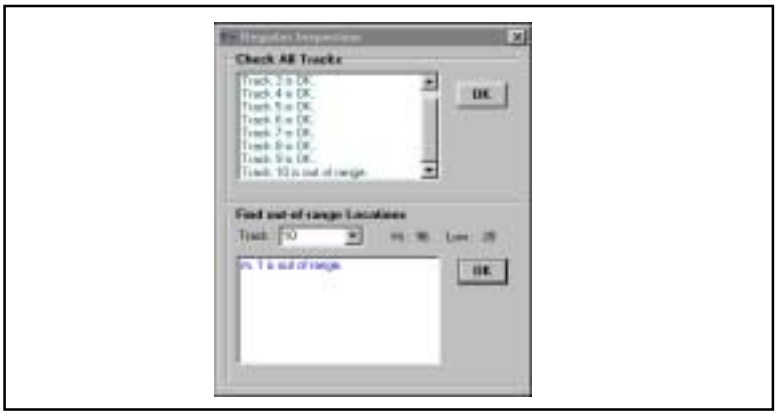

Fig. 31. An example of *Register Inspection*.

Rhythmic Density Analysis presents the total number of occurrences of notes in a period of time.

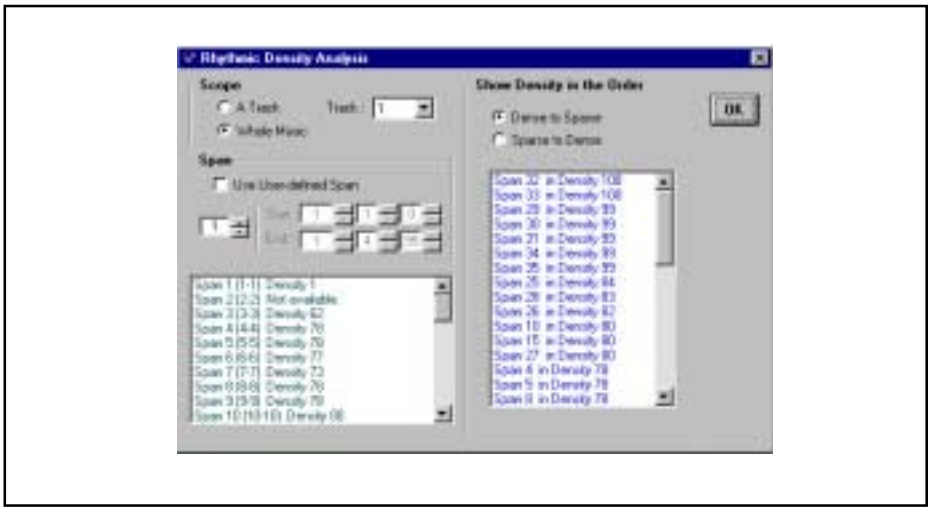

Fig. 32. An example of *Rhythmic Density Analysis.*

Rhythmic Tendencies Analysis presents the total frequency of each rhythm.

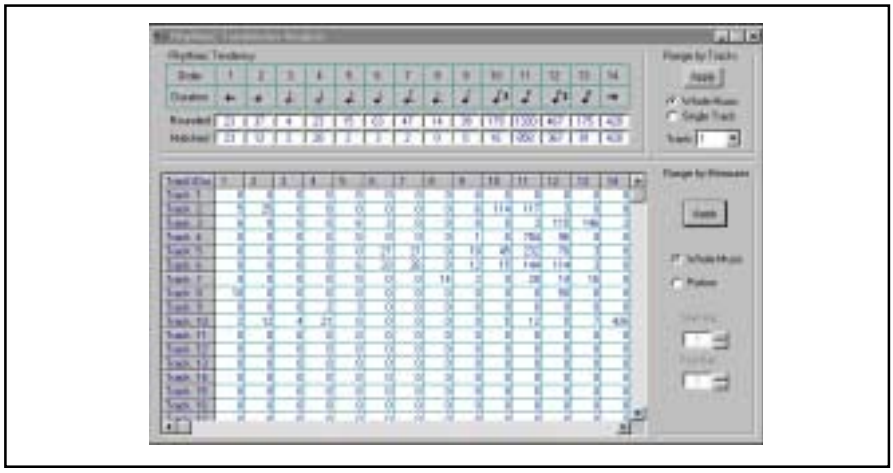

Fig. 33. An example of *Rhythmic Tendencies Analysis.*

Harmony Structure Analysis by Measure Span produces the vertical interval contents of music. In the analysis, the tensity degree of each chord is decided by the accumulated tensity of total intervals in a chord.

Fig. 34. An example of *Harmony Structure Analysis by Measure Span.*

Harmony Structure Analysis by Time Position is similar to *Harmony Structure Analysis by Measure Span*. The latter analyzes only chords that appear in the first time positions of the harmonic rhythm, while the former takes care of all chords. *Harmony Structure Analysis by Time Position* thus takes more time for the same target.

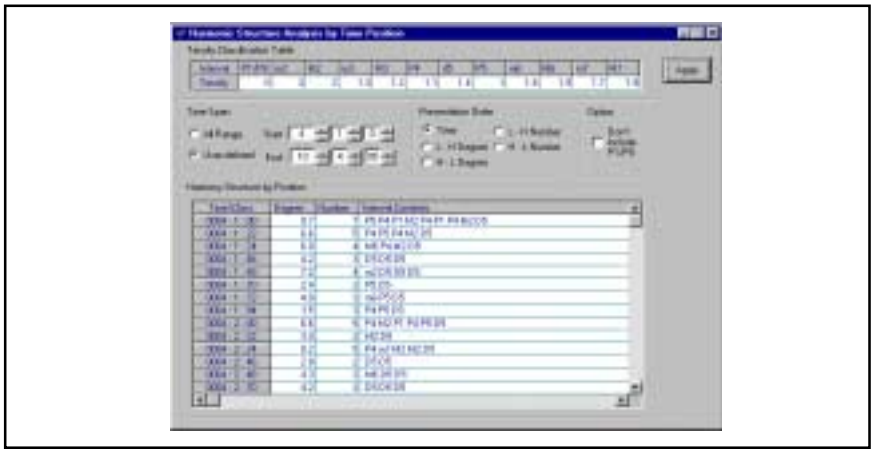

Fig. 35. An example of *Harmony Structure Analysis by Time Position.*

Vertical Interval Statistical Analysis presents the frequencies of the twelve intervals by spans.

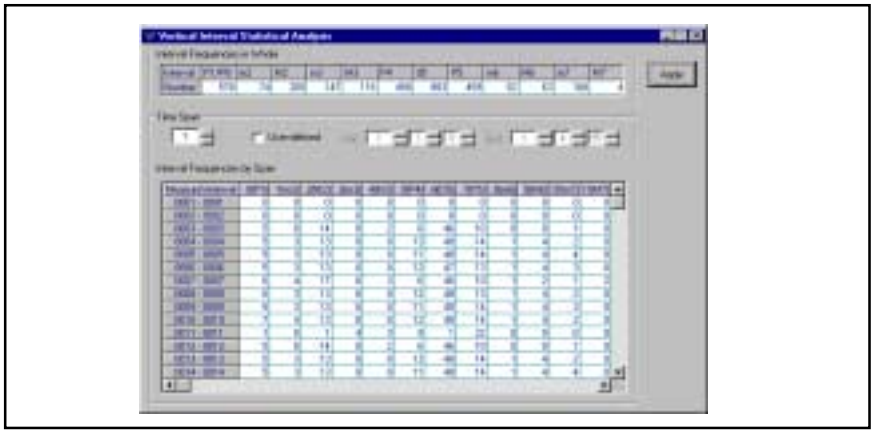

Fig. 36. An example of *Vertical Interval Statistical Analysis.*

Harmonic Tensity Analysis presents frequency, tensity degree, and contents of the intervals in each span. The composer can exclude the Perfect 1st and 8th degrees in the analysis.

Fig. 37. An example of *Harmonic Tensity Analysis.*

Linear Interval Statistical Analysis presents the horizontal intervals by spans. It includes a routine that excludes specific intervals regarding the time gap.

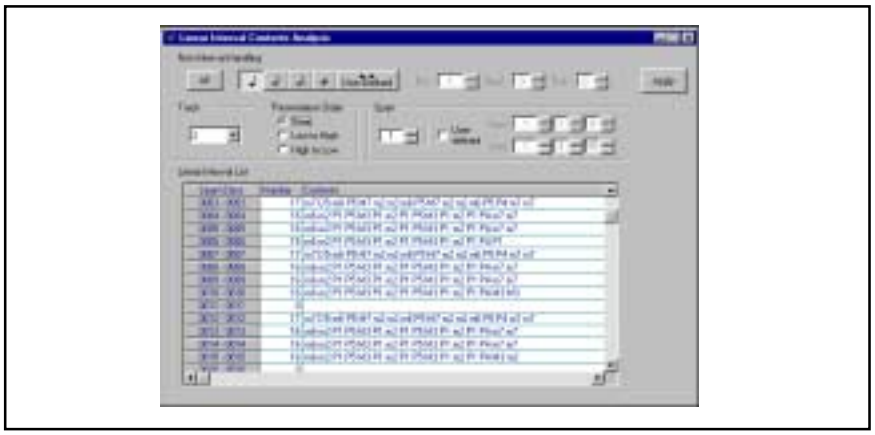

Fig. 38. An example of *Linear Interval Statistical Analysis.*

Linear Interval Contents Analysis presents the horizontal interval contents of music by spans. It includes a routine that excludes specific intervals regarding the time gap.

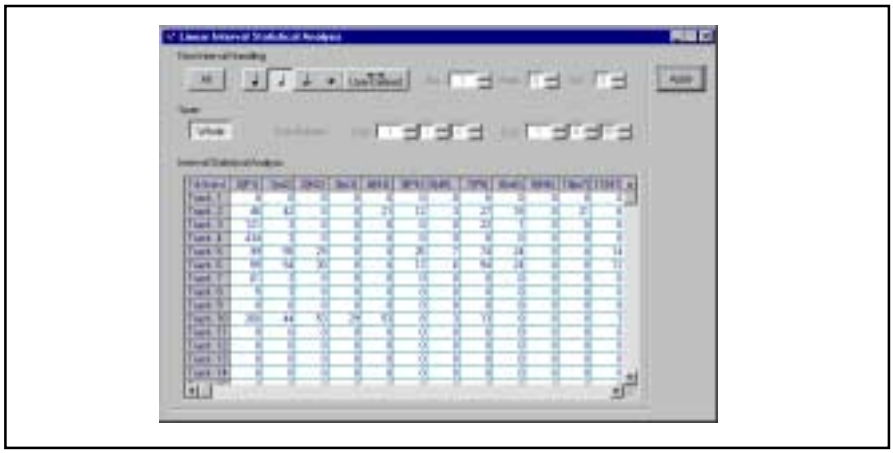

Fig. 39. An example of *Linear Interval Contents Analysis.*

Dynamics Analysis is accomplished by the following three MIDI elements: the volume messages, expression messages, and velocity values belonging to note messages.

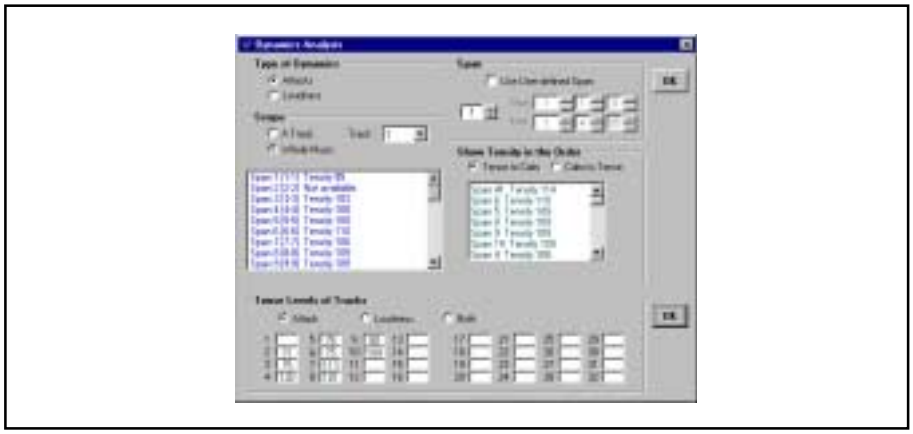

Fig. 40. An example of *Dynamics Analysis.*

The role of *Check Duplicated Notes window* is to find and remove duplicated notes.

Fig. 41. *Check Duplicated Notes window.*

Other menu commands

The commands in *File* menu handle file input and output routines. Among them, *Merge* command allows the composer to merge another file into the currently opened file.

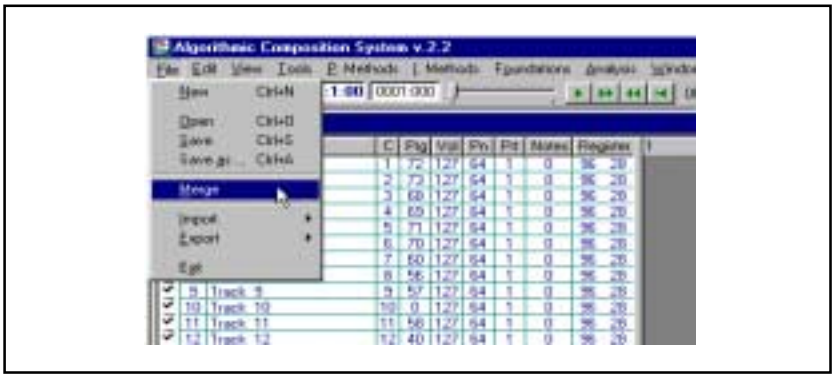

Fig. 42. *File* menu commands.

The commands in *Edit* menu include both single-track and multi-track editing features.

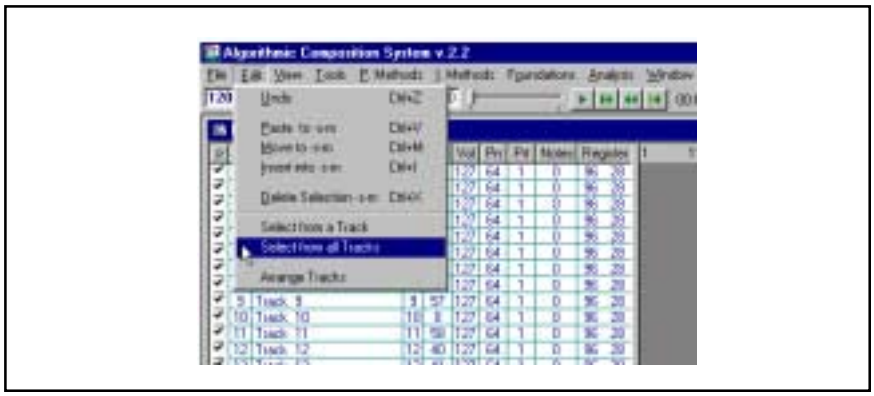

Fig. 43. *Edit* menu commands.

The commands in *View* menu consist of several diverse commands, including MIDI message editing windows, commands to the sequencer, and other miscellaneous configuring options.

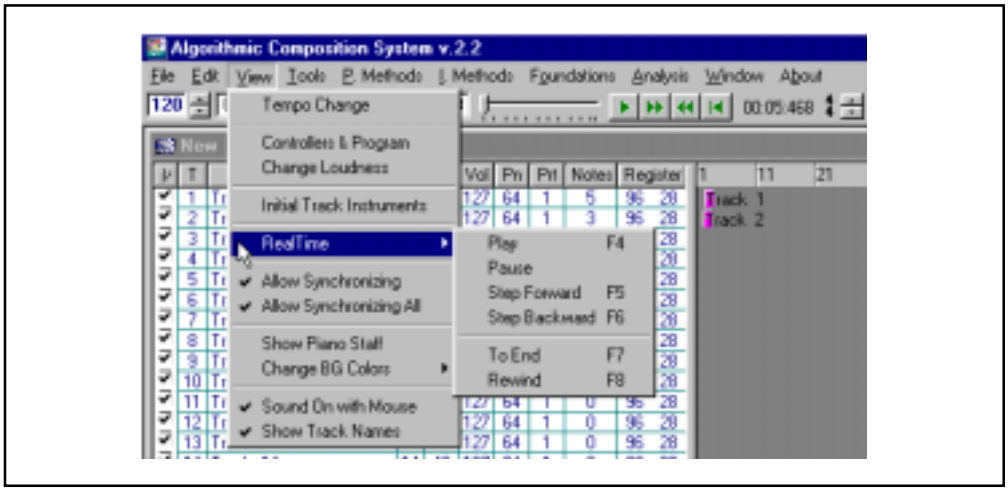

Fig. 44. *View* menu commands.

Window menu mainly consists of commands opening each corresponding window.

Fig. 45. The commands of *Window* menu.

Plan Pad submenus appear when *Plan Pad window* becomes active. The menus consist of *File*, *Edit*, *Format*, and *Tools* menus.

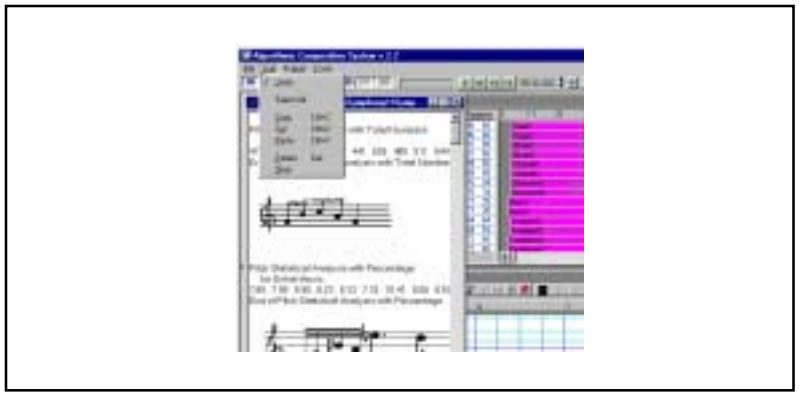

Fig. 46. A screen of *Plan Pad* submenus.

Analysis of *Symphony No. 1*

I composed *Symphony No. 1* using *Extended Serial* method that belongs to *Integrated Methods* of ACS. It is the newest algorithmic composition procedure that I added. Immediately beginning composing *Symphony No. 1*, I planned strategies and structures for the composition, and then I started coding, testing and debugging the algorithmic composition procedures. After finishing the method, I fed the input data for *Symphony No. 1* so that the program could write music as instructed.

I spent time collecting and constructing materials that would be used in the composition. The materials are rhythms, rhythmic patterns, rhythmic groupings, instrumental groupings, pitch ranges, pitch contents, pitch probabilities, note distributions, harmonic densities, harmonic tensity, rhythmic density, rhythmic tensity, tempos and dynamics. Constructing rhythmic structure was the most time consuming part of the composition.

Starting in the twentieth century, numerous things began to change in music. For example, the use of meter began to be loose and irregular, presumably to multiply the beauty of abstraction, which had been further widened along with tonality dissolved. At the same time, after Debussy's whole-tone scale, the Russian composer Skryabin's artificial scales resembling the octatonic scale, and the likes from others, finally the extreme pitch usage had come to the acme by the appearance of the equal distribution of pitches of Schoenberg's twelve-tone composition in 1923. The exhaustion of pitch usage and scales made a big impact on musical history along with the development of the science of time, so that it made many new branches of music, and composers started turning their focus to different directions of music. Many music scholars were worried

about the future of music, which brought so many arguments and writings involving tonality and atonality. Some composers like the American Harry Parch completely abandoned equal temperament system. Some composers like Ben Johnston went for micro tonality. A composer like Pierre Schaeffer, who was a sound technician, opened a complete different genre of music in 1948 called *concrète* music—now commonly called tape music--based on the transformation of natural sounds and artificial noises with the aid of the spiritual background of futurism in Italy in 1910. Others like Penderecki, Ligeti, Varese, Xenakis, Elliott Carter, and Cage had to start searching for new idioms from other musical components such as rhythms, tempos, dynamics, timbres, and even indeterminate elements as well as developing different concepts to pitches.

Symphony No. 1 follows the same traditional background since it used the equal temperament system, whether the media for soundings are traditional or electronic instruments. What I have really struggled with was how I should construct materials. As I composed *Symphony No. 1* using my own Algorithmic Composition System from the scratch to the final, I will explain about the symphony through the *Analysis functions* in the program. The *analysis functions* in ACS are founded on pure substantial phenomena, which will reveal some tendencies that gravitate materials in low probabilities.

Pitch Employment

The pitches in the low probabilities of occurrence tend to gravitate toward the ones in the high probabilities of occurrence. When we create a musical structure using pitch relationships as a unifying device, it is possible that we can achieve that by

manipulating the probability ratios of a pitch group and then by patterning the others after the original probability ratios. This will create consistency and unity of the composition.

Pitch Number	0	1	2	3	4	5	**6**	7	8	9	10	11
Pitch Name	C	C#	D	Eb	E	F	**F#**	G	Ab	A	Bb	B
Percentage	7.88	7.95	8.90	8.23	8.33	7.33	**10.41**	8.06	8.50	9.05	8.10	7.27
Note Number	474	478	535	495	501	441	**626**	485	511	544	487	437

Pitch Number	0	1	2	3	4	5	**6**	7	8	9	10	11
Pitch Name	C	C#	D	Eb	E	F	**F#**	G	Ab	A	Bb	B
Percentage	8.00	8.32	8.07	8.11	7.91	7.64	**9.38**	8.72	8.66	8.55	8.53	8.12
Note Number	593	617	598	601	586	566	**695**	646	642	634	632	602

Pitch Number	0	1	2	3	4	5	**6**	7	8	9	10	11
Pitch Name	C	C#	D	Eb	E	F	**F#**	G	Ab	A	Bb	B
Percentage	8.14	8.32	8.23	8.13	8.49	8.07	**10.49**	8.10	7.25	8.63	8.24	7.91
Note Number	639	653	646	638	666	633	**823**	636	569	677	647	621

Table 1. *Pitch Statistical Analysis* with percentages and total numbers for entire movement. The first, second, and third movements (From top).

In the above Table 1 the F# made the most frequent occurrence in all three movements since I decided the F# would have the highest probability among the twelve pitches.

Pitch Range Employment

As pitch probability became important, so has pitch range in modern compositions. This is because the probabilities of certain pitch ranges could bring significance to music as the textural music of Penderecki, Ligeti and others. If pitches lose their functions forming a melody, the pitch ranges will get more focused in practical situations. This will indicate that a position of a pitch in a certain range will have more weight than being a member of a scale, a member of a pitch set, or a member of a melody. We thus can think of specific pitch ranges as centers of controlling pitch clusters or sound masses that appear in the composition and consider the other pitch ranges to be subsidiary.

Measure	99	93	89	92	98	82	84	90	94	85	91	79	83	95	96
Highest Pitch	95	94	93	93	93	92	92	92	92	91	91	90	90	90	90
Measure	97	100	75	76	86	88	64	65	66	71	72	74	78	80	73
Highest Pitch	90	90	88	88	88	88	86	86	86	86	86	86	86	86	85

Measure	87	90	92	95	96	85	91	94	100	77	86	93	97	64	67
Highest Pitch	96	96	96	96	96	95	95	95	95	94	93	93	93	92	92
Measure	84	61	63	65	66	68	69	70	71	75	76	78	79	80	82
Highest Pitch	92	91	91	91	91	91	91	91	91	91	91	91	91	90	89

Measure	87	88	90	95	98	71	89	91	92	99	83	93	94	70	82
Highest Pitch	96	96	96	95	95	94	94	94	94	94	93	93	92	92	92
Measure	87	88	90	95	98	71	89	91	92	99	83	93	94	70	82
Highest Pitch	96	96	96	95	95	94	94	94	94	94	93	93	92	92	92

Table 2. A presentation by order of highest to lowest pitch occurrence for the first, second, and third movements (from top) up to thirty measures.

The above Table 2 presents only the top thirty measures in order of highest to lowest frequency in each movement. Since the total measures of the three movements are 110 for the first, 120 for the second and 120 for the third, we can notice that the top 30 high pitches appeared between measures 61 to 100, which means that the weight of the pitch range is in the second half of each movement. I didn't classify the pitch ranges in detail in this composition, but I disposed the high pitch ranges in the middle of the latter half of each movement as a turning point.

Rhythmic Employment

Constructing rhythmic structures became a highly time consuming portion in composition since composers turned their focuses to rhythm. The extreme case was made by Varèse with the composition *Ionisation* (1931), well known by the use of the screams of two sirens. The work is scored entirely for percussion instruments. Carter is famous for his rhythmic modulation using thoughtful combinations of metric rhythms through his compositions. Ligeti's *Atmosphères* (1961) presented the use of floating rhythms and fluctuating sounds with many paralleled percussive sounds on consistent changing rhythms.

As rhythms and rhythmic patterns have potential capabilities to generate infinite permutations without duplication, it seems they would never be exhausted unlike the pitches. Controlling rhythms thus became the most important concern to composers in the twentieth century.

Rhythmic Structure

In *Symphony No. 1*, I attempted rhythmic inheritance, so that the third twelve-rhythmic pattern inherits from the second, and the second inherits from the first movement. Each time the inheritor inherits, it inherits the same numbers of patterns with increased rhythmic density and faster rhythms. Each movement thus comprises the same number of rhythmic patterns. The introducing movement starts unfolding with the slowest and most sparse rhythmic patterns.

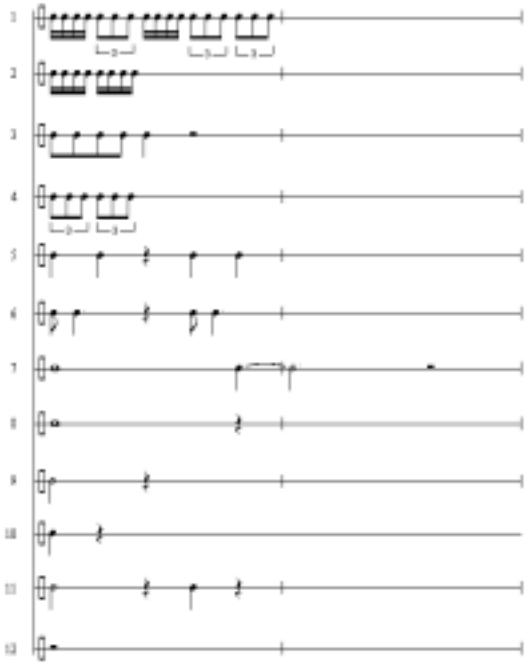

Fig. 47. The twelve rhythmic patterns used in the first movement.

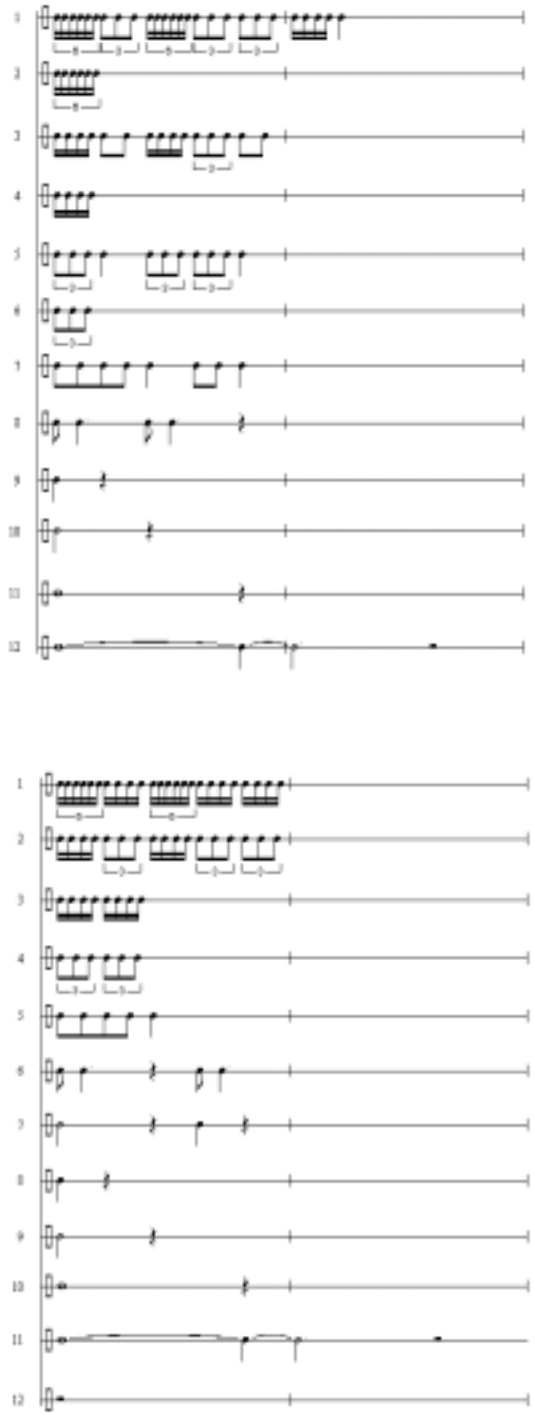

Fig. 48. The rhythmic patterns of the second and third movements from the top, which inherited from the ones in the first movement.

Rhythmic Density

The controlled rhythmic density will help establish a better formation for the composition. For example, if a composition consists of five or six sections like a suite, we may gradually increase the rhythmic density by sections. When performed, it will generate consistent focuses from the audience.

Rhythmic density is the total number of occurrences of notes in a period of time under a condition of the same or similar tempos. If notes occur more often in a period of time, the period will create more tension than other time periods.

Table 3 shows the rhythmic densities in order of dense to sparse for the top 30 measures for each movement. The *Density* value indicates the total note number in a s*pan*. The length of a s*pan* used for Table 3 is 5 measures. In the analysis we can find the peak periods of rhythmic densities: 71-100 for the first, 76-110 for the second, and 56-105 measures for the third movement respectively. As it shows, the spans for the peak periods are getting wider until the last movement, which means that the tensional weight is increasing gradually to the last movement.

DENSE TO SPARSE (FIRST MOVEMENT)	
Span 17 (81-85)	Density 504
Span 19 (91-95)	Density 496
Span 16 (76-80)	Density 462
Span 18 (86-90)	Density 450
Span 15 (71-75)	Density 388
Span 20 (96-100)	Density 360

DENSE TO SPARSE (SECOND MOVEMENT)	
Span 21 (101-105)	Density 692
Span 19 (91-95)	Density 540
Span 16 (76-80)	Density 526
Span 18 (86-90)	Density 492
Span 17 (81-85)	Density 454
Span 22 (106-110)	Density 442

DENSE TO SPARSE (THIRD MOVEMENT)	
Span 21 (101-105)	Density 634
Span 18 (86-90)	Density 622
Span 12 (56-60)	Density 614
Span 13 (61-65)	Density 502
Span 16 (76-80)	Density 470
Span 15 (71-75)	Density 454

Table 3. *Rhythmic Density Analysis* in order of dense to sparse rhythms.

Rhythmic Tendency

Rhythmic Tendency and *Rhythmic Density Analyses* help the composer level the overall rhythmic distributions of a composition. Fast rhythms stimulate and drive our mind unstable with distraction. This factor is very important as long as music exists for mankind. If one fills a specific time period with music, he/she needs a large number of notes if he places very short notes. Otherwise the time will be monotonous. It is thus important to observe rhythmic tendencies of the composition.

Rhythmic Tendency analysis can present the rhythmic similarity between movements. Table 4 shows the tendencies of rhythms used in *Symphony No. 1*. The two arrows in the top of the analysis indicate the notes longer than whole note and the notes smaller than 32nd notes, respectively. The analysis shows both rounded and matched note numbers for some irregular rhythms that don't fall in the default 14 rhythms of the top row in Table 4. The numbers after the top shown in the analysis mean the total numbers

of each rhythm that were employed for each movement. Table 5, 6 and 7 after Table 4 are *Rhythmic Tendency Analyses* for each instrument of each movement.

Rhythm	←	𝅝	𝅗𝅥.	𝅗𝅥	♩.	♩	♪.	♩.	♪	♪3	♬	♬3	𝅘𝅥𝅯	→
1 Mov.	130	134	0	244	268	762	0	0	748	1848	1880	0	0	0
2 Mov.	174	178	0	210	276	372	0	0	936	1796	2728	742	0	0
3 Mov.	104	222	0	142	236	676	0	2	1532	2718	1468	748	0	0

Table 4. *Rhythmic Tendency Analysis* for each entire movement. The numbers in the table are the total numbers of each rhythm that occurred in each movement.

Rhythm	←	𝅝	𝅗𝅥.	𝅗𝅥	♩.	♩	♪.	♩.	♪	♪3	♬	♬3	𝅘𝅥𝅯	→
Rhythm	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Track 1	7	10	0	10	12	35	0	0	28	91	85	0	0	0
Track 2	7	10	0	10	12	35	0	0	28	91	85	0	0	0
Track 3	7	10	0	10	12	35	0	0	28	91	85	0	0	0
Track 4	7	10	0	10	12	35	0	0	28	91	85	0	0	0
Track 5	7	10	0	10	12	35	0	0	28	91	85	0	0	0
Track 6	7	10	0	10	12	35	0	0	28	91	85	0	0	0
Track 7	4	3	0	7	10	25	0	0	41	74	56	0	0	0
Track 8	4	3	0	7	10	25	0	0	41	74	56	0	0	0
Track 9	4	3	0	12	6	23	0	0	19	60	63	0	0	0
Track 10	4	3	0	12	6	23	0	0	19	60	63	0	0	0
Track 11	4	5	0	2	6	18	0	0	24	23	43	0	0	0
Track 12	4	5	0	2	6	18	0	0	24	23	43	0	0	0
Track 13	4	3	0	12	6	23	0	0	19	60	63	0	0	0
Track 14	4	3	0	12	6	23	0	0	19	60	63	0	0	0
Track 15	4	3	0	7	10	25	0	0	41	74	56	0	0	0
Track 16	4	3	0	7	10	25	0	0	41	74	56	0	0	0
Track 17	6	5	0	11	13	39	0	0	38	75	61	0	0	0
Track 18	6	5	0	11	13	39	0	0	38	75	61	0	0	0
Track 19	6	5	0	11	13	39	0	0	38	75	61	0	0	0
Track 20	6	5	0	11	13	39	0	0	38	75	61	0	0	0
Track 21	6	5	0	15	17	42	0	0	35	105	141	0	0	0
Track 22	6	5	0	15	17	42	0	0	35	105	141	0	0	0
Track 23	6	5	0	15	17	42	0	0	35	105	141	0	0	0
Track 24	6	5	0	15	17	42	0	0	35	105	141	0	0	0

Table 5. *Rhythmic Tendency Analysis* for each track of the first movement. The numbers in the top column are equal to the rhythms in the top column of Table 4.

Rhythm	←	𝅝	𝅗𝅥.	𝅗𝅥	♩.	♩	𝅘𝅥𝅯.	𝅘𝅥𝅯.	𝅘𝅥𝅯	𝅘𝅥𝅯3	𝅘𝅥𝅰	𝅘𝅥𝅰3	𝅘𝅥𝅱	→
Rhythm	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Track 1	8	4	0	5	15	9	0	0	29	43	127	70	0	0
Track 2	8	4	0	5	15	9	0	0	29	43	127	70	0	0
Track 3	8	4	0	5	15	9	0	0	29	43	127	70	0	0
Track 4	8	4	0	5	15	9	0	0	29	43	127	70	0	0
Track 5	8	4	0	5	15	9	0	0	29	43	127	70	0	0
Track 6	8	4	0	5	15	9	0	0	29	43	127	70	0	0
Track 7	7	6	0	8	0	16	0	0	31	70	103	0	0	0
Track 8	7	6	0	8	0	16	0	0	31	70	103	0	0	0
Track 9	5	12	0	12	17	21	0	0	46	78	71	0	0	0
Track 10	5	12	0	12	17	21	0	0	46	78	71	0	0	0
Track 11	5	2	0	7	3	7	0	0	25	45	71	53	0	0
Track 12	5	2	0	7	3	7	0	0	25	45	71	53	0	0
Track 13	5	13	0	13	17	21	0	0	46	78	71	0	0	0
Track 14	5	13	0	13	17	21	0	0	46	78	71	0	0	0
Track 15	7	6	0	8	0	16	0	0	31	70	103	0	0	0
Track 16	7	6	0	8	0	16	0	0	31	70	103	0	0	0
Track 17	11	8	0	11	14	18	0	0	38	119	168	54	0	0
Track 18	11	8	0	11	14	18	0	0	38	119	168	54	0	0
Track 19	11	8	0	11	14	18	0	0	38	119	168	54	0	0
Track 20	11	8	0	11	14	18	0	0	38	119	168	54	0	0
Track 21	6	11	0	10	14	21	0	0	63	95	114	0	0	0
Track 22	6	11	0	10	14	21	0	0	63	95	114	0	0	0
Track 23	6	11	0	10	14	21	0	0	63	95	114	0	0	0
Track 24	6	11	0	10	14	21	0	0	63	95	114	0	0	0

Table 6. *Rhythmic Tendency Analysis* for each track of the second movement

Rhythm	←	𝅝	𝅗𝅥.	𝅗𝅥	♩.	♩	𝅘𝅥𝅯.	𝅘𝅥𝅯.	𝅘𝅥𝅯	𝅘𝅥𝅯3	𝅘𝅥𝅰	𝅘𝅥𝅰3	𝅘𝅥𝅱	→
Rhythm	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Track 1	4	7	0	6	10	20	0	0	49	108	51	57	0	0
Track 2	4	7	0	6	10	20	0	0	49	108	51	57	0	0
Track 3	4	7	0	6	10	20	0	0	49	108	51	57	0	0
Track 4	4	7	0	6	10	20	0	0	49	108	51	57	0	0
Track 5	4	7	0	6	10	20	0	0	49	108	51	57	0	0
Track 6	4	7	0	6	10	20	0	0	49	108	51	57	0	0
Track 7	1	10	0	7	7	32	0	0	80	97	66	0	0	0
Track 8	1	10	0	7	7	32	0	0	80	97	66	0	0	0
Track 9	4	8	0	3	2	24	0	0	38	104	47	0	0	0
Track 10	4	8	0	3	2	24	0	0	38	104	47	0	0	0
Track 11	4	6	0	3	10	28	0	1	65	105	51	41	0	0
Track 12	4	6	0	3	10	28	0	1	65	105	51	41	0	0
Track 13	4	8	0	3	2	24	0	0	38	104	47	0	0	0
Track 14	4	8	0	3	2	24	0	0	38	104	47	0	0	0
Track 15	1	10	0	7	7	32	0	0	80	97	66	0	0	0
Track 16	1	10	0	7	7	32	0	0	80	97	66	0	0	0
Track 17	7	11	0	7	18	29	0	0	77	141	77	81	0	0
Track 18	7	11	0	7	18	29	0	0	77	141	77	81	0	0
Track 19	7	11	0	7	18	29	0	0	77	141	77	81	0	0
Track 20	7	11	0	7	18	29	0	0	77	141	77	81	0	0
Track 21	6	13	0	8	12	40	0	0	82	123	75	0	0	0
Track 22	6	13	0	8	12	40	0	0	82	123	75	0	0	0
Track 23	6	13	0	8	12	40	0	0	82	123	75	0	0	0
Track 24	6	13	0	8	12	40	0	0	82	123	75	0	0	0

Table 7. *Rhythmic Tendency Analysis* for each track of the third movement

Harmonic Structure

Harmonic Structure Analysis presents the colors of parallel pitches—here I exclude the colors from instrumental timbres like Schoenberg's *Klangfarbenmelodien*. Harmonic colors touch our emotion and mood. Even if many different pitches are overlapped, we can notice the subtle differences or changes as long as the vertical contents are different. *Symphony No.1* has the high tensive parts in the range from 7 to 8/10^{ths} of each movement. The peak part is almost at the end of the movements. The longer the music, the more detailed schemes of harmonic tensity would be required to sustain attention from the audience to the end of music.

Harmonic Structure Analysis supports the composer to equalize or examine the overall harmonic deposition in the composition. Table 8 shows the tensity levels of each interval. The tensity values in *Interval Tensity Classification Table* are not from scientific measurements but from my own musical experiences, which can be changed.

I assigned the tensity value 0 for the interval perfect 1st (unison) and 8th degrees, the tensity value 1 for perfect 5th, the tensity value 2 for the major 2nd, and the tensity value 3 for the minor 2nd, and so forth. The analysis helps the composer find chords that hold certain specific tensity levels so that he/she can compare and stabilize the output. Table 9, 10, and 11 present the chords in the top 14 of high tense chords for each movement in order of highest to lowest tensity level.

Interval	P1/P8	m2	M2	m3	M3	P4	d5	P5	m6	M6	m7	M7
Tensity	0	3	2	1.3	1.2	1.1	1.4	1	1.6	1.5	1.7	1.9

Table 8. *Interval Tensity Classification Table* for the presentation of the harmonic tensity degree.

Measure	Tensity Degree	Interval Number	Interval Contents
0079 : 2 : 00	44.0	19	M7 M2 M2 M2 M2 M3 M2 M2 M2 M3 M2 M3 M3 M2 M3 M2 M2 M2 M2
0078 : 3 : 00	41.2	19	m2 m3 M3 M2 m3 M2 m2 P5 m2 M2 m2 m2 m2 m2 M2 M2 m2 P4 m3
0079 : 4 : 48	35.4	16	m3 m2 m2 m3 m2 m2 m2 m2 m3 m3 M2 m2 M3 M2 P5 m2
0074 : 4 : 00	34.3	17	D5 m3 m2 m3 M2 m3 m2 m2 m2 m2 m2 m3 m3 m3 P4 M2 M2
0079 : 4 : 00	33.2	17	m7 m2 m3 M3 M2 m2 M3 M3 M2 m2 m3 M2 M2 M2 m3 m2 M2
0062 : 3 : 48	31.5	14	m2 M2 m2 m2 P4 M3 M2 M2 m2 m2 M2 M3 M2 m2
0074 : 4 : 48	31.4	15	M3 M2 M3 m3 m2 m2 m2 M2 M2 m2 M3 M3 m3 m2 m2
0072 : 4 : 00	30.5	15	P5 P4 m2 m2 M2 m2 M2 M2 P5 M2 m2 m3 P4 m2 M2
0063 : 2 : 00	30.4	15	M3 m3 m2 m2 M2 m2 m2 P4 M2 M2 m2 m3 m3 M2 M3
0062 : 3 : 00	29.6	14	m2 M2 M2 m6 M2 m3 m2 m2 m2 m2 M2 m3 P4 m3
0078 : 3 : 48	29.6	13	m3 M2 m2 m2 D5 m2 m2 m3 m2 m2 D5 M3 m2
0074 : 1 : 48	29.5	13	m2 m2 P5 M2 m2 M2 m2 m2 M3 m2 M2 M2 m3
0074 : 2 : 48	29.1	14	m3 M2 M2 M2 m2 M2 m3 m2 M2 M3 m2 m2 M2 m3
0090 : 4 : 00	28.7	14	M3 m6 M2 m2 M2 m2 m3 m2 M3 M3 M3 M2 m2 m2

Table 9. The top 14 high tense chords for each movement in order of highest to lowest tensity level for the first movement by 8th step of the harmonic resolution excluding P1/P8.

Measure	Tensity Degree	Interval Number	Interval Contents
0042 : 4 : 00	33.9	15	m7 m2 m2 M2 m2 M2 M2 M2 m2 m2 m2 M6 m3 D5 M2
0107 : 4 : 48	33.5	16	m2 m3 M3 m3 m2 m2 m2 m2 M2 m2 D5 m3 m2 m3 m3 D5
0039 : 3 : 00	31.8	13	m2 m7 M2 m2 m2 M2 M2 P4 m2 m2 m2 m2 M2
0043 : 1 : 00	31.6	15	m3 M2 m2 m2 M2 m2 M2 m2 M2 m2 M3 m6 m3 M2 M3
0109 : 1 : 00	31.4	15	M2 m3 m2 m2 M2 m2 m3 M2 m2 P5 M3 m2 m2 D5 M3
0117 : 1 : 48	31.2	14	D5 m2 M2 m2 m2 P4 m3 m2 m2 m2 M2 P4 m3 m2
0066 : 4 : 00	31.2	15	m2 M3 m2 D5 m2 M2 P5 P4 m2 m2 M2 M2 M3 m2 m3
0061 : 2 : 00	30.5	16	M3 P4 m2 M2 M3 M2 m2 m2 M2 m3 M2 m3 M3 m2 M2 M3
0029 : 1 : 00	30.3	15	m3 m2 m3 m3 m2 M3 m2 M2 M2 m2 M2 P4 M2 m2 P4
0064 : 2 : 48	30.2	15	M3 M2 m2 P4 D5 M2 M3 M2 m2 m2 m2 M3 M2 P4 m2
0113 : 3 : 00	30.2	14	M2 M6 M7 M2 m2 m2 m2 M3 m2 m2 M2 m3 M2 m3
0060 : 1 : 48	29.3	15	M3 M3 m2 m2 m3 M2 m2 m2 M2 m3 P5 M2 M2 M2 m3
0104 : 4 : 00	29.2	14	m3 M2 m2 m3 M2 m2 m3 M2 m2 M3 M2 P4 m2 m2
0095 : 4 : 48	28.9	14	m3 M3 M2 m2 M2 m3 M2 m2 D5 m2 m2 m2 M6 M3

Table 10. The top 14 high tense chords for each movement in order of highest to lowest tensity level for the second movement by 8th step of the harmonic resolution excluding P1/P8.

Measure	Tensity Degree	Interval Number	Interval Contents
0087 : 2 : 00	44.2	20	P4 D5 M2 M2 M2 M2 M3 M3 P4 M2 M2 M2 M2 M2 M2 M2 M2 M2 M2 M2
0061 : 1 : 00	42.3	17	m2 m2 m2 m2 m2 m3 m2 M6 M2 m2 M2 m2 m2 P4 m2 m2 D5
0089 : 1 : 48	41.8	20	m2 m2 P4 M2 m2 m3 M2 m2 M2 m3 M2 m2 m3 m2 m2 P4 M3 m2 M3 m3
0078 : 1 : 48	38.2	17	m2 M3 m2 M2 m2 D5 m2 m2 M2 M2 m2 m2 M2 m2 P4 M3 m3
0059 : 3 : 00	38.1	17	M2 m2 m2 M6 P4 M2 M2 M2 m2 m2 M2 P4 M2 m2 D5 m2 m2
0060 : 1 : 48	37.1	18	M2 m2 M3 m3 M2 m3 M3 m2 M3 m2 M2 m2 m2 m2 m3 D5 m2 M3
0104 : 1 : 00	36.8	18	P5 m2 m2 M3 m2 M3 m2 M3 M2 m3 m2 m3 m3 M2 m2 m2 m3 M2
0060 : 2 : 00	35.7	16	m2 m2 M3 m3 m2 m2 m3 m2 M3 m2 m2 M2 D5 m2 M2 m3
0077 : 4 : 00	35.6	17	m2 m3 m2 M3 m2 m2 M2 m3 M2 M2 M2 M2 m2 M2 M2 D5 D5
0092 : 1 : 00	35.6	15	M6 P5 m2 m2 m2 M2 m2 P4 m2 m2 M2 m2 m2 P5 m2
0099 : 1 : 00	35.6	16	P4 M2 M3 P4 M2 m2 m2 M3 m2 m2 m2 m2 m3 m2 m2 m7
0060 : 4 : 48	35.6	15	m2 M2 m3 m2 m7 m2 m2 m2 M3 m2 M2 D5 m2 M2 m2
0032 : 2 : 48	34.9	16	M2 M3 m2 m3 M2 m2 M2 m2 M2 M2 m2 M2 M3 M3 m2 m2
0078 : 1 : 00	34.9	16	m3 P4 m2 M2 M3 m2 m2 m3 m2 m2 m2 m2 M3 M6 m3 m2

Table 11. The top 14 high tense chords for each movement in order of highest to lowest tensity level for the third movement by 8th step of the harmonic resolution excluding P1/P8.

Harmonic Tensity

Harmonic Tensity presents the tensity value created by each chord with its interval contents. When the harmonic tensity is low, the time period gets a low level of attention from the audience although occasionally this might get a high level of attention when the neighboring regions are in the same or a similar high level of tensity.

I present the harmonic tensity that occurred by periods of time for each movement through Tables 12 –14 in order of highest to lowest excluding unison and perfect 8th for each whole movement.

Measure	Degree	Number	Interval Contents
0079 – 0079	130.9	62	M2 M2 M2 P5 M2 M2 M3 M2 M7 M2 M2 M6 M7 M2 M2 M2 M2 M3 M2 M2 M2 M2 M3 M2 M3 M3 M2 M3 M2 M2 M2 M2 M3 M2 M3 M2 M3 M3 P5 M2 M2 M2 M3 M2 M2 M2 M7 M2 M3 M3 M2 M2 M3 M3 M2 M2 M3 M2 M2 M2 M3 M2 M2
0078 - 0078	109.1	52	m2 m3 m3 m3 M2 M2 m2 m2 D5 m3 m2 m2 M3 P4 m2 m3 P4 m2 m3 M3 M2 m3 M2 m2 P5 m2 M2 m2 m2 m2 m2 M2 M2 m2 P4 m3 M2 M3 m3 M2 m2 m2 M2 M3 m2 m2 m3 m2 m2 D5 M3 m2
0074 - 0074	103.5	52	m2 m3 m2 P4 m3 m2 m2 M3 m3 M2 m3 M3 M3 M2 m2 M2 m3 m2 M2 M3 m2 m2 M2 m3 m3 m2 m3 m2 P4 m3 m2 D5 P4 m2 M2 D5 m3 m2 m3 M2 m3 m2 m2 m2 m2 m2 m3 m3 m3 P4 M2 M2
0095 - 0095	101.6	48	M6 m2 m2 M3 m2 m3 M2 m2 M2 m3 m3 P4 M6 m3 M2 M2 m2 M2 m2 M2 m2 m2 m6 m2 M2 m3 m3 m3 M3 M2 m2 m2 m2 m3 m2 P4 m2 m3 m2 M3 M3 M2 m2 m2 m2 M2 m3 m2
0090 - 0090	100.4	52	m6 m2 m3 M2 m3 M2 M6 M2 M2 M6 M2 m3 D5 m2 m2 M3 m2 M2 m2 m3 M3 P4 P4 m2 m3 D5 m3 M2 M3 m2 P4 m3 m2 M2 m3 M2 m2 M2 M3 m6 M2 m2 M2 m2 m3 m2 M3 M3 M3 M2 m2 m2
0092 - 0092	96.1	45	M2 m2 m2 m2 m2 P4 M2 M2 m2 D5 m2 M3 M2 m6 M2 m2 m2 D5 m2 P4 m2 m2 M3 m2 m3 m2 m3 m3 M2 m3 m6 m3 m3 M2 M2 M7 P4 m2 D5 m3 m2 M2 m2 m2 m2
0098 - 0098	93.3	49	M2 M3 M3 P4 m2 M3 m2 m3 m3 m2 m2 M3 m3 M2 M2 M3 M2 m3 m2 M2 M2 P4 m2 M2 m2 m2 m2 M2 M2 M3 P5 M3 m3 m2 M2 m2 m2 m3 P4 m3 m2 P4 m2 M2 P5 P4 M2 P5 m3
0089 - 0089	91.4	44	m3 m3 M2 P4 M2 m2 m2 M2 M2 M2 M2 M2 m6 M6 M2 m2 m2 m2 P4 M2 m2 M7 M2 P4 M2 M2 m2 m2 m2 M3 m2 M2 m3 M2 m2 M2 m3 m3 m2 m2 m2 m3 P5 P4
0059 - 0059	79.3	41	m2 M2 P4 m7 M2 M2 M2 M2 M2 m2 m2 m3 m3 M2 m6 m2 P4 m2 P4 D5 m2 m3 D5 m3 m2 m3 M2 m2 m3 D5 P4 M2 m3 m2 m3 m2 M2 m2 M6 m3 M3
0041 - 0041	78.9	43	m2 m2 m3 m2 P5 m2 P4 m3 P4 M3 M2 m2 m6 M2 M2 M2 m6 D5 P5 M3 m3 m3 M2 m2 D5 P4 M2 M3 M3 M2 M2 m3 m2 M6 M2 M2 m2 M3 m3 m2 m3 P5 m2

Table 12. *Harmonic Tensity Analysis* of the first movement on a quarter note step resolution up to top 10 measures in highest to lowest order excluding P1/P8.

Measure	Degree	Number	Interval Contents
0108 - 0108	95.8	46	M6 M2 M2 M2 M2 M3 M2 P4 M2 M3 M2 M3 M2 P4 M2 M3 M3 M2 D5 M2 M3 M3 M2 M2 M2 M2 M7 M2 M2 M3 M2 M2 M2 M2 M6 M2 M2 M3 D5 M2 M7 M2 M2 M3 M2 M6
0113 - 0113	94.8	47	P5 M2 m2 P4 m2 m6 m3 P5 M2 m3 m2 m3 M2 M2 m2 m2 M2 D5 M2 m2 m6 m3 P5 m2 M2 m2 m2 m2 M3 m2 m2 M2 m3 M2 m3 M2 M6 M6 M2 m2 D5 M2 M2 D5 m2 M2 m3
0117 - 0117	93.5	49	M3 M2 m3 m2 m2 M2 m3 m2 M2 m2 M6 M3 P4 m3 m2 P4 m3 m2 M2 M2 m2 M2 P4 m3 m2 M6 M2 m3 M2 m2 D5 M2 D5 m2 M3 P5 M3 m2 M3 M2 m2 M2 P5 M2 M2 D5 m2 M3 P5
0105 - 0105	89.5	47	m2 m3 M2 M3 M2 M2 M2 M2 m3 m2 M3 M3 D5 M3 m2 M2 M2 m3 M2 M3 m2 m2 D5 M2 M3 m3 P5 m3 m2 M2 m2 m3 M2 M2 m2 m6 M2 M2 m2 M3 D5 M2 M2 M3 m2 m3 M2
0060 - 0060	88.9	48	m2 M2 m3 M3 M3 m2 m2 D5 m3 m2 M2 m2 P4 M3 m3 m2 M2 M7 M2 M2 P5 D5 M3 M2 M2 M2 P4 M2 M2 P5 D5 m2 M3 M3 M3 M2 P4 m2 m3 m3 m3 D5 m3 M2 m2 m2 m2 m6
0079 - 0079	88.5	44	m3 m2 M7 m2 m2 M6 M3 M2 M2 M3 m2 m2 M2 M6 M3 m2 m3 m3 P4 m2 m3 M2 m2 m2 m2 m3 M2 M6 M3 m2 m3 M2 M2 M3 M2 m3 m2 M2 P4 m2 M2 m2 M3 m6
0109 - 0109	88.1	43	M2 m3 m2 m2 M2 m2 m3 M2 m2 P5 M3 m2 m2 D5 M3 P4 M3 m2 m3 M2 m2 M2 m6 M3 m2 M3 D5 D5 m3 P5 m7 m2 m2 m2 D5 m3 P5 m2 m2 m6 m2 m2 m2
0104 - 0104	87.9	45	m7 M2 m2 P4 m2 M2 M2 P4 M2 m3 M2 D5 m3 m2 P5 D5 D5 m2 M3 P4 M2 m2 m2 m3 m2 m6 m2 m3 M2 m3 M3 m3 M2 m2 m3 M2 m2 m3 M2 m2 M3 M2 P4 m2 m2
0064 - 0064	86.9	43	M2 M2 m2 P4 m2 m2 M2 D5 M2 m3 m2 M2 m2 M2 m3 M2 m2 M2 m6 P4 M2 m3 m2 M2 M2 m2 m3 D5 m3 m3 m2 P4 D5 P4 P4 m2 m2 m3 m2 m6 m2 M2 M7
0080 - 0080	84.6	43	m3 M2 m2 M2 m3 m2 M3 m3 m2 M3 M2 M3 m2 m3 m2 M3 m2 M2 m2 P4 P4 M2 m2 P5 m3 m6 D5 m3 m2 m2 P4 M3 m2 P5 M2 M2 m2 m2 m2 M2 M2 M3 m3

Table 13. *Harmonic Tensity Analysis* of the second movement on a quarter note step resolution up to top 10 measures in highest to lowest order excluding P1/P8.

Measure	Degree	Number	Interval Contents
0087 - 0087	130.7	63	m2 P4 M3 M2 P5 M2 m3 M3 M2 M2 m2 m2 P4 D5 m2 M2 m2 M2 m3 m3 P4 m2 m2 m2 m2 M2 m2 M2 M2 M2 M2 m2 m6 m3 m2 M2 M2 m2 M2 M3 M2 m3 M3 m3 m2 m2 m2 m6 P4 m2 M2 m2 M3 P4 M3 m3 m2 M2 M2 m2 m3 m2 m2
0059 - 0059	123.7	58	m2 m2 m3 m2 m2 M2 M2 D5 m3 m3 m2 M2 m2 M3 D5 D5 M2 m3 P4 m2 M2 m2 M2 P4 M2 m3 D5 M2 m2 m2 M6 P4 M2 M2 M2 m2 m2 M2 P4 M2 m2 D5 m2 m2 m3 M2 m2 m2 D5 D5 P5 m2 m2 m2 m2 m2 M2 M2
0060 - 0060	119.9	58	m7 M2 m2 P4 M3 M2 M2 m2 m2 m2 M2 M3 M3 m3 m2 m3 m2 m2 M3 m3 m2 m2 m3 m2 M3 m2 m2 M2 D5 m2 M2 m3 M2 m2 M2 m6 m2 M2 M6 P5 m2 D5 M2 M2 M3 m2 M2 M2 M3 D5 m2 D5 m2 M2 m2 M2 M3 M2 m3
0104 - 0104	117.4	57	P5 m2 m2 M3 m2 M3 m2 M3 M2 m3 m2 m3 m3 M2 m2 m2 m3 M2 D5 M3 m2 m2 M3 M2 m2 M2 m3 m2 m3 P5 m3 m2 M2 M2 m3 m3 m2 m2 m2 M3 m3 m3 m2 m2 M2 M2 m6 m2 M2 m2 P4 m3 m2 M2 M2 M6 m2
0061 - 0061	112.1	54	m2 m2 m2 m2 m2 m3 m2 M6 M2 m2 M2 m2 m2 P4 m2 m2 D5 M2 M2 m2 P4 m2 M6 M3 m2 M2 m3 M2 M2 M2 D5 D5 M3 m2 M3 m3 M2 m2 m2 D5 P4 m2 P4 D5 D5 M3 M2 D5 M3 M2 m2 m2 D5 m6
0099 - 0099	109.6	50	m3 M2 M2 M2 M2 P4 M2 m2 m2 M3 m2 m2 m2 m2 m3 m2 m2 m7 M3 m6 m2 m2 D5 M2 M3 m2 M2 m3 m2 m3 M2 m2 m2 m2 M2 D5 D5 m2 M2 m2 M2 m2 M3 m3 M2 m2 m2 m2 m7 P5
0030 - 0030	105.7	55	m3 M2 m2 m2 m2 P4 m2 m3 m3 m2 P4 m3 D5 m3 M2 M2 m3 M2 M2 m3 D5 m2 P4 m3 m2 m2 m2 M3 m3 m3 P4 M2 m3 m3 M3 M2 m2 m2 M3 M3 m2 M2 M3 M2 m2 M3 m2 P4 m3 m2 M2 M2 M2 m3 m2
0077 - 0077	103.3	50	m2 m3 P5 m3 m7 M2 M3 M2 M2 D5 m2 M6 M2 m2 m2 M2 m2 m2 m2 M7 M3 M2 D5 M2 m3 m2 m2 M2 m2 P5 M3 m3 m2 m2 m3 m2 M3 m2 m2 M2 m3 M2 M2 M2 M2 m2 M2 M2 D5 D5
0057 - 0057	96.4	50	m2 m2 m2 m2 M2 m3 m2 M2 D5 M2 D5 P4 m3 D5 M3 D5 m3 M2 P5 m3 m2 m2 P5 D5 m3 m3 M2 m3 m2 M2 D5 M2 m2 M2 m2 m3 m2 m2 m3 M2 M2 M2 M2 M2 M3 m3 M2 m3 M3 m2
0089 - 0089	95.4	51	m2 P4 m2 m3 D5 m2 M3 m2 M2 M2 m2 M2 P4 m3 M3 m2 M2 M2 m2 M3 m3 M3 m3 M2 m2 m3 m2 M7 P5 M3 M2 m6 M2 M2 m6 m3 m3 m2 P5 M3 M3 M2 P4 m2 P5 M2 M3 M2 M2 m2 M7

Table 14. *Harmonic Tensity Analysis* of the third movement on a quarter note step resolution up to top 10 measures in highest to lowest order excluding P1/P8.

Linear Interval Statistics

Linear Interval Statistics Analysis presents the contents of horizontal intervals. These horizontal interval contents determine the overall tendency of the melodic shapes in the composition. Table 15 is from *Brandenburg Concerto No. 1* (1721) of J. S. Bach. The analysis shows that most frequent intervals are between P1/P8 (unison or octave) and minor 3rd, which means that a majority of the melodies move in step motion. Looking at Tables 16 through 18, we can assume that *Symphony No. 1* employed all 12 intervals in similar frequency, which implies that the music is not a tonal composition.

Intervals	0 (P1)	1 (m2)	2 (M2)	3 (m3)	4 (M3)	5 (P4)	6 (D5)	7 (P5)	8 (m6)	9 (M6)	10 (m7)	11 (M7)
Track 1	319	306	476	222	118	103	28	79	22	22	42	2
Track 2	313	148	232	216	116	132	30	70	36	40	44	4
Track 3	294	156	218	178	98	150	12	50	36	32	40	4
Track 4	344	209	354	203	122	114	28	102	22	26	41	2
Track 5	336	197	306	199	122	78	26	90	32	44	37	8
Track 6	348	183	268	189	98	114	6	78	30	38	35	10
Track 7	189	218	426	98	56	108	4	83	6	4	4	2
Track 8	189	218	426	98	56	108	4	83	6	4	4	2

Table 15. *Linear Interval Statistics Analysis* for *Brandenburg Concerto No. 1* of J. S. Bach.

Intervals	0 (P1)	1 (m2)	2 (M2)	3 (m3)	4 (M3)	5 (P4)	6 (D5)	7 (P5)	8 (m6)	9 (M6)	10 (m7)	11 (M7)
Track 1	12	39	34	30	35	32	32	17	17	15	7	7
Track 2	11	38	46	33	36	24	24	23	10	15	8	9
Track 3	5	42	41	36	32	25	39	19	18	11	7	2
Track 4	1	35	51	47	36	29	25	13	9	11	9	11
Track 5	10	26	27	50	28	43	35	12	12	16	8	10
Track 6	11	29	33	38	24	23	26	22	16	26	14	15
Track 7	8	23	23	24	24	22	19	14	18	20	13	10
Track 8	15	28	26	28	25	15	19	20	11	14	8	9
Track 9	5	21	27	22	24	23	14	12	19	8	10	3
Track 10	7	24	12	24	25	22	19	18	15	8	6	8
Track 11	0	23	13	21	11	19	5	8	7	4	6	5
Track 12	7	17	14	13	11	18	16	6	9	8	2	1
Track 13	3	24	23	26	27	21	20	16	11	8	7	2
Track 14	3	24	24	23	41	14	15	20	5	10	6	3
Track 15	8	30	26	32	21	27	16	17	16	8	11	6
Track 16	11	22	22	25	27	33	19	18	16	11	10	4
Track 17	7	18	34	34	28	21	33	24	17	11	4	16
Track 18	10	23	18	38	39	34	28	17	15	7	14	4
Track 19	14	26	36	23	35	25	18	21	15	11	11	12
Track 20	9	36	25	28	26	26	21	20	17	20	12	7
Track 21	17	36	34	38	37	47	33	29	33	20	23	18
Track 22	17	41	34	35	37	38	43	20	30	31	20	19
Track 23	7	40	46	47	52	39	36	37	26	15	9	11
Track 24	11	32	45	55	44	44	43	35	23	18	6	9

Table 16. *Linear Interval Statistical Analysis* for the first movement excluding intervals made by gaps longer than 10 measures.

Intervals	0 (P1)	1 (M2)	2 (M2)	3 (M3)	4 (M3)	5 (P4)	6 (D5)	7 (P5)	8 (M6)	9 (M6)	10 (M7)	11 (M7)
Track 1	11	38	42	39	30	29	25	24	28	16	18	8
Track 2	9	58	32	46	37	28	20	18	23	16	11	10
Track 3	8	29	42	31	35	34	34	35	22	14	10	14
Track 4	4	35	39	39	43	41	42	28	24	8	3	2
Track 5	16	21	40	35	47	50	35	18	18	12	12	4
Track 6	9	33	38	33	48	36	34	24	14	20	11	8
Track 7	14	14	37	30	38	32	15	20	12	10	12	5
Track 8	12	27	24	28	27	27	23	14	19	15	9	14
Track 9	8	30	44	28	28	24	20	26	14	20	10	7
Track 10	10	38	36	19	18	35	21	17	19	15	16	15
Track 11	6	29	13	22	29	27	21	17	18	18	8	8
Track 12	8	24	28	17	29	21	29	16	15	8	14	7
Track 13	5	26	24	41	34	30	33	23	18	11	9	8
Track 14	3	27	24	44	35	31	31	28	21	5	10	3
Track 15	6	22	31	36	26	28	17	19	21	12	7	14
Track 16	16	30	33	20	35	23	22	17	15	17	6	5
Track 17	14	44	44	49	51	48	55	40	29	30	19	17
Track 18	20	32	53	52	60	40	50	39	29	28	15	22
Track 19	19	42	53	50	58	45	47	26	30	26	26	18
Track 20	9	49	39	39	55	50	62	47	33	24	23	10
Track 21	8	42	43	32	43	35	37	20	32	21	10	8
Track 22	9	24	35	35	55	24	23	33	40	19	15	19
Track 23	6	42	41	33	42	35	42	28	23	14	13	12
Track 24	15	22	43	39	49	34	40	26	16	21	13	13

Table 17. *Linear Interval Statistical Analysis* for the second movement excluding intervals made by gaps longer than 10 measures.

Intervals	0 (P1)	1 (m2)	2 (M2)	3 (m3)	4 (M3)	5 (P4)	6 (D5)	7 (P5)	8 (m6)	9 (M6)	10 (m7)	11 (M7)
Track 1	9	55	52	41	30	27	23	19	19	15	11	9
Track 2	10	47	35	43	39	32	23	13	28	12	15	13
Track 3	13	36	37	42	42	28	31	25	18	18	14	6
Track 4	4	40	49	43	33	31	20	21	24	21	11	13
Track 5	11	41	35	33	36	21	26	24	23	13	30	17
Track 6	23	40	37	26	23	19	40	31	21	16	16	18
Track 7	7	27	38	30	36	32	25	33	20	18	17	15
Track 8	6	32	42	31	38	33	25	29	18	17	15	12
Track 9	13	23	33	26	25	22	22	15	18	13	5	12
Track 10	18	35	23	26	25	24	10	17	16	12	15	6
Track 11	9	46	41	35	43	29	28	20	19	20	10	12
Track 12	7	59	45	39	35	37	20	20	21	19	4	6
Track 13	4	34	30	29	31	16	17	17	18	8	9	14
Track 14	8	39	28	32	37	17	17	9	15	9	7	9
Track 15	6	41	38	26	33	41	23	25	21	16	22	6
Track 16	3	49	32	40	33	32	25	22	19	15	15	13
Track 17	21	64	43	45	42	52	44	38	32	22	28	16
Track 18	15	56	53	52	50	49	44	31	26	25	25	21
Track 19	8	78	49	53	47	37	47	44	24	15	30	15
Track 20	14	66	37	57	55	64	43	31	34	26	12	8
Track 21	19	54	36	34	26	39	28	34	28	17	22	21
Track 22	12	51	47	31	35	38	38	23	28	18	18	19
Track 23	8	47	43	46	43	33	42	30	21	21	11	13
Track 24	5	50	49	37	45	37	33	42	26	10	11	13

Table 18. *Linear Interval Statistical Analysis* for the third movement excluding intervals made by gaps longer than 10 measures.

CONCLUSION

Symphony No. 1 is the first complete work I created using the Algorithmic Composition System software, except several fragmented works. I found that composing with the algorithmic composition program increases both productivity and creativity through the short processing time, instant performance, and the easy organization of compositional ideas and musical data. For example, after creating the fundamental musical data, the composer can access them and modify them whenever he needs. On occasion, the composer can use the algorithmic composition program as a modeler only for the complicated portions, or to simulate the outcome especially when various diverse rhythms and numerous instruments are overlapped. Otherwise the composer will have to leave it to his/her imagination until performed.

I will continue developing the software as long as I compose music. I have several plans for my future compositions. One is that I incorporate the use of microtones into the composition. The thought of using microtones was one of the significant reasons I started ACS. When I studied composing twelve-tone serial music and the like, my disappointment had arisen from the uninteresting sound. When I heard about microtones and micro tonality, I wished I could try them, and I dreamt that I could find a system that would replace current directions of music from them. Now I think that there seem to be no such undiscovered physical phenomena that can compete with the system having tonic and dominant relationships with its related triads in the aspect of people's flavor. Nevertheless, I believe there may be other concealed relationships yet, although they will

not be so popular as the system of tonality. The microtones won't generate the same flavor as tonality does either. However, I am sure it will enrich our musical resources at least only if they harmonize well with semitones.

Symphony No. 1 has an important meaning to me as the first complete composition composed using the Algorithmic Composition System. Along with this composition my main goal as a composer will be to find better ways of constructing musical materials through compositions and developing ACS. I believe beauty comes not from degradation, nonexistence, or chaos, but from robust, elaborate, restrained, and refined structure.

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Jongmoon Choi

Symphony No. 1

October 2000

Notes for Performance

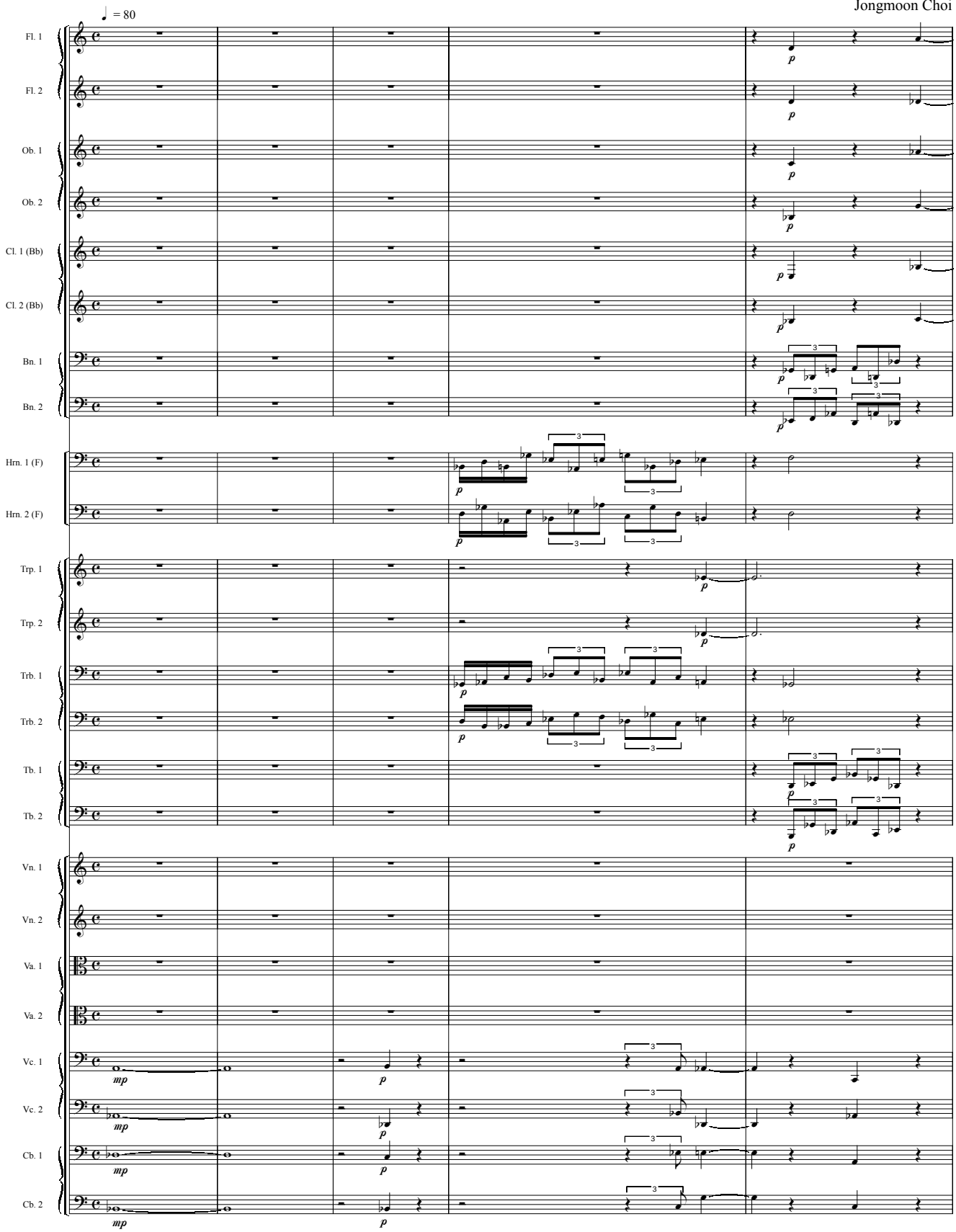
1. Accidentals take effect only in a measure and only for the same pitches that are in the same frequency.

2. The articulation for *Symphony No. 1*: All note groups or phrases, which are formed by being separated by rest notes, should be played legato.

Symphony No.1

1.

Jongmoon Choi



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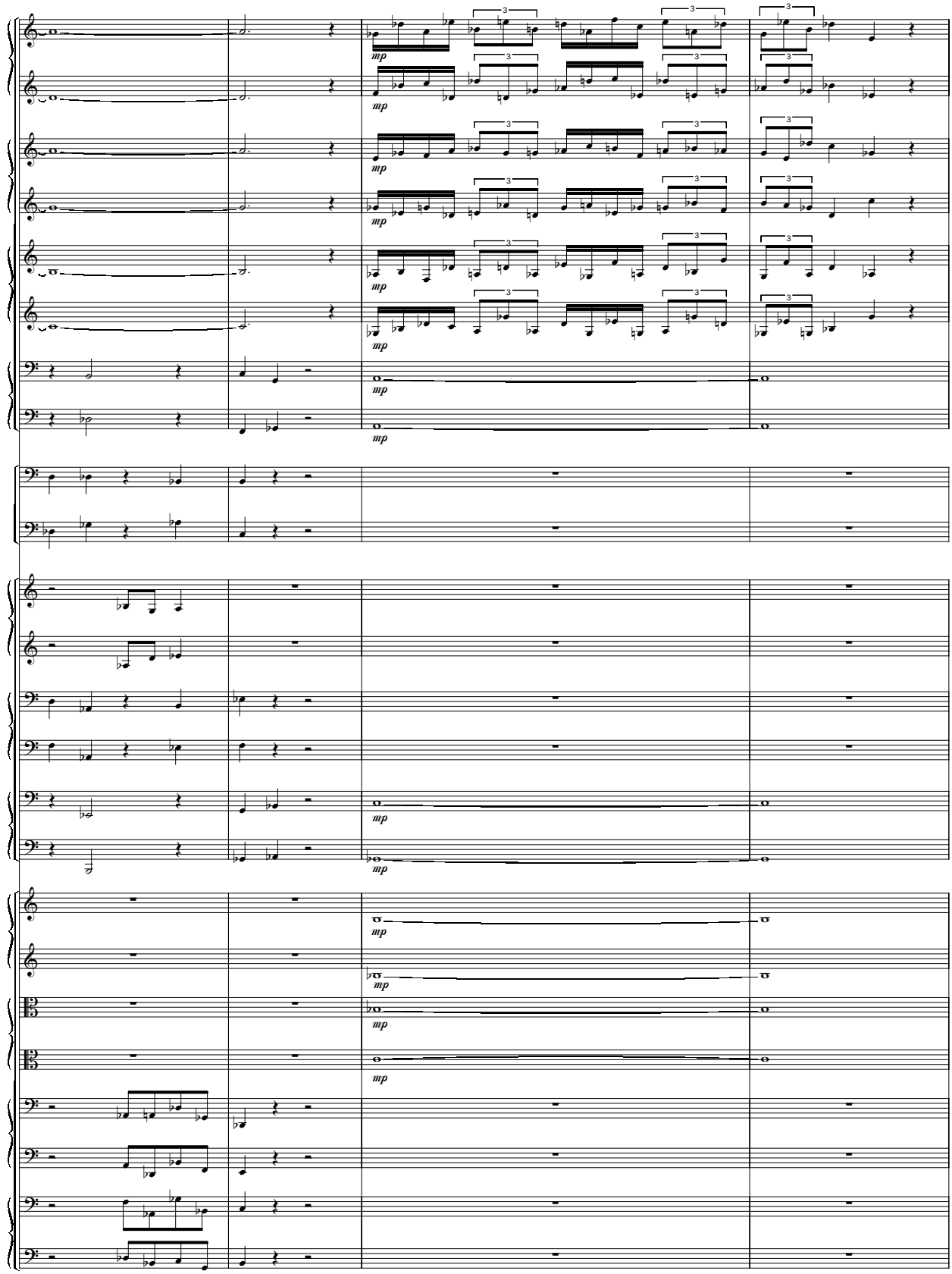
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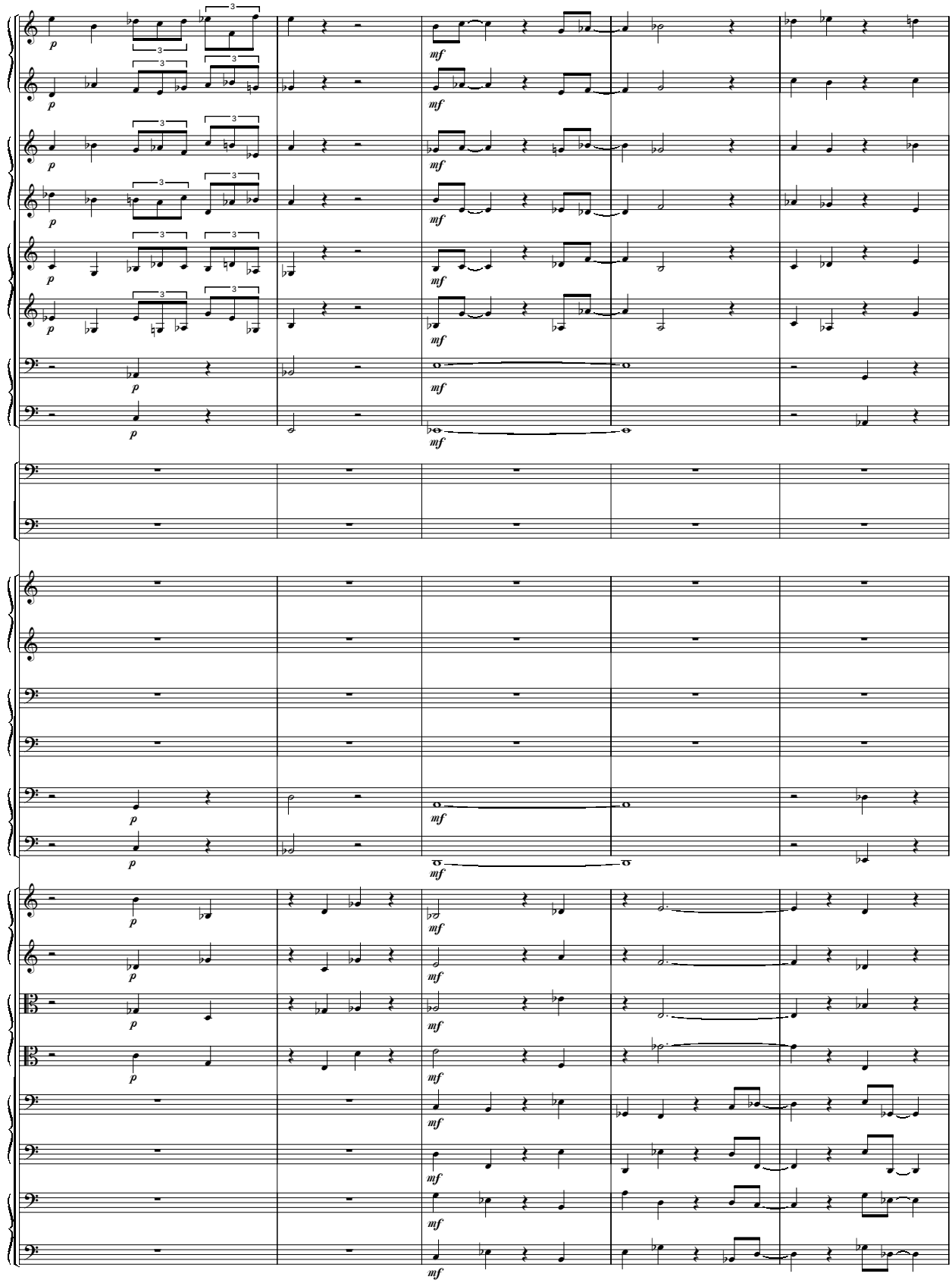
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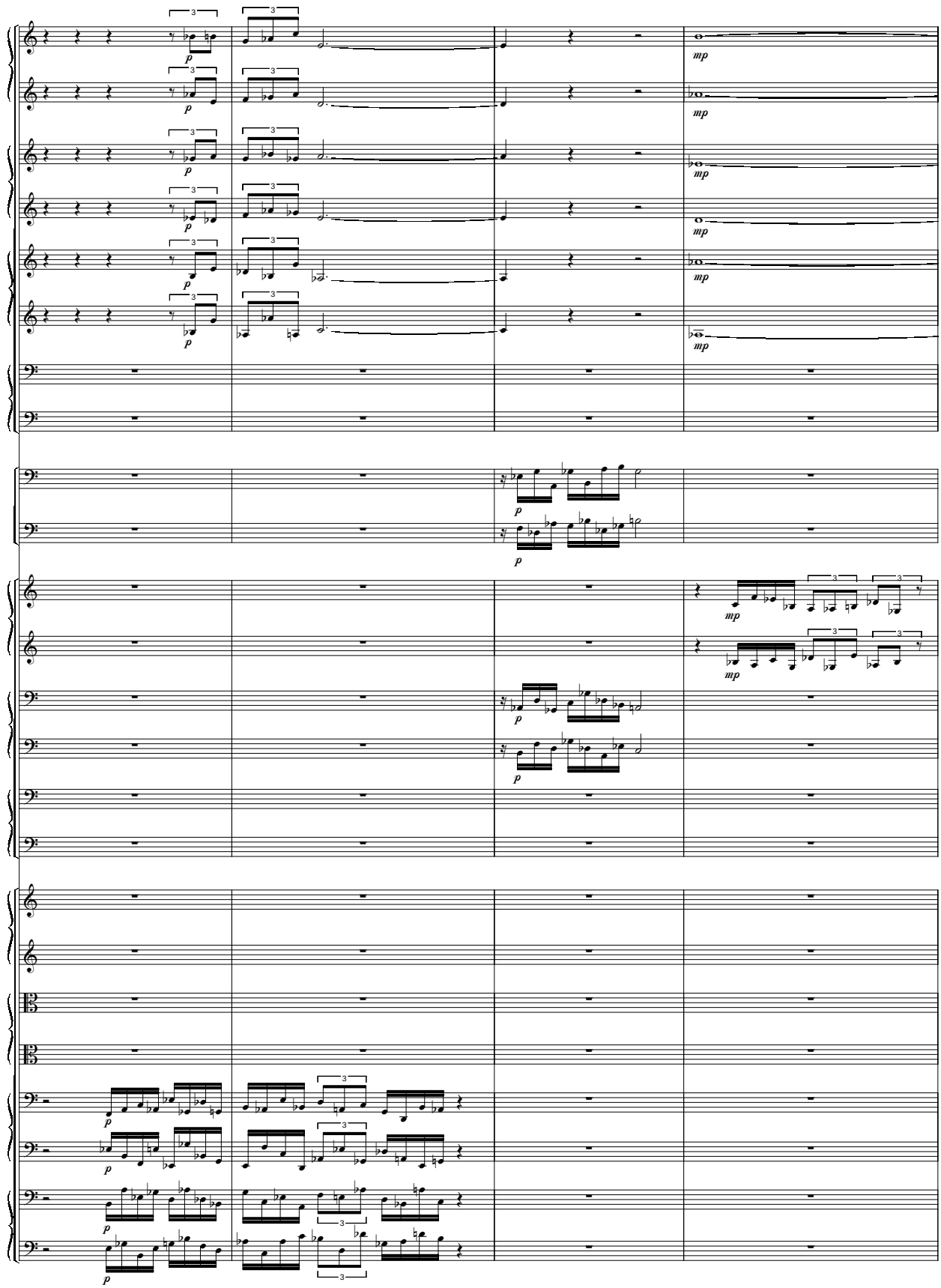
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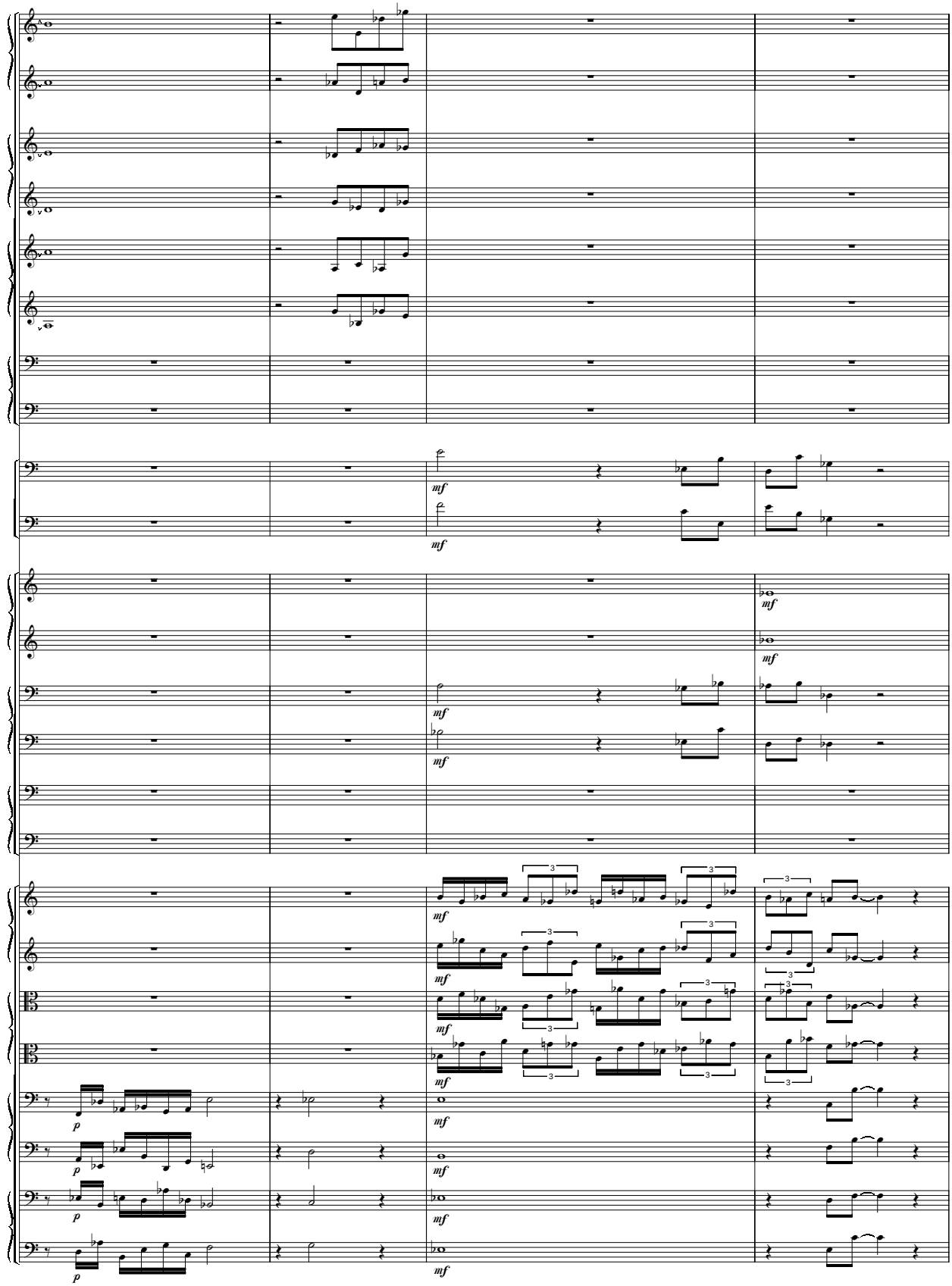
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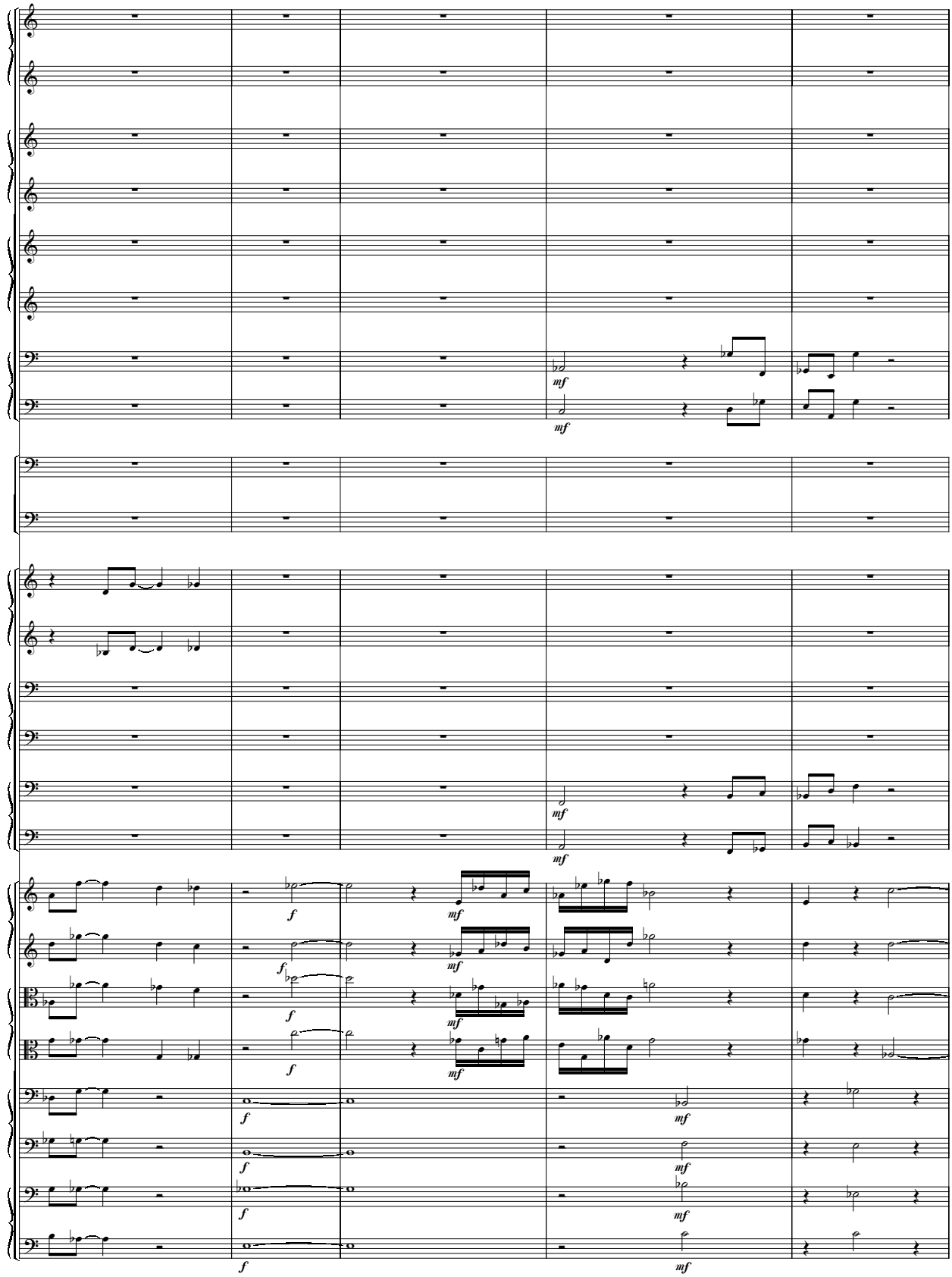
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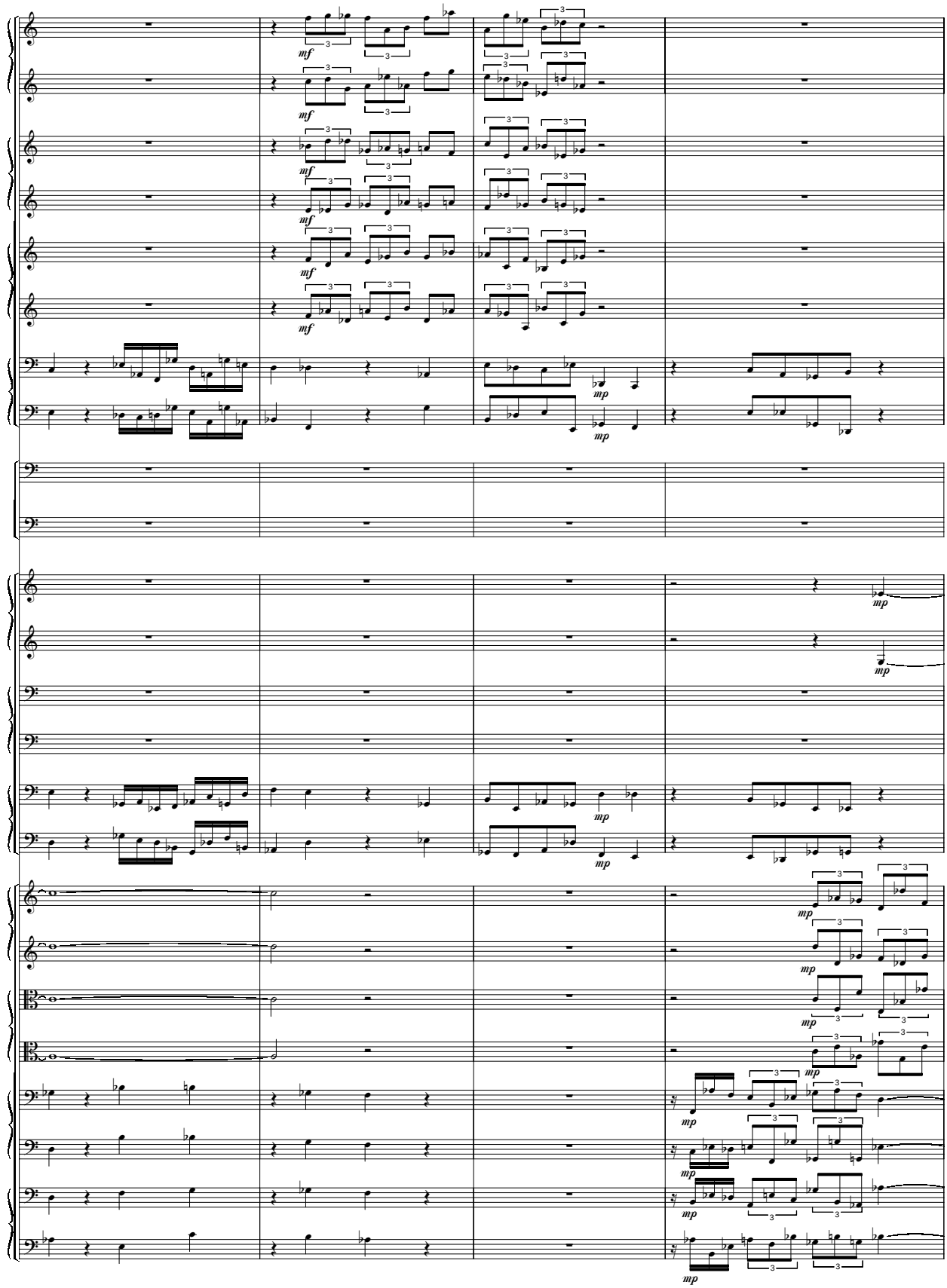
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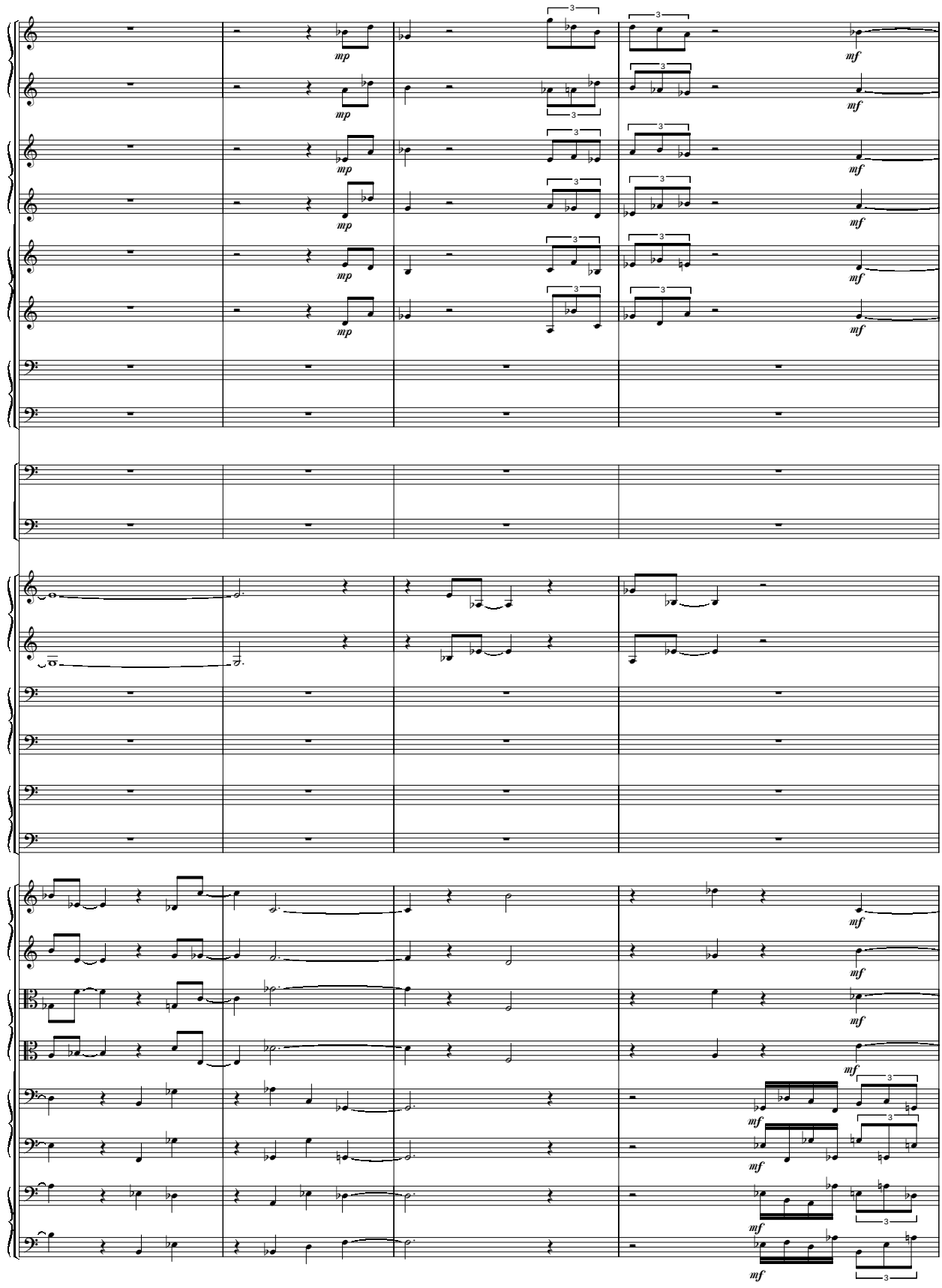
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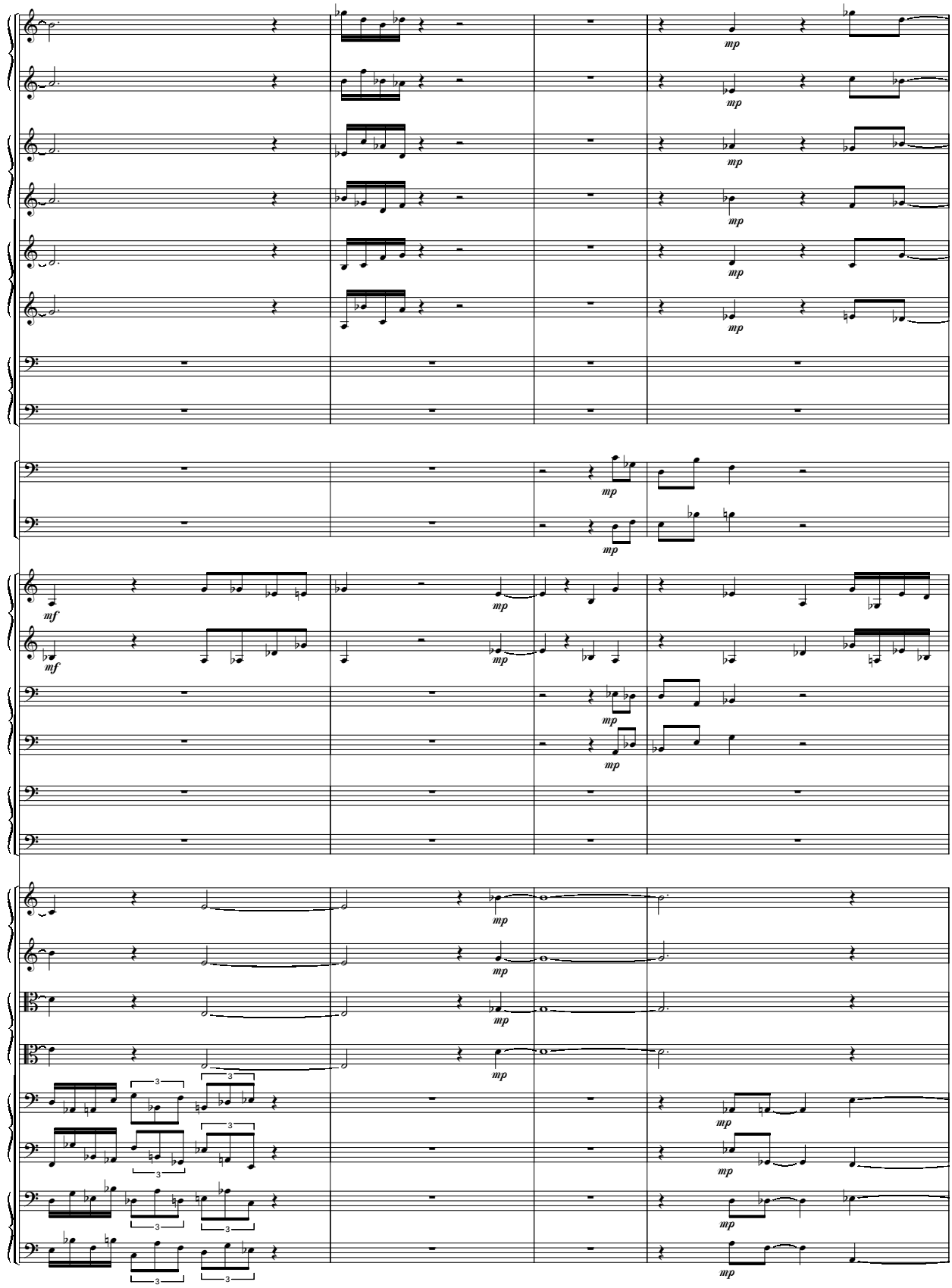
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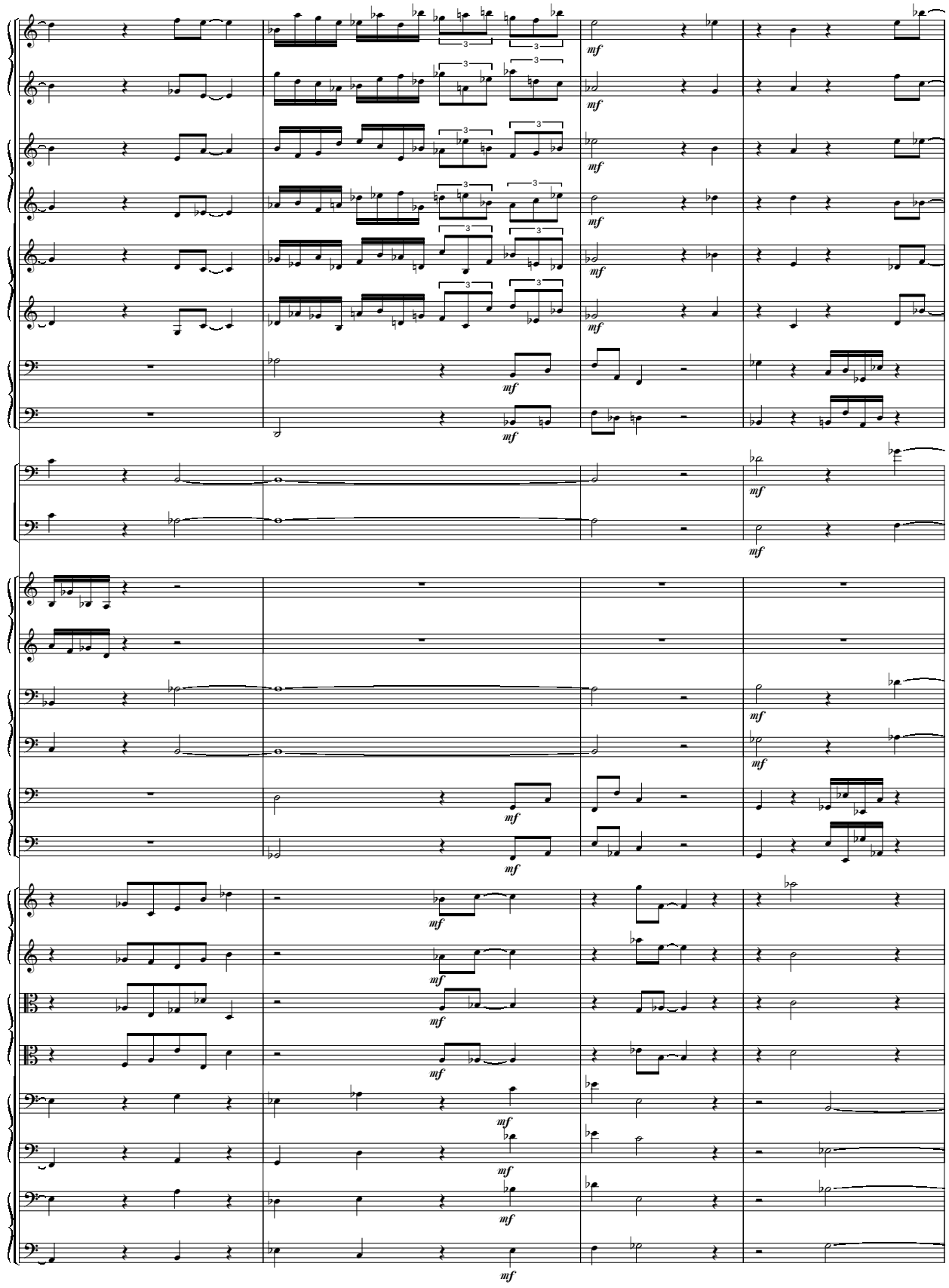
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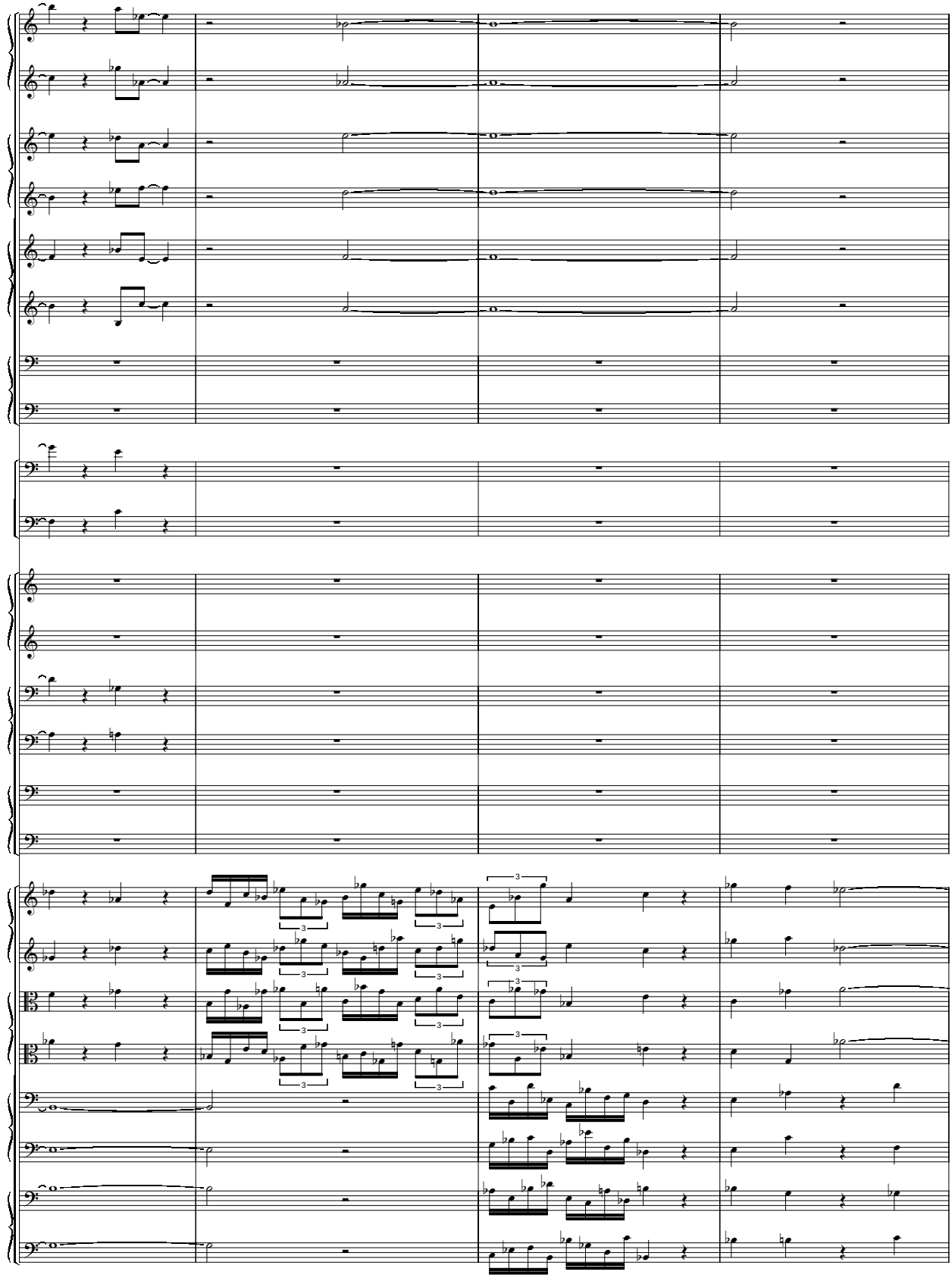

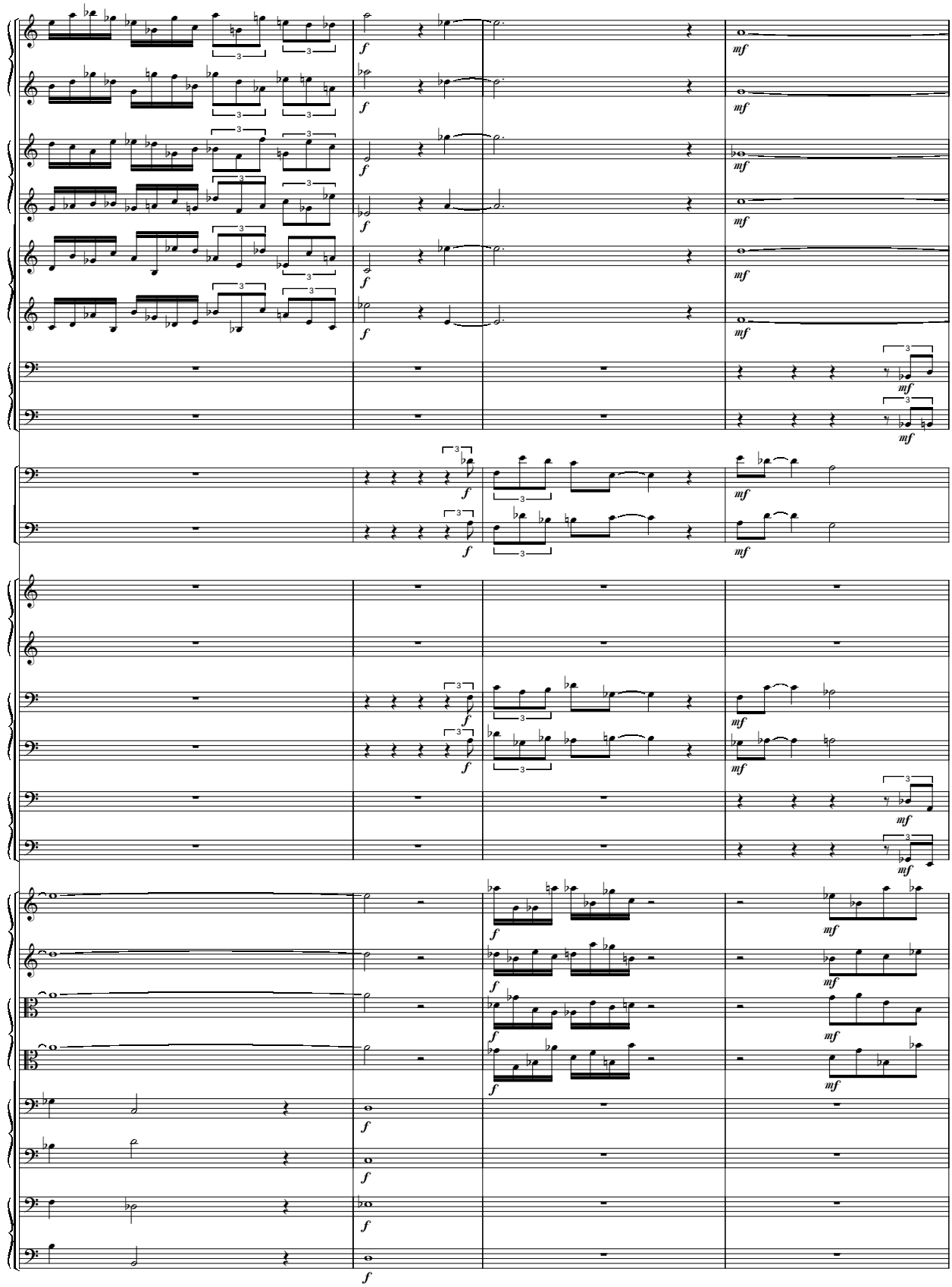

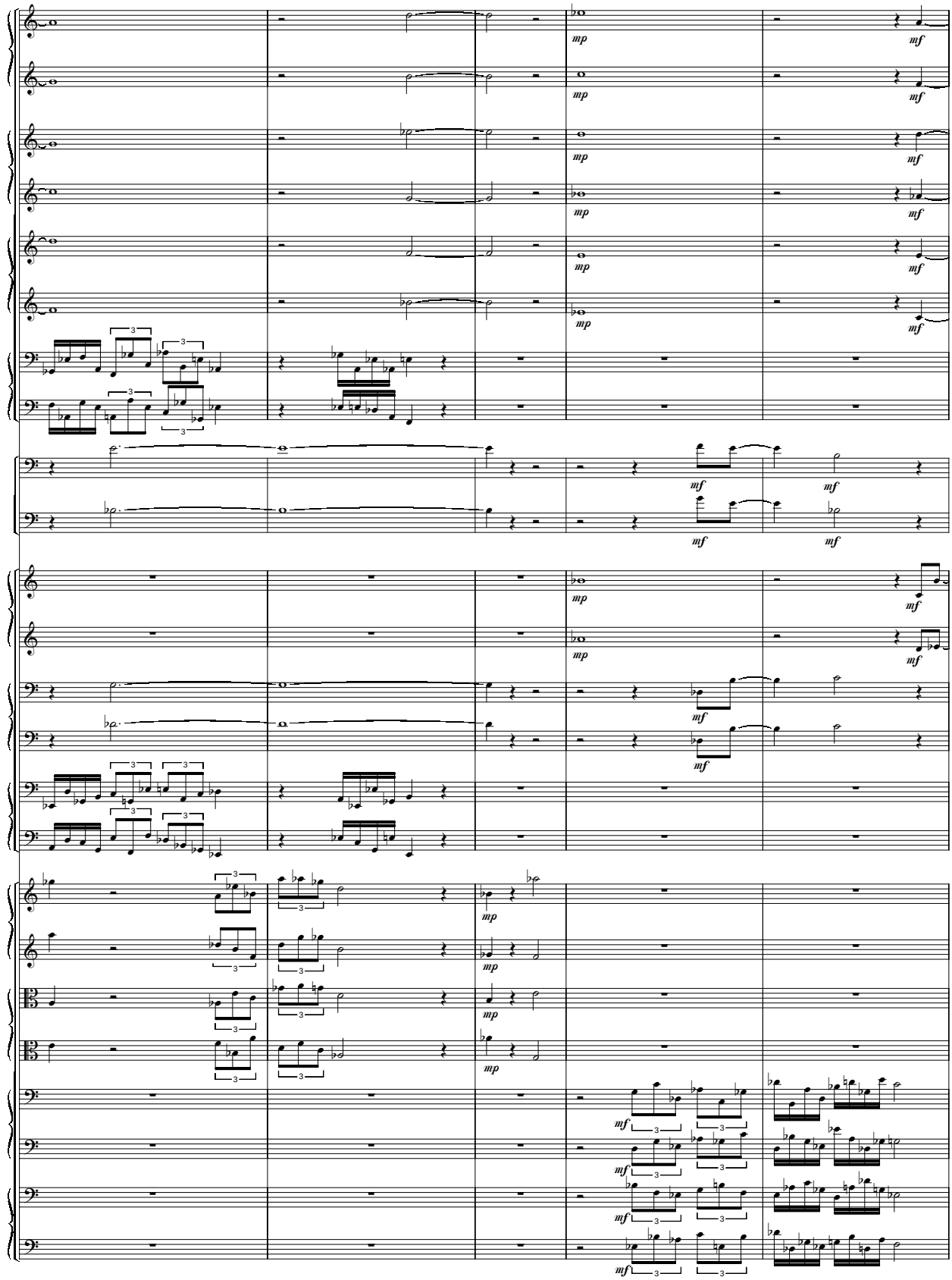
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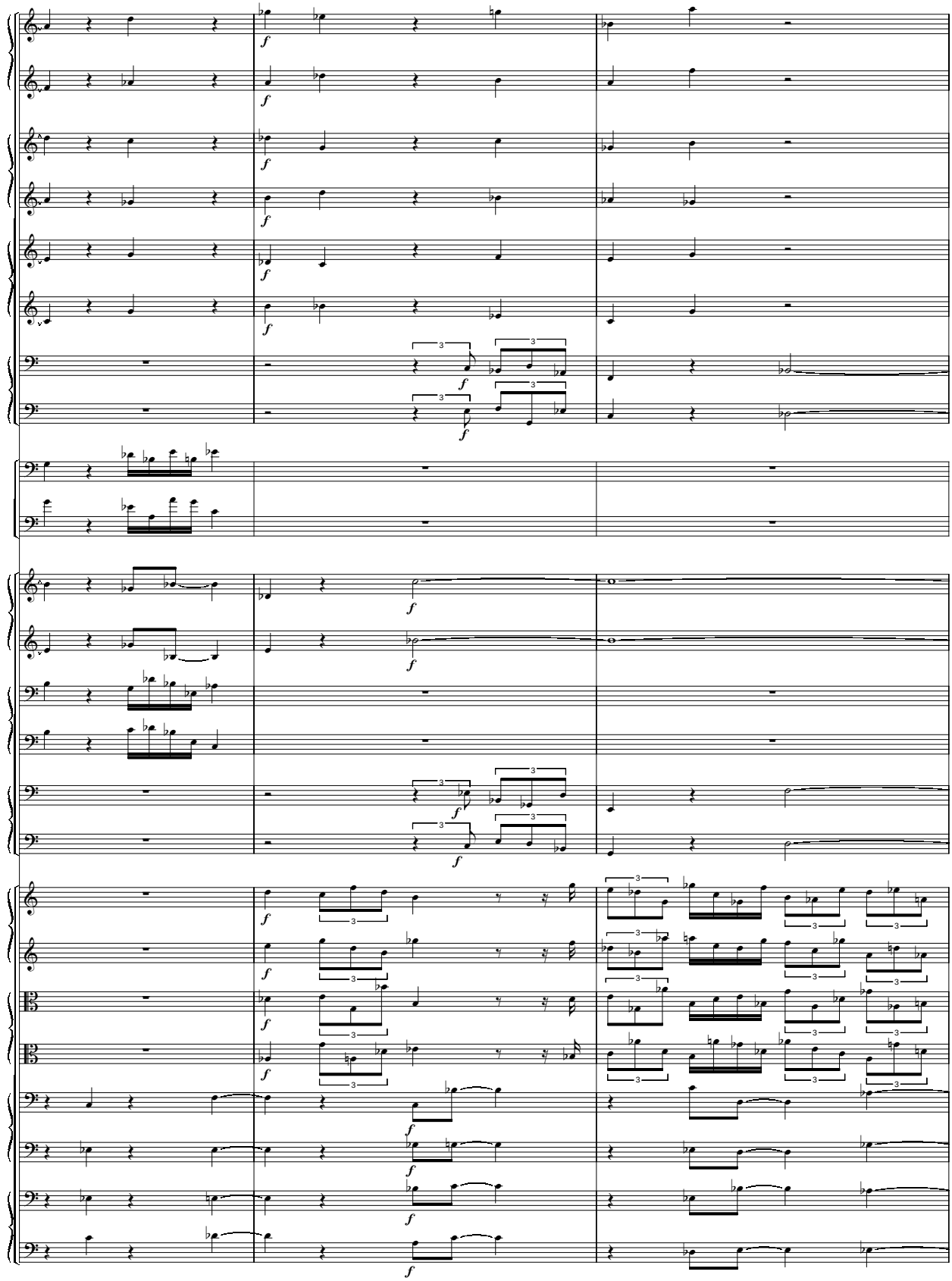

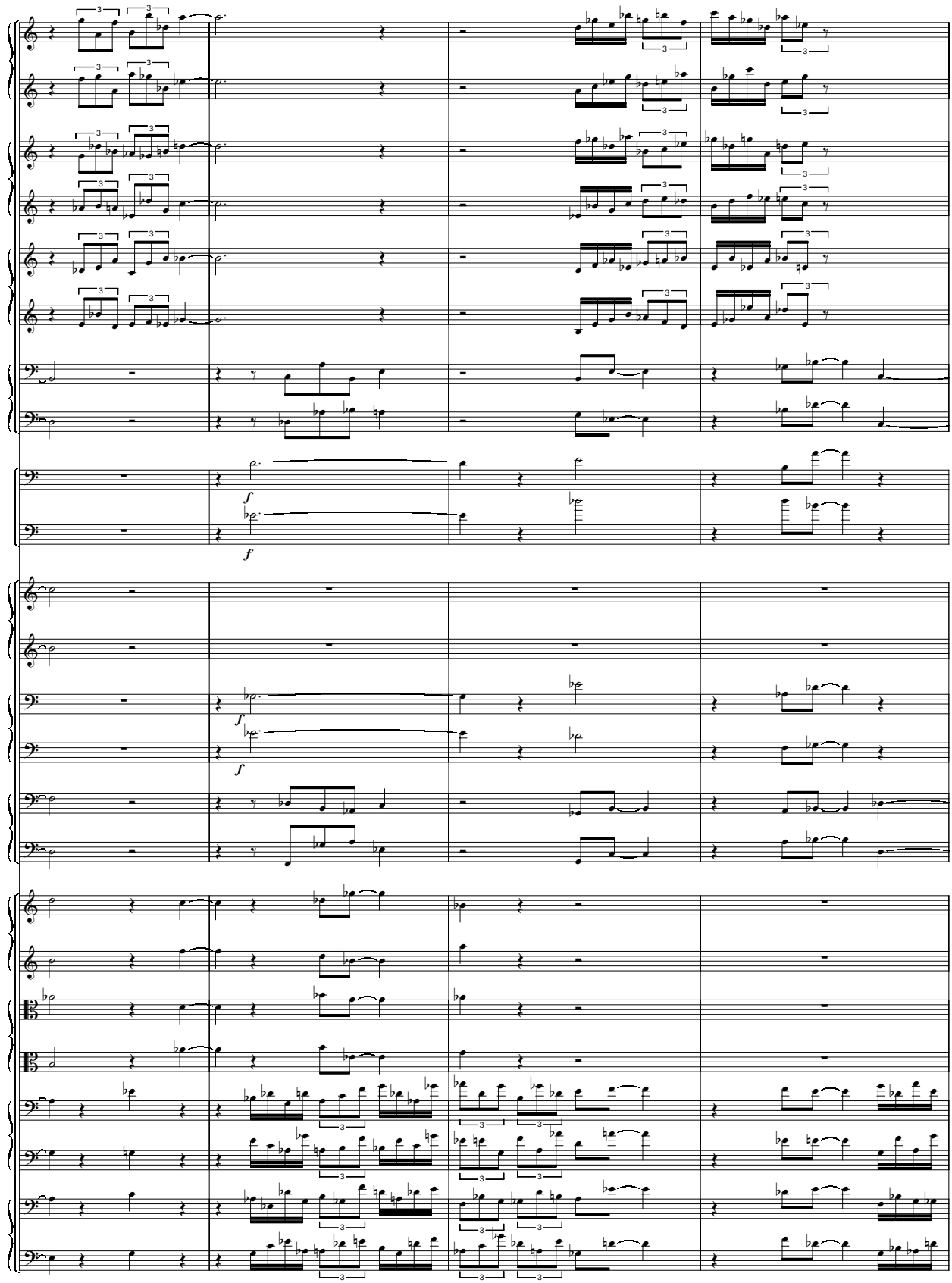
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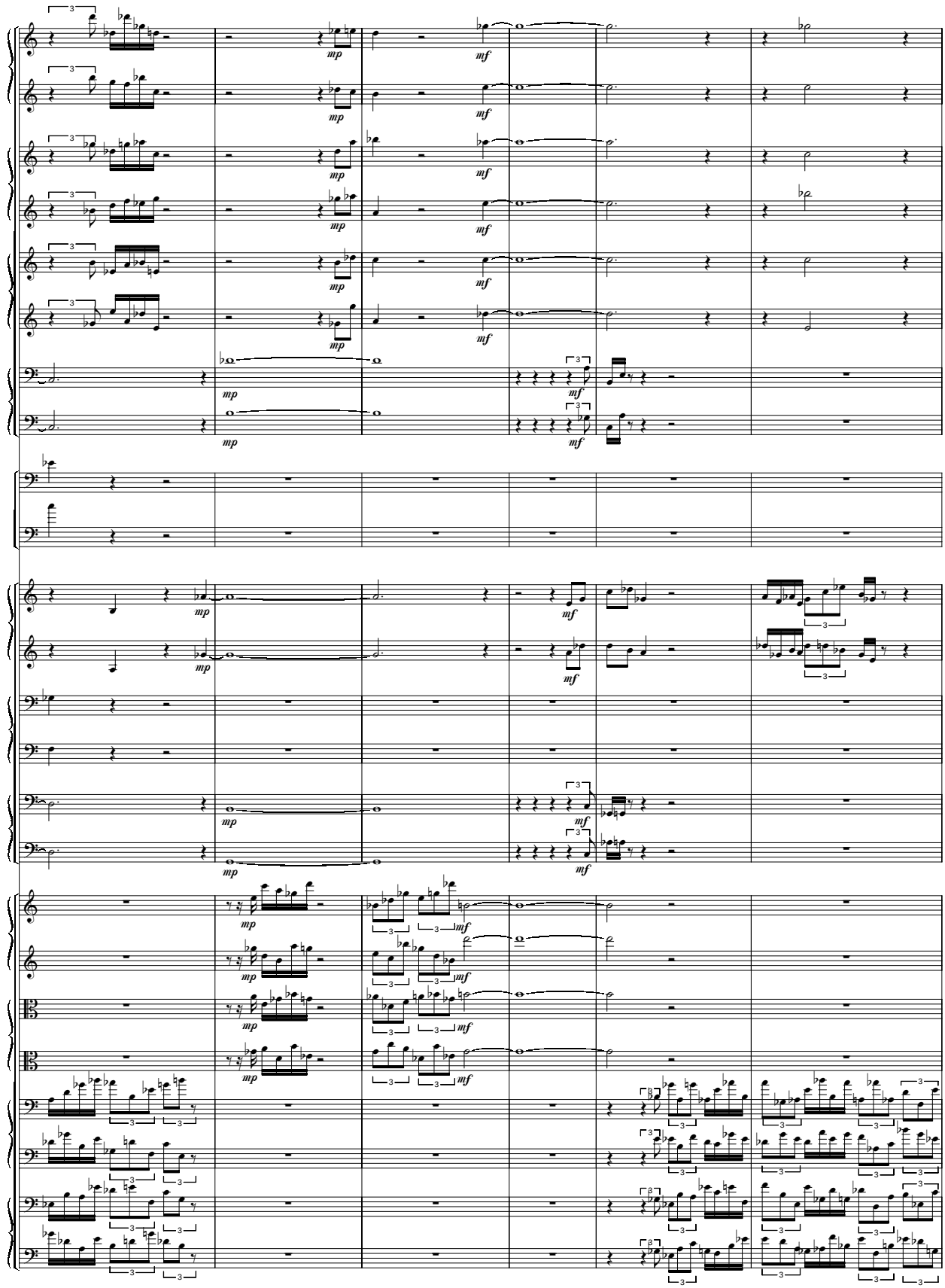

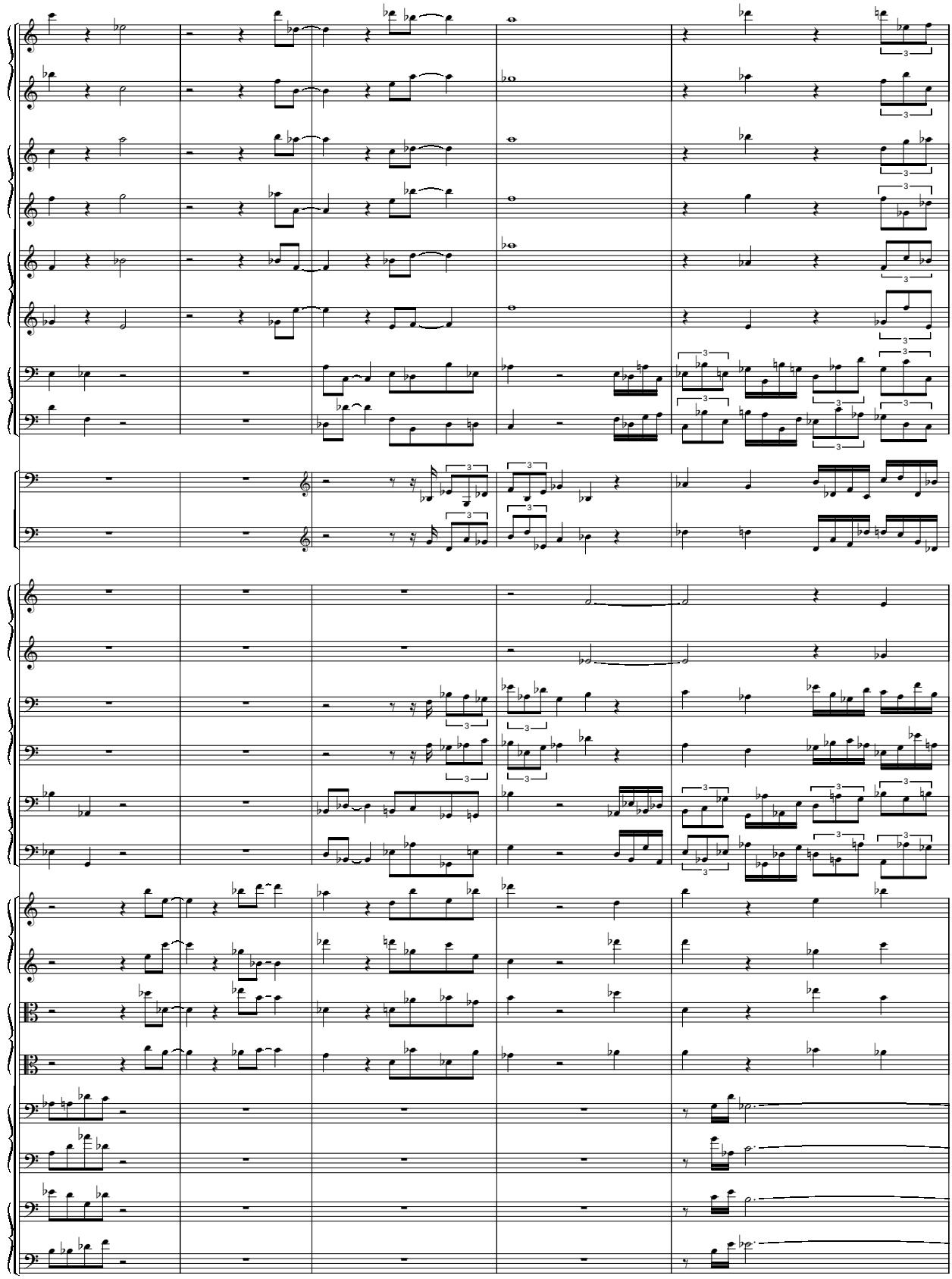

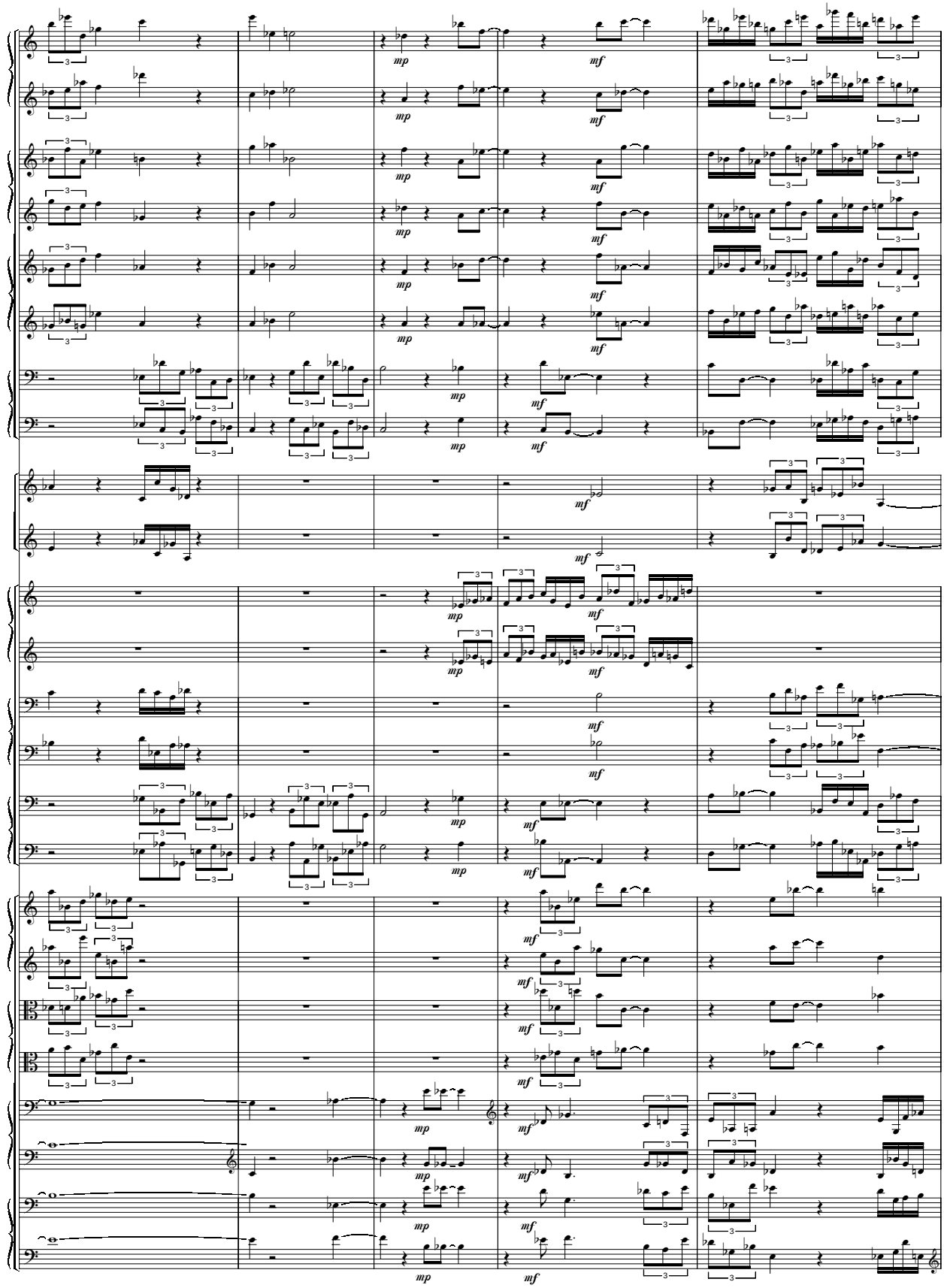
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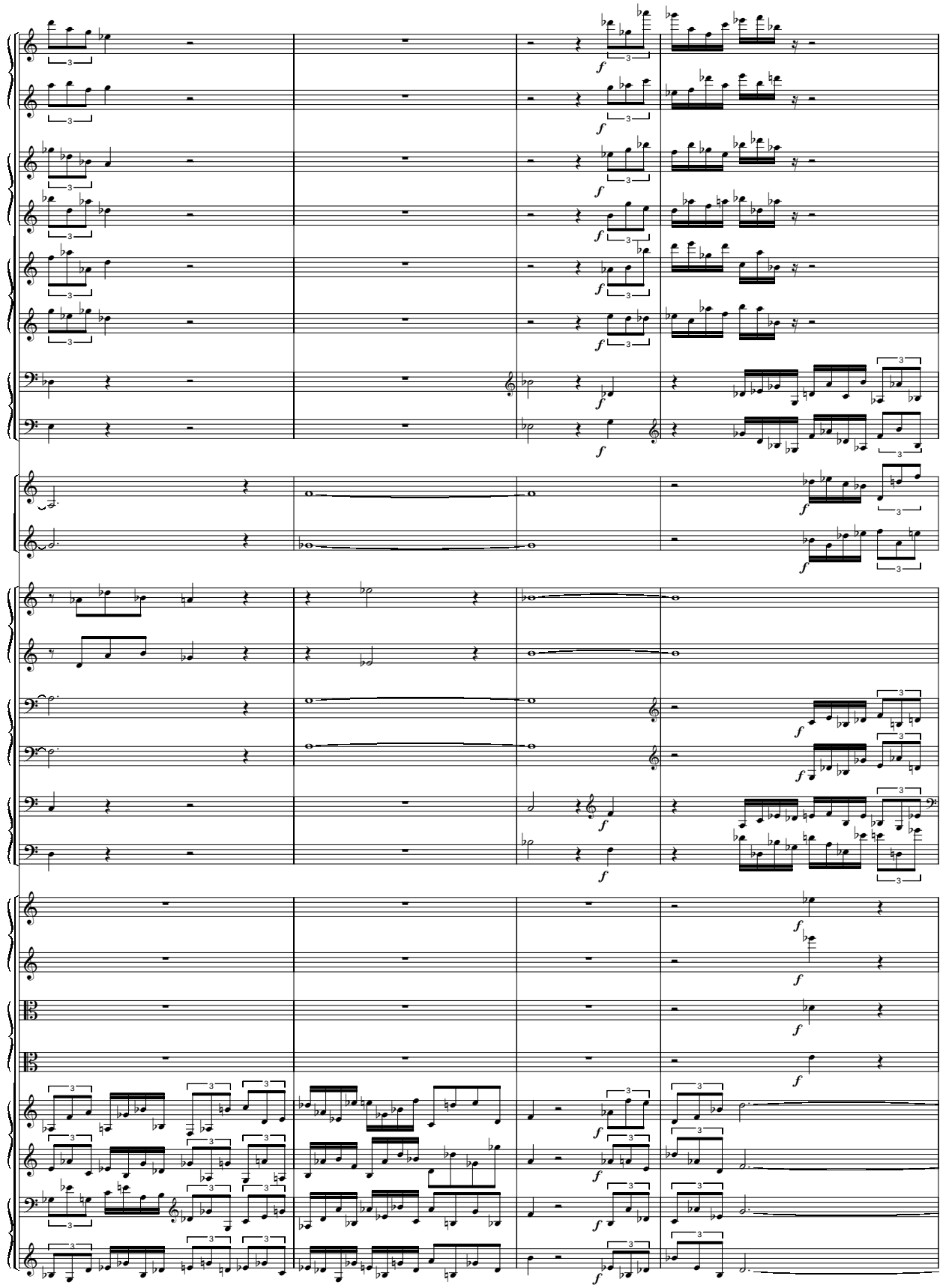

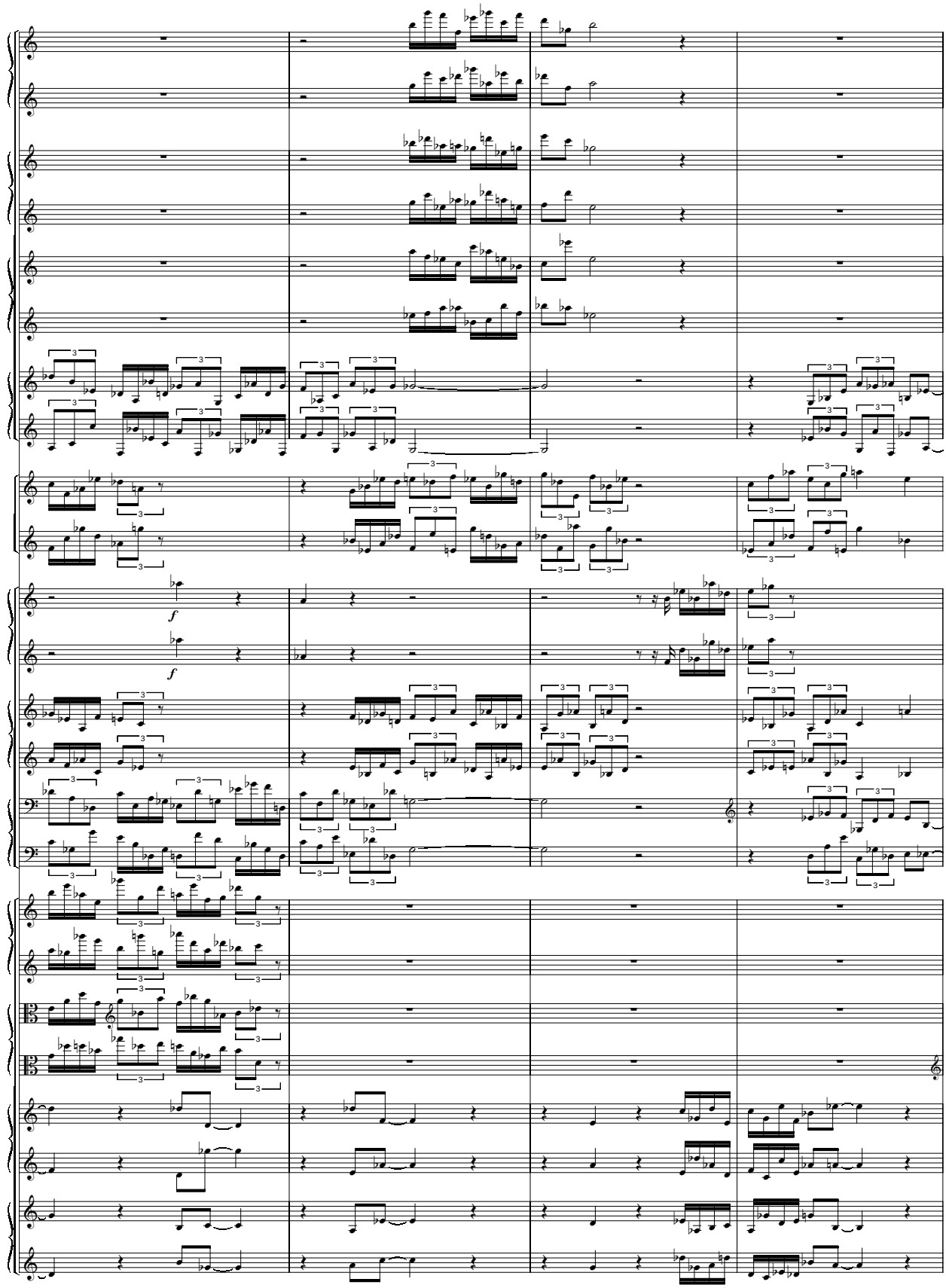
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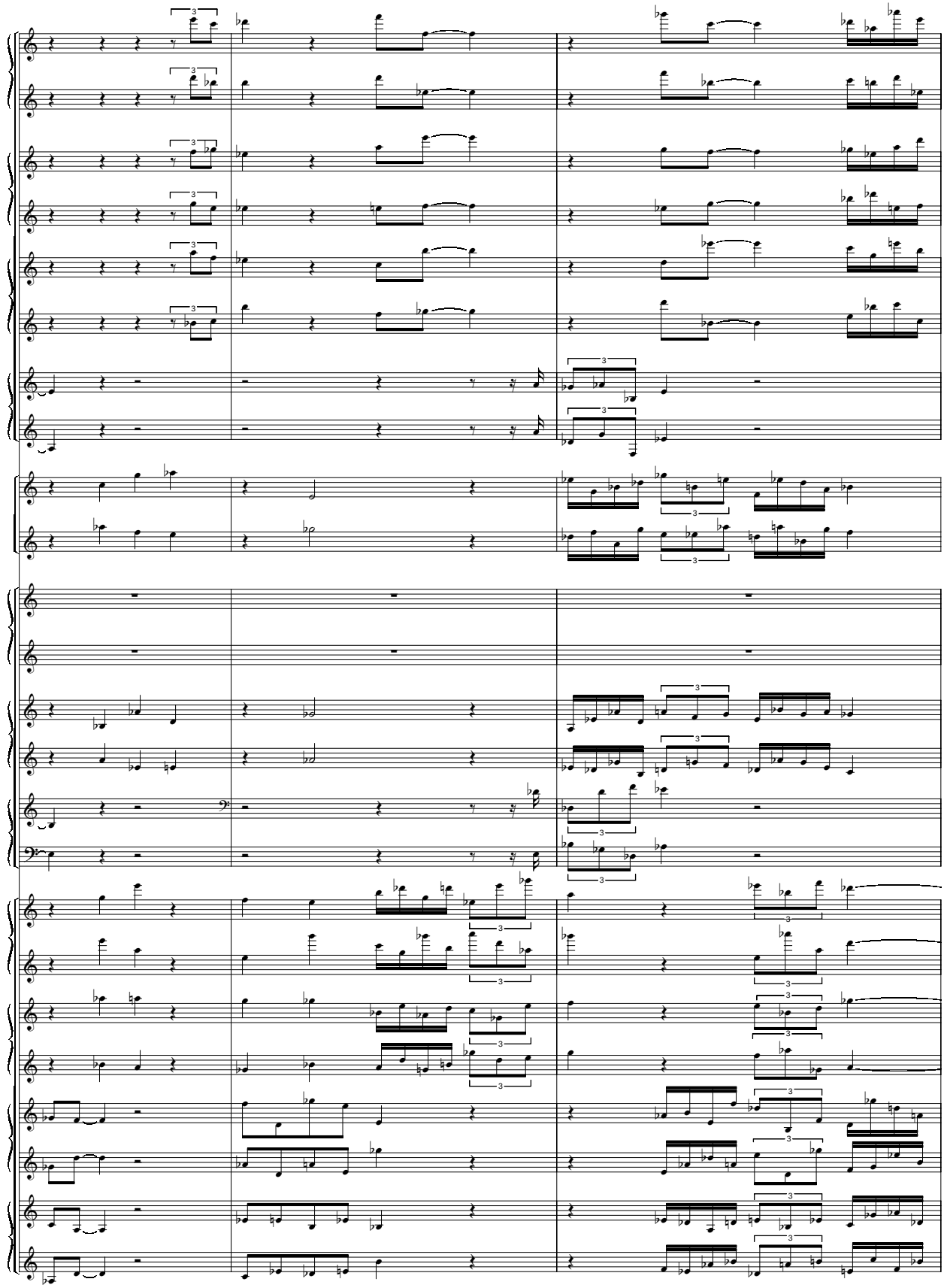

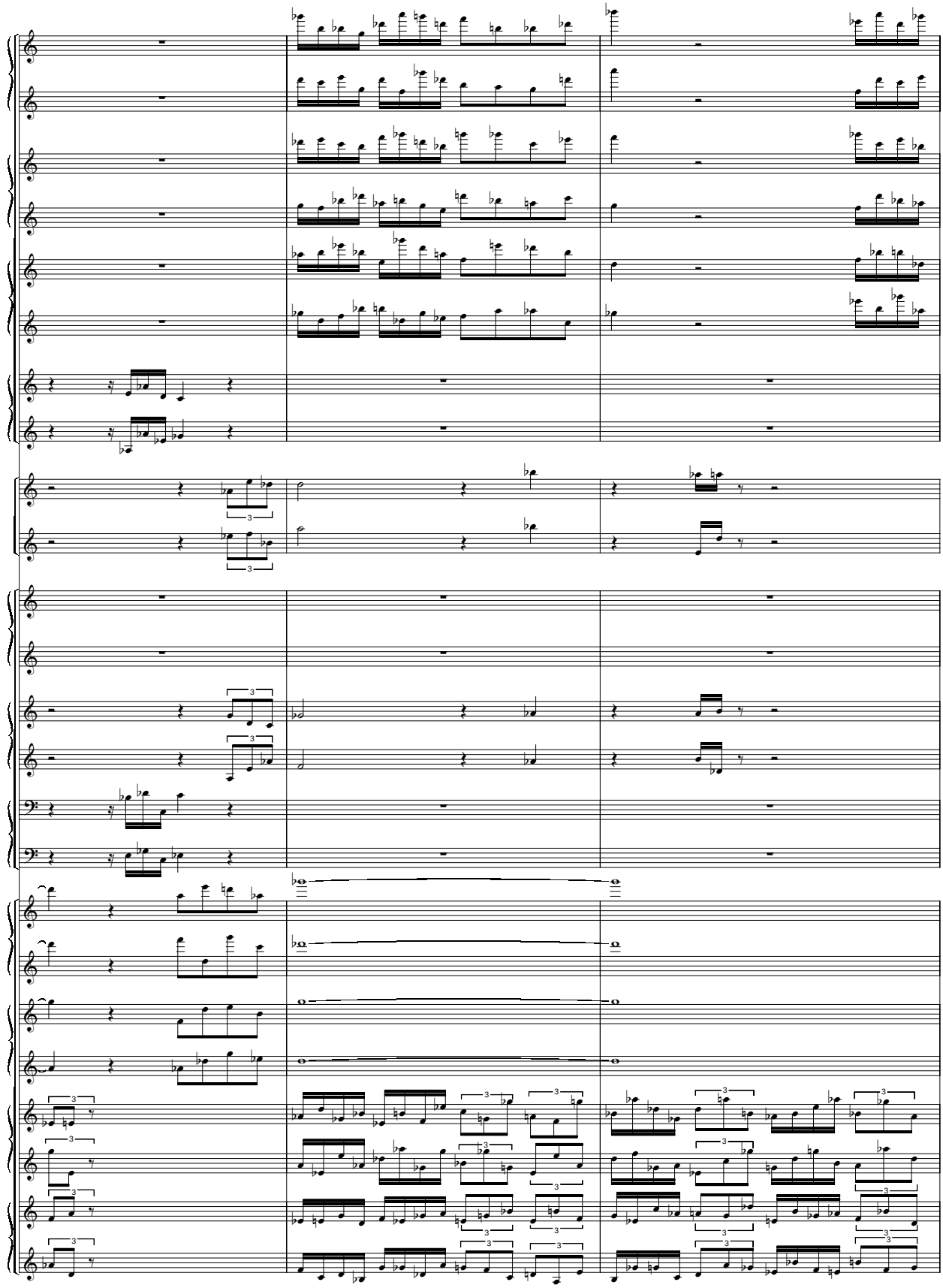

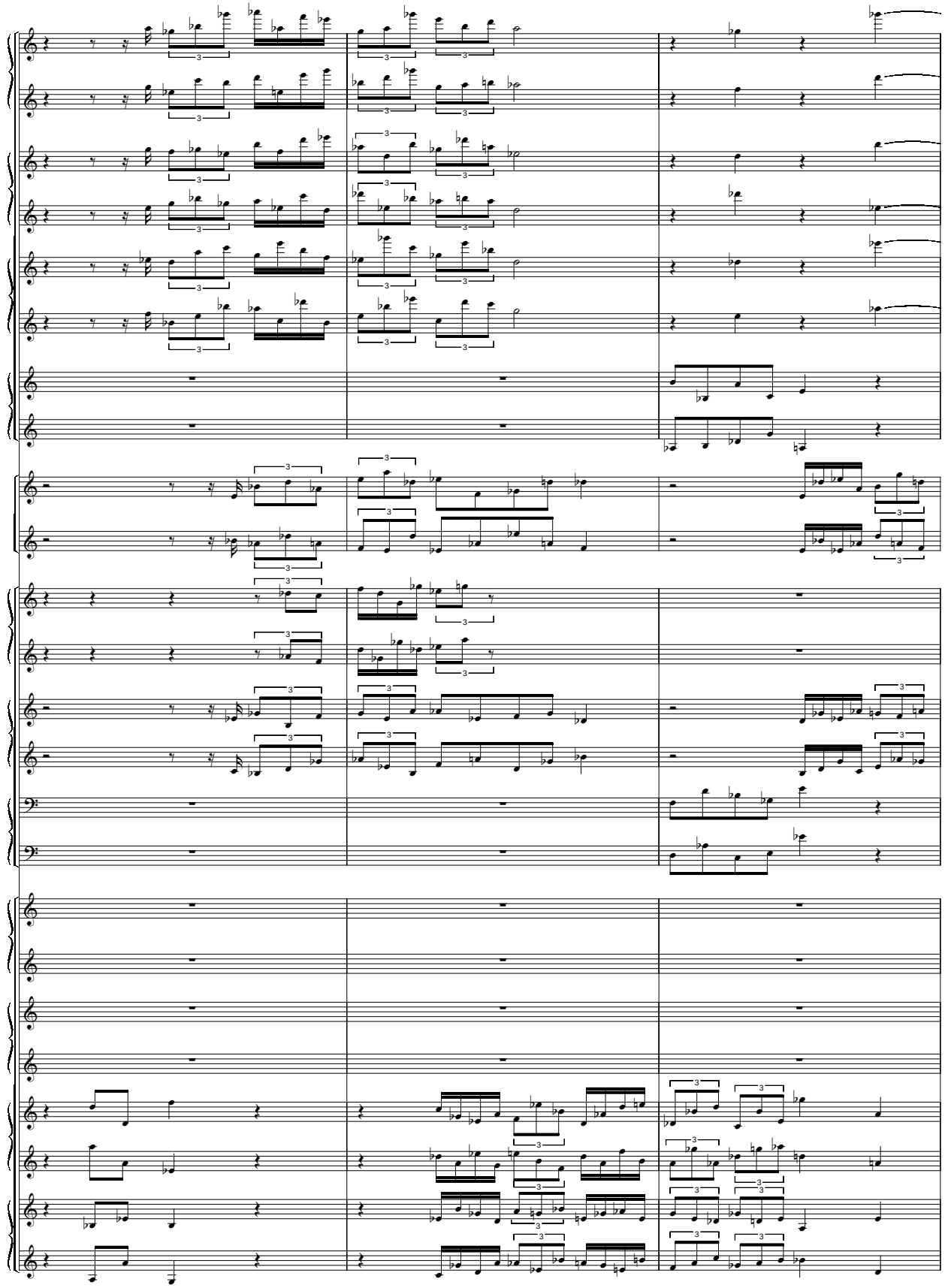

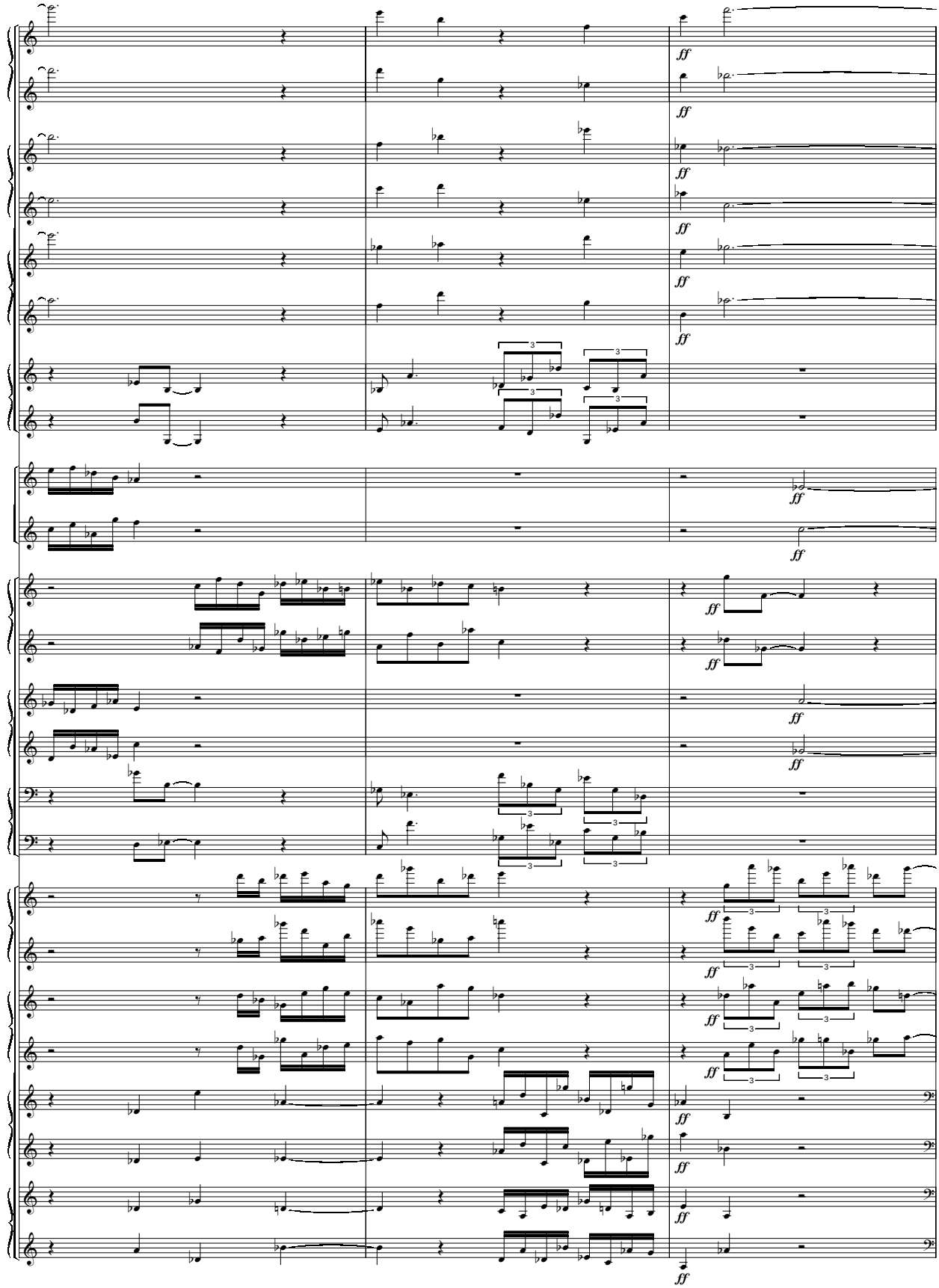
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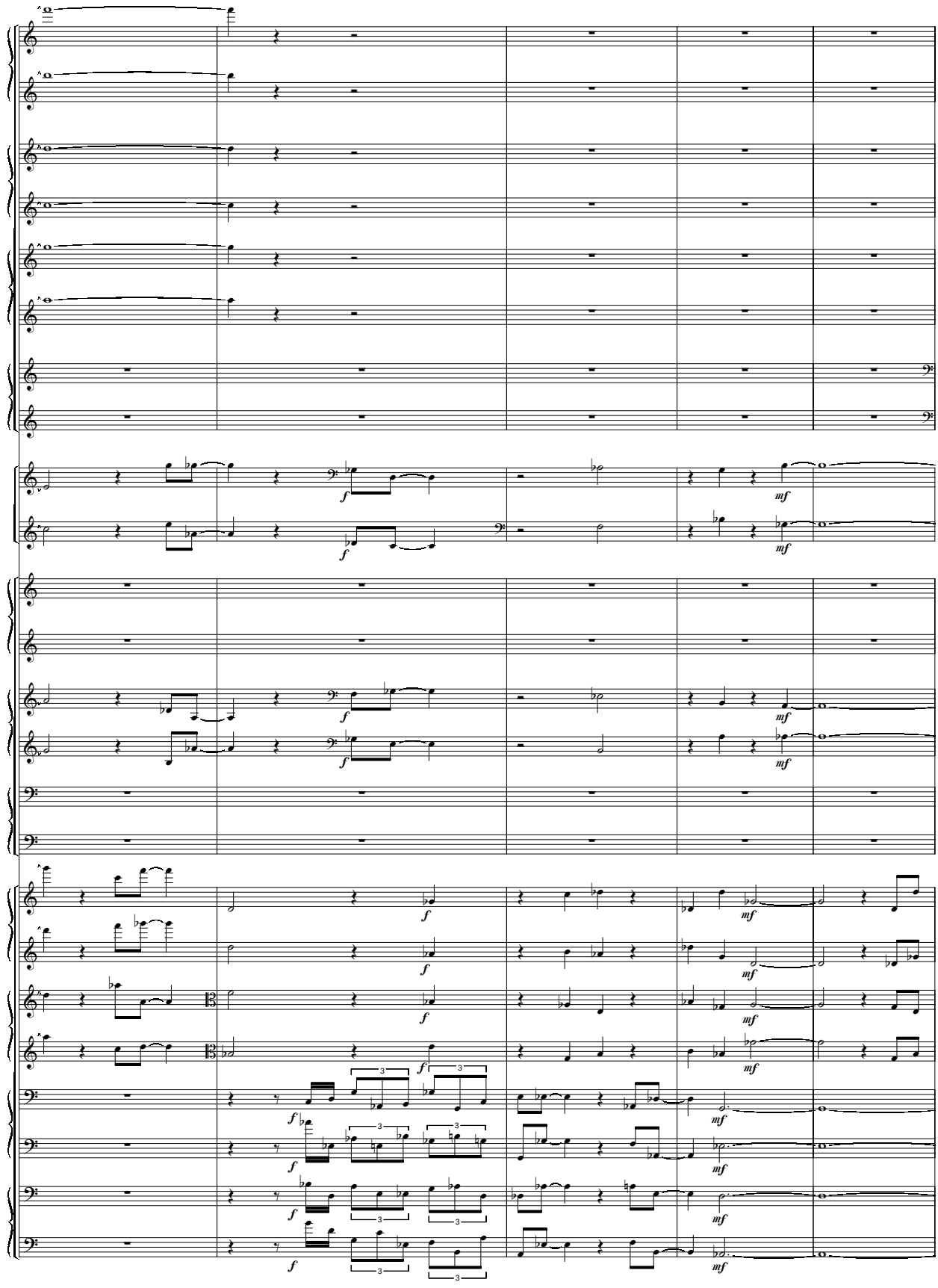

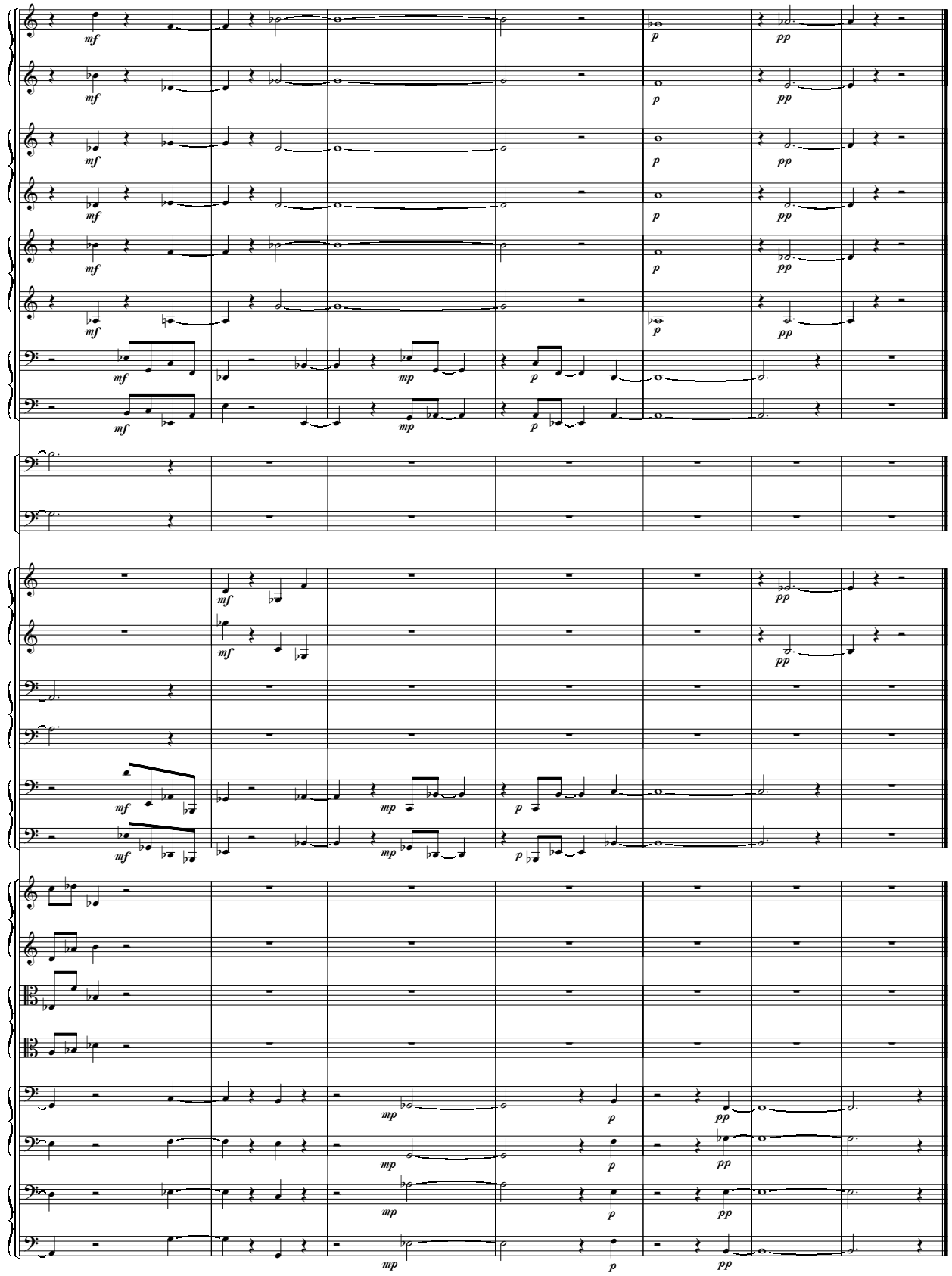
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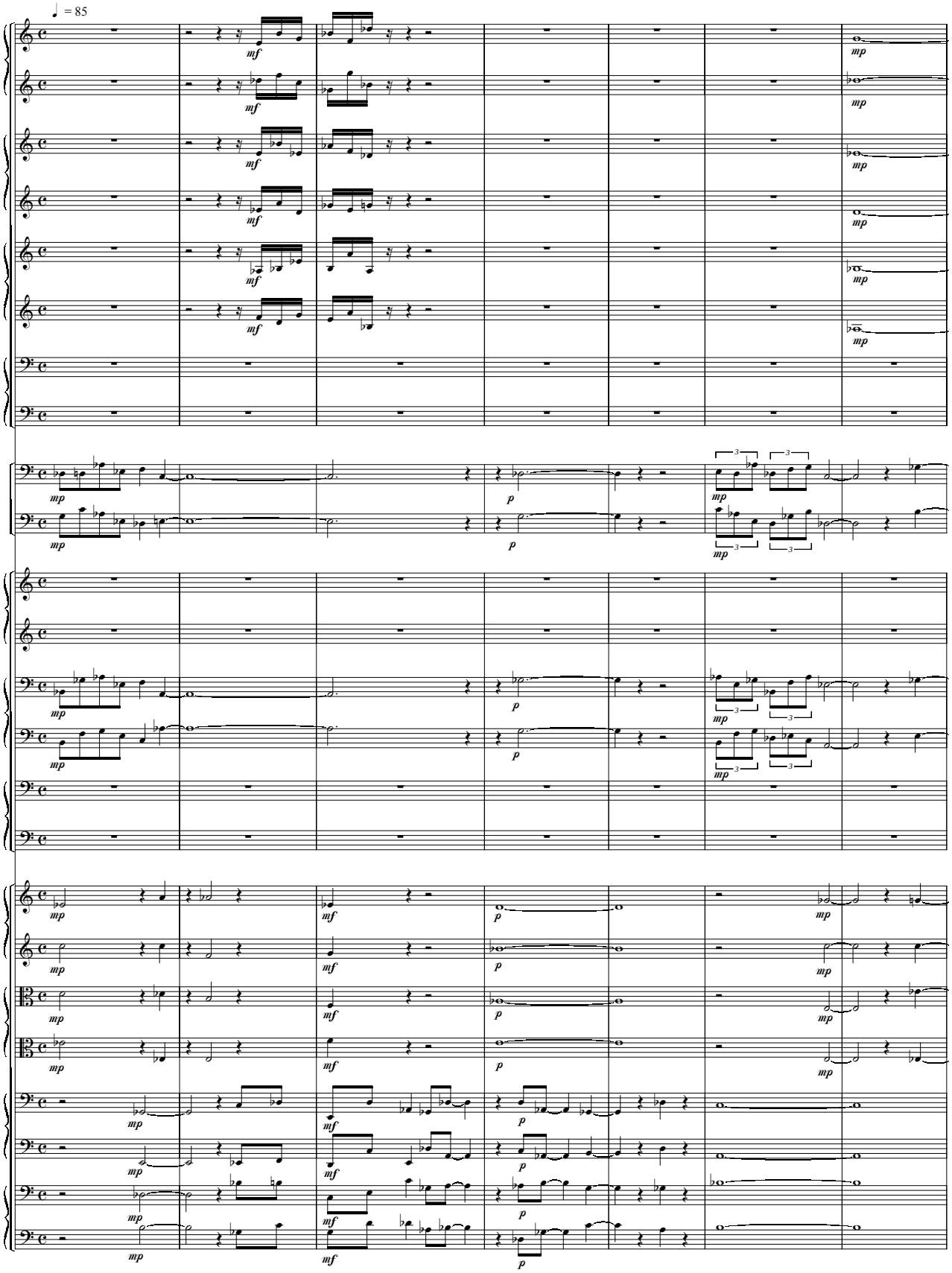
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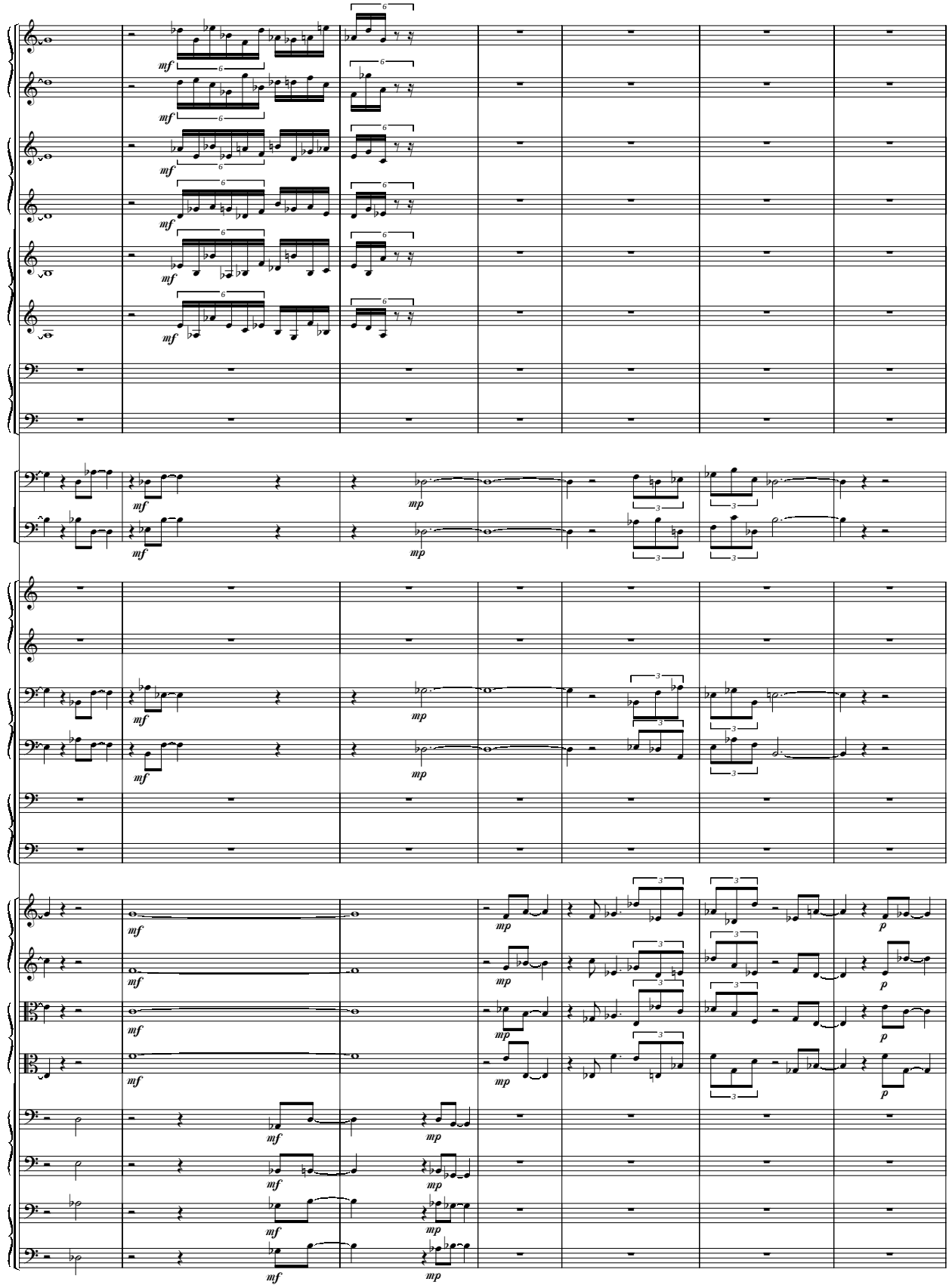

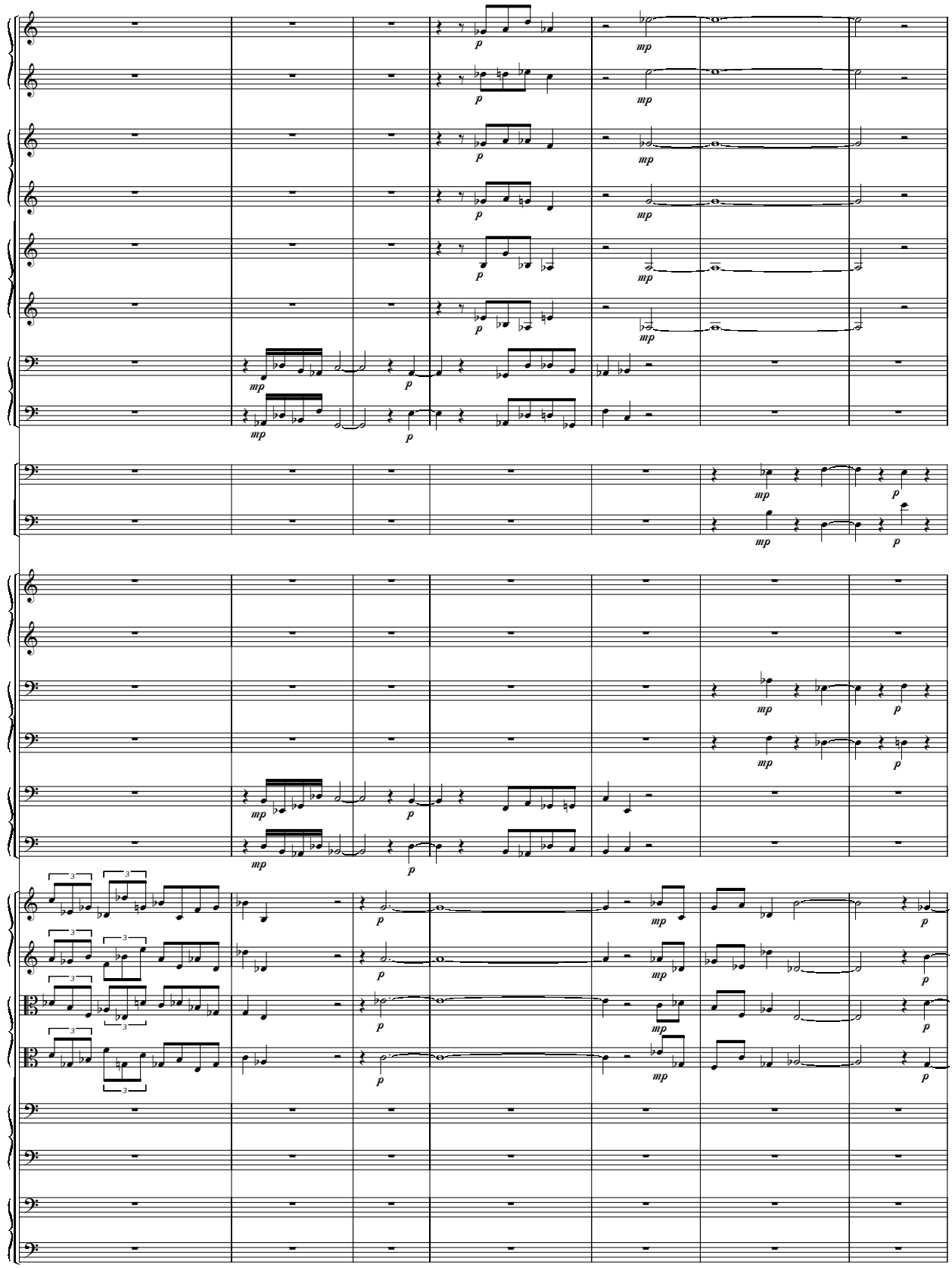

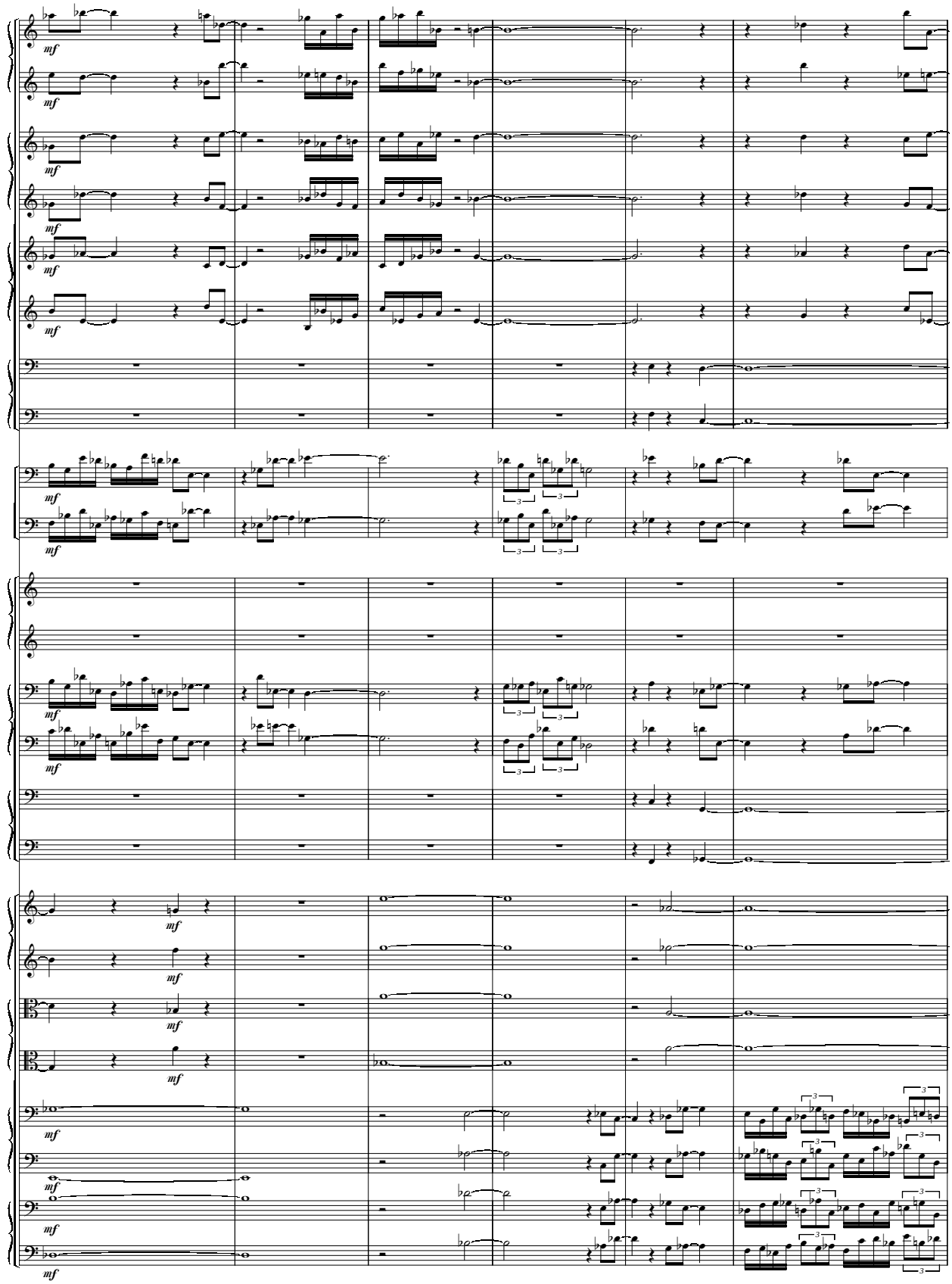
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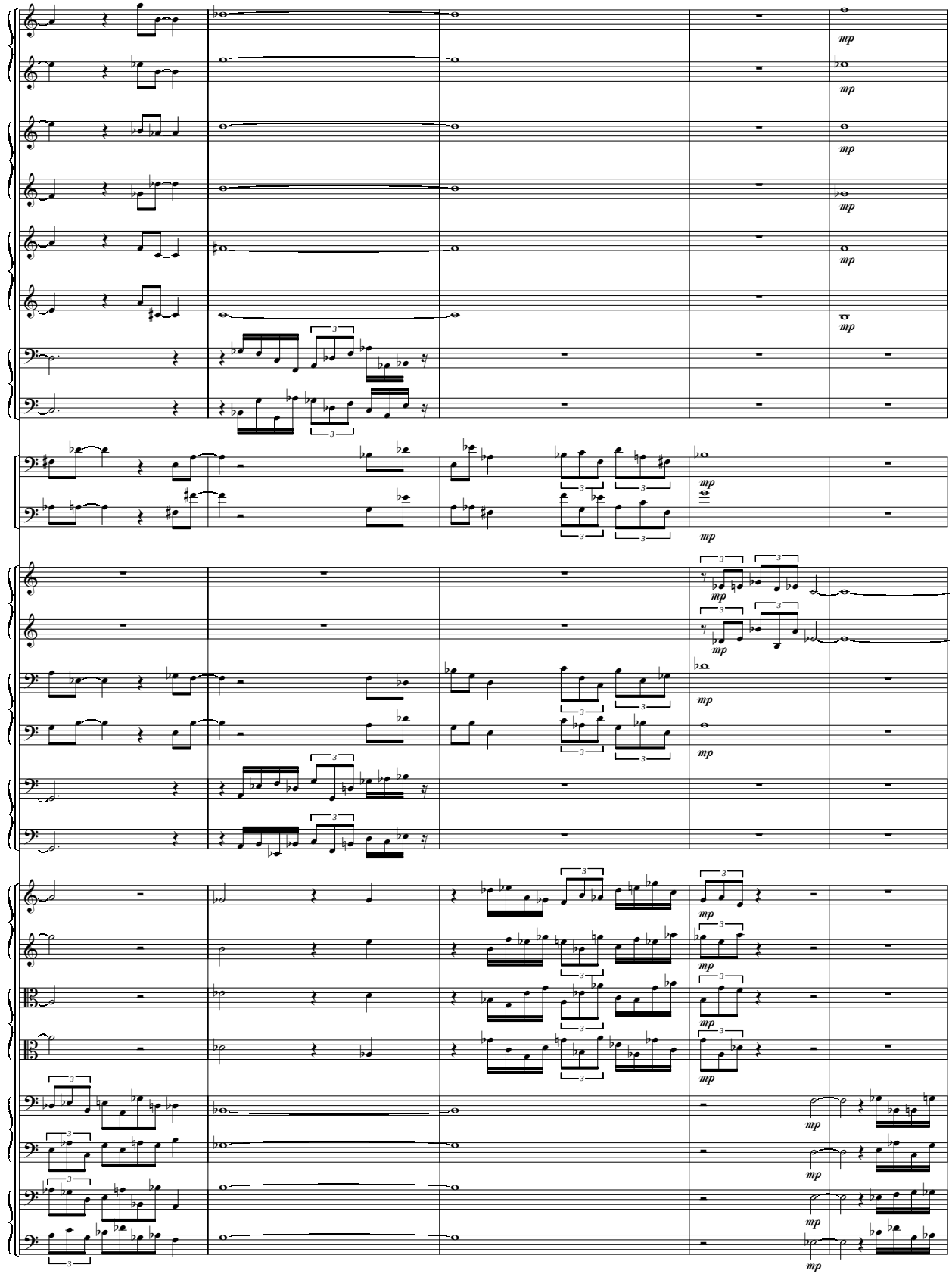
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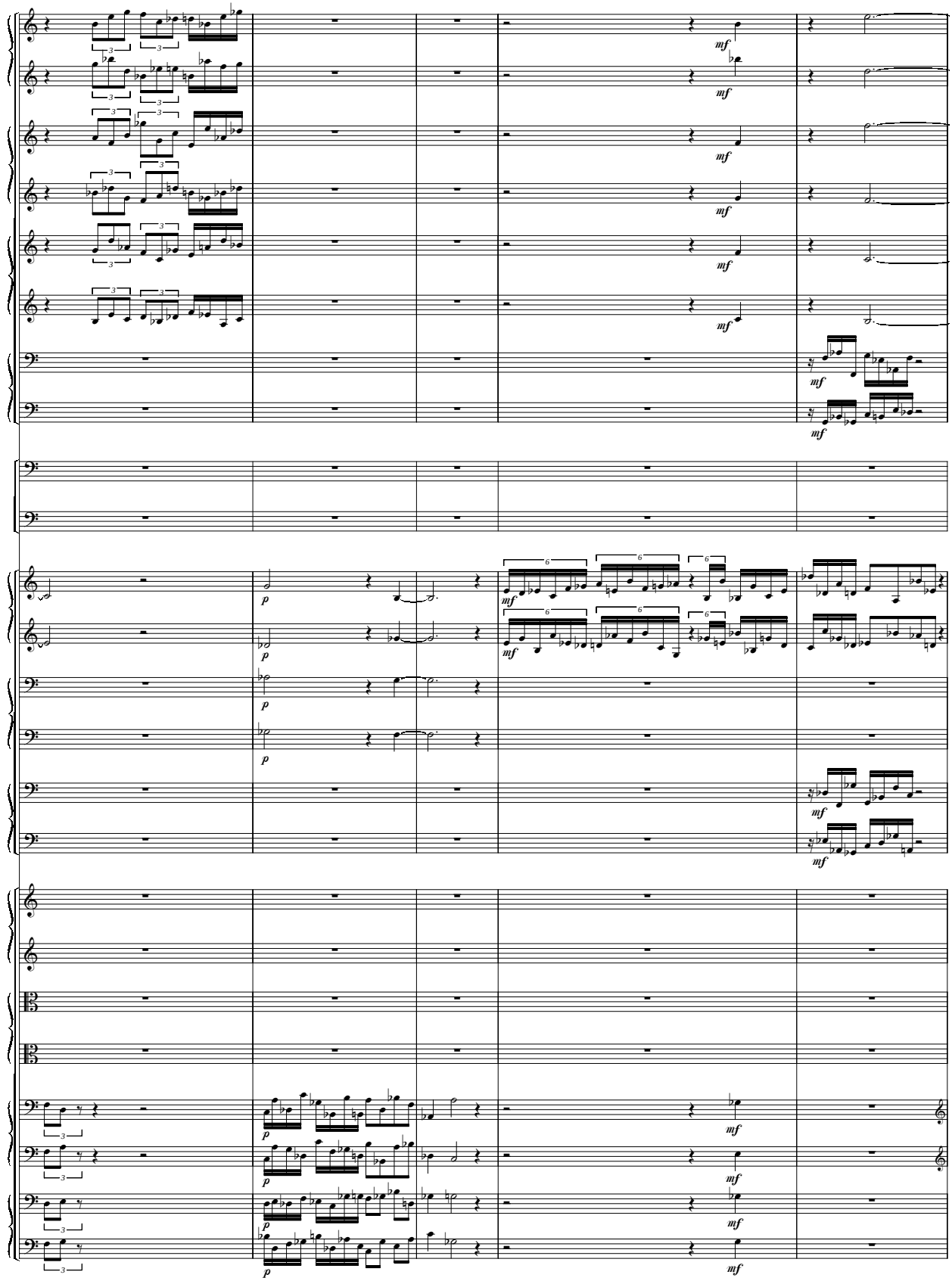
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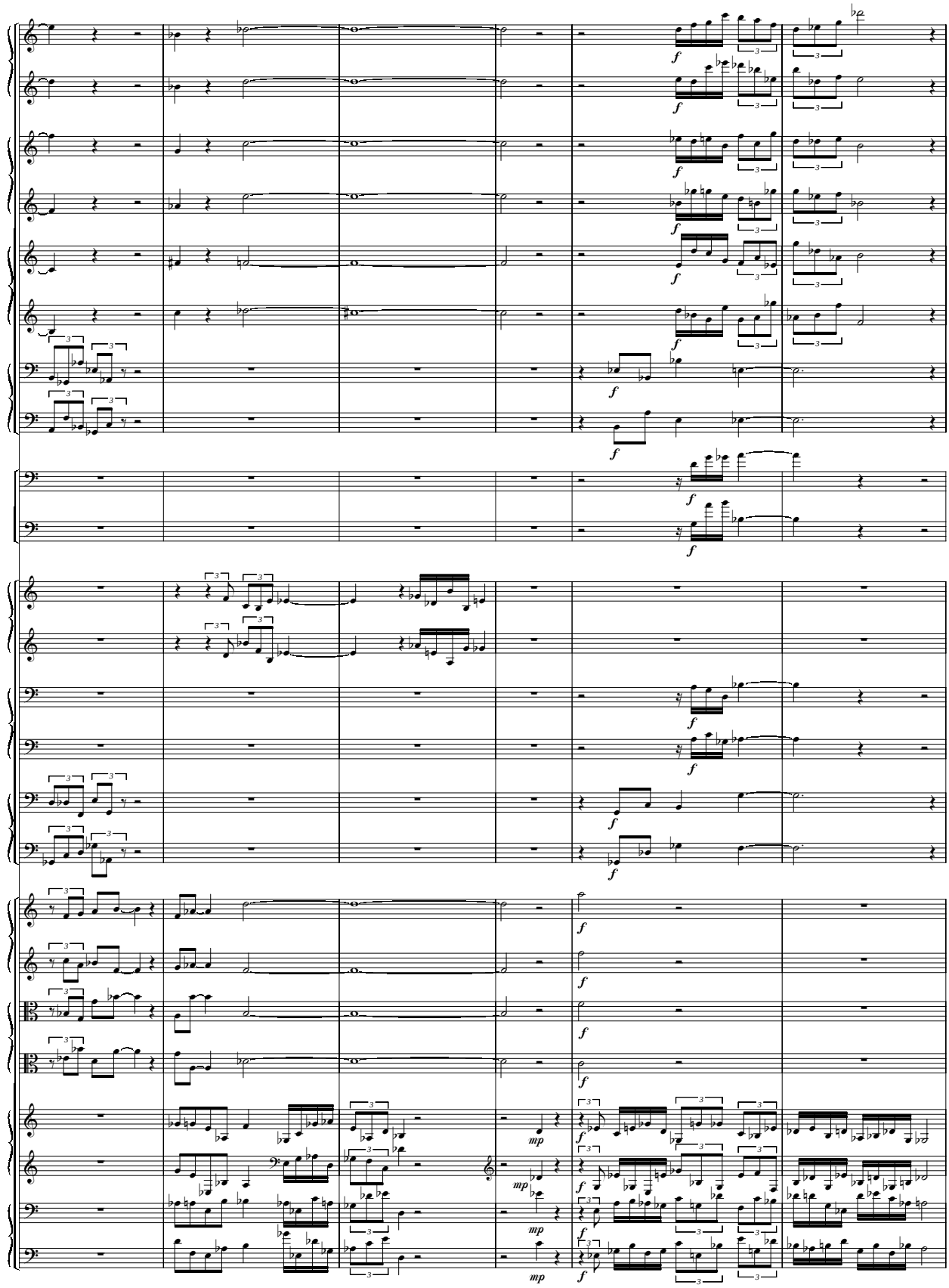

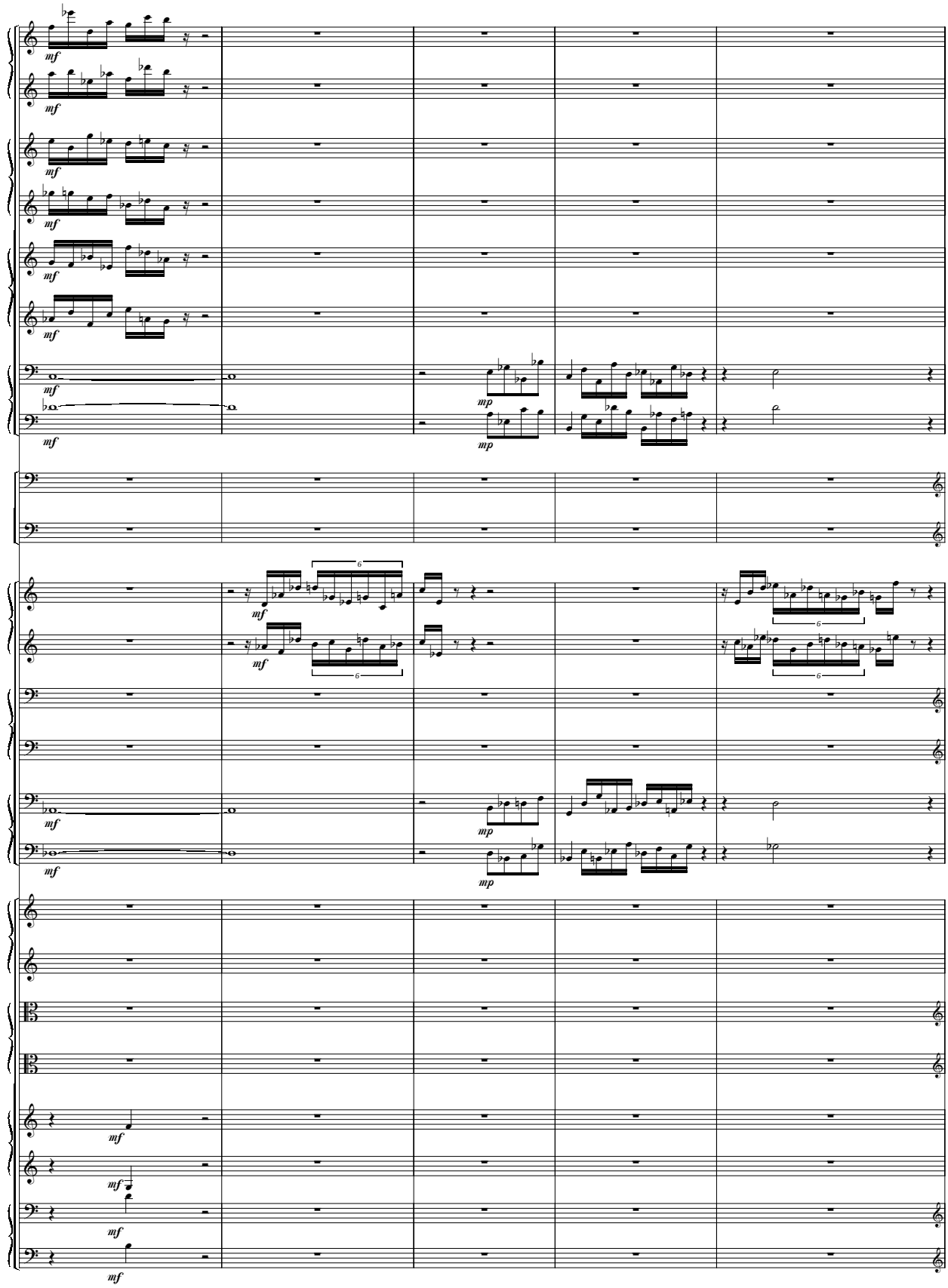
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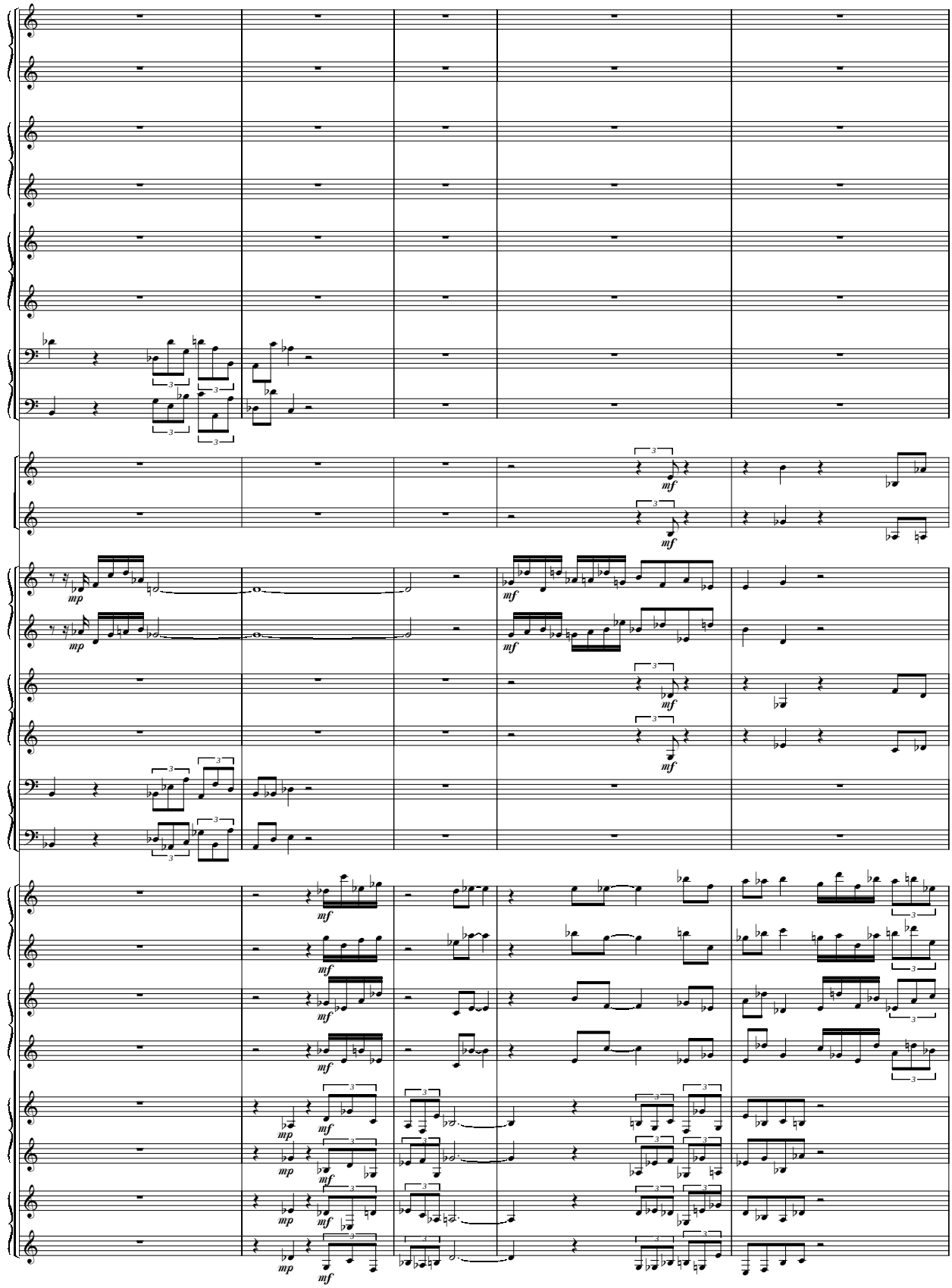
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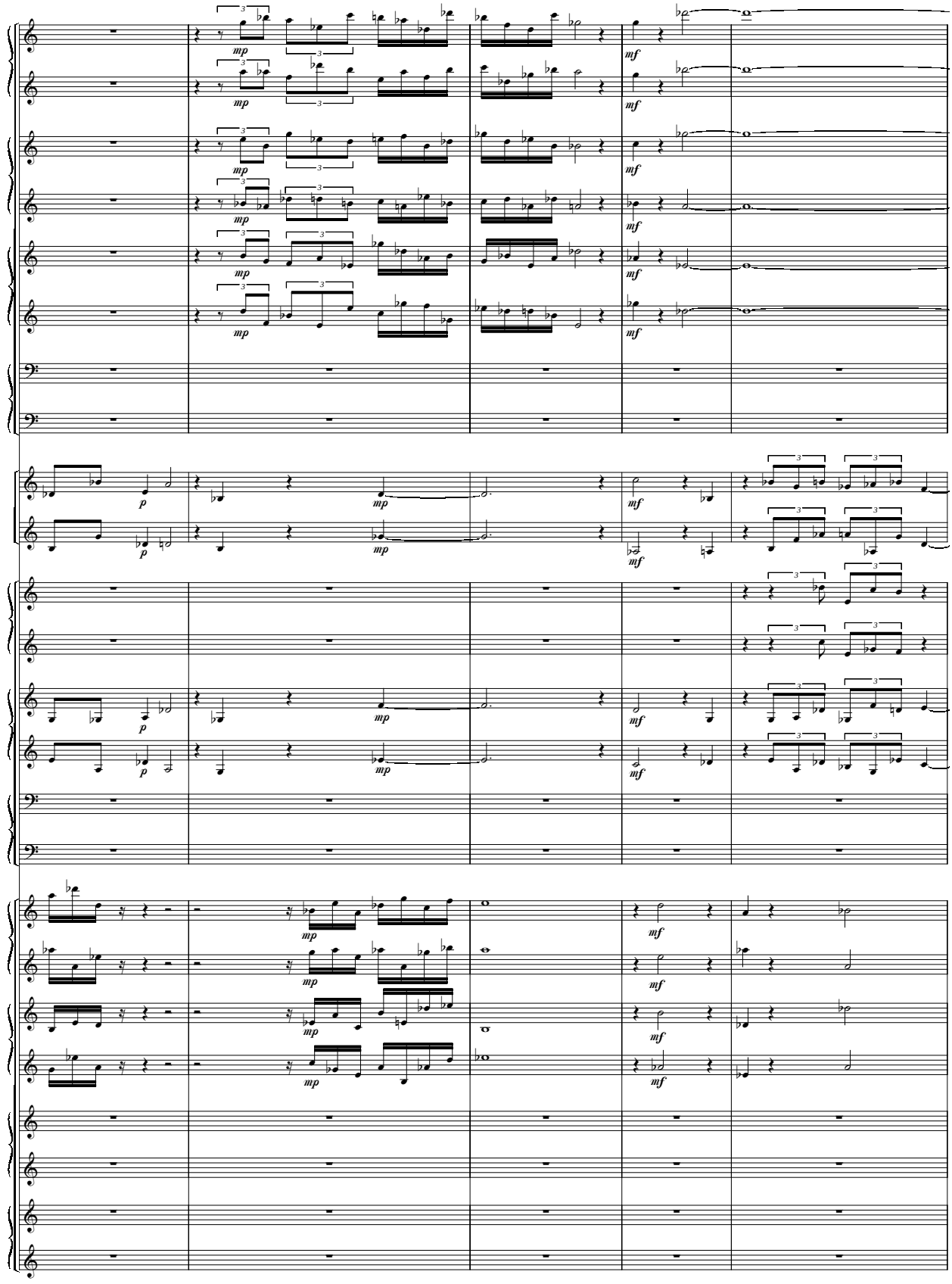
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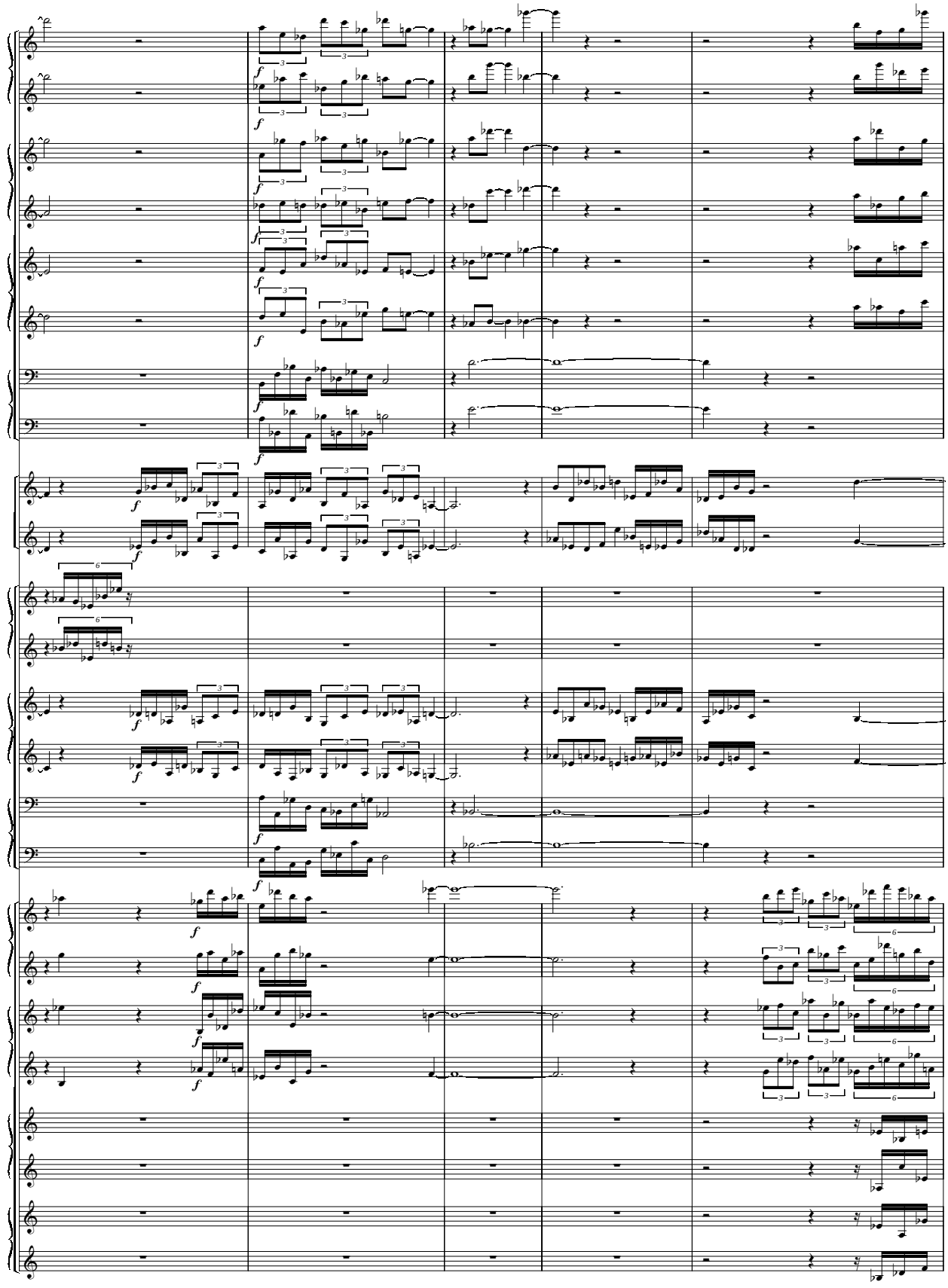

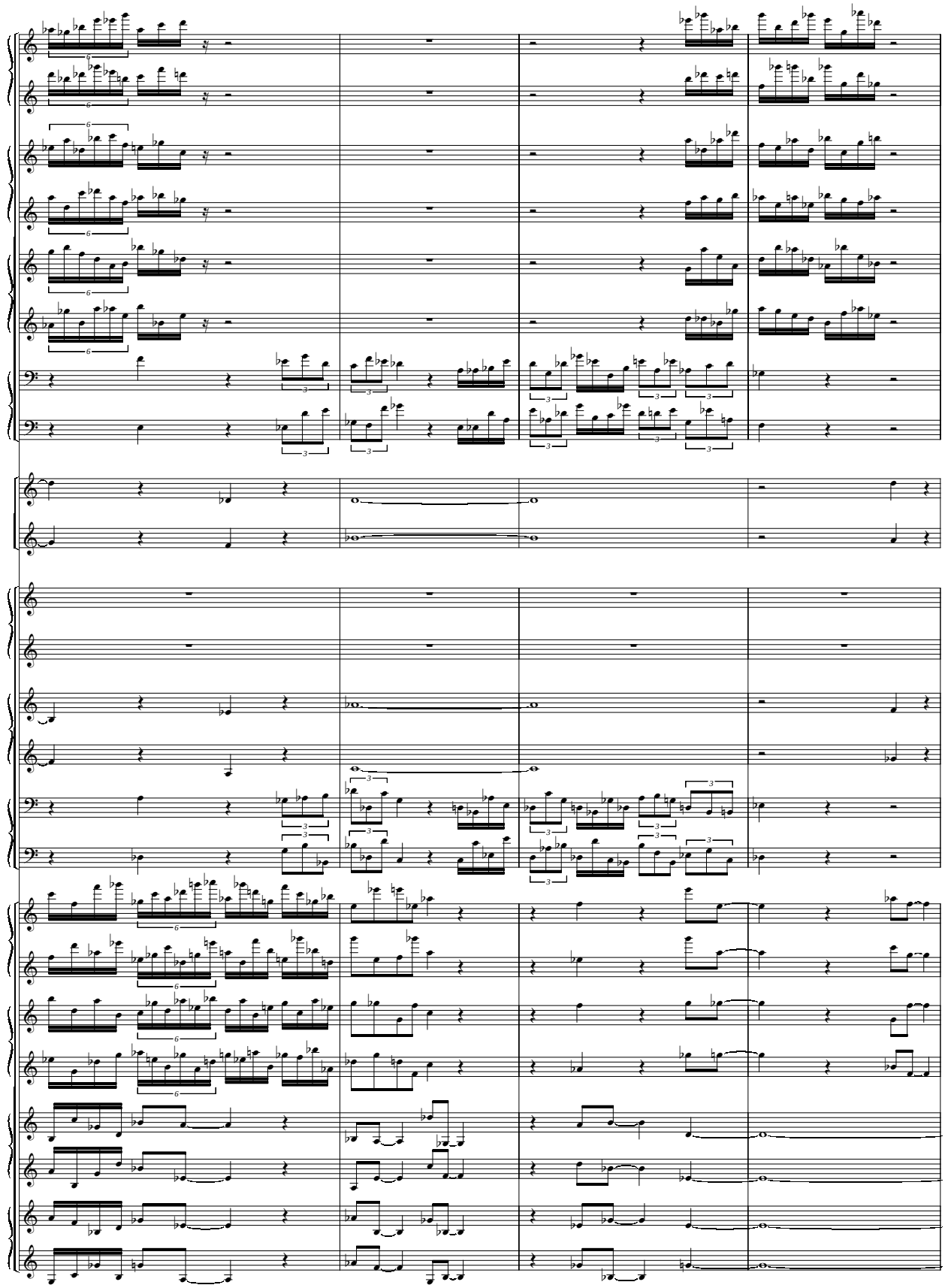

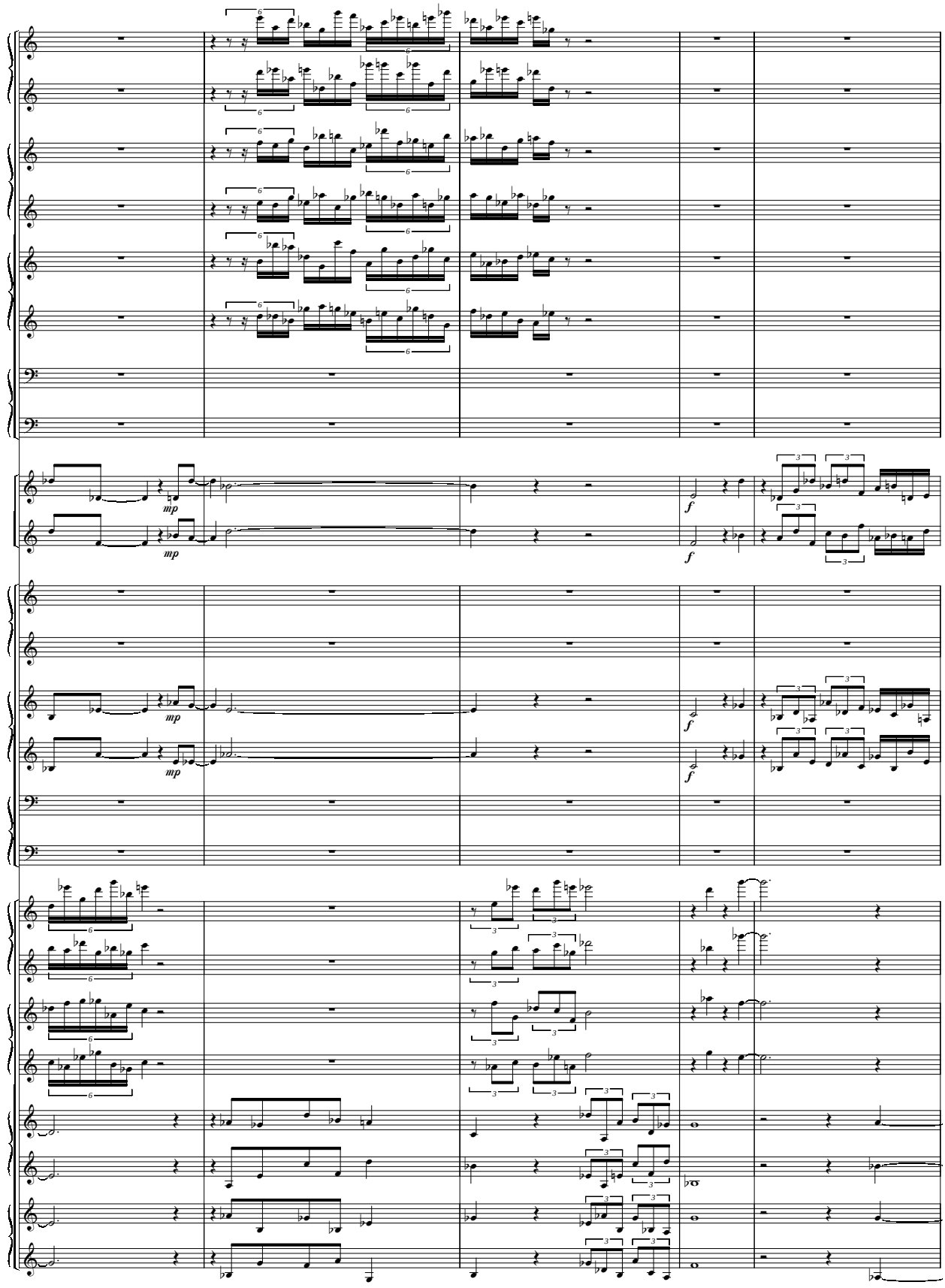
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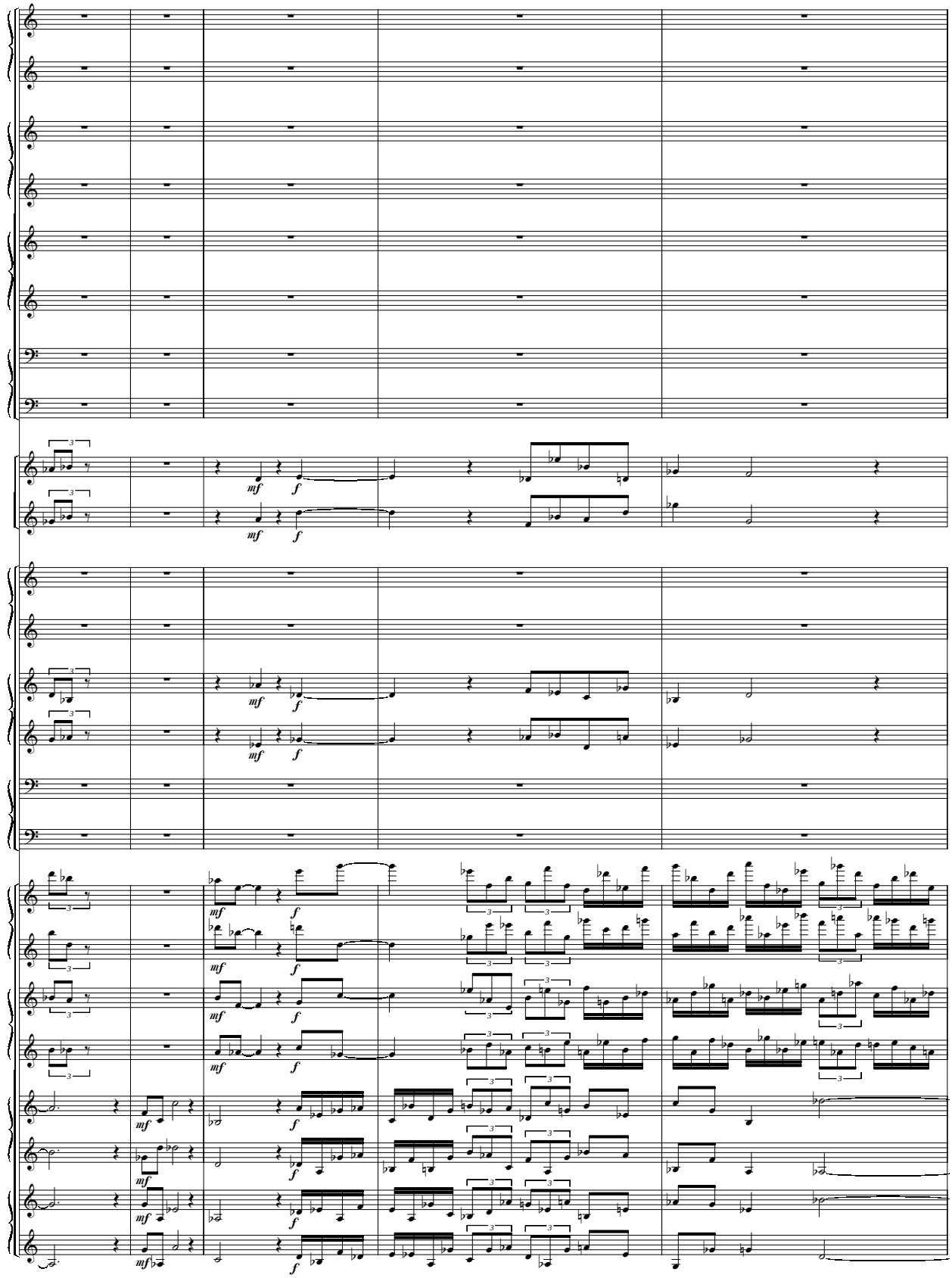
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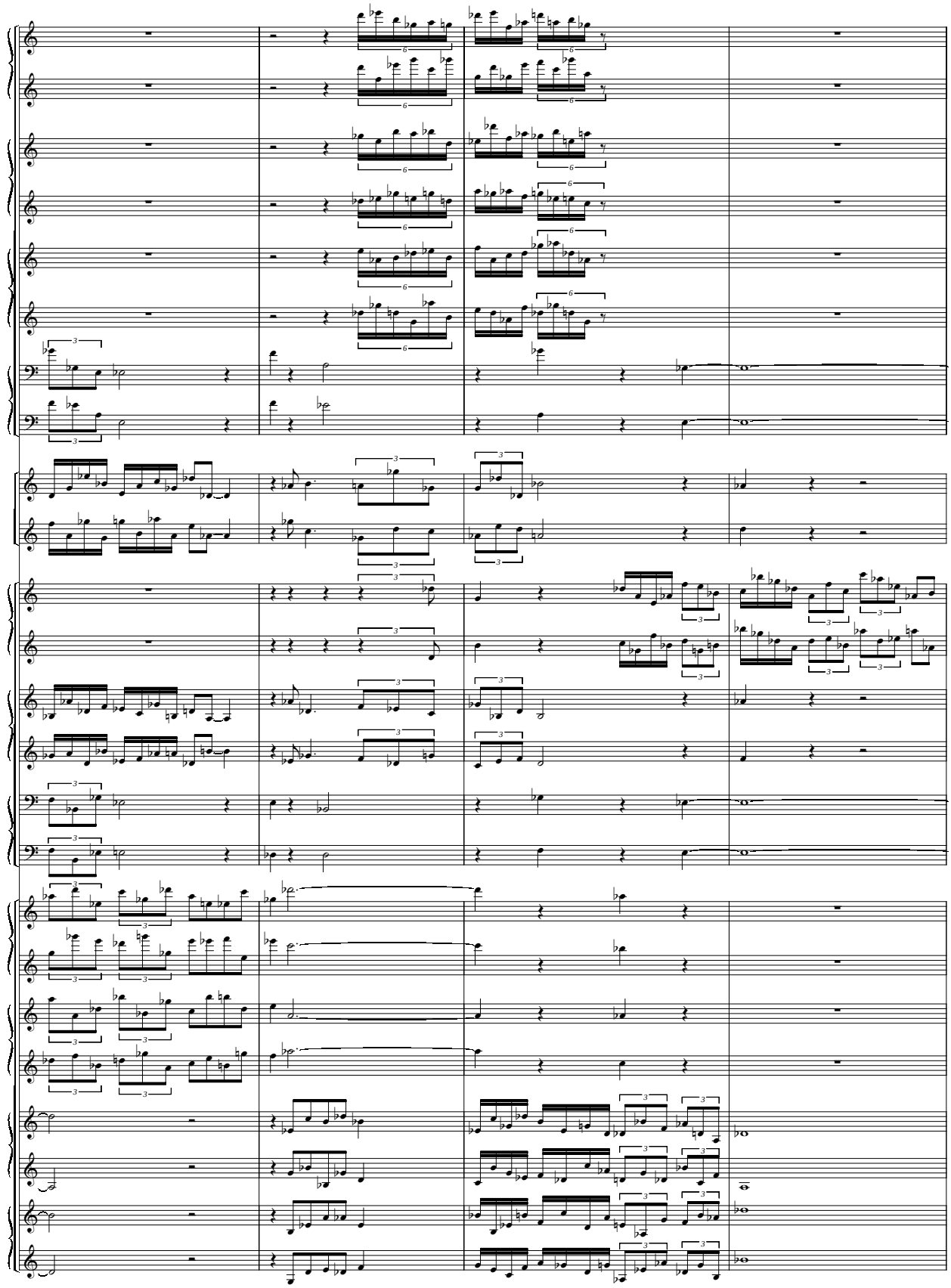

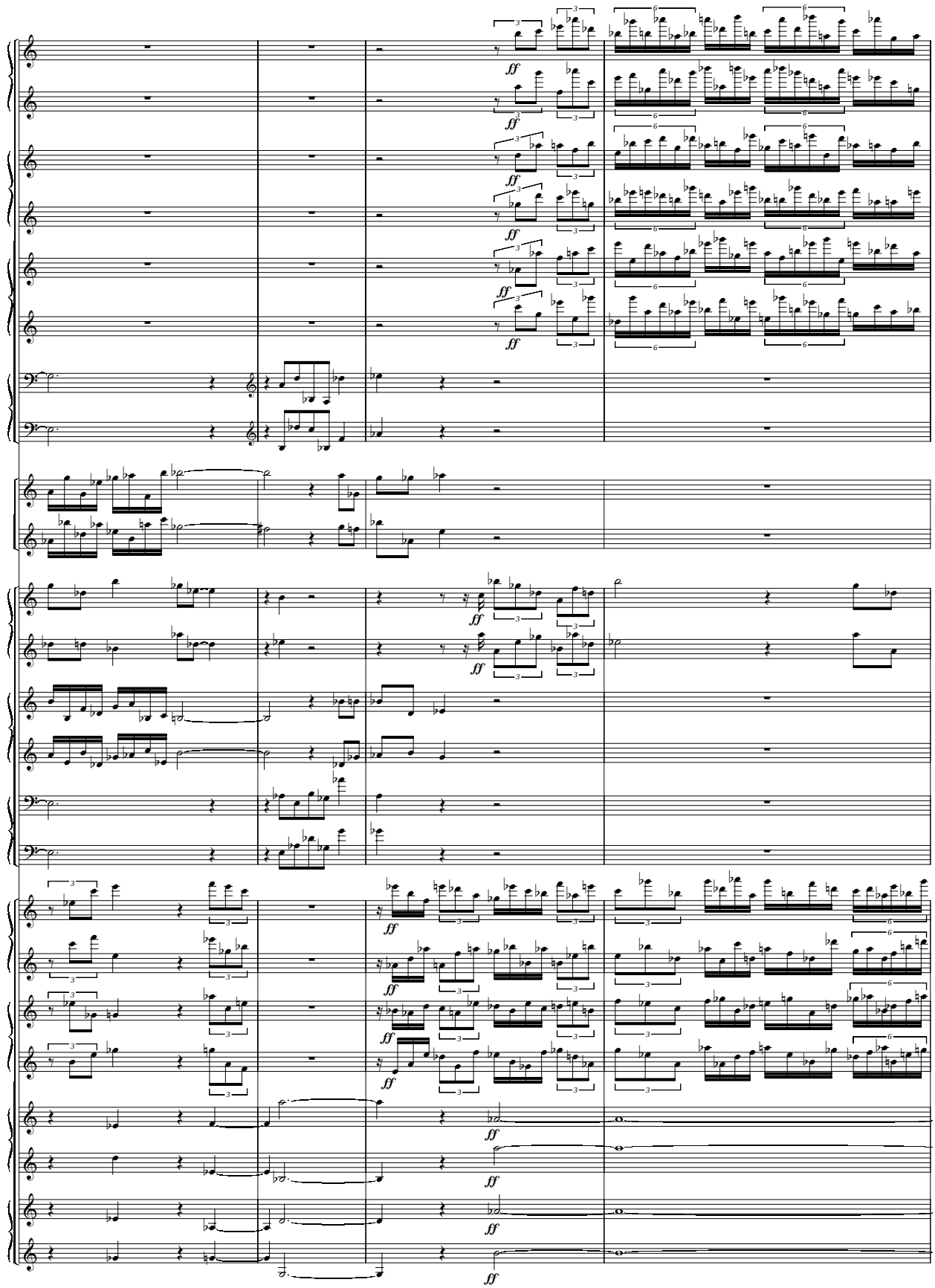

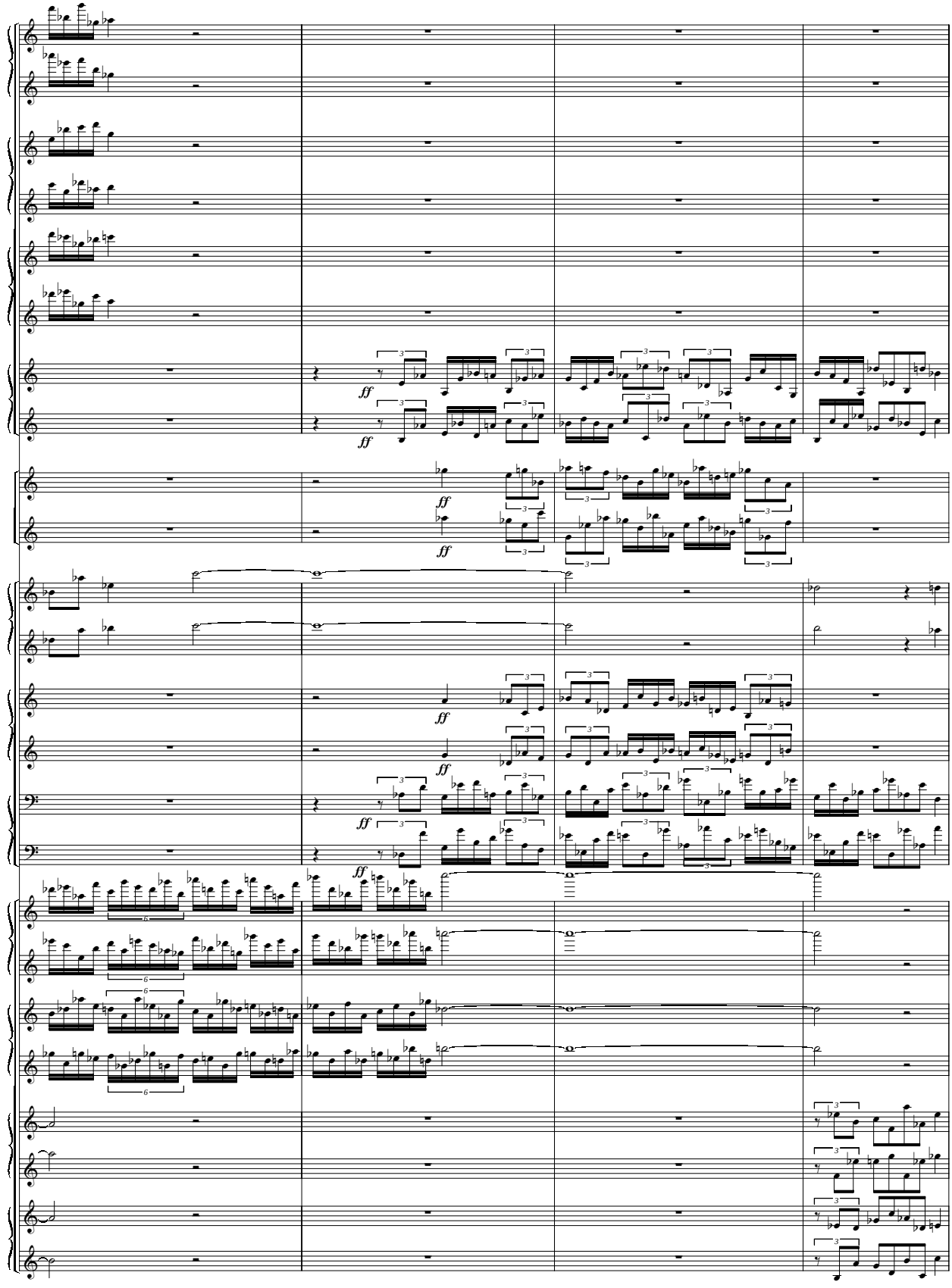
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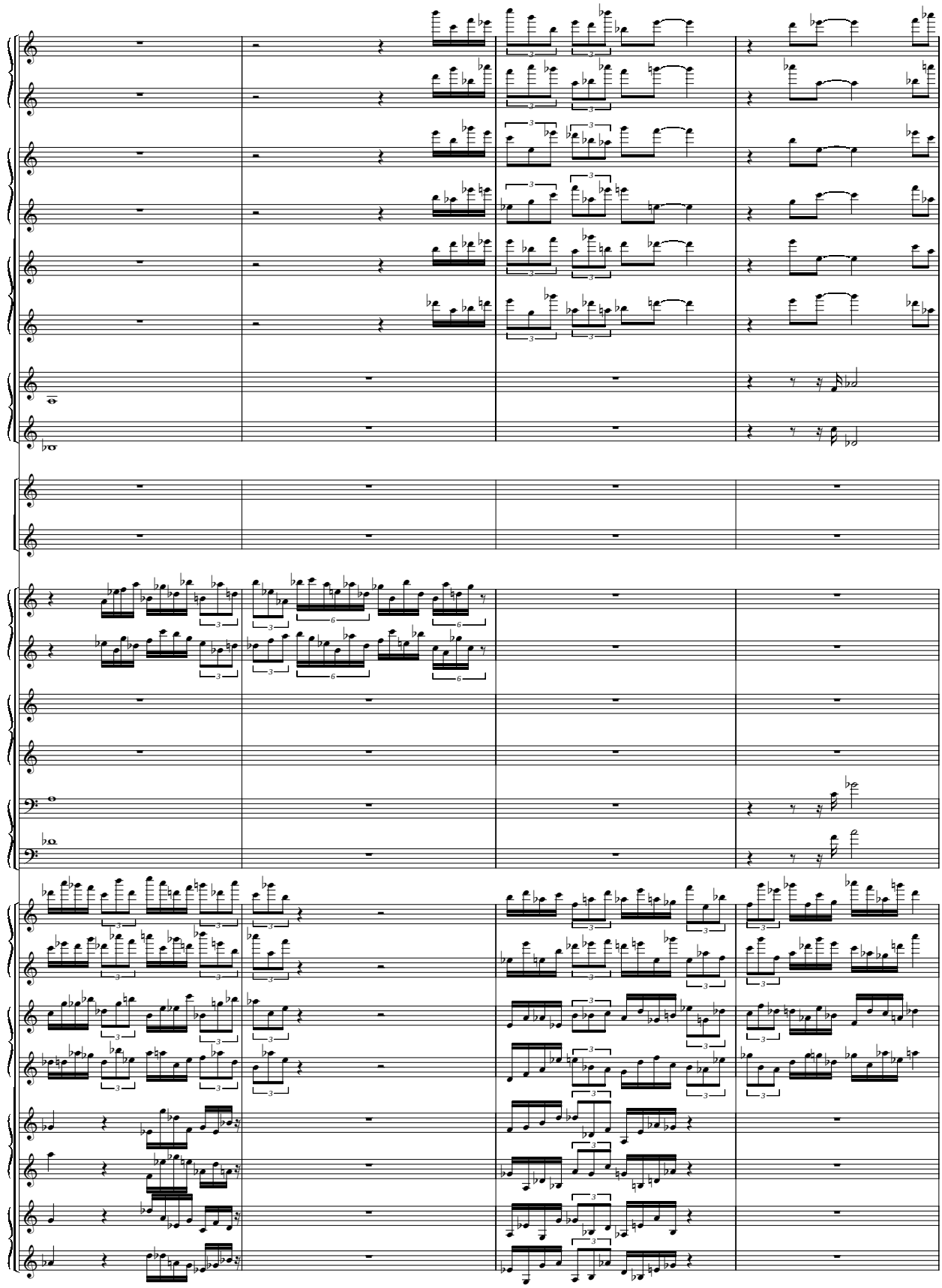

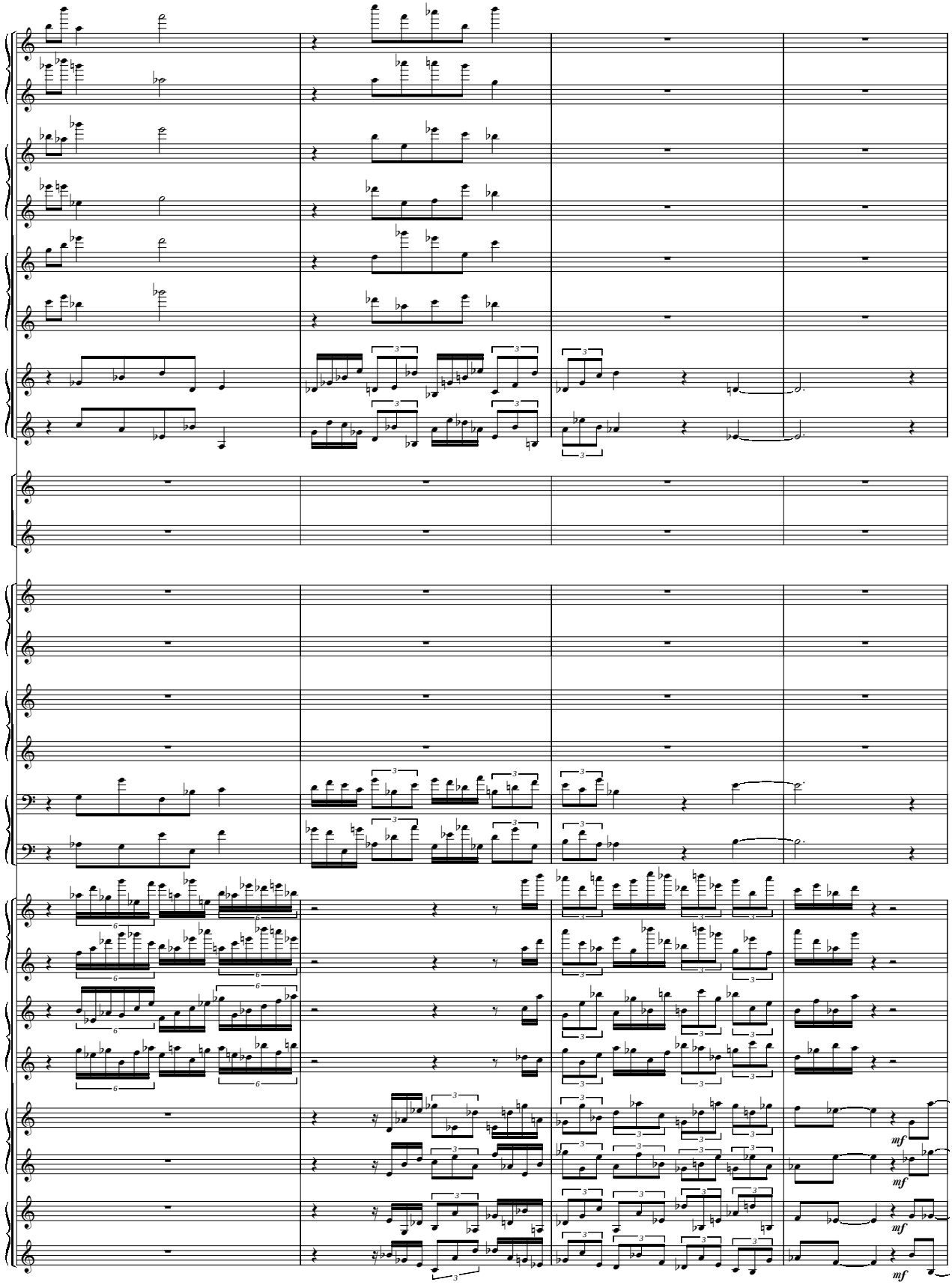
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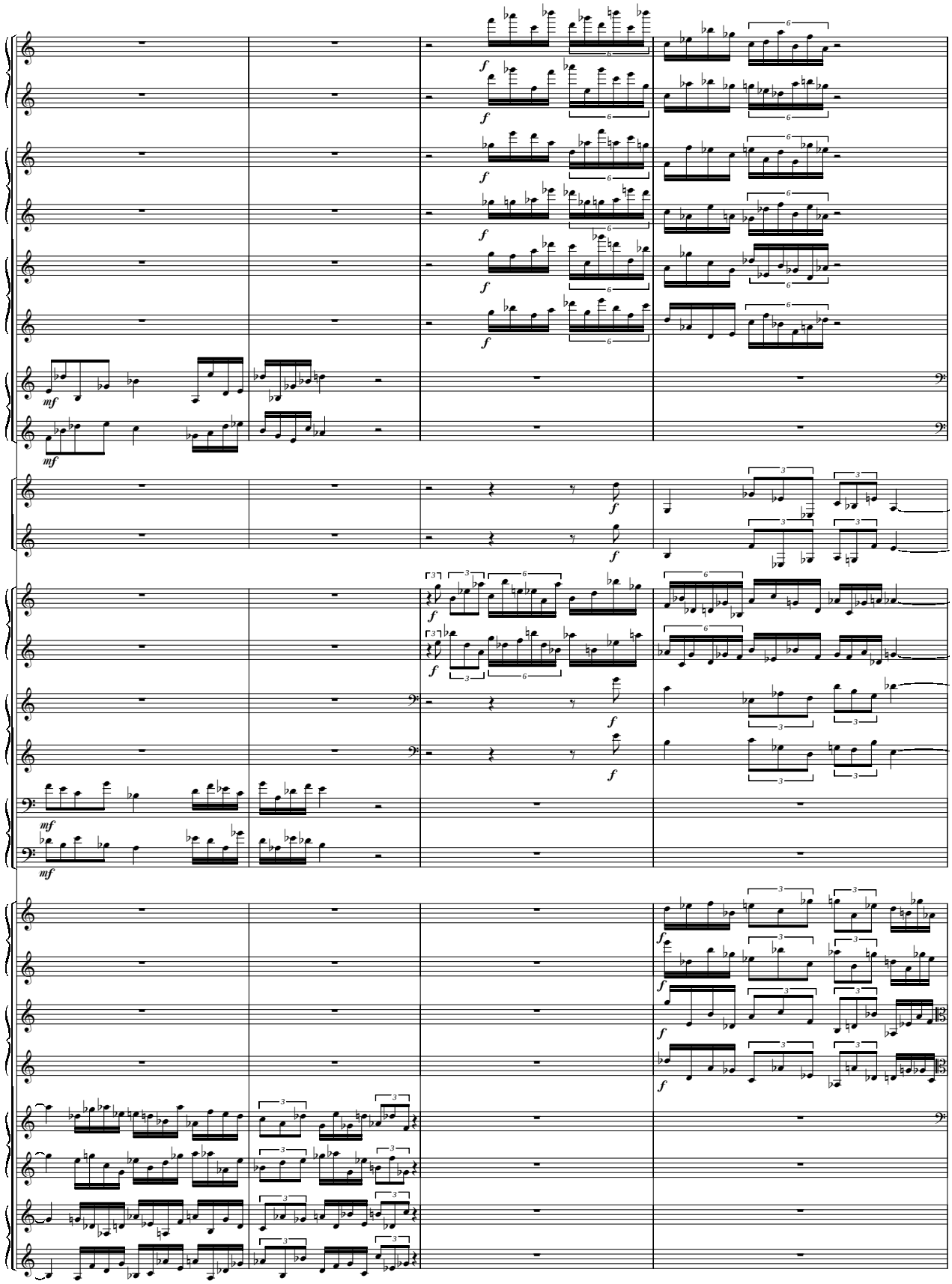
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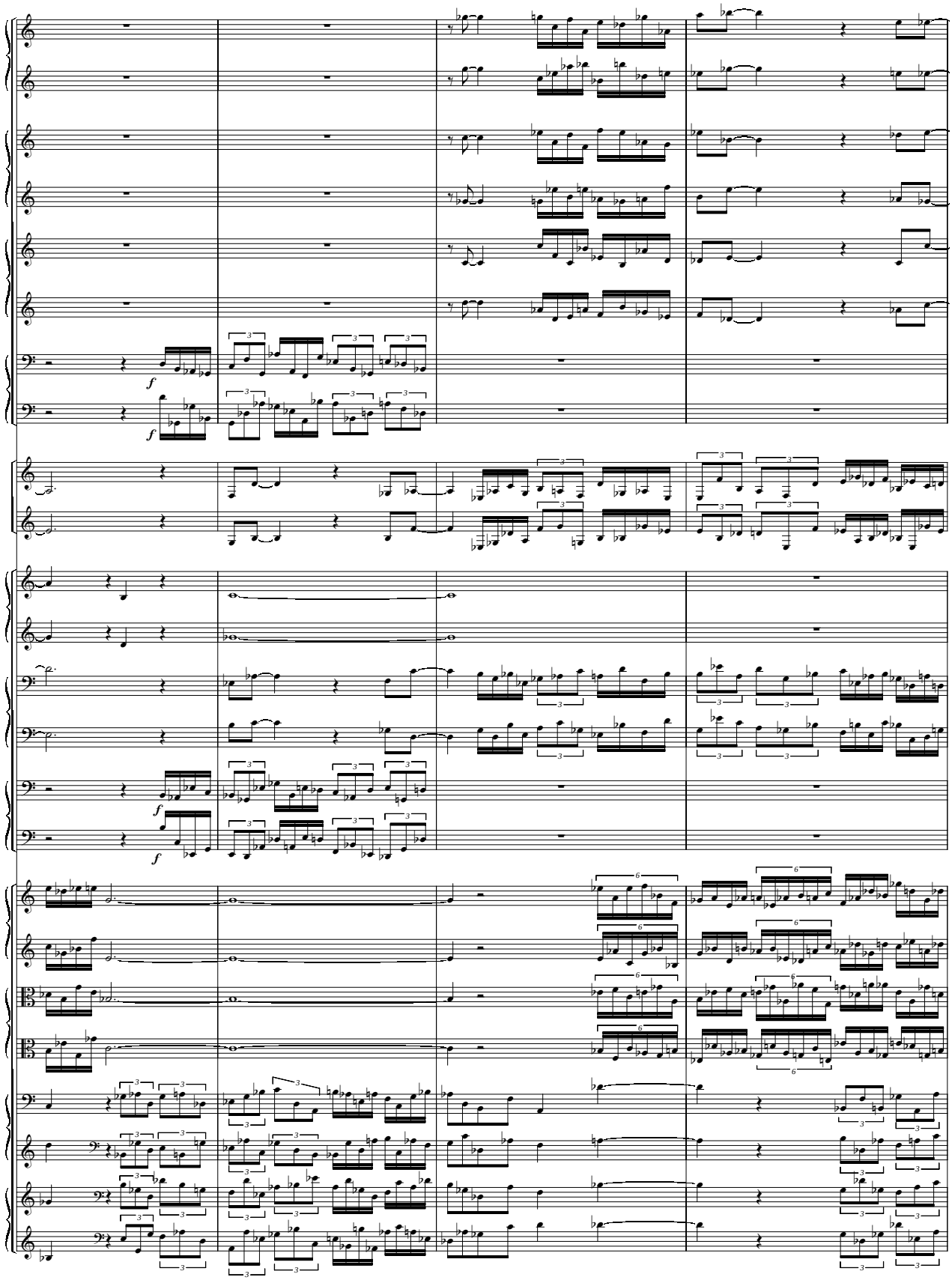

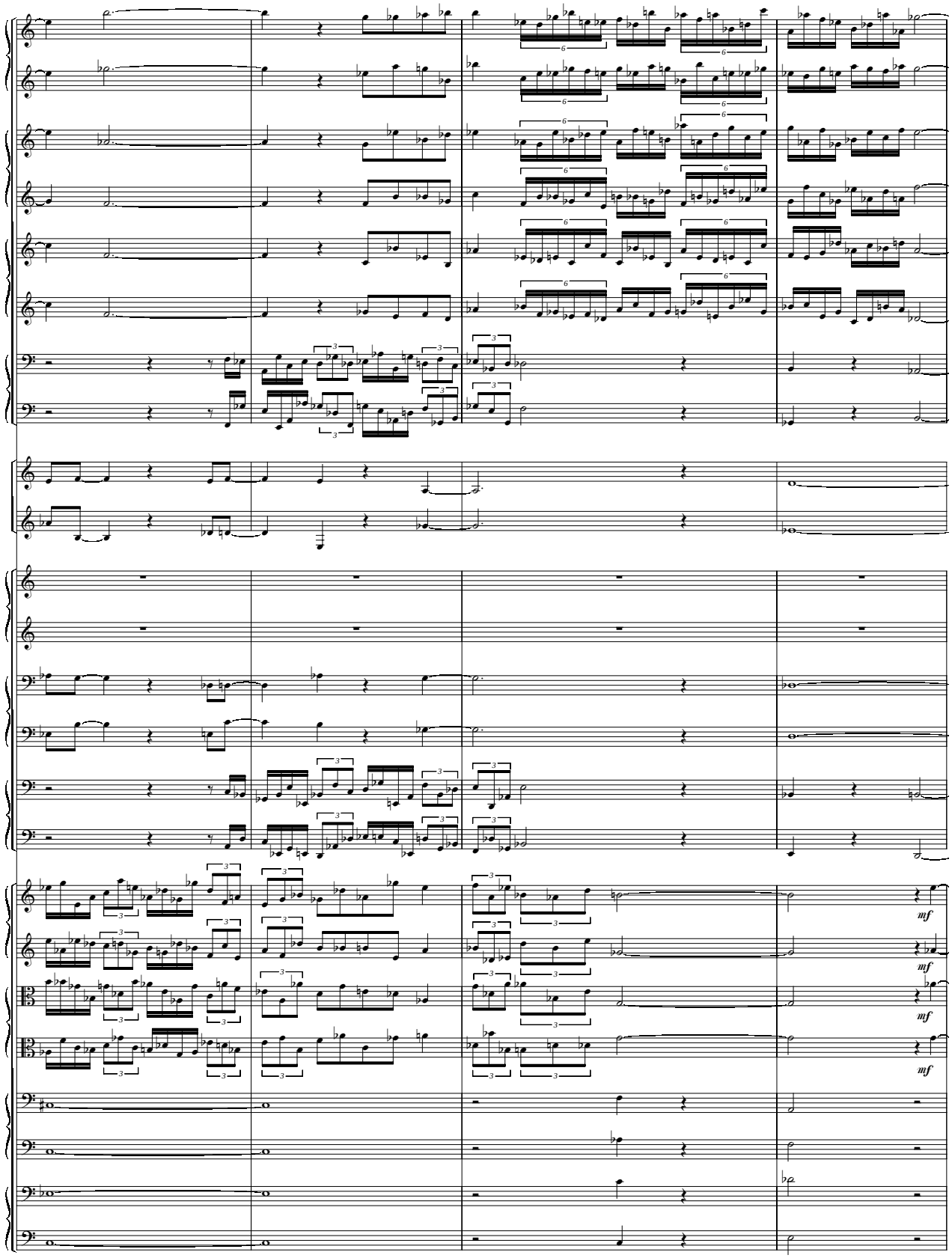
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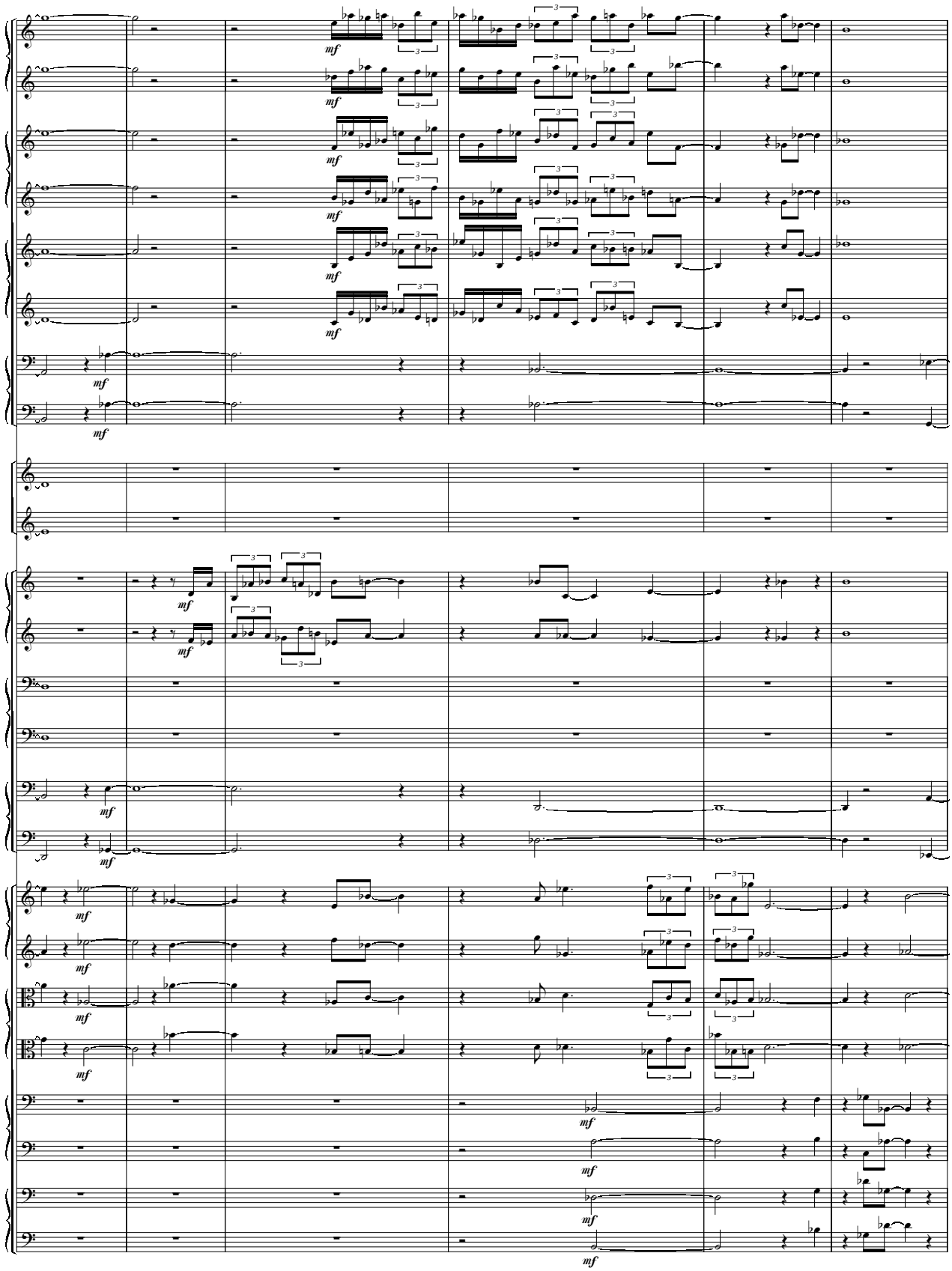
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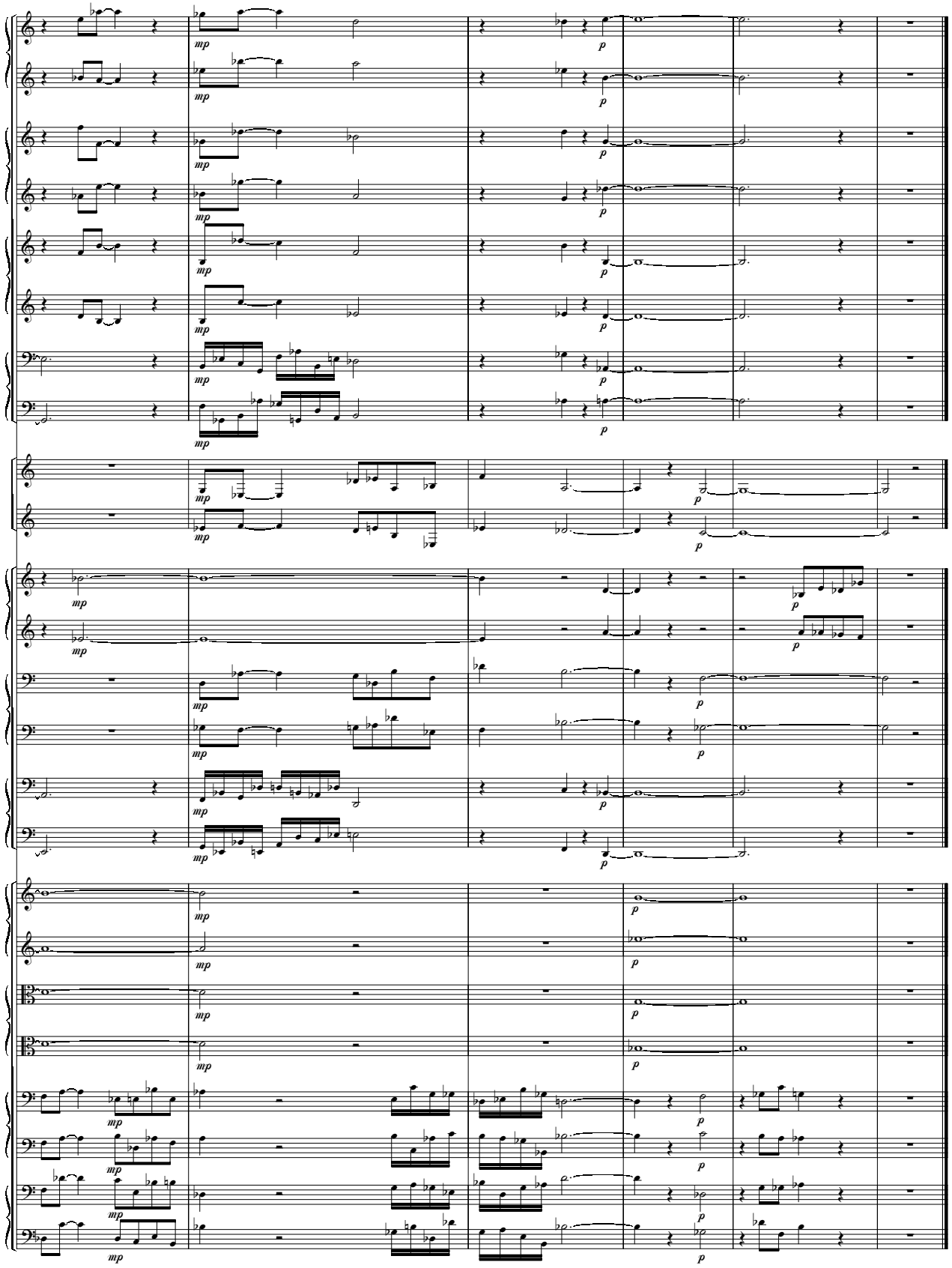
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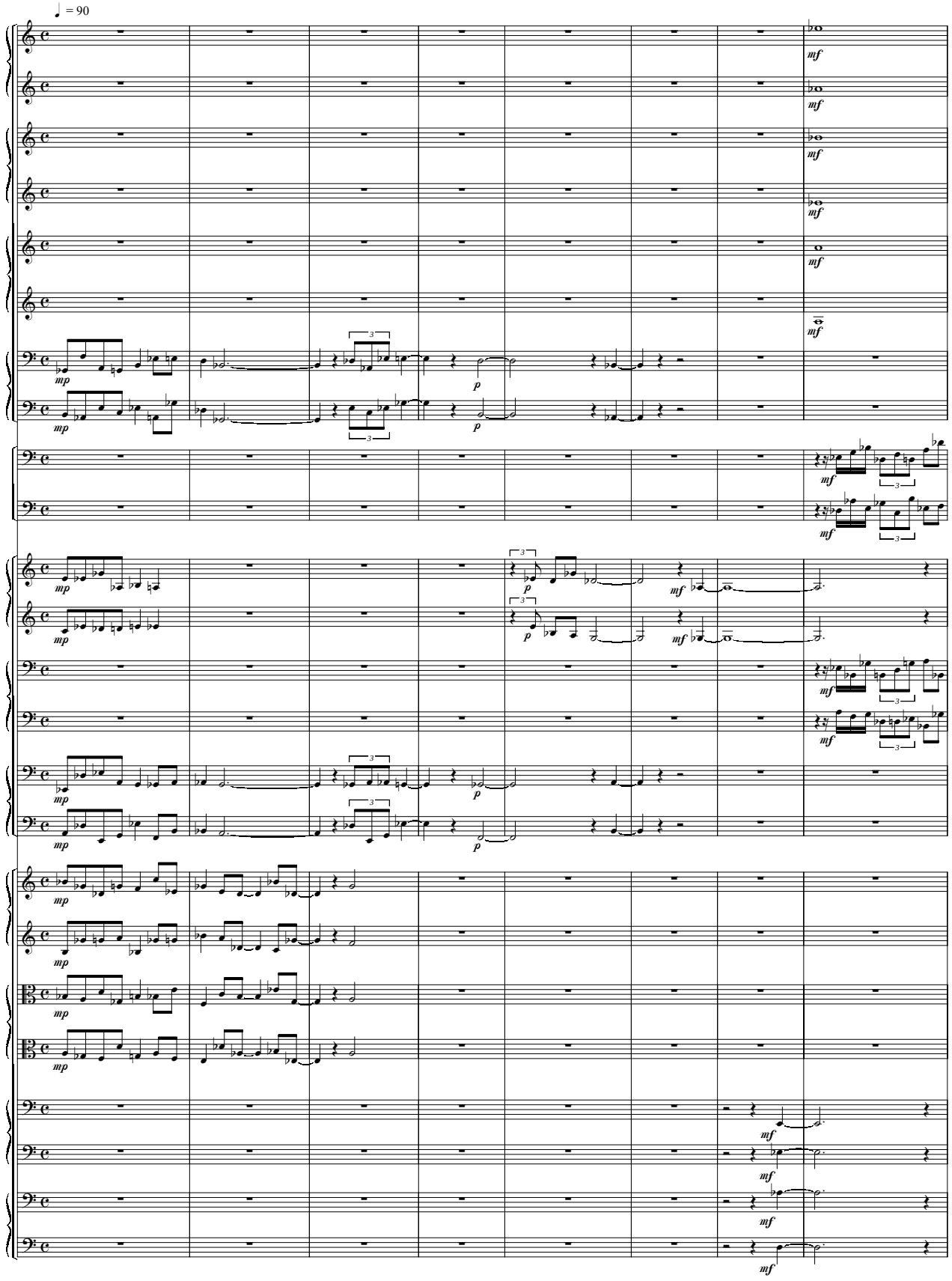
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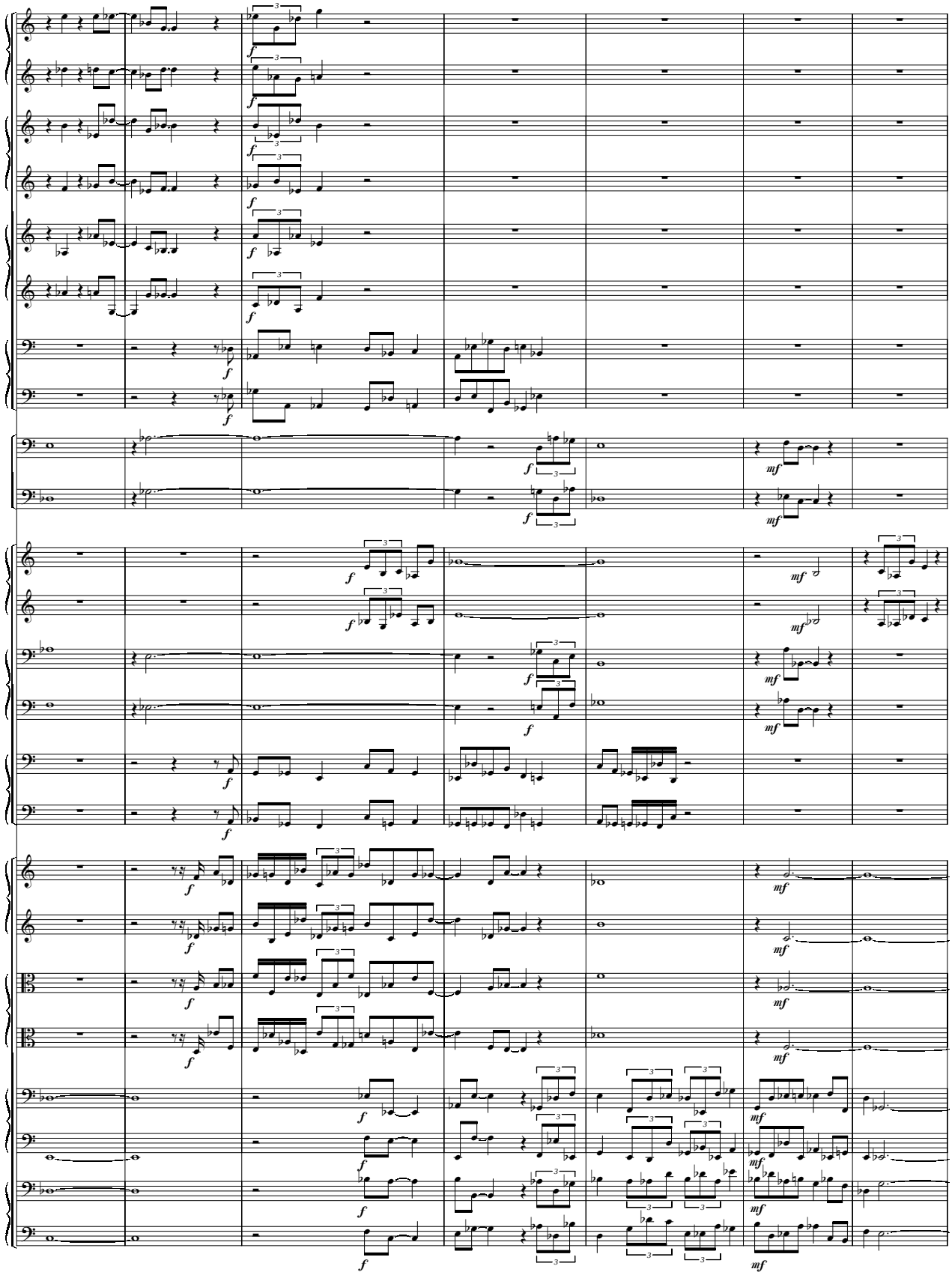

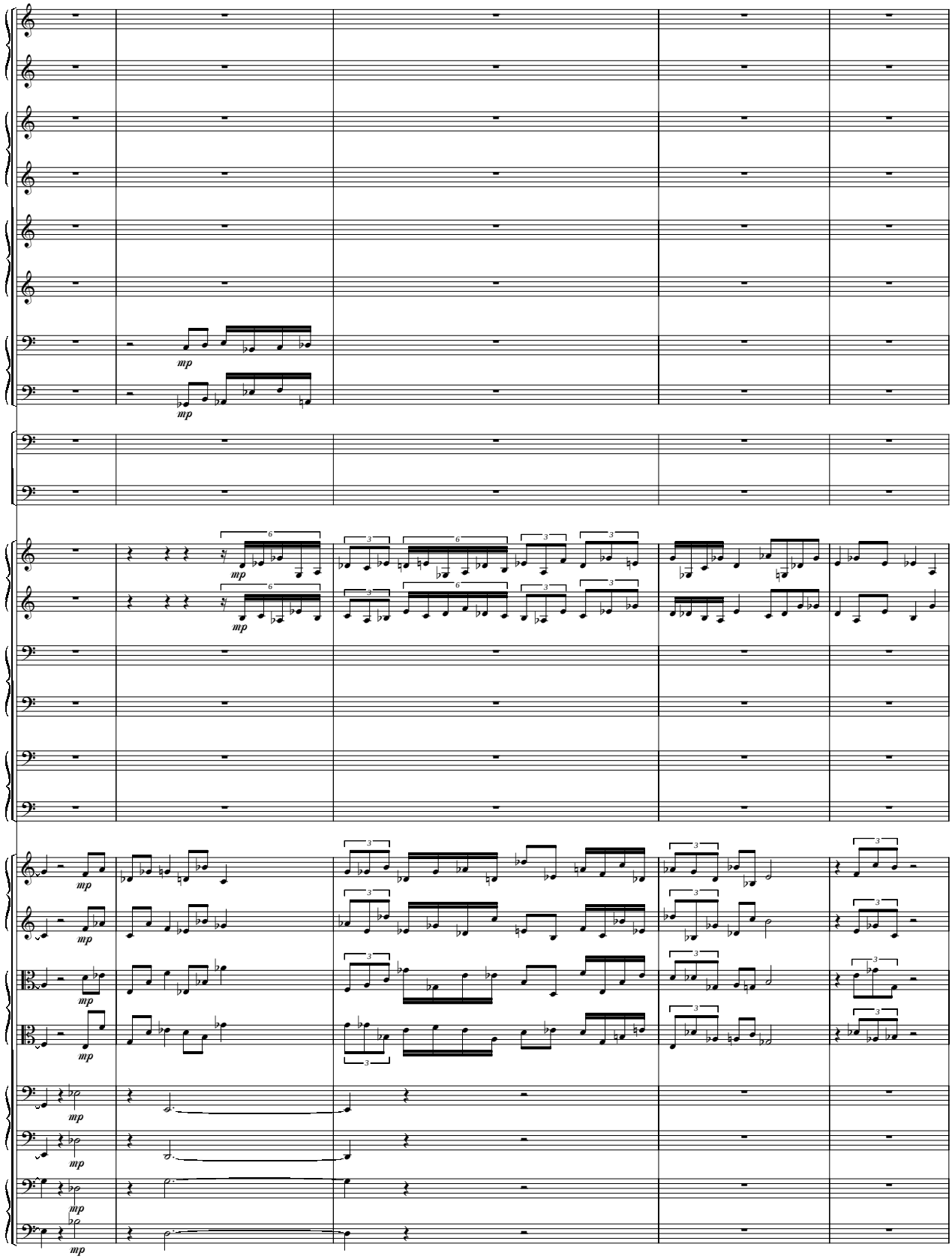
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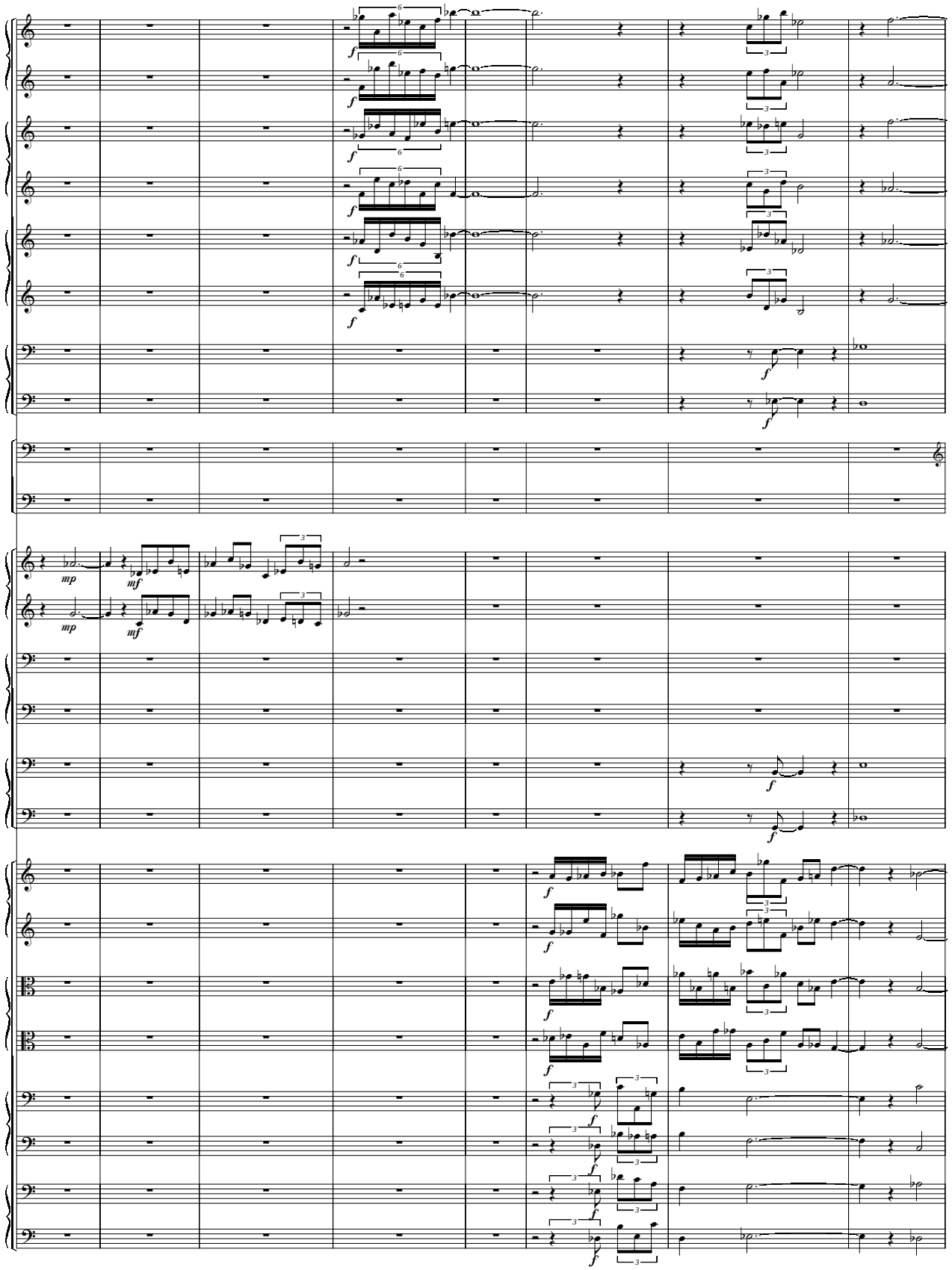
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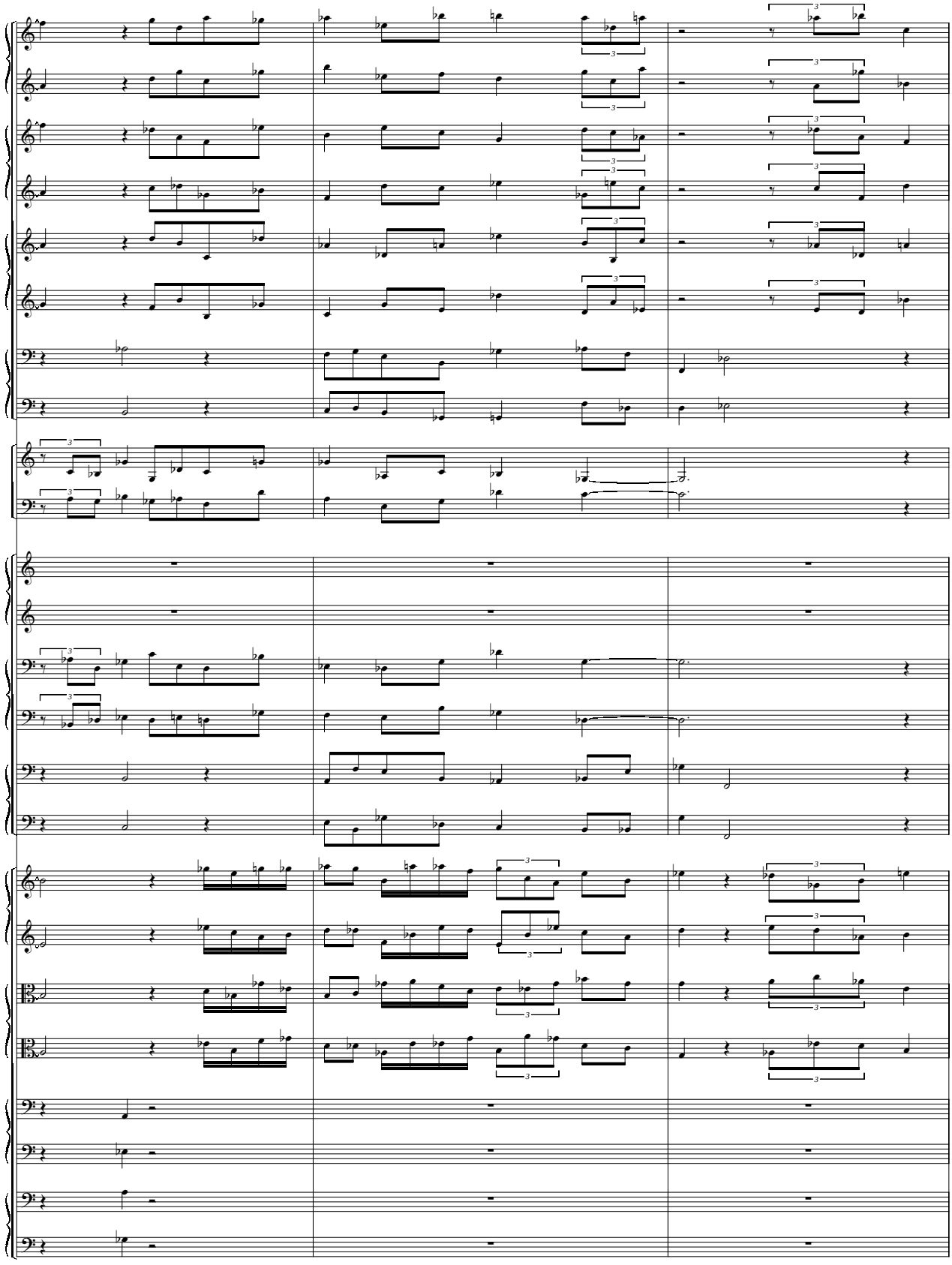

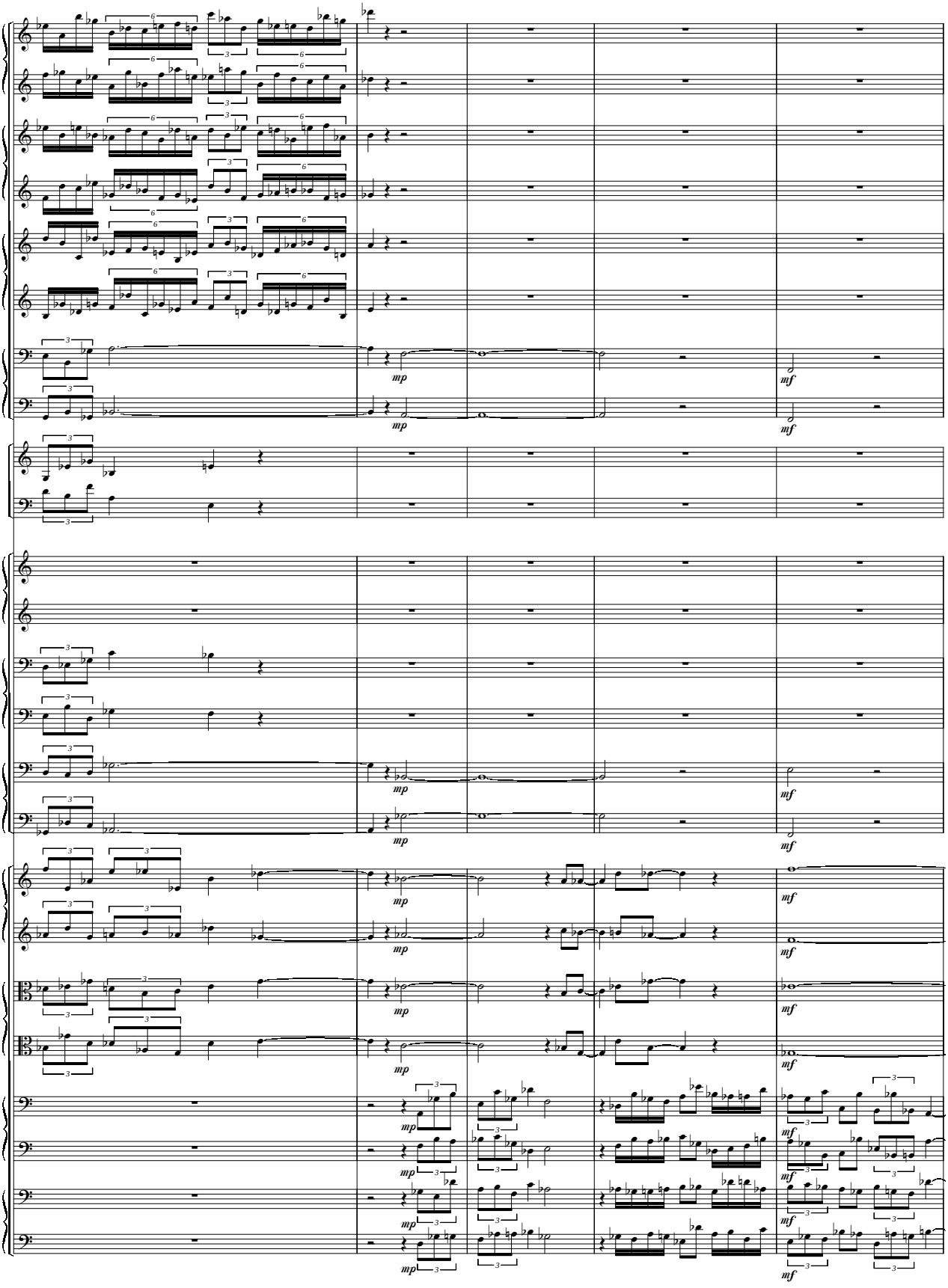
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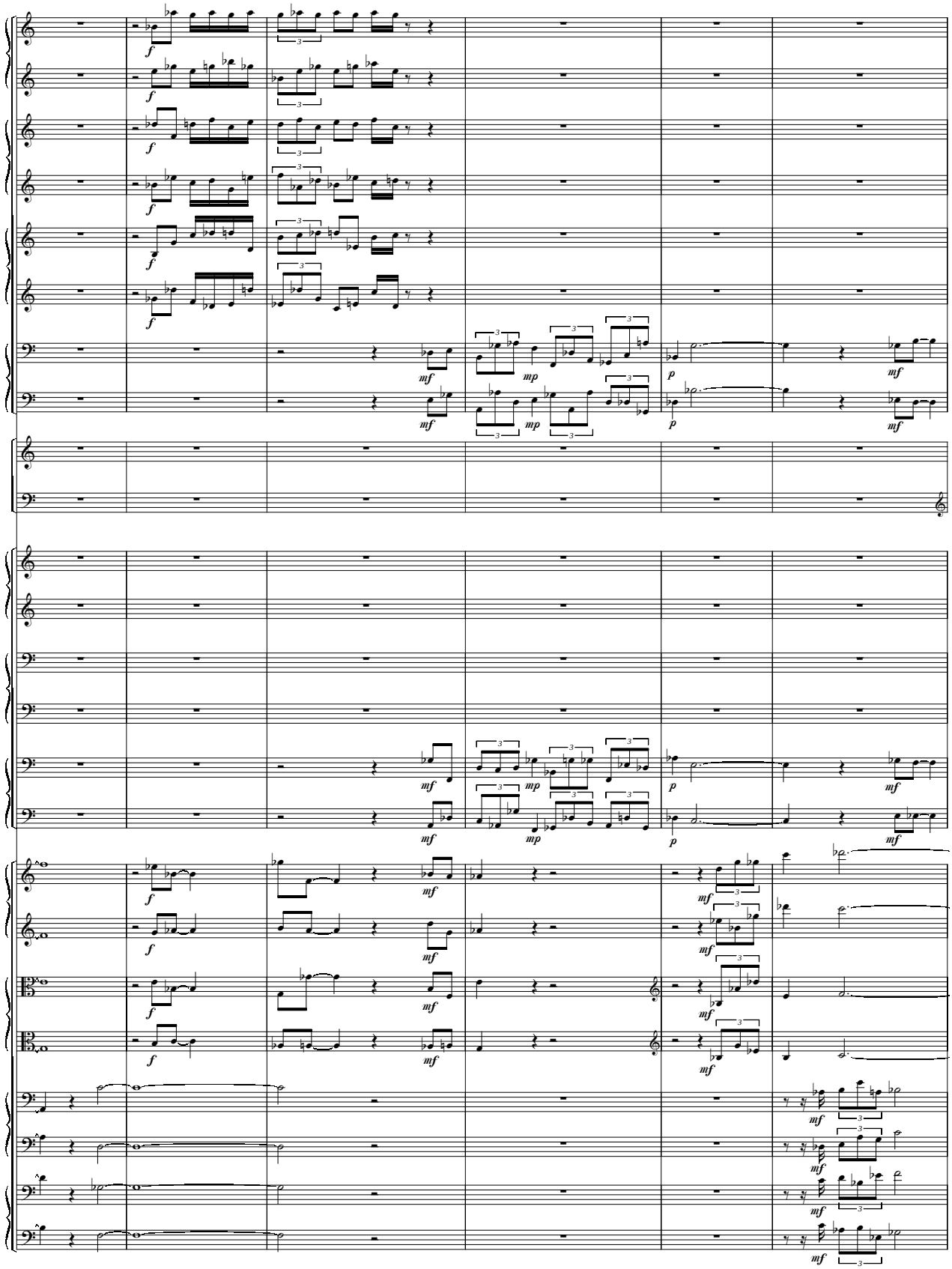
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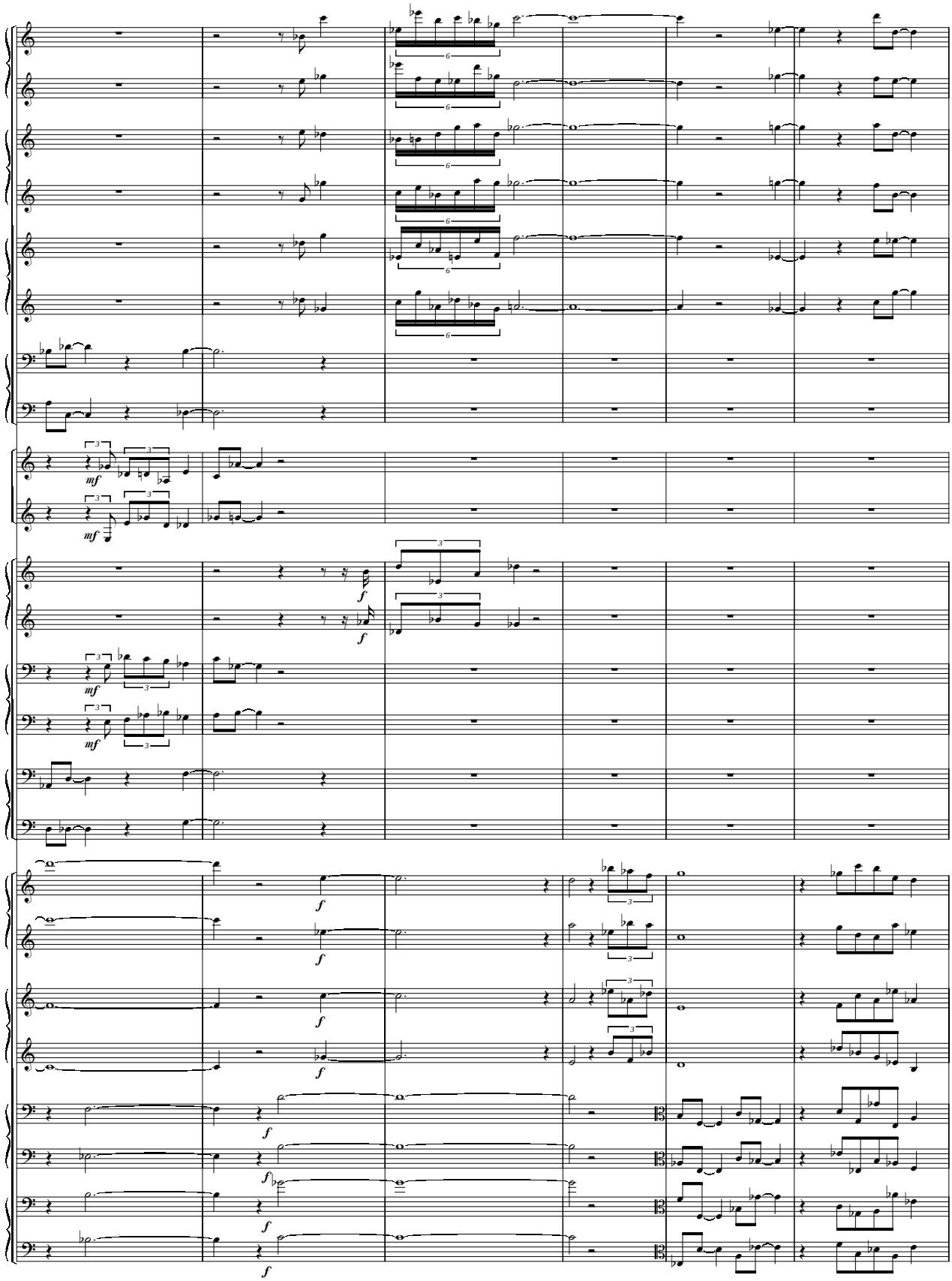
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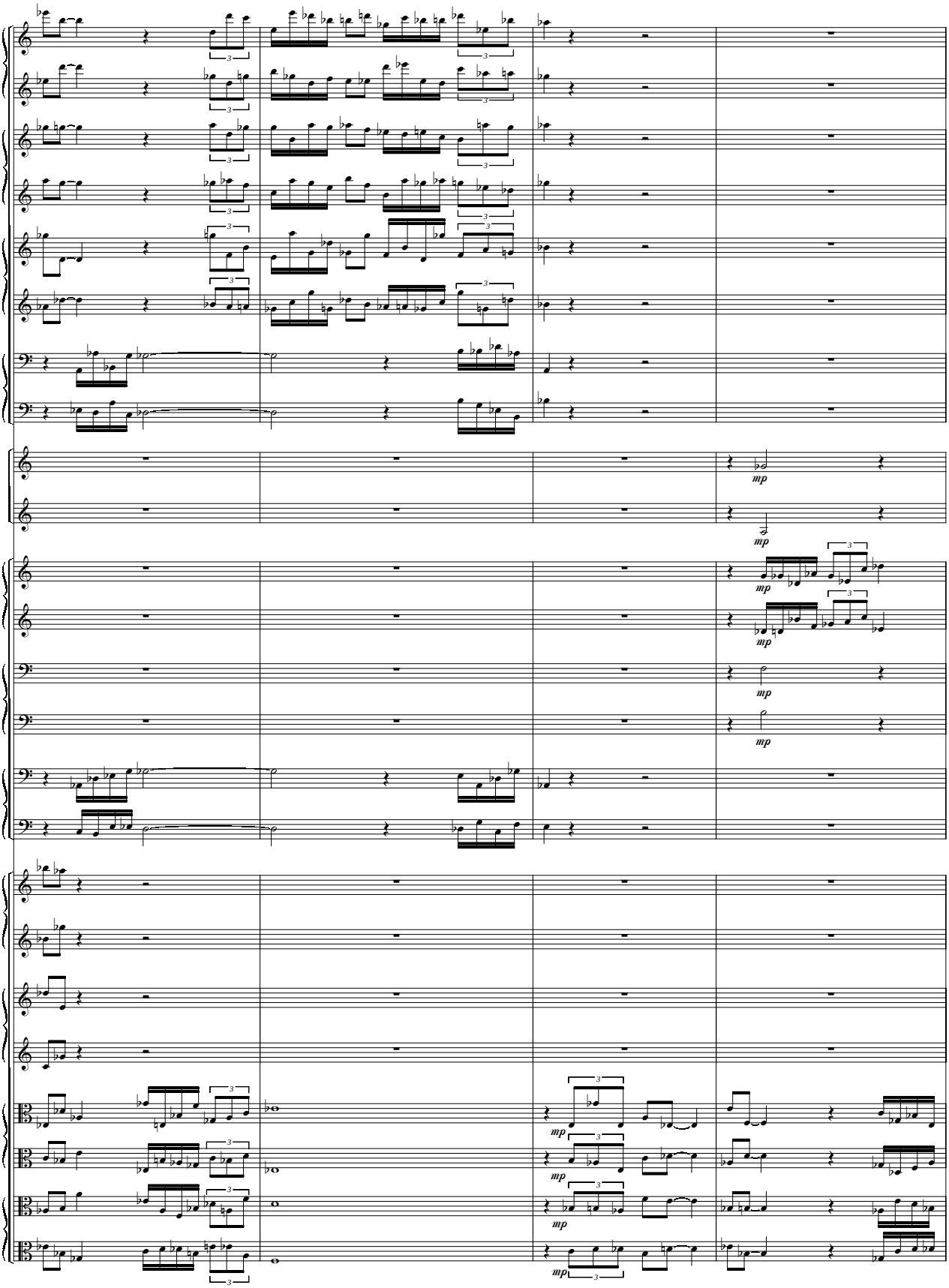
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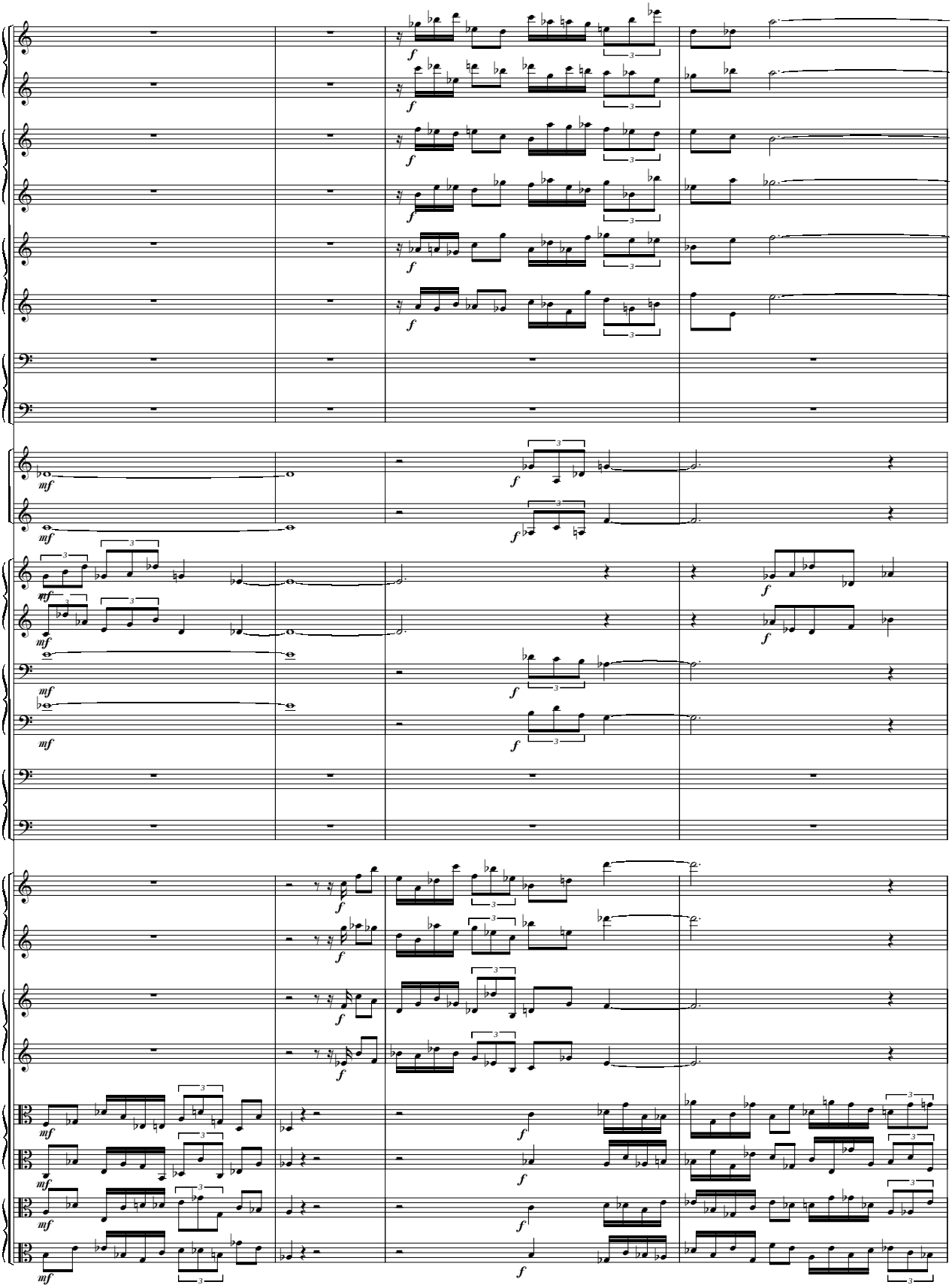

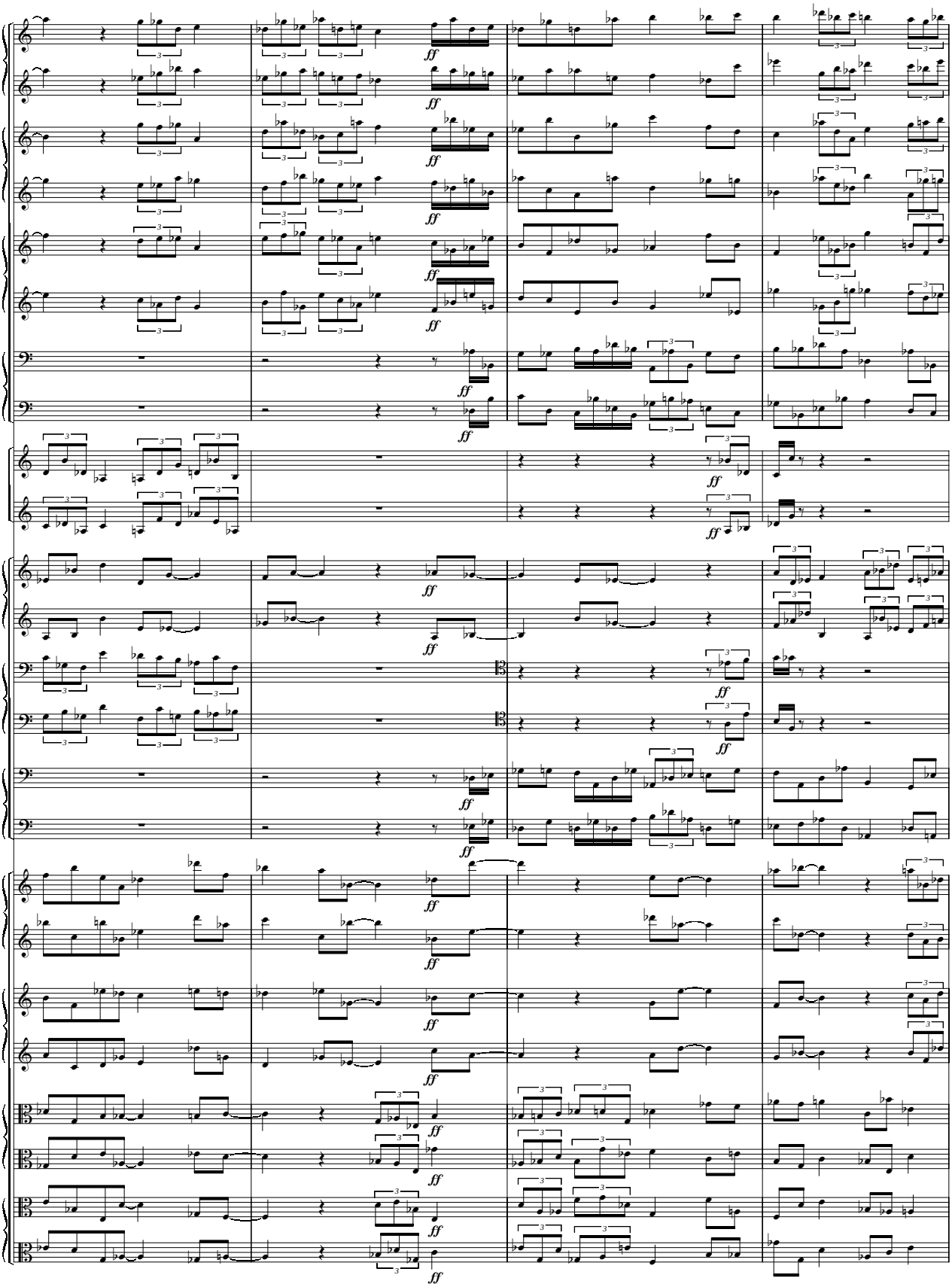
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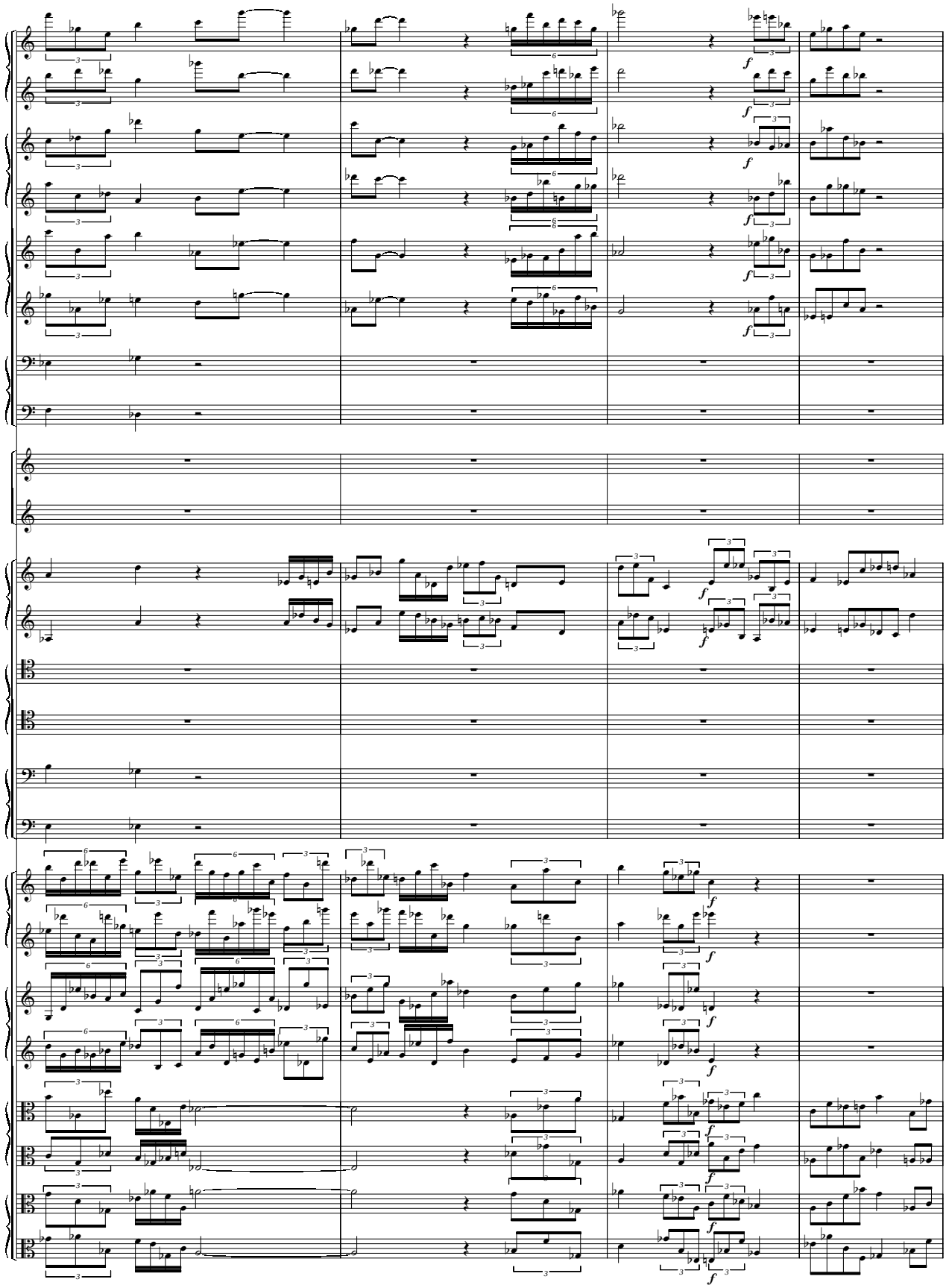

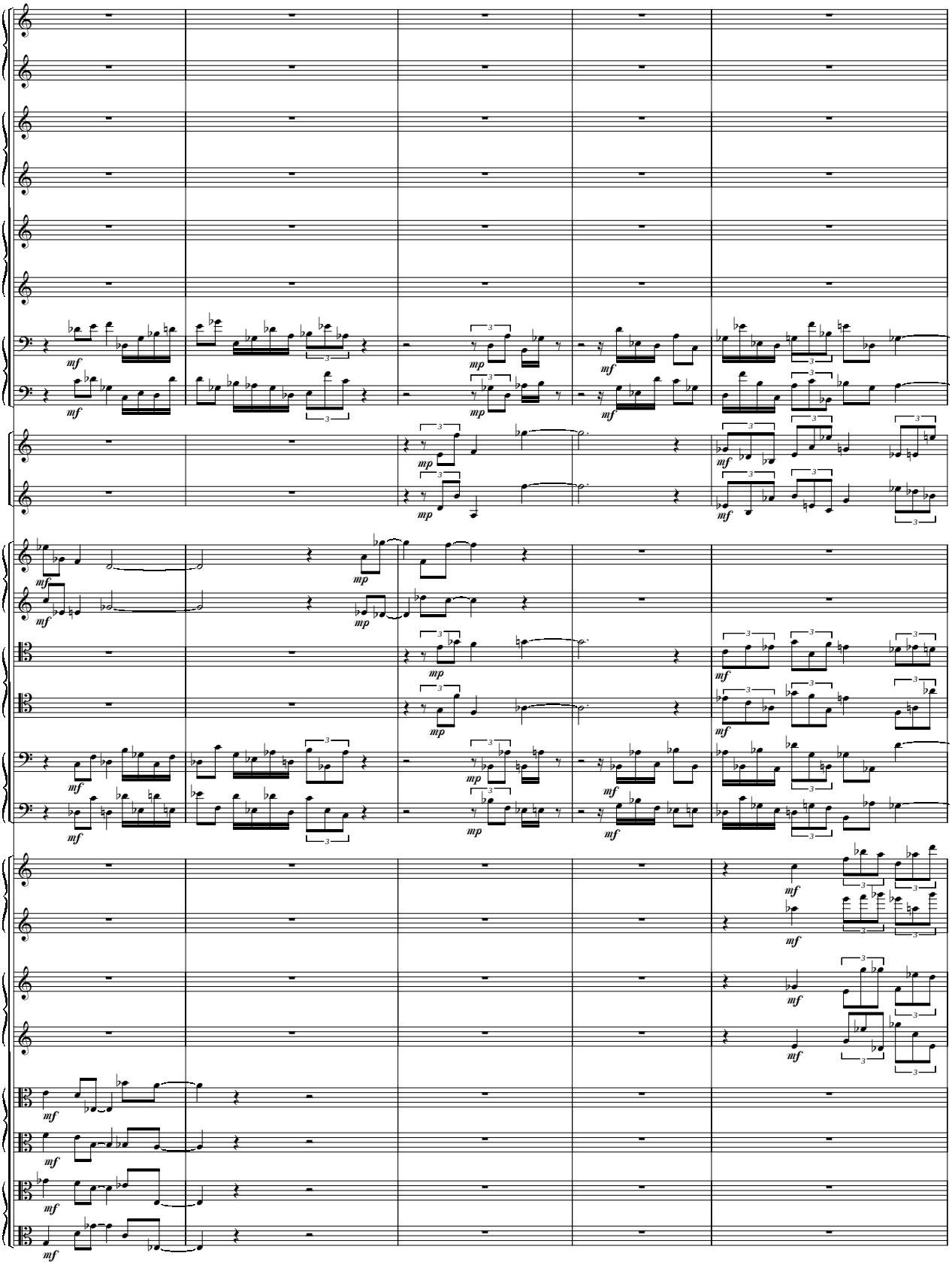

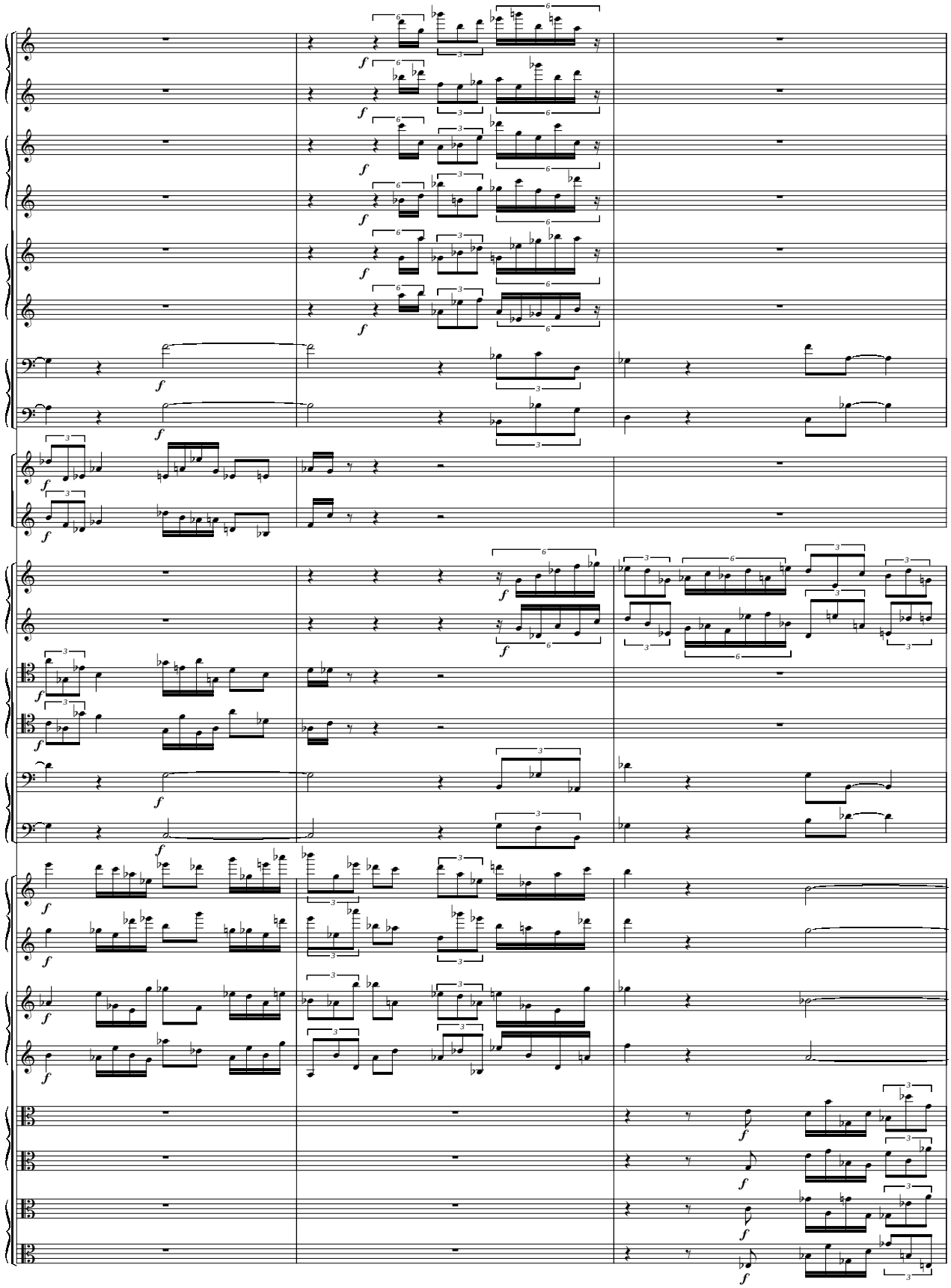

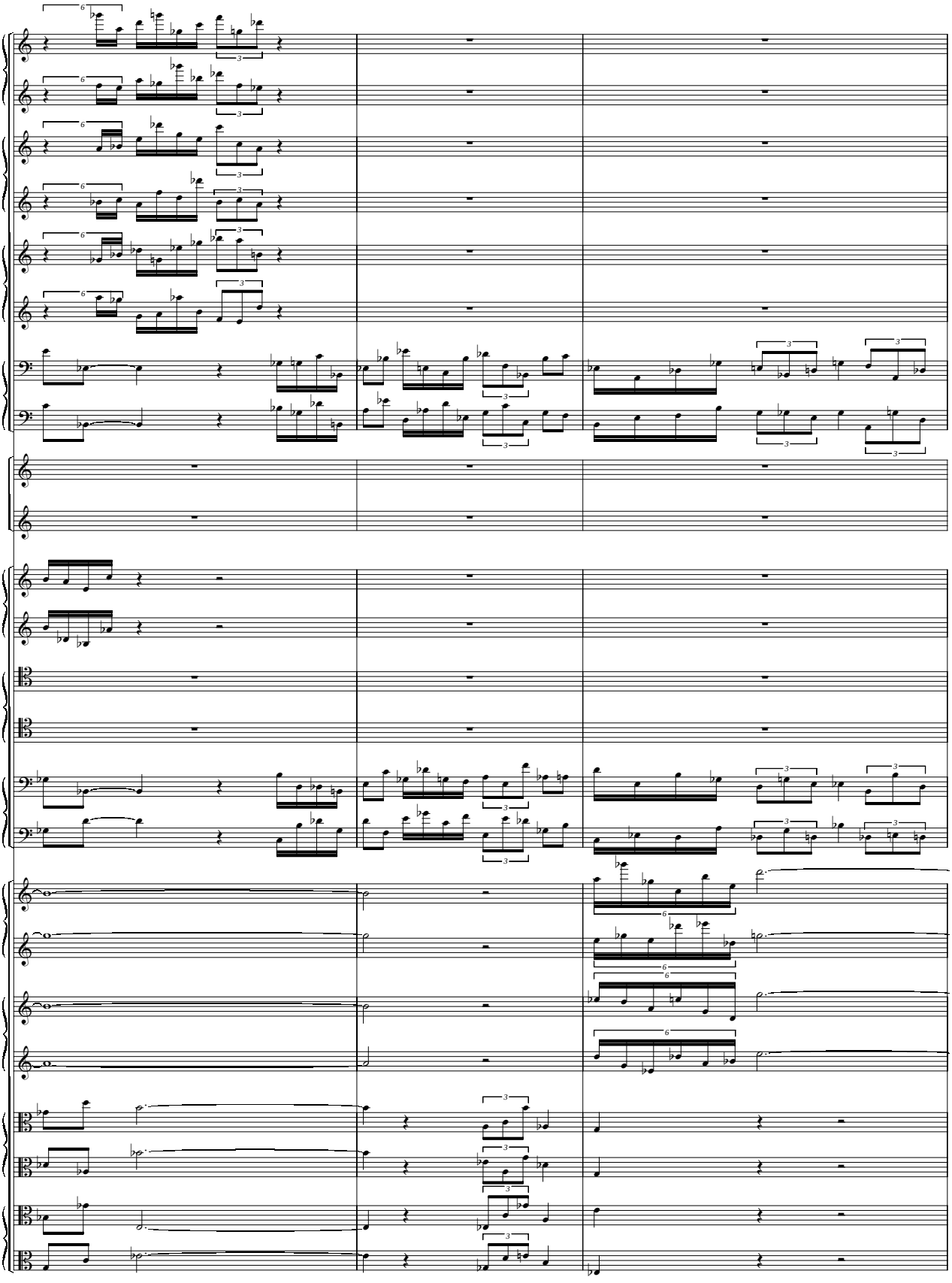

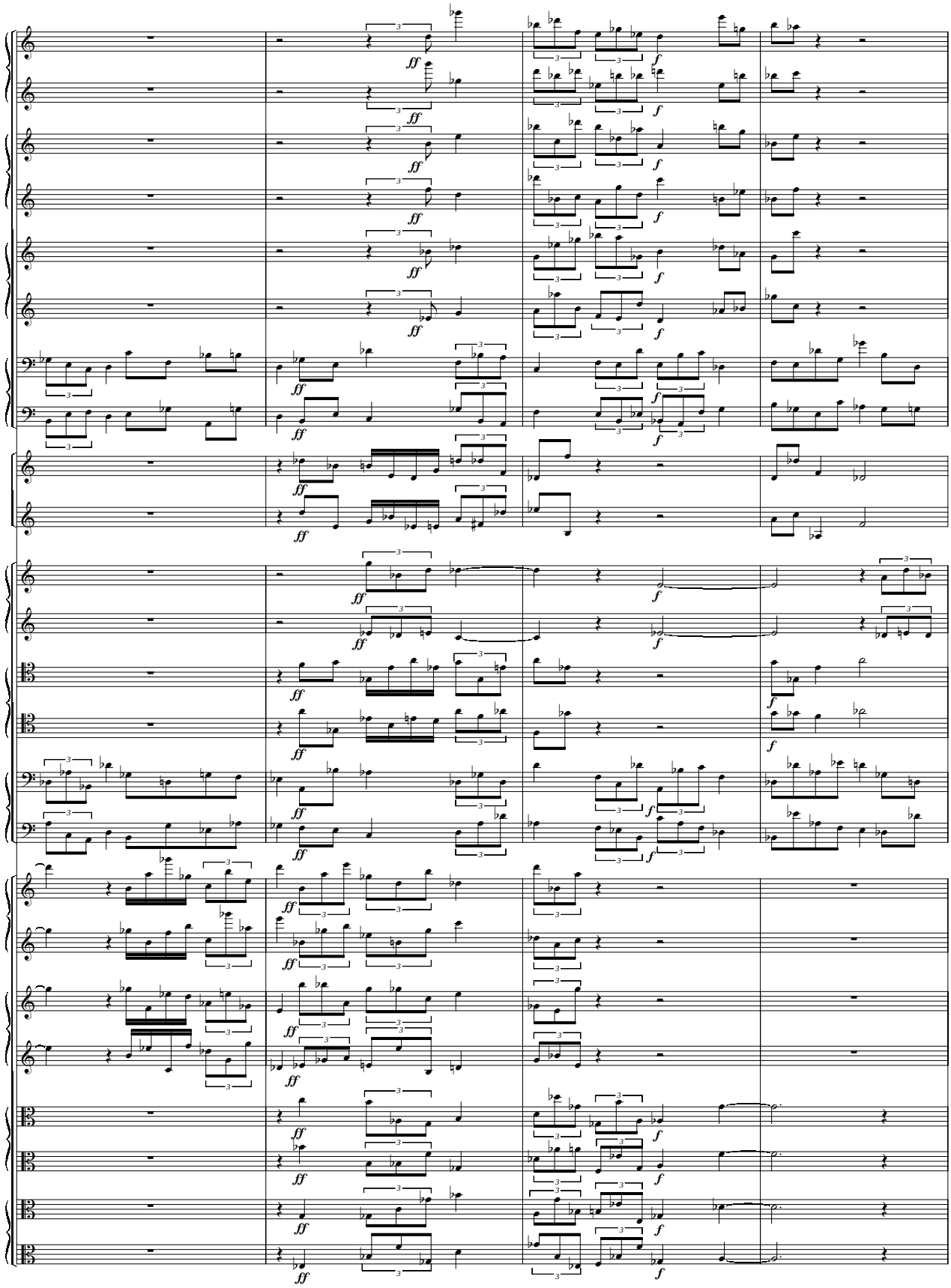

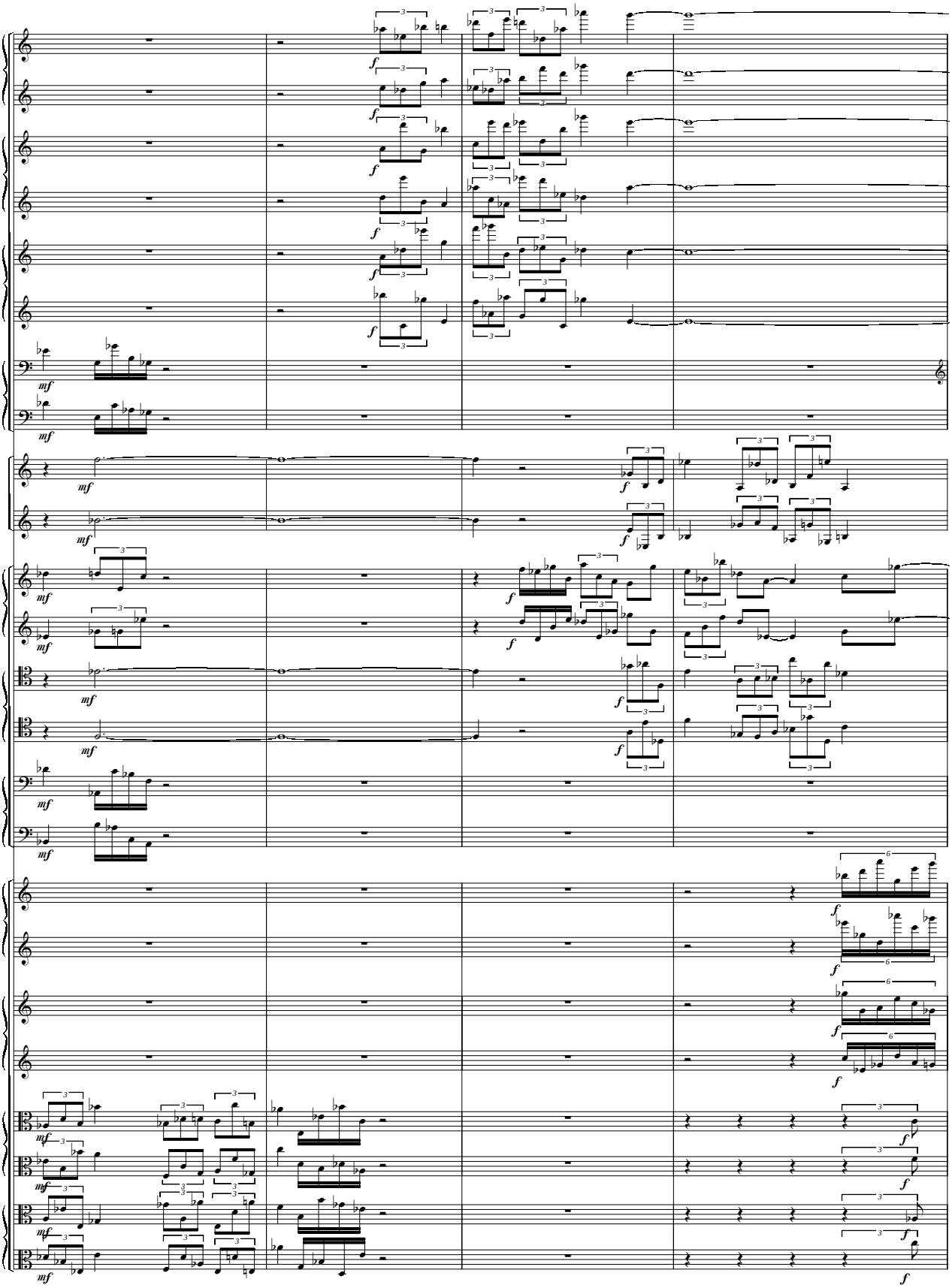

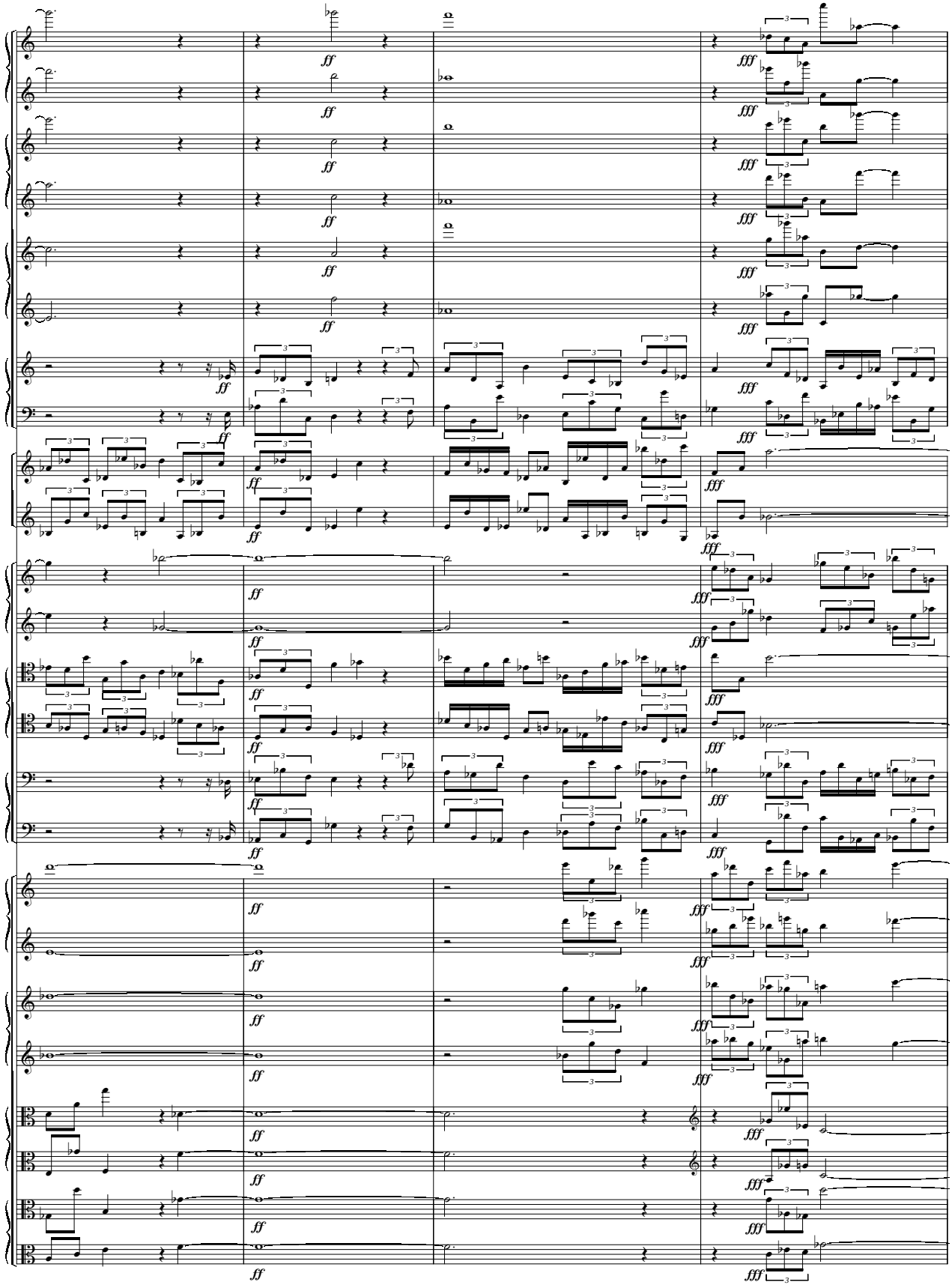

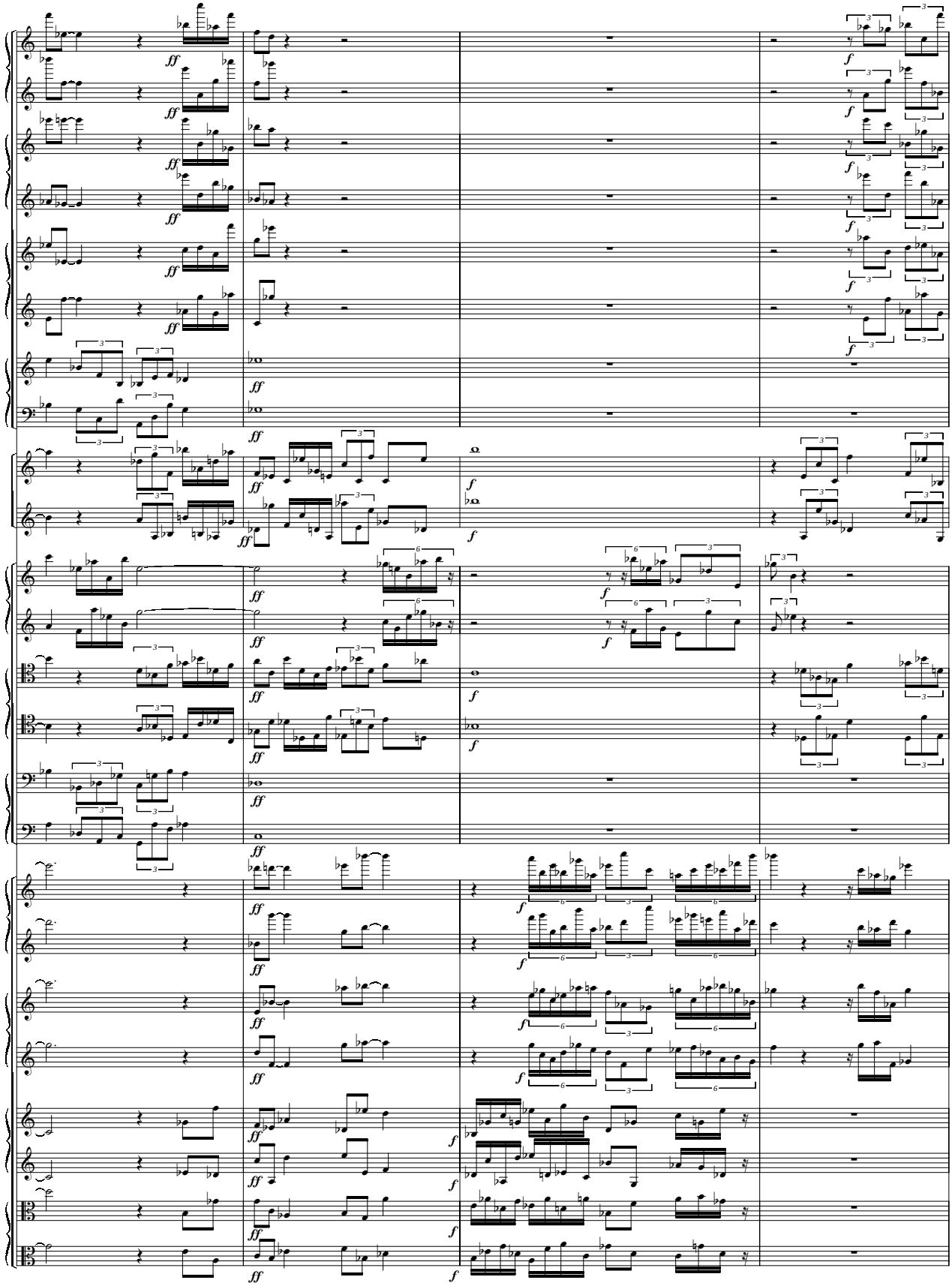

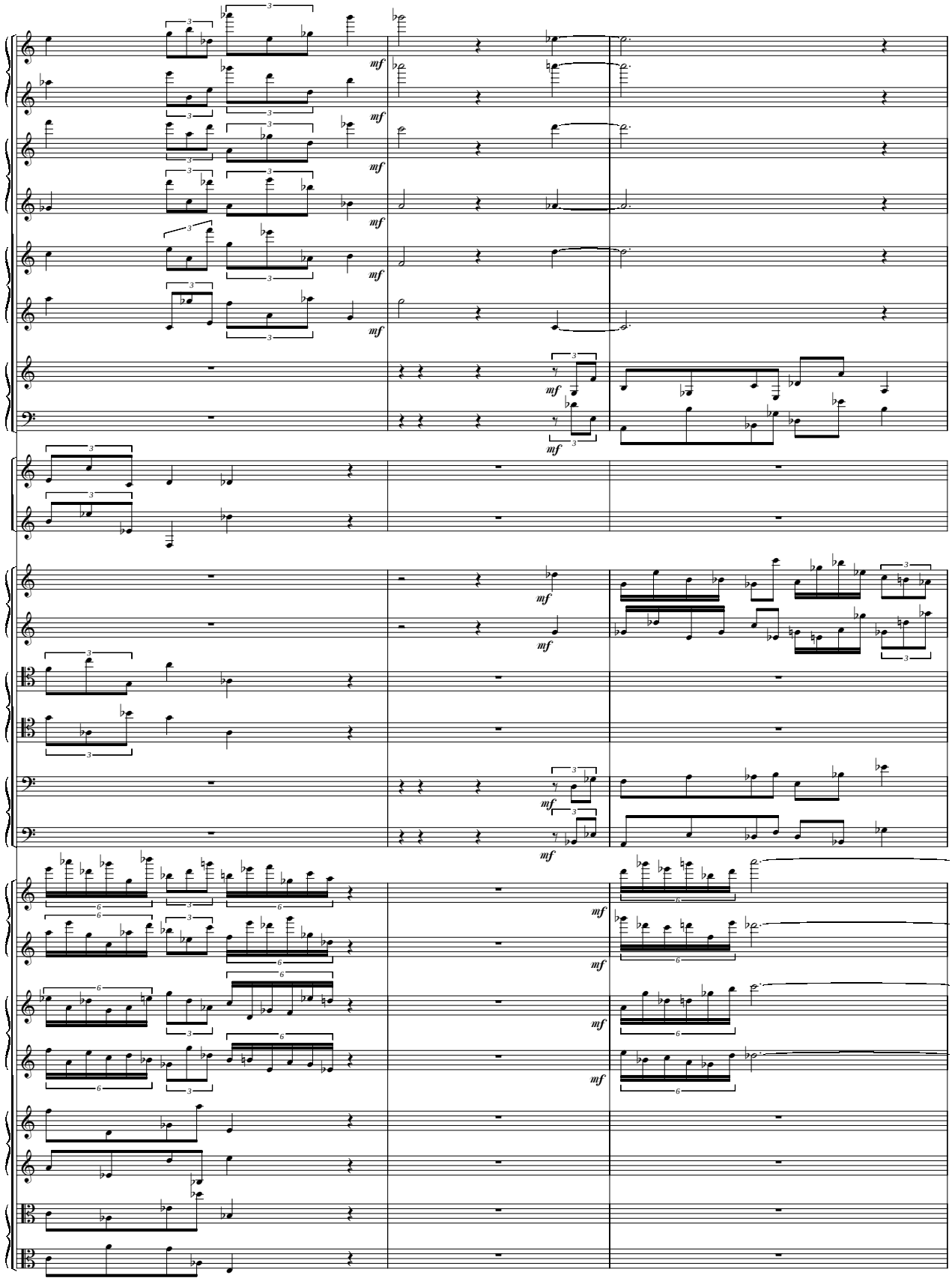
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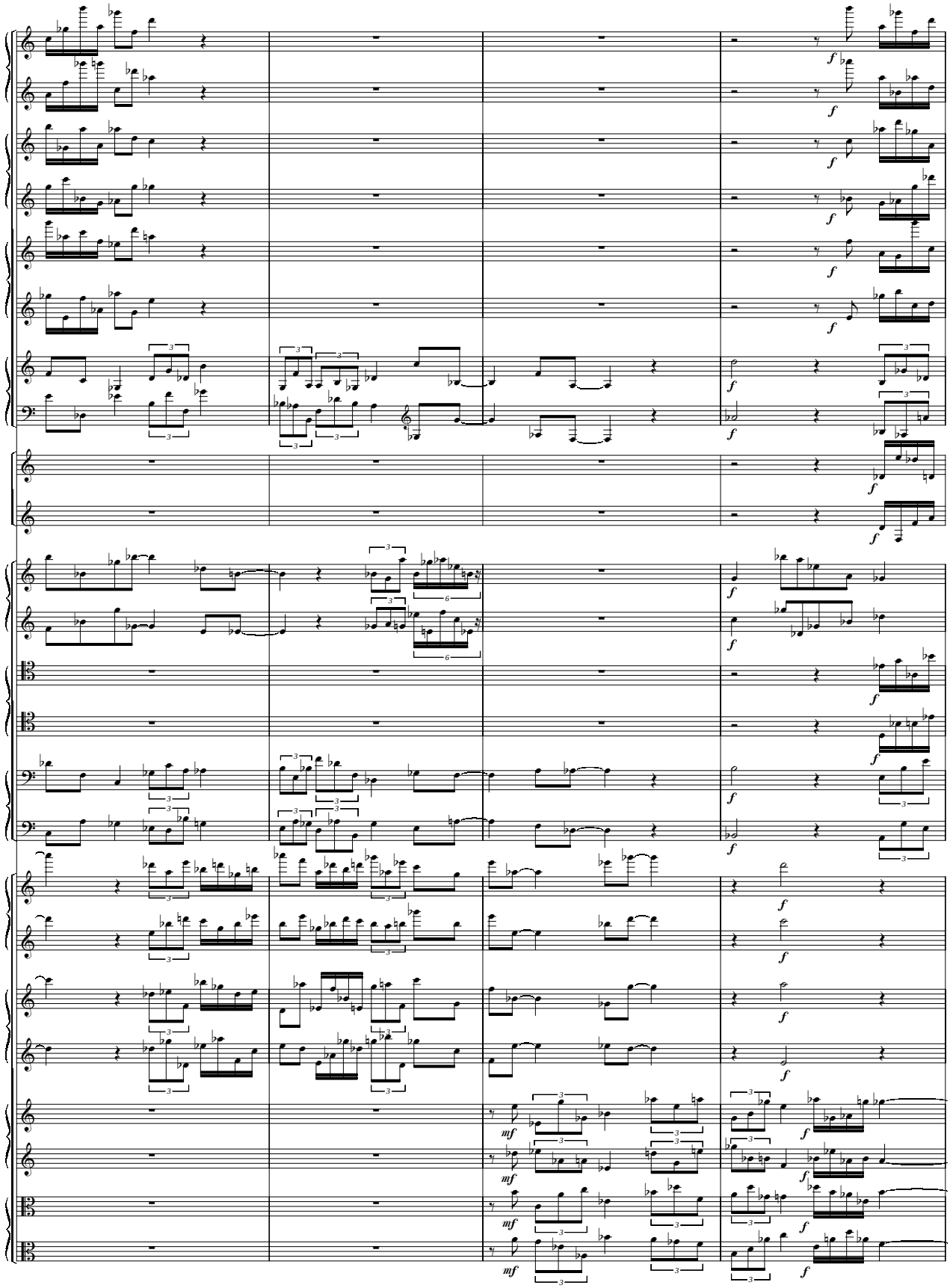

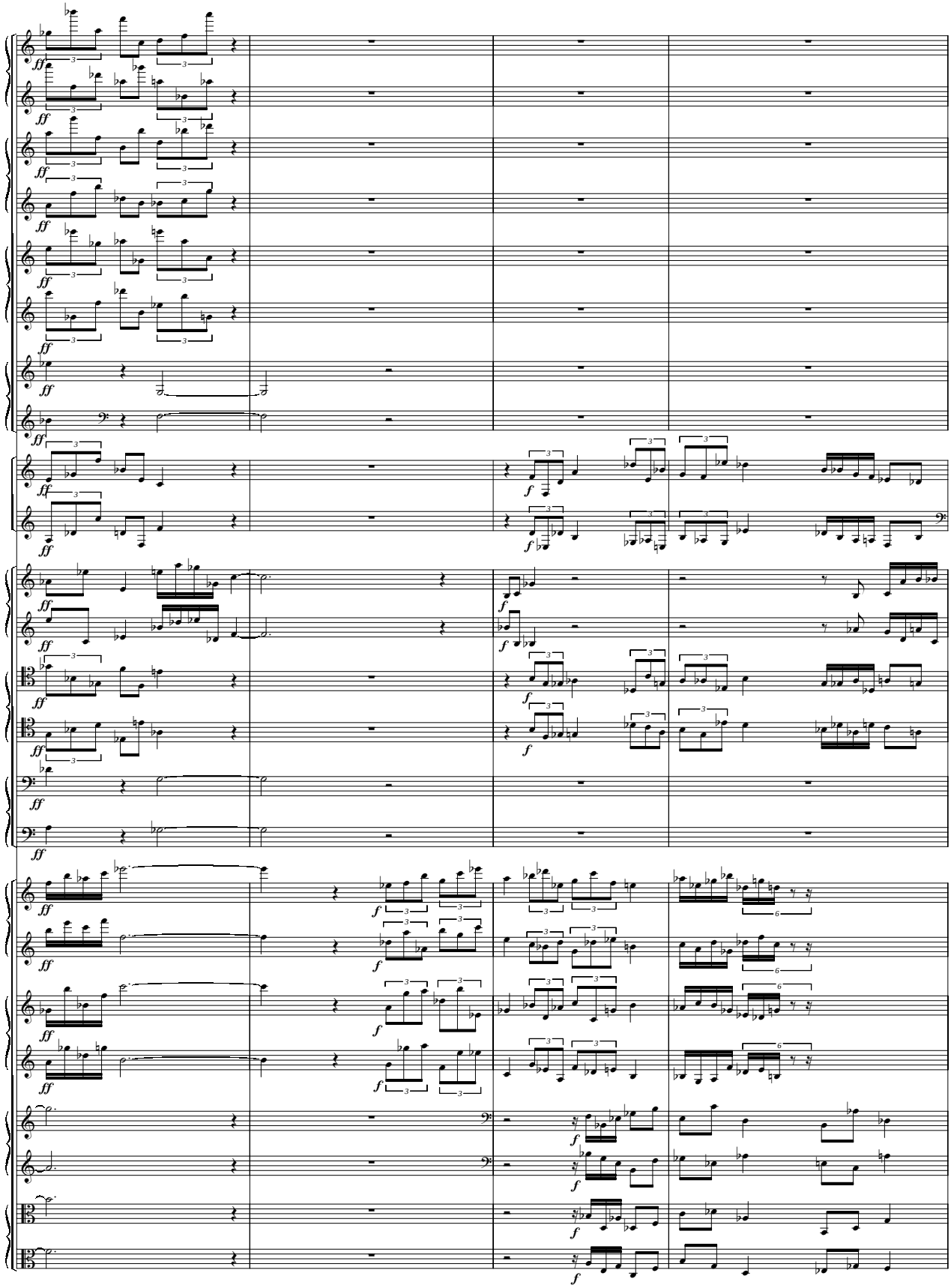

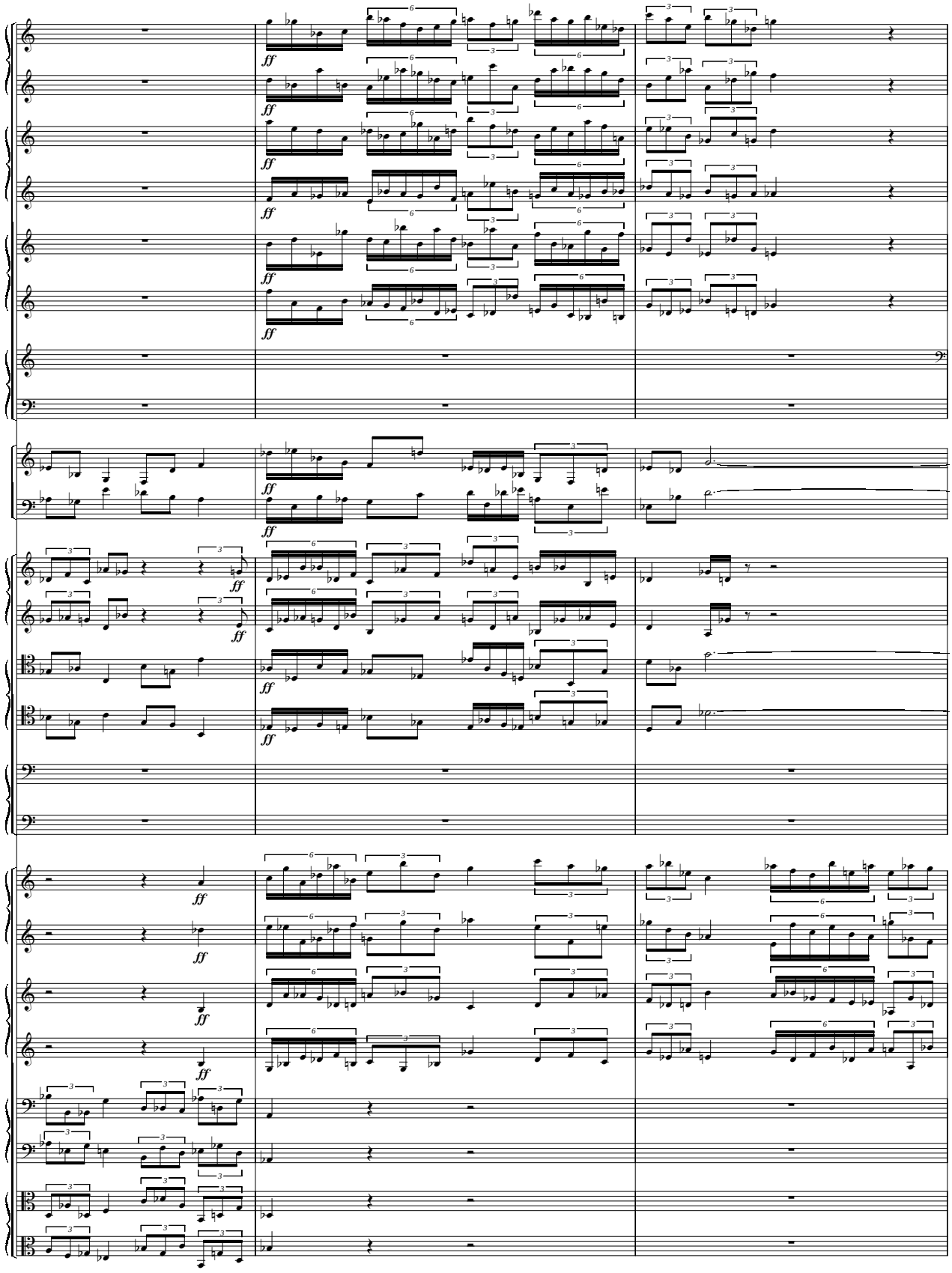

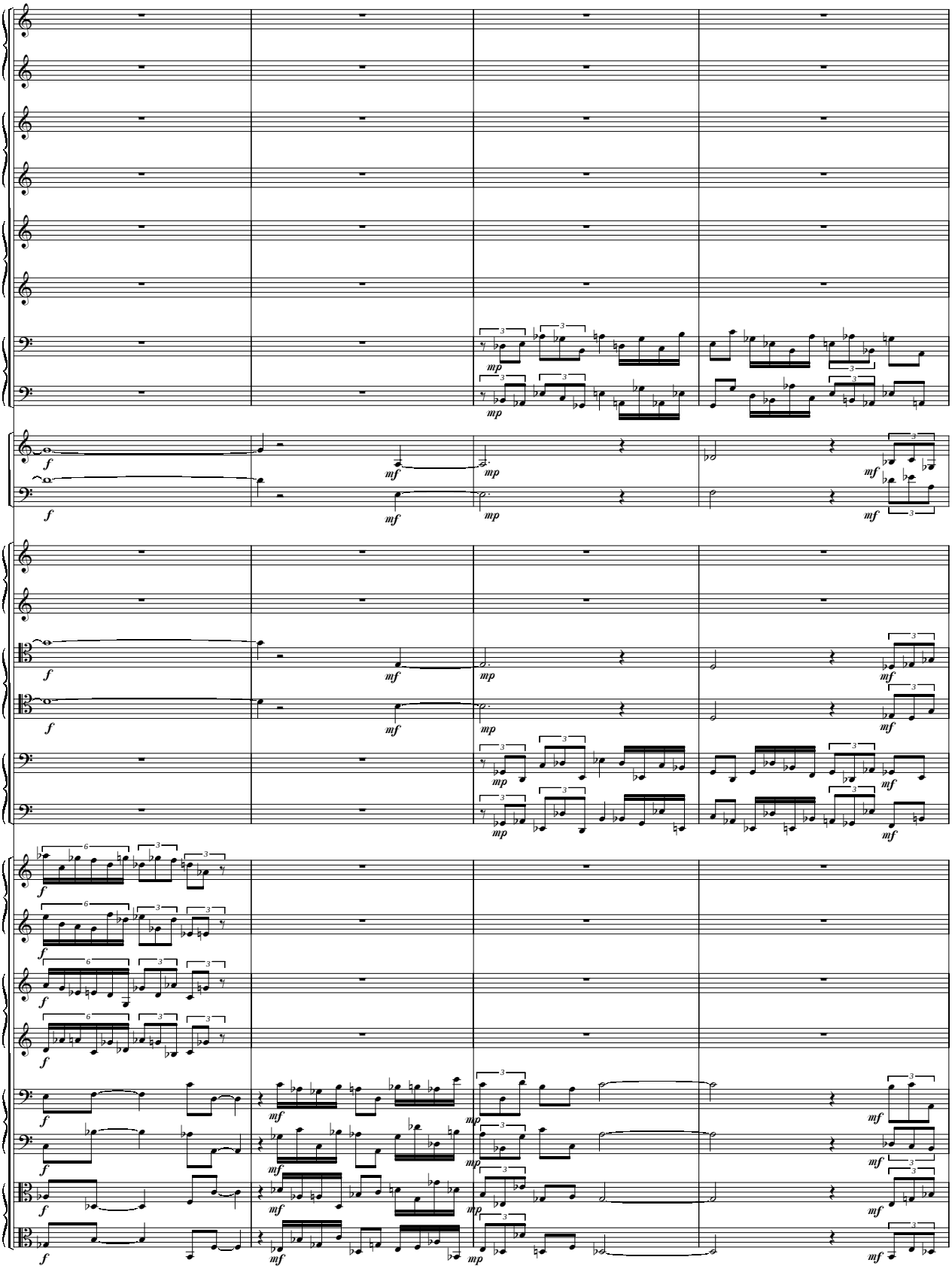

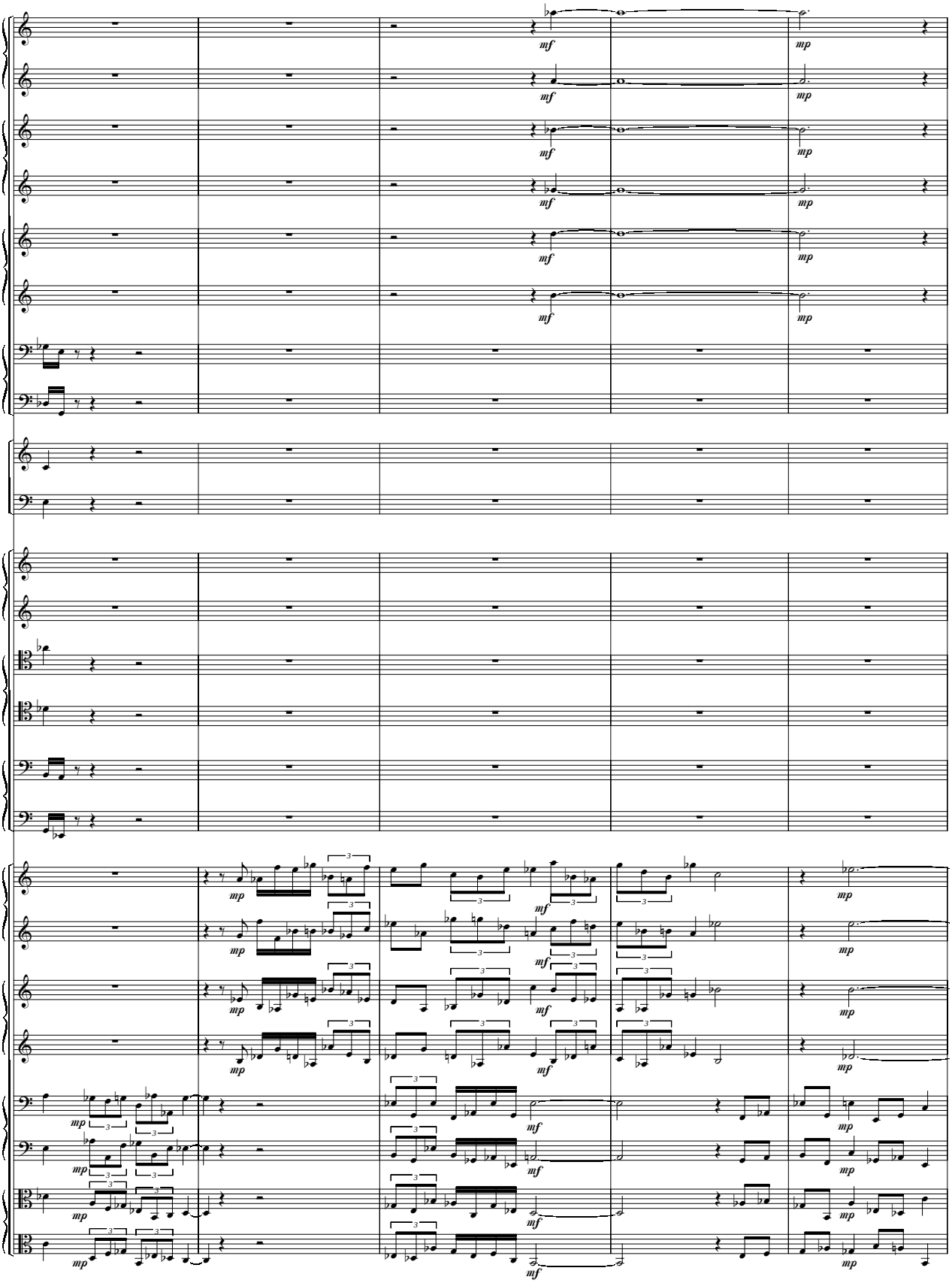
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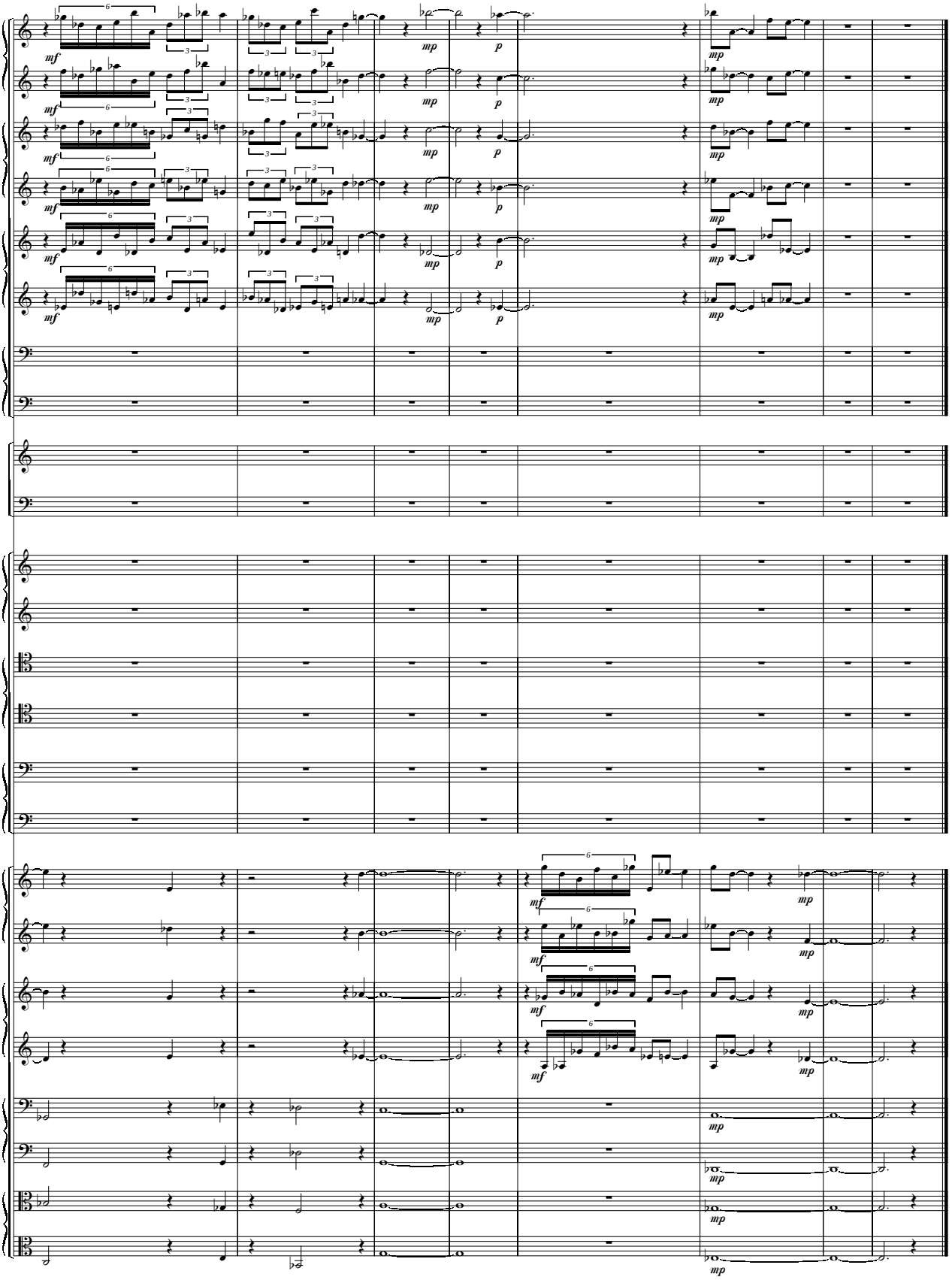
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