SYSTEMATIC COMPOSITION AND INTUITION IN A CONCERTO FOR ORGAN AND ORCHESTRA

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Historically, composers have used methods in addition to inspiration in writing music. Regardless of the source materials they used, composers ultimately rely on their musical sensitivity to inform the compositional decision-making. Discuses the rotational aspects of decimals that are created from certain prime-number denominators, and focuses on the prime number 17. Shows how these decimals can be transformed by converting them to different number bases. Looks at the Golden Proportion and its use in creating formal structures. Examines compositional and aesthetic issues arising from using number series to generate the pitches, rhythms, and sections in the Concerto for Organ and Orchestra. This process of composition reveals musical gestures that may not have been discovered using more intuitively based approaches to composition. Shows how musical sensitivity was necessary in shaping the numerically derived material in order to create aesthetically satisfying music.

ACKNOWLEDGEMENT

I would like to thank my father, David T. Worlton, for his assistance with the details of organ registration. His knowledge and experience helped me to choose timbres that are both idiomatic to the organ and appropriate to the concerto.

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CHAPTER 1

INTRODUCTION

Throughout the history of music, composers have utilized extra-musical sources to enhance the compositional process. The ancient Greeks believed that the mathematics controlling the motion of celestial bodies was a form of music–*musica mundana* ("music of the spheres"). In the Middle Ages, composers of the *ars nova* and *ars subtilior* wrote isorhythmic motets and masses. During the eighteenth century, Haydn, Mozart and C. P. E. Bach composed using mathematical principles from *ars combinatoria*. Composers in the twentieth century relied on mathematics to provide order in post-tonal music. Of course, not all extra-musical sources have been mathematical. Nineteenth-century composers frequently drew on literature and nature for inspiration. Regardless of the extra-musical influences they used, these composers had to decide how completely their sources and compositional systems would determine the music, and how much freedom they would allow themselves to modify what their sources produced.

Because composers care about how their music sounds, there must come a point at which they shift their focus away from the systems they have been using toward the sounds they are creating. In my experience, this shift does not occur only once in the course of composing a piece, but many times. This oscillation of focus between system and sound allows a composer to continually weigh that which the system is producing against his or her desired sound. In order to focus on what will be heard, composers must employ their musical sense to shape the finished work.

Musical sense (intuition), as it applies to composition, is the composer's realization that what he or she has written is acceptable and complete. This realization transcends any series of procedures that the composer may have used in developing the music; and it comes as an insight, without conscious thought. Intuition develops through study and imitation, as John Winsor suggests:

> Part of a composer's training is the study of past masterpieces—essentially a verbal-analytical process that includes memorizing rules, studying scores, and so forth. But the training also involves writing in the styles of past masters. This helps young composers to internalize the underlying principles, to exercise their intuition by *doing* what past composers have done. In this way, composers develop the ability to think in the same way that their predecessors thought.[1]

Every composer experiences moments of musical intuition differently, and I believe this individuality influences a composer's style.

In this paper I explain how I approached the composition of the Concerto for Organ and Orchestra, and the way intuition informed my compositional systems. My favorite source of non-musical stimuli is numbers, and basic elements of numerical relationships and patterns. Most often I have used prime numbers and the Golden Ratio as inspiration, but I have also used elements of chaos theory, particularly Michel Henon's "strange attractor."[2] Many of my mathematical procedures, and the way they produce music, could be accomplished on a computer. However, I generally prefer to work them out by hand. I find that this method facilitates the oscillation between system and sound—or more broadly, between system and intuition. The following section discusses the use of computers in composition, and my approach to algorithmic composition.

Computer-assisted Algorithmic Composition

Algorithmic composition is the use of computers to make decisions that composers have historically made themselves. Bruce L. Jacob illustrates the

[1] John Winsor, *Breaking the Sound Barrier: An Argument for Mainstream Literary Music* (New York: Writer's Showcase, 2003), 98.

[2] In my *Henon Improvisation*. See James Gleick, *Chaos: Making a New Science* (New York: Penguin Books, 1989), 144-50.

rationale behind the use of computers in composition:

> Creativity comes in two flavours: genius and hard work. While the former may produce more 'inspired' music, we do not fully understand it and therefore have a slim chance of reproducing it. The latter resembles an iterative algorithm that attempts to achieve some optimal function of merit, and is therefore more easily realisable as a computer program.[3]

Richard Orton expands the definition to include all musical composition. "Some musicians have difficulty with the concept of 'algorithmic composition', so at the start I might turn the notion around and say that I believe that all composition is algorithmic composition, whether the composers realise this or not."[4] He says that in the process of planning a composition, the composer performs two different tasks: generating source materials, and creating the set of processes that the composer will use to drive the music through time. He argues that these procedures can be made just as well through the use of a computer.[5]

With regard to algorithmically-generated music, Jacob asks whether or not there is a difference between a composer recognizing something that he or she likes and composing something desirable. He describes two opposing viewpoints to this question. First, some people think that "art is communication, and so anything that communicates to another is art; art is the physical equivalent of 'hey–look at this'."[6] Those on the other side think that "only what comes directly from the hands of an artist is of the artist."[7] In other words, art can only come directly from a human. Jacob offers no answers to this dilemma, but says that "the more closely an algorithm reflects a

[3] Bruce L. Jacob, " Algorithmic composition as a model of creativity," *Organised Sound: An International Journal of Music Technology* 1, no. 3 (December 1996): 157.

[4] Richard Orton, "Design strategies for algorithmic composition," *Contemporary Music Review* 15, no. 3-4 (1996): 39.

[5] Ibid., 39-40.

[6] Jacob, "Algorithmic composition," 158.

[7] Ibid.

composer's methodology, the less question there is that the work is authentic and of the composer."[8] My compositional method falls in between the two extremes.

My Approach to Algorithmic Processes

Enjoyment of Discovery

I do not typically rely on a computer when I compose, but I do employ procedures that a computer could be programmed to perform. I prefer to work them out myself and to decide on a moment-by-moment basis how to apply the non-musical data to composition; in other words, how to map the data on to musical parameters.[9] Under the broad umbrella given earlier by Orton, arguing that my method of composition is not "as algorithmic" as music which is generated entirely by a computer is moot. But under the generally accepted definition (the use of computers to make compositional decisions) I would not qualify as an algorithmic composer.

I prefer to compose this way because of the joy of discovery—I enjoy deciding how to convert number patterns into music. Part of the excitement of composition comes from seeing what can be created from the rules of a system, and whether or not they have musical merit ("hey–look at this"). For me, this is a rewarding part of the compositional process. O. B. Hardison, in talking about formula poetry, said

> Why should intelligent artists accept formulas that force them to say things they might not otherwise say in ways that they most certainly would not use unless forced to by the formulas? Beyond the fact that they liberate, the appeal of the formulas is precisely that they force the writer out of predictable paths; that is, they encourage–in fact, they compel–discovery.[10]

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[8] Ibid.

[9] However, in my *Henon Improvisation*(2000) I did use a computer to generate notes, rhythms, and dynamics, which I then had to shape in a real-time performance.

[10] O. B. Hardison Jr., *Disappearing Through the Skylight* (New York: Penguin Books, 1989), 199.

This applies to music as well, and represents the way I look at using systematic approaches to composition.

Point of View as a Listener

As a listener to music, I prefer to know what lies “behind” the sounds both in terms of “program” as well as technique. This preference has evolved as I have learned more about music. However, non-musician listeners tend to be interested in the programmatic elements of a piece rather than its technical aspects. Therefore, as a composer I try to write music that is successful for a listener who does not have a knowledge of my systems. I do not care whether or not they can recognize the technical procedures that went into the work. I agree with John Winsor when he says that it does not matter what techniques a composer uses as long as the musical result is coherent and appears “inevitable and devoid of artifice.”[11]

Compositional Approach for the Concerto

The fifth of Charles Wuorinen’s five “general but not universal” suggestions for composition advises:

> A compositional method exists only to write pieces. It is not sacred, and when the piece has reached, through application of the method, a sufficient degree of completeness, it will begin to assert its own rights and needs. These may often seem to contradict the original method or call for changes in the work’s design. Do not hesitate when such a situation arises. If the method has served long enough to allow the work it has produced to contradict it, it has more than fulfilled its function.[12]

My Concerto for Organ and Orchestra evolved through the application of systems that will be examined in the remainder of this paper. I did not construct an algorithm to

[11] Winsor, *Breaking the Sound Barrier*, 47.

[12] Charles Wuorinen, *Simple Composition* (New York: Longman, 1979; reprint, New York: Schirmer Books, 1988), 148.

control these systems and create a finished piece, even in rough form. My intent was to balance the procedures I used with my musical intuition, which would then determine the final shape of the music.

In Chapter 2 I explain the mathematical basis for my organ concerto—the rotational aspect of some decimals that are created when the denominator of its fraction is a prime number. Chapter 3 deals with the way I calculated the formal divisions of the work. In Chapters 4 through 7 I discuss issues related to turning numbers into music; from generic possibilities through some of the more complex and convoluted occurrences in the concerto.

CHAPTER 2

MATHEMATICAL BASIS OF THE CONCERTO

Periodic Decimals

A terminating decimal eventually arrives at a remainder of 0. For example:

1/2 = 0.5*0*; 3/8 = 0.375*0*; 7/20 = 0.35*0*

All infinite (non-terminating) decimals can be classified as either periodic or irrational. Numbers such as *pi* = 3.14159265. . . and the "golden number" (representing the Golden Ratio) = 1.61803398. . . are irrational because their sequence of digits never repeats. A rational number contains whole numbers in the numerator and denominator; and a rational number whose decimal does not terminate, creates a periodic decimal. For example:

1/3 = 0.333. . .

where the "3" repeats indefinitely with a period of 1;

5/11 = 0.4545. . .

where the "45" repeats indefinitely with a period of 2; and

11/12 = 0.91666. . .

where the 6 repeats indefinitely with a period of 1 and a delay of 2. The periodic aspect of these types of decimals plays an important role in generating the music of the Organ Concerto; particularly those that have a prime number in the denominator.

Prime Numbers as Denominators

When certain prime numbers (hereafter labeled *p*) appear as the denominator of a fraction (*a/p*, where *a* is equal to or greater than one, but less than *p*) they create rotating periodic decimals. For many values of *p* the length of the period is *p* - 1.

Conway and Guy call primes with this characteristic *long primes*.[1] For example, using 7 as the denominator creates an infinitely repeating decimal with a period of 6:

$$1/7 = 0.142857\ 142857\ .\ .\ .$$

$$2/7 = 0.285714\ 285714\ .\ .\ .$$

$$3/7 = 0.428571\ 428571\ .\ .\ .$$

and so on, up to

$$6/7 = 0.857142\ 857142\ .\ .\ .$$

In this example the six digits (*i.e.*, p - 1), *142857*, rotate with each successive value of a. For certain other values of p this is not true, that is, the rotating period is some other length. For example, for p = 13 there are two distinct rotating periods of six decimal places–the rotating period is (p - 1) / 2. Other periodic lengths are also possible for larger values of p.[2]

For the Organ Concerto I have chosen the long prime p = 17 to use as p. Each a creates a distinct ordering of the set of sixteen values, *0588235294117647*, that I can then apply to musical composition. I chose 17 because it offers more material to work with than p = 7. Also, I did not want to work with a periodic length other than p - 1, and 17 is the next long prime after 7.

Expanding the group of numbers

In addition to the rotational aspect of the set of digits created in $a/17$, I was interested in ways of transforming the set in order to create related sets of various lengths. In order to illustrate how I accomplished this, I must first explain the concept of "carousel numbers."

My method for augmenting the basic set of numbers required that they become

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[1] John H. Conway and Richard K. Guy, *The Book of Numbers* (New York: Copernicus, 1996), 161.

[2] Ibid., 157-63.

"carousel numbers."[3] Carousel numbers are created by extracting the series of numbers from its decimal context (by removing the leading 0 and decimal point). This does not change the relationship between the digits in the number since these numbers behave in the same way as their decimal counterparts. For example: we have seen how the digits in *a*/7 rotate for different values of *a*. When the six numbers stand alone, 142857 (as opposed to 0.142857), they will also rotate when multiplied by any number up to the number of digits in the carousel, but not beyond. For example:

$$142857 \times 2 = 285714$$

$$142857 \times 3 = 428571$$

$$142857 \times 4 = 571428$$

$$.\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .$$

$$142857 \times 7 = 999999$$

$$142857 \times 8 = 1142856$$

This concept allowed me to expand the pool of numbers by converting them to different number bases without the complications of converting the decimals.[4] For example:

$$2/17 = 0.1176470588235294\ 1176470588235294\ .\ .\ .$$

The decimal portion, when extracted, becomes the carousel number

1176470588235294

and when converted to base 12 it becomes

tee47t6e75t2t6

[3] Gary Klatt, "Carousel Numbers: A Lead-in to Number Theory," *The Math Forum*, 1994-2003 [Internet site]; Available from http:mathforum.org/orlando/klatt7.orlando.html; Internet; accessed October 2001.

[4] The idea of converting the decimals of *a*/17 into its equivalents in other bases was never a part of the original plan for this composition.

(where “t” and “e” stand for “10” and “11,” respectively).[5] One advantage of this procedure is the ability to reduce the variety of digits in the number. Where the conversion from base 10 to base 12 created *more* available digits per “place” (twelve instead of ten), by converting to base 3, for example, the only available digits are 0, 1, 2:

122010211121110200021021012111 00

Obviously, with fewer available digits the number as a whole lengthens. However, one significant byproduct of changing number base this way is the loss of the rotational relationship between values of *a* that appears in base 10.

Using different number bases this way appealed to me more than processing the numbers with a modulus. A modulus would only produce one value for any input, such as the 9 in the following process:

142857 is congruent to 9 modulo 12

In other words, 142857 / 12 = 11904 with a remainder of 9. For the composition I was more interested in each individual digit in the carousel numbers as it related to the others.

When composing, one can use these numbers for many different musical processes such as successive intervals in a melodic line, absolute pitch-class values (C = 0, C-sharp = 1, etc.), durational values (rhythm), structural proportions, vertical intervals within a chord, and so on. Any two or more of these processes may also occur simultaneously (this will be discussed in more detail in Chapter 4). However, for the *structure* of the concerto I used the Golden Ratio.

The Golden Ratio

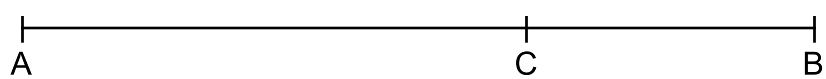
The general interest in the Golden Ratio lies in its application to a myriad of

[5] For digits larger than 9 in base 11 to base 20 I used the following letters: *t*=10, *e*=11, *L*=12, *h*=13, *f*=14, *i*=15, *x*=16, *v*=17, *g*=18, *n*=19. See also Appendix C for the complete set of base conversions.

different situations. Mario Livio asks: “What do the delightful petal arrangement in a red rose, Salvador Dali’s famous painting ‘Sacrament of the Last Supper,’ the magnificent spiral shells of mollusks, and the breeding of rabbits all have in common?”[6] The answer is that they all relate to the Golden Ratio. Euclid provided the first clear definition of the Golden Ratio around 300 B.C.[7]

The simplest way to visualize the Golden Ratio (GR) is to consider a line segment AB. If the segment AB is divided, C, such that the ratio between AB and AC is the same as the ratio between AC and CB, then C divides the segment according to the GR (See Ex. 2.1). Mathematically it is defined as $(1 + \sqrt{5}) / 2$.[8] This produces the irrational number 1.618003398. . ..

My interest in the Golden Ratio for this work was to provide structural points of importance that logically related to one another and to the whole. I discuss this aspect of the composition in Chapter 3.



Ex. 2.1. Line segment divided by the Golden Ratio.

[6] Mario Livio, *The Golden Ratio: The Story of Phi, the World’s Most Astonishing Number* (New York: Broadway Books, 2002), 2.

[7] Ibid., 3.

[8] Richard A. Dunlap, *The Golden Ratio and Fibonacci Numbers* (Singapore; River Edge, NJ: World Scientific, 1997), 1-2.

CHAPTER 3

STRUCTURAL PLAN

Before discussing the structural plan of the concerto I must point out that all of the calculated timings served only as a point of departure in writing the work. While composing I tried to match the structure that I will describe here, but I found that musical intuition dictated some freedom within this plan. Also, in the world of acoustic instrumental performance, these indicated timings could never be achieved exactly, due to the imperfect nature of a hundred musicians working together. As a composer I do not think that this inevitability negated the value of the structural plan. Béla Bartók, for example, indicated timings in the scores of many of his works, which he certainly knew would not be perfectly attainable by all performers. For me at least, building the structure of the concerto this way ensured that the twenty minutes of sound that I was creating had a logical framework.

Proportions and Maps

Application of the Golden Ratio to the Movement Lengths

I decided that the work should theoretically last 1,201 seconds, or twenty minutes and one second (20’01”). Using this prime number as the total duration allowed each of the three movements to have a prime duration also: 599 seconds (9’59”) for the first movement; 229 seconds (3’49”) for the second movement; 373 seconds (6’13”) for the third movement. In addition to being all primes, these durations also relate to each other by the Golden Ratio (GR). To illustrate: I calculated the length of the third movement by multiplying the duration of the first movement by the golden mean: 599 x 0.618 = 370.182 (the nearest primes are 367 and 373). Following the same procedure with this new duration, the length of the second movement became: 373 x 0.618 = 230.514 (the nearest primes are 229 and 233).

Two Simultaneous GR Maps

To make smaller divisions within each movement I created two independent layers or maps, one for the organ and one for the orchestra, again using the GR. The divisions in the orchestra's layer came from successive multiplications of the resultant durations by 0.618. To clarify: beginning with the total duration, I calculated the first point this way:

1,201 x 0.618 = 742.218 (rounded to nearest prime: 743)

the next point similarly:

742.218 x 0.618 = 458.69 . . . (rounded: 457)

and so on for eleven more iterations. I then mirrored this sequence towards the end of the piece, always rounding to the nearest prime, so the compression of durations would also occur at the end. Rounding the numbers resulted in an imperfectly symmetrical sequence of points throughout the length of the piece, since there are fewer points that are prime in the area of 1,201. (See Appendix B for the structural maps of each movement).

The process just described produced the organ's layer of divisions also, but within each movement individually, and without the mirroring. By only allowing the process to run in one direction, I could decide whether the values would increase or decrease towards the end of each movement. Therefore, the first and third movements "compress" and the second movement "expands." One interesting result of comparing the two layers is that the two "main" points in the orchestra's map coincide within four seconds to points in the first and second movements in the organ's map. These coincidences suggested possible major arrival points in the music. Apart from these two connections between the layers, and four at the end of the work (in Movement III; see Appendix B), the layers remained independent.

The first of these junctures, in the first movement, appears between 7'37" and 7"41", leaving 2'18" before the scheduled double bar. I decided that this juncture should mark the beginning of the cadenza. This plan worked successfully since the length of the cadenza in relation to the rest of the movement sounded appropriate. The second coincidence between the two layers appeared at the GR of the second movement (which is also the GR of the whole piece), and serves to initiate the climax.

Originally I thought I would keep the organ and the orchestra materials independent, like their respective maps. As I got further into the composition, however, this proved to be impractical. I wanted more cohesion between the soloist and the orchestra, so the two layers ended up contributing to the whole musical texture, regardless of their original affiliation.

Internal Structure of Each Movement

Movement I

In the orchestral map of GR points, the first six occurred so close together that they could not serve to mark section changes that would be musically appropriate for the beginning of the piece. These appear in the timpani as low F-sharp attacks. Subsequently, every point in the orchestral map marks a change of section. However, since the last two spans before the cadenza make up half of the time of the movement, and I wanted some smaller units to work with, I needed a logical way to subdivide them.

The first span that I divided (109" - 173") was sixty-four seconds long. I sectioned it by multiplying the duration by the smaller part of the GR (0.382):

64" x 0.382 = 24.448 (or 25" rounded)

This created a unit of twenty-five seconds followed by a unit of thirty-nine seconds.

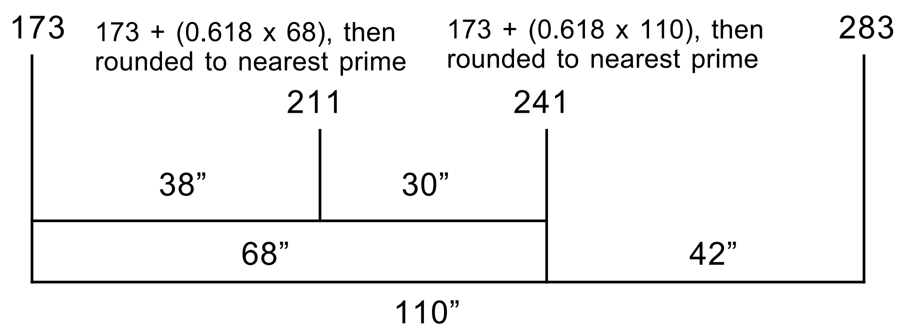
The next span fell between 173" and 283" (1'50" in duration). To divide it I used a function that would give me successively smaller sections: N = 173 + (0.618 x *d*), where *d* is the current duration being divided, and 173 marks the point at which these subdivisions would begin. The results would indicate boundaries between sections on the time map. For example, the first subdivision was created in this manner:

173 + (0.618 x 110) = 240.98, or 241 (the nearest prime)

That left sixty-eight seconds, which I also subdivided:

173 + (0.618 x 68) = 215.024, or 211

Ex. 3.1 shows this process graphically.



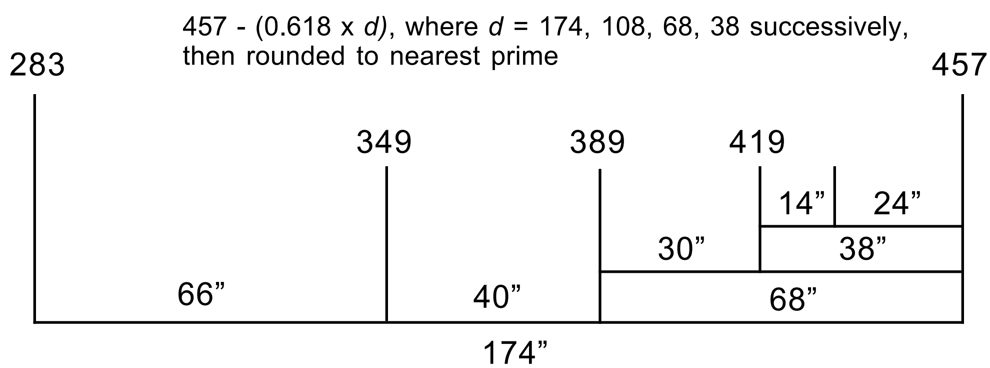
Ex. 3.1. Subdivisions between 173" and 283", Movement I.

I used this same approach in the next span (from 283 to 457, which is 174" long) but modified the function to read: N = 457 - (0.618 x *d*). The difference here is that the 457 represents the end of the time to be divided, and that the product is subtracted from it. At the end of this procedure I had created five units, following which would begin the cadenza (see Ex. 3.2).

At 457" the orchestra reaches its arrival before the cadenza, and holds that chord for four seconds, at which time the organ's cadenza begins.[1] The map for the

[1] These four seconds are the difference between the closely coinciding GR points in Movement I (see Appendix B).

organ from this point to the end shows six units based on the calculations described earlier for the two separate maps. Since they compress in size towards the end, they served as good references for changing the material throughout the cadenza by providing a sense of acceleration. (See Appendix B).



Ex. 3.2. Subdivisions between 283” and 457”, Movement I.

Movement II

The second movement has only one GR point in its orchestral map. This point represents the GR of the entire duration of the work, and as such, it plays an important role in the movement in that it marks the beginning of the climax. The first three GR points in the organ map appear too close together to serve as sectional divisions, but function well as points of change in the upper strings. The remaining points in the organ’s map indicate new sections through metric modulations.

Movement III

In the third movement I had planned on using the two maps to provide points of emphasis for the organ and the orchestra. I also knew that the movement would be a passacaglia. The ground bass ended up being exactly 20” long, which meant that I could fit eighteen of them in the allotted time with 13” left over. This shorter bit became the introduction. The bass and sixteen variations follow, leaving the last 20” unit as the coda. I knew early on that 20” would be too short for the coda; as it turned out, it expanded to about 1’13”. Early in the composition of the movement I also intended to incorporate the GR points from the two maps. However, several months later, after recomposing several of the variations, I realized that it would be impractical to go back and impose a conflicting structure on the music. Therefore, the two maps do not influence the structure of this movement.

Variances in the End Result

At this point in the discussion, it would be intriguing to examine how the final form of the music diverged from the carefully planned structural maps. There are two major instances where the music ended up longer than planned, these occurring at the end of both the first and third movements. Other than that the music remained close to its original plan.

Movement I: Cadenza

The cadenza came together fairly easily according to the plan, but I felt there needed to be a departure from the map in order to create a satisfying end to the movement. For the first two units of the cadenza (48” and 38”) the tempo is MM=60. It appeared that this tempo would work for the rest of the cadenza also. However, after composing the next three units (22”, 8”, and 10”), which was the pedals solo, it seemed to me that the music moved too quickly. To make it work I decreased the tempo to MM=52 and left all of the notes intact, which increased the overall length of this section. In addition, the movement was not complete at the end of the last unit; it still required fifteen more beats (or about 17”) for the conclusion to sound logical. In total, the cadenza grew by 25”, from a planned 2’18” to 2’43”. That was acceptable to me, however, since planned structures must be able to be changed to serve the good of the whole.

Movement III: Coda

As in the first movement, the changes to the original plan of the last movement came at the end. However, in this instance I knew after creating the map that the ending would require more time than I had allotted. I had no systematic way of extending the duration, unlike in the first movement, so I composed until it sounded complete. As a result, the 20" allotted to the coda grew to about 1'13".

As I have alluded to, my divergence from the original calculated plan came about for aesthetic reasons. The music did not have enough room to evolve "musically" in the rigid, carefully planned structure. John Winsor warns against following a system too strictly:

> Systematic approaches to composition can, indeed, produce elegant structures, but they are not likely to be *musical* structures. Even if a systematic approach is tentatively applied, the composer's choices *must* be tempered by aural sensitivity. What we discover upon reflection is that the *musical ear*–primarily a function of the pattern-recognizing and pattern-generating intuitive mode–*does* inform our choices with order–order that is as impressive as any that can be imposed by mathematical formulae and which is decidedly more musical.[2]

Even though he seems to believe that composers should not utilize systematic approaches to composition, his assertion that their musical ear must inform compositional choices supports my compositional methodology.

[2] Winsor, *Breaking the Sound Barrier*, 108-9.

CHAPTER 4

GENERAL MAPPING PROCEDURES

In using generative processes during the creation of a musical work, the composer must determine how the results will become music. Perhaps the most basic way to do this is to create a one-to-one correspondence with the various musical elements that are being generated. For me this frequently proves insufficient, especially over large durations (several phrases or whole sections). I prefer to limit a particular mapping scheme to single phrases or periods, but as I will show later, they occasionally determine longer spans also. First, I will introduce general procedures for converting data to music, with an emphasis on what I used in composing the concerto.

Music from Numbers

Numbers as Pitch

At some point in the compositional process the composer needs to decide how to convert the generated data (numbers in this case) into pitches. Two possibilities come to mind. First, the numbers can represent specific pitch classes. Depending on whether the resultant music should be diatonic, chromatic, or some other collection, the composer can transform the data to fit the size of the desired set of pitches. The second possibility involves using the numbers as distances between successive pitches (i.e., intervals).

To generate pitch classes, the composer can either apply a modulus, or convert the numbers to a base other than 10. For a diatonic set, processing numeric data mod 7 provides only the values 0 through 6 no matter what the size of the original. For example, if an algorithm produced a “586,” processing it mod 7 would produce a “5”

(586 / 7 = 83 with a remainder of 5), which could then specify the fifth element of the diatonic set ("A" in the case of C major, where C = "0"). The same 586, if converted to base 7, can also produce a non-diatonic set. In base 7, each "place" in the output can contain only a 0 through 6, in this case resulting in 1465. As pitch classes (where C = "0"), this output becomes the sequence C-sharp, E, F-sharp, F. These pitches could then be used melodically or harmonically.

As mentioned in Chapter 2, I chose to work with number bases rather than moduli because I was interested in the decimals as strings of individual numbers. My original idea was to see how I could create a phrase with one decimal string (or more accurately, one permutation of the related carousel number). Since I was composing in a chromatic context, I frequently converted strings of digits from base 10 to base 12. For example: the basic repeating segment for 1/17 is 0.0588235294117647. I removed the decimal point and the zero to its left, which left the carousel number

0588235294117647

(the leading zero is necessary) and converted that to base 12:

055e83e3598e153

(See Chapter 2, note 5 for an explanation of the letters in the number.) This process resulted in a string of 15 pitch classes, each of which could be positioned in any octave and still conform to the system.

Another method of generating pitch from numbers is to use the numbers as intervals, where 1 = minor second, 2 = major second and so on.[1] Where using the numbers as pitch classes gives the composer choice of octave placement, by using the numbers as intervals the composer has the choice of interval direction (i.e., up or down). Conceivably, this choice could also be determined by an algorithm, although I prefer to make those decisions myself; it allows me to shape the line more intuitively.

[1] This method specifies the distance between two successive pitches. It does not specify interval *classes*, although a system for interval classes could be created as well.

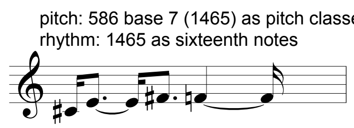
Example 4.1 compares the output of the two methods, both using 1/17 base 10 as the source material. They both produce interesting lines, however the one created from interval mapping appears in the concerto while the pitch-class mapping does not.

Ex. 4.1. Comparison of interval and pitch-class mapping in a melodic line.

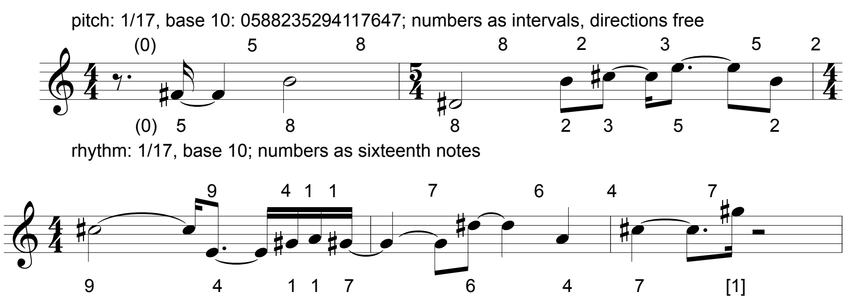
As I composed the piece I found that I generally preferred melodic lines and chords that came from using intervals over those that came from using pitch classes. I felt that the resulting lines or chords felt more "organic," while the pitch-class method sounded too artificial. Here, musical intuition tempered what could have become an impossible system. Fortunately, mapping intervals worked well; otherwise my musical intuition may have required a completely different approach to writing the concerto.

Numbers as Rhythm

As with mapping algorithmic output for pitch, numbers can have a one-to-one relationship with durational values. By using sixteenth notes as the basic unit, a 1 becomes one sixteenth-note; a 2 becomes an eighth-note (two sixteenths) and so on. For example, if a composer took the 1465 from the output of the hypothetical algorithm mentioned earlier and applied it also to the rhythm of the generated pitches (from the conversion to base 7), the result would be a gesture like what appears in Ex. 4.2. Any other durations could also be used as the basis, such as eighth-note triplets; or different durations could be mixed. For this system to generate longer phrases the composer would need to have a lot of numbers for mapping. Example 4.3 shows the creation of a phrase using the decimal of 1/17 base 10 for pitch and duration mapping, and placed in a metric context.



Ex. 4.2. Combination of pitch and rhythm mapping.

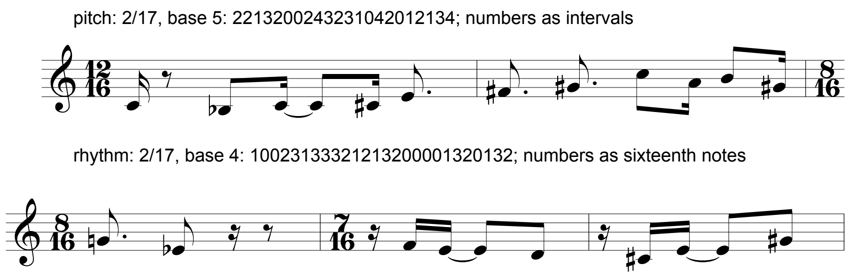


Ex. 4.3. Phrase generated with a long string of numbers.

Using alternate number bases creates more rhythmic possibilities, and also allows the composer to limit the number of durations in a particular phrase. In base 10 there are nine possible durations plus a zero (which is useful for rests).[2] In base 4, however, there are only three possible durations plus many more zeros. This reduction of possible durations lets the composer create more rhythmically integrated rhythms. The melody in Ex. 4.4 uses the numbers from 2/17 as a basis, with intervals

[2] Nine is a significant amount, considering that Mozart, for example, used only two durations, quarter and eighth, for most of the first theme in the first movement of his Symphony no. 40.

coming from base 5 and rhythmic durations from base 4. This presents a more homogeneous rhythmic and intervallic character than it would using larger bases. In the Organ Concerto, utilizing the different number bases provided a wealth of material for rhythmic generation.



Ex. 4.4 Melody using different number bases

Numbers as Other Quantifiable Musical Parameters

Number series can also provide mapping possibilities for other musical elements. For example, numbers could determine the sizes of structural components such as phrases or sections when mapped as beats or seconds, or some other unit that the composer desires. In his book *Simple Composition* Charles Wuorinen explains how composers can apply the twelve-tone system of composition to form.[3] The procedure with these numbers would be similar. (I did not create the formal divisions of the concerto this way, however. Instead, I used the golden ratio calculations that I described in Chapter 3.)

Another mapping procedure could determine the placement of accents or dynamics. Here the composer could indicate where accents or dynamic changes will occur by using the numbers to indicate durations between changes. In the concerto it

[3] See Charles Wuorinen, *Simple Composition* (New York: Longman, 1979; reprint, New York: Schirmer Books, 1988), Chapter 11.

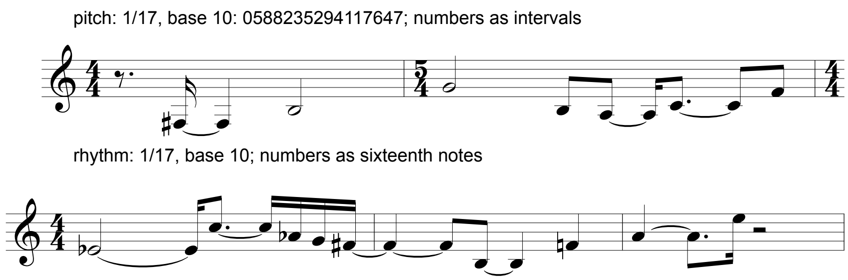
relates closely to my process of generating rhythm (see Chapter 5 for a more detailed explanation).

A series of numbers could also define transposition levels of larger sections, such as for the repetitions of the ground bass in a passacaglia. In the concerto I determined the transpositions of the passacaglia theme in Movement III by using 3/17 base 8 (62117663320026455) as pitch-classes. I allowed myself to substitute one of the unused pitch-classes (8, 9, t, e) for one of the values in each pair of repeated numbers (11, 66, 33, 00). Following this procedure the bass transposition became 629176t3e2082-6455 for the theme and the sixteen variations.

Compositional Responsibilities

Except for the use of number systems to organize the variations of Movement III, my choice of a specific decimal and number base at any given time in the music arose from practical and aesthetic considerations. This meant that I chose them based on the amount of time that needed to be filled (for rhythmic and melodic considerations), and what sounded good (usually after several poor choices). Only in the passacaglia did the numbers determine which fractions I would use long in advance. For all other fraction and base choices it took a lot of trial and error to create usable material. But that is really no different from composing purely from “intuition” in my experience.

I should note that mapping the same number series could produce a myriad of distinct pieces. To illustrate, compare Ex. 4.3, which ended up being rather diatonic, with Ex. 4.5. I used the same set of numbers for intervals and rhythm in each example and only varied the interval direction, which produced radically different results. I based the choices I made in Ex. 4.3 on a certain sound that I was looking for, while those of Ex. 4.5 were more randomly chosen. This reflects the process for the whole composition. As I have mentioned before, I allow myself the freedom to suspend any system that I set up if I feel that the system is inadequate in some way. Musical intuition drives the decision to revise the procedures, or to adjust the output freely until the results are acceptable.



Ex. 4.5. Alternate version using the same procedure as Ex. 4.3.

It has probably become apparent that I give myself quite a bit of freedom in deciding what to use and how to apply it. While a lot of what I have discussed so far could be programmed into a set of instructions for a computer, the remainder of this paper will demonstrate that the finished form of the concerto could not have resulted from a self standing series of algorithms. My method of composing is freer than serial composition in that I break the “rules” (in this case my own rules) more frequently than strict serial composition allows. As with any compositional method, I strive to create music that is satisfying in and of itself. For me, the limitations inherent in any compositional system add interest to the process of composing, if not to the resulting music as well.

CHAPTER 5

STRAIGHTFORWARD MAPPING

In Chapter 4 I showed some possible mappings of number series into elements of music. As I was composing the concerto, I always strove to use as few steps as possible in generating the finished music, and in some cases I succeeded in just one or two steps. However, those represent the minority of cases. Most of the pitch generation went through several phases to arrive at usable material. In this chapter, however, I will show some of the more straightforward mappings that became part of the concerto.

Percussion and the Binary Sequence

The simplest application of generated material involved the percussion, since a pitch dimension frequently was not needed for it. I found that the different base 2 (binary) series worked well for this purpose, and I composed a lot of percussion material this way, particularly the introduction of the third movement. In composing this part I wanted to try superimposing several binary streams. Starting with 1/17, I decided to use as many additional fractions as I could. After vertically aligning the number streams I noticed that 1/17 and 2/17 had exactly the same sequence of zeros and ones (but offset by the leading zero that was necessary for all of the base conversions for 1/17). Upon closer inspection I noticed that for the fractions with the numerators 1, 2, 4, 8, and 16 the binary sequence of digits was the same, with an extra zero added for each higher fraction (see Ex. 5.1).[1] This congruence proved to be useful because I could assign the 2/17 and the 4/17 sequences to the same percussionist playing two different instruments at the same time, and the 3/17 and

[1] These relationships occur because the numerators are related by B^n (B to the *n*th power), where *B* is the number base and *n* is any whole number 0 and larger. See Appendix C for a more detailed explanation of the mathematics involved.

6/17 sequences to another percussionist. Example 5.2 shows how the music looked before editing. In this instance all of the ones in the sequence are sixteenth note attacks and all of the zeros are sixteenth note rests.

1/17 base 2: 010000101101111111110011001111000000000001111000011111
2/17 base 2: 100001011011111111100110011110000000000011110000111110
4/17 base 2: 1000010110111111111001100111100000000000111100001111100
8/17 base 2: 10000101101111111110011001111000000000001111000011111000
16/17 base 2: 100001011011111111100110011110000000000011110000111110000

Ex. 5.1. Relationship between numerators related by powers of 2.

Ex. 5.2. Rhythmic generation from binary sequences

I also mapped another layer onto the opening percussion texture. At first I wanted to take the fraction that generated each instrument and use the same binary sequence for accents. Here the zeros in the sequence would indicate skipped notes (that are already in the texture), and nothing would be counted over the rests. However, I did not like this arrangement once it was completed because there were too many accents. A larger base for each fraction solved the problem. I assigned base 4 to generate all of the accents, using the fractions 7/17 for the timpani, 5/17 for percussion 1, 2/17 for percussion 2, and 3/17 for percussion 3. Zeros meant no accent on a particular note; a one indicated an accent. Since base 4 also includes the values of two and three, I decided that a two would mean no accent on the second "part" of the digit, so that a "2" would be identical to the sequence "1,0." Likewise, a "1,0,0" and "2,0" and "3" would all mean the same thing. I ignored all of the "extra" values at the end of the base 4 strings. See Ex. 5.1 for the way the accents mapped on to the rhythms.

The "Original" Main Theme of Movement I

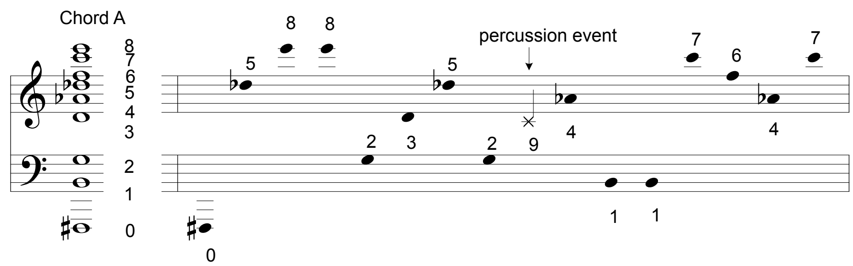
Example 4.3 shows a melody I generated using 1/17 base 10 for both interval content and rhythm. It took many adjustments to the intervallic directions for me to arrive at its final form. Once it was complete, I felt that it needed to appear somewhere in the concerto. For a while I considered it to be the main thematic material for Movement I. Eventually, after trying unsuccessfully to incorporate it into the movement, I began writing the movement again and left it out. However, I did not want to abandon it altogether, because I liked it and it served as an excellent model for this process of composing. It just was not consistent with the direction the concerto was taking. I eventually decided that I would keep the contour of the melody (the intervals and their directions), discard the rhythm, and then see how I could extend its content. This resulted in the set of transformations as shown in Appendix D.

I include the above example in this discussion because it illustrates the validity of both Wuorinen's and Winsor's somewhat opposing views on composing with systems. I had to allow the integrity of the concerto as a whole carry a higher priority than my attachment to a “perfect specimen.”

The New Opening of Movement I

I have shown how I used numbers to create melodies and their rhythms, but I also used the system for larger sections, notably the opening of Movement I. Here, a nine-member chord builds up one pitch at a time (the construction of the chord itself is discussed in the next chapter). I determined the timing of the pitch entries with 1/17, base 10. First, I dealt with the discrepancy between the number of elements in the chord and the sixteen places in the decimal. The decimal includes all ten digits (zero through nine) and most of them appear twice. I assigned the digit “9”, which only appears once, to a percussion event, and each of the remaining digits to one of the members of the chord. Starting with the lowest note of the chord, I numbered them all upwards, and assigned their first entry to appear when their representative number appears in the decimal (see Ex. 5.3). The number I assigned to each pitch also represents the duration in eighth notes before the next entry appears. The one exception is the opening low F-sharp (“0”), which lasts for eight eighth-notes before the next entry. For those digits that occur more than once I applied an orchestrational component to add interest to the texture.

This process resulted in a slow, introductory opening to the movement. Because it sounds introductory, I decided to undermine that perception by giving it more importance throughout the movement. This had no relationship to the algorithmic processes I used, but came from musical intuition.

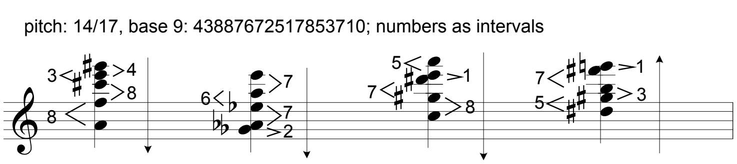


Ex. 5.3. Chord element entry order at the beginning of Movement I.

Chord Progressions in Movement II

Strings at the Beginning of Movement II

Another relatively straightforward mapping appears in the construction of the chords at the beginning of the second movement. After trying a few sixteen-digit number series that had created a lot of duplicate pitch classes, I found that 14/17, base 9 produced a usable series of chords. I used the numbers to determine the intervals between each chord member from top to bottom, except for the last chord. A common E in the first three chords and a common G-sharp in the last two link them together as a progression (see Ex. 5.4). This method of creating chords proved so successful that I generated nearly all of the chord progressions in the piece using similar procedures.



Ex. 5.4. Chord construction at the beginning of Movement II.

Rhythm in the Wind Chords and in the Organ

To create the rhythm for the wind chords in Movement II (mm. 21-24), I applied 12/17 base 2 as sixteenth notes (where 1 = attack and 0 = rest) to the six chords I had created for this part. The chords each received a different number of digits from the binary string (6, 7, 8, 9, 11, 12). However, this does not indicate the number of "hits" each chord received, since many of the digits are 0s.

The big hole towards the end of the series (eight 0s together) needed to be filled. It seemed to me that the organ could re-enter at this point, so I freely borrowed from the organ part in mm. 52-53. This led seamlessly to the point where the organ picks up on the rhythmic idea that the winds just finished.

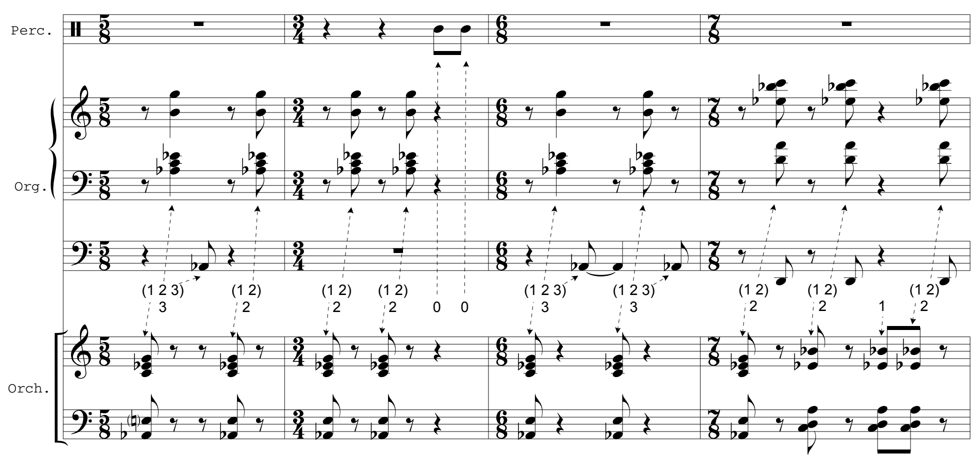
I then took the chords from the orchestra and put them in the organ in reverse order and with different transpositions and common tones. I also embedded a line based on the material from mm. 50-55. I needed sixty-five sixteenth-notes to fill the section up to the tempo change, so the rhythm of the chord hits (separate from the embedded line) came from 12/17 base 11. Here, the numbers represent the time, in sixteenth-notes, between each appearance of the chord. As before there are six chords, for a total of fifteen hits, so each chord gets a different number of digits from the string. They follow the pattern 2, 3, 2, 1, 3, 4, which I had freely determined.

The Climax of Movement II (Part 1: Rhythm)

The climax of Movement II involves a layer of straightforward mapping and a layer of convoluted mapping. The following discussion explains how the method of rhythmic mapping serves as a foundation for the more complex process of pitch generation, which is covered in Chapter 6.

Rhythmically, the climax of Movement II is straightforward. Unlike other sections of the concerto, I did not know beforehand how long this section should be. I knew where the climax would start, but since it initiates the last section of the movement, and I did not want it to fill the entire section, I needed a way to determine its length. By using 7/17 bases 2, 3, and 4 in succession, with the eighth note as the basic unit, this section became 25” long.[2] The mapping procedure for all bases was as follows: 0 = percussion event, 1 = orchestral event (non-percussion), 2 = organ manuals, 3 = organ pedals. When 2 and 3 appeared I subdivided them so that a 2 consisted of “1 and 2,” and 3 consisted of “1, 2, and 3” (see Ex. 5.5). The directness of this system results in its being more audible than most of the processes involved in the concerto.

At the time I came up with this plan, I trusted that the system would produce something usable. I only had one chord, which I knew would start the section, so at that point I needed to generate pitches (see the first section of Chapter 6). As the pitch content of the section came together, I realized that the procedure for generating this section had proved to be successful.



7/17 base 4: 3 2 2 2 0 0 3 3 2 2 1 2 2 2 1 0 0 0 1 2 2 1 1 2 2 1

Ex. 5.5. Rhythmic mapping in the climax of Movement II.

[2] The entire climax is 46” in duration. After 25” there is an interruption, lasting for 14”, which is followed by a restatement of the 7” preceding the interruption.

CHAPTER 6

CONVOLUTED MAPPING

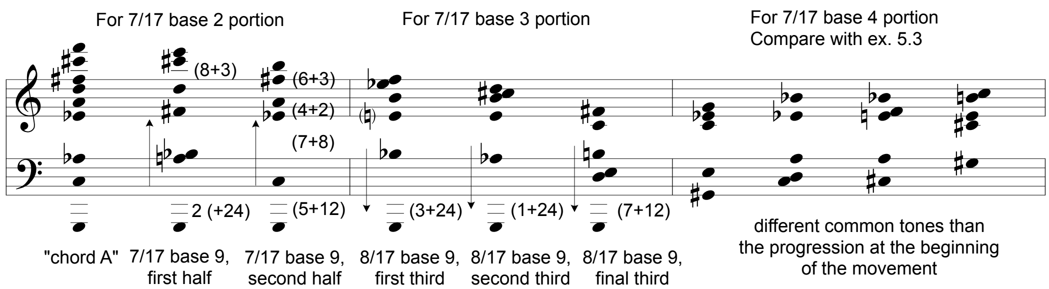
The material covered in this chapter represents more complex applications of the number systems described earlier. I would say that none of the mathematical processes that I discuss here are directly audible in the music (even less so than the material in the previous chapter). However, their inaudibility does not detract from their compositional importance to the concerto.

The Climax of Movement II (Part 2: Pitch)

The complex procedures that I followed to generate the chord sequence in this section are overshadowed by the straightforward rhythmic mapping, and its audibility, as shown at the end of Chapter 5. Nevertheless, the mapping of the pitch material proved to be equally successful.

I used the initial chord from the first movement ("chord A"–explained in the next section) to begin the climax of this movement, and transposed it up a semitone so the bass would be a G. This was an intuitive decision to highlight both the pitch and the beginning of the new section, since G had not received any weight so far in the bass.

To extend the sequence, I constructed two additional chords based on 7/17 base 9, which fit nicely into the base 2 rhythm. The three chords of this first part now appeared 5, 11, and 8 times, respectively, to fill the twenty-four 1s in the base 2 sequence. Seven more chords were needed to get through the rhythm, so I made three from 8/17 base 9 (as intervals, starting at the top). These I placed in the twenty-two orchestra hits that comprise the 7/17 base 3 rhythmic section (mm.80-86), still with the low G pedal point. They appear 9, 8, and 5 times, respectively (more or less freely chosen). For the 7/17 base 4 rhythm (mm. 87-93) I employed the four chords from the beginning of the movement (in the strings), but with a new transposition, and new relationships in the progression (see Ex. 6.1). For their twenty-one necessary hits I decided on the sequence 7, 6, 5, and 3, respectively.

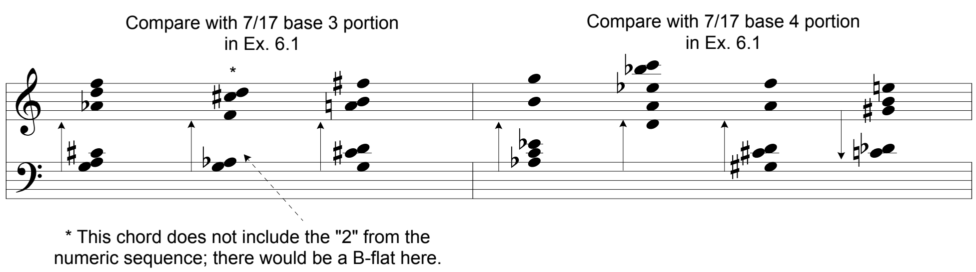


Ex. 6.1. Orchestral chord construction for the climax of Movement II.

This chord progression came about largely through intuition. Certainly an autonomous algorithm could have produced the mapping of the pitches into these chords. But I would not have known ahead of time, in programming the algorithm, which pitches to leave out (as indicated by instances such as “8+3”). I would have had to edit the output heavily in order to get the chords to this state. Also, I organized the chords into an acceptable progression much more easily by working with pencil and paper than I would have if I had had to create a program to do it. In short, this illustrates that, for me, working with a relatively minimal amount of external data and a lot of musical sense produces results more efficiently than relegating most of the decisions to a system.

For the organ’s chords during the base 3 and base 4 rhythmic sequence, I inverted the direction of the intervals in the orchestral chords (see Ex. 6.2). When the base 4 portion begins, the organ pedals enter the texture whenever there is a “3” and the pedal notes come from an appropriate pitch from chords in the manuals (see Ex.

5.5). The transposition of the last few organ chords was harder to determine. I used maximally similar sets for the organ chords as compared to the ones in the orchestra, and then transposed the chord until it sounded right. The pedal line originally would have stopped soon after entering (since only the first third of the base 4 sequence has "3s" in it), so I freely involved this part in the rest of the section as well.

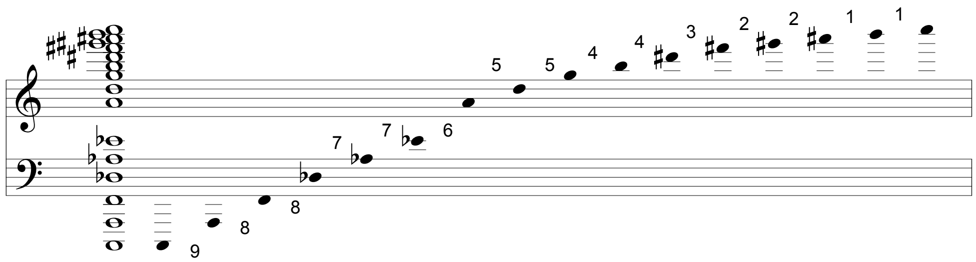


Ex. 6.2. Organ chord construction for the climax of Movement II.

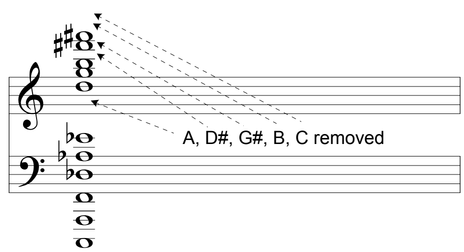
The Genesis of "Chord A" and its Descendants

What I call "chord A" figures prominently in the concerto. It appears gradually throughout the beginning of the first movement (see Chapter 5) and is the main feature of the movement's four "A" sections. It also begins the climax of Movement II, as discussed above, and it appears in the coda of Movement III. Its appeal also inspired me to make additional chords based on it, which figure into the cadenza of Movement I and the end of Movement III. The following detailed description of its creation shows the interaction between intuition and procedure that was required.

I did not set out to create a "generic" chord, as I later referred to it, but rather a chord based on the essence of the set of numbers, base 10, that make up the rotating decimal. I began by arranging them in descending order (9887765544322110) and then built a chord up from the bottom following this sequence (see Ex. 6.3). I eliminated the duplicate pitch classes by starting at the bottom and removing any pitch class that had already appeared (Ex. 6.4).

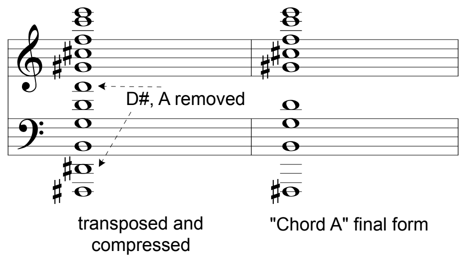


Ex. 6.3. Chord A, stage 1.



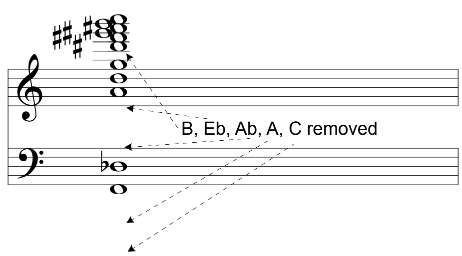
Ex. 6.4. Chord A, stage 2.

Next, I realized that the lowest pitches were out of range, so I transposed the whole chord up six semitones. This necessitated that I transpose the top five notes down an octave as the top was now out of range. Finally, I eliminated the sixth note from the top (the A; see Ex. 6.5) and the low D-sharp to clean up the sound. The result was chord A in its completed form. Unlike the other methods of music generation that I have shown so far, the "generic" aspect of its generation allows it to relate to materials coming from all of the base 10 series in that it originated from the same group of digits, but with a "generic" reordering of the elements.



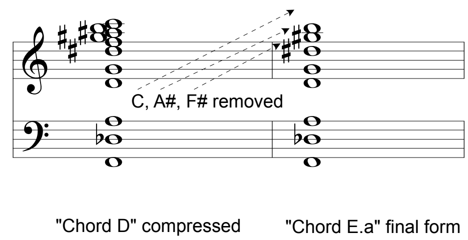
Ex. 6.5. Chord A, stage 3 and completed.

I created six more chords from this idea. Chords B and C came directly from chord A; and chords E.a, E.b, F, and G came from a reduced set (called chord D for convenience; see Ex. 6.6) which I made by starting from the top of the full set (shown in Ex. 6.3) and removing duplicate pitches while working down.

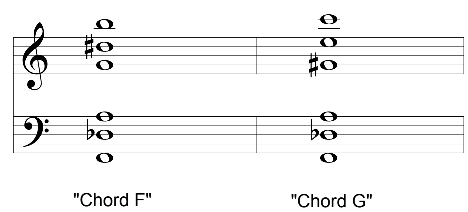


Ex. 6.6. Chord D.

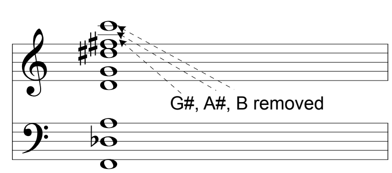
I moved the top part down an octave to eliminate the large gap between the D-flat and the A, and then thinned out the top starting with the C. The result was chord E.a (Ex. 6.7). While this chord did not find its way into the concerto, chords F, and G originated from it. To derive chord F I removed the D and the G-sharp, leaving six pitches that all belong to the same whole-tone set. Chord G differs from F only in that the upper three pitches are transposed to the complementary whole-tone set (Ex. 6.8). Chord E.b results from thinning out alternate pitches from the top of chord D (Ex. 6.9).



Ex. 6.7. The creation of Chord E.a.

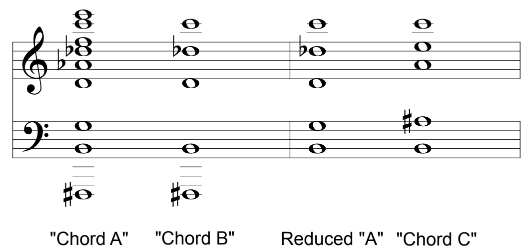


Ex. 6.8. Chords F and G.



Ex. 6.9. Chord E.b.

Chords B and C both stem from chord A. Chord B contains fewer pitches than A; and by inverting a reduced version of A, I derived chord C (Ex. 6.10).



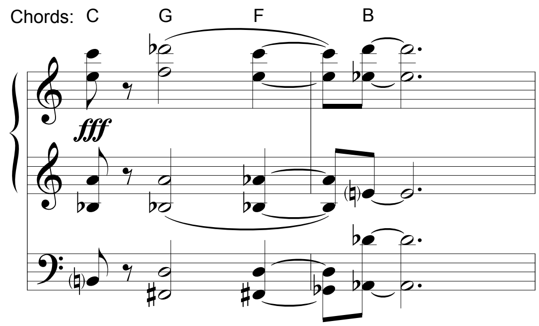
Ex. 6.10. Chords B and C.

These chords arise at various times during the concerto: chord A appears in all three movements; the progression of chords C, G, F, B appears all throughout the cadenza; and chord E.b is heard in the orchestra just before the cadenza.

The Cadenza in Movement I

The following discussion serves as another instance where musicality and a systematic method worked together to create the resulting music. I offer it as a contrast to the intuitively based construction of the chord sequences as illustrated above. In composing the cadenza I relied more on the procedural aspect of the system, and then modified the results as needed to create convincing music.

The beginning of the cadenza uses what I called the “great slow progression” (GSP) comprised of chords C, G, F, and B (Ex. 6.11). It took several experiments in transposition before I found a progression that worked. No particular system yielded the transpositions; I was guided by just my ear. In this unit I incorporated material from the B sections along with the GSP. This provided a link to what had happened previously in the movement.[1]



Ex. 6.11. The progression at the beginning of the cadenza.

In the second unit I included the whole set of melodic treatments and transformations, which came from the abandoned “original main theme” described in Chapter 5 (see Appendix D). Forty-three of the notes spilled beyond the 38” limit that I had allotted to this unit. To squeeze them all into the unit I started from the note at the end of the 38” limit and marked specific notes working back towards the beginning of the unit. I followed a simple additive sequence, 0, 1, 2, 3, 4. . ., where the numbers indicate the unmarked notes between each point in the process (see Appendix E). This resulted in twenty-one marks (the asterisks below the staff). To generate the needed twenty-two remaining marks, I started at the beginning and followed the same type of procedure: 0, 0, 1, 2, 3 . . . (the asterisks above the staff). Then each marked location became two thirty-second notes instead of one sixteenth note. At this point it was necessary to *remove* some of notes; I decided that all sixteenth and thirty-second notes that immediately repeated a pitch were to be combined into a single eighth or sixteenth, respectively.

To create rests, first I mapped some base 2 strings onto the whole unit such

[1] A comparison of mm. 71-78 (one of the B sections) to the beginning of the cadenza (mm.172-83) illustrates this relationship.

that wherever there was a “one” the note would remain, and for every “zero” a note would be removed. That resulted in too many holes, so instead I took 1/17, 3/17, and 5/17 (base 2) and let every 1 count as an eighth note, and every 0 as a sixteenth. This was a much more acceptable solution.

At this point I wanted to incorporate the GSP. I found that 1/17 base 18 (with the values multiplied by 3) produced 228, which is the number of sixteenths in this unit. Therefore, the beginning of each value in the string indicates a chord from the GSP. To make playing easier, I reordered each chord in the GSP to fit in a smaller vertical space, but left the pitch-class content identical to the original form. The twelve digits in the base 18 number produced three full cycles of the GSP, some of which fell on rests, and some of which fell on notes that remained. Those that landed on rests could be any transposition, but those that appeared on remaining notes had to incorporate that note.

To complete the section, I freely added some notes in the pedals, with A being very prominent. I also extended some of the notes through the rests, so there would not be as many holes, and I changed some of the placement of the remaining thirty-second notes so that they would not sound so temporally disjunct.

Summary

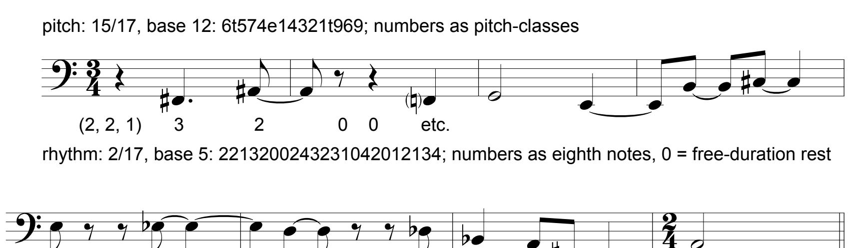
I have shown in this chapter that the more complex a set of generating and mapping procedures was, the more direct input from me was required; not only for the difficulty of figuring out some of the processes, but also for the increased involvement of my musical sense. I enlisted my intuition to temper the procedures. This way I would know when either that a process was finished or that I needed to keep working.

CHAPTER 7

INTUITION AND PROCEDURE IN MOVEMENT III

Evolution of the Passacaglia Theme

The passacaglia theme changed substantially from its inception to its final form.[1] I wanted it to be less “melodic” than the displaced original theme from the first movement (which possibly could have been used; see Ex. 4.3 in Chapter 4), because I wanted it to be able to disappear into the background. At first I tried to derive the bass using 1/17 and 2/17 base 5 as both intervals and durations (since I liked the rhythm that 2/17 base 5 yielded), but I was never satisfied with the results. Mapping 15/17 base 12 as pitch classes (0 = C) proved to be more successful. Since that process provided fewer pitches than the number of rhythmic values available in 2/17, I began on the fourth value of 2/17 in order to align the ends (see Ex. 7.1). Intuition played an important role by informing me when the processes resulted in unacceptable material. It also influenced the way I shaped the final version regarding the length of the rests. Here I tried to balance metric conformity with syncopation, while trying to emphasize the important parts of the line.



Ex. 7.1. Passacaglia theme of Movement III.

[1] The term “passacaglia” is used to refer to a ground bass ostinato, over which continual variations occur, much like J.S. Bach’s famous *Passacaglia and Fugue* in C minor.

Rewriting Movement III

Realizing the Need for Change

I had felt unconvinced about the state of Movement III since completing the first draft (without the coda). I knew that eventually this movement would have to be revisited and fixed.[2] Several months later I removed the variations that did not work and replaced them with new material.[3] I wanted to include tempo changes and also add virtuosic material for the soloist, since this was to be the finale. I initially resolved to rewrite the sixth through the eleventh variations, particularly utilizing references to previous movements. However, I ended up replacing, remapping, or adding to all of the remaining variations (six through sixteen), except for the fourteenth. The earlier variations changed the most, with the changes becoming less drastic towards the end of the movement.

The Process

I began with the sixth variation by adding a tempo change and incorporating the rhythm of the climax in Movement II (which meant that this material now appeared in all three movements). I changed the mapping, and assigned the 1s to the percussion (timpani) and the 0s to the orchestra. After working through that process I realized that the material I was working with came from 7/17, which conflicted with the process I had originally devised for composing this movement. This plan dictated that each of the sixteen variations would use exclusively the fraction that corresponds to the variation number in order to generate all of the material in that variation. Once I had rewritten the sixth variation using this approach (and moved the 7/17 material into the seventh), I found that the new setting was more appealing.

[2] This movement was composed first.

[3] While this may seem obvious, I had originally thought that reworking the existing material would suffice.

In the eighth and ninth variations I retained as much of the original versions as possible, since these seemed to work well. I also kept the new tempo (MM=115), which was established in the previous two variations, since the flow would be weakened if it returned to the original tempo (MM=69). To maintain the duration of ground bass in real time I expanded it appropriately (5:3). The rhythm in the accompaniment, however, was doubled, which meant that additional material was required to fill out the two variations.

The organ material in the tenth and eleventh variations changed so that the pitches were derived from the 10/17 and 11/17 series as intervals instead of pitch classes. This change undoubtedly arose due to my preference for intervallic mapping.[4] I also applied this type of change to the material in the violas and marimba in variations xii and xiii.

In the last two variations the texture gradually builds, and in the last variation the tempo doubles (to MM=138), as are all of the values of the existing material. This allowed me to add orchestral "flurries" to the texture that sound foreign to the main material.

In every case, musicality controlled the outcome, whether by determining which processes would effectively improve the music or by actually supplying the changes. Again, this proved to be the most efficient way for me to write. It also functioned as the final filter through which all of the music had to pass before becoming a permanent part of the concerto.

Fortuitous Discoveries

Some of the most exhilarating experiences in the compositional process occur when something unexpected happens, and the results are aesthetically pleasing.

[4] See the discussion on numbers as pitch in Chapter 4.

This happened several times during the course of composing the concerto, one example of which occurred near the beginning of the compositional process for Movement III.

I began with the material that would eventually become the third variation, although I did not realize it at the time. I had been using 3/17 to generate all of the material above the bass, exploring various procedures in order to generate material. At the time I had yet to decide whether or not to transpose the bass for each new repetition, so I assumed that the material I was developing would be the first variation. I soon realized that transposing the bass would add a fresh component to each variation, and created the bass transposition pattern independently of the material already composed, as illustrated in Chapter 4. Along with this process I assigned each of the sixteen variations to its corresponding fraction. Once the bass was transposed according to this pattern and the upper material was placed in its proper variation, I found the interaction of the parts to be much more interesting than before. This also facilitated the composition of the remaining variations, as one of the most difficult compositional decisions (i.e., where to get the basic material) had been made. Again, intuition and process worked together to create music that would not have resulted from either one of these modes working independently.

CHAPTER 8

CONCLUSION

Using algorithmic processes can relieve composers from some of the aspects of composition (the "hard work")[1] that they have to address. However, anyone who can program a computer could create a set of rules to generate music-like results, whether they have had musical training or not. Is that music? Is that composing? Everyone has an opinion, so I will not answer for all. However, I tend to agree with the group that believes that "only what comes directly from the hands of an artist is of the artist."[2]

For me, the process of composing must have a direct relationship with the mind of the composer. I do not believe that any composer should relegate all, or even most, of the musical decisions required to write a piece of music to a set of predefined processes, regardless of whether or not he or she established the processes. However, processes can prove to be very useful when tempered with human input. At some point musicality must inform the compositional process, and that can only happen when filtered through a human mind.

The systematic processes that I have described in this paper originated outside of the domain of music. The mathematical content and the way it informed the music was abstract and "cerebral." Their reason for existence, however, was to stimulate my musical imagination, with musicality as the final goal. John Winsor illuminates this issue:

> Many people have claimed that the modernists were 'too cerebral,' but that was not true. Bach, Mozart, Beethoven, and Brahms were all cerebral composers. They all wrote music that exhibits extraordinarily elegant order. However, they didn't place systematic approaches to composition above

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[1] Jacob, "Algorithmic Composition," 157.

[2] Ibid., 158.

> musicality; indeed, the cerebral aspect of their writing was specifically directed *toward* musicality.[3]

As demonstrated in this paper, musicality ultimately informed my decisions in every case.

[3] Winsor, *Breaking the Sound Barrier*, 118.

APPENDIX A

PRIME NUMBERS THROUGH 1,201

APPENDIX A

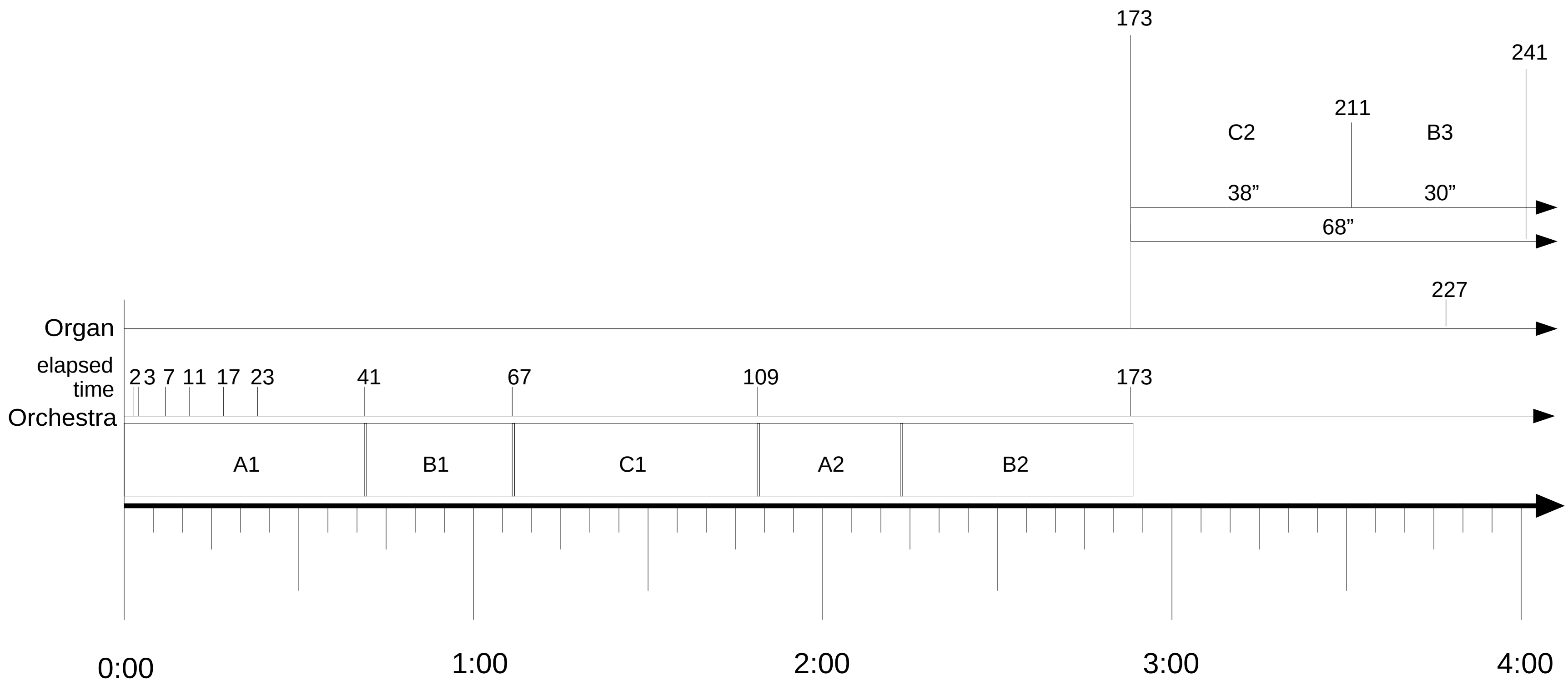
Prime Numbers through 1,201

2	3	5	7	11	13	17	19	23	29	31	37	41	43	47
53	59	61	67	71	73	79	83	89	97	101	103	107	109	
113	127	131	137	139	149	151	157	163	167	173	179	181		
191	193	197	199	211	223	227	229	233	239	241	251	257		
263	269	271	277	281	283	293	307	311	313	317	331	337		
347	349	353	359	367	373	379	383	389	397	401	409	419		
421	431	433	439	443	449	457	461	463	467	479	487	491		
499	503	509	521	523	541	547	557	563	569	571	577	587		
593	599	601	607	613	617	619	631	641	643	647	653	659		
661	673	677	683	691	701	709	719	727	733	739	743	751		
757	761	769	773	787	797	809	811	821	823	827	829	839		
853	857	859	863	877	881	883	887	907	911	919	929	937		
941	947	953	967	971	977	983	991	997	1009	1013	1019	1021		

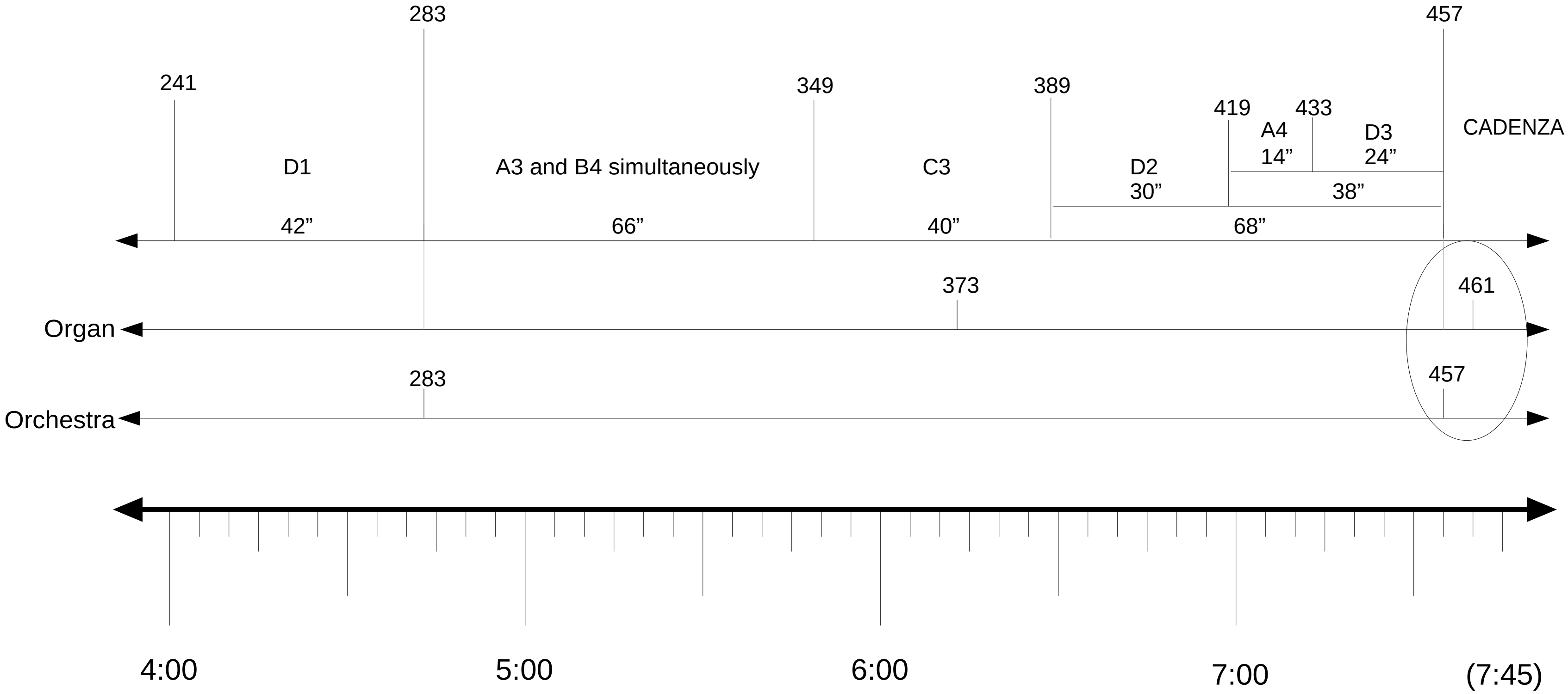
APPENDIX B

STRUCTURAL MAPS

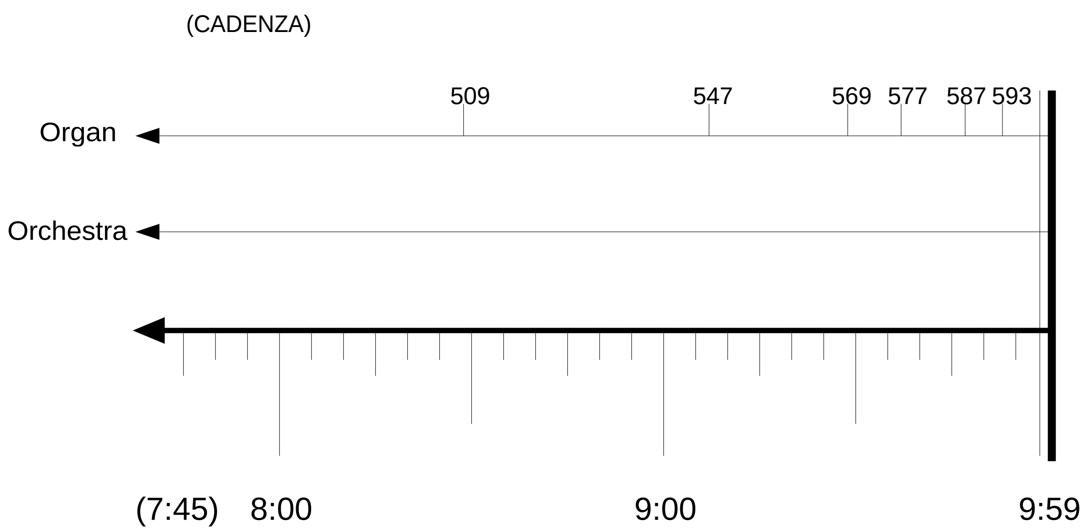
Movement I (part 1)



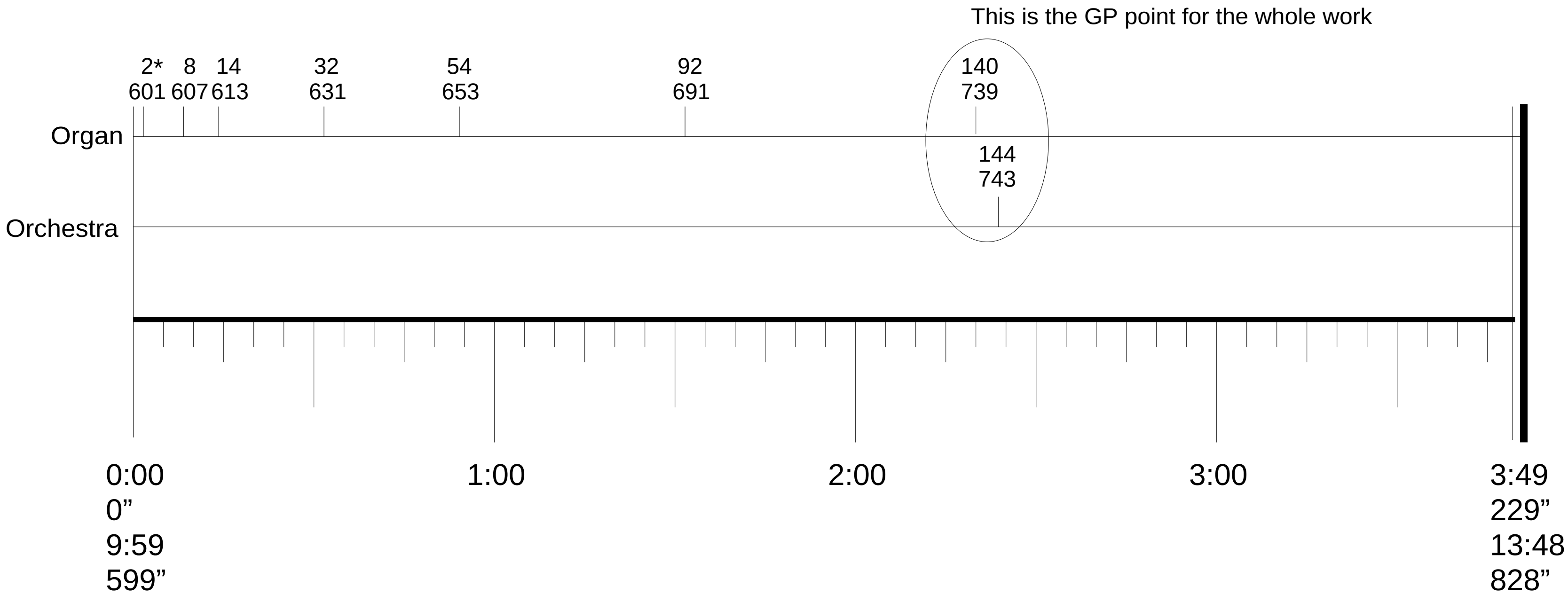
Movement I (part 2)



Movement I (part 3)

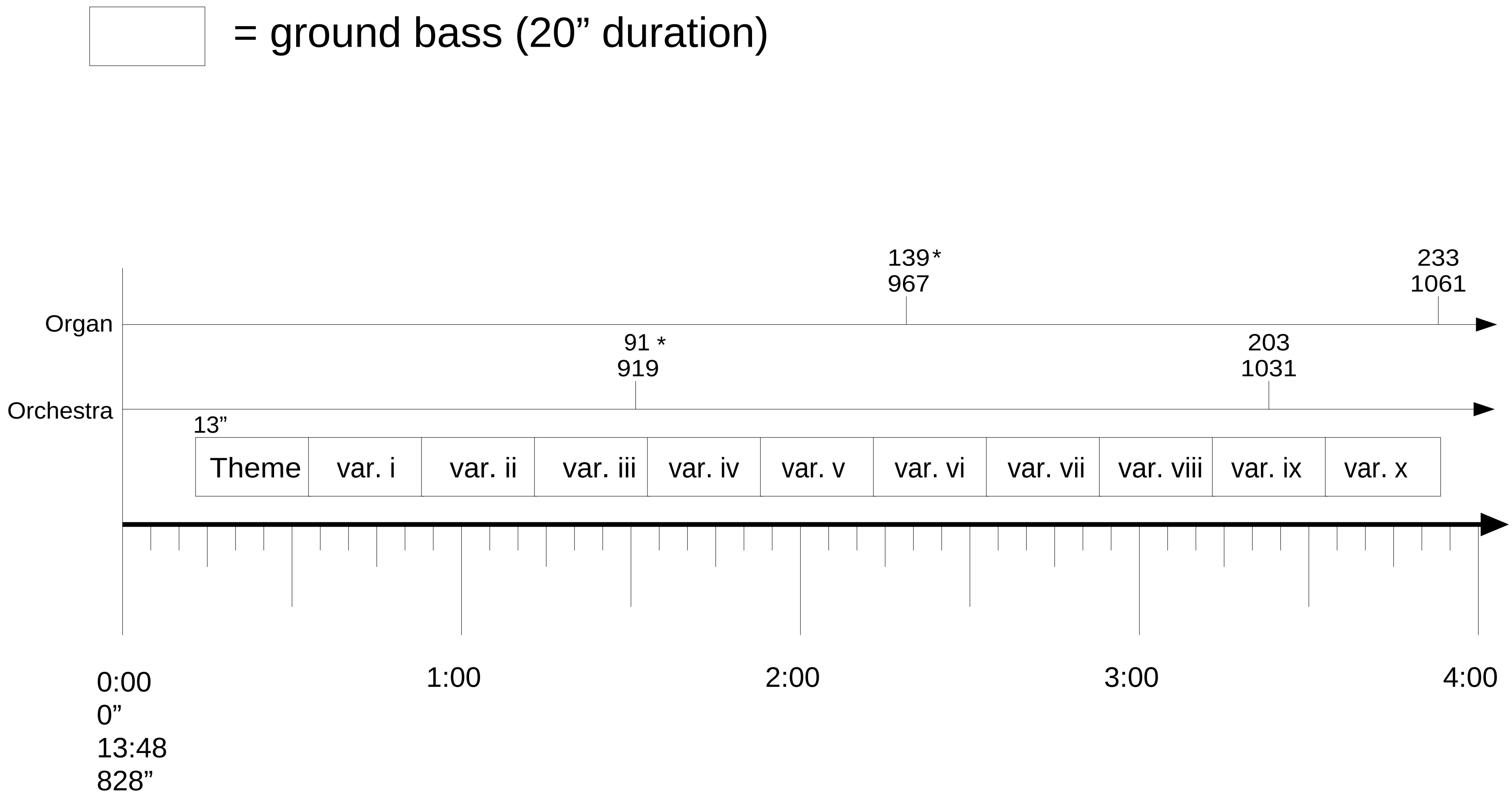


Movement II



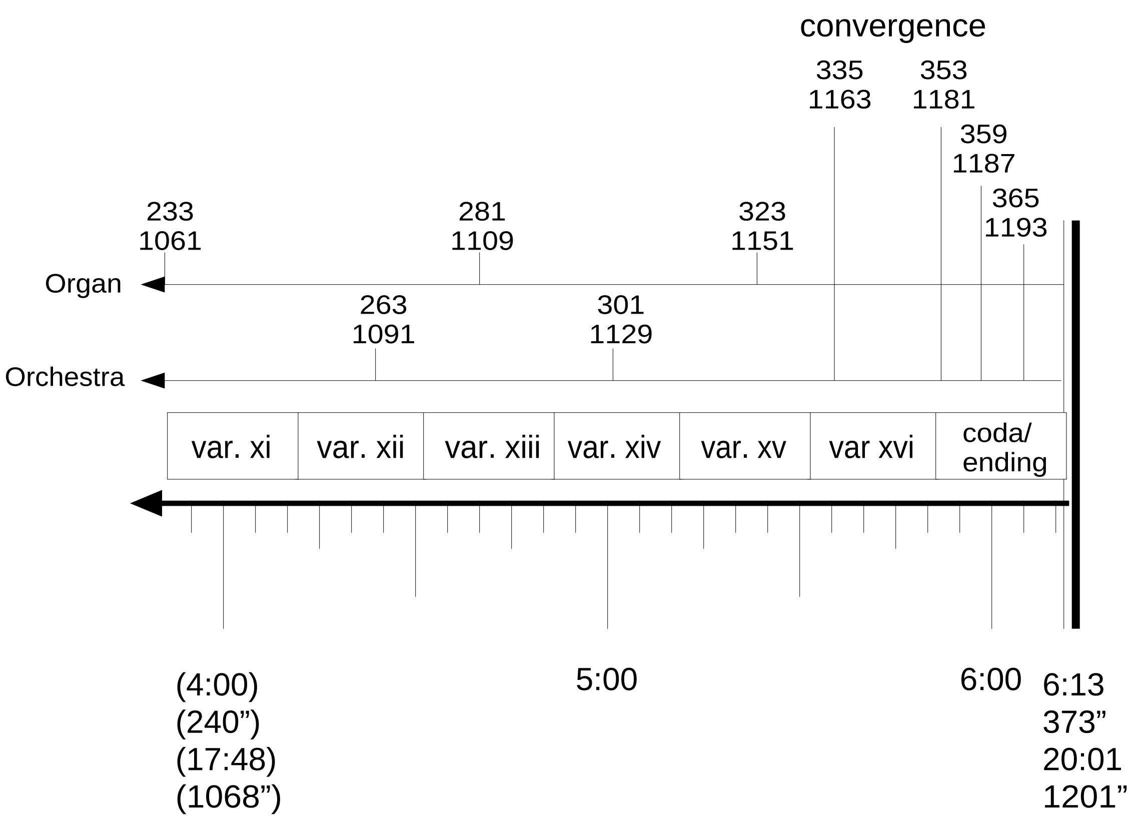
* Top numbers show elapsed time in seconds for Mvt. II; bottom numbers show total elapsed time.

Movement III - Passacaglia (part 1)



* See note on Movement II map.

Movement III (part 2)



APPENDIX C

COMPLETE LIST OF DECIMALS AND THE NUMBER BASE CONVERSIONS AND A MATHEMATICAL EXPLANATION OF THEIR RELATIONSHIPS

APPENDIX C

In base 2, the fractions with the numerators 1, 2, 4, 8, and 16 produced the same sequence of digits with an additional zero for each higher fraction. These relationships occur because the numerators are related by B^n (B to the ***n***th power), where ***B*** is the number base and ***n*** is any whole number 0 and larger:

$$2^0 = \mathbf{1};\ 2^1 = \mathbf{2};\ 2^2 = \mathbf{4};\ 2^3 = \mathbf{8};\ 2^4 = \mathbf{16}$$

This type of relationship also occurs between the numerators 3, 6, and 12 in base 2 following a related pattern: $B^n + B^{n-1}$ (where ***n*** is any whole number 1 and larger), so that

$$2^1 + 2^0 = \mathbf{3};\ 2^2 + 2^1 = \mathbf{6};\ 2^3 + 2^2 = \mathbf{12}$$

Another such relationship occurs between the numerators 5 and 10 (following $2B^n + B^{n-1}$); and another one between 7 and 14 (following $3B^n + B^{n-1}$). This leaves 9, 11, 13, and 15 as the only unique patterns in base 2.

Similar relationships exist for base 3 and base 4 as well. In base 3 the numerators 1, 3, and 9 are related; and in base 4 the numerators 1 and 16 are related.

The following is a list of all of the decimals of x/17 converted to number bases 2 through 20. For all digits above 9 I use the following system:

t=10; e=11; L=12; h=13; f=14; i=15; x=16; v=17; g=18; n=19

1/17 : 0.0588235294117647. . .
base:

2	0100001011011111111001100111100000000000111100001111
3	0221201020220201000101220022020
4	0201123333030330000033003 3
5	0110410012134024323104 2
6	0544302332141554454 3
7	0234621411645234621
8	0205577463600074 17
9	0276368210118082 0
10	0588235294117647
11	01604802072t3310
12	055e83e3598e153
13	01L32L47257e3e7
14	0t538t50h5LL11
15	0480153tffLL4L
16	0216ii33L00i0i
17	0102h5e17140t8
18	092h916135h59
19	050vvthi5L968
20	02v8vgx984f27

2/17 : 0.1176470588235294. . .
base:

2	1000010110111111110011001111000000000001111000011110
3	1220102111211102000210210121110 0
4	1002313332121320000132013 2
5	2213200243231042012134
6	1533005104323553353 0
7	5025431236235025 42
8	4133771474001703 6
9	563747420237174 0
10	1176470588235294
11	310950413596620
12	tee47t6e75t2t6
13	3e65e914e297t1
14	16t736t1Leet22
15	9102t76fft999
16	42hif67801f1f
17	2059e52f2813x
18	105902L26e8e0
19	t1xx28ee5gLx
20	5fvivLgx984f

3/17 : 0.1764705882352941. . .
base:

2	1100100010011111101100110110100000000101101001011O1
3	22120102022020100010122002202000
4	12101033312123100002310231
5	3322300420121340243231
6	2521311440505552251З
7	1040464535602040463
8	62117663320026455
9	8512266303562660
10	1764705882352941
11	47132061t889930
12	145e0e9t5529439
13	5t98e0873t7e88
14	231tL312L3t833
15	h9040e2ff86f6
16	644ih9e402h2h
17	3085xx443L1f7
18	198494039v3x9
19	i2ifh37xg905
20	8L6hx984f271

4/17 : 0.2352941176470588. . .
base:

2	1000010110111111110011001111000000000011110000111100
3	1021021200012221100112112101222OO
4	20112333303033000003300330
5	4431401042012134024323
6	3510014213051551150O
7	1305416250550305414
8	102677631700036074
9	12376058404753580
10	2352941176470588
11	6217t0827082140
12	19et9391e2e8590
13	79Let529956272
14	2h706h63e99644
15	132055fhff6443
16	85eiLLi003L3L
17	40e25t5e4x27i
18	20e00564h4v40
19	113fh4v43eg6h
20	e9iei5vLgx98

5/17 : 0.2941176470588235. . .
base:

2	1010011100101111110000000010110000000100101101001011
3	112021200211201120020001111120100
4	2213023330000230010231023
5	11041001213402432310420
6	44543205452335500443
7	1543340662525543335
8	123457600260045513
9	15250751506044510
10	2941176470588235
11	782170t33375450
12	235t57855087723
13	9931999L204659
14	39L419e4e18455
15	17t06e39ff4190
16	t72iL02L04e4e
17	50hie47163316
18	29hh96L5xtL99
19	164heiL0958h2
20	f749f2713tei

6/17 : 0.3529411764705882. . .
base:

2	1100100010011111101100110110100000000101101001011010
3	122010211121110200021021012111000
4	30202133230312200011221122
5	12200101340243231042012
6	54430233214155445430
7	2111262404504111256
8	144237546640055132
9	18124543607235430
10	3529411764705882
11	93264113t668760
12	28et1e78tt56876
13	e8649141782t43
14	4637t625t77266
15	1L308175ff1hhL
16	L89ie36805t5t
17	60xexi88773ef
18	30x908071x7i0
19	1e5Lt76ifvg0t
20	v4h7Lgx984f2

7/17 : 0.4117647058823529. . .
base:

2	111010100000111110100110101001000000110100101101001
3	2012222221010122100221102201012000
4	32220033221222100012211221
5	13304202012134024323104
6	10431330054001543441 3
7	2346214116452346210
8	165017515220064551
9	21888335708426350
10	4117647058823529
11	t93011346960t70
12	3259t3704825t09
13	1079785e403112t
14	528e52769h6077
15	21e096e1fhfe39
16	ft0it6t406969
17	7128599i8e455
18	3t14996854329
19	1x6e8g1L1e86g
20	10225ei5vLgx9

8/17 : 0.4705882352941176. . .
base:

2	1000010110111111110011001111000000000011110000111100 0
3	2112120100102212201002001210221000
4	10023133321213200001320132 0
5	14413302134024323104201
6	1142003243014354234000
7	2614135531430614131
8	205577463600074170
9	24763127810617270
10	4705882352941176
11	1143491553154280
12	37e96763t5e4e60
13	126Lt7t565tL514
14	5h00hLL7954L88
15	2640tefLfhL886
16	10e7i99f007878
17	8154e3e59i4ih
18	41400tL989x80
19	227t79i874vh7
20	12ne3tei5vLgx

9/17 : 0.5294117647058823. . .
base:

2	10010110011101111100011010001110000001000011110000111
3	221201020220201000101220022020000
4	102303233203101300020132013
5	21022402310420121340243
6	124043352023255412343
7	3152060243406152052
8	226357432160103607
9	27636821011808200
10	5294117647058823
11	12t396175t447590
12	41592e5743840e3
13	1463071L8e5t8Le
14	695489388e3t99
15	2tL0L238fht5h3
16	12Lfi8h1L08787
17	9180xfLLe2594
18	4t6h9L0teieh9
19	278961t4Lv80i
20	15v01984f2713

10/17 : 0.5882352941176470. . .
base:

2	10100111001011111100000000101100000001001011010010110
3	1001120101200110010110010000010200
4	110321133200011200021122112
5	22132002432310420121340
6	133530415343115401330
7	3420011655354420003
8	247137400540113226
9	31511613113100120
10	5882352941176470
11	145433196673t8t0
12	46e8e34tt153246
13	16563666e408Le5
14	75t835898328tt
15	3050h774fh8330
16	14f5i805809696
17	t1tf58f2L662L
18	51990h6ei3710
19	2L984L50gtv74
20	18f8n84f2713t

11/17 : 0.6470588235294117. . .
base:

2	10110111111001111011100111001010000001010010110100101
3	1011102112110012020111022201001100
4	112333033130321100022112211
5	23241103104201213402432
6	143413443110535350313
7	3654633400332654624
8	267717347120122645
9	34375405214281040
10	6470588235294117
11	1604802072t33100
12	505877423e22399
13	184965e1098739L
14	821eL1ht7916ee
15	34h0fLe0fh607L
16	16iLi73940t5t5
17	e1hte2i9ht6h3
18	5tL49fLh09269
19	2vt733gx547hL
20	1eevv713tei5v

12/17 : 0.7058823529411764. . .
base:

2	11001000100111111011001101101000000001011010010110100
3	102102120001222110011211210122000
4	121010333121231000023102310
5	24400203231042012134024
6	153300510432355335300
7	4222555112311222545
8	310477315500132264
9	37250187315471860
10	7058823529411764
11	176518227t226410
12	55e83e3598e1530
13	1t3L95283235786
14	8L716L4e7104LL
15	396112fefh3LL9
16	1913i66h00e4e4
17	L1x6xhxxff76e
18	61i00x0f3fiL0
19	33e61fhLtxv11
20	1f96i5vLgx984

13/17 : 0.7647058823529411. . .
base:

2	11011001010101111010110100000110000001100001111000011
3	1101010210222200110120202002212200
4	1230222331122003000300330003
5	31004303402432310420121
6	203143534154215324243
7	4460506524256460466
8	331257264060141703
9	41123880416662780
10	7647058823529411
11	1915652486519720
12	5e5803293680683
13	1L32L47257e3e70
14	98L5189L66h2hh
15	3hf12837fh1t26
16	1e2ti5t0L0L3L3
17	h2235816x1802
18	6tvh9v6i72tv9
19	38L50688xt779
20	1v6ih4f2713te

14/17 : 0.8235294117647058. . .
base:

2	11101010000011111010011010100100000001101001011010010
3	1110222221202102120121221210210100
4	131100133103110200031023102
5	32113404024323104201213
6	213031001520035313230
7	5025431236235025420
8	352037232440151322
9	43887672517853710
10	8235294117647058
11	1t76022692811t30
12	64e78720944e816
13	212623e98062257
14	t538t50h5LL110
15	43713h73fLf773
16	1h41i4h480h2h2
17	f24xe22f058tt
18	722910Lxt8650
19	3hh3vv3533xhv
20	2044e3tei5vLg

15/17 : 0.8823529411764705. . .
base:

2	11111010110001111010000001000010000001110000111100001
3	11202120021120112002000111112010000
4	1331120331000201000320132010
5	33223004201213402432310
6	222514025241455302213
7	5263352651213263341
8	372617201020160741
9	46762464620144630
10	8823529411764705
11	21264t289t005240
12	6t574e14321t969
13	23195333t610641
14	e18L516054th21
15	480153tffLL4L0
16	1i58i40840f1f1
17	i27Lxh4419941
18	7e54t20vhf1t9
19	3gf2x8v18x716
20	231h92713tei5

16/17 : 0.9411764705882352. . .
base:

2	1000010110111111110011001111000000000001111000011110000
3	12002010200212202102011010121212000
4	2011233330303300000330033000
5	34332104323104201213402
6	232401053003315251200
7	5531304363161531262
8	413377147400170360
9	50636256721335550
10	9411764705882352
11	2286972tt62t8550
12	73e713078et9e00
13	250L827tLe8et28
14	eL01hee14t9e32
15	4L8168ftfLt21L
16	216ii33L00i0i0
17	x2t9575e2h9f9
18	82801370v1fx0
19	44i1i0exf9x7f
20	25n2713tei5vL

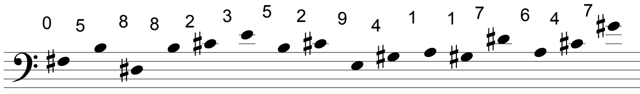
APPENDIX D

MELODIC TRANSFORMATION PROCESS

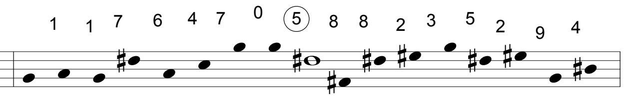
APPENDIX D

Every circled number represents a change of interval direction from the 1/17 model. They appear in the sequence of the 1/17 decimal, base 10. Through these means a complete inversion of the original series gradually evolves. The open noteheads show the inverted portions.

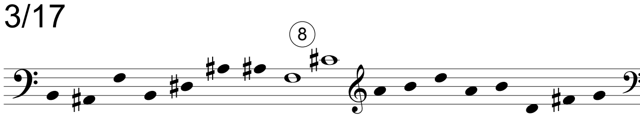
1/17



2/17

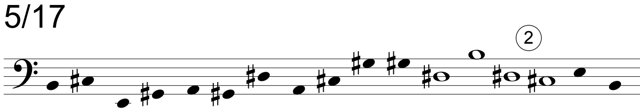


3/17

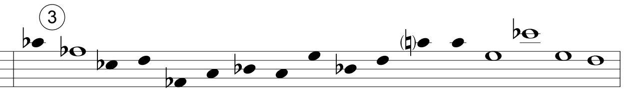


4/17

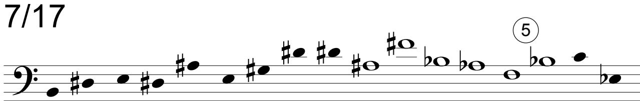
5/17



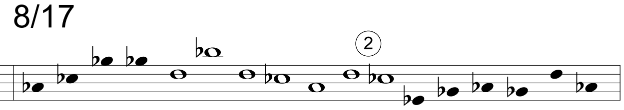
6/17



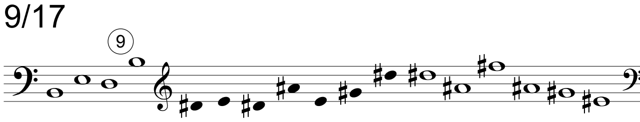
7/17



8/17

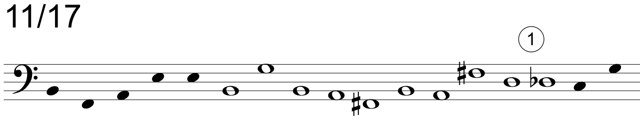


9/17

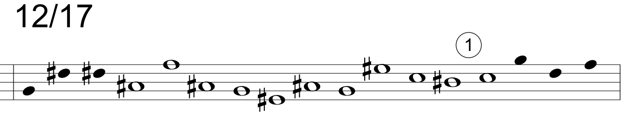


10/17

11/17



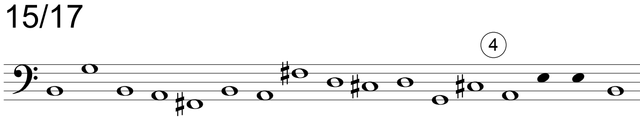
12/17



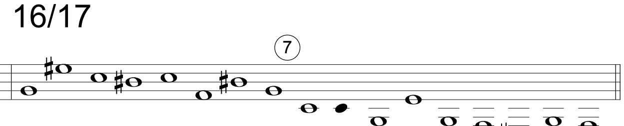
13/17

14/17

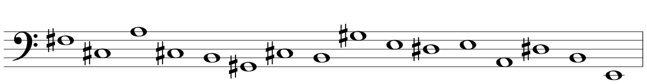
15/17



16/17



1/17 completely inverted



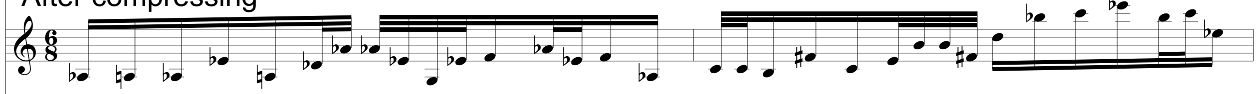
APPENDIX E

GENERATION OF THE SECOND UNIT IN THE ORGAN CADENZA

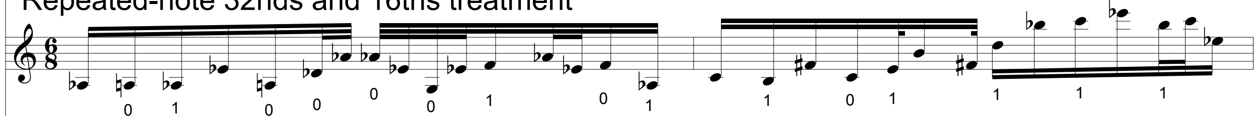
APPENDIX E

Whole "melodic transformation" sequence; asterisks indicate changes to 32nd notes

After compressing



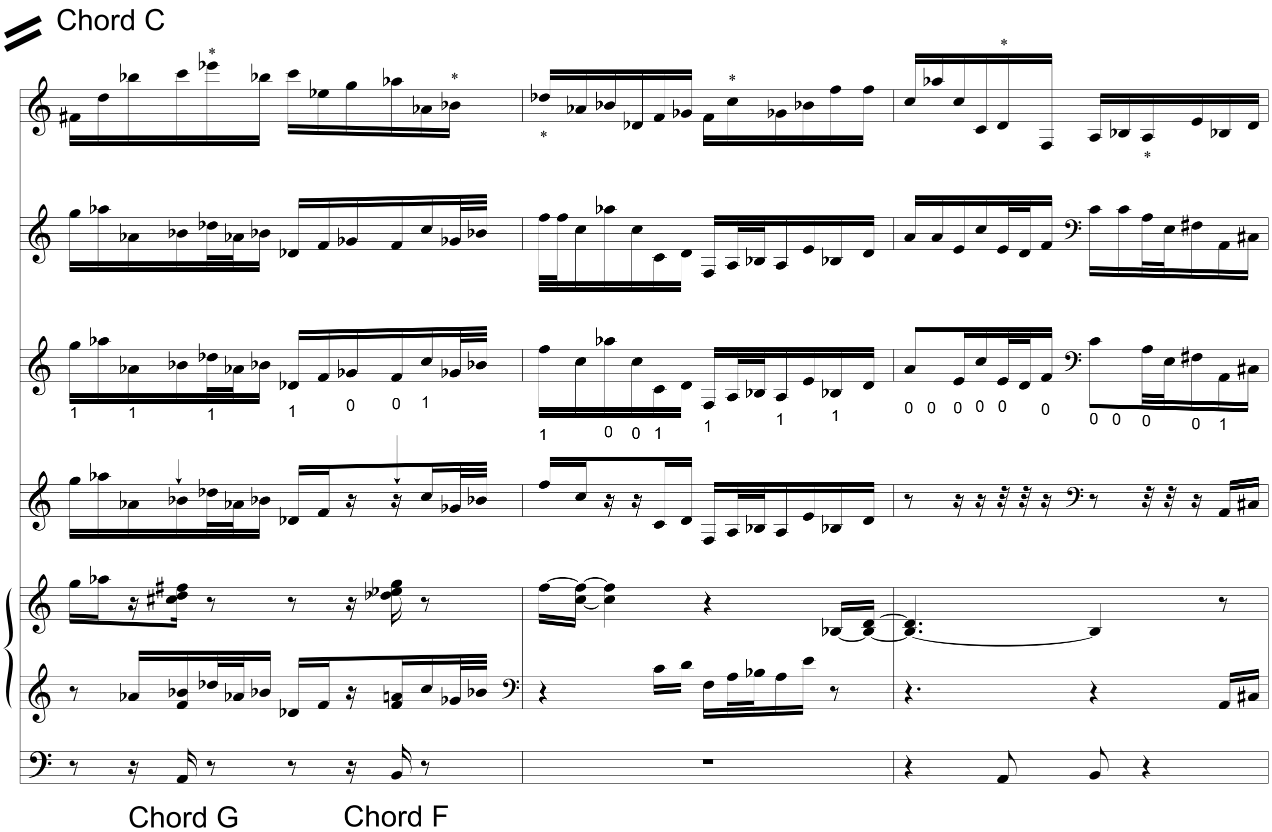
Repeated-note 32nds and 16ths treatment

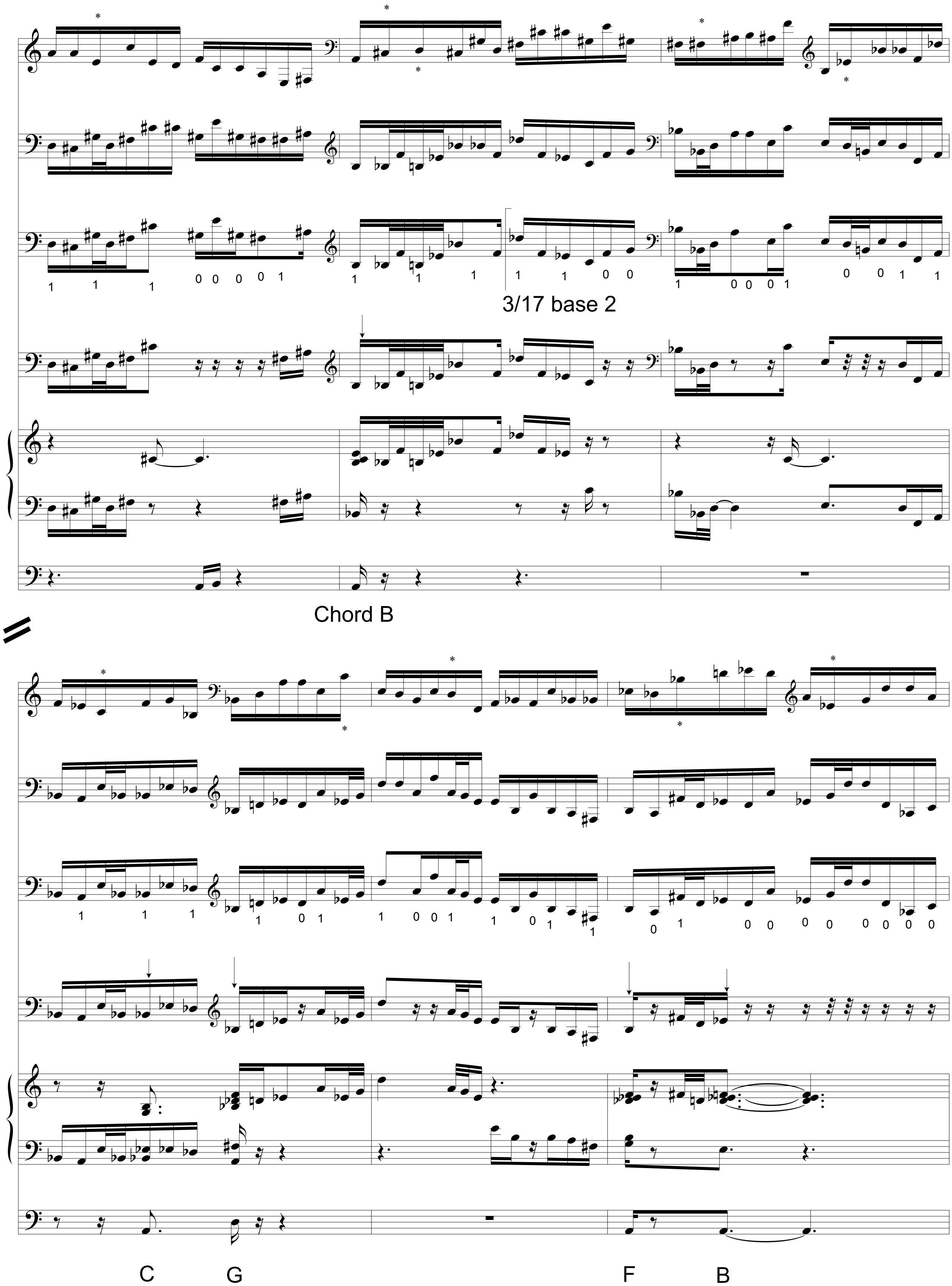


1/17 base 2: 0s = one 16th; 1s = two 16ths

Arrows: 1/17 base 18, values x3; indicate where "GSP" chords will appear

Finished version, after some freely composed changes and additions




3/17 base 2
Chord B
C
G
F
B


5/17 base 2
C
G


F
B

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James T. Worlton

Concerto for Organ and Orchestra

INSTRUMENTATION

Piccolo (Picc.)
2 Flutes (Fl.)
2 Oboes (Ob.)
English Horn (Eng. Hn.)
2 Clarinets in B-flat (Cl.)
Bass Clarinet (Bass Cl.)
2 Bassoons (Bsn.)
Contrabassoon (Cbsn.)

4 Horns (Hn.)
3 Trumpets in C (Trp.)
2 Trombones (Tbn.)
Bass Trombone (B. Tbn.)
Tuba

Timpani (4 drums)
3 Percussion

1. Trgl. (lg.); 3 Sus. Cym. (sm., md., lg.)*; 2 Tam-tams (sm., lg.); Temple Bl. (5); Snare Dr.*; Timbales; Bass Dr.**; Vib. (motor off)
2. 3 Sus. Cym. (sm., md., lg.)*; Brake Dr.***; Snare Dr.*; 4 Tom-toms; Bass Dr.**; Glock.***; Xyl.; Crotales (full chromatic set)
3. Trgl. (md.); Brake Dr.***; Tambourine; Snare Dr.; Tenor Dr.; Bass Dr.**; Chimes; Glock.***; Marimba

* Perc. 1 and 2 may share the same Sus. Cyms. and Snare Dr.
** All three may share Bass Dr.
*** Perc. 2 and 3 may share Brake Dr. and Glock.

Organ Solo

Violins I
Violins II
Violas
Cellos
Basses (C extension)

Score in C

Duration: approx. 22'

Accidentals affect only the notes to which they are attached, except for tied notes. Cautionary naturals are used to facilitate reading.

For all changes of meter the eighth-note remains constant, unless otherwise specified.

Organ manuals: I - Great; II - Choir; III - Swell

CONCERTO FOR ORGAN AND ORCHESTRA

I

James T. Worlton
(2003)


9
a 2
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
hard mallets
Timp.
Tam-Tam
Perc. 1
Bs. Dr.
Perc. 2
secco
I: princ. full + mixt.
III: reeds 8, 4
I+III
princ. 32, 16, 8; reeds 16
+I, III
ORG. SOLO
A
Vn. 1
Vn. 2
Vla.
Vc.
Cb.


B
(♩=105)
Trp. 1
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vc.
Cb.
soft mallets
Vib.
with bow
Tom-toms
snare sticks
S. Dr.
snares off
Sus. Cym.
snare sticks
crown
l.v. sempre
Bs. Dr.
secco
Glsp.
princ. full (no mixt. or 16)
III: strings 8
senza sord. pizz.
unis.
Eng. Hn.
Cl. 1, 2
med. mallets
Chm.
Vla.

27
C
Eng. Hn.
Bass Cl.
+III reed 8
ORG. SOLO
senza sord.
unis.
Vn. 1
Vn. 2
Vla.
Vc.
33
a 2
1.
D
♩= 60
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Brake Dr.
hard beater
Perc. 3
III: strings 8
ORG. SOLO
tutti div.
N.B.
1. solo
arco
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
N.B. A uniform balance is not desired.
Let each string part dim. independently
from the others.


39
E
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bsn. 1, 2
Hn. 1, 2
Hn. 3, 4
I: princ. 8, 4, 2
III: reed 8
I+III
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
46
Tbn. 1, 2
+32
div.
sul tasto
unis.
Cb.


52
♩= 105
F
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
a 2
med. mallets
Vib.
Tom-toms
S. Dr.
snares on
Glsp.
Chm.
I
+16, mixt.
ord.
div.


G
57
Cl. 1, 2
II: Cromorne (8)
ORG. SOLO
sim.
III: strings 8, 4
59
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
a 2
Perc. 1
Vib.
with bow
ORG. SOLO
unis.
Vn. 1
Vn. 2
Vla.
Vc.


63
H
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
p sempre
Bass Cl.
Bsn. 1, 2
Cbsn.
Timp.
Perc. 1
f
Perc. 2
Perc. 3
I: princ. 8, 4, 2
ORG. SOLO
H
Vn. 1
mf
p
Vn. 2
Vla.
Vc.
Cb.


66
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
a 2
Vib.
soft mallets
Glsp.
Sus. Cym.
soft mallets
S. Dr.
rim shot
I: princ. 8, 4, 2
III: reed 8
I+III
div.
I

72
I: full
I+II
ORG. SOLO
+I
77
K
♩. = 70 (♩ = 105)
med. mallets
Timp.
Sus. Cym.
metal beater
Trgl.
Perc. 1
Tom-toms
snare sticks through m. 98
Bs. Dr.
Tom-toms
Perc. 2
Mar.
med. mallets
Perc. 3
III: princ. 8, 4; reed 8
III
II
II: princ. 8, 2
ORG. SOLO
83
L
Timp.
Sus. Cym.
med. mallets
T. Bl.
Perc. 1
S. Dr.
snares on
Sus. Cym.
crown
Tom-toms
Perc. 2
Ten. Dr.
snare sticks
Brake Dr.
med. beater
Perc. 3
I: princ. 8, 2
I+III
III
I+III
ORG. SOLO
flute 16, 8; +III
pizz.
Cb.


89
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
a 2
1.
Bs. Dr.
S. Dr.
Tam-Tam
metal beater
Sus. Cym.
crown
snare sticks through m. 100
Tom-toms
Chm.
unis.
pizz.
arco
-III
+III


94
M
Fl. 1, 2
a 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Hn. 1, 2
Hn. 3, 4
3.
Trp. 1
str. mute
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Perc. 1
Bs. Dr.
Sus. Cym.
Tam-Tam
Timb.
Perc. 2
Tom-toms
S. Dr.
Perc. 3
Chm.
secco
Trgl.
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
arco
div.
unis.


99
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
N
a 2
no mute
S. Dr.
Brake Dr.
Chm.
Vib.
med. mallets
Glsp.
I: full
strings 8; flutes 8, 4
+III
+I
-I
div. con sord.
con sord.


106
Timp.
Perc. 1
Perc. 2
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
O
111
Vib.
Glsp.
Chm.
Perc. 3
princ. 8, 4
II
div.


116
= 105
P
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
a 2
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
Vib.
S. Dr.
snares on
Glsp.
princ. full (no mixt. or 16)
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
mute off


Q
121
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bsn. 1, 2
Chm.
Perc. 3
flutes 8, 4
III
ORG. SOLO
1. solo
Vn. 1
R
125
a 2
Trp. 1
Vib.
with bow
Perc. 1
Glsp.
Perc. 2
tutti
unis.
Vn. 2
Vla.
Vc.


130
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
ORG. SOLO
pp
p
f


133
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
a 2
Cbsn.
Trp. 1
Trp. 2, 3
B. Tbn.
Tuba
Perc. 1
Vib.
Trgl.
Perc. 2
Glsp.
Sus. Cym.
soft mallets
Bs. Dr.
II: princ. 8
II+III
III: princ. 8, 4; reed 8
III
II: princ. 8, 2
flutes 16, 8
ORG. SOLO
S
div.
Vn. 1
Vn. 2
138
Perc. 1
Sus. Cym.
med. mallets
T. Bl.
Perc. 2
Tom-toms
snare sticksthrough m. 171
S. Dr.
snares on
Sus. Cym.
crown
Perc. 3
Mar.
med. mallets
Ten. Dr.
snare sticks
I: princ. 8, 2
II
I+III
ORG. SOLO

144
T
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Timp.
Bs. Dr.
Tam-Tam
metal beater
Perc. 1
Tom-toms
S. Dr.
Sus. Cym.
crown
Perc. 2
Brake Dr.
med. beater
Chm.
Perc. 3
III
II
ORG. SOLO
flute 16, 8; +III
-III
+III
unis.
pizz.
arco
Vn. 1
Vn. 2
Vla.
Vc.
Cb.


150
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Trp. 1
Trp. 2, 3
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
a 2
1.
str. mute
Sus. Cym.
snare sticks through m. 154
crown
Bs. Dr.
Tom-toms
S. Dr.
Chm.
secco
Trgl.
-III
arco
arco div.
div.
pp sub.
= 60
U


155
♩. = 70 (♩ = 105)
V
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
a 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Timp.
Perc. 1
Bs. Dr.
Perc. 2
S. Dr.
Sus. Cym.
crown
Perc. 3
Chm.
ORG. SOLO
III
+III
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
unis.
pizz.
arco


161
W
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tuba
a 2
str. mute
Tam-Tam
metal beater
Sus. Cym.
snare sticks through m. 171
crown
Bs. Dr.
Tom-toms
S. Dr.
Chm.
secco
Trgl.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
arco
div.


♩= 60
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
a 2
no mute
Tam-Tam
Bs. Dr.
Timb.
Tom-toms
Trgl.
Chm.
S. Dr.
Ten. Dr.
I+III
I: full
unis.
div.


cadenza
fff tutti
ORG. SOLO
-1
-32
II+III
8:6
III
f
-32; -reeds
II
f
rit.
♩= 52
rubato
ff
II: full


X
212
Picc.
Fl. 1, 2
a 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
hard mallets
Timp.
Vib.
Perc. 1
Tom-toms
Perc. 2
Glsp.
Perc. 3
fff
ff
tutti
ORG. SOLO
+32
X
non div.
Vn. 1
Vn. 2
Vla.
Vc.
Cb.


215
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
a 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
a 2
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
C - B♭
Perc. 1
Tam-Tam
Vib. mallets
l.v. sempre
Sus. Cym.
Perc. 2
Perc. 3
Bs. Dr.
secco
ORG. SOLO
Vn. 1
div.
put on mute
Vn. 2
put on mute
Vla.
put on mute
Vc.
non div.
Cb.
attacca

II


♩= 132
II: flute 8
III: oboe 8
II+III
mp
+II: flute 4
Manuals
ORGAN SOLO
flutes 32, 16, 8
Pedal
p
div. con sord.
Violin 1
div.
con sord.
Violin 2
con sord.
Viola
pizz.
f
Cello
Contrabass
9
+II: 2-2/3
+II: 2
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
dim.

15
(♩= 99)
A
Picc.
Fl. 1, 2
a 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 2
S. Dr.
+II: 1-3/5
I: princ. 8, 4, 2
I+II+III
-I; -II
ORG. SOLO
+ princ. 32, 16, 8
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
arco

21
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
a 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Bs. Dr.
secco
Perc. 3
Brake Dr.
II: full (no 16)
II
ORG. SOLO


(♩= 132)
B
25
Cl. 1, 2
Bass Cl.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Cb.
1.
T. Bl.
S. Dr.
rim shot
Tom-toms
snare sticks
Brake Dr.
III: full (no 16)
III
-II
30
Fl. 1, 2
Eng. Hn.
a 2
Timb.
Sus. Cym.
metal beater
with med. Xyl. mallets
sub.
Ten. Dr.


35
Picc.
Fl. 1, 2
Ob. 1, 2
Perc. 2
Perc. 3
ORG. SOLO
Cb.
1.
Xyl.
med. mallets
II: full (no 16)
C
39
Ob. 1, 2
Cl. 1, 2
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Cb.
a 2
Tam-Tam
metal beater
T. Bl.
Tom-toms
snare sticks
I: full (no 16)

44
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Cb.
med. mallets
mp
Bs. Dr.
mf secco sempre
S. Dr.
mf
Chm.
3
Ten. Dr.
f
50
D
Xyl.
med. mallets
Trgl.
snare sticks
I
II
+II
unis. senza sord.
f marcato
senza sord.
Vn. 1
Vn. 2
Vla.
Vc.
ff
marcato


Timp.
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
Perc. 1
Sus. Cym.
snare sticks
crown sempre
l. v. sempre
Brake Dr.
Crot.
ff
marcato
sffz
fp
E
meno mosso (♩. = 76)
III: flutes 8, 4, 2
p legato
flutes 16, 8
T. Bl.
med. mallets
ord.
Tom-toms
f sub
I: princ. full (+16)
princ. 16, 8; +I


65
♩= 114
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Timp.
hard mallets
Perc. 1
Vib.
(med. T. Bl. mallets)
Perc. 2
Perc. 3
Glsp.
ORG. SOLO
full with reeds
Vn. 1
div.
Vn. 2
Vla.
Vc.
Cb.

F
70
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
sim.
a 2
Bs. Dr.
snare sticks
secco sempre
S. Dr.
Tom-toms
Brake Dr.
unis.
div.
unis. sim.


77
G
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
a 2
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
a 2
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Sus. Cym.
Perc. 1
Bs. Dr.
Perc. 2
Ten. Dr.
Brake Dr.
Perc. 3
Ten. Dr.
I+II+III: full (no reeds)
ORG. SOLO
G
Vn. 1
unis.
Vn. 2
Vla.
Vc.
Cb.


84
Ob. 1, 2
Eng. Hn.
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
sim.
ff
a 2
Tam-Tam
rim shot
Tamb.
snare sticks
Ten. Dr.
+reeds
full (32 reed)
unis.


91
H
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
a 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Perc. 1
Tam-Tam
with bow
Perc. 2
S. Dr.
Perc. 3
Tamb.
placed on Ten. Dr.
ORG. SOLO
III
reduce
div.
Vn. 1
Vn. 2
Vla.
Vc.
1. solo
espr.
Cb.


96
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
p
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
p
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
ff
mp
fp
f
p
Cb.
p
3
4


I
G. P.
K
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
a 2
Trgl.
sim.
S. Dr.
handle end of soft Xyl. mallets
Xyl.
Tamb.
placed on Ten. Dr.
I+II+III full
Tutti
flutes 8, 4, 2
III
+reeds
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
unis.
div.
tutti

109
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Cb.
Sus. Cym.
crown sempre
L
l. v. sempre
Trgl.
sim.
117
Tamb.
placed on Ten. Dr.
S. Dr.
snares off
with brushes
Vc.
1. solo
127
in hand, with finger
with knuckle
136
Timp.
med. mallets
unis.
Vn. 1
Vn. 2
Vla.
altri
attacca

III


c. 69
Timpani
Percussion 1
Percussion 2
Percussion 3
Timb.
Tom-toms
S. Dr.
snares off
Ten. Dr.
Manuals
ORGAN SOLO
Pedal
I: full, reed 8; (no 16)
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
princ. full (no mixt.)

A
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Bs. Dr.
con sord.
p sempre
2. con sord. p sempre
a 2
(1.)
pizz.
Vn. 1
Vn. 2
Vla.
Vc.
Cb.


B
C
21
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Hn. 1, 2
Trp. 1
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 3
Trgl.
princ. 8, 4, 2
II
I+II
I: princ. 8, 4, 2, mut.
princ. 16, 8; +II
+I
ORG. SOLO
pizz.
(pizz.)
Vn. 1
Vn. 2
Vla.
Vc.
Cb.


30
Perc. 1
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
Trgl.
D
sul tasto
arco
39
Bsn. 1, 2
Vib.
Perc. 2
Bs. Dr.
Ten. Dr.
l. v.
molto
ord.
sul pont.
E


F
(♩. = 115)
46
Bsn. 1, 2
Hn. 3, 4
Timp.
Perc. 1
Perc. 2
Perc. 3
princ. 8, 4; reed 8
ORG. SOLO
Vn. 1
Vla.
Vc.
54
Picc.
Hn. 1, 2
Crot.
l. v. sempre
flute 16, 8; +II

Picc.
Timp.
Perc. 3
ORG. SOLO
G
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Hn. 1, 2
Perc. 1
Trgl.
princ. 8, 4; reed 8
-II; +I
Vn. 1
Vn. 2
Vla.
Vc.
a 2

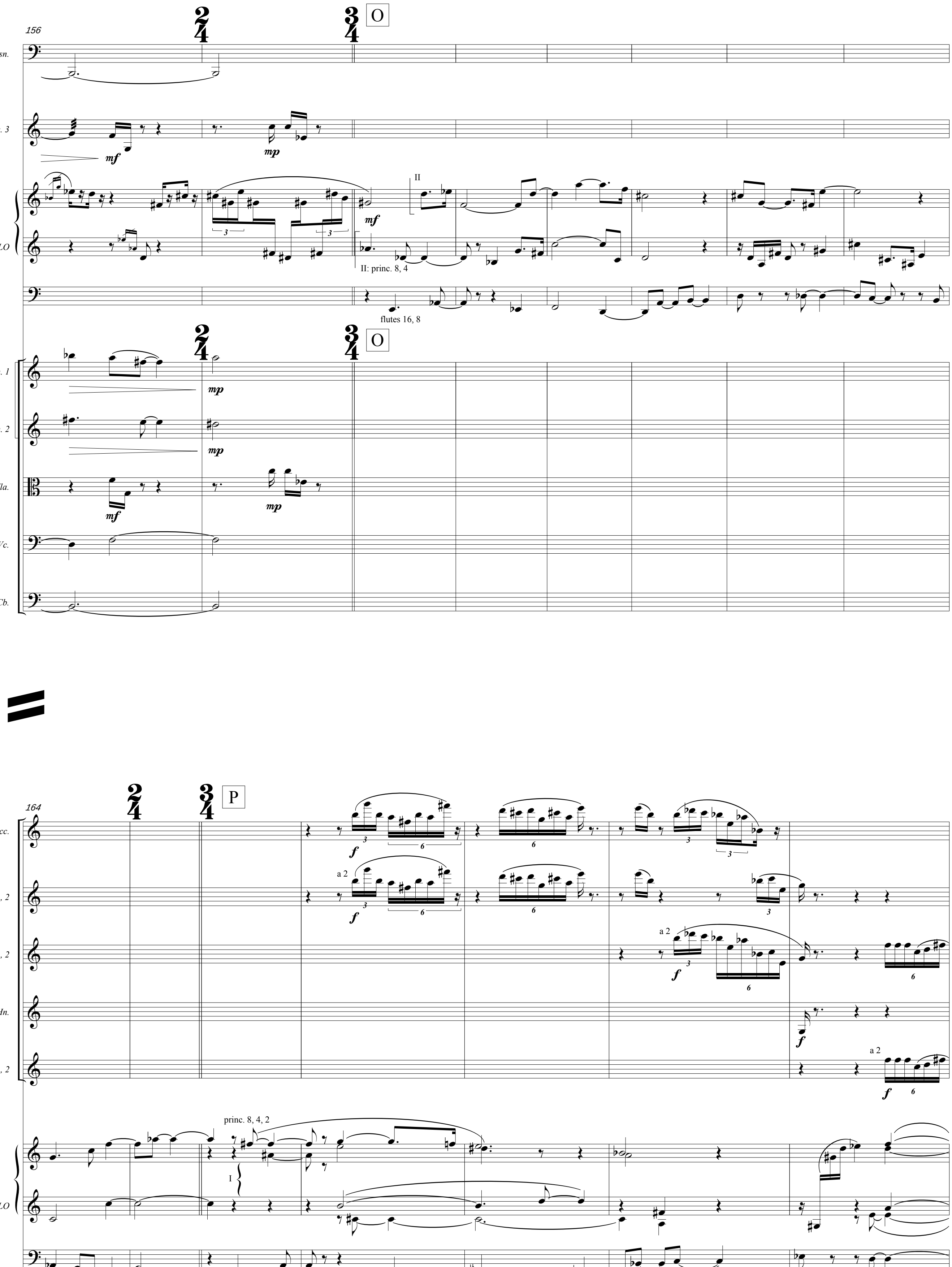

78
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
f
pp
f
pp
2.


86
H
Picc.
Fl. 1, 2
a 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
con sord.
Trp. 1
Trp. 2, 3
1. con sord.
Tbn. 1, 2
S. Dr.
snares on
rim shot
Perc. 2
Mar.
Perc. 3
flutes 8, 2, 1-3/5
III
ORG. SOLO
Vn. 1
Vn. 2
div.
pizz
arco
Vla.
Vc.
pizz.
Cb.

94
Perc. 3
ORG. SOLO
Vla.
Vc.
Cb.
104
I
Hn. 1, 2
Hn. 3, 4
1.
3.
II: flutes 8, 4; +III
II


115
Hn. 1, 2
Hn. 3, 4
ORG. SOLO
Vla.
Vc.
Cb.
K
♩= 69
125
Perc. 1
Vib.
III
p flutes 8, 4
II: flutes 4, 2 only (no Ped. stops)
131
L
flute 8 only


136
ORG. SOLO
141
M
Cbsn.
Perc. 3
Mar.
+ flutes 4, 2
con sord.
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
tutti pizz.
tutti arco con sord.
arco con sord.
pizz.
148
N


156
Cbsn.
Perc. 3
mf
mp
ORG. SOLO
II
mf
II: princ. 8, 4
flutes 16, 8
O
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
164
P
Picc.
Fl. 1, 2
a 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
f
princ. 8, 4, 2
I
+princ.


171
(♩=138)
Q
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
a 2
Trp. 1
+II; mutations
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
senza sord.
legato
arco


178
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Trp. 1
B. Tbn.
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.

184
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Hn. 1, 2
a 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Sus. Cym.
l. v. sempre
crown
Perc. 1
Xyl.
Perc. 2
Mar.
hard mallets
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.


190
R
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
a 2
Hn. 3, 4
Trp. 1
Timp.
ord.
Perc. 1
Perc. 2
Perc. 3
III: full
ORG. SOLO
Ped.: full
R
Vn. 1
Vn. 2
Vla.
Vc.
Cb.


197
rall.
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Tuba
ORG. SOLO
rall.
Vn. 1
Vn. 2
Vla.
Vc.
Cb.


S
♩= 112
205
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
pesante
ff
a 2
Bs. Dr.
med. Vib. mallets through m. 221
S. Dr.
snares on
Ten. Dr.
f
II: full; +III
II+III
+32
div.


212
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Sus. Cym.
Perc. 1
Tom-toms
Perc. 2
S. Dr.
snares on
Perc. 3
ORG. SOLO
unis.
Vla.
Vc.
Cb.


220
T
Picc.
Fl. 1, 2
Ob. 1, 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
Vc.
Cb.
ff
2.
4.
Timb.
rim shot
Ten. Dr.
Tutti I
fff
unis.
div.


230
Picc.
Fl. 1, 2
Ob. 1, 2
Cl. 1, 2
ff
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
2.
a 2
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
G - G♯
Perc. 1
Perc. 2
Perc. 3
ORG. SOLO
Vn. 1
Vn. 2
Vla.
div.
Vc.
Cb.

238
Picc.
Fl. 1, 2
Ob. 1, 2
a 2
Eng. Hn.
Cl. 1, 2
Bass Cl.
Bsn. 1, 2
Cbsn.
Hn. 1, 2
Hn. 3, 4
Trp. 1
Trp. 2, 3
Tbn. 1, 2
B. Tbn.
Tuba
Timp.
Perc. 1
Perc. 2
Perc. 3
Vib.
Glsp.
Tamb.
Tam-Tam
(Vib. mallets)
Bs. Dr.
Tom-toms
Brake Dr.
ORG. SOLO
tutti non div.
Vn. 1
Vn. 2
Vla.
Vc.
Cb.