Residual Ramifications: A Collection of Etudes Composed Using Residue Cycles of Fibonacci Series Modulo *m* as Serial Tools

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Abstract

Residual Ramifications: A Collection of Etudes Composed Using Residue Cycles of Fibonacci Numbers Modulo *m* as Serial Tools

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Chair of the Supervisory Committee:
Professor John Rahn
Music

This dissertation contains sixteen original pieces of music written for a wide variety of ensembles, with representatives from every instrumental family (including electronics). Each short piece in the collection is an intense compositional study using a range of new serial methods. The basis for all serial techniques employed in the dissertation derives from Fibonacci series. In its natural state, the Fibonacci series of numbers (0, 1, 1, 2, 3, 5, 8, …, $F_{n-1} + F_{n-2}$) is limited in musical usefulness due to its rapid growth toward extremely large numbers (e.g., $F_{12} = 144$ and $F_{24} = 46368$). A more practical set of numbers emerges, however, by reducing each integer in the series to its residue (i.e., by taking modulus *m*, the remainder after division by *m*). As a rule, these residues form a repeating cycle of integers no matter how large the Fibonacci numbers become. Residue cycles can be derived from any general Fibonacci series (starting with any two positive integers less than *m*) for all positive integers *m*, thus providing a profusion of useful number sets. As demonstrated in this

dissertation, each Fib(mod m) cycle, rich in mathematical relations, has the potential to create a particular musical persona. Traditional twelve-tone serialism has been avoided in favor of new alternatives for mapping numbers to musical parameters. The goal of this dissertation was to compose a set of pieces, ultimately accessible, rooted in rigorous serial schemes.

TABLE OF CONTENTS

INTRODUCTION

This collection of sixteen original pieces contains music composed for a wide variety of ensembles, with representatives from every instrumental family:

I – piano solo
II – ensemble (four or more players – see performance notes)
III – computer-realized sound (quadraphonic – see performance notes)
IV – double woodwind quintet (4 fl., 2 ob., 2 cl., 2 bsn.)
V – viola sextet
VI – counter-tenor, tenor, baritone
VII – ensemble (four or more players – see performance notes)
VIII – flute, glockenspiel, vibraphone, piano
IX – piano solo and live electronics (see performance notes)
X – guitar duet
XI – flute, glockenspiel, vibraphone, piano
XII – counter-tenor, tenor, baritone
XIII – trombone quintet
XIV – double woodwind quintet (4 fl., 2 ob., 2 cl., 2 bsn.)
XV – guitar duet
XVI – ensemble (four or more players – see performance notes)

Performance notes are included for the two pieces involving electronics (III and IX) and for the three open ensemble pieces (II, VII, and XVI). Etude III is written for computer-realized sound and therefore has no physical score. Instead, the page of performance notes (Performance Notes for III on page 13) explains the use of the sound files and other files found on the Pocket Material CD. The Pocket Material CD also contains the necessary computer programs for the piano and live electronics piece (see Performance Notes for IX on page 81).

This collection of short pieces is the result of extensive research into the mathematical properties and musical potential of Fibonacci series modulo *m*. All sixteen pieces were composed using a variety of new serial techniques based

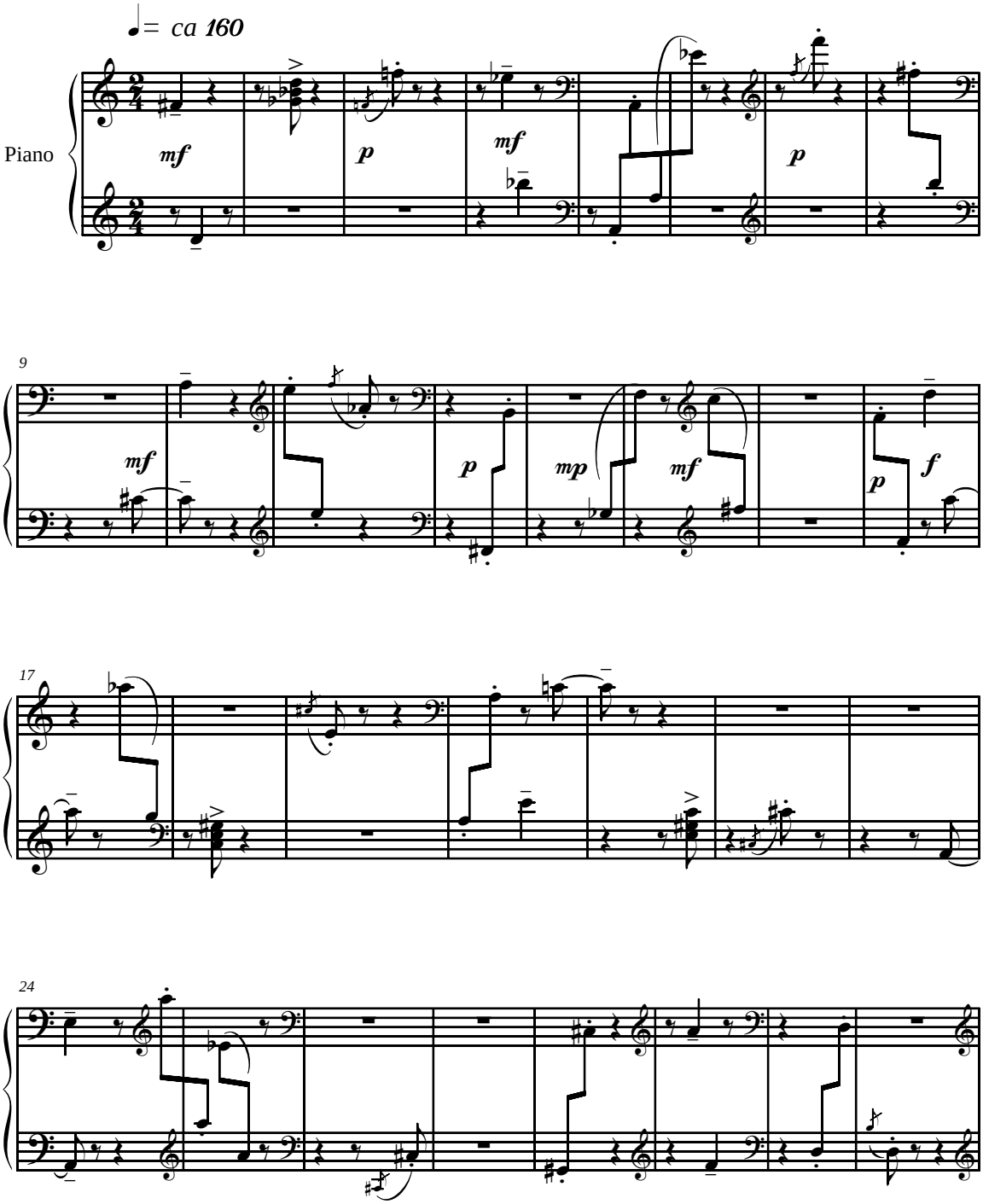
on cycles of integers that arise from taking the modulus of a series of Fibonacci numbers. These integer cycles have been called residue cycles since each number in a cycle is the residue (or remainder after division by m) of each number in a Fibonacci series.

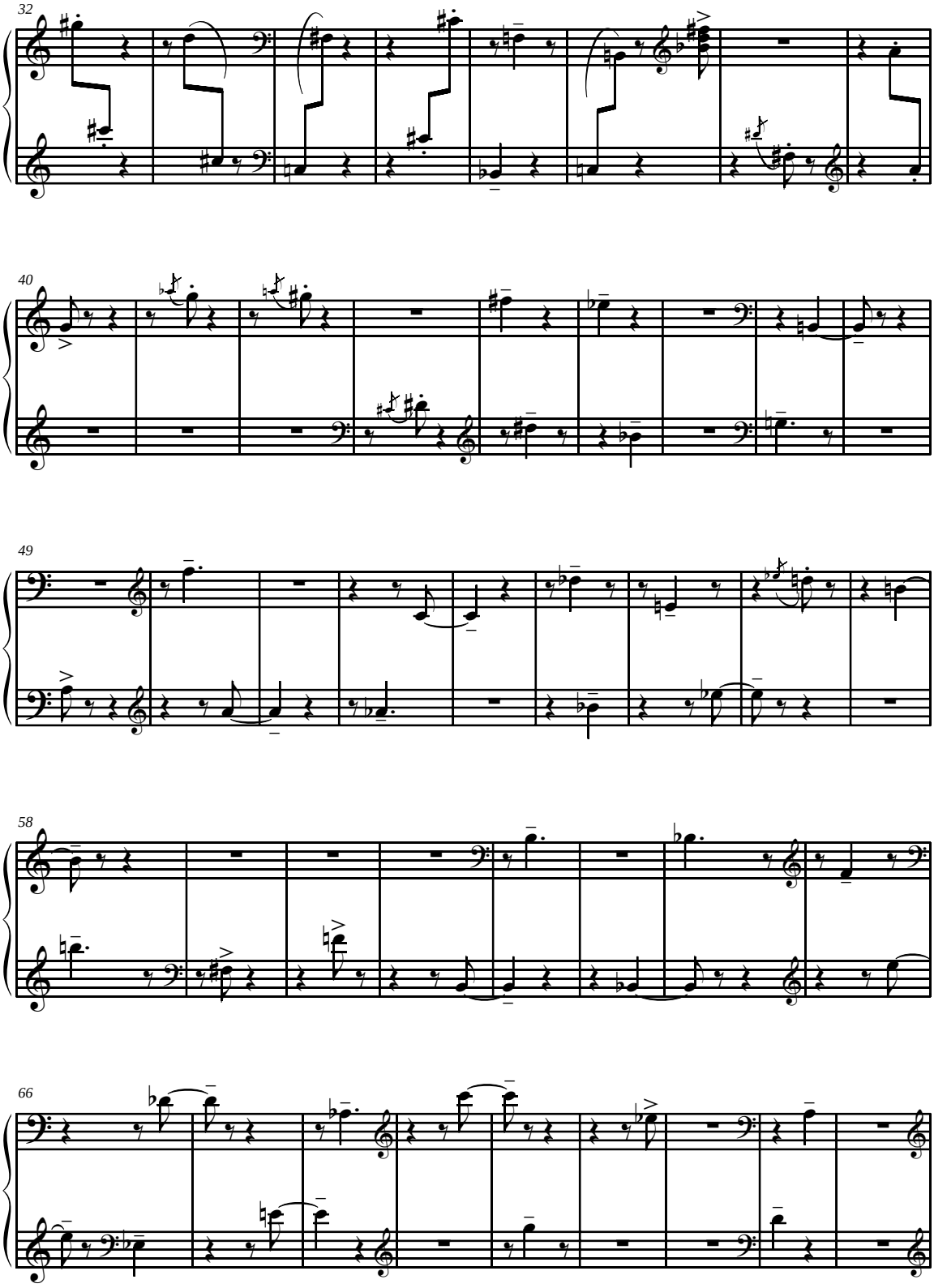
Due to the recursive definition of a Fibonacci series (i.e., the next number in the series equals the sum of the previous two numbers, or $F_n = F_{n-1} + F_{n-2}$), consecutive integers grow rapidly to extremely large numbers. For example, $F_{12} = 144$ whereas, just twelve integers later, $F_{24} = 46368$. When reducing a Fibonacci series to its residue cycle by taking modulus m of each integer, the series becomes, as a rule, a repeating cycle no matter how large the Fibonacci numbers grow. This special property increases the utility of Fibonacci series as serial tools for music composition. Residue cycles, moreover, can be derived from any general Fibonacci series (starting with any two positive integers less than m) for all positive integers m, thus providing a profusion of useful number sets.

Rich in mathematical relations, the order of numbers within a residue cycle provides the main inspiration for various serial schemes throughout the collection. While traditional twelve-tone serialism has been avoided, new methods of mapping numbers to musical parameters are used to create pieces that encapsulate particular personae exhibited by the residue cycles and are ultimately accessible.

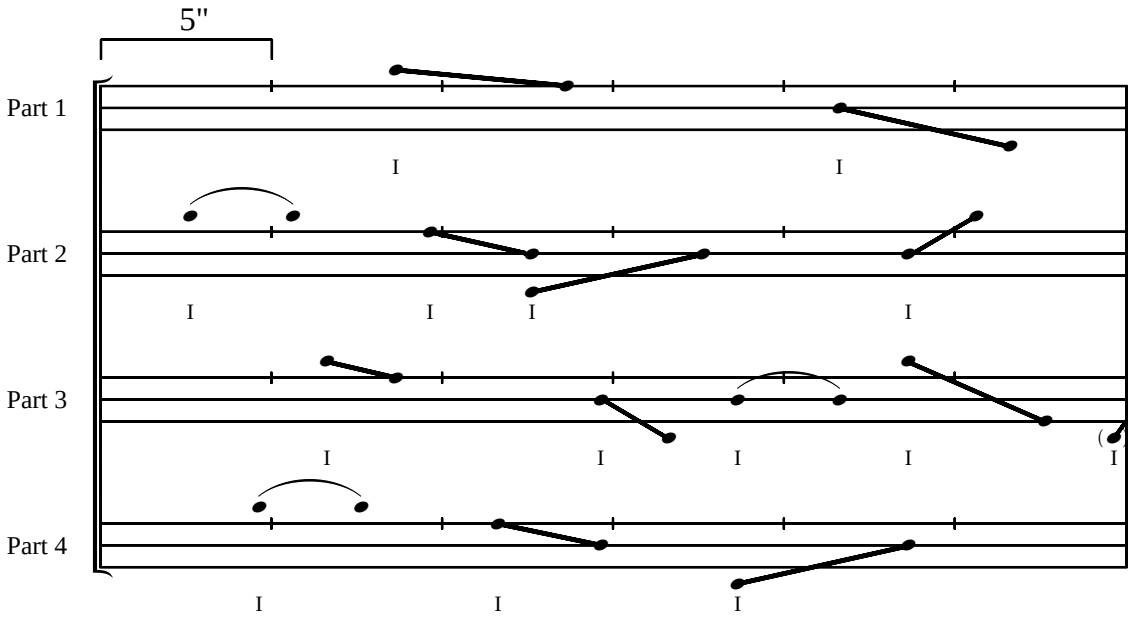
I

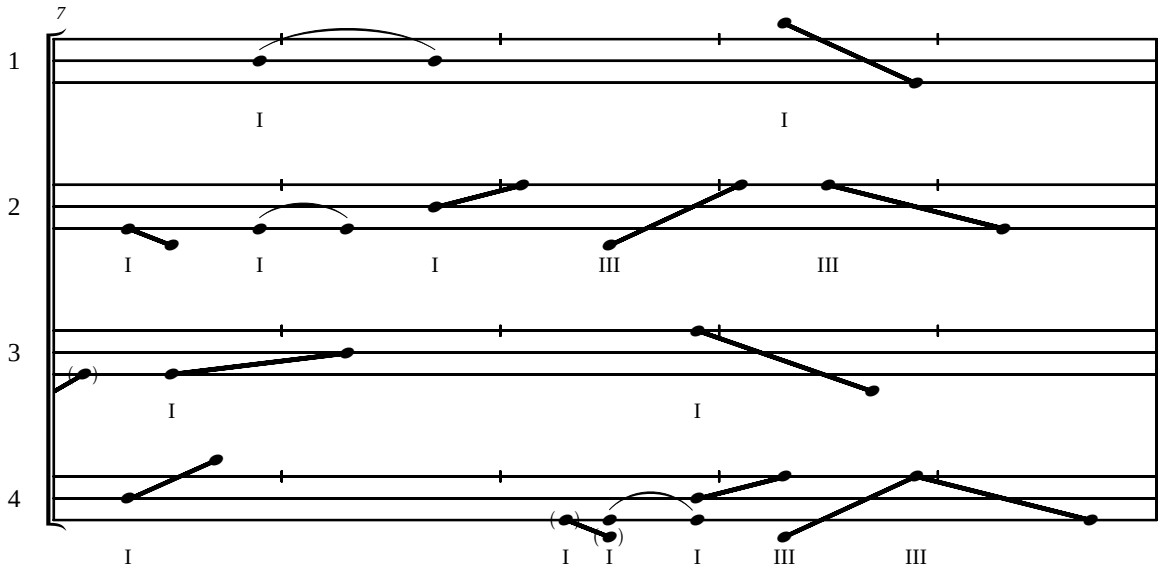
for M.P.N.

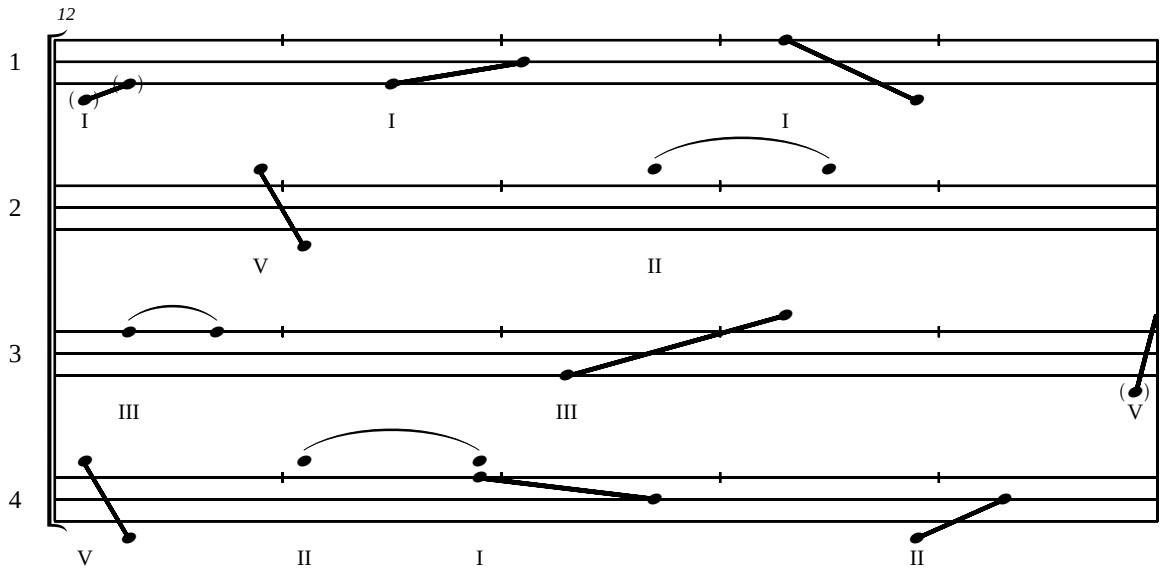


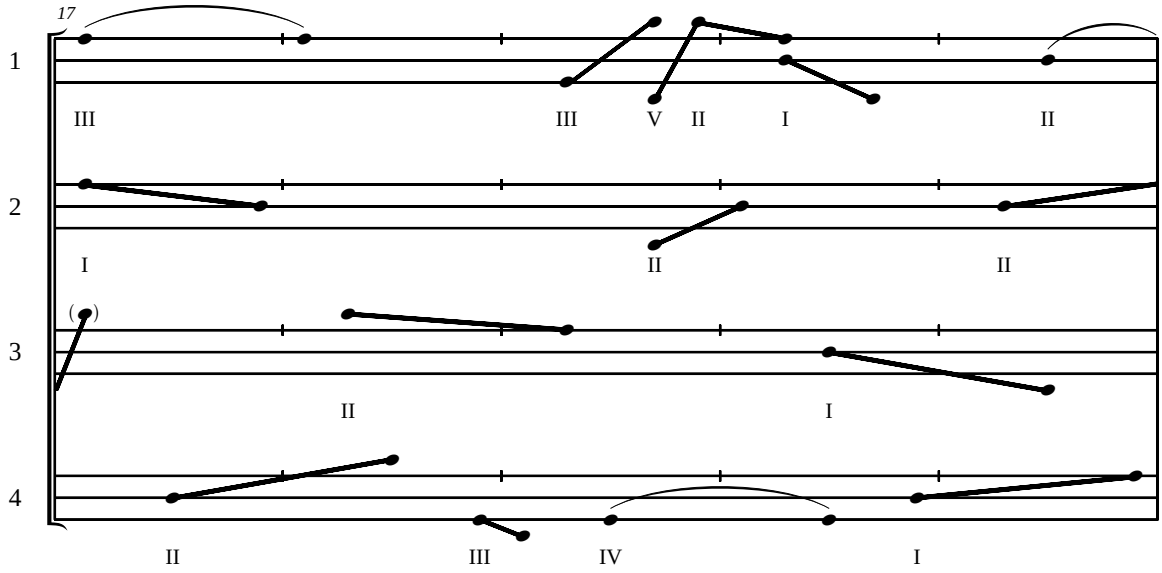

32
40
49
58
66

II






12
1
2
3
4
I
I
I
V
II
III
III
V
V
II
I
II


17
1
2
3
4
III
III
V
II
I
II
I
II
II
II
I
II
III
IV
I

Performance Notes for II

- This piece is written for at least four players, playing any instrument(s) capable of performing glissandos across the entire range of the instrument. When there are more than four players, the ensemble should distribute the parts as uniformly as possible.

- Each line on the three-lined staff represents three midpoints of the instrument's frequency range: the top line represents the midpoint of the high range; the middle line represents the midpoint of the entire range; and the bottom line represents the midpoint of the low range. Hence, if a figure begins above the top line and ends below the bottom line, the player will have traversed the entire range of the instrument from the highest extremity to the lowest extremity.

- The Roman numerals (I-V) should be predetermined by each player to correspond to five distinct timbral aspects the instrument is capable of producing. For example, a vocalist might choose to sing on five distinct syllables.

- Throughout the piece, a notehead signals the beginning and end of a glissando (two noteheads connected by a downward or upward sloping line) or a sustained note (two tied noteheads). Glissandos with noteheads in parentheses should be produced by an alternate means (e.g., whistling) not related to the instrument.

- The progress of time is indicated by “ticks” through the top line of each staff, each tick marking the passage of five seconds. Glissandos should be performed as a continuous change in frequency from the beginning to the end of a figure. Thus, the speed of the glissando is determined by the slope of the line.

Performance Notes for III

- This piece is written for quadraphonic computer-realized sound, thus there is no physical score. It has been composed in the computer music programming languages CSound and Common Music.

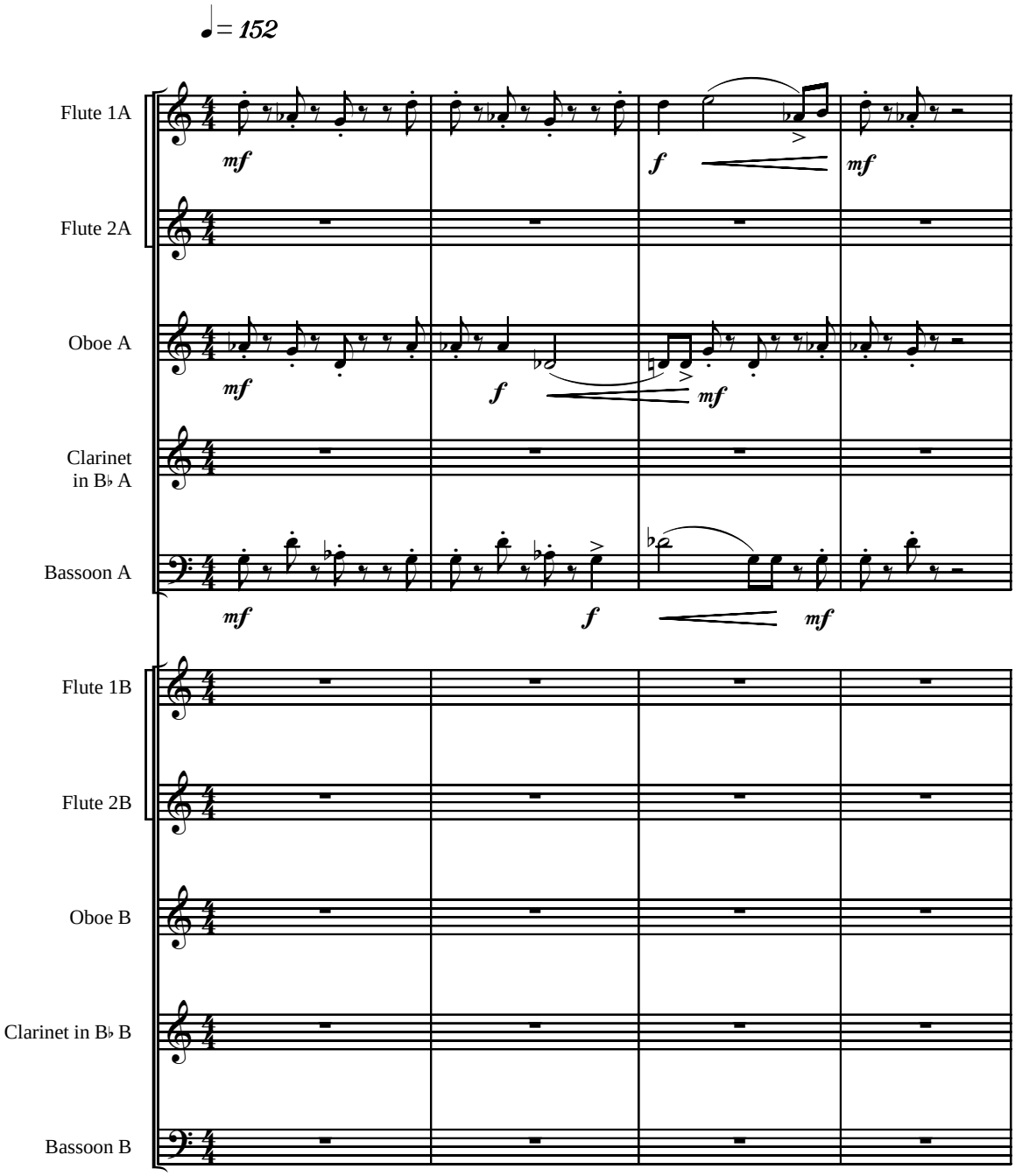
- The Pocket Material CD includes, in the "Residual-3" folder, four separate monophonic audio files (*Residual-3-1.wav*, *Residual-3-2.wav*, *Residual-3-3.wav*, and *Residual-3-4.wav*) and two source code files (*Residual-3.csd* and *Residual-3.lisp)*.

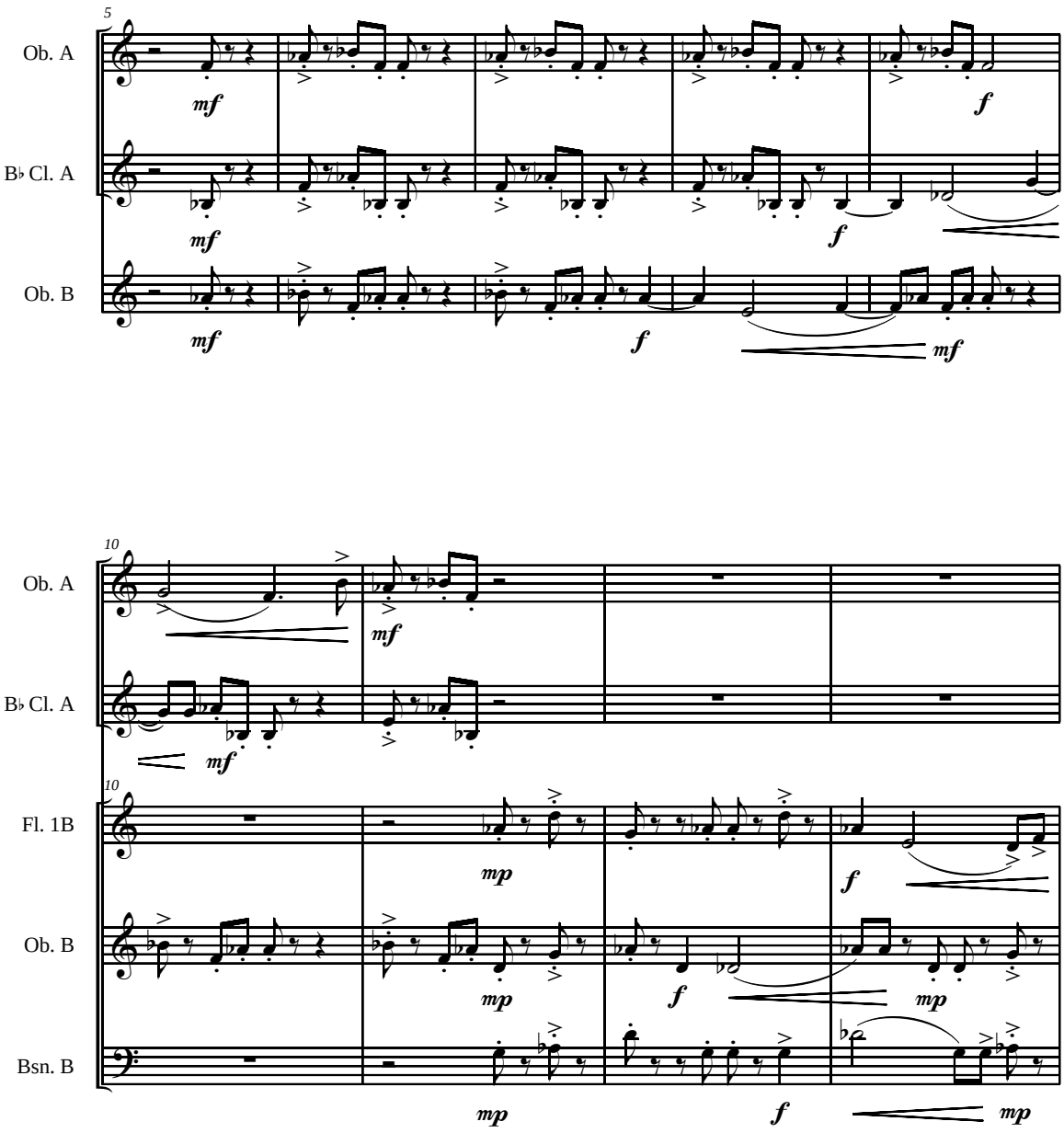
- The four *.wav* files are for each of the four speaker channels: 1, the front left channel; 2, the front right channel; 3, the back left channel; and 4, the back right channel. These audio files can be used directly to perform the piece (recommended).

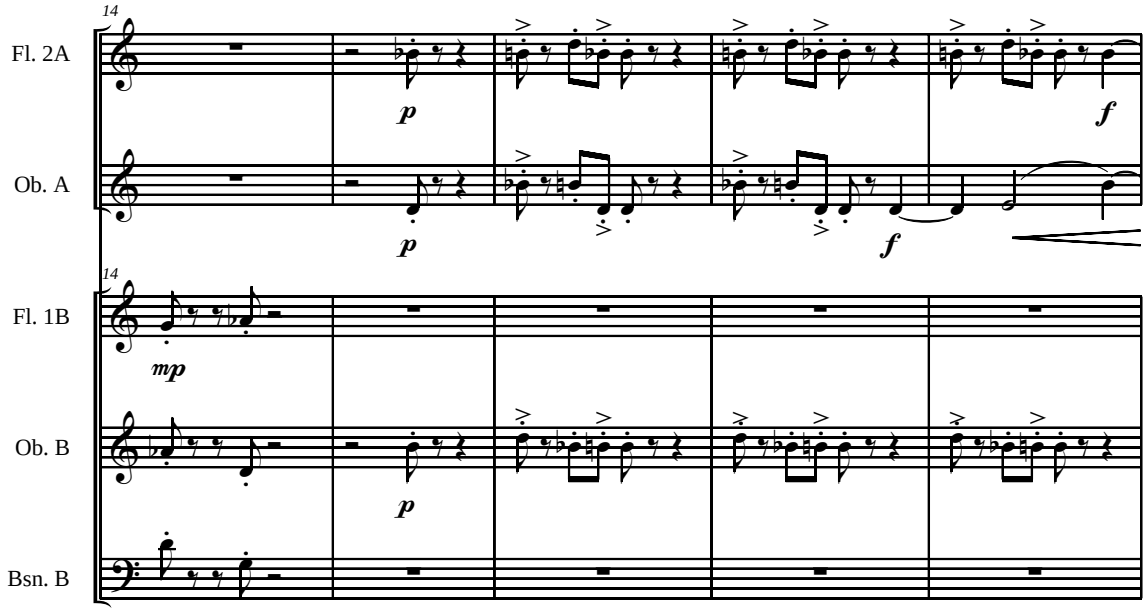
- The *.csd* file can be used to render the piece in real-time (or to a file) in an appropriate CSound environment (see http://csounds.com). *Residual-3.lisp* is the Common Music lisp code that generates the notes in the score file for the CSound code and has been included for reference purposes. These source code files may need to be opened in a text editor and copied to a new project.

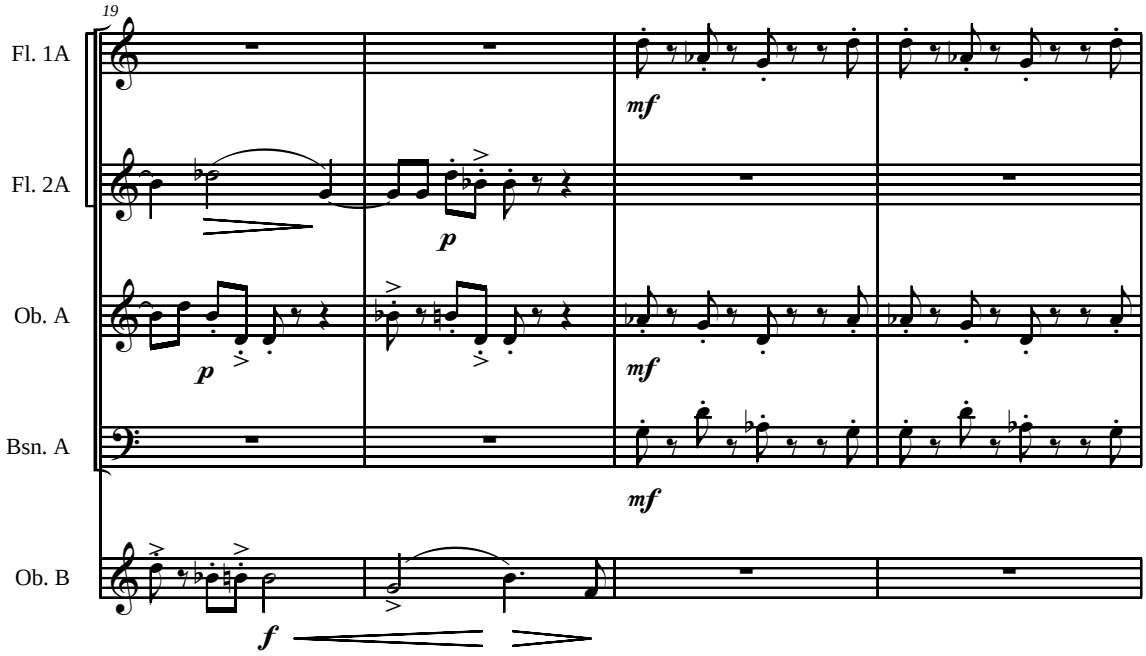
Score in C

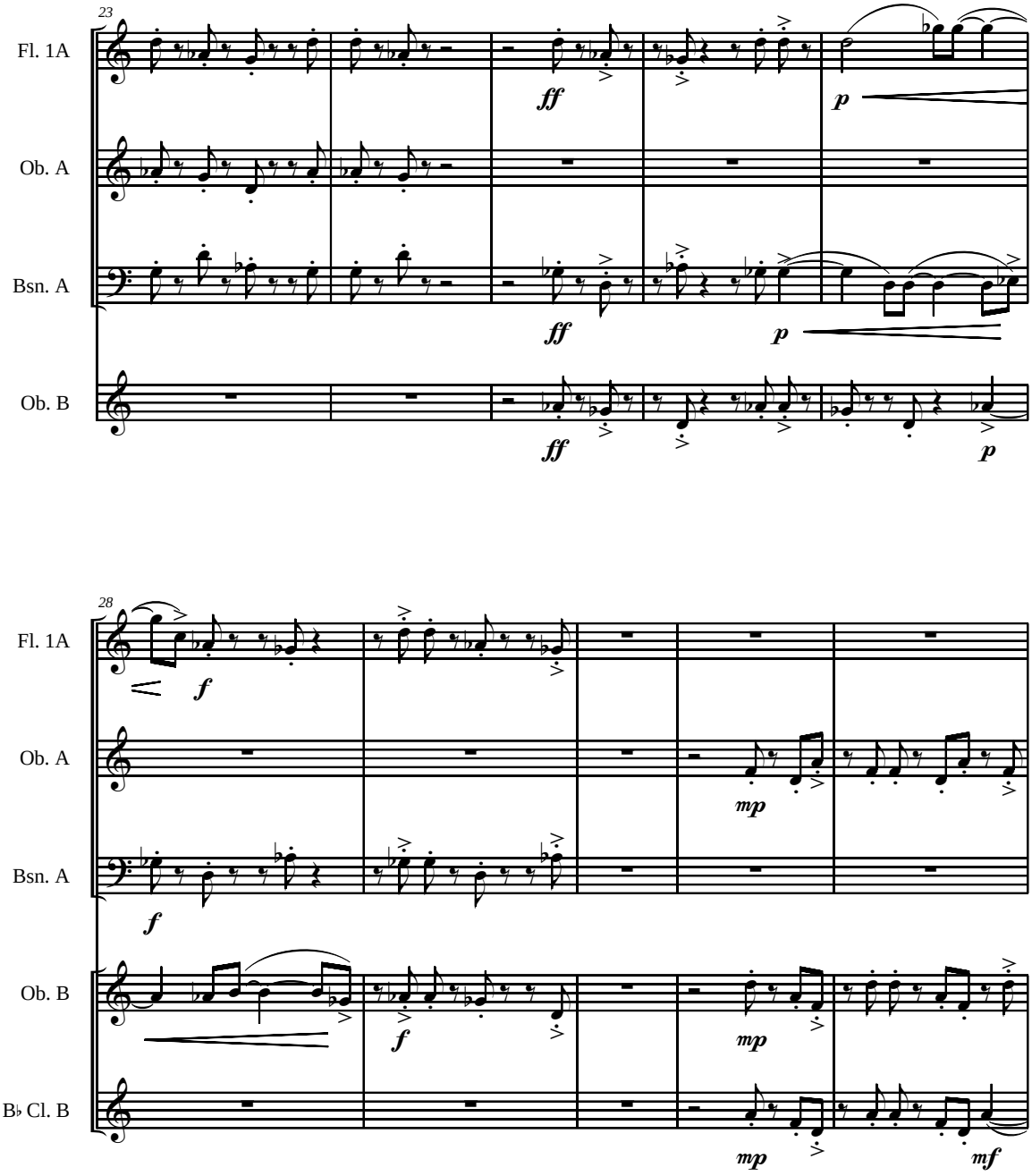
IV


♩= 152
Flute 1A
Flute 2A
Oboe A
Clarinet in B♭ A
Bassoon A
Flute 1B
Flute 2B
Oboe B
Clarinet in B♭ B
Bassoon B
mf
f
mf


5
Ob. A
B♭ Cl. A
Ob. B
mf
f
mf
f
mf
10
Ob. A
B♭ Cl. A
mf
mf
10
Fl. 1B
Ob. B
Bsn. B
mp
f
mp
f
mp
mp
f
mp

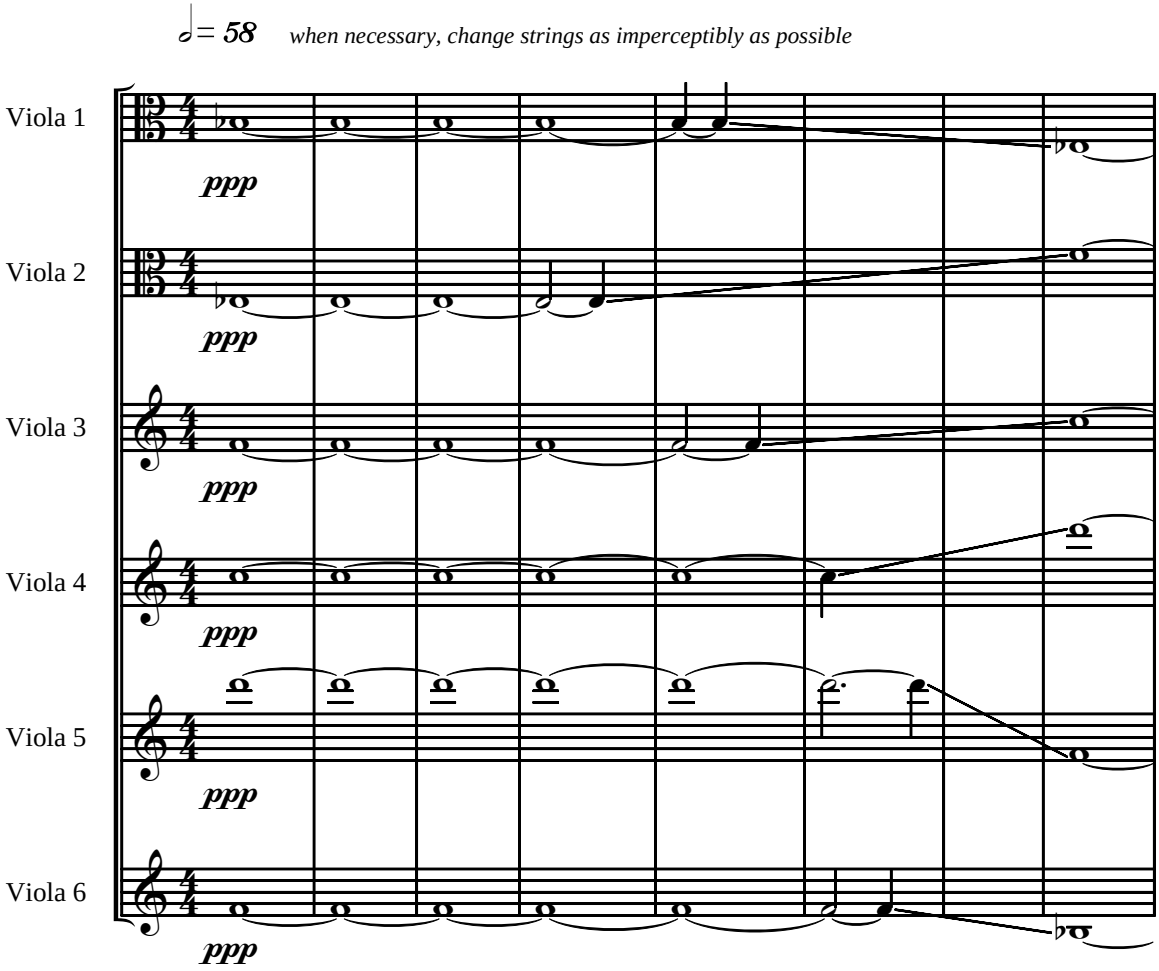

14
Fl. 2A
Ob. A
14
Fl. 1B
Ob. B
Bsn. B
p
f
mp

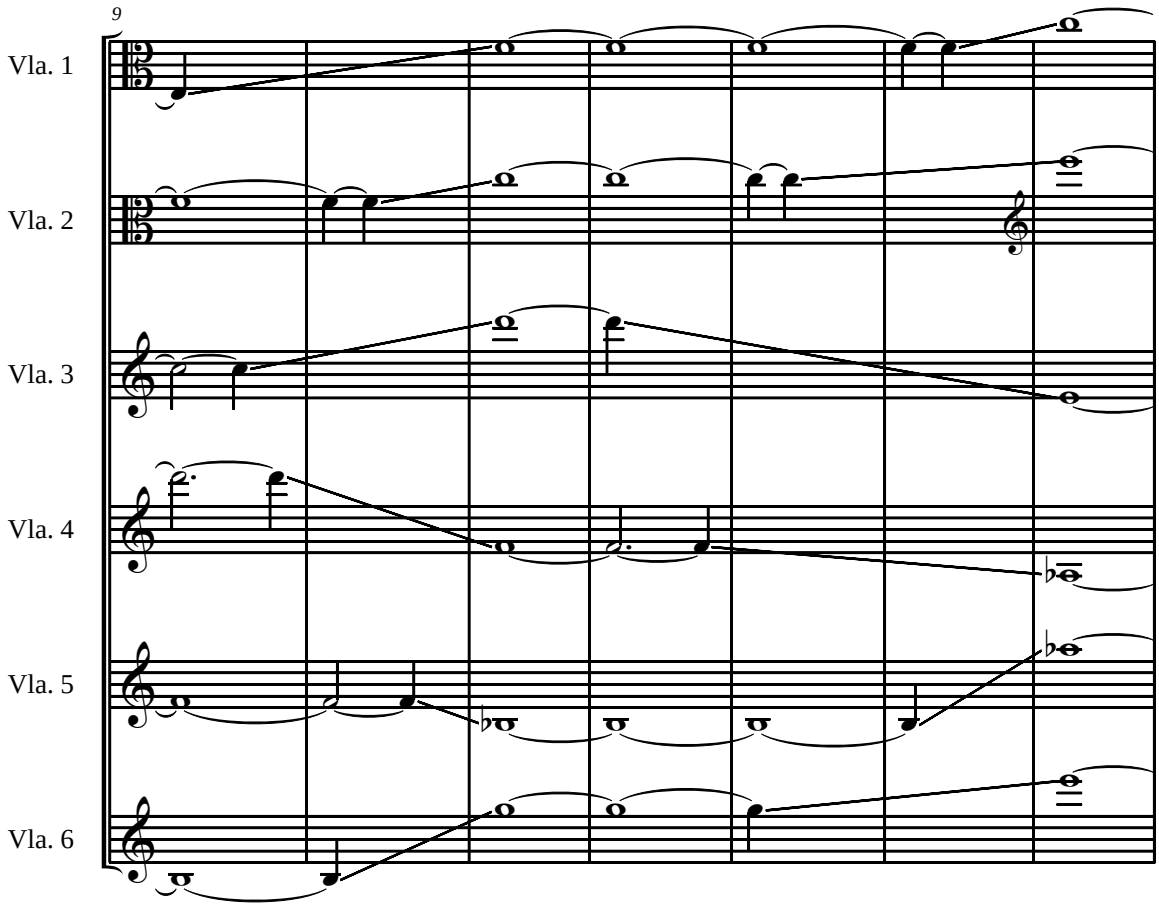

19
Fl. 1A
Fl. 2A
Ob. A
Bsn. A
Ob. B
p
mf
f

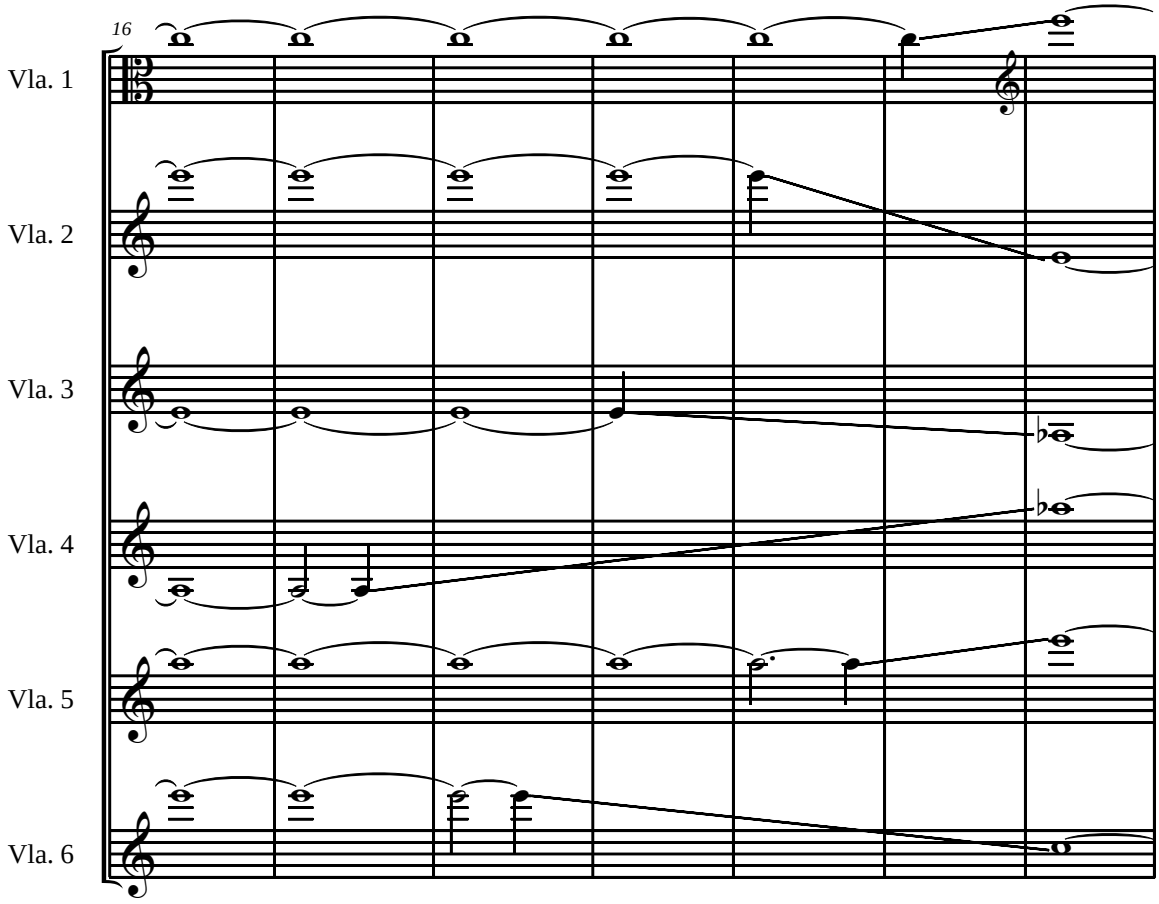

23
Fl. 1A
Ob. A
Bsn. A
Ob. B
ff
p
28
B♭ Cl. B
mp
mf

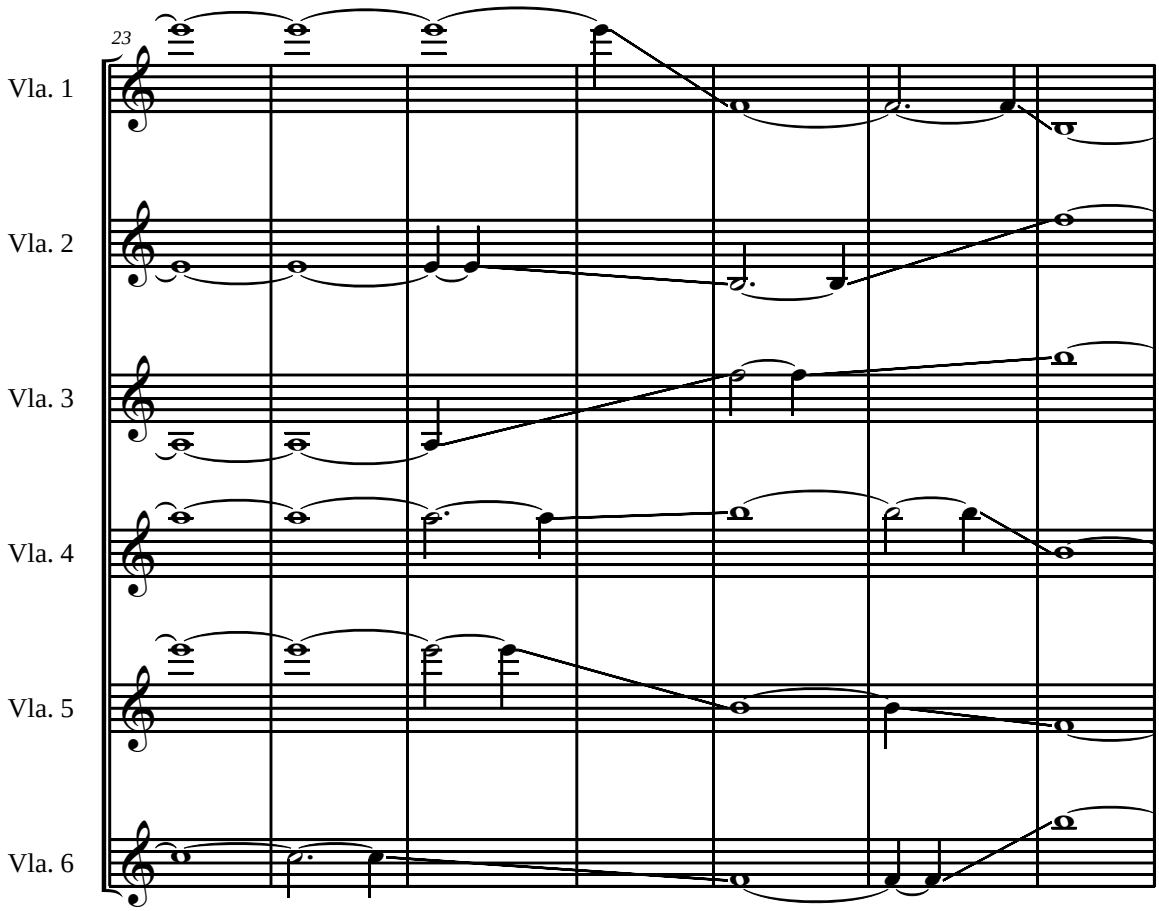
V

for C.T.A.

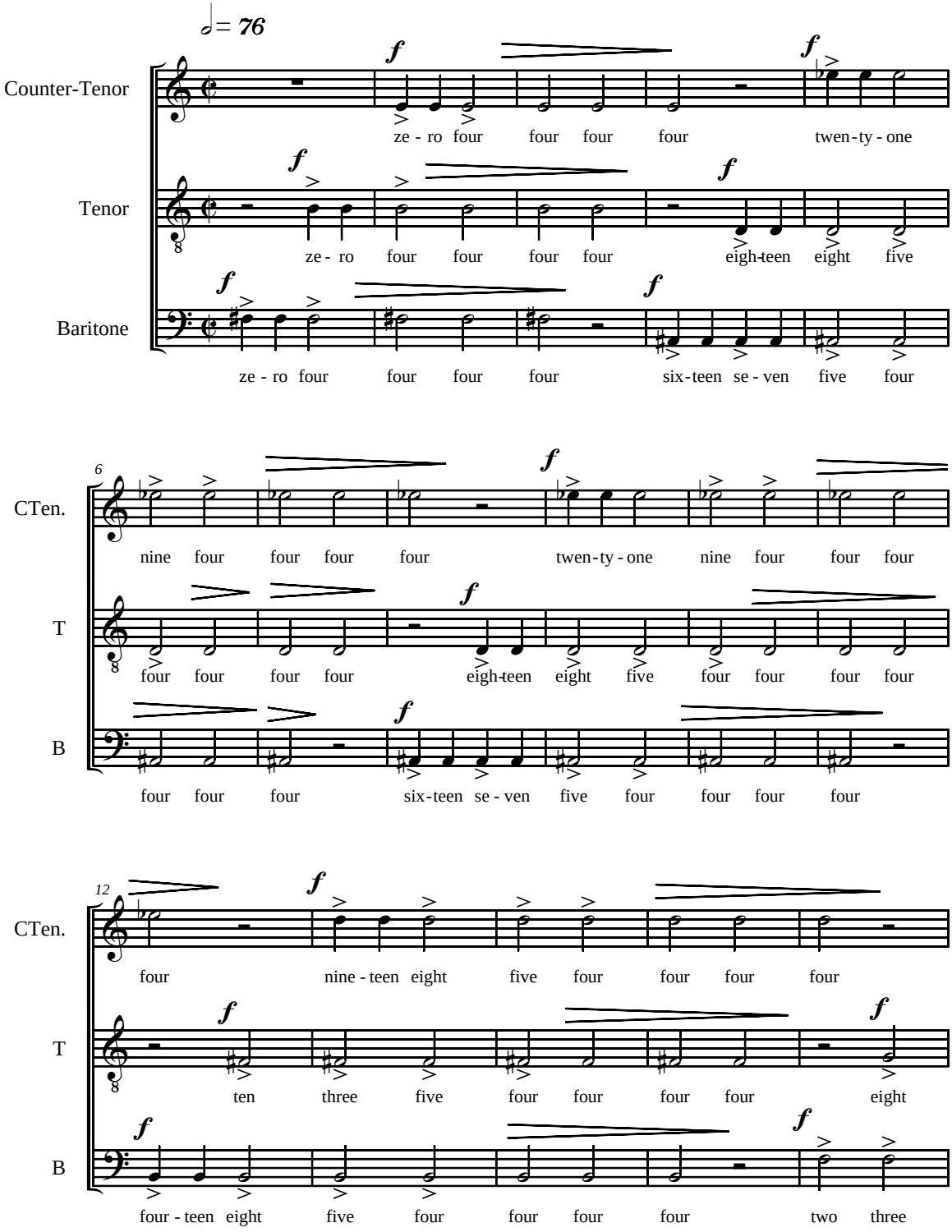

𝅗𝅥 = 58
when necessary, change strings as imperceptibly as possible
Viola 1
Viola 2
Viola 3
Viola 4
Viola 5
Viola 6
ppp

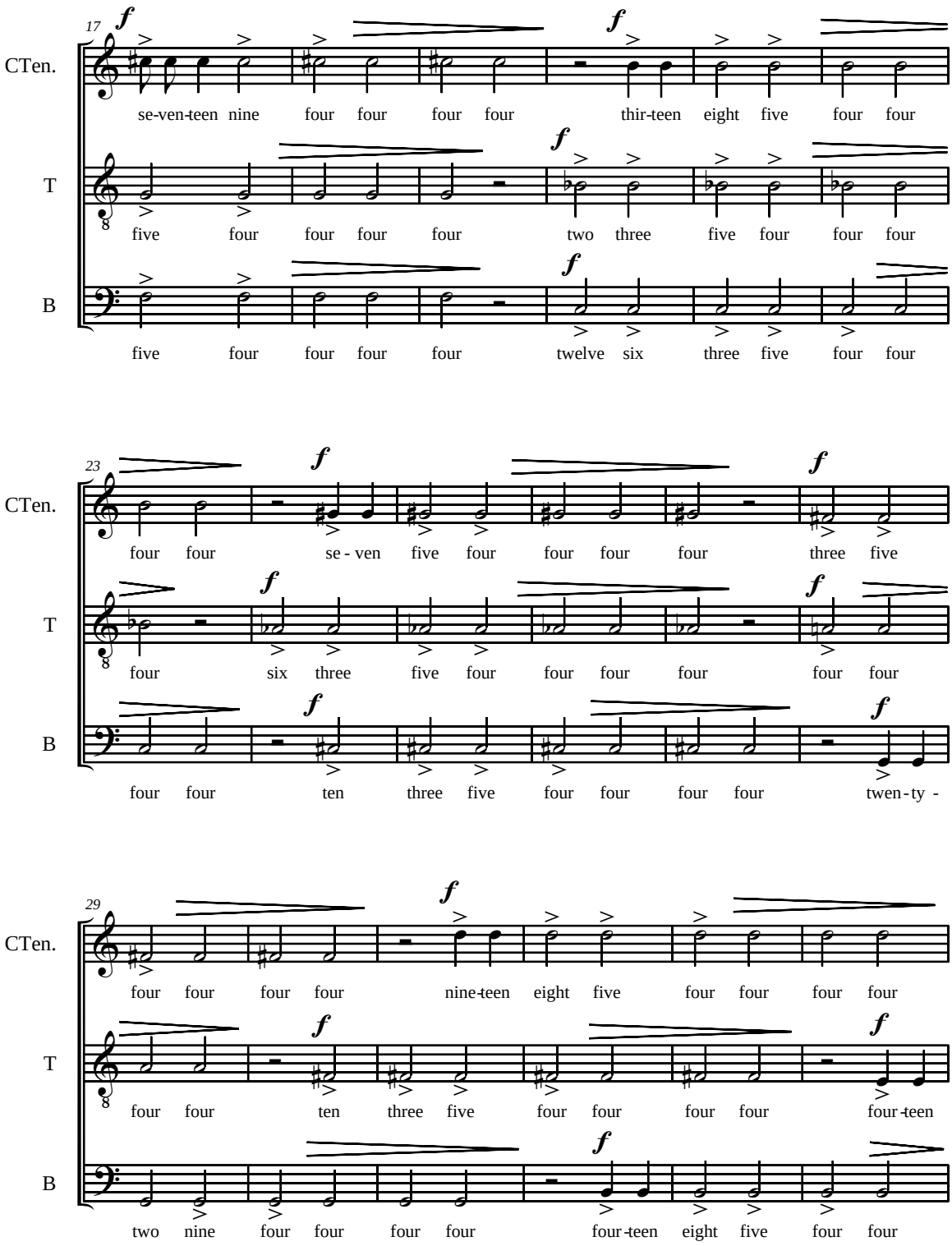

9
Vla. 1
Vla. 2
Vla. 3
Vla. 4
Vla. 5
Vla. 6


16
Vla. 1
Vla. 2
Vla. 3
Vla. 4
Vla. 5
Vla. 6

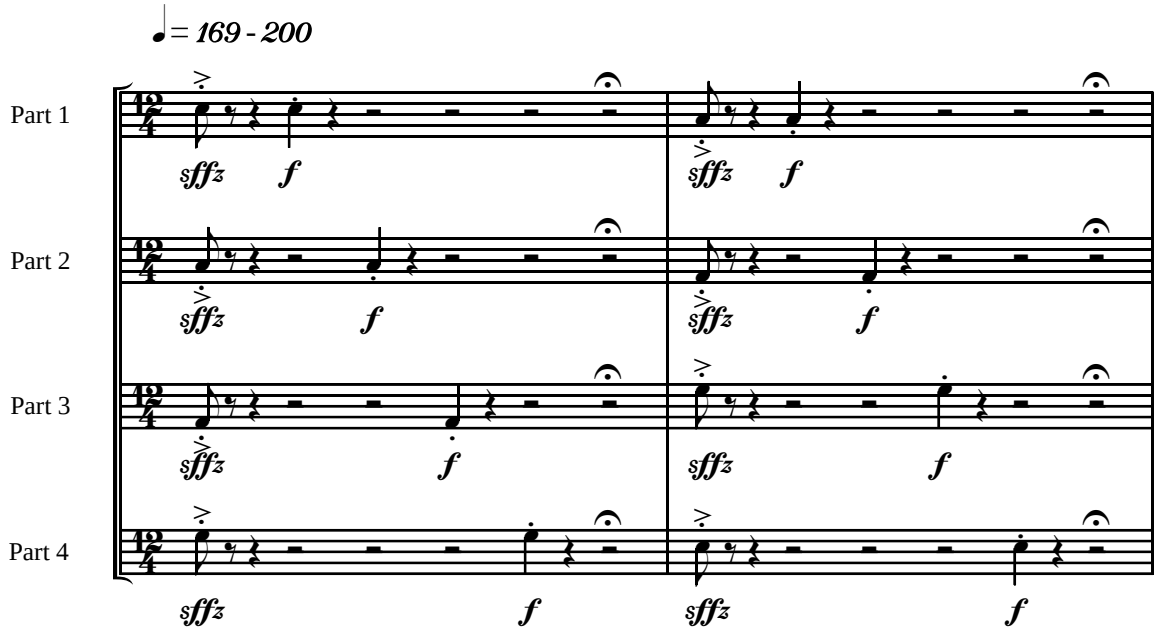

23
Vla. 1
Vla. 2
Vla. 3
Vla. 4
Vla. 5
Vla. 6

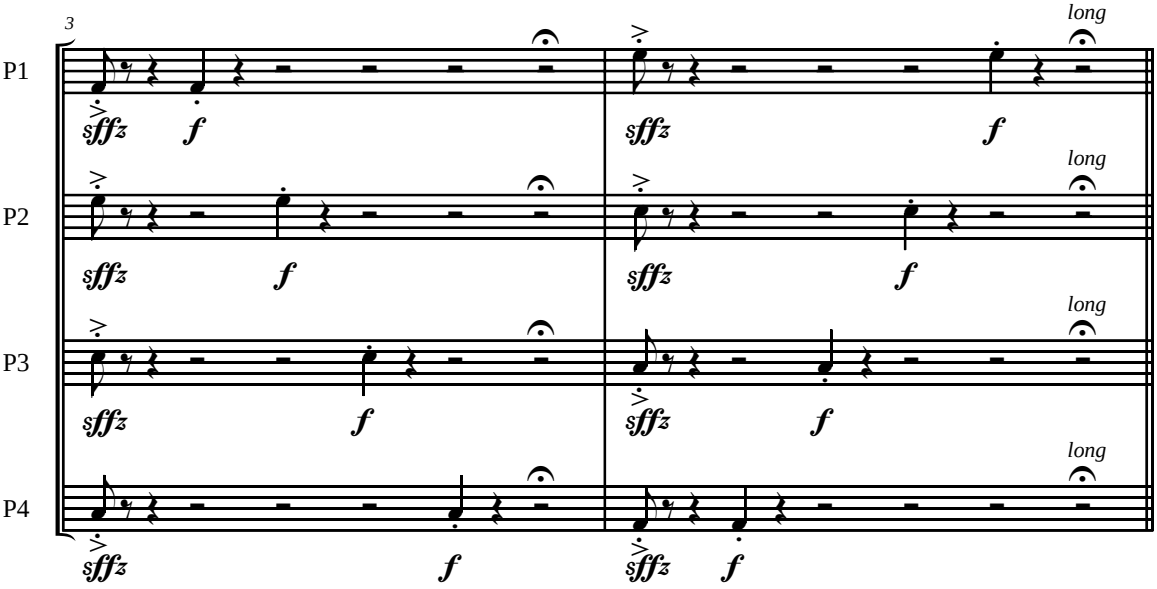
VI

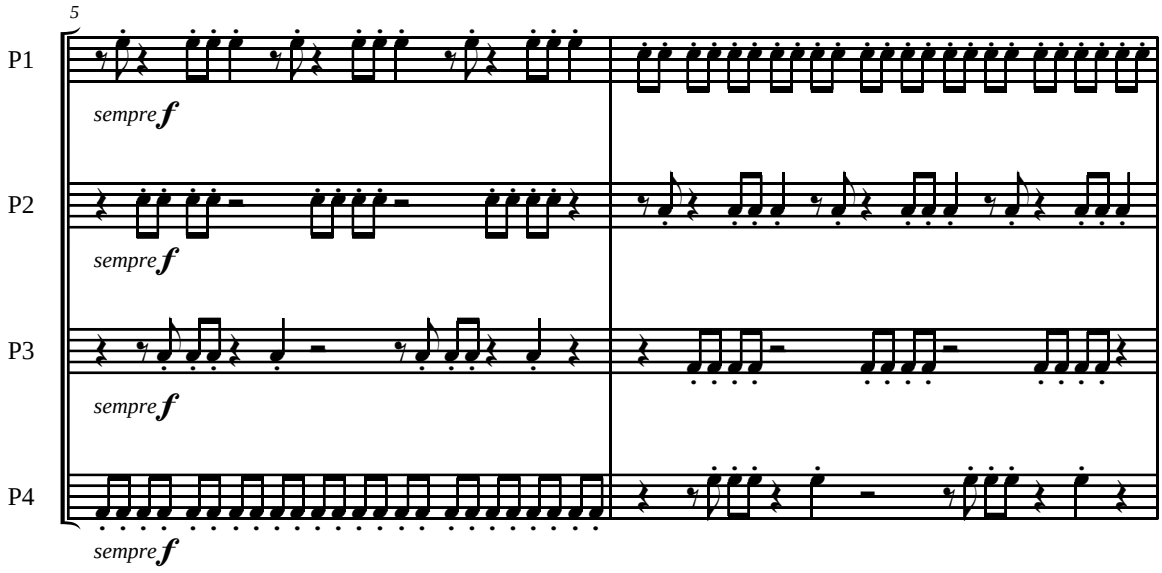

♩= 76
Counter-Tenor
Tenor
Baritone
ze - ro four four four four twen-ty - one
ze - ro four four four four eigh-teen eight five
ze - ro four four four four six-teen se - ven five four
6
CTen.
T
B
nine four four four four twen-ty - one nine four four four
four four four four eigh-teen eight five four four four four
four four four six-teen se - ven five four four four four
12
CTen.
T
B
four nine - teen eight five four four four four
ten three five four four four four eight
four - teen eight five four four four four two three

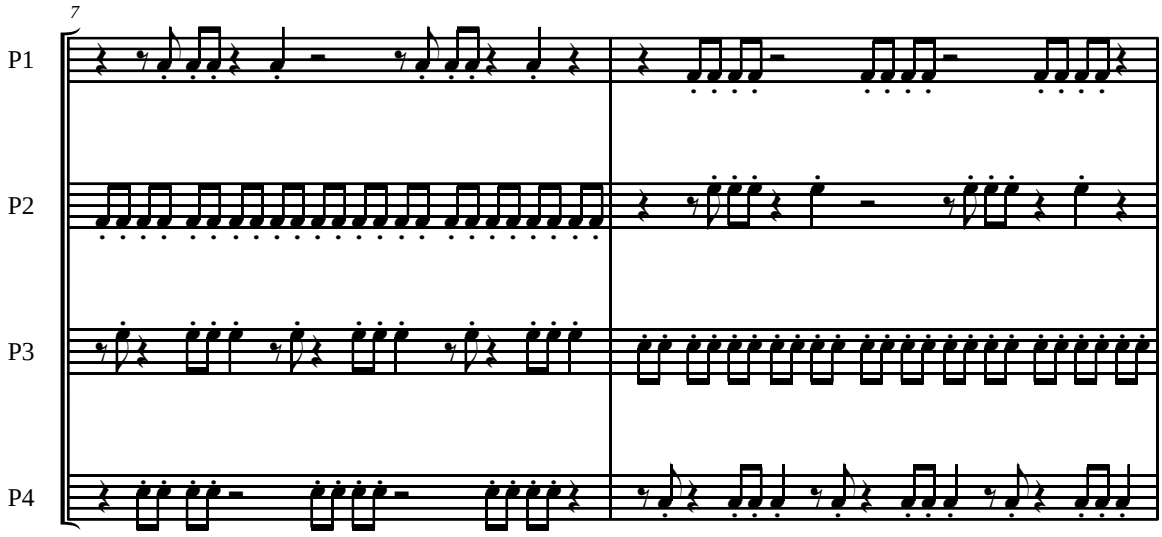

17
CTen.
T
B
f
se-ven-teen nine four four four four thir-teen eight five four four
five four four four four two three five four four four
five four four four four twelve six three five four four
23
four four se - ven five four four four four three five
four six three five four four four four four four
four four ten three five four four four four twen - ty -
29
four four four four nine-teen eight five four four four four
four four ten three five four four four four four-teen
two nine four four four four four-teen eight five four four

VII






5
P1
sempre f
P2
sempre f
P3
sempre f
P4
sempre f


7
P1
P2
P3
P4

Performance Notes for VII

- This piece is written for at least four players, playing any instrument(s) capable of making four separate sounds. When there are more than four players, the ensemble should distribute the parts as uniformly as possible.

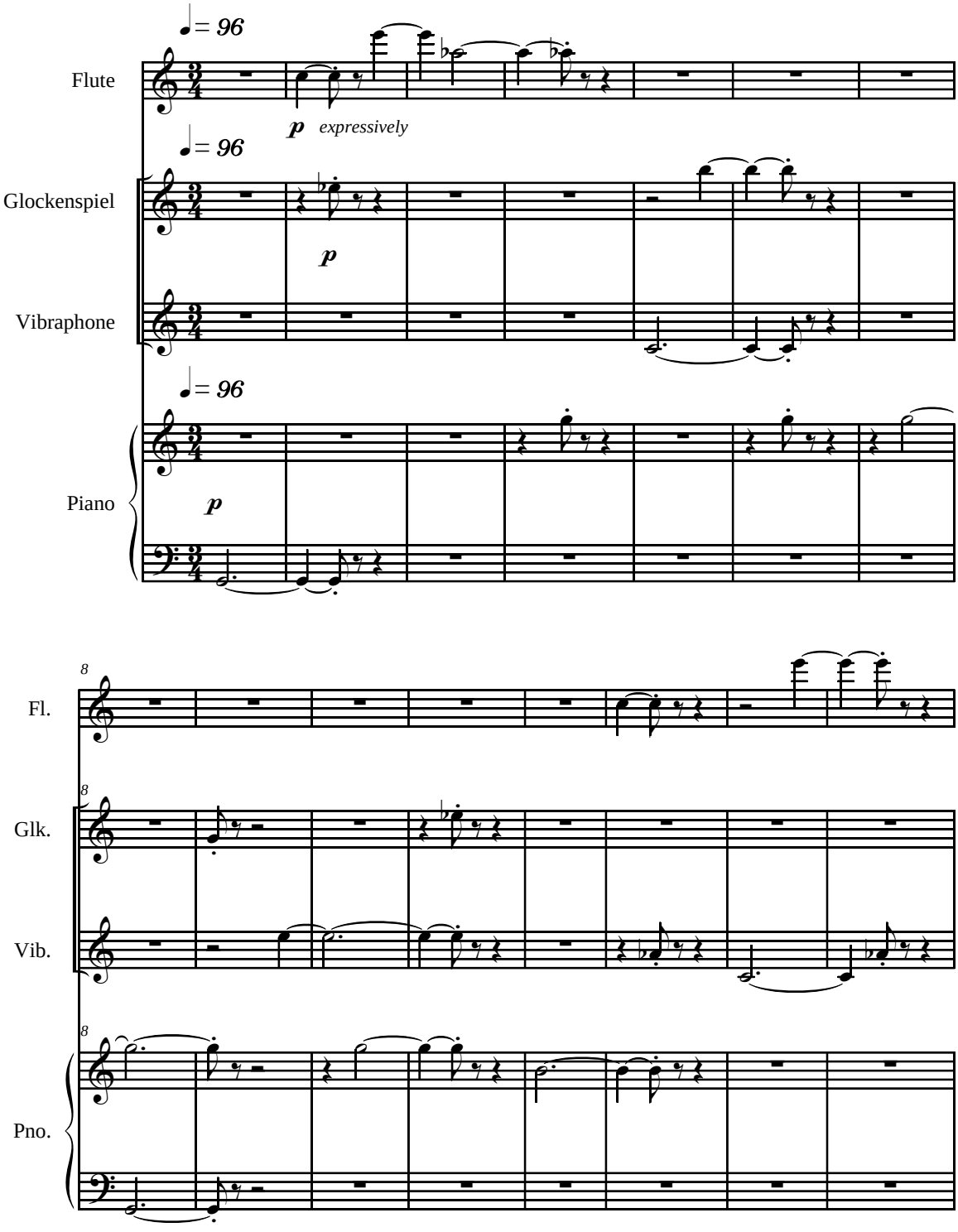
- Each space on the five-lined staff represents one of four sounds a player can make. These sounds should be different in at least one aspect (e.g., pitch, timbre, instruments, etc.) aside from volume, which should be *forte* throughout unless otherwise marked.

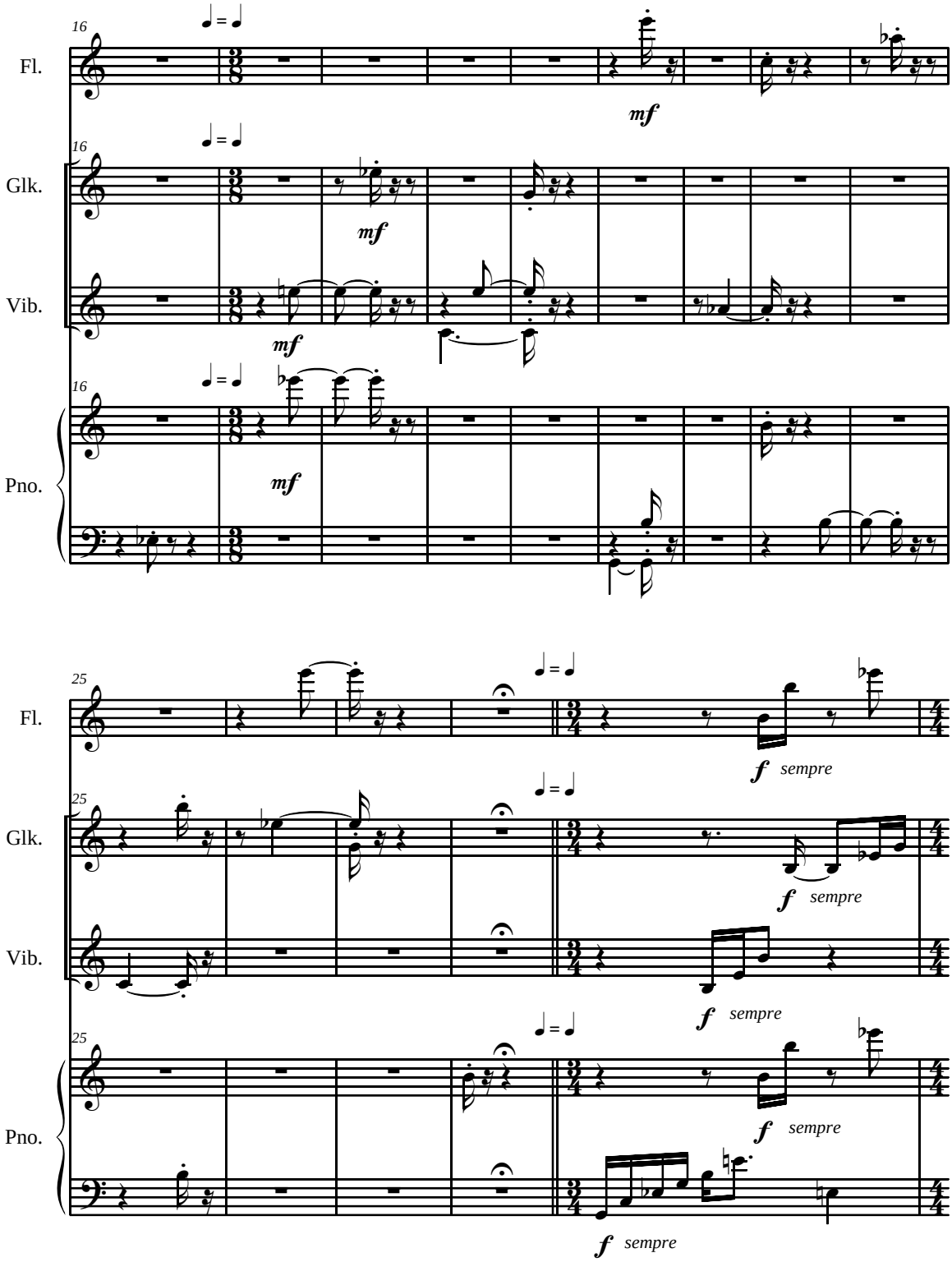
- The top space on a player's staff should represent the "highest" (in some aspect) of the four sounds; the bottom space on a player's staff should represent the "lowest" (in some aspect) of the four sounds; and so on.

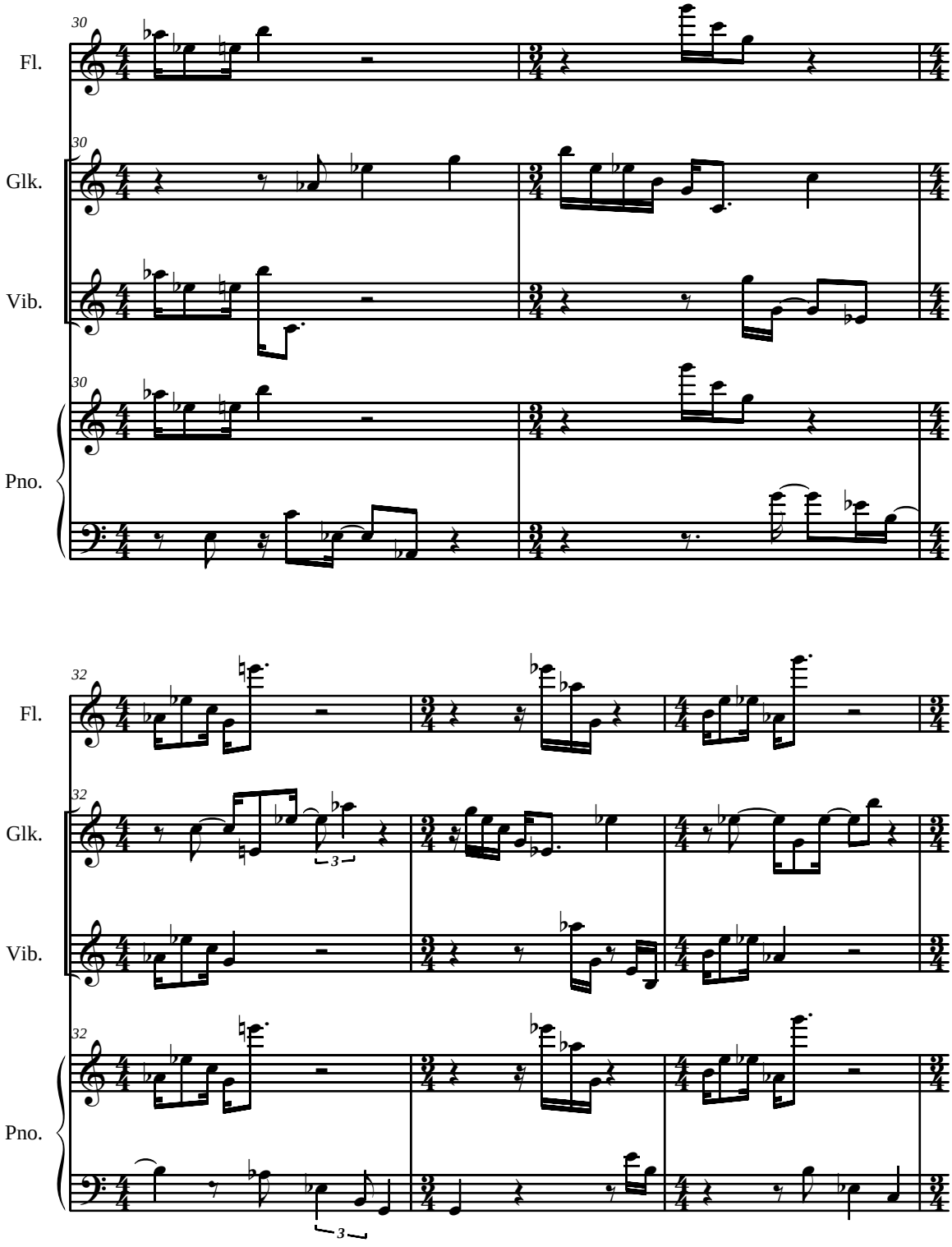
- If using instruments that can be ranked from "highest" to "lowest" (in some aspect): Part 1 should be played by the "highest" of the four instruments; Part 4 should be played by the "lowest" of the four instruments; and so on.

- Examples of sound combinations:
    - Two violins, viola, and 'cello each playing, in its respective clef, *pizzicato* pitches as if notated on a traditional five-lined staff.
    - Flute, oboe, clarinet, and bassoon each playing pitches in their high to extreme-high range (for the top-space notes), medium to high range (for the second-space notes), low to medium range (for the third-space notes), and extreme-low to low range (for the bottom-space notes).
    - Electronic instruments using four different types of sound synthesis.

VIII

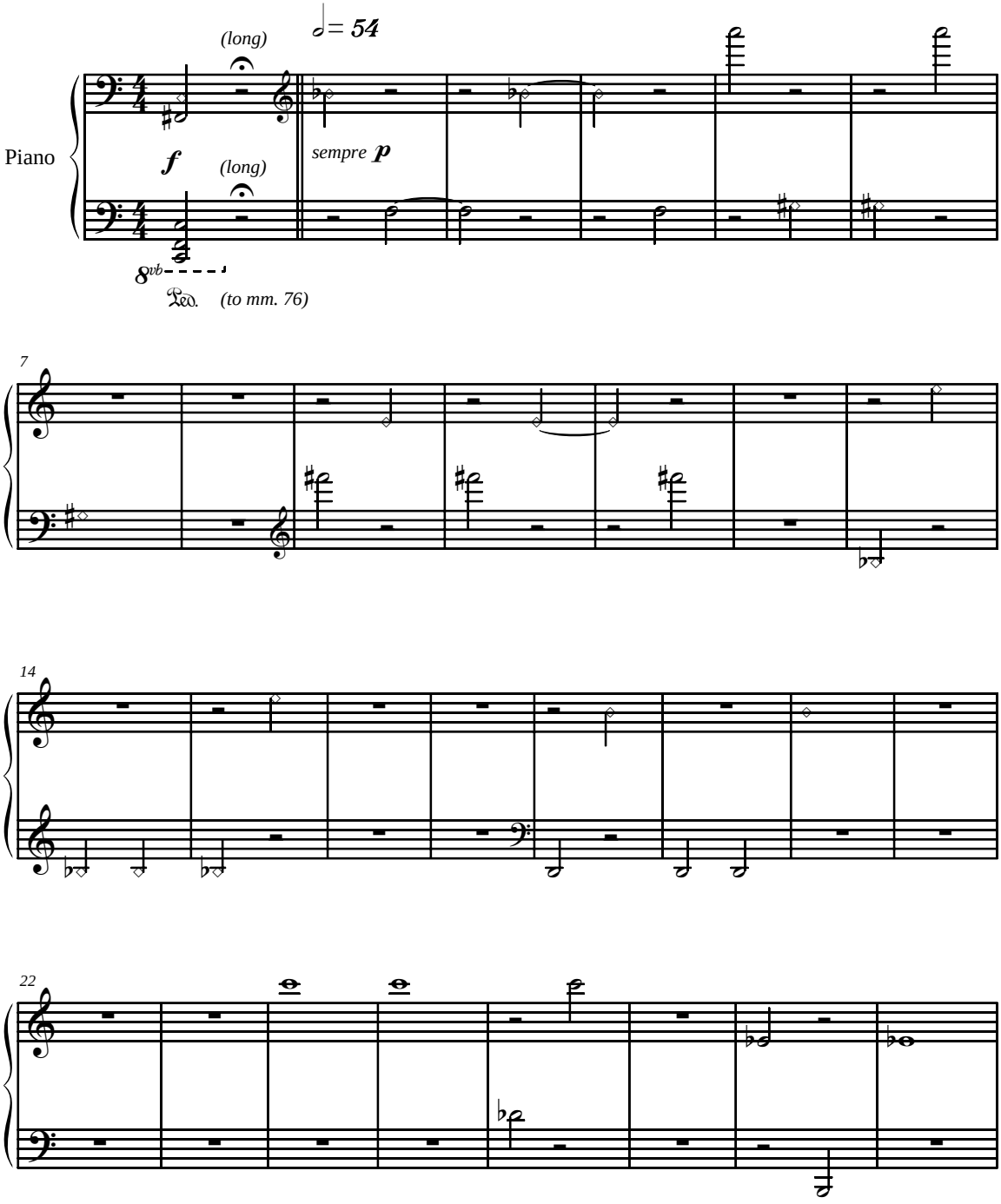

♩ = 96
Flute
p expressively
♩ = 96
Glockenspiel
p
Vibraphone
♩ = 96
Piano
p
8
Fl.
8
Glk.
Vib.
8
Pno.

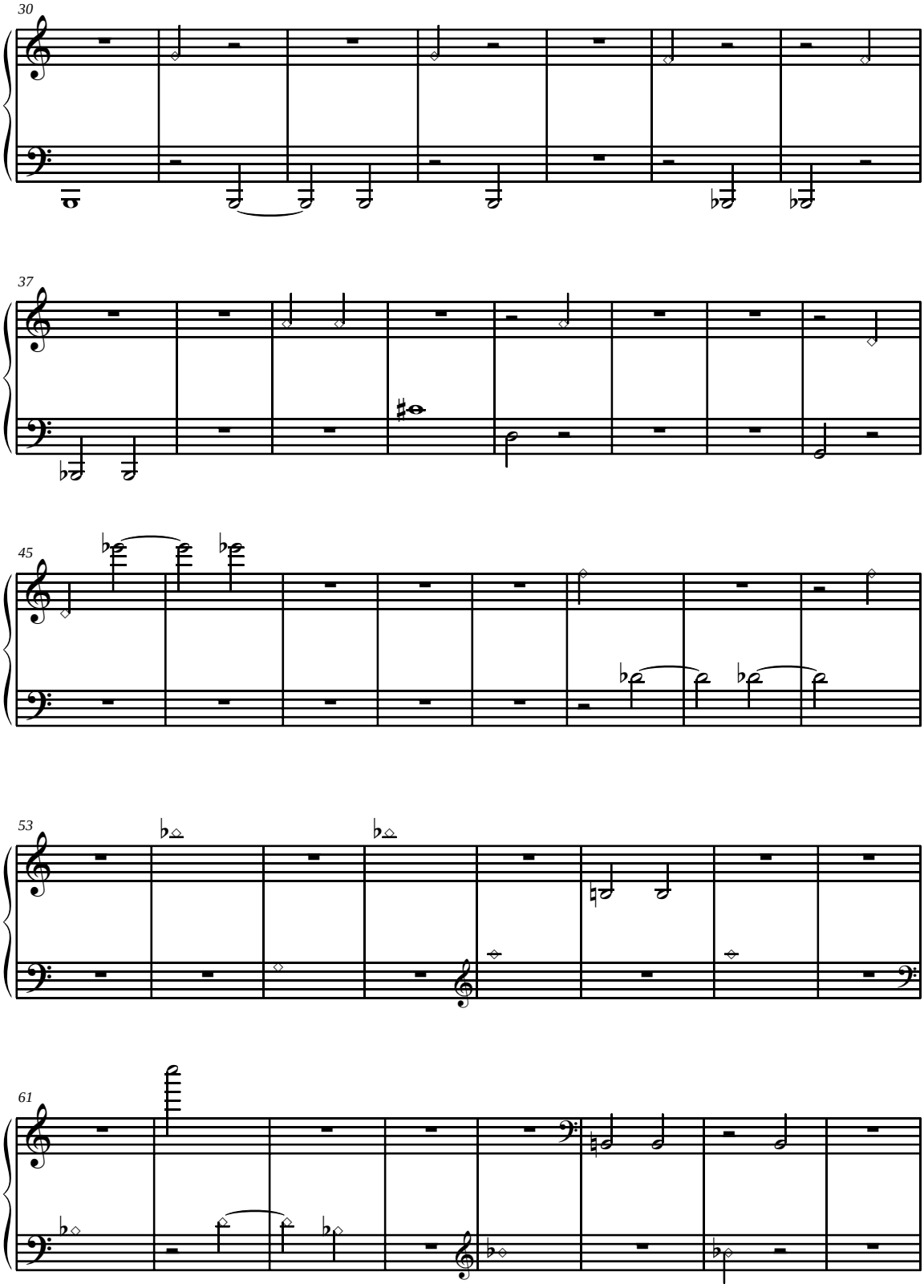

16
Fl.
Glk.
Vib.
Pno.
mf
25
f sempre

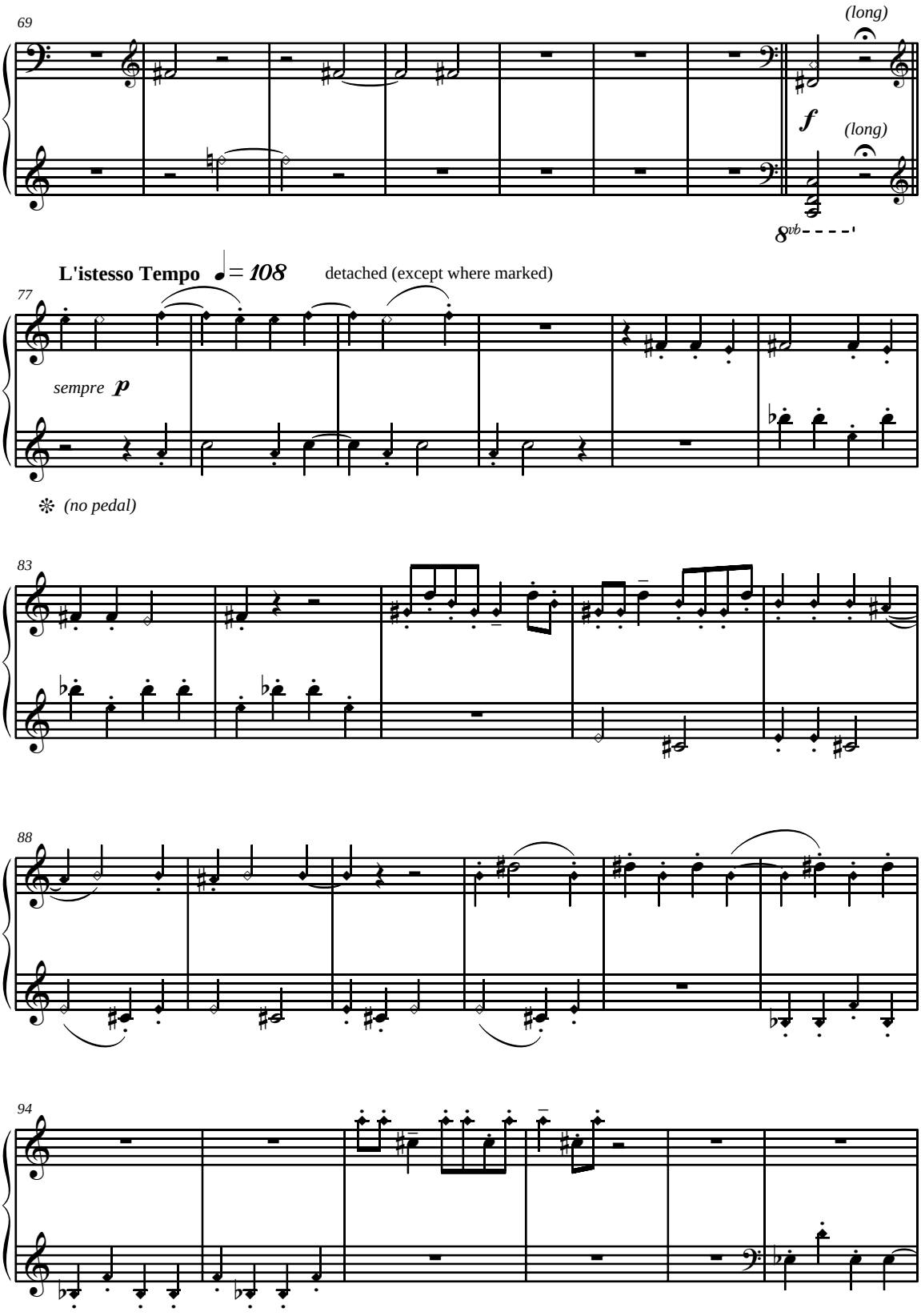

30
Fl.
30
Glk.
Vib.
30
Pno.
32
Fl.
32
Glk.
Vib.
32
Pno.
3
3

IX

for T.S.

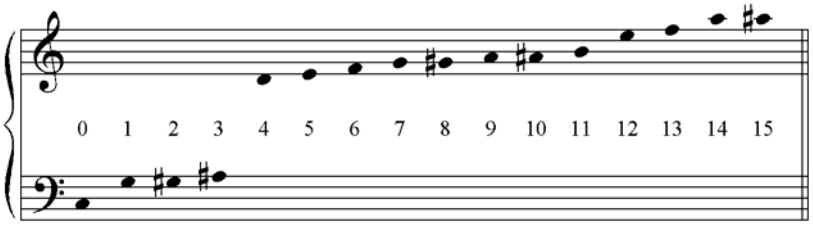



30
37
45
53
61


69
(long)
f
(long)
8vb
L'istesso Tempo ♩= 108
detached (except where marked)
77
sempre p
(no pedal)
83
88
94

Performance Notes for IX

- This piece is written for piano and live electronics. The piano is to be prepared with small piezo sensors attached to the strings with poster clay. There are sixteen sensors total which should be applied to the following notes:



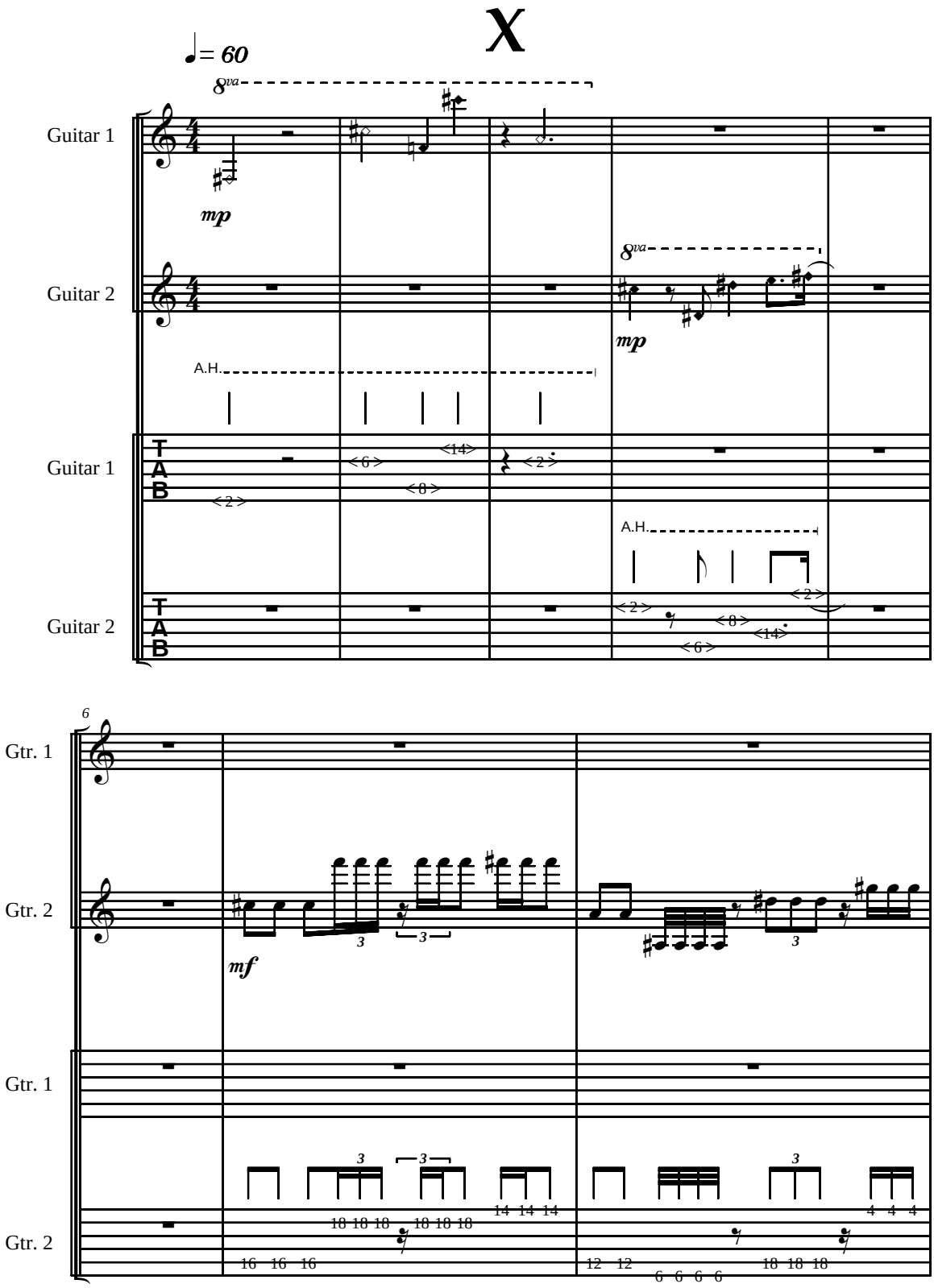
- The sensors act as triggers inside a computer music program written in Max/MSP. The Pocket Material CD includes, inside the "Residual-9" folder, all the necessary components to run the program. The file *Residual-9.pat* is the main program to be run in the Max/MSP environment (see http://cycling74.com). Be sure to change the File Preferences in Max/MSP so that it is directed to the "Residual-9" folder.

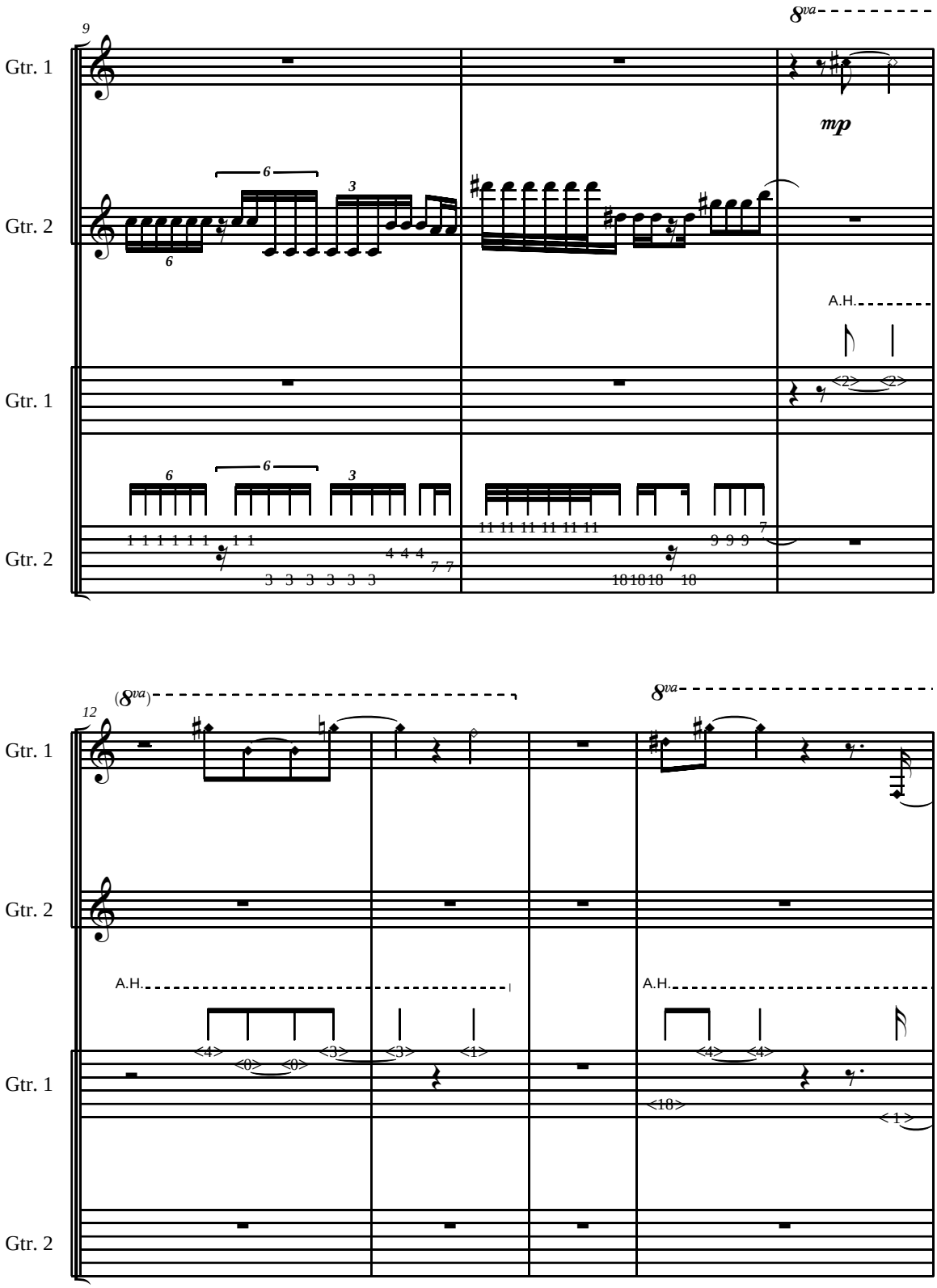
- At the time of this writing, Teleo hardware modules (one "Analog In" module, and one "Multi I/O" module) were used as the interface for transmitting sensor information to the computer. Currently, the makers of Teleo (see http://makingthings.com) have discontinued the product, so obtaining the modules in the future may be difficult. The Max/MSP program can be easily modified, however, to accommodate other compatible sensor interfaces.

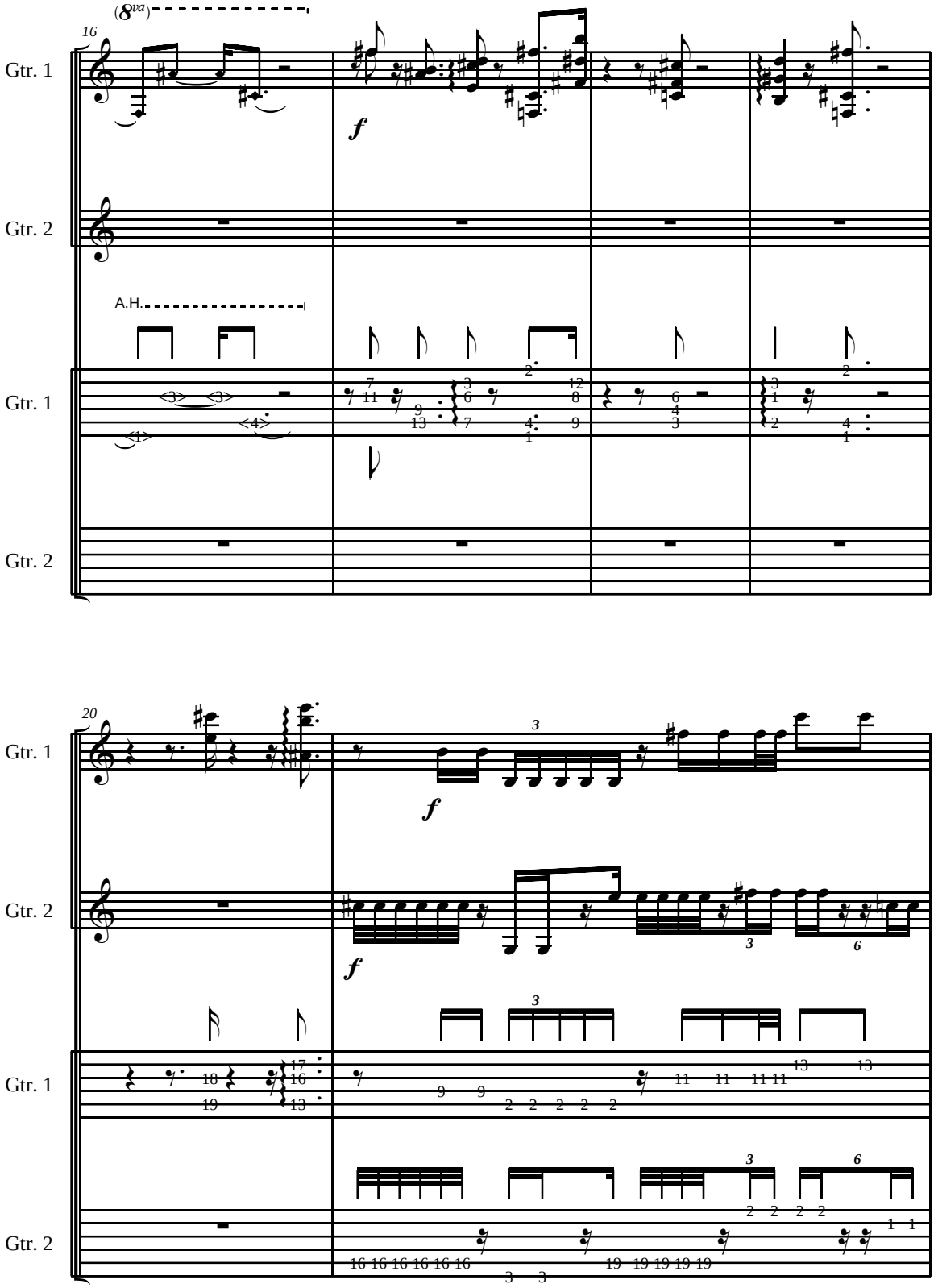
- *Residual-9.pat* is quite demanding on the computer's processor during operation. At the time of this writing, the piece is performable from a Macintosh MacBook Pro laptop computer running Mac OS X, v. 10.4.8, with a 2.16 GHz Intel Core 2 Duo processor and 2 GB of SDRAM memory.

- Notes about the piano score:
    - Diamond shaped noteheads indicate prepared notes. This serves merely to inform the performer, and treatment of these notes should not be modified in any way.
    - Sensor 0 (attached to the C below middle-C) triggers the beginning, the end, and switches between sections in the middle of the piece.
    - The B section of the piece should be rhythmically coordinated with the electronic sounds. This can be achieved by adjusting the object labeled "B section tempo" (in pink) in the main program.

- Be sure to adjust all pink colored objects inside *Residual-9.pat* to appropriate levels for the intended sound system. If repeat performances with the same sound system are planned, the patches *drone~.pat*, *play-palms.pat*, *back-bank[1-5]-select.pat*, and *play[3, 4, 5, etc.].pat*, in addition to the master faders and B section tempo, can be modified to have specific settings loaded when the program is opened.

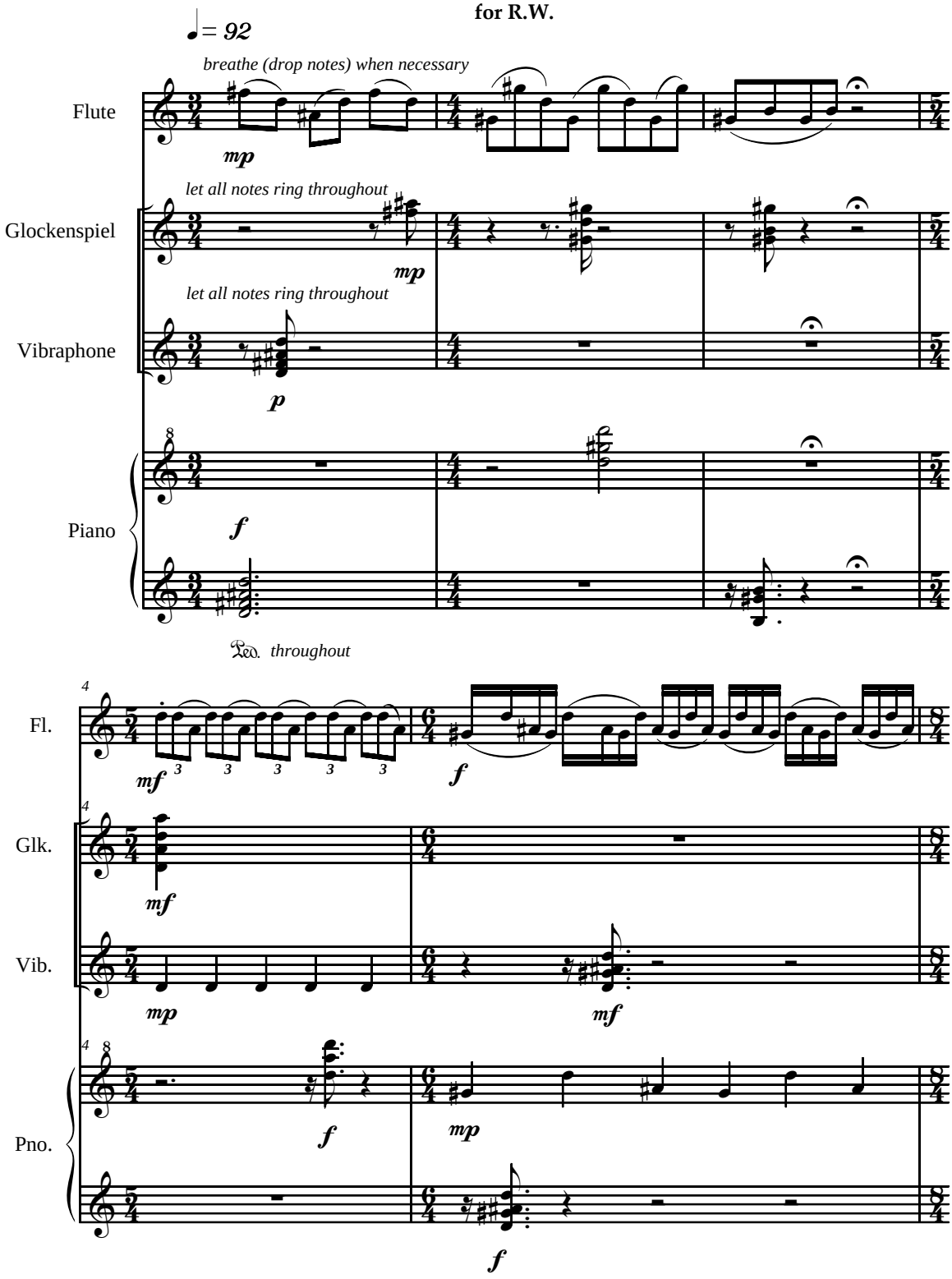

X
♩= 60
8va
Guitar 1
mp
Guitar 2
A.H.
T
A
B
Guitar 1
Guitar 2
6
Gtr. 1
Gtr. 2
mf
Gtr. 1
Gtr. 2

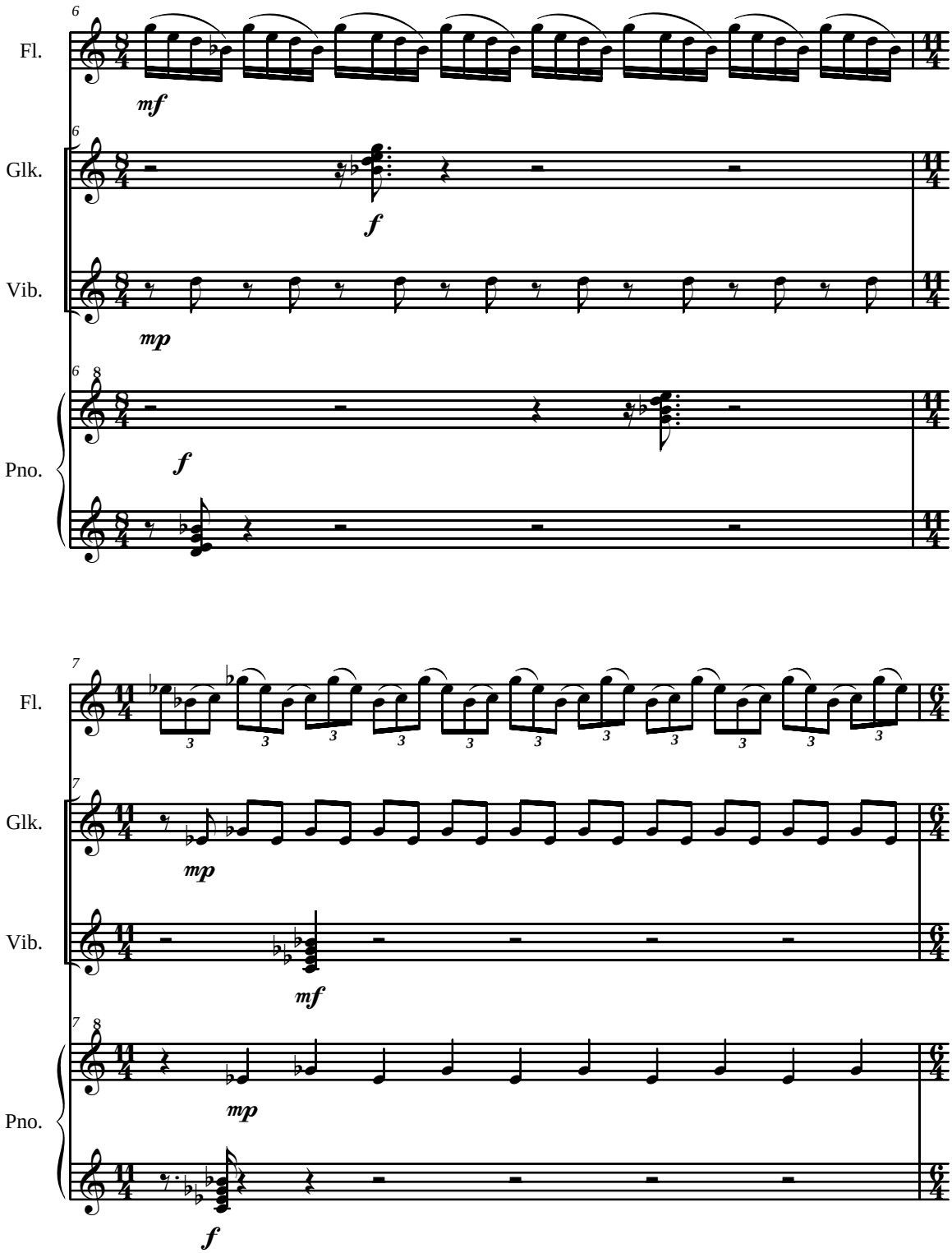

9
8va
Gtr. 1
Gtr. 2
mp
A.H.
Gtr. 1
Gtr. 2
12
(8va)
8va
Gtr. 1
Gtr. 2
A.H.
A.H.
Gtr. 1
Gtr. 2

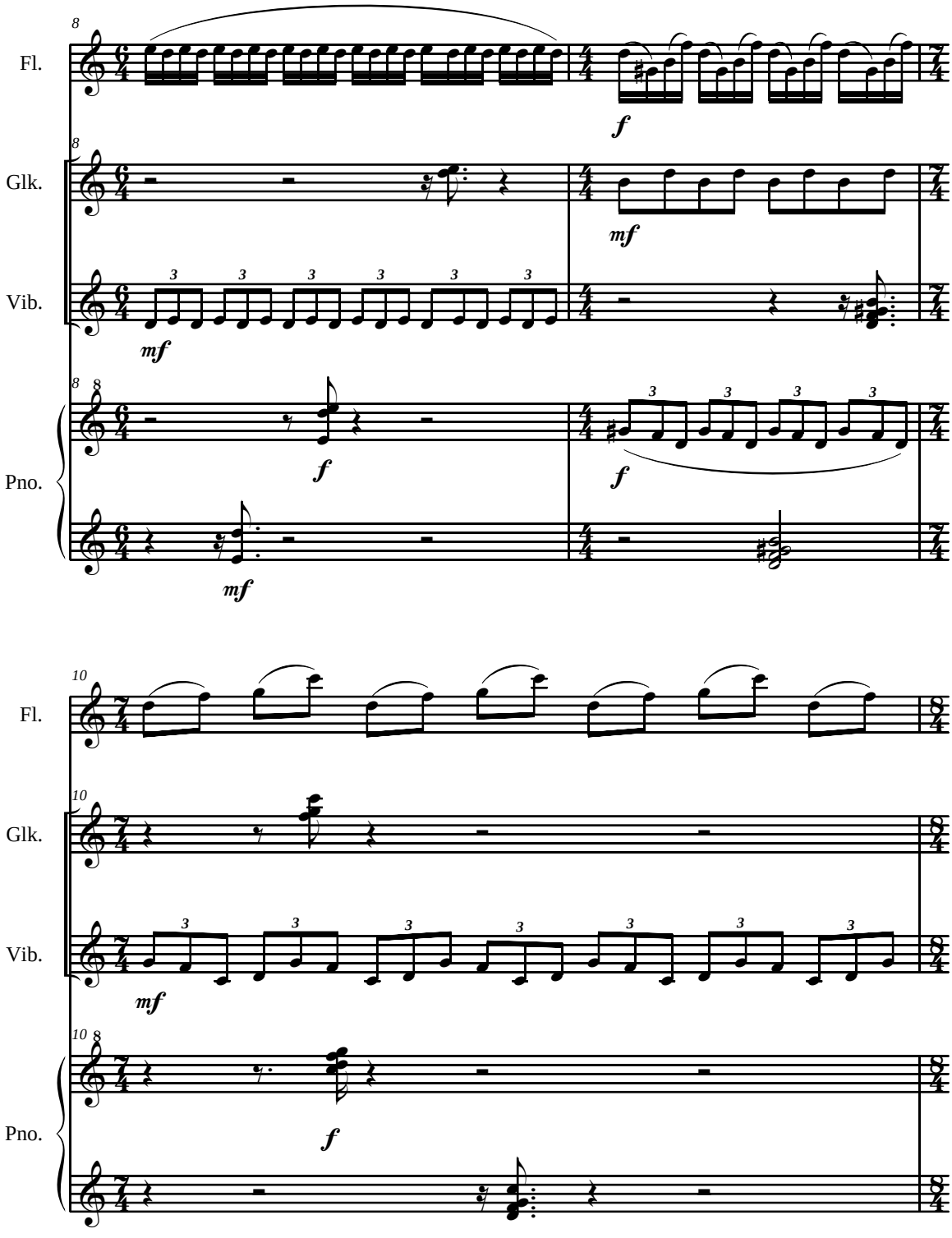

(8va)
16
Gtr. 1
Gtr. 2
A.H.
Gtr. 1
Gtr. 2
f
20
Gtr. 1
Gtr. 2
f
f
Gtr. 1
Gtr. 2

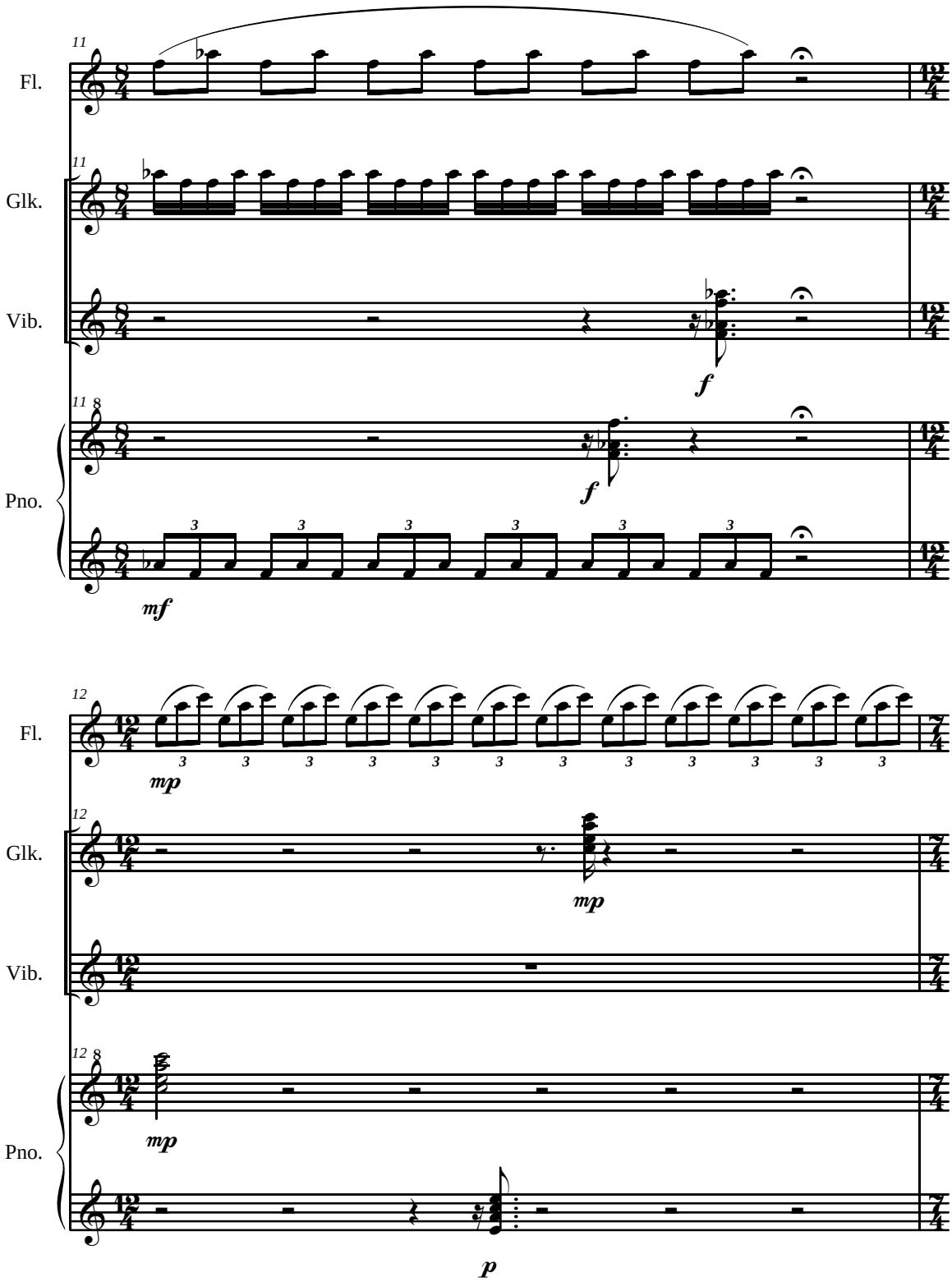
XI

for R.W.


♩= 92
breathe (drop notes) when necessary
Flute
mp
let all notes ring throughout
Glockenspiel
mp
let all notes ring throughout
Vibraphone
p
Piano
f
Ped. throughout
Fl.
mf
f
Glk.
mf
Vib.
mp
mf
Pno.
f
mp
f

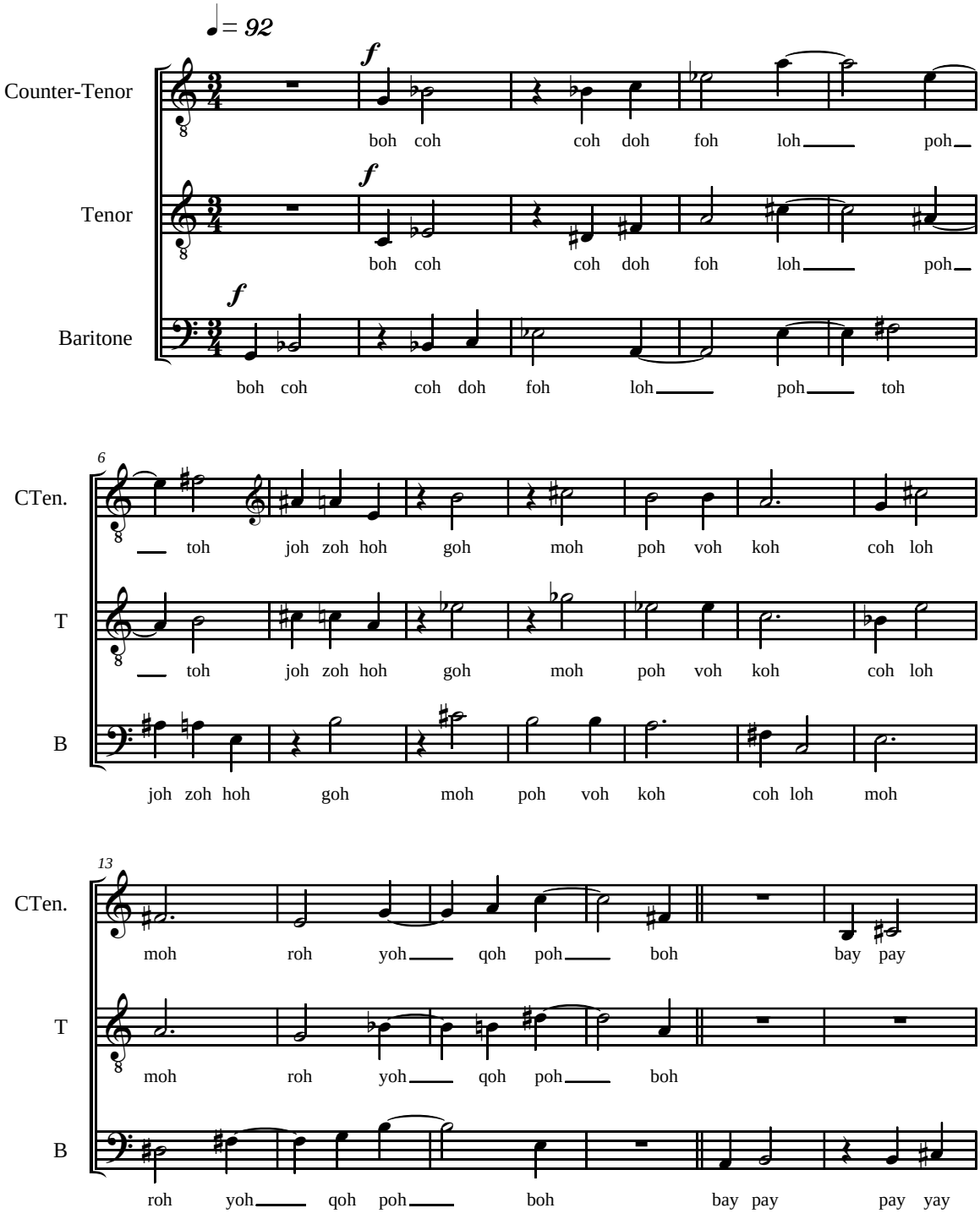

6
Fl.
mf
6
Glk.
f
Vib.
mp
6 8
Pno.
f
7
Fl.
7
Glk.
mp
Vib.
mf
7 8
Pno.
mp
f

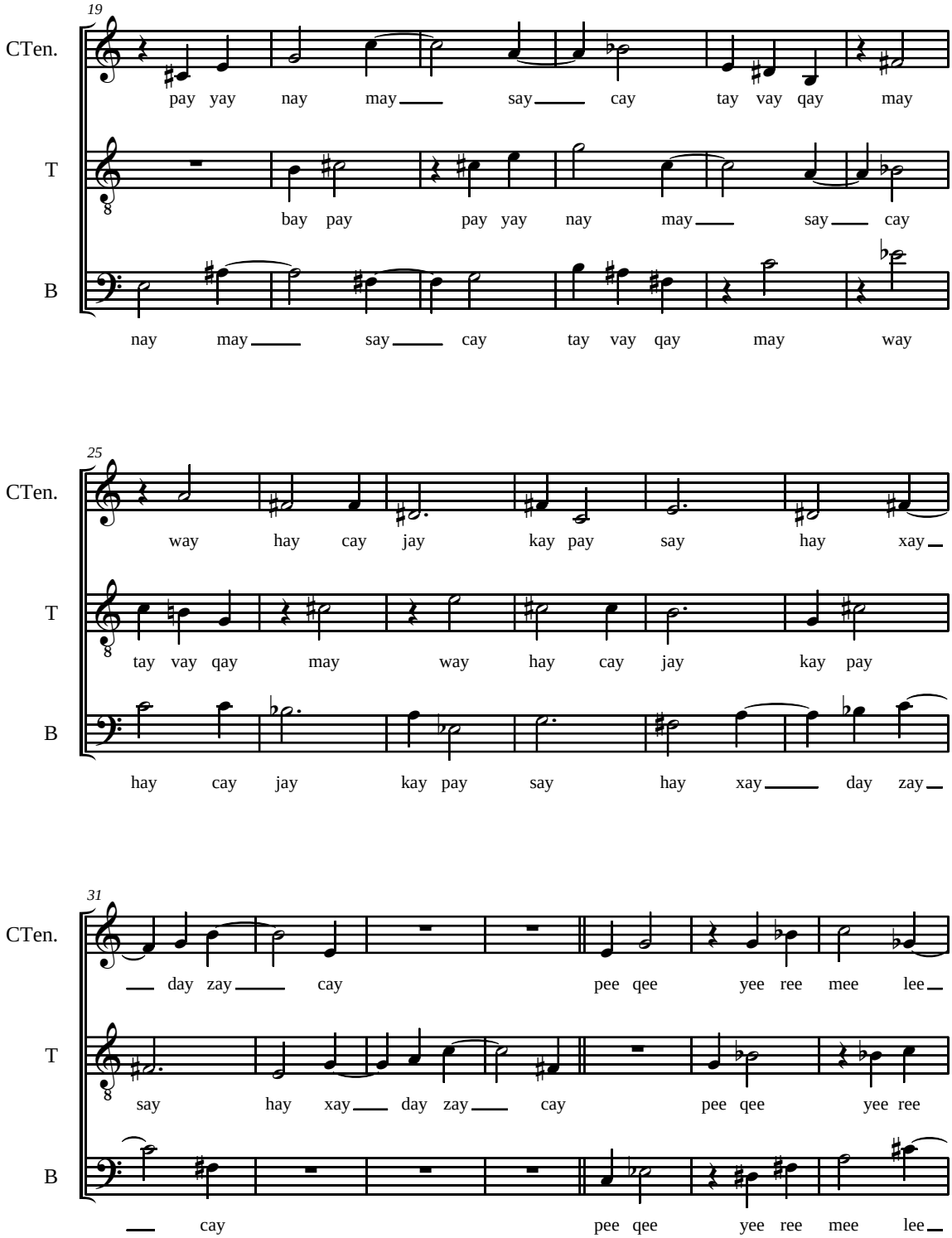

8
Fl.
Glk.
Vib.
Pno.
f
mf
10

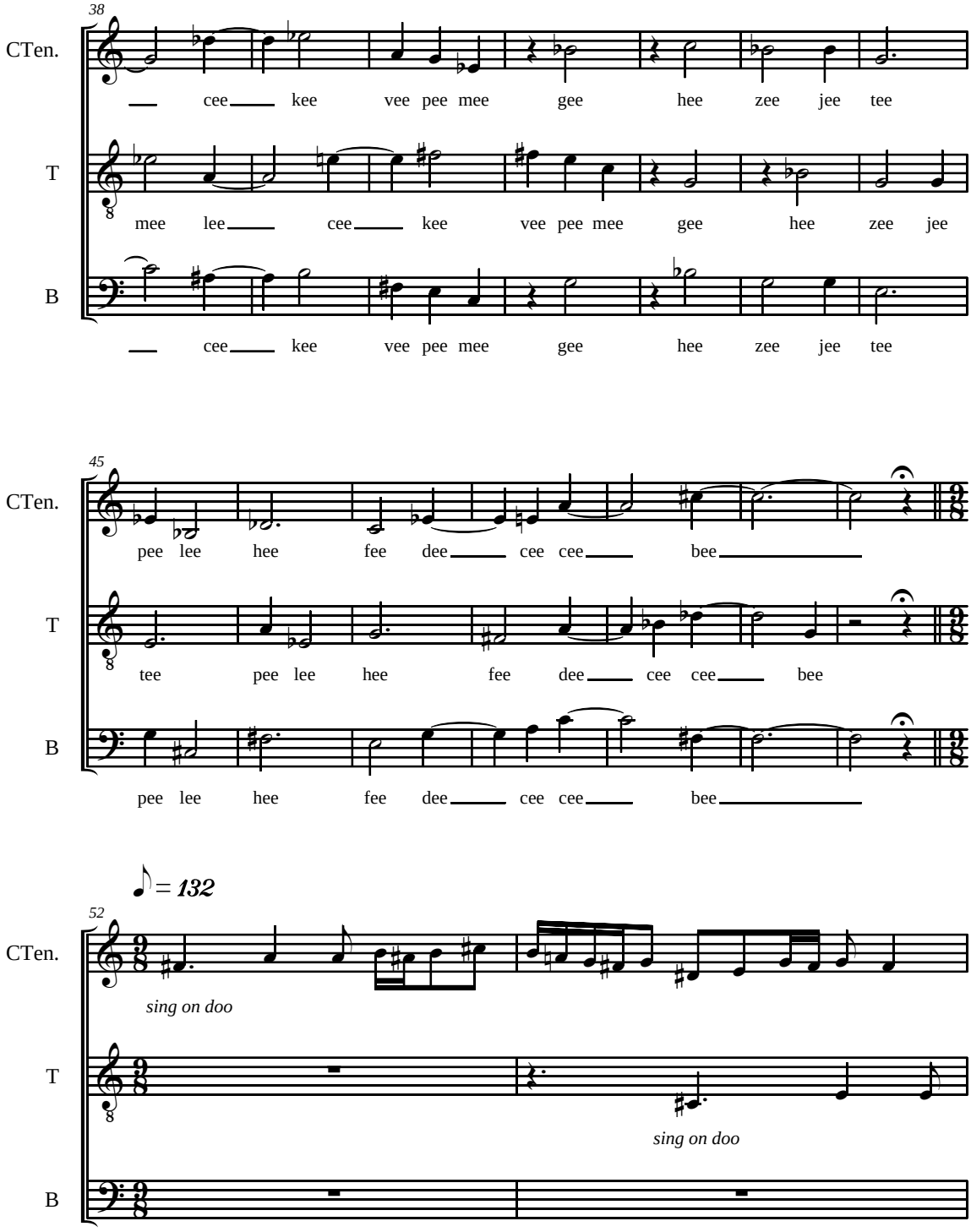

11
Fl.
11
Glk.
Vib.
f
11 8
Pno.
f
mf
12
Fl.
mp
12
Glk.
mp
Vib.
12 8
mp
Pno.
p

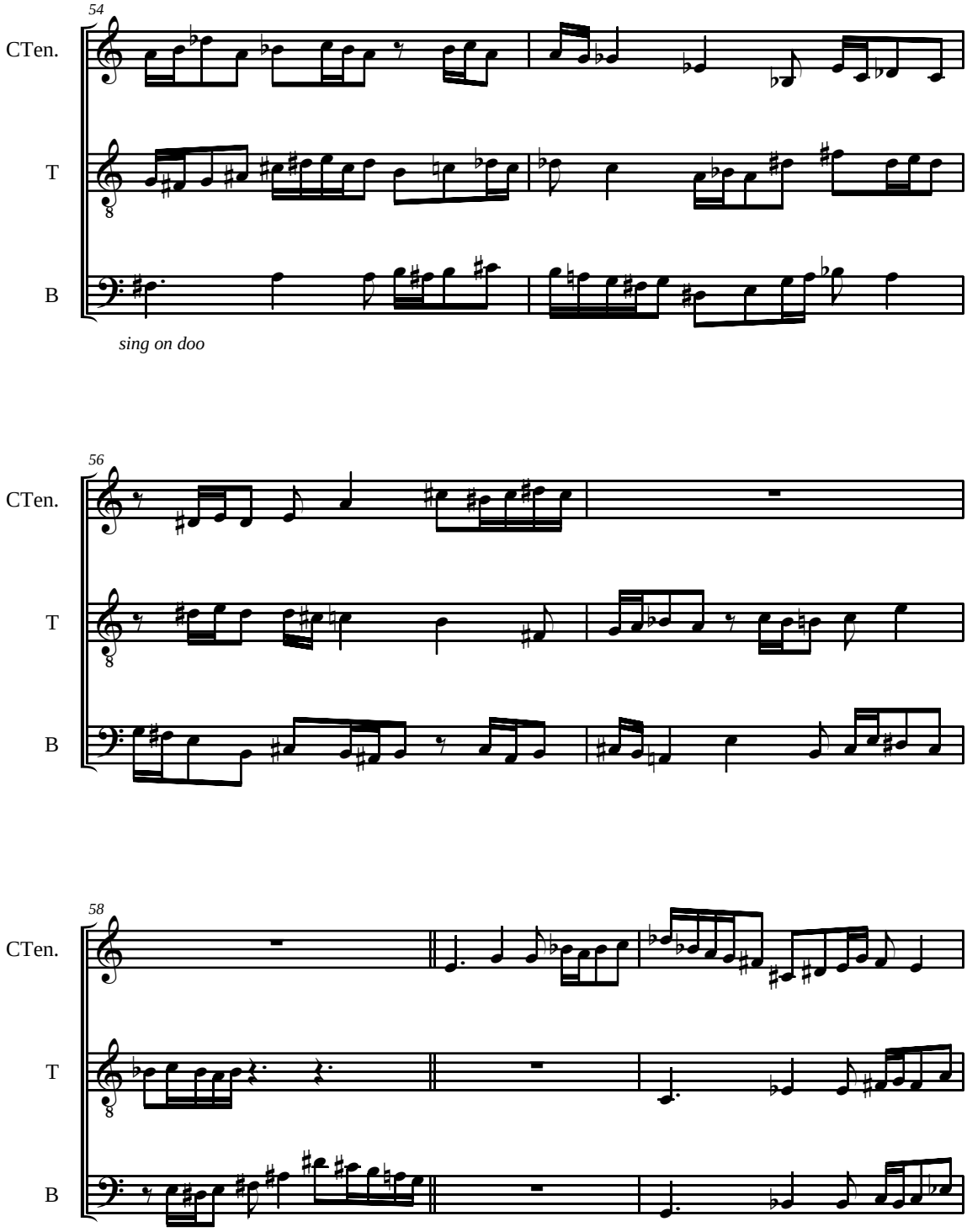
XII

for P.A.F.


♩= 92
Counter-Tenor
Tenor
Baritone
f
boh coh coh doh foh loh poh
boh coh coh doh foh loh poh
boh coh coh doh foh loh poh toh
6
CTen.
T
B
toh joh zoh hoh goh moh poh voh koh coh loh
toh joh zoh hoh goh moh poh voh koh coh loh
joh zoh hoh goh moh poh voh koh coh loh moh
13
CTen.
T
B
moh roh yoh qoh poh boh bay pay
moh roh yoh qoh poh boh
roh yoh qoh poh boh bay pay pay yay

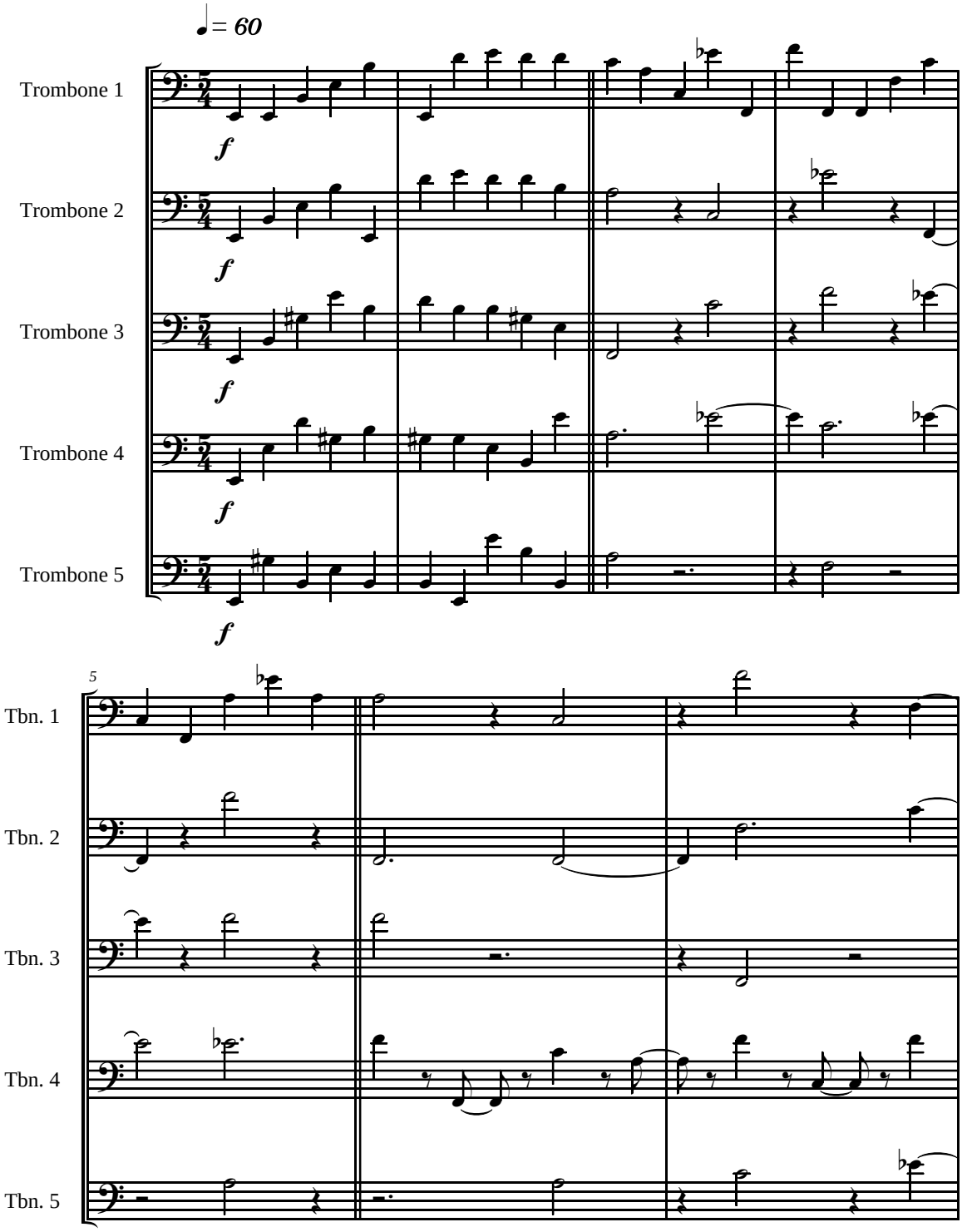

19
CTen.
pay yay nay may say cay tay vay qay may
T
bay pay pay yay nay may say cay
B
nay may say cay tay vay qay may way
25
CTen.
way hay cay jay kay pay say hay xay
T
tay vay qay may way hay cay jay kay pay
B
hay cay jay kay pay say hay xay day zay
31
CTen.
day zay cay pee qee yee ree mee lee
T
say hay xay day zay cay pee qee yee ree
B
cay pee qee yee ree mee lee

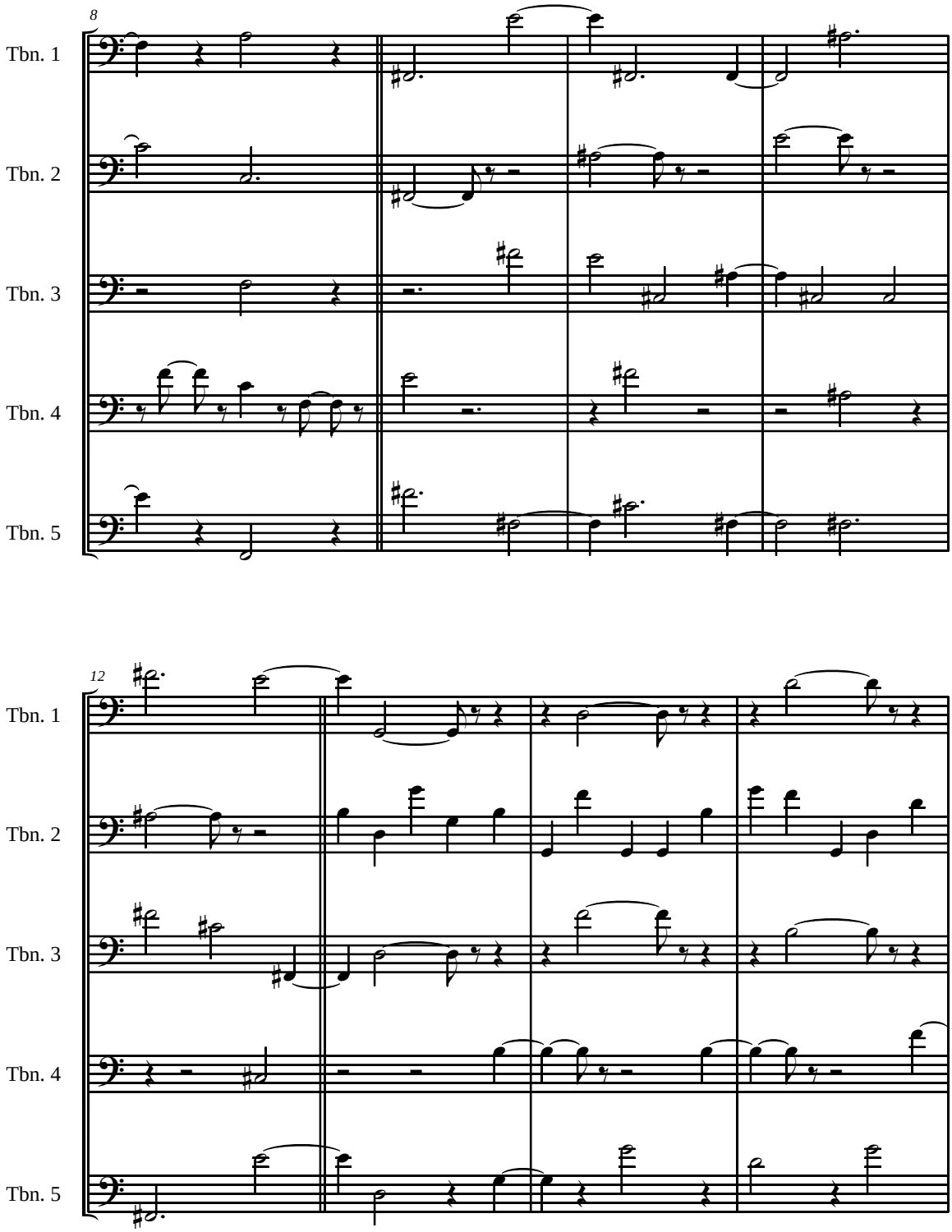

38
CTen.
cee kee vee pee mee gee hee zee jee tee
T
mee lee cee kee vee pee mee gee hee zee jee
B
cee kee vee pee mee gee hee zee jee tee
45
CTen.
pee lee hee fee dee cee cee bee
T
tee pee lee hee fee dee cee cee bee
B
pee lee hee fee dee cee cee bee
♪ = 132
52
CTen.
sing on doo
T
sing on doo
B

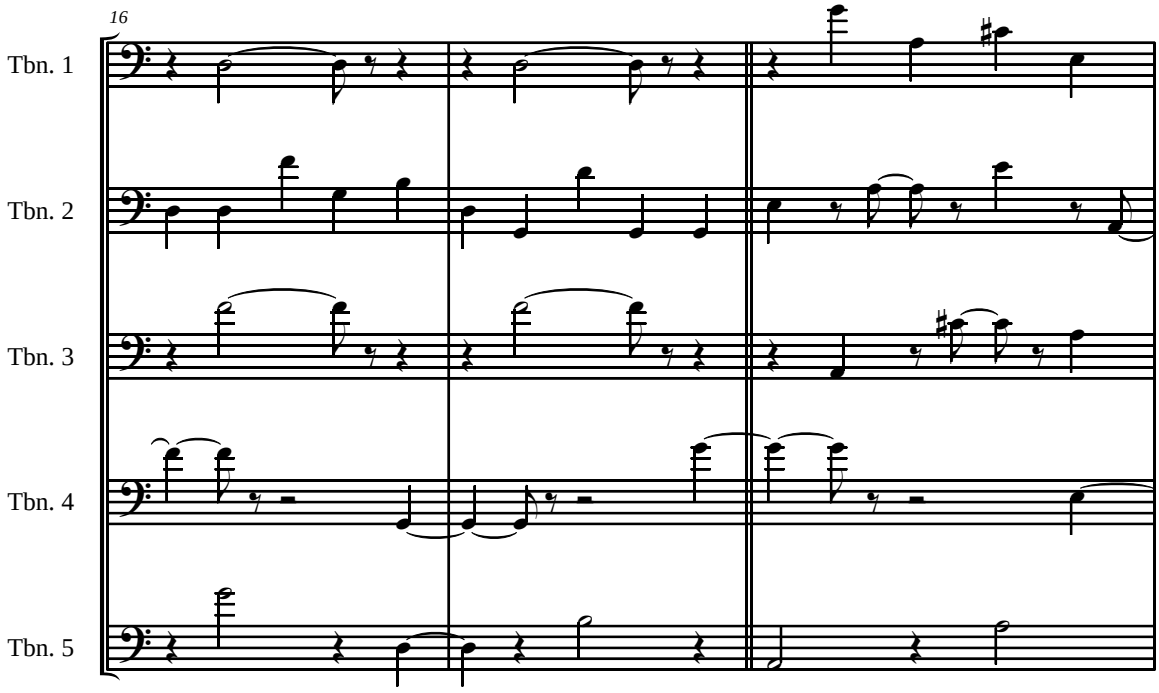

54
CTen.
T
B
sing on doo
56
CTen.
T
B
58
CTen.
T
B

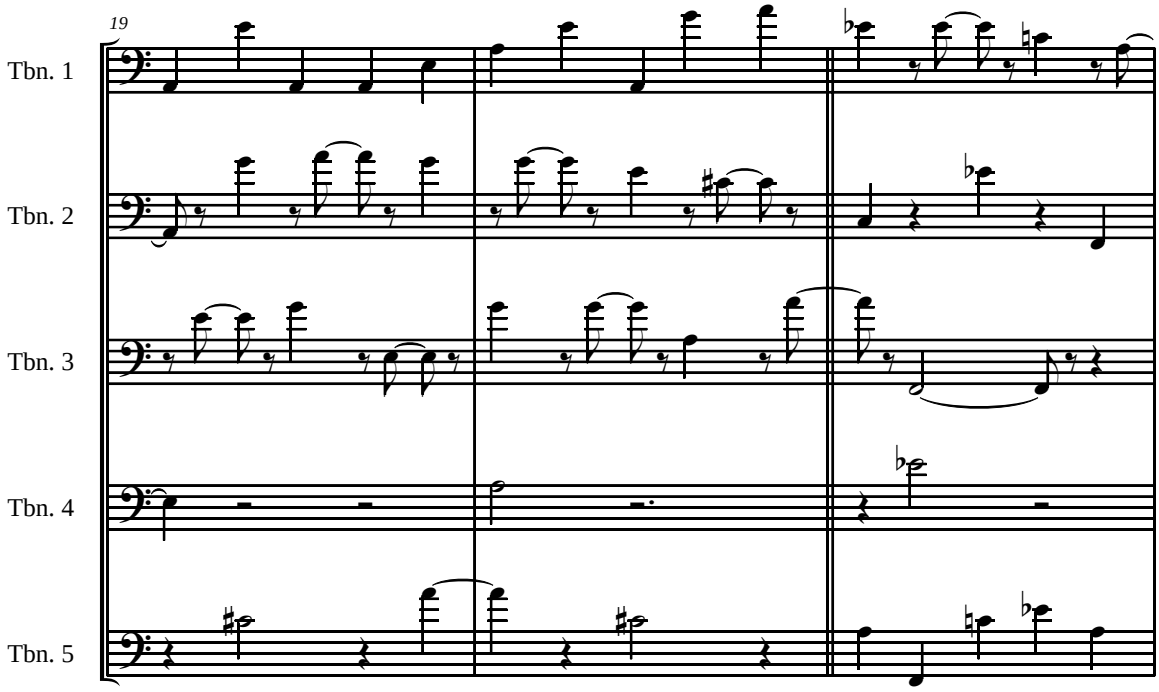
XIII

for B.R.S.


♩= 60
Trombone 1
Trombone 2
Trombone 3
Trombone 4
Trombone 5
f
5
Tbn. 1
Tbn. 2
Tbn. 3
Tbn. 4
Tbn. 5

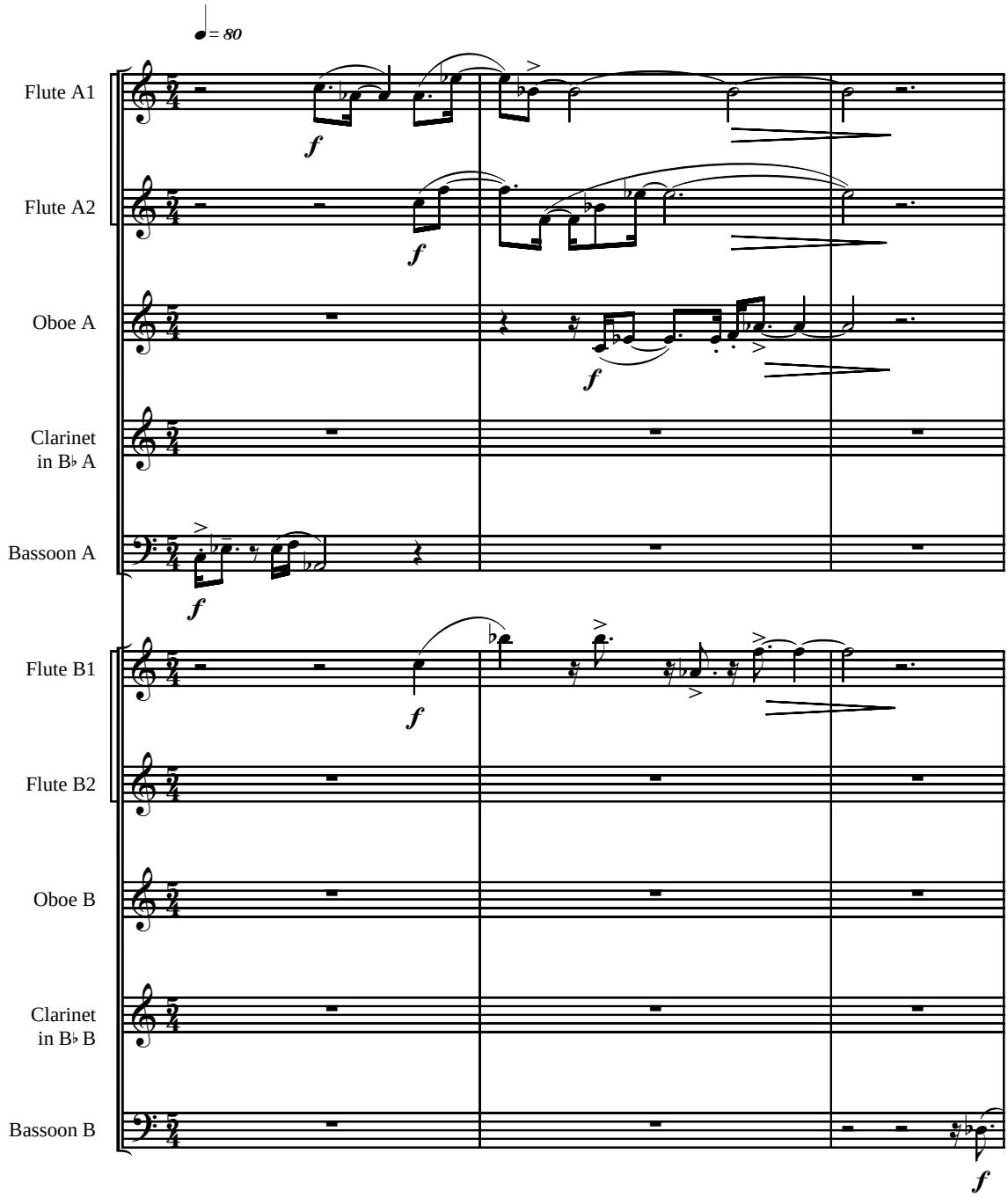

8
Tbn. 1
Tbn. 2
Tbn. 3
Tbn. 4
Tbn. 5
12
Tbn. 1
Tbn. 2
Tbn. 3
Tbn. 4
Tbn. 5

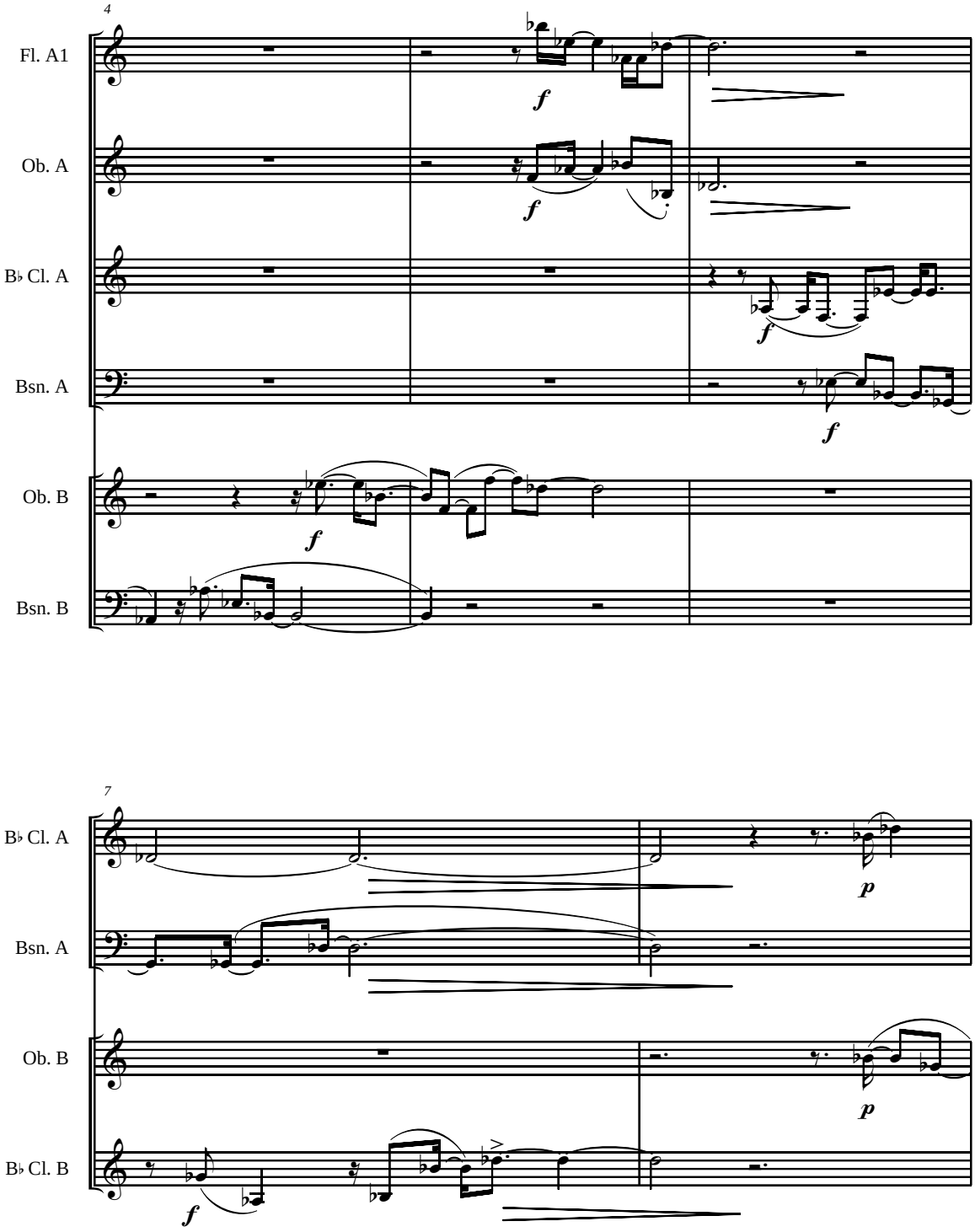

16
Tbn. 1
Tbn. 2
Tbn. 3
Tbn. 4
Tbn. 5

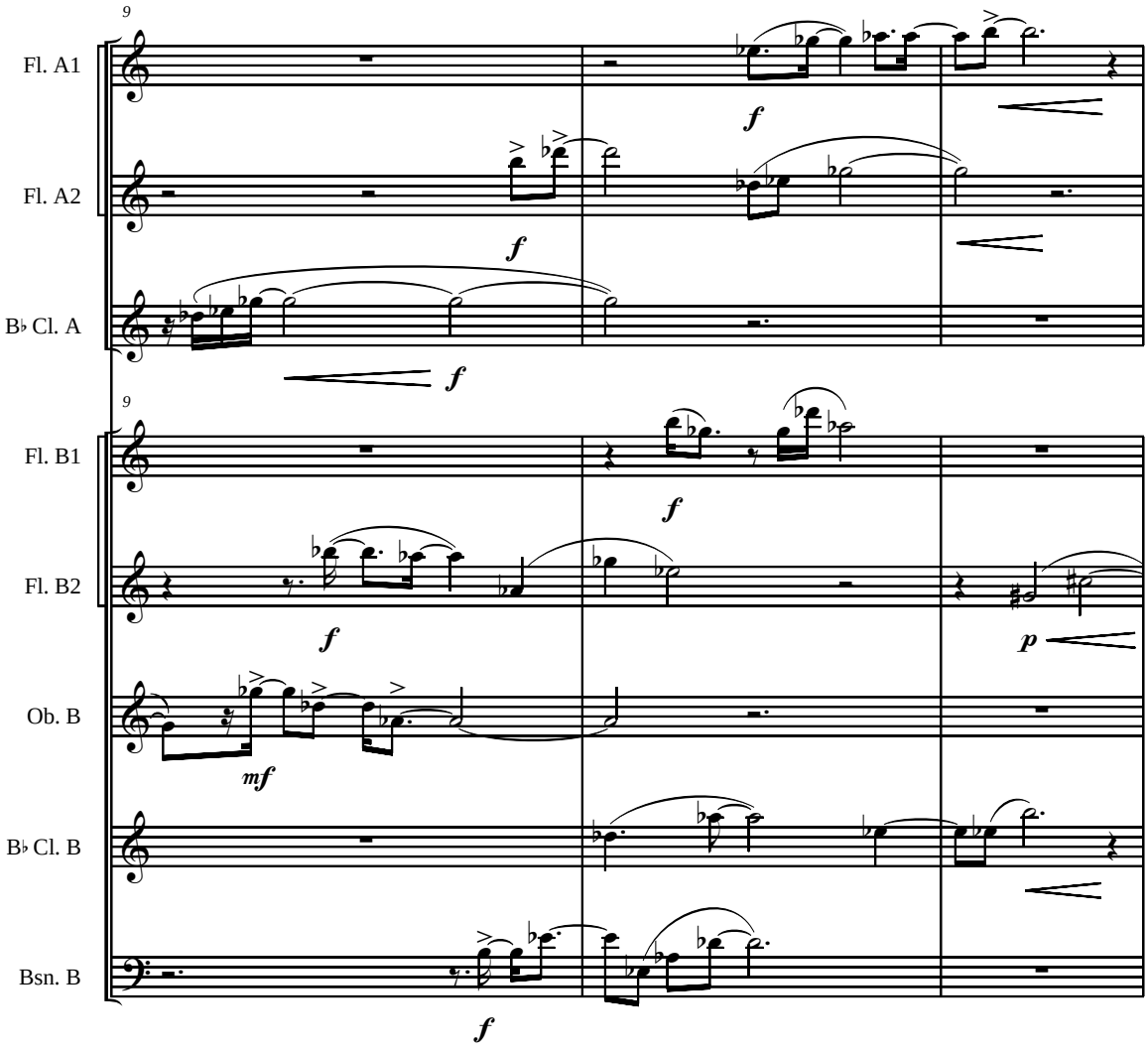

19
Tbn. 1
Tbn. 2
Tbn. 3
Tbn. 4
Tbn. 5

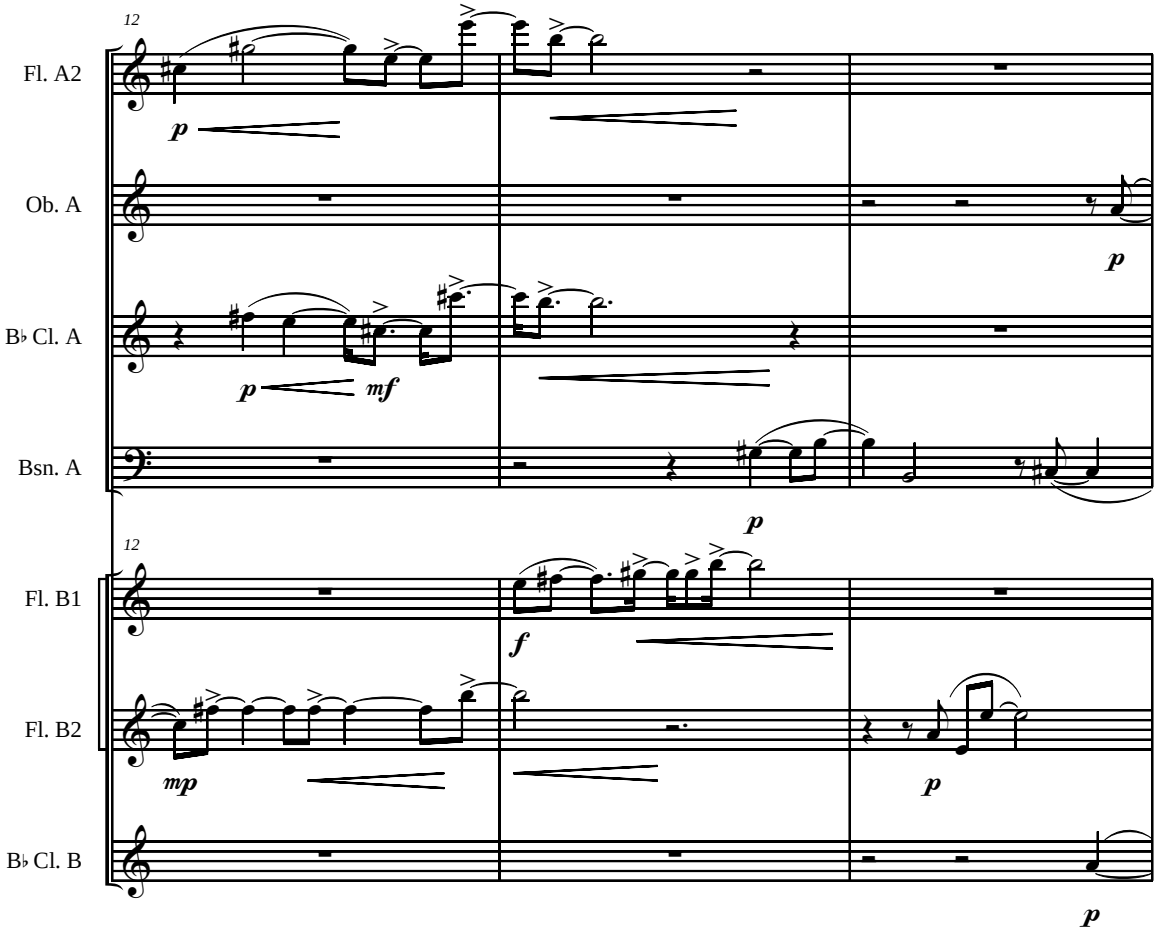
Score in C

XIV

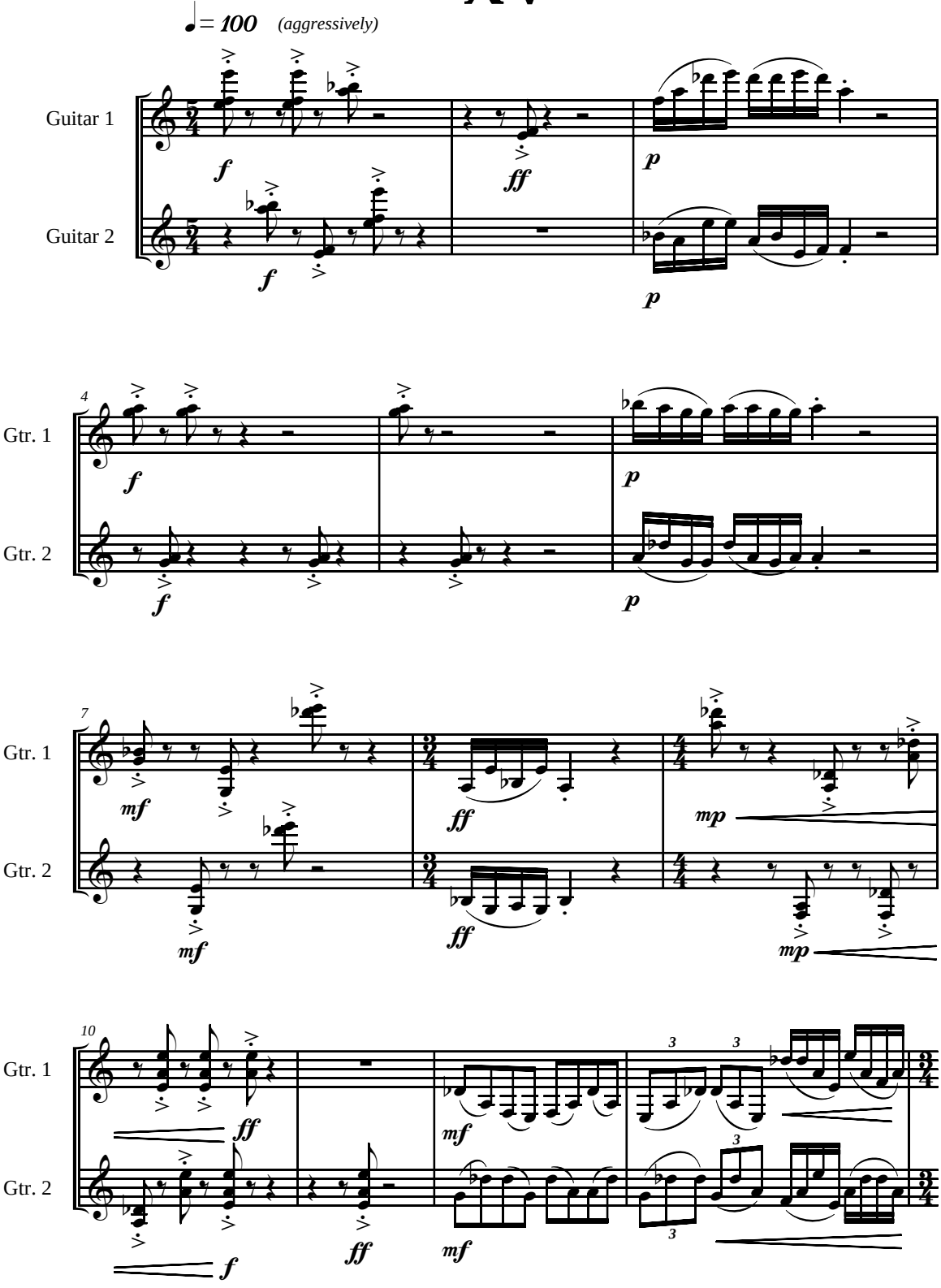


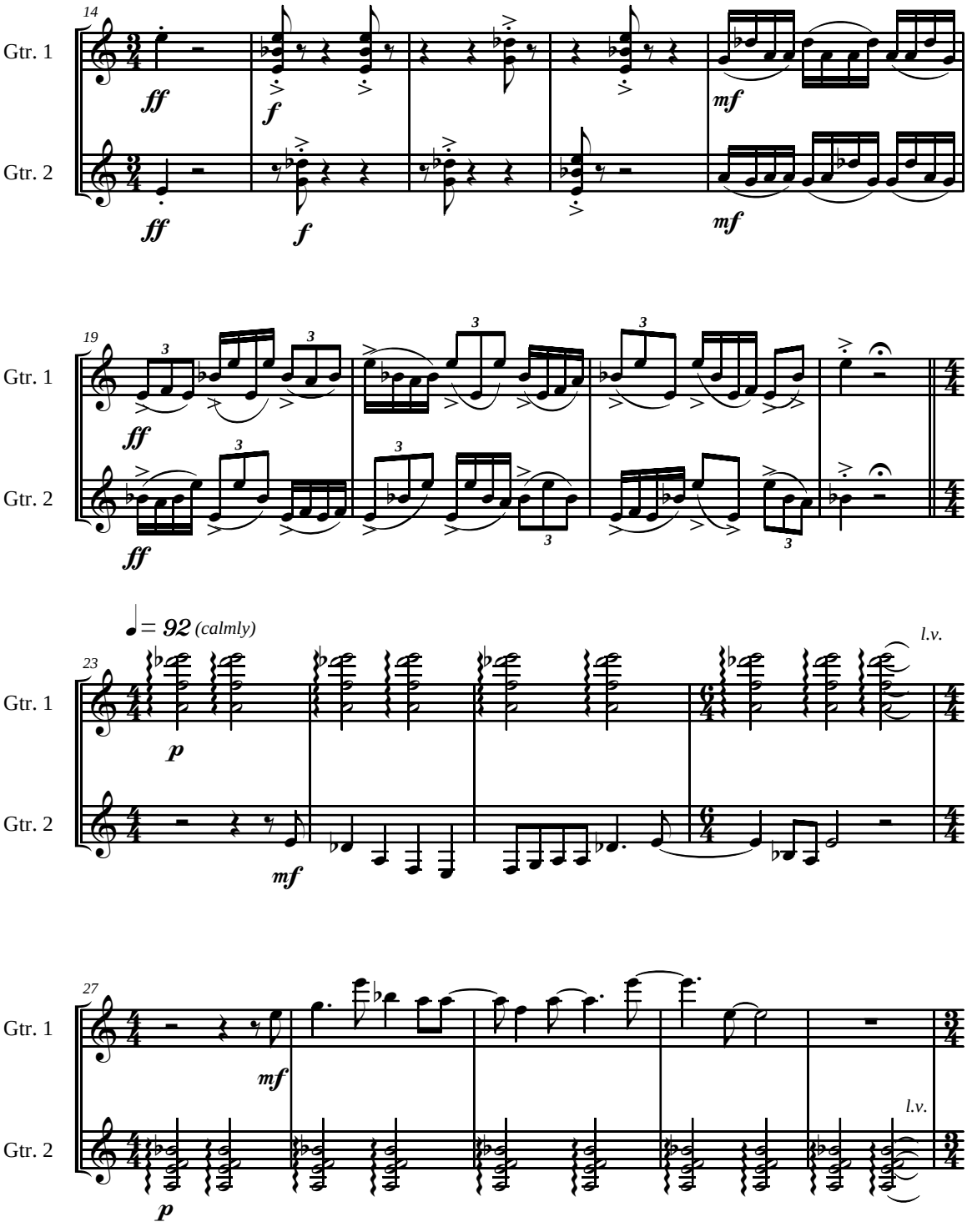

4
Fl. A1
Ob. A
B♭ Cl. A
Bsn. A
Ob. B
Bsn. B
7
B♭ Cl. A
Bsn. A
Ob. B
B♭ Cl. B


9
Fl. A1
Fl. A2
B♭ Cl. A
9
Fl. B1
Fl. B2
Ob. B
B♭ Cl. B
Bsn. B
f
mf
p


12
Fl. A2
Ob. A
B♭ Cl. A
Bsn. A
12
Fl. B1
Fl. B2
B♭ Cl. B
p
mf
f
mp

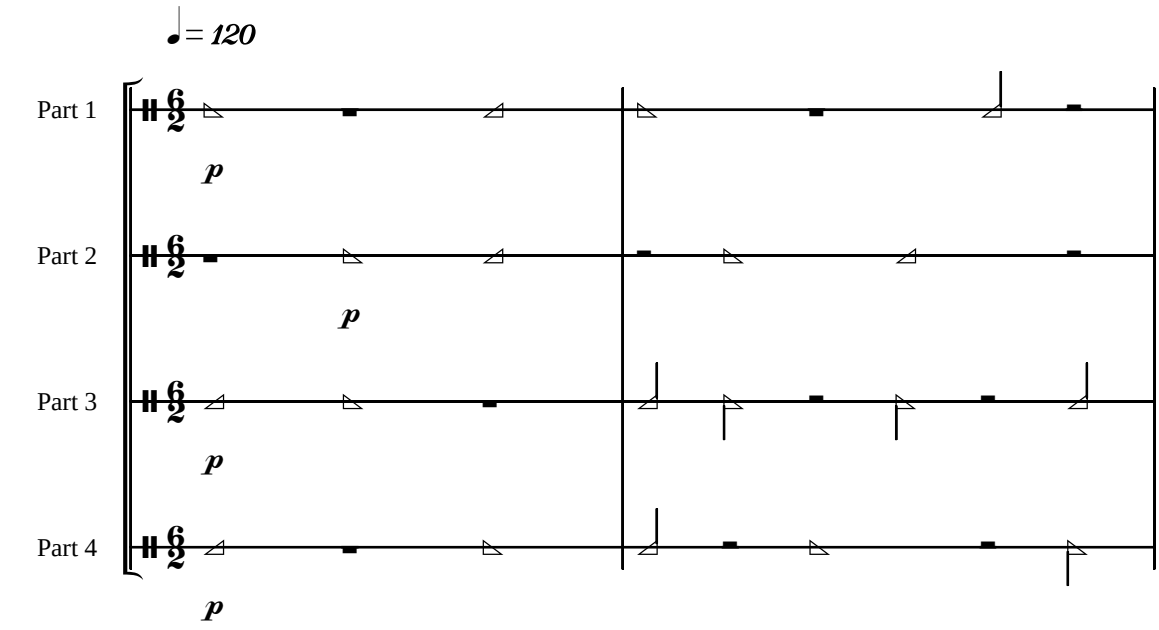
XV

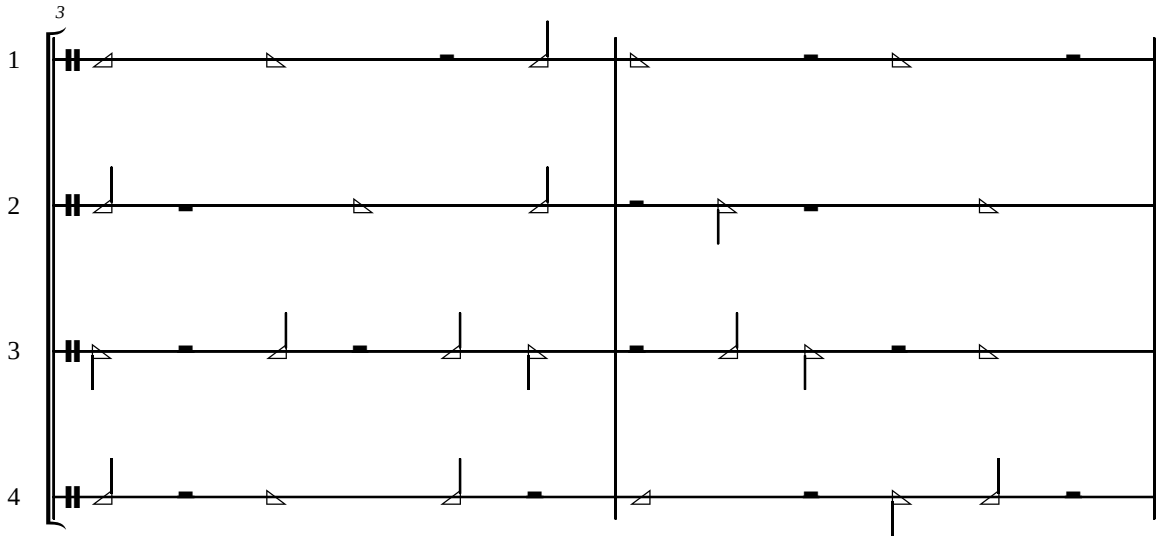


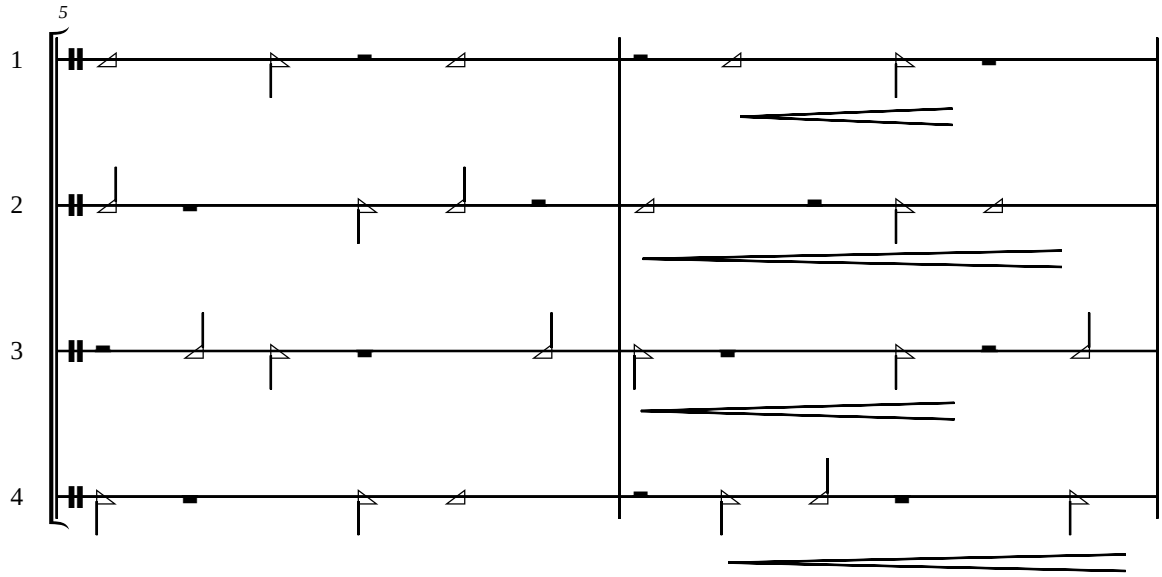

14
Gtr. 1
Gtr. 2
ff
f
mf
19
3
23
♩= 92 (calmly)
p
l.v.
27

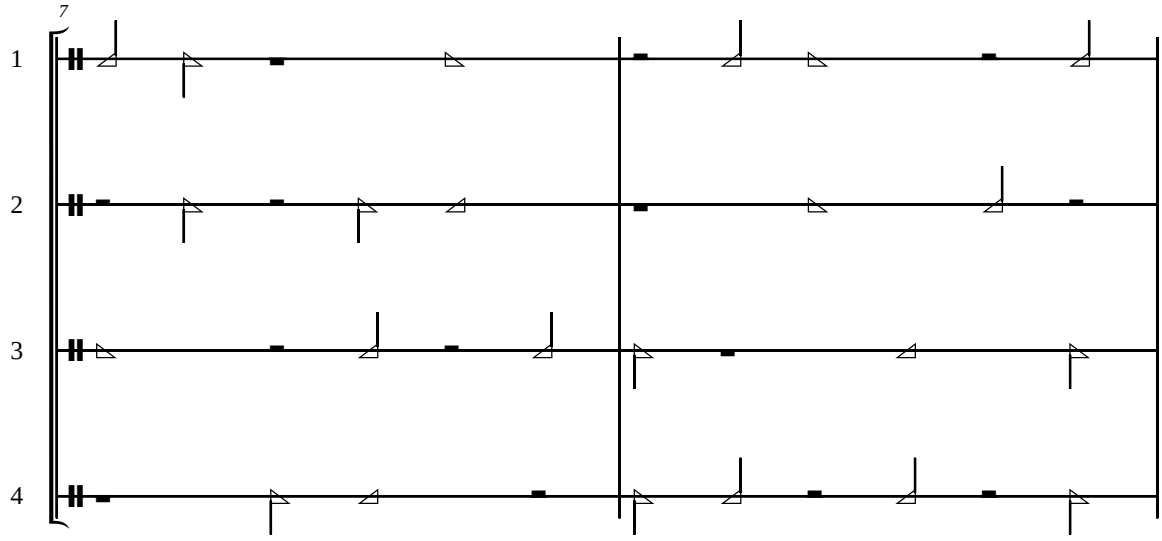
XVI

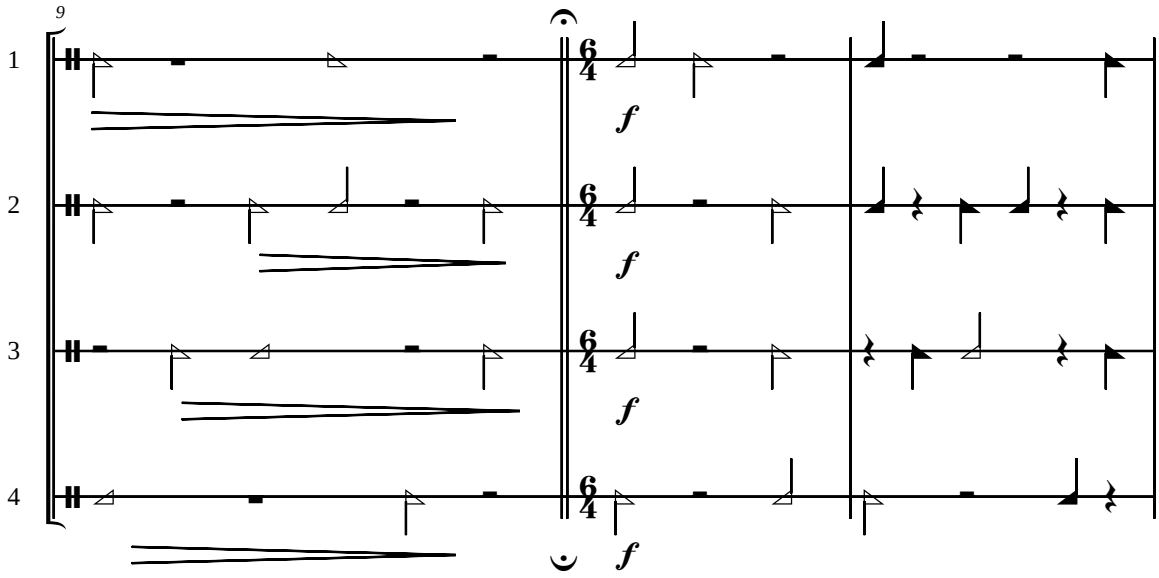
for R.E.M.

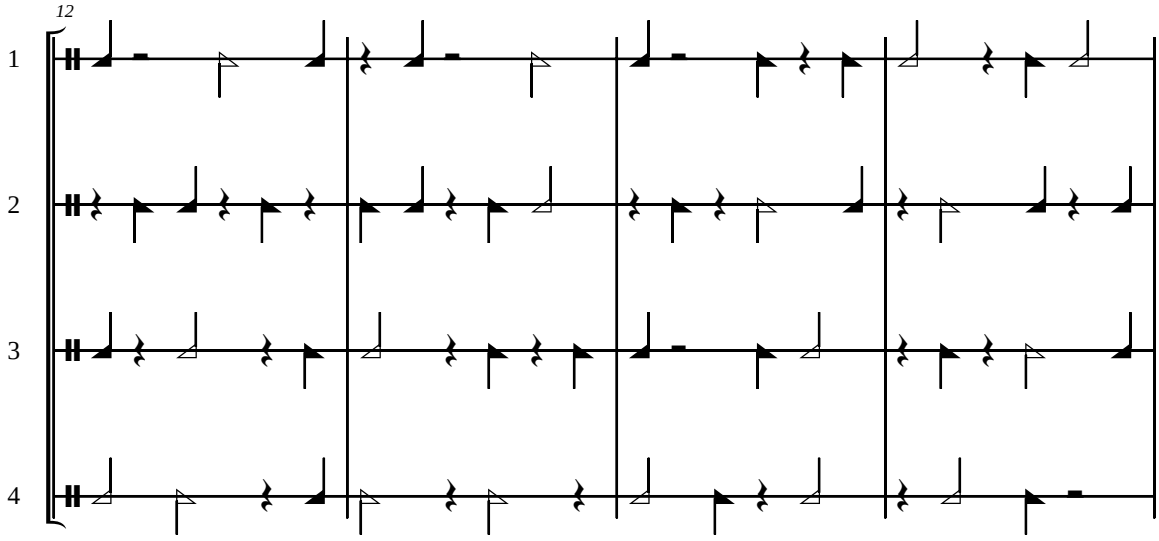


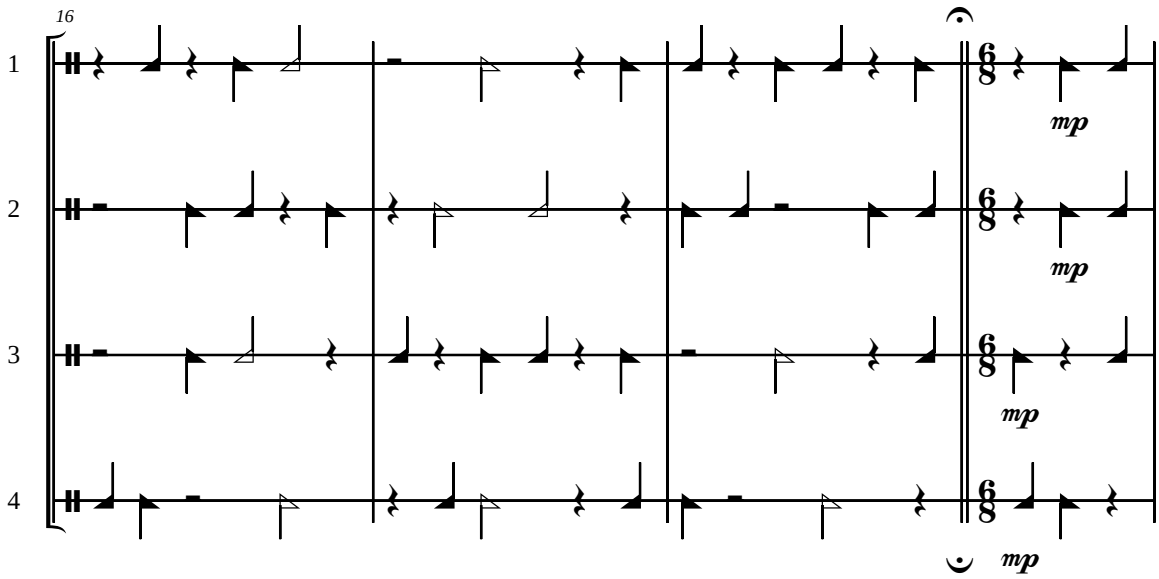


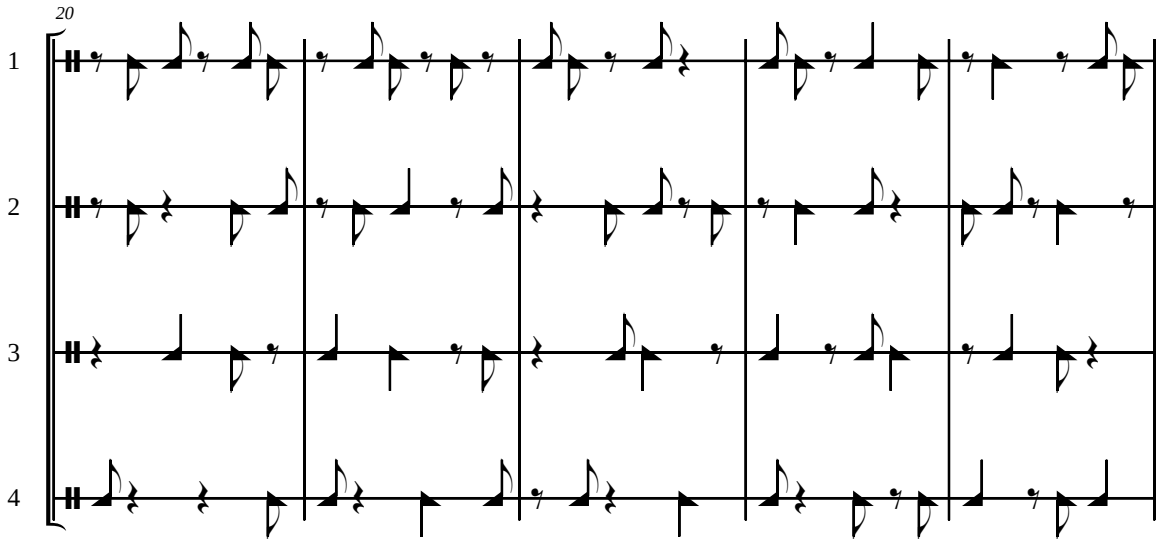

5
1
2
3
4


7
1
2
3
4


9
1
2
3
4
6/4
f


12
1
2
3
4


16
1
2
3
4
mp
mp
mp
mp


20
1
2
3
4

Performance Notes for XVI

- This piece is written for at least four players, playing any instrument(s) capable of being breathed through (string players, percussionists, and anyone else may join the vocalists and perform by simply breathing through their mouths). When there are more than four players, the ensemble should distribute the parts as uniformly as possible.

- The alternative noteheads indicate the following:

  Inhalation and exhalation is also denoted by the direction of stems: a down-stem equals an exhale; and an up-stem equals an inhale.

- Breathing is to be performed such that all air passes through the instrument, creating a comfortably audible sound even at the quietest dynamic (this may require a larger or smaller volume of air depending upon the instrument). As the dynamics become louder, a player's instrument (or mouth, or voice) may respond to the sharp blasts of air by squeaking or otherwise. This is to be expected and welcomed.

- While rehearsing this piece, players should be aware of their lung capacity and plan moments to inaudibly replenish or expel extra air in order to avoid having too little air in the lungs when needing to exhale, or too much air in the lungs when needing to inhale (Part 2 should pay particular attention to this from m. 28 to the end).

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Rahn, John. "On Pitch or Rhythm: Interpretations of Orderings of and in Pitch and Time." *Perspectives of New Music*, Vol. 13, No. 2 (Spring-Summer, 1975): pp. 182-203.

Wall, D. D. "Fibonacci Series Modulo *m*." *American Mathematics Monthly*, Vol. 67 (1960): pp. 525-532.

VITA

Jonathan Haek (b. 1977) is originally from Portland, Oregon. He has earned a Music Theory Certificate from the University of Washington (2005), an M.M. degree in Composition from the University of Oklahoma (2002), a B.A. degree in Flute Performance from Oregon State University (2000), and a B.S. degree in Mathematical Sciences with a minor in Computer Science from Oregon State University (2000). At the time of this writing, Haek's article "Serial Composition Using Residue Cycles of Fib(mod *m*)," an examination of techniques used to compose his dissertation, has been accepted by the journal *Perspectives of New Music* for forthcoming publication. Having collaborated extensively with choreographers at the University of Washington, Haek's music has been performed at various venues in and out of the Seattle area including the Velocity Mainspace Theater, Western Washington University at the American College Dance Festival's Northwest Regional Competition, and most recently at the University of Southern Mississippi. On the CD titled ">3" (Maritime fist glee club 2001), Haek performs free improvisation on the flute and piccolo. This recording emerged from weekly jam sessions with Christian Asplund and Michael Lee, a collaboration called >3 happening from 2000-02. Stemming from an interest in creating graphical user interfaces (GUIs) for exploring new musical territories, Haek has programmed a GUI which simulates a 15-stringed kithara useful for hearing and exploring Ancient Greek Tuning Systems, and another GUI which calculates residue cycles of Fib(mod *m*) and displays various aspects of their structure. An ongoing interest of his is in interactive and computer music composition using Lisp, Common Music, CSound, Max/MSP, Teleo hardware modules, and various non-linear digital editing programs. From 2005-06, Haek served as Visiting Instructor at the University of Oklahoma teaching composition and a variety of music technology courses. Haek has studied composition with John Rahn, Joël-François Durand, and Christian Asplund.