‘Structure Formation’: An Analysis of Electronic Superimpositions in Stockhausen’s *Solo*

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July 25, 2012

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Doctor of Musical Arts

Major Research Project

Written under the supervision of Dr. Scott Wilson

Abstract

In his work *Solo für Melodieinstrument mit Rückkopplung, Nr. 19* (*Solo for Melody Instrument with Feedback*), Karlheinz Stockhausen employs a variable length tape delay and feedback system to record and play back the material of the soloist live, creating layers of superimposed electronic sound. It is this structure of electronic superimpositions which will be the focus of analysis. I will begin by providing a detailed overview of the work and continue by examining and creating a nomenclature for electronic superimpositions, which form patterns and manifest techniques that evolve across complete and partial cycles (sections). In an attempt to prove an overall structure of electronic form, I will present a topology of these patterns and techniques that demonstrates a systematic organization of elements. Finally, I will carry out a comparative musical analysis of a hypothetical score (of my own construction) with an actual performance (flutist Dietmar Wiesner's 1995 CD recording) in order to yield insight into the multilayered processes at play. Although *Solo* appears to be an open-form work, electronic superimpositions manifest structures which function at a macro-formal level, whereas content (and a number of other parameters) shape form at a micro-formal level. Thus, *Solo* has a definite fixed form: a structure of electronic superimpositions which Stockhausen systematically conceives and distributes across the six Versions of the work.

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I imagined a music in which—as in life—at certain moments splinters or figures of memory *simultaneously* superimpose audibly, to which the soloist could play commentaries, supplements, something new: a music in which one senses that the player is ‘thinking out loud’, and in which one experiences the creation and dissolution of multi-layered processes, as they take place. Only when music makes us aware of the polydimensional thinking and experiencing and of the *process of the structure formation*—instead of an object—a higher level of composing for a soloist would be achieved.[1]

Karlheinz Stockhausen, in his work *Solo für Melodieinstrument mit Rückkopplung, Nr. 19* (*Solo for Melody Instrument with Feedback*), sought a new conception of form, a ‘memory’ form in which a feedback of musical ideas would interact in realtime. The creation of the score itself follows an interactive process whereby the instrumentalist extracts fragments from Stockhausen’s pre-composed musical material and patches them together anew. A performance of *Solo* incorporates a variable length tape delay and feedback system that superimposes recorded material and plays it back live. It is this ‘*Strukturbildung’* (‘structure formation’ of electronic superimpositions) which will be the focus of analysis. Although *Solo* appears to be an open-form work, electronic superimpositions manifest structures which function at a macro-formal level, whereas content (and a number of other parameters) shape form at a micro-formal level. Thus, *Solo* has a definite fixed form: a structure of electronic superimpositions which Stockhausen systematically conceives and distributes across the six Versions of the work.

Stockhausen began sketching *Solo* in 1964, completed the work in March and April of 1966, and made final revisions in 1969. The score is dedicated to his friend Alfred Schlee, the director of the Vienna branch of Universal Edition (Stockhausen’s publisher at the time), and the work was commissioned by NHK (Nippon Hoso Kyokai) of the Japanese Radio Broadcasting Services. Two versions of *Solo* were premiered on April 25, 1966, at NHK in Tokyo, a version for trombone and another for flute,[2] along with a premiere of Stockhausen’s electronic composition *Telemusik*.

Stockhausen’s original concept for *Solo* was, in essence, a live electronic version of his groundbreaking composition *Gesang Der Jünglinge*, although in this case the montage

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[1] Stockhausen, *Programm zu den Interpretations*, 50.

[2] The soloist were Yasusuke Hirata, trombone, and Ryū Noguchi, flute; the assisting technicians were Akira Honma, M. Nagano, Shigeru Satō, and Wataru Uenami.

process would take place during the performance and the soloist would spontaneously interact with the electronic superimpositions produced by the feedback system.

> In the solo music to date, one thing had always succeeded another; the temporal span was conceived and heard as a line. What I had in mind, however, were musical spaces, in which the order of events is not fixed, but rather in which it is possible to move in all directions, similar to the way in which a mobile sculpture is viewed. The spontaneity of the playing and the acoustical 'accumulation' and 'verticalisation' of musical moments should make it possible to experience this spatial awareness.[3]

Ultimately, Stockhausen's intentions proved too difficult to realize in actual performance. Even for the premieres, Stockhausen allowed the instrumentalists to prepare worked-out written versions. The revised score of 1969 (the source of our analysis) incorporates these modifications and is the score in use today.

Stockhausen likens *Solo* to several of his own works from the same period: *Plus-Minus* (1963), *Momente* (1962–9) and *Mikrophonie I* (1964–5).[4] The score of *Plus-Minus*, Stockhausen's first process composition, comprises seven 'symbol pages' and seven 'note pages'; instructions govern the manipulation of a number of different parameters (usually, but not always, consisting of seven permutations), including types of rests (short, medium, or long) and types of superimposition. *Momente* consists of thirty interchangeable sections ('moments') which Stockhausen categorizes according to their musical content as 'M moments' (monophony/heterophony), 'K moments' (homophony), and 'D moments' (polyphony). *Mikrophonie I*, preceded by *Mixtur* as Stockhausen's first live electronic work, incorporates the concepts of moment form and process composition with live electronics. All these works share many similarities with *Solo*; in fact, they are closely linked and in many respects extensions of each other.

Solo is preceded by Terry Riley's *Music for the Gift* (1963) as the first composition to employ a tape delay and feedback system; however, Riley's composition lacks a score, thus *Solo* is the first such composition employing a score. Riley began working with tape loops in the 1950s, his experiments culminating in the 'Time-lag Accumulator' (a multifunctional tape delay and feedback system designed for live performance). In 1961, the San Francisco Tape Music Centre was founded; in addition to Terry Riley, its members included Pauline Oliveros and Steve Reich. In 1966, Oliveros composed *I of IV* (no score), employing an "interactive performable system involving tone generators, tape delays, and amplifiers to produce combi-

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[3] Stockhausen, *Programm zu den Interpretations*, 50–51.
[4] Ibid., 51.

nation tones, repetitions, layering of sounds, and different kinds of reverberation."[5] Working with closed tape loops, Steve Reich pioneered the technique of phase shifting with his composition *It's Gonna Rain* (1965). Other notable works of the time include John Cage's *Rozart Mix* (1965), in which the performers "make, repair, change, and play tape loops"[6] using at least eighty-eight closed tapes loops on at least twelve tape machines; and Alvin Lucier's tape composition *I am Sitting in a Room* (1969). Cage incorporates the superimpositions of the various tape loops into his processes of indeterminacy and Lucier exploits the technical weakness of tape recording as a means of exploring a compositional use of resonant frequencies. Although Stockhausen's use of tape delay and feedback was not novel for its time, his approach was: he was the first composer to attempt to exert compositional control over electronic superimpositions in a sophisticated manner.

Stockhausen cultivated a sense of mysticism and enigma in many of his compositions; this, along with the complexity of *Solo*, has led to misconceptions about the work which I will attempt to elucidate. The only published analysis of *Solo* to date, written by Thomas Sylvand,[7] focuses mainly on the mathematical relations between Versions, sections, and subsections. I will draw upon and supplement these findings. As well, Sylvand attempts to relate the derivation of musical content to the Fibonacci series; he does not, however, deal with electronic superimpositions. I have divided my analysis into three parts: Part I provides an overview of the mechanics of *Solo*, including an explanation of the feedback system; Part II involves a categorization and analysis of electronic superimpositions and techniques in an attempt to arrive at a systematic organization of electronic form; Part III offers a comparative, subjective analysis in which I utilize the nomenclature and findings of the previous section to examine both hypothetical and performance models of *Solo*. It will not be my aim to provide a definitive analysis of *Solo* (impossible, considering its 'open' nature), but to investigate the variables at play: *Solo* is a formally complex and multilayered work in which the comprehension of form and structure is only attainable through a process of extrapolation.

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[5] Chadabee, *Electronic Sound*, 77.
[6] Ibid., 75.
[7] Sylvand, "Solo op. 19 de Karlheinz Stockhausen."

Part I
Overview

I will begin with an overview of the attributes of *Solo* most pertinent to our analysis, including a discussion of instrumentation, formal organization, score generation, the role of the instrumentalist and assistants, and the feedback system.

Instrumentation and Electronics

For a performance of *Solo*, Stockhausen calls for an instrumentalist (on any melody instrument) and four assistants. Three assistants respectively control the microphone levels, feedback levels, and output levels, and a fourth assistant controls the change of playback heads (although the third assistant may double on this task).

Stockhausen prescribes four different timbres to the instrument: N (normal), I, II, and III; arrows between symbols signify that the performer should attempt to transition between timbres. The instrumentalist has several options in determining the four specific timbres: the use of various techniques on the same instrument, the possibility of selecting other instruments (presumably of the same family), or the use of electronic means.

> In a version for a flutist, the following timbres were used: N: flute; I: piccolo and flute with emphasized overtone content, and recorder; II: flute with simultaneously hummed tones; III: alto flute (in transitions such as N → III, the flutist on the transverse flute attempted to imitate increasingly, with the aid of labials, the timbre of the alto flute).[8]

As well, Stockhausen provides three further timbral indications: *Sehr Geräuschhaft* (somewhat noisy), *Etwas Geräuschhaft* (noisy), and *Geräuschhaft* (very noisy). In addition to extended techniques such as overblowing, key clicks, and increased bow pressure, Stockhausen again permits the use of electronic means (e.g. electro-acoustical noise modulation). Thus, *Solo* is scored for a single melodic instrument or group of instruments, with the possibility of the live processing of sound.

The Central Role of the Number Six

The number six is central to the organization of the formal structure of *Solo* and to the systemization of certain temporal elements. The score consists of six pages of musical notes and

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[8] Stockhausen, “Solo für Melodieinstrument mit Rückkopplung,” 13.

six *Formschemen* (Form Schemes) labelled 'Version' I–VI. Each page of musical notes consists of six systems (or in the case of one of the pages, six sets of systems grouped in pairs). Additionally, each Form Scheme comprises six 'cycles'(sections) labelled from A to F, and each cycle is further divided into a number of 'periods' (subsections) ranging between six and eleven. In this case, the number six functions as the initial operand of a simple mathematical operation to generate a discrete set of numbers:

$$6+1=7+1=8+1=9+1=10+1=11$$

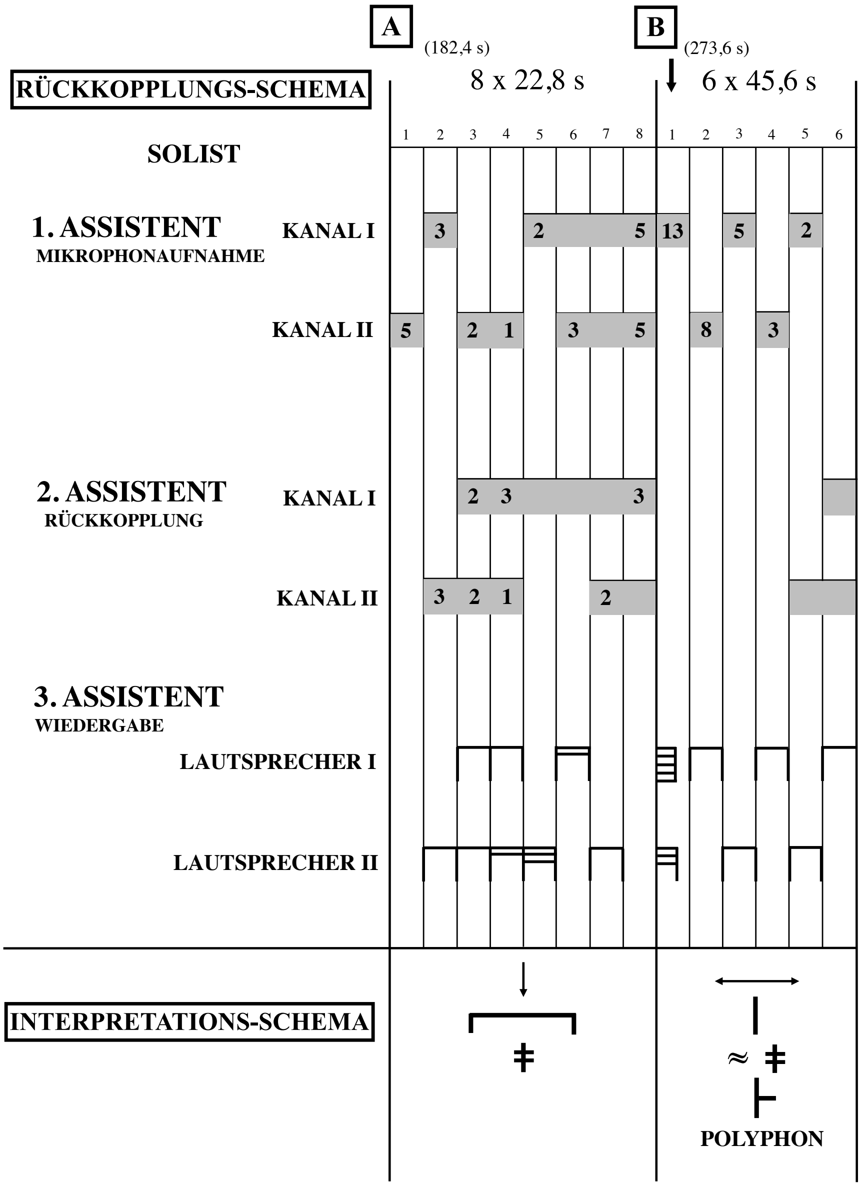
Periods range in length from 6 seconds to 45.6 seconds. In determining the duration of each period, Stockhausen employs a slightly more complex mathematical formula coupled with an arbitrary selection process in which the number six again functions generatively. (I will expound upon this procedure in the section outlining the temporal and formal properties of *Solo*.) Finally, our analysis will reveal that Stockhausen categorizes electronic superimpositions into six pattern types and allocates each pattern type to one of the six cycles. Thus, the number six plays an important generative role and is ubiquitous in the systematic creation of structure.[9]

Form Schemes, Interpretation Schemes, and the Preparation of a Version

In addition to specifying the number and duration of periods in every cycle, each Form Scheme consists of a *Rückkopplungs-Schema* (Feedback Scheme) and an *Interpretations-Schema* (Interpretation Scheme). The Feedback Scheme instructs the assistants to open and close their respective potentiometers at precise times. For the first and second assistants, hatched boxes indicate that potentiometers must be opened. The numbers within the hatched boxes specify the number of 'perforations' (rapid closing and reopening of the potentiometers) to be performed per period. For the third assistant, a line indicates that potentiometers must be opened (multiple vertically stacked lines indicate the number of superimposed layers); the absence of a line indicates that potentiometers must be closed. The Interpretation Scheme provides indications (mainly consisting of symbols which Stockhausen defines in the score notes) for the instrumentalist to follow in the preparation of a performance score.

[9] I will not explore the mathematical or symmetrical properties of the number six in an attempt to discover the rationale behind Stockhausen's choice (as Sylvand has done); however, the selection of the number six could be related to a minimum viable loop time.

Fig. 1 Excerpt of the Version V Form Scheme



In the preparation of a Version, Stockhausen instructs the instrumentalist to select one Form Scheme and to assign one page of musical notes to each cycle. (The pages of musical notes are unnumbered in the score of *Solo*.) The instrumentalist then 'interprets' (extracts) systems, 'parts' (sections of systems separated by bar lines), or 'elements' (individual notes, individual grace notes, or groups of grace notes) from the original musical material and inserts these components (for the most part, interspersed with rests of varying length) onto a new musical score which will serve as the actual performance score.

Fig. 2 Example of a Score Page from the Six Pages of Musical Notes

This collage-like procedure follows a set of detailed written instructions provided at the beginning of the score which defines the following parameters: page interpretation, musical component interpretation, method of interpretation, duration of pauses between parts and elements, and acoustic entry patterns.[10] Stockhausen assigns a set of symbols or indications to each parameter and they appear in the Interpretation Scheme. Since the explanatory notes in the score delineate the parameters of the Interpretation Scheme in a concise manner, what fol-

[10] I will use the term 'acoustic' throughout the analysis to refer to the live sound produced by the instrumentalist (although, strictly speaking, the instrumentalist could perform on an electronic instrument, be amplified, or be electronically processed).

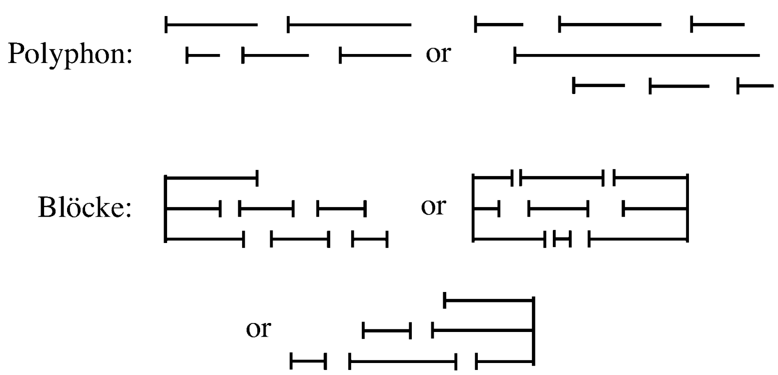
lows is only a brief summary of pertinent information; however, when dealing with specific examples later on, I will elaborate further as needed.

The page interpretation parameter defines which page or pages act as the source for the instrumentalist's extraction process. While creating the page of musical notes that correlates to a specific cycle, the instrumentalist will always interpret musical components from the page of notes which they originally chose for a particular cycle (the source page), but according to the page interpretation symbol assigned to the cycle, the instrumentalist may also include components from the previous page, the following page, or both the previous and following pages.

The musical component parameter instructs the instrumentalist to extract either entire systems, parts, elements, or combinations thereof. The method of interpretation involves selecting musical components that are either the same, different, contrasting, or a combination thereof (based on register, pitch, dynamics, timbre, duration, articulation, etc.).

According to the pause duration parameter, the instrumentalist will always intersperse parts and elements with either 'relatively long pauses', 'medium-long pauses', 'short pauses', or combinations thereof, but consecutive entries of systems are not separated by pauses.

Fig. 3 Stockhausen's Diagrams of Acoustic Entry Patterns



The final interpretation parameter, the acoustic entry pattern, stipulates that the entry of parts and elements should obey one of the following three textural structures or a combination thereof: '*Polyphon*' (polyphonic), '*Akkorde*'(chordal), or '*Blöcke*'(in blocks). Stockhausen illustrates the characteristic structure of two of these indications (Fig. 3); however, he does not illustrate the *Akkorde* texture, instead defining it as a structure in which entries should be synchronous and layers should produce as many chords as possible. As we will discover in the analysis, acoustic entry types play a role in shaping electronic form but not to a significant degree.

The preparation of a score for a Version of *Solo* is a formidable task. In order to achieve the characteristic features of each acoustic entry pattern, the instrumentalist must map out and take into consideration all the electronic reiterations which the tape delay and feedback system will produce and attempt to create superimpositions that adhere to Stockhausen's guidelines. Although Stockhausen's directions are extremely methodical, they are not exhaustive, and as a result certain inconsistencies and conflicts arise which force the soloist to make decisions outside the scope of the Interpretation Scheme. (We will examine some specific examples in the musical analysis section of the paper.)

The Role of the Instrumentalist and Assistants

The instrumentalist exercises the most significant influence over musical material, but the assistants also play a role in shaping musical content and form, although to a lesser extent. The first and second assistants must decide at which points to 'perforate' the electronic superimpositions. Stockhausen instructs them to monitor the feedback with earphones in order to create 'variations' of periods by leaving out single tones from melodic sequences, 'puncturing' held tones, or, in certain instances, deciding to omit perforations altogether to allow held tones to sustain for an entire period or longer. The third assistant, in addition to opening and closing potentiometers at the precise moments indicated in the Feedback Scheme, must constantly regulate output levels (reacting to the instrumentalist and attempting to achieve an extreme differentiation in sound output), diffuse the sound ad lib., and interpret the duration of partial periods.[11] The fourth assistant must judge the precise points at which to change playback heads, because these changes (indicated by arrows at the top of the Feedback Scheme) do not necessarily occur at the beginning of cycles. Thus, all the assistants make musical decisions which influence both form and content, and as a result they act as performers.

Temporal and Formal Properties

Stockhausen applies precise durations to Versions, cycles, and periods (see Appendix I); the derivation and relation of these durations present somewhat of a puzzle. In order to unravel this puzzle, I will draw upon the section of Thomas Sylvand's analysis[12] pertaining to the

[11] In general, the assistants keep potentiometers either open or closed for the entire duration of a period (disregarding perforations), but sometimes the assistants must open potentiometers for only a segment of a period, requiring them to gauge the length of these partial periods according to musical content and their spatial proportions on the written page. Stockhausen only occasionally provides precise durations in these instances.

[12] Sylvand, "Solo op. 19 de Karlheinz Stockhausen," i–xiii, 1–48.

temporal and formal properties of *Solo*. In what follows, I will summarize Sylvand's findings; however, Sylvand's analysis of the derivation of durations is incomplete in one respect. Therefore, I will supplement his findings in order to provide a complete theory governing the derivation of durations.

Fig. 4 Durations of the Six Versions of *Solo*.

I	II	III	IV	V	VI
10' 39.8"	12' 49"	15' 25.9"	15' 25.9"	17' 16"	19' 5"
(639.8s)	(769s)	(925.9s)	(925.9s)	(1036s)	(1140s)

Except for Versions III and IV, all Versions progressively increase in duration. Although Version durations display an apparent central symmetry, they are not mathematically symmetrical (contrary to Sylvand's claim[13]); instead, Stockhausen derives Version durations (and as a matter of course cycle durations) from the procedure he applies to the derivation and allocation of period durations and repetitions.

Fig. 5 Period Repetitions and Durations

Cycles

(Repetitions x Duration of Periods in Seconds)

Versions	A	B	C	D	E	F	
I	11 x 6s	8 x 14.2s	7 x 19s	6 x 25.3s	9 x 10.6s	10 x 8s	
II	9 x 12s	7 x 24s	11 x 6s	10 x 8.5s	6 x 30.4s	8 x 17.1s	
III	7 x 30.4s	10 x 9s	8 x 20.25s	9 x 13.5s	11 x 6s	6 x 45.6s	Retrograde
IV	6 x 45.6s	11 x 6s	9 x 13.5s	8 x 20.25s	10 x 9s	7 x 30.4s	
V	8 x 22.8s	6 x 45.6s	10 x 11.4s	11 x 8s	7 x 32s	9 x 16s	
VI	10 x 14.2s	9 x 19s	6 x 45.6s	7 x 34.2s	8 x 25.3s	11 x 10.6s	

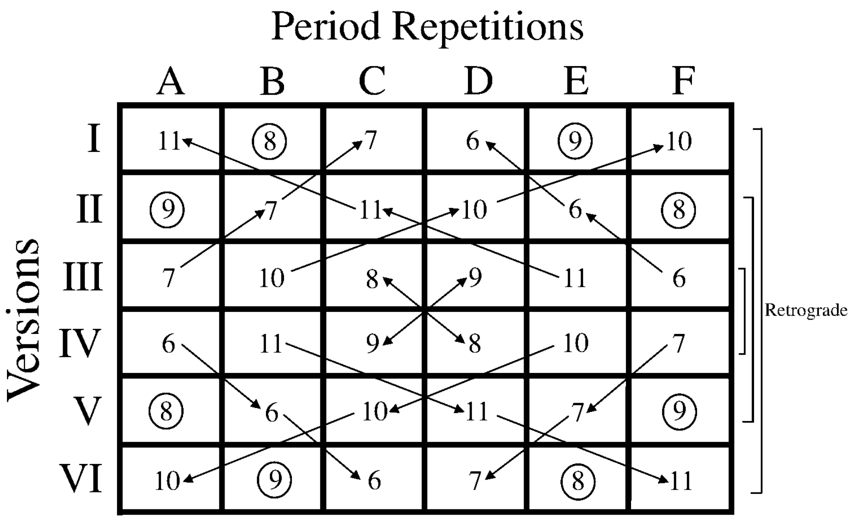
Figure 5 displays the duration of each period and the number of repetitions per cycle for all six Versions of *Solo*. This chart elucidates the fact that Version IV is the retrograde of

[13] Sylvand claims that V2 = V5 x 3/4; V1 = V6 x $(3/4)^2$; and V3 = V4. The final equation is correct, but there is no mathematical basis for the other equations. In addition, Sylvand's miscalculation of the duration of Form Scheme V leads to flaws in some of the mathematical relations he attempts to demonstrate between Versions.

Version III. Additionally, the chart reveals a central symmetry in the organization of period durations and repetitions across Versions. Although it is not immediately apparent, this symmetry continues outwards and all subsequent entries in the chart follow a procedure in which they function as permutations of this central symmetry.

In order to comprehend the manner in which this procedure unfolds, we will consider period repetitions and durations separately. Examining Figure 6, which displays the number of period repetitions exclusive of durations, we can now clearly see that Version VI is a retrograde of Version I and that Version V is a retrograde of Version II. The arrows in the chart indicate the operations necessary to generate numbers in the chart originating from a central axis point; the circled numbers indicate numbers which follow a different yet still systematic logic.

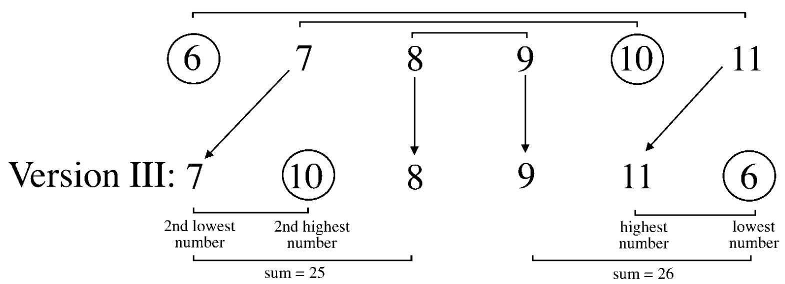
Fig. 6 Number of Period Repetitions



Employing Version III as a starting point, I will describe the process to generate all the numbers in the chart. (I could, however, use any other starting point.) To generate the series of numbers in Version II from Version III, one follows the following procedure: shift the number 7 one degree to the right; shift 10 two degrees to the right; the numbers 6 and 11 follow the mirror image of this process (6 shifts one degree to the left and 11 shifts two degrees to the right); the numbers 8 and 9 reverse order and fill in the remaining spaces, moving from the centre of the chart to the extreme outer points. To generate the series of numbers for Version I, one repeats the exact process but now using Version II as the source. Thus, the numbers 6, 7, 10, and 11 follow a symmetrical system of movement and the numbers 8 and 9 follow a different, logical system. Since the bottom half of the graph is a retrograde of the top, the process to generate the number of repetitions for Versions IV–VI is the mirror image of the process described for Versions I–III.

Therefore, the distribution of numbers across the chart is entirely systematic, originates from a central axis, and is mostly symmetrical. The processes for the numbers 6, 7, 10, and 11, viewed from a central axis point, are mirror images of each other on both the horizontal and vertical plane. The division of numbers into different processes, in which the central numbers function uniquely, is another manifestation of inherent symmetry. Furthermore, the derivation of the order of repetitions in Version III is itself logical and symmetrical (as Figure 7 illustrates).

Fig. 7 Derivation of the Period Repetition Number Series for Version III



Next, we will examine the procedure employed to generate the durations of periods. Stockhausen generates all period durations from mathematical permutations of the number six in combination with an arbitrary decision process. In order to more clearly see this process at work, durations have been reordered from lowest to highest, (ignoring the order of cycles for now). Figure 8 illustrates the reordering of period durations for each Version and the mathematical formula required to produce each subsequent number in each series. Again, symmetry manifests itself in the process at hand: Versions III and IV share the same mathematical operations; as do Versions II and V; and Versions I and VI.

In order to examine Stockhausen's arbitrary decision process, we will study Versions I–III and Versions IV–VI separately. In Versions I–III, Stockhausen selects the number 6 as the initial operand, and mathematical operations act to generate progressively longer periods. The process for Versions I and III is a straightforward mathematical formula, but the process for Version II is unique and incorporates an arbitrary decision on the part of Stockhausen.

Fig. 8 Mathematical Permutations of Period Durations

Version I	6	8	10.6	14.2	19	$\boxed{25.3}$
	$A + \frac{A}{3} = B$					
Version II	6	(8.55)	12	17.1	24	$\boxed{(34.2)}$
		8.5				**30.4**
	$A \times 2 = C$					
Version III/IV	6	9	13.5	20.25	30.4	$\boxed{45.6}$
	$A + \frac{A}{2} = B$					
Version V	8	11.4	16	22.8	32	45.6
	$A \times 2 = C$					
Version VI	10.6	14.2	19	$\boxed{25.3}$	$\boxed{34.2}$	$\boxed{45.6}$
	$A + \frac{A}{3} = B$					

Version II begins with the operand 6, but the indicated mathematical operation produces a result only at every second number in the series. Thus, from the number 6 we arrive at the numbers 12 and 24. To arrive at the other numbers (8.55, 17.1, and 34.2), Stockhausen applies the same mathematical operation in retrograde.[14] He selects the number 34.2 to act as the final result in the series. This number is derived from the final three numbers from Version VI; the final three numbers here become, in order, the final numbers for Versions I–III. The numbers 25.3 and 45.6 occur as a result of the mathematical formula at hand, but the number 34.2 is an arbitrary yet logical selection. (The process is illustrated by the numbers in boxes.) Working in reverse, the number 34.2 is sequentially divided in half to generate the remaining numbers in the series.

Versions IV–VI follow a similar logic and practically in mirror form. Here, all Versions end with the same number (45.6) but begin with different numbers (6, 8, and 10.6). The initial numbers are arbitrary selections and can be traced back to the first three numbers of Version I (the circled numbers in Fig. 8).

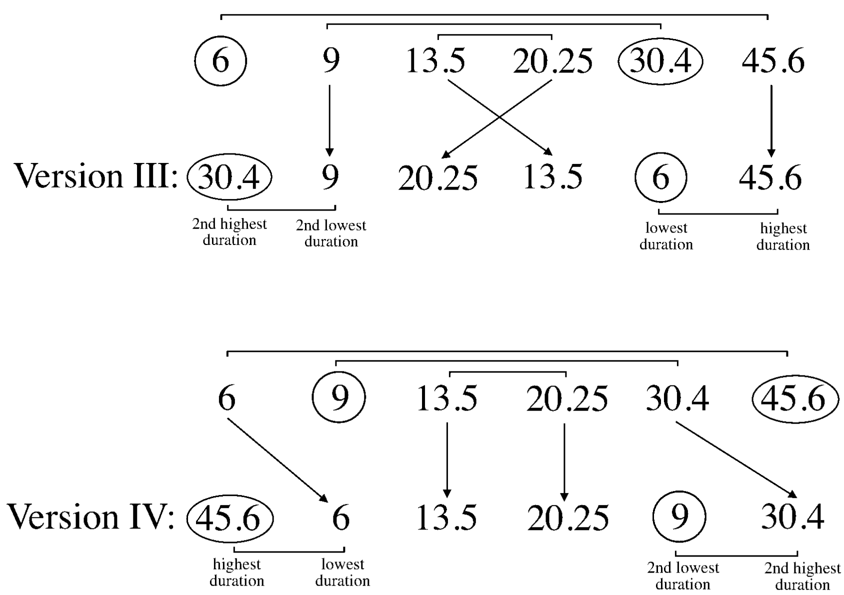
However, there exists a single mathematical flaw and a single logical flaw in this procedure (parenthesized numbers in Fig. 8), both occurring in Version II. Stockhausen employs the number 8.5 as the actual duration in the score (instead of 8.55) and the number 30.4 (in-

[14] This mathematical formula and process supplements Sylvand's findings and constitutes the one respect in which his explanation of duration and repetition derivations is incomplete.

stead of 34.2). The former represents the mathematical flaw and the latter the logical flaw. It is not possible to determine if these flaws were errors or intentional deviations from the process.

Finally, we will examine the process for allocating durations to cycles, thus completing all the processes involved in the derivation of durations and repetitions in Versions, cycles, and periods.

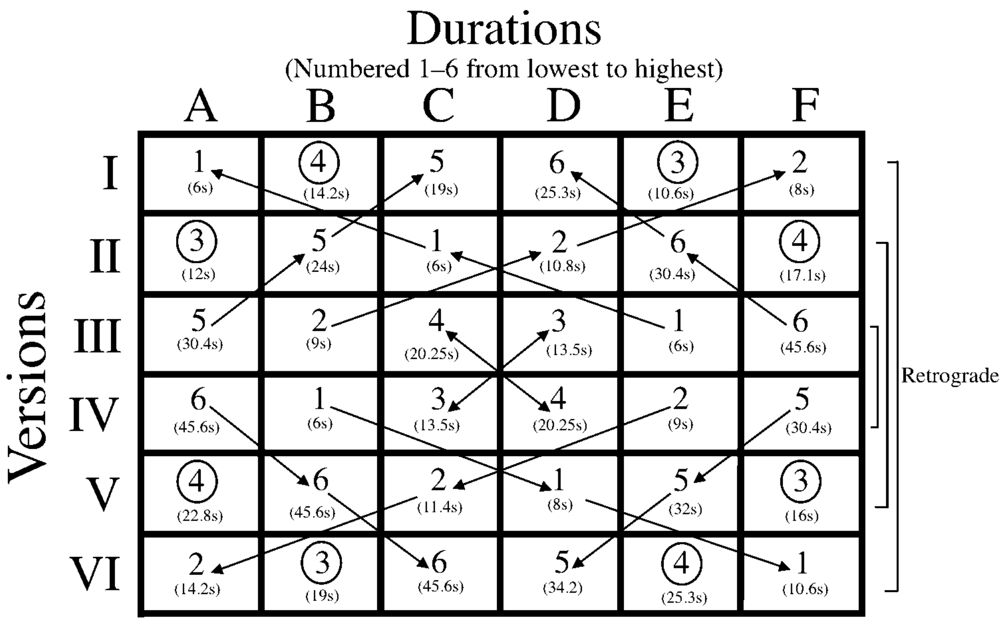
Fig. 9 The Allocation of Durations to Cycles



The allocation of durations to cycles follows the same process as that for period repetitions, except that the derivation of the source differs. In the latter case, Version III functions as the source, but for the allocation of durations, Stockhausen transfers the process for the generation of the source to Version IV and adds a slight alteration. In order to view this alteration, we must compare the schematic of the derivation of the source of period repetitions (cf. Fig. 7) with that of cycle durations. Figure 9 reveals that the central numbers act in accordance with the previous system, but that the outer pair of numbers are mirror images of the processes of the previous system.

Other than this alteration, the process for the allocation of durations to cycles follows the same process as for period repetitions. In order to more clearly visualize this process, durations have been numbered from 1–6 (from lowest to highest) based on their respective value in each cycle (Fig. 10).

Fig. 10 Allocation of Durations to Cycles

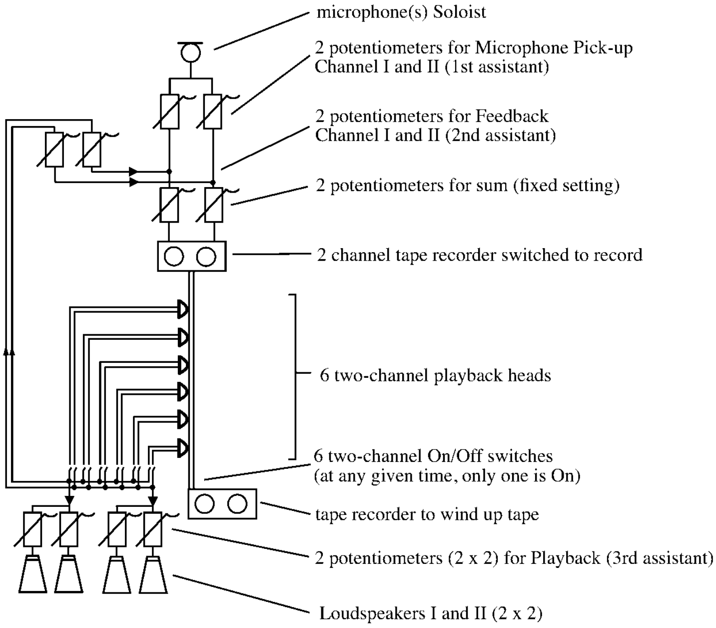


In summary, the process for the derivation and allocation of durations and repetitions across Versions is entirely systematic, relies on mathematical permutations originating from the number six, and follows a symmetrical logic that often incorporates the concept of retrograde (mirror image) and a number of arbitrary decisions. In addition, this process contains a logical and a mathematical flaw; therefore, the durations of Versions are idiosyncratic and not purely mathematically related (except for V3 and V4 which are of identical duration). The analysis here provides us with an understanding of the temporal and formal organization of *Solo*, and we will see further on that the mathematical correlation between period times within a single Version transfers itself to metronome markings (and thus tempo). Lastly, we will see that Stockhausen employs a similar process in the allocation of electronic superimposition patterns to Versions.

Variable Length Tape Delay and Feedback System

Even though Stockhausen's original technical set-up is no longer practical for use in performance, we will begin with an examination of it in order to comprehend the nature of the feedback mechanism. In the score notes, Stockhausen describes the equipment necessary and provides the following schematic diagram:

Fig. 11 Schematic Diagram of the Technical Set-up

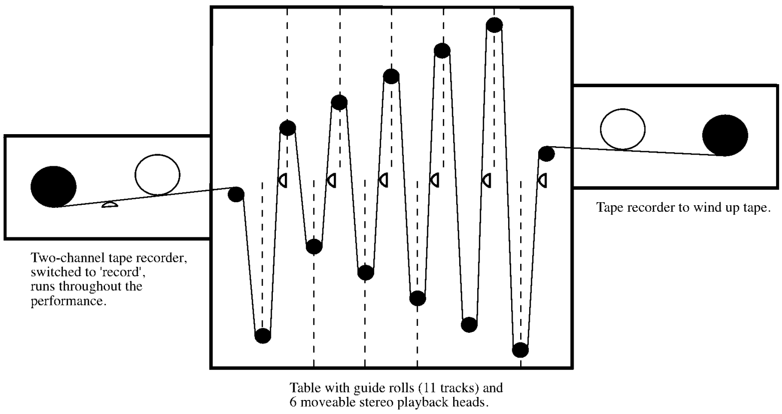


The instrumentalist's sound is captured by a microphone (or microphones) and is fed through two potentiometers (controlled by the first assistant). These two signals continue on to a two-channel tape recorder where they are recorded onto Channels I and II. The tape then travels through the six playback heads and finally reaches a second tape recorder that functions solely to wind and store the tape. Only one of the playback heads is set to play at any one time during the piece. The playback heads are spaced at exact distances corresponding to the period durations of cycles (thus playback heads are not set to play in consecutive order). Once the tape reaches the playback head which is currently switched on, the recorded signals are fed through four potentiometers (controlled by the third assistant) and through four loudspeakers; at the same time, these signals are sent through a feedback circuit, in which they travel through another set of potentiometers (controlled by the second assistant) before being combined with the live sound captured by the microphone and added to the next period.

Summarizing, Stockhausen utilizes a variable length tape delay (consisting of six different delay times) in combination with a feedback circuit. By instructing the assistants to open and close their potentiometers at precise times, Stockhausen controls the material entering the feedback system and the material being output. The diffusion of sound is monophonic; Stockhausen uses the two channels to increase the combinational possibilities of superimpositions. Stockhausen's feedback system, unique for its time, allows for a surprisingly vast range of superimposed structures but has its limitations as well.

The original design for the tape apparatus made use of a table with guide rolls, eleven moveable tracks, and six playback heads (Fig. 12).[15] In 1968, the first apparatus exclusively for *Solo* was built at the *Studio voor Elektronische Musik* of the *Rijksuniversiteit* in Utrecht, Holland and was made available for rent.[16] This apparatus was a modified version of Stockhausen's original design in which a tape loop passes straight through six horizontally moveable playback heads. It is important to note that this device in no way alters Stockhausen's original feedback system; it is only a more efficient design of the apparatus from a technical standpoint.[17] A schematic diagram and photographs of the apparatus can be found in the score notes.

Fig. 12 Original Tape Apparatus with Guide Rolls and Moveable Tracks



Karlheinz Stockhausen "Solo für Melodieinstrument mit Rückkopplung (1 Spieler und 4 Assistenten) Nr. 19" © Copyright 1969 by Universal Edition A.G., Wien/UE 14789

The West Square Electronic Music Ensemble (founded in London in 1973 by Barry Anderson) had a feedback system built according to Stockhausen's original design with the intent of showcasing *Solo* in a number of concert series and to commission works for the system, with performances by Christopher Taylor (flute, 1975), Barry Guy (double bass, 1976), Jane Manning (voice, 1977), Edwin Roxburgh (oboe, 1978/9), James Fulkerson (trombone, 1980/81), and Harry Sparnaay (bass clarinet, 1981).[18]

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[15] Stockhausen, "Solo für Melodieinstrument mit Rückkopplung," 15.
[16] Ibid., 20.
[17] When the tape loop re-enters the tape recorder, it first passes over an erase head, meaning the sound does not 'loop' (the tape loops only in a physical sense). This design is more efficient and reliable because it requires one tape recorder instead of two, and passing the tape straight through the playback heads eliminates the need for guide rolls and moveable tracks.
[18] Emmerson, "Live Electronic Music in Britain: Three Case Studies," 183.

Unfortunately, the technology of the late sixties and early seventies lagged behind Stockhausen's artistic vision for *Solo*. In addition to technical difficulties, the tape apparatus suffers from low fidelity, compromising the realization of superimposed electronic layers. Stockhausen addresses the issue of tape noise in the score and suggests the use of low pass filters to attenuate this effect. These issues affected the performability of *Solo*, to which Robin Maconie attests when he remarks in the 1990 edition of his overview of Stockhausen's works that "*Solo* has had a chequered career."[19]

However, the advent of portable, commercially available digital technology gave new life to *Solo*. In 1988, trombonist and researcher Benny Sluchin began considering a computer realization and by 1992 had completed, with the aid of Cort Lippe, a version of *Solo* that ran using Max on IRCAM's Signal Processing Workstation and the NeXT computer.[20] A modernized version followed in 1998 using an Apple Macintosh G3 running Max/MSP.

> In our setup, the computer produces the delays, performs and coordinates the tasks of the four assistants (notated precisely by the composer), and gives the player an easy-to-use interface. The synchronization required in the piece is thus greatly simplified. The computer also handles the sound transformations. Because there is only one assistant necessary for the sound control in the performance space and practically all of the tasks have now been preprogrammed, a more musical context between soloist and assistant can evolve.[21]

More recent published computer versions of *Solo* include a realization by Enrico Francioni[22] using MacCsound and Csound, and a realization by Robert Esler[23] running Max/MSP; both versions automate all tasks, allowing the instrumentalist to perform without the aid of assistants.

Nowadays, a computer realization of *Solo* is quite simple to achieve using any of a number of commercially available or public domain software programs and a laptop computer. However, the automation of certain tasks is problematic because, as noted previously, the assistants at times carry out musical tasks affecting form and content (e.g. perforations and sound diffusion), and the output of sound, in the case of partial periods, is often content specific. Conceivably, an automated computer version of *Solo* could include programmable pre-

[19] Maconie, *The Works of Karlheinz Stockhausen*, 151.
[20] Sluchin, "Computer-Assisted Version of Stockhausen's 'Solo,'" 42.
[21] Ibid., 42.
[22] Francioni, "SOLO_MV_10.1."
[23] Esler, "Digital Autonomy in Electroacoustic Music Performance."

sets for all content specific parameters, but consequently this would require an exact rendition of the score (only theoretically possible with a click track). The allocation of electronic superimpositions to output channels can easily be programmed, and while certain elements of diffusion could be automated, the diffusion of sound must be performed live in order to achieve the level of nuance which Stockhausen demands. Thus, a computer version of *Solo* must include at least one assistant (sound diffusion) and in practical terms (for authenticity as well), another two assistants to apply the perforations and in certain cases, to interpret partial periods.

As a compromise to the live electronic version, Stockhausen allows the use of a two-channel recording, prepared with strict adherence to the instructions in the Feedback Scheme and diffused live by an assistant, to which the instrumentalist plays in a concert performance.[24] In fact, Stockhausen prepared a version of *Solo* in 1994 recorded on digital tape using a sequencer and a sampler in collaboration with flutist Dietmar Wiesner and Simon Stockhausen. This version replaced the tape apparatus for both Wiesner's compact disc recording of *Solo* in 1995 and subsequent public performances.[25]

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[24] It is important to note that Stockhausen carries out the role of the assistants himself, thus displacing their function from real-time to non-real-time; however, he does not negate their roles.

[25] Stockhausen, Solo; Spiral, (Liner Notes) 26.

Part II
Analysis of Electronic Superimpositions and Techniques

This brings us to the analysis section, in which I will begin by examining and creating a nomenclature for electronic superimpositions, with the caveat that certain factors (which we will consider further on) may distort actual electronic output (e.g. perforations and acoustic rests). Electronic superimpositions form patterns and manifest techniques that evolve across complete and partial cycles. In an attempt to prove an overall structure of electronic form, I will present a topology of these patterns and techniques which demonstrates a systematic organization of elements. Then, we will compare these findings to an original sketch of electronic superimpositions in which Stockhausen methodically allocates patterns across Versions. Finally, I will analyze the diffusion of superimpositions and we will see that, here as well, Stockhausen makes use of a set of patterns and techniques that involve a structural logic.

Superimposition Graphs

Although the Feedback Schemes provide precise instructions for the assistants, they do not present a clear visual image of electronic superimpositions, which we, however, require for analysis. Therefore, I have transferred the data from the Feedback Schemes of all Versions onto two sets of graphs in order to more clearly visualize superimpositions and facilitate analysis. The Electronic Superimposition Graphs (Appendix I) display electronic superimpositions while specifying the acoustic source (represented by the numbers above lines) and whether electronic periods result from the opening of microphone potentiometers (thus manifesting a tape delay) or from feedback. The Acoustic/Electronic Superimposition Graphs (Appendix II) combine acoustic and electronic periods without a visual division of channels, thereby providing the clearest representation of the actual structure of superimpositions within *Solo*. Reference to both sets of graphs will allow the reader to more clearly comprehend the analysis which follows.

Electronic Rests

We will begin by comparing the ratio between the presence of electronic playback (i.e. output from the feedback system from either Channel I or II) and the absence of electronic playback (i.e. lack of output from both Channels I and II). I will refer to the latter as electronic rests (most clearly visualized in Appendix I) and differentiate between complete rests (i.e. rests that last an entire period) and partial rests (i.e. rests that last for a segment of a period). Figure 13 enumerates the periods in which complete or partial rests (marked with an asterisk) occur and outlines 4 different types of partial rests (PR1–4).

Fig. 13 Electronic Rests

	V1	V2	V3
A	1	1	1
B	1* (PR1)	1* (PR2)	1* (PR1, PR2), 9* (PR1, PR2), **10**
C	1* (PR2)	1* (PR3), 11* (PR4)	1* (PR1) 2* (PR2)
D	1* (PR1), 6* (PR4)	1* (PR4)	
E	1* (PR3)	1* (PR1)	1* (PR2)
F	1* (PR3)	1* (PR4)	1* (PR1)

	V4	V5	V6
A	1	1, **8**	1
B		1* (PR1)	1* (PR3), 9* (PR4)
C	1* (PR2)	1* (PR3)	
D	1* (PR4)	1* (PR1)	1* (PR4)
E		1* (PR3)	1* (PR4)
F	1* (PR1), 7* (PR4)		1* (PR1), <u>**4**</u>

*<u>Partial Rests</u>:
-PR1: begins at start of period; ends mid-period
-PR2: begins mid-period; ends at end of period
-PR3: begins and ends mid-period
-PR4: two or more partial rests of type PR3; or a combination of type PR3 with either PR1 or PR2 (or both PR1 and PR2)

The first period of the first cycle of every Version (A1) is always a complete electronic rest; this is a condition of the feedback system, which requires at least 1 period of input before it is able to produce output (the time it takes the tape to travel from the record head to the playback head). Interestingly, this fact parallels the common practice of many traditional contrapuntal works, for example, the fugue, in which the subject first appears alone and the texture gradually builds as new voices appear.

Yet after A1, electronic playback predominates in all Versions. The few electronic rests that occur do so mainly during the first period of cycles, and the majority of cycles begin with some form of electronic rest.[26] In Version I and Version II (hereinafter V1, V2, etc.), rests occur in the first period of all cycles; in V3, V5, and V6, rests occur in the first period of all cycles except one; and in V4, rests occur in the first period of all cycles except two. However, rests occurring in the first period of cycles are always partial rests (except of course in A1). Across Versions, the most common type of partial rest is PR1, followed by PR2, PR4, and PR3; but the placement of the different types of partial rests does not appear to be systematic, except for the fact that they mainly correlate with the change of playback heads.

Electronic rests do occur in periods other than the first although the dispersion of such rests is extremely sparse. Every Version contains between 1 and 3 instances of rests occurring in a period other than the first, and except for in V6F4, all these rests occur in the final period of cycles (or in the case of V3B9 and B10, the final periods). From a total of 9 such rests, 3 are complete rests and 6 are partial rests.

Stockhausen's placement of all electronic rests (except one) either at the end or beginning of cycles points to the fact that electronic rests play an important role in defining form by setting off cycles from one another. This fact is significant because the musical content of cycles (and for that matter periods) does not necessarily accomplish this task; therefore, electronic rests are in many cases important markers of form. (We will investigate this topic further in the musical analysis section.) Thus, the complete electronic rest in V6F4 seems to be an anomaly, and Stockhausen may have included it within this cycle to create a subdivision of form.

To summarize, Stockhausen creates a form in which electronic playback predominates. After A1, four different types of partial rests in different combinations often divide cycles from one another, but within cycles, electronic playback is constant (except the anomaly V6F4). Other than A1, complete rests are scarce (only 3 such occurrences).

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[26] One might presume that Stockhausen placed electronic rests at the start of cycles to avoid a sense of discontinuity that might arise from the change of playback heads (which could result in the abrupt cutting off of one electronic superimposition and the immediate entry of a different superimposition). While Stockhausen, for the most part, precedes or follows the change of playback heads with electronic rest, he does not always do so. Thus, in these cases we cannot conclude that electronic rests function solely as a means of avoiding this type of discontinuity.

Electronic Canon Structure

Next, we will examine what I refer to as electronic canon structure. The use of the term ‘canon’ here (borrowed from Stockhausen’s score notes) refers to the electronic playback of an acoustic period[27] in the immediately subsequent period. Stockhausen’s feedback system permits an acoustic period to be played back in the immediately subsequent period only if the microphone input for a channel is open in the current period and if the loudspeaker input for the same channel is open in the subsequent period (a manifestation of tape delay). Thus, Stockhausen’s feedback system allows for canons but does not necessitate them. Accordingly, an acoustic period may be played back in another period other than the immediately subsequent period (playback of an acoustic period may be delayed for two or more periods), or it may not reappear at all. Figure 14 outlines canon structure across Versions, i.e. the presence or absence of electronic canons in all periods of all cycles.

Canon structure predominates in all Versions (the ratio of canons to the total number of periods, excluding A1, in Versions ranges from 37/50 to 44/50) and every cycle of every Version contains at least 3 canons (the ratio in cycles ranges from 3/7 to 11/11). However, the average ratio of canons to periods in cycles is fairly high; nearly all cycles contain a majority of canons, only a few do not (V4E, V6C, and V6D). As well, every Version contains at least 1 complete canon structure (a cycle in which all periods are canons); V2 contains 3 such cycles and V4 contains 2 such cycles.

The majority of canons are complete repetitions of an acoustic period, but a much smaller number of canons are partial repetitions. In addition, most partial canons occur in the first period of cycles, and the majority of first period canons are partial canons (18/23). Of course, the use of partial canons in first periods is linked to partial electronic rests, and this explains their use here. Only 7 partial canons occur in a period other than the first period (V1C6, V3A3, V3B9, V3C2, V4F7, V6A5, and V6B9).

Thus, Stockhausen clearly favours the use of canon structure in all Versions, which leads one to ask, why did Stockhausen rely so heavily on canons when he had at his disposal a feedback system surpassing the capability of a simple tape delay? The answer may be that he was attempting to maintain a sense of continuity and structure. An electronic canon functions here much the same way as a canon does in traditional contrapuntal music: binding new

[27] I will use the term ‘acoustic’ period to refer to the live sound of the instrumentalist and an ‘electronic’ period to the output of the tape delay and feedback system.

Fig. 14 Electronic Canon Structure

V1 $\frac{40}{50}$

A	(1)	2	3	4	5	6	7	8	9	10	11	8/10
		C	C	C	C		C		C	C	C	
B	1	2	3	4	5	6	7	8				CC
	C*	C	C	C	C	C	C	C				
C	1	2	3	4	5	6	7					5/7
		C		C	C	C*	C					
D	1	2	3	4	5	6						5/6
	C*	C	C	C	C							
E	1	2	3	4	5	6	7	8	9			6/9
		C	C		C	C	C		C			
F	1	2	3	4	5	6	7	8	9	10		8/10
		C	C	C		C	C	C	C	C		

V2 $\frac{44}{50}$

A	(1)	2	3	4	5	6	7	8	9			CC
		C	C	C	C	C	C	C	C			
B	1	2	3	4	5	6	7					CC
	C*	C	C	C	C	C	C					
C	1	2	3	4	5	6	7	8	9	10	11	CC
	C*	C	C	C	C	C	C	C	C	C	C	
D	1	2	3	4	5	6	7	8	9	10		9/10
	C*	C	C	C	C	C	C		C	C		
E	1	2	3	4	5	6						4/6
	C*	C	C			C						
F	1	2	3	4	5	6	7	8				4/8
	C*			C		C		C				

V3 $\frac{37}{50}$

A	(1)	2	3	4	5	6	7					4/6
		C	C*	C			C					
B	1	2	3	4	5	6	7	8	9	10		8/10
	C*	C	C	C	C	C		C	C*			
C	1	2	3	4	5	6	7	8				5/8
	C*	C*	C		C		C					
D	1	2	3	4	5	6	7	8	9			6/9
	C	C			C	C	C		C			
E	1	2	3	4	5	6	7	8	9	10	11	8/11
	C*	C	C	C			C		C	C	C	
F	1	2	3	4	5	6						CC
	C*	C	C	C	C	C						

V4 $\frac{39}{50}$

A	(1)	2	3	4	5	6						CC
		C	C	C	C	C						
B	1	2	3	4	5	6	7	8	9	10	11	10/11
	C	C	C	C		C	C	C	C	C	C	
C	1	2	3	4	5	6	7	8	9			7/9
	C*	C	C		C	C	C		C			
D	1	2	3	4	5	6	7	8				5/8
	C*	C	C		C			C				
E	1	2	3	4	5	6	7	8	9	10		4/10
		C			C			C				
F	1	2	3	4	5	6	7					CC
	C*	C	C	C	C	C	C*					

V5 $\frac{42}{50}$

A	(1)	2	3	4	5	6	7	8				6/8
		C	C	C	C	C	C					
B	1	2	3	4	5	6						CC
	C*	C	C	C	C	C						
C	1	2	3	4	5	6	7	8	9	10		7/10
		C	C	C	C	C			C	C		
D	1	2	3	4	5	6	7	8	9	10	11	10/11
		C	C	C	C	C	C	C	C	C	C	
E	1	2	3	4	5	6	7					6/7
	C*	C	C		C	C	C					
F	1	2	3	4	5	6	7	8	9			7/9
	C	C	C	C	C	C		C				

V6 $\frac{38}{50}$

A	(1)	2	3	4	5	6	7	8	9	10		CC
		C	C	C	C*	C	C	C	C	C		
B	1	2	3	4	5	6	7	8	9			7/9
		C	C	C	C	C		C	C*			
C	1	2	3	4	5	6						3/6
	C	C	C									
D	1	2	3	4	5	6	7					3/7
	C*	C	C									
E	1	2	3	4	5	6	7	8				6/8
	C	C	C	C	C			C				
F	1	2	3	4	5	6	7	8	9	10	11	9/11
	C*	C	C		C	C	C	C		C	C	

*Asterisk denotes a partial canon
C = A canon is present in the current period
CC = Complete canon (all periods are canons, excluding A1)

musical phrases with the old, while maintaining unity. Although the use of canons maintains unity when the number of periods is relatively low (2–4), in denser textures (4–11) canons would no longer have the same unifying effect. In such textures their unifying role would be nullified and instead an entirely different effect would be created. As well, in order to build accumulation structures, canons must be formed.[28] Thus, we will see that canons are mainly

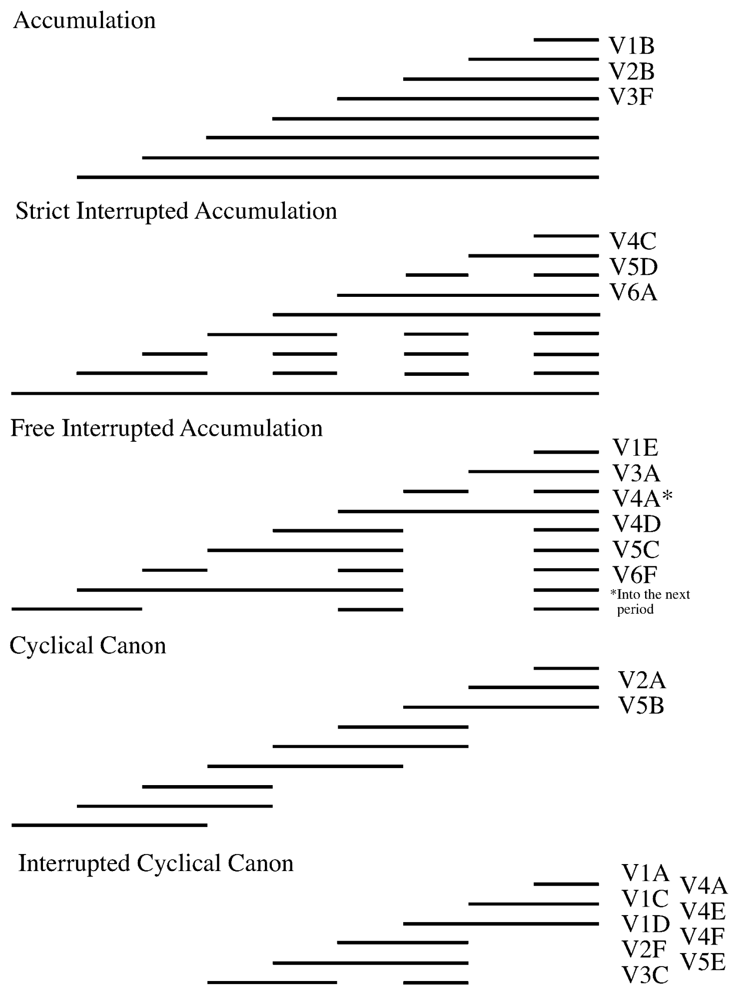
[28] I have limited my analysis of canon structure to occurrences of single period canons, but canons often repeat for more than one period.

used as part of larger structures. This leads us to the next section of the analysis, where we will examine more thoroughly the use and placement of electronic material.

Complete Cycle Superimposition Patterns

Referring to the Acoustic/Electronic Superimposition Graphs (Appendix II), it becomes immediately evident, visually, that certain logical and often symmetrical superimposition patterns exist within cycles. In order to describe and categorize these patterns, I have devised a

Fig. 15 Visual Characteristics of Complete Cycle Superimposition Patterns



terminology relating to how such structures might be perceived aurally. First, we will examine patterns that occur over the duration of an entire cycle (i.e. Complete Cycle Superimposition Patterns) and I will attempt to describe their hypothetical musical effect. Figure 15 illustrates the visual characteristics of each acoustic/electronic superimposition pattern. (For now, we will ignore the feedback from previous cycles which carries into the current cycle; we will, however, consider this feedback in the section on Partial Cycle Patterns.) In addition to these patterns, I will discuss what I refer to as a Complete Cycle Drone.

Accumulation Patterns

Accumulation utilizes the full capabilities of Stockhausen's feedback system: microphone levels are constantly open, feedback levels are constantly open, and loudspeakers levels are constantly up (though not necessarily in both channels). In total, 3 instances of Complete Cycle Accumulation occur across Versions (V1B, V2B, and V3F). The effect of such a structure is musically unique: in the case of V1B, it would be analogous to eight layers of ostinati. But full accumulation could prove overwhelming to a listener. The use of canons in the first few periods of a cycle may aid in creating a coherent, unified musical texture, but most likely from the fifth period on, any such effect would be nullified due to the fact that the human brain is not capable of processing so many musical layers. At a certain point, individual superimpositions might no longer be discernible; instead, the listener would only perceive a change in musical content as superimpositions would blend into a chaotic whole. This effect could be advantageous to a composer as a unique means of development; however, Stockhausen mostly avoids these potential problems by employing Accumulation in only a few instances and in cycles with a relatively lower number of periods (8, 7, and 6 respectively for V1B, V2B, and V3F). Thus, Stockhausen avoids the use of this structure in cycles with more periods, possibly to avoid the inherent musical pitfalls.

Stockhausen makes use of 2 variations of Accumulation. The first is Strict Interrupted Accumulation, which alternates full accumulation (i.e. accumulation of all previous periods) with sub-accumulation (i.e. accumulation of a subset of periods) on successive periods beginning in the fourth or fifth period. Additionally, sub-accumulation follows a consistent logical pattern, and the final period always reaches full accumulation. For example, in V5D, the first interruption occurs in the fourth period with the omission of D2, and subsequent interruptions occur in even-numbered periods with the omission of even-numbered electronic periods. In V6A, sub-accumulation follows an equally strict pattern, but less so in V4C. Three such patterns occur across Versions (V4C, V5D, and V6A).

The second variation, Free Interrupted Accumulation, is a less strict version of its counterpart in which interruptions do not necessarily alternate on successive periods and in which sub-accumulation does not necessarily follow a logical pattern. In total, 6 such patterns occur across Versions (V1E, V2E, V3A, V4D, V5C, and V6F). Despite the fact V4A has not been included in this classification, it does present an interesting case, as it reaches full accumulation in the first period of the following cycle.

The 2 Interrupted Accumulation Patterns offer the listener a respite from the possibly static structure of Accumulation by including variation, especially in the case of Free Interrupted Accumulation. Most likely as a result, Stockhausen includes more occurrences of the latter than the other two types of accumulation.

Cyclical Canons

The next pattern, the Cyclical Canon, I define as a continuous series of canons that cycle within a relatively sparse texture (maximum 3 layers). For example, in V2A, all periods are canons, and all periods, except P6, repeat twice, producing a texture that builds to 3 layers in the third period, diminishes to 2 layers in the eighth period, and returns to 3 layers in the final period. The only other example of a Cyclical Canon, V5B, strictly maintains a two-voice texture. The definition limits the number of layers to a maximum of 3 because a denser structure would produce an effect more in line with an Accumulation Pattern or a Chordal Block (which we will examine further on). Although Cyclical Canons must be complete canon structures, complete canon structures do not by definition always result in cyclical canons. Most other complete canon structures result in some type of accumulation pattern, with the exception of V4F, which forms the next pattern we will consider.

The Interrupted Cyclical Canon is a less strict version of the Cyclical Canon in which acoustic periods do not necessarily have to form canons, yet most periods still do. (V4A and V4F are the only examples exhibiting complete canon structures.) As well, repeated periods are sometimes interrupted for a single period and return in the next period. As with Cyclical Canons, the texture consists of between 2 to 3 layers, yet occasionally, and only for a single period, the texture may increase to 4 layers. For example, in V1A interruptions begin in the fifth period: electronic period 1 (hereinafter P1) returns after a rest in the fourth period, and electronic P3 does not repeat for a second time as the other superimpositions do. In the sixth period, electronic P1 returns again, and acoustic P5 does not form a canon. Periods 7–9 contain similar interruptions, and P10 consists of 4 layers as electronic P7 persists for an extra period after being interrupted in P8. In total, Stockhausen makes use of 9 Interrupted Cyclical

Canons (V1A, V1C, V1D, V2F, V3C, V4A, V4E, V4F, and V5E).

Cyclical Canons and variations thereof provide the listener with an anchor to guide their listening, somewhat analogous to the experience of traditional contrapuntal music. As well as providing an anchor, Interrupted Cyclical Canons engage the ear by varying the texture: the number of layers fluctuates and the composition of layers changes in much less a predictable pattern than in Cyclical Canons.

Drones

Finally, we will consider the Complete Cycle Drone, which I define as a period (or periods) that repeats (loops) for an entire cycle. Stockhausen employs 5 Complete Cycle Drones across Versions (V2E1, V3A1, V4D2, V6A1 and A2, and V6C2), V6A being the only example of a double Drone. The first or second period must form the drone, so the drone is able to establish itself as an entity within a cycle. As well, in order for the listener to perceive a drone, it must mainly occur within a relatively sparse texture (usually 2–3 layers but also less frequently 4). Drones may be occasionally ‘hidden’ within Chordal Blocks of 5 layers or more; however, exposed drones (i.e. drones that occur in a sparse texture) must outnumber hidden drones, and hidden drones can at the most only alternate between exposed drones, meaning hidden drones cannot occur consecutively. Finally, Drones occurring within Complete Cycle Accumulation will not be considered (Accumulation structures naturally consist of a series of Drones, though the Drones function much differently here, being subsumed within a larger process). Drones may, however, exist within Complete Cycle Interrupted Accumulation Patterns. For example, in V2E the first period functions as a drone, but in the fifth, seventh, and ninth periods it is hidden within chordal blocks (V2E extends into the next cycle for 3 periods). In addition, all Complete Cycle Drones extend into the next cycle for either a full period, partial period, or partial periods; for example, V3A1and V4D2 extend into the following cycle by a full period; V2E1, V6A1, and V6A2 as a partial period; and V6C2 as partial periods.

Complete Cycle Drones can, but do not necessarily have to, occur within any of the Complete Cycle Patterns. For example, the Complete Cycle Drone in V2E does not occur within Accumulation or a Cyclical Canon, but those in V3A, V4C, V4D, and V6A all occur within Interrupted Accumulation Patterns. As well, V6A is the only case of a double drone: P1 and P2 form a Complete Cycle Drone.

The musical effect of Drones depends largely on their content: repetition of a period containing a single tone results in a drone effect, but various types of melodic or rhythmic ostinati could also be formed.

Partial Cycle Patterns and Period Elements

All the aforementioned superimposition techniques occur within partial cycles as well. In what follows, we will examine these techniques along with several new devices which occur only within partial cycles: Interrupted Drones, Deaccumulation, Delayed Canons, and Chordal Blocks.

Partial Cycle Accumulation and Cyclical Canons

Partial Cycle Interrupted Accumulation and Cyclical Canons of all types must be at least 3 periods in length in order to be recognizable as patterns (Accumulation, on the other hand, must only be 2 periods in length), but otherwise these superimposition patterns follow the same guidelines as their complete cycle counterparts. However, we will ignore any type of Partial Cycle Accumulation which occurs within any type of Complete Cycle Accumulation or Cyclical Canon since accumulation is inherently subsumed within these processes. The only exception will be accumulation that extends into the following cycle, as it is important to mark this.

Partial Cycle Accumulation occurs frequently (14 instances) and, except for V5, in all cycles. Partial Cycle Strict Interrupted Accumulation occurs only twice (V5C1–6 and V6E1–5) and Partial Cycle Free Interrupted Accumulation occurs in 3 instances (V1F1–4, V2D1–7, and V5F1–6). Accumulation only extends into the following cycle in 1 case (V2D10–E1). As accumulation is the natural product of Stockhausen's feedback system, it is not surprising that it continues to function as an important superimposition technique in partial cycles as well.

Partial Cycle Drones and Interrupted Drones

Partial Cycle Drones differ from their complete cycle counterpart in that they must span at least 4 periods, the Drone must be exposed for at least 2 of these periods, and they do not occur within Partial Accumulation Patterns of 4 periods or more. An example of a Partial Cycle Drone occurs in V1E: acoustic P2 forms the drone and continues until the sixth period. Five Partial Cycle Drones occur across 3 Versions (V1C1, V1E2, V1E6, V3C2, and V5C3), and in

V1E two Drones overlap. Unlike Complete Cycle Drones, only 1 Partial Cycle Drone extends into the next cycle, but here it no longer continues to function as a Drone, instead its use is more structural, as it forms part of a ten-layer Chordal Block.

Interrupted Partial Cycle Drones follow the same guidelines as Partial Cycle Drones except that the Drone may be interrupted by a single or partial period of rest one or more times (V1A1, V1D4, V1F1, V1F3, V2D1, V2E6, V3E1, V4B2, V5F2, V5F4 V6C1, V6D1, V6D2, V6E1, and V6E2). Interrupted Partial Cycle Drones occur more frequently than Partial Cycle Drones (15 occurrences of the former compared to 5 of the latter), and they occur in all Versions. I have excluded V4B6 as a Partial Cycle Interrupted Drone because, even though it does meet the above criteria, the drone never has a chance to establish itself as aurally recognizable because it is immediately buried within a four-layer texture in B7–8 and upon its return in B10 it is again buried in a Chordal Block of 5 layers (V2D2, V5C2, and V5F1 present similar circumstances). Additionally, in V1F, V5F, V6D and V6E two Interrupted Partial Cycle Drones overlap. Finally, the majority of Interrupted Partial Cycle Drones extend into the next cycle: V6D1 and V6D2 as full periods; and V1D4, V2D1, V2E6, V3E1, V6C1, V6E1, and V6E2 as partial periods (V2E6 extends 3 periods into the next cycle). However, most of this extension is structural as the overlap moves onto Chordal Blocks of 5 layers or more (except V1D4 at 2 layers). All Interrupted Partial Cycle Drones that extend into the next cycle, with the exception of V1D4 and V2E6 (and with the addition of V5F2) occur over the length of an entire cycle, although the process is interrupted. Stockhausen consistently uses the different Drone types across all Versions and they play an important unifying structural role within cycles.

Chordal Blocks

Chordal Blocks span a full or partial period and involve the sudden addition of 2 or more electronic layers to a period. Accordingly, Chordal Blocks contain a minimum of 3 layers including the acoustic period, but more often they contain a greater number of layers (up to 12, e.g. V3F1). As well as the sudden addition of layers, a sudden subtraction of layers most often, though not necessarily, follows Chordal Blocks. For example, following the Partial Period Chordal Block in V1B1, there is a layer reduction of 6/1. However, Chordal Blocks may also be followed by a decrease of just a single layer, an increase of a single layer (at most), or a voice exchange (which involves the simultaneous addition of a new acoustic period with the subtraction of an electronic period). Stockhausen makes frequent use of Chordal Blocks (more than any other superimposition technique), and they often appear more than once within a single cycle. For example, V6A contains 4 Chordal Blocks and every cycle except for V1A, V1E, V2B, V4E, and V5A contains at least 1 Chordal Block.

Chordal Blocks fall into 2 categories: Structural Chordal Blocks and Cadential Chordal Blocks. The first category includes Chordal Blocks which are subsumed within the process of Interrupted Accumulation Patterns and Interrupted Cyclical Canons (although there are only 3 examples of the latter, V1C4, V4A4, and V5E5). Across Versions, Stockhausen employs 23 such Chordal Blocks (e.g. V5D5, D7, D9, and D11). These Chordal Blocks create variety within the texture, but at the same time tend to blend in with the textural development taking place and do not, in themselves, play an important formal role; however, the second category of Chordal Blocks do, as they serve mainly to mark divisions between cycles. This fact is important because, as mentioned previously, an inherent formal musical division between cycles does not necessarily exist.

The vast majority of Cadential Chordal Blocks occur in either the first period or the final period of cycles and act as markers of form by emphasizing the formal division between cycles, mainly by virtue of a sudden change in texture. With Cadential Chordal Blocks, Stockhausen achieves a division between cycles through the use of several different methods. For example, in V5B1 there is an abrupt change to 6 layers from 1 layer in A8 and then an abrupt return back to 1 layer in B1 (Partial Period Cadential Chordal Block). Abrupt changes from a relatively large number of layers to an acoustic layer are a characteristic of Cadential Chordal Blocks and occur frequently. Stockhausen at times precedes a Cadential Chordal Block by a sudden reduction in layers, usually at the end of some type of accumulation process; for example, the Cadential Chordal Block in V1C1 is preceded by a layer reduction of 8/1, the last period of V1B being the apex of an Accumulation Pattern. This example represents one method of framing a structural division between cycles. In V5E1 another method is used: the Chordal Block is preceded by another Chordal Block in V5D. In fact, Stockhausen will sometimes employ a series of Partial Period Chordal Blocks, such as in V2C11–D1 (where he uses 7 Partial Period Chordal Blocks in a series) and V6D1. The appearance of Chordal Blocks in partial periods is exclusive to initial and final periods (with one exception, V1F2–3), so we can add that standalone partial periods (i.e. periods separated from the previous or following whole period with a rest) serve to mark formal divisions as well. (Connected partial periods are used but are imperceptible.)

Stockhausen uses Cadential Chordal Blocks in the first period of every cycle except for V1E, V2E, V4E, and V5D. However, V2E, V4E, and V5D are all preceded by Cadential Chordal Blocks in the final periods of their respective cycles. As well, in these cases the final period Chordal Blocks are extended into the first period of their respective cycles for a partial period, followed by a sudden, large layer reduction (6/1, 8/2, and 10/1 respectively). Thus, even though these cycles do not contain first period Cadential Chordal Blocks, they are still separated by Chordal Blocks (V4E and V5D by Cadential Chordal Blocks, and V2E by a Structural Chordal Block, although here it has a dual function and could also be considered a Cadential Chordal Block). Although V1E is the only exception, it mimics the partial stand alone period technique, and even though this effect is on its own not as strong as Cadential Chordal Blocks, it still provides a level of formal division.

But not all Cadential Chordal Blocks occur in the first or last period of cycles, and as such create interesting perceptions of form. One such case occurs in V3B9, which ends with a partial period Cadential Chordal Block and is followed by a layer reduction of 3/1. Although B10 is the final period of V3B, the listener could easily perceive this as the beginning of a new cycle. In V1C1, there is another Cadential Chordal Block (1/10/1) with a much stronger character, which may signal the actual start of new material. Thus, the Cadential Chordal Block in V1B10 serves as a ‘deceptive’ cadence (weaker in layer reduction), followed by a stronger ‘authentic’ cadence in C1. Similar deceptive cadences occur in V1F7 and V4B10. The only other occurrence of a mid-period Cadential Chordal Block is V3E7, and this occurrence is something of an exceptional case as it manifests a relatively large layer addition and reduction (2/7/2). As well, it occurs towards the middle of the cycle, contrary to the other examples which appear near the end. This Cadential Chordal Block could function to create a division within the cycle, but V3E maintains a sense of unity due to the E5–F1 Drone which binds the cycle together until an even stronger Cadential Chordal Block in F1 (5/12/1), the sole instance of the use of 12 layers in any Version.

In summary, Stockhausen’s use of Chordal Blocks, and especially Cadential Chordal Blocks, plays an important role in defining form, and Chordal Blocks are probably the most readily recognizable superimposition technique, as well as the most frequently used.

Deaccumulation

Deaccumulation involves a reduction of layers over a partial period (in only 2 instances), a single period, or a number of periods; however, I will not classify a reduction of layers following a Chordal Block as Deaccumulation. (As mentioned previously, a Chordal Block, in itself, often entails both the sudden addition and subsequent subtraction of layers.) As well, Deaccumulation mainly involves the reduction of a single layer per period and at most 2 layers per period. From a total of 26 occurrences of Deaccumulation, only 4 involve the reduction of 2 layers (V2A7–8: 6/5/4/2; V3B6–8: 6/4/2; V4B4–5: 4/2; and V4B8–9: 4/2). Due to the nature of Stockhausen's feedback system, a reduction of layers can only occur after an accumulation of layers; therefore, Deaccumulation occurs mid-cycle or later. Stockhausen reaches but never surpasses 4 consecutive periods of Deaccumulation; however, the average span is 2 periods. Deaccumulation occurs only 5 times over a span greater than 2 periods. An example of Deaccumulation occurs in V1F4–6, which decreases by one layer in each period over a span of 3 periods (4/3/2).

To a certain extent, Deaccumulation serves to balance the aural effect of Accumulation; but Stockhausen's feedback system is limited in that the maximum possible span of Deaccumulation is 5 periods (although Stockhausen does not exploit this possibility). As well, Stockhausen achieves accumulation through a natural process (which simply involves leaving the microphone, feedback, and output levels open). The manifestation of Deaccumulation, on the other hand, is much less straightforward and involves specific manipulation of the feedback system, which is the main reason accumulation processes dominate throughout *Solo*.

This is especially true regarding the 3 instances of Deaccumulation which span 4 periods (V2C6–9, V5A5–8, and V6B5–8). (The clearest manner in which to see this process at work is to refer to the Electronic Superimposition Graphs in Appendix I.) For example, in order to achieve a layer reduction of 5/4/3/2 in V6B5–8, the feedback system accumulates 2 different electronic periods in each of Channels I and II (2/4 and 1/3 respectively), which combine with the acoustic material in P5 and add up to 5 layers. In the next period, the third assistant closes the output for Channel I, and another layer is added to Channel II (1/3/5), which combines with the new acoustic period to create 4 layers. In the same period, the second assistant closes the feedback input for Channel II, clearing all material so that feedback output will be empty for the next 2 periods. The third assistant then closes the output for

Channel II in P7 and reopens the output for Channel I (2/4); however, no new layers have been added so the texture now totals 3 layers with the addition of the new acoustic period. In P8, Channel I is closed and Channel II is reopened; feedback output on Channel II is now empty but a new period has been added through the microphone input (during P7), resulting in a total of 2 layers including the acoustic period. (Stockhausen could have continued Deaccumulation into the next period by closing both output channels, leaving only the acoustic period; using this method, 5 periods of Deaccumulation would have been possible.)

Therefore, Deaccumulation spanning 4 periods relies on manipulation of both output channels (among other factors) to effectuate a gradual reduction of layers. The same holds true for Deaccumulation spanning 2 or 3 periods. In fact, Stockhausen utilizes 5 methods of channel manipulation: an alternation between channels (spanning 2 or 3 periods); moving from a single channel to closing both channels (spanning 2 periods, only occurrence being V6F3–4); moving from 2 channels to a single channel (spanning 2 periods); moving from 2 channels to an alternation of channels (spanning 3 or 4 periods); or an alternation of channels followed by closing both channels (spanning four channels, only occurrence being V5A5–8). Thus, diffusion in *Solo* is often more a matter of achieving certain superimposition techniques rather than diffusion for its own sake (or possibly vice versa), but we will consider this subject in greater detail further on.

Although Stockhausen's superimposition techniques are quite simple to achieve with modern computers and software, the degree to which he was capable of pushing the limitations of his feedback system are quite astounding. Two interesting examples are V5A and V6B, which both display a mirror image Accumulation and Deaccumulation process, expressed in number of layers per period: 1/2/3/4/4/3/2/1 and 1/2/3/4/5/4/3/2/1 respectively (disregarding Partial Period Chordal Blocks in the latter).

Delayed Canons

The majority of periods form canons, but those that don't, fall into several categories: periods that never repeat (e.g. V1D5); periods that eventually repeat but within some type of Accumulation Pattern (e.g. V1E3) so that their reintroduction is not aurally perceivable and their use is mostly structural (in the sense that they are used to build a dense layer structure); and finally, the reintroduction of a period with a delay of a single period into a texture where this period is recognizable. I will refer to the latter instance as delayed canons, of which there are

5 examples (V1A5, V1A7, V4E2, V4E5, and V5E8) and only within 2 different Versions and 2 different cycles. Although Delayed Canons appear infrequently, their use is interesting: they function to create a similar unifying effect to canons and contribute to an overall sense of 'memory' form.

Non-recurring Techniques

In addition to the recurring complete cycle and partial cycle patterns and techniques I have outlined, Stockhausen makes use of a variety of superimposition patterns which do not recur but still exhibit logic and/or symmetry in their design. For example, in V6D Stockhausen employs 2 interrupted drones (D1 and D2) that alternate beginning in the third period and continue to the end of the cycle. At the same time, P3–7 do not form canons (the only incidence of 4 consecutive periods not forming canons), but the use of the alternating double Drone maintains a sense of unity and structure throughout the cycle.

As well, much more complex and irregular patterns exist; an examination of the Superimposition Graphs will reveal other non-recurring patterns; however, these patterns are beyond the scope of the present analysis.

Static Layer Density

Next, we will turn to a discussion of layer density: the number of acoustic and electronic layers present in each period. (Layer density appears at the bottom of each period in the Acoustic/Electronic Superimposition Graphs.) In general, layer density is dynamic, for the most part continually decreasing or increasing mainly by a factor of one. Again, the exception is Chordal Blocks, which involve abrupt changes in layer density occurring mainly at the beginning and end of cycles or during interrupted accumulation. Another exception is what I will refer to as static layer density, which occurs when the number of layers remains unchanged from one period to the next.

Figure 16 demonstrates that instances of 2 periods of static density are fairly common and occur within all Versions, but 3 periods of static density are much less common, occurring only 3 times within 3 different Versions. In these cases, the number of layers per period is usually 2 or 3, only occasionally reaching 4 and in one case 5. But these instances of static density are generally too short to be perceived as a deviation from the norm and thus are not of great significance.

Fig. 16 Static Layer Density

Two Periods of Static Layer Density

V1C2–3 (2)	V3A5–6 (2)	V5A4–5 (2)
V1C5–6 (2)	V3C7–8 (2)	V5C7–8 (2)
V1D3–4 (3)	V3D2–3 (5)	V5D3–4 (2)
V1E7–8 (2)	V3E3–4 (3)	V5F2–3 (2)
	V3E5–6 (2)	V5F4–5 (2)
V2A3–4 (3)		
V2A6–7 (3)	V4A2–3 (2)	V6E3–4 (3)
V2E4–5 (2)	V4B7–8 (4)	V6E6–7 (3)
V2F2–3 (4)	V4D6–7 (2)	V6F2–3 (2)
		V6F8–9 (3)

Three Periods of Static Layer Density

V2D3–5 (3)
V3D4–6 (2)
V4D2–4 (2)

Five or more Periods of Static Layer Density

V1A3–9 (3) 7 periods	V4E1–10 (2) 10 periods
V1D5–E4 (2) 6 periods*	V5B2–6 (2) 5 periods
V2F4–8 (2) 5 periods	V6D2–7 (2) 6 periods

(2) Number in parentheses indicates layer density
*D6 and E1 contain partial periods

Much more pertinent are the 6 instances of static density exceeding 4 periods, which Stockhausen makes use of in all Versions except V3. For example, in V1A3–9 layer density remains static at 3 for a total of 7 periods. In all the other examples of static layer density exceeding 4 periods, there are a total of 2 layers and the length of each ranges from 5–10 periods. I have listed V1D5–E4 as an example of static layer density although in D6–E1 density does change briefly due to the use of an Interrupted Drone. All examples of static density exceeding 4 periods occur as part of Interrupted Cyclical Canons except for V6D2–7. As well, V1D5–E4 occurs across 2 cycles (an Interrupted Cyclical Canon and Free Interrupted Accumulation). Although dynamic layer density predominates, static layer density, and most especially instances exceeding 4 periods, acts as an important method of textural variation.

Summary of Superimposition Patterns and Techniques

I have presented and endeavoured to categorize a list of superimposition patterns and techniques which recur across cycles, and as we have seen, certain patterns do recur and certain techniques are common among Versions. Thus, the use of the electronic superimposition structures across cycles employs recognizable techniques and patterns. In addition, superimposition patterns predominately exist within a single cycle, only occasionally extending into the following cycle, but in no instances do patterns exist over the span of 2 or more cycles. As a result, superimposition patterns mark the boundaries of cycles, along with Cadential Chordal Blocks and electronic rests, and establish cycles as independent formal entities.

Fig. 17.1 Topology of Superimposition Techniques

V1

A — Interrupted Cyclical Canon (A1–6 Interrupted Drone; A5 Delayed Canon; A7 Delayed Canon; A10–11 Deaccumulation)

B — Accumulation (B1 Chordal Block)

C — Interrupted Cyclical Canon (C1 Chordal Block; C1–4 Drone; C4 Chordal Block)

D — Interrupted Cyclical Canon (D1 Chordal Block; D4–E1 Interrupted Drone; D4–5 Deaccumulation)

E — Free Interrupted Accumulation (E1 Continuation of D4 Interrupted Drone; E2–6 Drone; E6 Chordal Block; E6–9 Drone; E9 Chordal Block)

F — (F1 Chordal Block; F1–4 Free Interrupted Accumulation; F1–7 Interrupted Drone; F3–7 Interrupted Drone; F4 Chordal Block; F4–6 Deaccumulation; F5–9 Cyclical Canon; F7 Chordal Block; F8–10 Accumulation)

V2

A — Cyclical Canon (A4–5/A7–8 Deaccumulation)

B — Accumulation (B1 Chordal Block)

C — (C1 Chordal Block; C1–6 Accumulation; C6–9 Deaccumulaton; C9–11 Accumulation; C11 Chordal Blocks)

D — (D1 Chordal Blocks; D1–4 Cyclical Canon; D1–7 Free Interrupted Accumulation; D1–E1 Interrupted Drone; D7 Chordal Block; D8–9 Deaccumulation; D10 Chordal Block; D10–E1 Accumulation)

E — Free Interrupted Accumulation and Drone E1–F3 (E1 Continuation of D1 Interrupted Drone and D10 Accumulation; E1–3 Cyclical Canon; E3–4 Deaccumulation; E6 Chordal Block; E6–F3 Interrupted Drone)

F — Interrupted Cyclical Canon (F1 Chordal Blocks; F1–3 Continuation of E1 Drone and E6 Interrupted Drone)

V3

A — Free Interrupted Accumulation and Drone A1–B1 (A4/A7 Chordal Blocks)

B — (B1 Continuation of A1 Free Interrupted Accumulation and Drone; B1 Chordal Block; B1–6 Accumulation; B6–8 Deaccummulation; B8–9 Accumulation; B9 Chordal Block; B10 Acoustic Solo)

C — Interrupted Cyclical Canon (C1 Chordal Block; C2–6 Drone; C3–4/C6 Deaccumulation)

D — (D1 Chordal Block; D1–2 Accumulation; D4–9 Interrupted Cyclical Canon; D7 Deaccumulation; D9 Chordal Block)

E — (E1 Interrupted Continuation of E9 Chordal Block; E1–2 Accumulation; E1–F1 Interrupted Drone; E3–4 Canon; E4–5 Deaccumulation; E7 Chordal Block; E8–11 Accumulation)

F — Accumulation (F1 Continuation of E1 Interrupted Drone; F1 Chordal Block)

V4

A — Interrupted Cyclical Canon (A4 Chordal Block)

B — (B1 Chordal Block; B2–4 Accumulation; B2–10 Interrupted Drone; B4–5 Deaccumulation; B5–11 Cyclical Canon; B8–9 Deaccumulation; B10 Chordal Block)

C — Strict Interrupted Accumulation (C1 Chordal Block; C3–4 Deaccumulation; C5/C7/C9 Chordal Blocks)

D — Free Interrupted Accumulation and Drone D2–E1 (D1/D5/D8 Chordal Blocks)

E — Interrupted Cyclical Canon (E1 Continuation of D1 Interrupted Accumulation Pattern; E2/E5/E8 Delayed Canons)

F — Interrupted Cyclical Canon (F1 Continuation of E1 Interrupted Cyclical Canon; F1 Chordal Block; F4–6 Deaccumulation)

V5

- A (A1–4 Accumulation; A5–8 Deaccumulation; A8 Acoustic Solo)
- B Cyclical Canon (B1 Chordal Block)
- C Free Interrupted Accumulation (C1 Chordal Block; C3–4 Deaccumulation; C3–D1 Drone; C5/C10 Chordal Blocks)
- D Strict Interrupted Accumulation (D1 Continuation of C10 Chordal Block and C3 Drone; D5/D7/D9/D11 Chordal Blocks)
- E Interrupted Cyclical Canon (E3–4 and E5–7 Deaccumulation; E5 Chordal Block)
- F (F1 Chordal Block; F1–6 Free Interrupted Accumulation; F2–F9 Interrupted Drone; F4–9 Interrupted Drone; F6 Chordal Block; F7–8 Deaccumulation; F9 Chordal Block)

V6

- A Strict Interrupted Accumulation and Drones A1–B1 and A2–B1 (A5/A6/A8/A10 Chordal Blocks)
- B (B1 Continuation of A1/A2 Drone; B1 Chordal Block; B1–5 Accumulation; B5–8 Deaccumulation; B9 Chordal Blocks)
- C Drone C2–D1 (C1 Continuation of B9 Chordal Blocks; C1–D1 Interrupted Drone; C2–3/C4–5 Accumulation; C3–4/C5–6 Deaccumulation)
- D (D1 Continuation of C2 Drone and C1 Interrupted Drone; Chordal Blocks; D1–E1 Interrupted Drone; D2–E1 Interrupted Drone; D1–3 Cyclical Canon; D3–7 Random Voice Exchange with no Canons)
- E (E1 Continuation of C1/C2 Interrupted Drones; E1 Chordal Block; E1–5 Strict Interrupted Accumulation; E1–F1 Interrupted Drone; E2–F1 Interrupted Drone; E7–8 Accumulation)
- F Free Interrupted Accumulation (F1 Continuation of E1/E2 Interrupted Drones; F1 Chordal Block; F3–4 Deaccumulation; F4 Acoustic Solo; F6/F10 Chordal Blocks)

Fig. 17.2 Condensed Topology of Superimposition Techniques

	A	B	C	D	E	F
V1	Canon	Accumulation	Canon	Canon	Accumulation	Mixed
V2	Canon	Accumulation	Mixed	Mixed	Accumulation	Canon
V3	Accumulation	Mixed	Canon	Mixed	Mixed	Accumulation
V4	Canon	Mixed	Accumulation	Accumulation	Canon	Canon
V5	Mixed	Canon	Accumulation	Accumulation	Canon	Mixed
V6	Accumulation	Mixed	Mixed	Mixed	Mixed	Accumulation

Topology of Superimposition Patterns

Having categorized the various superimposition techniques at Stockhausen’s disposal, we will now turn to an analysis of their use. Figure 17.1 presents a topology of superimposition techniques across Versions. In Figure 17.2, I have condensed the various subcategories of superimposition techniques down to their basic elemental patterns (Canon and Accumulation) and have labelled cycles not displaying a single uniform pattern as Mixed.

Stockhausen distributes the 3 condensed patterns types fairly evenly across cycles. As well, all Versions, except V6 (which omits a Canon), contain at least 1 cycle of all 3 condensed pattern types. Furthermore, from V1 to V5 Stockhausen mainly intersperses pattern types, for the most part avoiding consecutive fixed patterns, but with 4 exceptions: in V1 between cycles C and D (Interrupted Cyclical Canons), in V4 between C and D as well (Strict Interrupted Accumulation and Free Interrupted Accumulation respectively), again in V4 between E and F (Interrupted Cyclical Canons), and in V5 between C and D (Free Interrupted Accumulation and Strict Interrupted Accumulation). The alternation of fixed pattern types creates formal variety. (Consecutive Mixed patterns, of course, do not oppose this principle.) Only V6 does not follow an alternating pattern as it begins and ends with Accumulation and the inner cycles are all Mixed; however, it still follows the same principle of formal variety.

A Systematic Allocation of Superimpositions: Layer Density Patterns

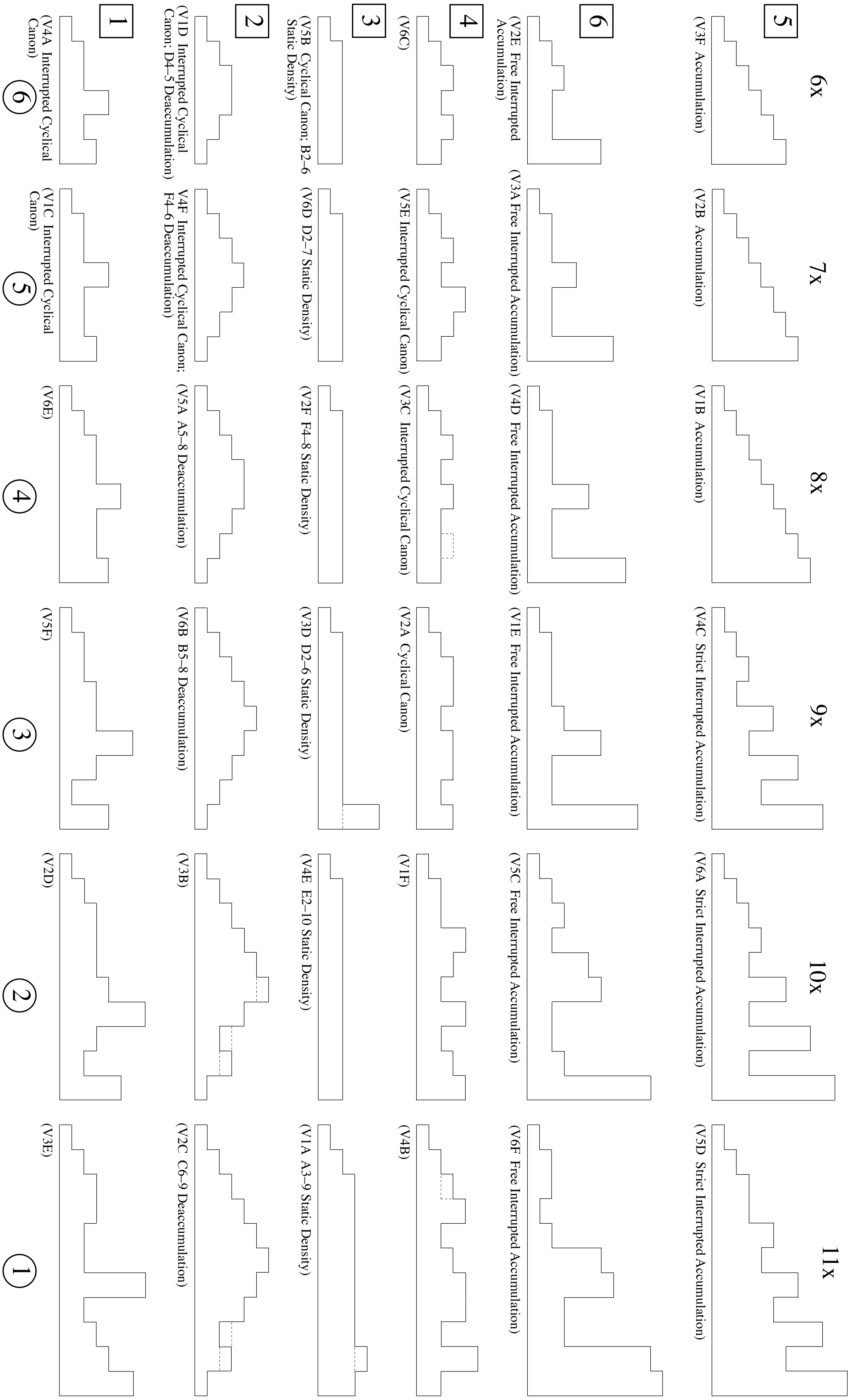
Although our analysis of complete cycle Superimposition patterns and techniques does not point to an entirely systematic organization, Stockhausen did conceive a precise system to determine and allocate superimpositions. In a sketch of electronic form,[29] Stockhausen organizes superimpositions into 6 groups, apparently on the basis of layer density patterns, and disperses these patterns across the 6 Versions of *Solo* using a system similar to the one for the allocation of period durations.

In Figure 18, I have transcribed the schematic of layer density patterns from Stockhausen's sketch. Stockhausen omits feedback from previous cycles (as we did in the analysis of superimposition patterns), but he also omits partial periods. In addition, Stockhausen's sketch is not an exact representation of the Feedback Schemes (deviations are marked with dotted lines).

I will begin with an analysis of the layer density patterns from Stockhausen's original sketch (ignoring deviations for now). Stockhausen groups the layer density patterns into 6 categories (represented by the numbers in boxes) each displaying similar characteristics. Group 5 consists of accumulation structures: the first 3 patterns display full accumulation and the remaining 3 display interrupted accumulation; all patterns end with full accumulation. Group 6 patterns also display accumulation structures ending with full accumulation, but the density of overall accumulation is lower than in group 5 and is not systematic. Group 4 pat-

[29] Stockhausen, *Texte zur Musik*, 88–89.

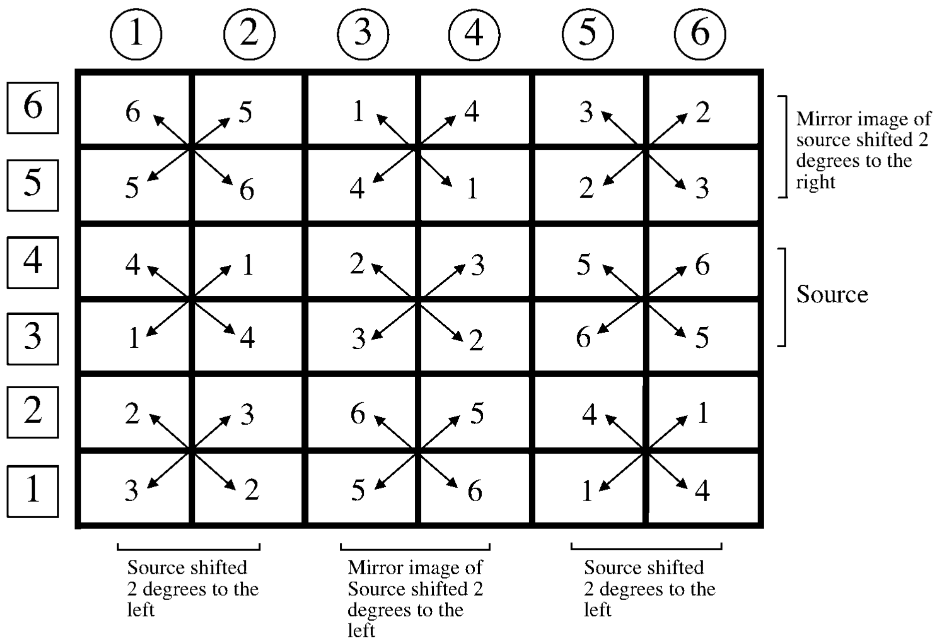
Fig. 18 Stockhausen's Sketch of Layer Density Patterns



terns reach accumulation of approximately half the total layers; the first 2 patterns involve 2 nearly equal points of accumulation and the remaining patterns involve 3 equal (or nearly equal) points of accumulation. Group 3 patterns accumulate to a point of static density of 2 layers in the case of the first 5 patterns and of 3 layers in the final case. Group 2 patterns all involve a symmetrical accumulation and deaccumulation structure. Finally, group 1 patterns involve an accumulation to a peak point in the middle of the cycle followed by deaccumulation and then accumulation to another lesser point.

The dispersion of layer density patterns across Versions follows a process which incorporates symmetry, logic, and a number of arbitrary decisions on the part of Stockhausen; I have illustrated this process in Figure 19. Thus, Stockhausen did have in mind a systematic method of deriving and allocating superimpositions; however, deviations and the later addition of partial periods somewhat obscure the original conception of superimpositions.

Fig. 19 Allocation of Layer Density Patterns Across Versions



Next, we will examine the extent to which deviations and the existence of partial periods (cf. Appendix II) alter the original layer density schematic presented in Stockhausen's sketch. In most cases, deviations in layer density result in minor variations and do not alter the categorization of patterns. The only exception might be V3D; with the addition of 3 layers in the final period, V3D becomes an anomaly, as it no longer fits into the categorization of group 5 or any other group. The addition of partial periods do not significantly alter layer density patterns, with the exception of most of the group 2 patterns. In fact, only V5A retains its original accumulation/deaccumulation structure; in all other cases the addition of partial periods at, or near, the end of cycles completely obscures the structure of these patterns. This is especially the case with V3B and V2C because they are altered by both deviations and partial periods. Therefore, group 2 patterns exist only at a pre-compositional level, but the remaining patterns retain their defining characteristics.

A comparison of Stockhausen's schematic of layer density patterns with our analysis of superimposition patterns and techniques reveals a number of correlations. Group 5 and 6 layer density patterns correlate precisely with the Accumulation Patterns. Group 3 patterns correlate to occurrences of static density, and group 2 patterns, for the most part, correlate to occurrences of Deaccumulation. However, Canon structures, which are spread across groups 1 to 4, do not correlate with any specific group.

Stockhausen's schematic of layer density patterns explains the usage and allocation of different superimposition patterns across Versions, but it does not provide a meaningful understanding of the functionality of all the patterns and techniques in use. And while our analysis of superimposition patterns and techniques elucidates this important functional aspect, it does not offer a systematic method of allocation. Thus, Stockhausen's sketch of layer density patterns and our analysis complement each other, creating a vital bridge towards the comprehension of electronic form in *Solo*.

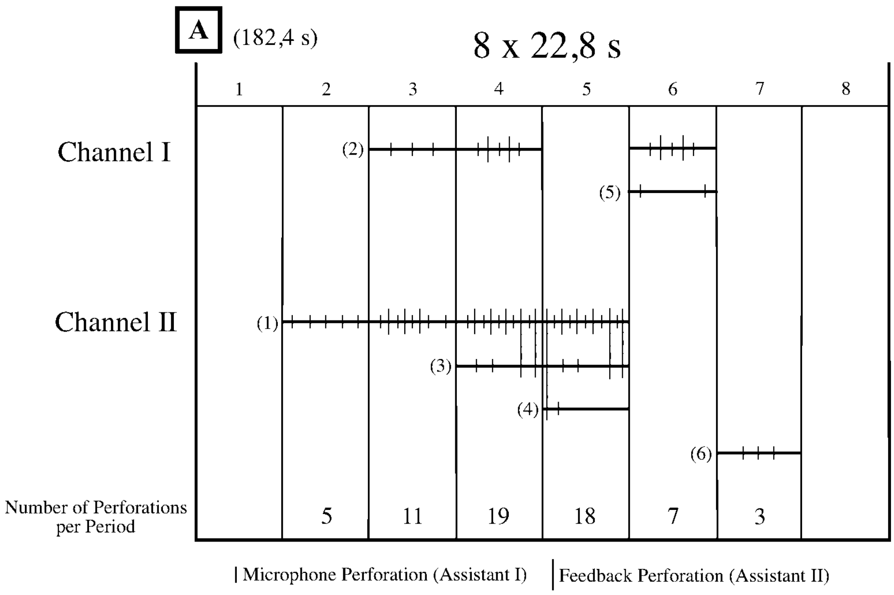
Factors Influencing the Superimposition Structure Paradigm

Having completed our analysis of superimposition patterns and techniques, it is important to recall that the material in the Superimposition Graphs is not an exact representation of actual electronic output. Perforations, acoustic pauses, and acoustic entry types alter, to a varying degree, the output of electronic material. In what follows, we will examine the extent to which these factors influence the superimposition structure paradigm.

Perforations

Stockhausen defines 'perforations' as short interruptions that serve to add variation to played back periods. Assistant I (microphone) and Assistant II (feedback) attain these interruptions by briefly closing and reopening their respective potentiometers; this process is carried out ad lib. and Stockhausen provides no specific instructions regarding the exact duration of perforations other than remarking that single tones may be omitted from melodic sequences and held tones may be ‘punctured’. Perforations are permanent and cumulative: once a perforation has been applied to a period it will remain in all subsequent electronic repetitions, and perforations implemented by Assistant II affect all periods currently being played back via the feedback circuit. Figure 20 illustrates this process for V5A. (I have distributed the perforations randomly in this hypothetical example.)

Fig. 20 V5A Diagram of (Hypothetical) Perforations



Every Cycle of every Version contains perforations although the number of perforations varies greatly between cycles. The number of perforations per instruction is between 0–13, but the vast majority fall into the range of between 0–3, occasionally 4, and rarely 6–13. In general, cycles with shorter period durations have less perforations per instruction (ergo per cycle as well); for example, in cycles with period durations of 6 seconds, the number of perforations per instruction is in the vast majority between 0–2 and occasionally, but never more than 3. Clearly, performability dictates the number of perforations per period in the latter case since more than 3 perforations during a six-second period would not be feasible. Although cycles with longer period durations do sometimes have more perforations per instruction, this is not necessarily the case. For example, V5B (6 x 45.6s) contains a relatively high number of perforations per instruction approximately half the time (13/8/5/3/0/2/0/0) whereas V3F (6 x 45.6s) exhibits the opposite extreme (2/2/0/1/0/1/0/0/3/0/0/1/0/3/0/0/3/2).

Furthermore, the effect of perforations is often cumulative; thus, in certain cases, periods towards the end of cycles, and especially cycles with a greater number of periods, will be altered the most, meaning that perforations could have a reverse effect on Accumulation. For example, in V6F (11 period Free Interrupted Accumulation), the parallel accumulation of a relatively large number of perforations may significantly attenuate the actual density of P10–11 (full accumulation).

Since the implications of perforations are visible in the Feedback Schemes, I will not pursue a more detailed analysis here. Suffice it to say that perforations do, to a varying extent, alter the paradigm presented in the Superimposition Graphs, but not drastically so. We will consider perforations again during our hypothetical analyses and discover that, in fact, they can produce different effects, especially in the case of full accumulation.

Acoustic Pauses and Entry Types

In the preparation of the performance score, Stockhausen prescribes the use of pauses between parts and elements. Pauses fall into three categories based on duration: relatively long, relatively medium, and relatively short. Stockhausen further stipulates that in longer periods pauses may last up to 50 percent the duration of the period and in shorter periods up to 90 percent: an example of a long rest in a period with a duration of 34.4s would be a pause of between 15–20 seconds. In every Version, one cycle has no pauses (the cycle in which only systems are interpreted), but all other cycles contain 1 of the 3 types of pauses or a combination of 2 thereof. In such cases, the use of pauses is mandatory between all entries (with 1 or 2 possible exceptions permitted per Version, which we will discuss further on). Thus, rests make up a significant portion of the acoustic material of every Version.

Although prescribed durations of acoustic pauses are the main factor in determining the placement of rests, acoustic entry types (*Polyphon*, *Akkorde*, and *Blöcke*) also play an important role. For example, in cycles in which the performer has a choice between using 2 different lengths of pauses, the acoustic entry type will govern to a large extent the placement and duration of pauses, as the performer attempts to adhere to Stockhausen's intended textures. Thus, acoustic entry types play an important role in shaping the electronic texture on a micro-level, as opposed to the electronic Superimposition Patterns which shape form on a macro-level. Further on in the analysis, we will consider this micro-formal aspect in more detail, as an understanding of its functionality leads to a broader understanding of form within *Solo*.

Summary of Factors Influencing the Superimposition Structure Paradigm

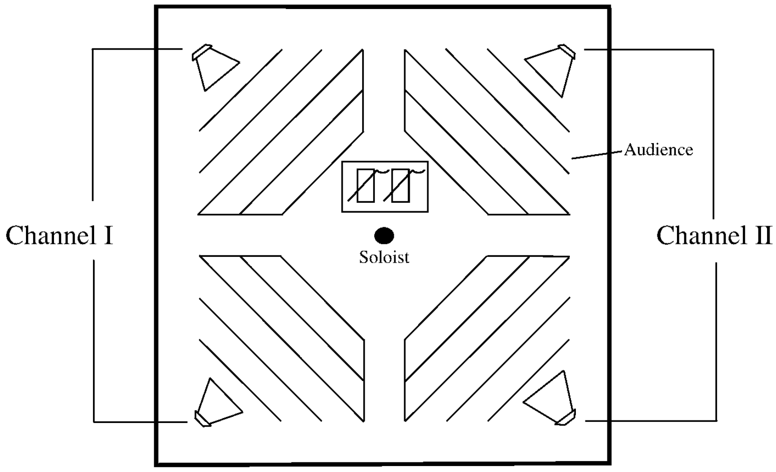
Due to the fact that such a great deal of electronic material will consist of recorded rests, consideration of acoustic pauses is paramount to a clearer conceptualization of electronic form in *Solo*. Thus, we have ascertained that the Superimposition Graphs can only serve as initial fixed frameworks of form, from which perforations, acoustic entry types, and most importantly, acoustic pauses (all non-fixed elements of form) modify these frameworks through processes of omission.

Diffusion

At this point, we will turn our attention to a consideration of the diffusion of sound. Although the means at Stockhausen's disposal are comparatively primitive, the extraordinary degree to which he is able to exploit these limited resources and maximize the spatial effect is quite astounding. I have again constructed a set of graphs to aid in the visualization of the processes at hand. The Diffusion Graphs (Appendix III) display the spatial location (left, centre, or right) of electronic superimpositions (the numbers over lines specify the acoustic source periods).

Stockhausen's sound system comprises 4 loudspeakers, each controlled by a separate potentiometer, and sound is diffused through 2 channels, each utilizing 2 loudspeakers: Channel I (left) and Channel II (right). Stockhausen suggests situating the soloist in the middle of the hall, surrounded by the audience, and placing the four loudspeakers in the corners of the hall (Fig. 21). The input signal which feeds both Channels I and II is monophonic, but Stockhausen does not preclude the possibility of a stereophonic signal (although even the use of a stereophonic input signal would not produce stereophonic output, as we will see in the analysis of diffusion patterns). As well, Stockhausen permits the use of more than 2 loudspeakers per channel and amplification of the instrumentalist through additional loudspeakers; however, I will conduct the analysis employing Stockhausen's initial configuration: monophonic input, two loudspeakers per channel, and no amplification or processing of the live sound.

Fig. 21 Staging



Diffusion within *Solo* exists at 2 different levels: performer controlled diffusion and compositionally controlled diffusion. I will focus on the latter.

Performer controlled diffusion entails the manipulation of the potentiometers in order to affect dynamic levels for each of the loudspeakers. Stockhausen not only instructs the third assistant to completely open and close the potentiometers at the precise points indicated in the Form Schemes in order to manifest the electronic superimposition patterns, but also to manipulate output levels between the 2 channels and between the 2 loudspeakers in each channel.

When speakers I and II are both open at the same time, then stereophonic alternation (irregular, ad lib.) should be effected between the speakers: at various speeds, sometimes extremely rapid (especially with sustained sounds). The regulation of the volume of the speakers should be extremely differentiated; react completely to the instrumentalist (indicated dynamics are not binding). Speaker sounds should sometimes (especially during the pauses of the soloist) be extremely soft (far away). The two channels, in relationship to each other as well as to the soloist, should create several dynamic and hence spatial layers.[30]

In addition to the general instructions above, Stockhausen occasionally provides more precise instructions in the Feedback Schemes. For example, in V2B Stockhausen requests the following:

The same is in both channels; mix ad lib. stereophonic motion and parallel envelopes at all speeds (also extremely slow ones); speaker with dotted lines should be open less and with interruptions.[31]

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[30] Stockhausen, "Solo für Melodieinstrument mit Rückkopplung," 16–17.
[31] Ibid., 18.

Almost entirely at the discretion of the third assistant, performer controlled diffusion functions to create a sense of different spatial layers (up to 5) through the manipulation and differentiation of the dynamic levels of the 4 loudspeakers.

Compositionally controlled diffusion, entirely predetermined and the consequence of the execution of the instructions in the Feedback Scheme, involves the distribution of recorded and fed-back material across a series of different channel arrays. Stockhausen makes use of 7 such arrays as outlined in Figure 22.

Fig. 22 Channel Arrays

<u>Channel Arrays</u>

1. <u>Left</u>: Output of material from Channel I only. **Single layer** (L)
2. <u>Right</u>: Output of material from Channel II only. **Single layer** (R)
3. <u>Centre</u>: Simultaneous output of identical material from Channels I and II. **Single layer** (C)
4. <u>Left/Right</u>: Simultaneous output of discrete material from Channels I and II. **Two layers** (L/R)
5. <u>Left/Centre/Right</u>: Combination of L/R and C. **Three layers** (L/C/R)
6. <u>Left/Centre</u>: Combination of L and C. **Two layers** (L/C)
7. <u>Right/Centre</u>: Combination of R and C. **Two layers** (R/C)

Channel Arrays L and R involve the diffusion of 1 layer of electronic material through a single channel, whereas Channel Array C involves the diffusion of 1 layer of material through 2 channels (monophonic). Channel Array L/R involves the diffusion of 1 layer of material through Channel I and another, discrete layer of material through Channel II. For example, in V1A3, electronic P1 is diffused through Channel I and electronic P2 is diffused through Channel II. (But Channel Array L/R does not present a stereophonic image of sound.) Channel Array L/C/R involves the diffusion of 3 layers of material through 2 channels. For example, in V4C7, P1, P2, P3, P4, and P6 are diffused through Channel I; P1 is diffused through Channel II; and P5 is diffused through both Channel I and II. Finally, both L/C and R/C involve the diffusion of 1 layer of material through a single channel and the diffusion of a second layer of material through both channels.

Thus, through the use and manipulation of various spatial layers combined with the allocation of recorded and fed-back electronic material into the Channel Arrays, Stockhausen achieves a comparatively high number of combinational possibilities for diffusion. And when one includes the soloist in a consideration of spatialization, the possibilities increase exponentially: 5 layers of spatial sound, 14 Channel Arrays (including the live sound as another 'channel'), and up to 4 distinct layers of musical material (both electronic and acoustic). Of course, all the aforementioned elements form combinations of their own. The result is a remarkably high number of combinational possibilities for diffusion considering Stockhausen employs a monophonic input and two-channel output. (Stockhausen, however, does not fully exploit these possibilities.)

Next, we will examine the distribution of Channel Arrays across Versions and the proportion between one-channel diffusion and two-channel diffusion (Fig. 23). The second table demonstrates that Stockhausen diffuses sound most often through a single channel, predominantly through Channel I. The ratio of one-channel to two-channel diffusion in V1 is approximately 3 to 1; the ratio in V3, V4, and V5 is approximately 2 to 1; and in V2 and V6 the ratio is approximately 1.5 to 1. Thus, Stockhausen obviously favoured a somewhat sparse diffusion of sound.

Fig. 23 Distribution of Channel Arrays across Versions

Distribution of Channel Arrays across Versions

	L	R	C	L/R	L/C/R	L/C	R/C
V1	24	16	4	8	1	0	0
V2	15	10	5	20	0	0	1
V3	20	15	2	10	1	4	1
V4	17	19	0	13	2	0	1
V5	19	17	0	9	3	1	0
V6	18	14	0	12	4	4	0

One-channel Difussion versus two-channel Diffusion

	1 Channel	2 Channels	Ratio
V1	40	13	3.08
V2	35	26	1.35
V3	35	18	1.94
V4	36	16	2.25
V5	36	13	2.77
V6	32	20	1.6

(The whole numbers in the tables refer to occurences of the respective Channel Arrays and diffusion types. A single occurence equates to the use of a Channel Array for the duration of a period or less. Since a single period occassionly contains the use of two different arrays, the total number of arrays in V1, V2, V3, and V6 exceeds the total number of periods.)

Accordingly, Stockhausen most frequently employs Channel Arrays L and R (one-channel diffusion) across Versions, followed by Channel Array L/R (although in V2 Channel Array L/R is the most prevalent, but still less than the combination of L and R). Use of the remaining Channel Arrays across Versions ranges from sparse to nonexistent.

The Diffusion Graphs (Appendix III) reveal that Stockhausen mainly distributes Channel Arrays according to patterns (marked with brackets in the graphs). These patterns fall into four different categories: two-element alternating patterns, three-element alternating patterns, four-element (and one 6 element) alternating or non-alternating patterns, and fixed patterns. (Alternating patterns repeat in entirety at least once; fixed patterns consist of at least 3 repetitions.) Figure 24 displays the four Channel Array Diffusion Patterns. I have attempted to isolate (hypothetically) perceivable patterns; different analytical approaches could easily produce different sets of patterns, but my main aim here is to prove the existence and usage of diffusion patterns. In what follows, I will analyze the distribution of Channel Array Patterns and consider some of their perceptual qualities.

Fig. 24 Channel Array Diffusion Patterns

Two-element Alternating Patterns:		Three-element Alternating Patterns:	
Z1	L, R (11)	Y1	L, L, R (1)
Z2	L, L/R (2)	Y2	L, L/C, R (1)
Z3	L, C (1)	Y3	R, L, L/R (1)
Z4	R, L/R (1)	Y4	R, L/R, L (1)
Z5	R, L/C/R	Y5	L/R, R, L (1)

Four-element and Six-element (Non-)Alternating Patterns:

(A)X1	L, L, R, R (2)
(A)X2	L, L, L, R (1)
(A)X3	L, L, L/R, L/R (3)
(A)X4	L, L/R, R, L/R (3)
(A)X5	C, L, C, R (1)
(A)X6	L, L/R, L/R, R, L/R, L/R (1)

Fixed Patterns:

W1	L, L, L (4)
W2	R, R, R (1)
W3	C, C, C (1)
W4	L/R, L/R, L/R (4)
W5	L/C, L/C, L/C (1)

*The number in brackets indicates the number of repetitions across Versions.

Two-element alternating patterns comprise 5 different patterns, of which Z1 is the most sonically recognizable; it is also the only commonly recurring pattern and the only pattern which appears consistently across Versions, occurring in all Versions except V2. However, reliance on such a pattern (alternation between L and R) could easily become tedious for the listener. It is most likely for this reason that Stockhausen mainly limits the repetition of elements (Channel Arrays) to 4 in Z1. From the 11 occurrences of Z1, 7 occurrences involve the repetition of 4 elements; 1 occurrence involves the repetition of 5 elements; two occurrences involve the repetition of 6 elements; and 1 occurrence involves the repetition of 10 elements. The final case, which occurs in V5D, is exceptional for a number of reasons. First, period durations are relatively short in V5D (8 seconds), and this fact increases the prominence of the left/right alternation effect of A1. (In cycles with longer periods, the alternation effect of Z1 would be significantly less prominent; for example, in a cycle with period durations of 45s, alternation between L and R would have an entirely different effect.) As well, the Z1 diffusion pattern in V5D is combined with Strict Interrupted Accumulation. This pairing is significant because the tedium of Z1 could be attenuated by a second layer of perceptual material provided by this superimposition pattern, or the 2 processes may work in tandem to create a musical effect which builds tension. (We will return to this example in the musical analysis of V5D.)

The remaining diffusion patterns in the first category, Z2–5 (four-element patterns), all execute a similar effect: the alternation of one-channel output with two-channel output. The only difference between these patterns are the variables (Channel Arrays), and the perceptual difference between Z4 and Z5 is very minimal. Except for Z2, which recurs, these patterns only appear once across Versions.

The second category of Diffusion Patterns, like the first category, consists of 5 distinct patterns. Y1–5 all occur once and are much less sonically perceivable than the first category of Diffusion Patterns, although Y1 is in fact a variation of Z1 in which one Channel Array is prolonged.

Unlike the previous categories of Diffusion Patterns, the third category consists of patterns which have more of a structural significance than a perceptual one. Although four-element (non-)alternating patterns are analytically manifest, they may not be aurally apparent. The 6 patterns in this category occur from 1–3 times, both as alternating and non-alternating patterns.

The final category of patterns, the fixed patterns, involve 3–5 repetitions of a single Channel Array. W1 and W4 both occur 4 times; the remaining fixed patterns all occur once. All fixed patterns, with the exception of W3, consist of 3 or 4 elements. Stockhausen likely limited the number of elements to 4 in most cases to avoid monotony. The exception, W3, consists of 5 elements and occurs in a cycle with the relatively long period durations of 24s. However, monotony is mitigated here mainly by two factors: W3 occurs in Channel C and Stockhausen prescribes specific panning instructions.

Next, we will briefly consider the dispersion of the various Channel Array Patterns across Versions. Referring to the Diffusion Graphs and Figure 25, we can see that all Versions, except V5 (which consists of four Z1 patterns and a single W1 pattern), consist of a relatively balanced mixture of Channel Array Pattern types. As well, all Versions mainly employ a series of patterns which follow each other immediately, overlap, or are separated by a period or periods which do not form patterns (random alternation between Channel Arrays, though mainly some sort of alternation between L and R and C).

Fig. 25 Dispersion of Array Pattern across Versions

V1	AX1, AX5, Z3, W1, Z1, Y5, AX2, Z1
V2	Y4, W3, W4, W4, Y3, Z2, W4, X1
V3	Z2, X3, W1, W1, X4, W5, AX3, W2, Z1
V4	Z1, X6, Z1, Z4, Z5, Z1, Y1
V5	Z1, W1, Z1, Z1, Z1
V6	Y2, W4, X4, Z1, X4, AX3

Thus, Stockhausen employs a definite set of diffusion patterns and disperses them systematically across Versions. Diffusion within *Solo* consists mainly in the placement of electronic material in the various Channel Arrays, but spatial movement does not manifest itself to a significant degree (only occasional panning). Finally, it is important to emphasize the symbiotic relationship between diffusion and electronic form. Since Stockhausen utilizes the 2 audio channels as a means of creating superimposition patterns, it is difficult to separate the diffusion of sound from the creation of electronic form.

Part III
Musical Analysis of Version V

Musical analysis of *Solo*, or of any open-content/form type work, is inherently problematic; in itself, such an analysis provides only a glimpse of one of the many possible manifestations of a work and thereby risks redundancy. In light of these difficulties, I propose a comparative analysis of a hypothetical score (of my own construction) with an actual performance, in this case flutist Dietmar Wiesner's 1995 CD recording.[32] The main purpose of the analysis will be to determine the degree to which micro-elements of form (such as musical content, perforations, period structure, acoustic entry patterns, etc.) affect the structural paradigm of V5 presented in the Superimposition Graphs. Additionally, the construction of a hypothetical score will clarify the instrumentalist's interpretation process (i.e. score creation), an important element of micro-form. Although the analysis will by no means provide a definitive understanding of form, it will elucidate many of the formal properties of *Solo* and put into perspective the findings presented in Part II.

The analysis will focus on Cycle A (Mixed Electronic Pattern), Cycle B (Cyclical Canon), and Cycle D (Accumulation Pattern), thereby taking into consideration all three condensed superimposition pattern types. I will provide an analysis of the remaining cycles, but I will examine only their salient features in order to avoid redundancy. Finally, I will consider the overall form and the significance of page structure.

Stockhausen was involved in the production of three recordings of *Solo*. In the first, for trombone (Vinko Globokar, LP 1969),[33] Stockhausen overlaid the recording with other material, including recordings of sections of his own work *Hymnen*. The remaining two include the Wiesner flute recording and a version for synthesizer, sampler, sequencer and eight-track tape, realized by Simon Stockhausen (released on the same CD). The version for flute was created by Karlheinz and Simon Stockhausen in 1994; they used a sequencer and sampler to record the superimpositions of Version V onto eight-track tape. In this version, the performer plays live to the eight-track tape with the aid of a click-track (premiered August 15, 1994, in Salzburg).[34]

I have chosen the 1995 Wiesner flute recording as the most suitable version for analy-

[32] Stockhausen, *Solo*; *Spiral* (Wiesner).
[33] Stockhausen, *Solo* (Globokar).
[34] Stockhausen, *Solo; Spiral*, (Liner Notes) 26.

sis; however, even this version is not an entirely authentic representation of *Solo* due to the fact Stockhausen edited the recording in a number of ways and did not always adhere to the instructions in the Interpretation Scheme. For example, at the opening of V5A7 Stockhausen added a short pause, the content of certain superimpositions has been altered, and V5F is approximately four seconds longer than its specified length. Most of the edits are very minor (though it's difficult to ascertain the extent to which Stockhausen altered the content of certain superimpositions). In addition, Stockhausen processed parts of the recording (notably some of the Cadential Chordal Blocks) "through digital temporal expansion, transposition, filtering and reverse play-back."[35] Although Stockhausen allows for the use of electroacoustic means to produce the instrumental timbral variations, strictly speaking, he does not allow for the arbitrary application of sound processing. Nevertheless, Wiesner's flute recording provides an excellent model for analysis, considering the composer himself carried out the role of the instrumentalist, in the creation of the performance score, and the first and second assistants, in the application of perforations and the regulation of output. Finally, we will see, that the minor edits Stockhausen made give insight into his formal intentions.

I have randomly assigned page numbers to Stockhausen's pages of musical notes in order to provide our analysis with a means of reference:

Fig. 26 Assigned Page Numbers

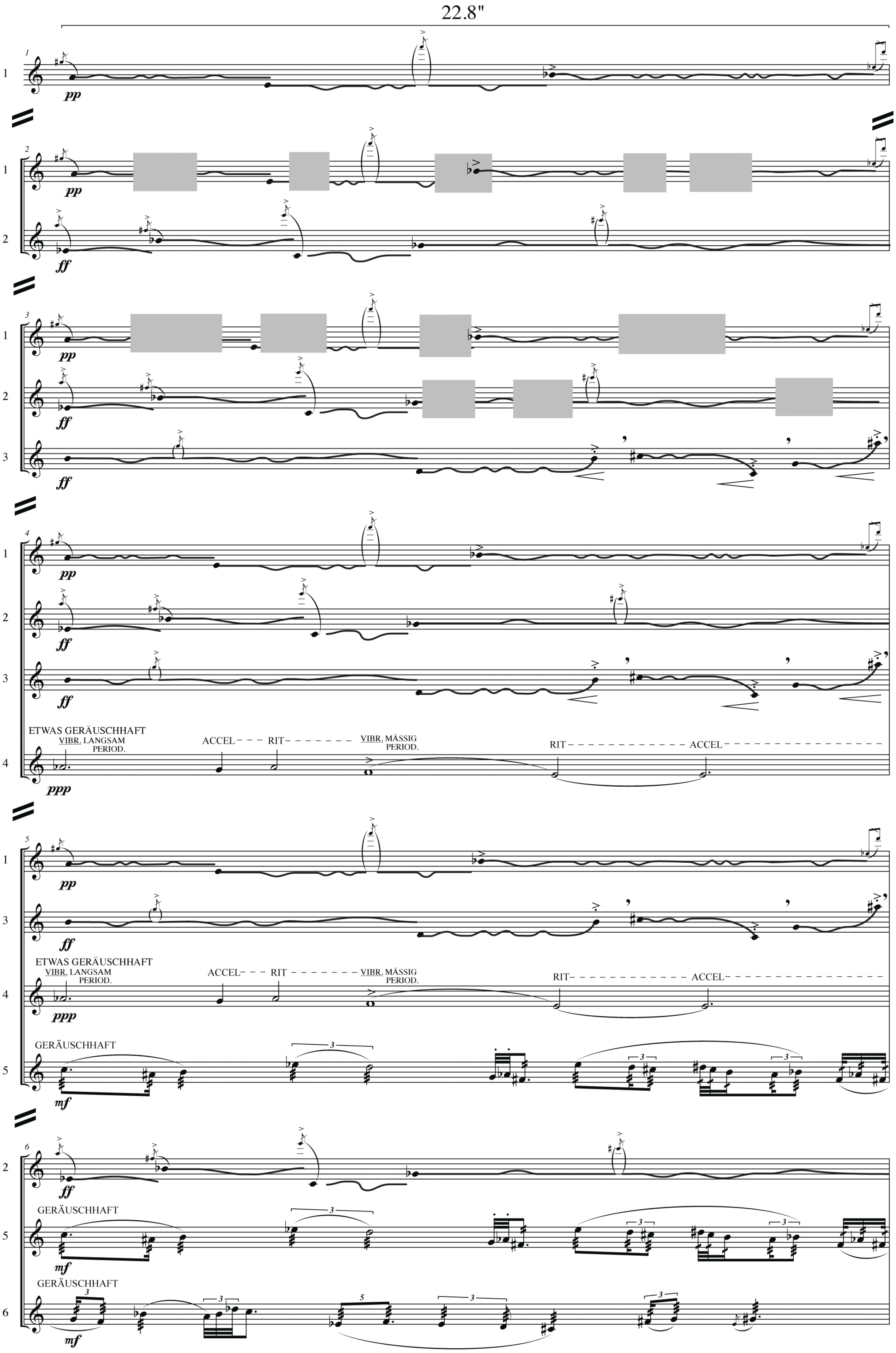
Page Number	First Note
Page 1	G ***ff***
Page 2	G ***pp***
Page 3	E ***pp***
Page 4	G♯
Page 5	F
Page 6	E ***ff***

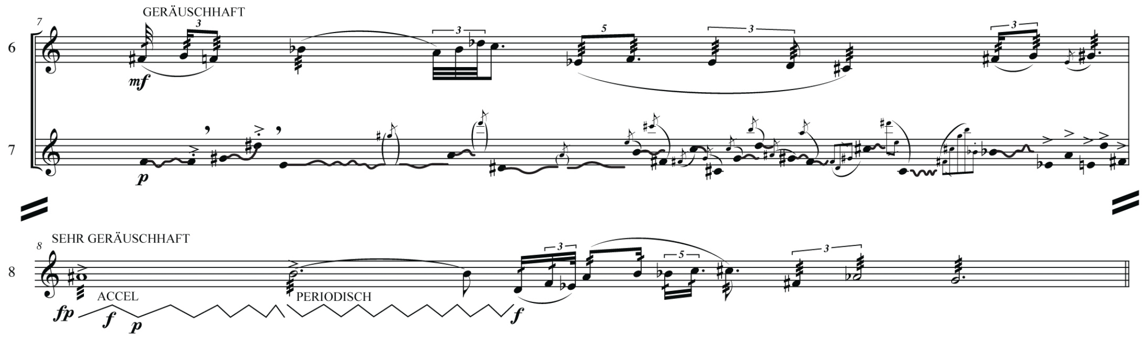
Cycle A

Employing a transcription of the CD recording (Fig. 27) as the basis for analysis, I will discuss Stockhausen's selection of musical material, analyze the musical content and structure of P1–8, and consider the effect of perforations.

[35] Stockhausen, *Solo*; *Spiral*, (Liner Notes) 26.

Fig. 27 Transcription of V5A CD Recording





V5A manifests a Mixed pattern (Group 2 Layer Density Pattern) in which P1–5 forms a Partial Interrupted Accumulation Pattern and P5–8 forms a Deaccumulation Pattern, creating a symmetrical structure that moves from 1–4 layers then back down to a single layer (1/2/3/4/4/3/2/1).

Stockhausen selects page 4 as the source for V5A, which consists of 8 periods of 22.8s each, and according to the Interpretation Scheme, 'complete systems' that are 'different from one another' are to be interpreted. In his notes, Stockhausen states that the performer must "interpret complete systems (as notated, from beginning to the end of the system). The order of the systems is interchangeable. Systems must enter at the beginning of a period and follow one another without pauses."[36] Further on in his notes, Stockhausen also stipulates that "a system may not be repeated within a cycle."[37] Therefore, the instrumentalist is faced with the dilemma of creating 8 periods from 6 complete systems without repetitions. Accordingly, the instrumentalist seems obligated to choose page 2 (the only page that contains 12 systems) as the source for this cycle. However, Stockhausen does not do so; instead, he stretches a single system across 2 periods on 2 occasions, thereby creating the required 8 periods. (System 2 is stretched across P2 and P3; system 6 is stretched across P5 and P6.) As well, Stockhausen does not interpret systems that 'are different from one another'. In this case, and as we will see, in other instances, Stockhausen does not adhere to his own procedural rules in order to achieve a specific musical purpose.

The first 3 periods of V5A manifest an audibly clear Accumulation structure, emphasized by the absence of rests (acoustic or electronic), relatively short period durations, and a

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[36] Stockhausen, "Solo für Melodieinstrument mit Rückkopplung," 14.
[37] Ibid., 15.

perceivable period structure.[38] In addition, P1–3 blend to create a cohesive contrapuntal texture, mainly due to the fact that they make use of very similar musical material: long lower-register notes with fluctuating pitch bends punctuated by very short high-register grace notes.

Comparing these findings with a different, hypothetical score or a live performance, we must acknowledge that a variety of factors could easily yield different results. For example, in a cycle with longer periods or with an unclear period structure, the overall aural effect could be much different, i.e. the listener might not readily recognize the reappearance of musical material, affecting the perception of a clear musical phrase structure. As well, amplitude is a factor. P1 is acoustically *pianissimo*, but when played back through the loudspeakers the amplitude could be increased or decreased at the discretion of the third assistant. Such is the case in the recording; electronic P2 (which is acoustically *fortissimo*) matches the dynamic of P1. This not only affects the overall balance and blending of different dynamic layers but amplification also vastly increases the range of timbres. Here, breaths and flute transients are greatly amplified and in turn blend in with the overall flute sounds, creating 'timbral counterpoint', another textural dimension of sound. Therefore, throughout the analysis which follows, the reader should concede that there are a number of factors affecting form.

In the fourth period, the texture alters due to the introduction of new melodic material and the use of vibrato. The soloist begins to emerge from the texture, and the texture itself transforms from contrapuntal to melody and accompaniment (though the accompaniment is itself contrapuntal).

This transformation completes itself in the fifth period. Although the fifth period contains 4 layers, as did the fourth period, the texture metamorphoses. Similar to P4, P5 consists of melodic material; however, the perception of a distinct melody is stronger here because it moves at a faster pace (as opposed to the long held low-register notes of the P4 melody which at times blended in with the low register contrapuntal material of P1–3) and within a higher register. What is more, P5 is marked '*Geräuschhaft*' (noisy), in the CD version this translates into singing the notated pitch an octave lower while playing the written pitch, and is performed with fluttertongue. The timbral, registral, and melodic differences all combine to strongly distinguish P5 from the material that preceded it, manifesting a melody and accompaniment texture. Another factor which contributes to relegating the electronic material to the

[38] The use of the term 'period structure' refers to the ability of the listener to recognize the beginnings and ends of periods and thus perceive periods as a formal element analogous to a musical phrase.

background are the perforations, and we will discuss these in more detail shortly. Therefore, instead of a prominent Accumulation structure from P1–5, the listener would probably perceive the aforementioned transformations and textural changes as more structurally significant.

The arch form (of layers, textural change, and perforations) completes itself in P5–8 with a clearly perceivable Deaccumulation Pattern. Likewise, the texture reverses itself: in P6 there is a return to a more contrapuntal texture with the combination of the 'noisy' melodic material.

The solo in P8 (an electronic rest) is striking, both structurally and musically, as it seems to signify an important formal event. Once again, Stockhausen's choice of material is an important factor; the system chosen here is the most musically unique system on the source page (marked *accel. periodisch* and accompanied by a graphic symbol indicating extreme dynamic swells, it occurs only once in the pages of notes; see the last measure of the transcription, Fig. 27). Had another system been chosen here, the results could differ substantially. As mentioned earlier, electronic rests are rare and thus their presence significantly impacts form, as evidenced in this example.

Next, we will examine how perforations function within an actual musical example, referring again to the diagram of hypothetical perforations in V5A (Fig. 20) and the transcription (Fig. 27), where perforations have been marked in the score for the second and third periods only (due to the density of perforations in the remaining periods, it is not possible to transcribe them with accuracy).

In P2–3, perforations are approximately between 1 and 1.5 seconds. The beginnings and endings of perforations display a range of diverse envelopes: sometimes perforations gradually fade out the electronic sound (or fade in), sometimes the fade out (or fade in) is much quicker, and sometimes there is an abrupt cut-off (or cut-in) of the electronic sound. Although perforations may cover the entire duration of a single note or group of notes (thereby causing them to be 'omitted' in electronic reiterations), none of the perforations in P2–3 do so. As well, all perforations here (except for the first perforation of electronic P2) occur after the attack of a note, allowing the passage to retain more of its original flute timbral identity. Thus, Stockhausen does not employ perforations here as a means of variation through omitting single tones. Instead, perforations are involved in another, equally important process which I will refer to as 'acoustic timbral transformation'.

Acoustic timbral transformation involves the alteration of the perception of acoustic sound, caused by the disconnection of the attack of an acoustic sound from its sustain. In the present case, this alteration produces an 'electronic effect'. When the attack of a note is disconnected from its sustain (or when the attack is omitted), the listener perceives the resulting sound as more 'electronic' than acoustic. Due to the nature and source of the musical material here (long sustained pitch bent flute notes), these passages lose their flute timbre identity and take on more of the characteristics of a series of undulating sine tones.

In the fourth period, the 'electronic effect' on P1–3 is even stronger, and in the fifth period the electronic layers almost entirely lose their timbral identity. Thus, from P2–P5 there is a gradual deterioration of timbral identity of played back periods. The fact that the number of layers and perforations increase here is a factor in this progressive deterioration, but not entirely so. Comparing P4 to P5, P5 has the same number of layers (4) and one less perforation, but it is still much less timbrally distinct than P4, because the placement of perforations is a major factor determining acoustic timbral transformation, and electronic P1 in P5 has 11 perforations, completely deteriorating the acoustic timbral properties of this period.

The recording of V5A displays a definite and coherent musical structure, an overall arch form in terms of layers and timbre: acoustic flute to electronic sound back to acoustic flute, with the dramatic P8 entry accentuating this process. Stockhausen's choice of musical material strongly supports the timbral arch form and perforations play an important role in this process as well. Comparing these findings with the Superimposition Graph of V5A, we are able to ascertain that in cycles in which complete systems are interpreted (meaning that there are no acoustic rests), the Superimposition Graphs will provide a fairly accurate view of electronic form. However, we must keep in mind that only one cycle per version solely involves the interpretation of complete systems.

Cycle B

For the analysis of V5B, a Cyclical Canon displaying 6 periods of static layer density (Group 3 Layer Density Pattern), I have constructed a hypothetical performance score following the instructions in the Interpretation Scheme (Fig. 28), using page 5 as the source. I will provide an analysis of overall form and discuss period structure, diffusion, the acoustic entry pattern, rhythm, and perforations. As a means of verification, I will compare my findings with a brief aural analysis of the CD recording in which we will then consider the P1 Chordal Block.

Fig. 28 Hypothetical Performance Score V5B

N = Flute
II = Alto Flute

A comparison of the hypothetical performance score with its source page (cf. Fig. 2) offers a glimpse into the interpretation process involved in the transformation of one of Stockhausen's pages of notes into an actual performance score. The Interpretation Scheme for V5B indicates that material from the chosen page should be used in alternation with material from the previous and following pages; I have chosen page 1 for the former and page 6 for the latter; the instrumentalist should extract 'parts'; these parts should be followed by 'medium long' rests (which I have interpreted as rests between 10–15 seconds), yet different rest durations can be used to accommodate the acoustic entry pattern, which in this case is *Polyphon*; and the selection of 'parts' is 'same and different'. Employing the hypothetical performance score as the source, I have also constructed an acoustic/electronic score (omitting the P1 Cadential Chordal Block) to guide the analysis (Fig. 29).

Fig. 29 V5B Hypothetical Acoustic/Electronic Score V5B

The Acoustic/Electronic score exhibits a surprisingly sparse texture, which belies the information in the Superimposition Graph. The most salient observation is the preponderance of silence (overlapping acoustic and electronic rests): every period has 2 instances of silence.

(However, in P1, the first silence would be covered by feedback from Cycle A.) The average duration of silence is approximately 3–4 seconds; the longest silence, in the fifth period, is 9.2 seconds. This results in a frequently interrupted musical line, often with relatively long periods of silence. The score clearly demonstrates how a Cyclical Canon with long periods and long rests will typically result in such a sparse texture.

Although Stockhausen applies the term '*Polyphon*' to this cycle, as we can see here, the musical result will not necessarily be polyphonic. In our hypothetical example, polyphonic lines rarely form, mainly due to the nature of the material and the frequency of rests. For example, measure 8 contains a tremolo pattern set against a melodic figure in measure 13, and measures 10 and 15 contain long held notes. Neither of these superimpositions create a contrapuntal texture: a more apt description of the texture here is a series of intermittently overlapping solos. As well, the intersection of material is quite disparate in terms of dynamics, timbre, and as mentioned above, musical material. Thus, the actual textural identity of a cycle depends more on other factors than the designation given by Stockhausen; acoustic entry patterns guide the performer in the choice and placement of musical material but do not create form at a macro-level, nor do they act as reliable predictors of texture.

Next, we will consider period structure. From P1 to P2, period structure is discernible to a certain degree but only because of the sudden appearance of a second layer, the electronic layer. However, following this entry, the musical material of the hypothetical example does not manifest an aurally perceivable period structure. This lack of period structure is mainly due to the fact that there is nothing inherent in the musical material to demarcate the beginning of periods. Having said that, period structure manifests itself to a certain extent as a result of the Diffusion Pattern in V5B. Beginning in P2 there is an alternating Diffusion Pattern (L/R/L/R/L). The extreme L/R changes do demarcate the beginnings of P3, P4, and P6. Diffusion does not demarcate the beginning of P5 because it begins with an electronic rest; in fact, this may deceive the listener into thinking that the beginning of this period starts later (after the electronic rest). But the degree to which diffusion demarcates period structure is variable and depends on a number of factors; in the present case, the perception of the beginnings of periods is greatly attenuated due to the frequency of acoustic and electronic rests, the relatively long periods of silence, and the relatively long duration of periods. (We will see in V5D that diffusion plays a much more important role in defining period structure when the aforementioned factors are nearly opposite.) The lack of period structure here contributes to the perception of a very free formal structure in which the Cyclical Canon structure itself is not aurally perceivable.

This does not mean, however, that the cycle is formless. On the contrary, V5B does manifest a definite and exact form, that of a 45.6 second tape delay. It is a formal structure which stimulates the memory: fragments of musical information return at exact intervals but their recognition challenges the brain because they reappear in new contrapuntal combinations, at different dynamics, and in new spatial locations at a relatively long temporal distance. While the form here parallels that of tape delay music, it also differs due to the fact that V5B contains many rests, not typical of the uninterrupted layers of sound most often associated with tape delay music. Thus, the form of this cycle is somewhat unique.

Although an analysis of rhythm is beyond the scope of the present essay, we will briefly consider the subject. The metronome markings in the hypothetical score reveal that the proportional temporal relationships between cycles produce tempi which are multiples of each other (15.8 x 2 = 31.6 x 2 = 63.2). Theoretically, this should facilitate the shift to the different tempi, but practically speaking, it is extremely difficult for a player to execute the score accurately. Nevertheless, overlapping metrical material provides an important addition to the compositional vocabulary. Although independent rhythmic lines commonly occur in purely acoustic aleatoric music (and in certain cases of notated music), Stockhausen expands the possibilities for multiple layers of tempi.

Next, we will examine perforations, the density of which in V5B is considerably lower than in V5A. From B2–B6 the number of perforations is 13/8/5/3/2. As well, cycles are twice as long in V5B and perforations do not overlap (in V5B there is never more than a single concurrent electronic layer). Thus, perforations do not play an important role in shaping the musical material in V5B, at least no where nearly to the extent as they do in V5A; instead, perforations only slightly alter the playback of sound. For example, in measures 15–16, perforations would produce an occasional wavering effect.

I will now provide a brief comparison of my observations with the CD recording. Stockhausen chose page 1 as the source for this cycle (for the previous cycle he chose page 4 and the following cycle page 5). Of course, different sources of musical material will produce different results, but we will see that the salient formal features of V5B remain largely the same.

To begin, we will consider the Cadential Chordal Block at B1 (omitted from our hypothetical analysis). The Chordal Block here clearly punctuates the form: there is a sudden movement from the solo acoustic sound of V5A8 to the densest texture yet in V5B1 (5 electronic layers in addition to the acoustic layer), then back to solo acoustic sound. At the same time, the Chordal Block also densely reiterates the previous cycle, providing a short 'recapitulation' of many of the 'themes' presented. Yet, it is difficult to classify the formal role of the Cadential Chordal Block here due to the nature of V5A8, which by virtue of its sudden textural change, creates a formal division of its own. Nevertheless, the P1 Chordal Block functions as an important marker of form.

In entirely subjective terms, the recording of V5B presents a semi-chaotic collage of timbres and melodic lines, seemingly without much musical connection. V5B does at times reference recognizable material from cycle A, reinforcing the notion of a 'memory' form (with two layers of reiteration: acoustic and electronic). Due to long rests and the length of the tape delay, it is difficult to perceive this cycle as a strict tape delay, and in fact, a listener would probably not recognize it as such. Neither would a listener likely associate the texture with any sort of polyphony, the diversity of musical material and the fact that two lines rarely intersect for any significant length of time acting as contributing factors. Perforations do not play a significant role here, only a 'wavering' effect is evident. In terms of overall form, V5B provides a definite and stark contrast to the material and texture of V5A.

Thus, the recording confirms the findings of much of the hypothetical analysis. Important to note is the fact that cycles containing pauses will not directly correlate to their respective Superimposition Graphs; such cycles will only produce a substructure of these superimpositions. Equally important is the fact that content does not significantly alter the formal paradigm here.

Cycle C

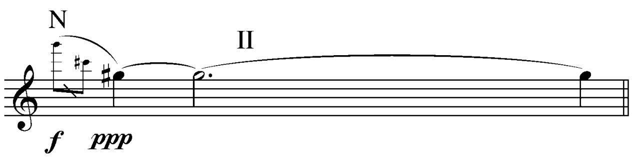
For V5C, I will carry out an aural analysis of the CD recording, focusing on the Drone but also taking into consideration the P1 Cadential Chordal Block. V5C is a Free Interrupted Accumulation Pattern (Group 6 Layer Density Pattern): P1 Chordal Block; P3–4 Deaccumulation; C3–D1 Drone; P5/10 Chordal Blocks. The instructions in the Interpretation Scheme are: interpret with the previous page (source is page 5 and the previous page is page 1); interpret 'parts' and 'systems' with 'relatively medium and long pauses'; and the acoustic entry pattern is an alternation between *Akkorde* and *Blöcke*.

The P1 Cadential Chordal Block does not begin directly at the start of the period but in the middle. Although the Chordal Block here consists of only 2 electronic layers, it still serves as a formal marker because it is preceded and followed by such sparse material and the musical content itself is very striking. The suddenness of its appearance and disappearance and the fact that it is preceded and followed by such contrasting material causes it to stand out.

However, the most interesting feature of V5C is the P3–9 Drone. Figure 30 displays the musical figure from which the Drone originates. This musical figure begins at the very end of P2, continues through the entirety of P3 and briefly into the opening of P4. Therefore, the P3 drone comprises only the sustained G-sharp (without the attack) and not the grace notes preceding it. The fact that a single note is held across 3 periods is made possible by an exception which Stockhausen permits the instrumentalist:

> Parts and elements taken from the previous or (and) following pages retain their timbre and duration; if such a duration is longer than the present period, it is possible to hold one tone for the whole period and into the next, so that, because of feedback, it may continue to sound for several periods. This should occur at least twice within a version.[39]

Fig. 30 V5C3–9 Layer 3 Drone



The P3 Drone (sustained G-sharp) then carries on for the remainder of the cycle, but it is also supplemented at times with electronic P2, which contains the opening grace note figures of the Drone and the attack of the G-sharp (electronic P2 repeats 4 times), and P4, which contains the continuation and release of the G-sharp (electronic P4 repeats 3 times). P3 is diffused to Channel Array L; P2 and P4 are diffused to Channel Array R. Thus, there is an interesting interplay between the Drone and similar material in P2 and P4. Stockhausen obviously made a strategic formal decision in selecting this figure for the Drone and choosing to use the exception here: the Drone functions as an anchor of form and development in this cycle.

[39] Stockhausen, "Solo für Melodieinstrument mit Rückkopplung," 14.

Cycle D

For the analysis of V5D, a Strict Interrupted Accumulation Pattern (Group 5 Layer Density Pattern), I have once again constructed a hypothetical score (Fig. 31). I will provide an analysis of superimpositions, period structure, perforations, metre, and diffusion, again followed by a comparative aural analysis of the CD recording, including the P1 Chordal Block.

I will employ page 5 once more (see Fig. 2) as the source for our hypothetical example here in order to demonstrate how different parameters in the Interpretation Scheme affect the transformation of musical material. Stockhausen provides the following instructions for the preparation of V5D: use material only from the chosen page and interpret this material 'in comparison to what is being played back over the loudspeakers'; interpret 'elements' and 'complete systems that are approximately the same'; use 'relatively long pauses' in combination with 'relatively short pauses'; and use a combination of *Polyphon* and *Blöcke*. I have used a range of pauses from very short (less than a second) to a maximum of 4 seconds. As well, Stockhausen adds two more specific instructions pertaining to this Cycle: 'first period reacts to the last of Cycle C' and 'separate element blocks with long pauses'.

Figures 31 and 32 illustrate the results of the interpretation process.[40] A comparison of the hypothetical performance scores of V5B and V5D illustrates the degree to which different interpretation instructions can result in a drastically changed score. Again, many of Stockhausen's interpretation instructions conflict. First, interpreting elements interspersed with rests to produce a contrapuntal texture is contradictory; such instructions naturally produce a pointillistic texture. I have attempted to mitigate this issue by selecting as many long held notes as possible and to overlap them in the score to produce as much polyphony as possible. The creation of the *Blöcke* is also problematic, but I have managed to create one *Blöcke* which appears on the last beat of every system and overlaps into the next period.

The Acoustic/Electronic Superimposition Graph for V5D displays a systematic structure which comprises 2 alternating patterns: an Accumulation Pattern which starts in the third period and continues in all subsequent odd-numbered periods; and an Accumulation Pattern that only repeats odd-numbered periods, which begins in the fourth period and repeats in all subsequent even-numbered periods. We can surmise that the aural result would create an interesting effect: a constant building of texture, but not in a predictable manner, and a multi-

[40] I have slightly simplified the rhythmic notation here for analytical purposes, for example, a single eighth note extracted from a tuplet figure will be notated as an eighth note, etc.

layered process of accumulation. A comparison of the Acoustic/Electronic Superimposition Graph to our hypothetical score reveals that the graph presents a reasonable, albeit not exact, representation of the output of sound. Thus, we can conclude that the effectiveness of the representation of the Acoustic/Electronic Graphs is directly related, in an inverse relationship, to the number, frequency, and duration of acoustic pauses.

Fig. 31 V5D Hypothetical Performance Score

Fig. 32 V5D Hypothetical Acoustic/Electronic Transcription


7
1
2
3
4
5
6
7
8
9
pp
ppp
p
mf
f
ff
3
5
6
7

Next, we will examine the period structure of V5D. Due to short period durations and repetition of material, one might predict that musical content would define period structure. But this is not the case in the first few periods. Since the first period begins with a rest, this somewhat distorts the perception of period structure when electronic P1 returns. Adding to this distortion, P1 ends with a note which carries through to P2. Due to these factors, between P1 and P2 there is absolutely no sense of period structure: the listener cannot ascertain where one period begins and the other ends. In addition, P2 does not begin with strikingly recognizable musical material, further attenuating the perception of period structure. When electronic P2 appears in P3, the attack of the first note has been perforated, which may inhibit the listener's ability to perceive the G-sharp as the same musical event as in acoustic P1. When electronic P2 appears again in P5, the listener may not recognize the repeated material because it is registrally buried within the added new layers. But, beginning in P4 and continuing through to the remaining periods, musical content does contribute to a clear sense of period structure, especially with the inclusion of entire systems, which provide more recognizable musical material (and don't include rests).

However, despite the fact that musical material does not contribute significantly to period structure, V5D does have a very clear period structure, mainly due to diffusion. The constant alternation between L and R (within a relatively short timespan) clearly establishes a musical sense of structure here, which is eventually reinforced through the musical material. Thus, diffusion plays an important formal role in this case.

Perforations are comparatively sparse in V5D and do not play a significant role in altering the musical material from either a variation or 'electronic effect' perspective. It is interesting to note though that P1, P3, P5, and P7 are recorded in both channels, allowing for the application of different perforations in alternating periods.

Next, we will return to a brief discussion of rhythm and metre. As can be seen from the score, the music lines up metrically, made possible by three factors: the source page contains metric music, there is a single source page, and the durations of pauses correspond to the metre (although I could have chosen pauses that did not correspond metrically). Again, the conventionally layered metric material may or may not facilitate performance, but it adds another interesting dimension to rhythm within the work as a whole: movement from rhythmically free sections to metered sections.

We will now move to a comparative aural analysis of the CD recording of V5D, which employs page 3 as its source. The Chordal Block which separates V5C and V5D begins in the last period of cycle C and then repeats for only several seconds at the start of V5D. However, the V5C10 Cadential Chordal Block does not function as a marker of form because it blends in with the preceding material. Most likely for this reason, Stockhausen has electronically edited the continuation of the Chordal Block in V5D1 by combining musical material from cycle C in a much denser manner and adding sound processing. The result is that the continuation of the Chordal Block at D1 is very striking (the most unique section of the piece so far) and now serves as a very definite marker of form. This process supports the claim that Cadential Chordal Blocks serve as formal markers: Stockhausen apparently intended the Chordal Block to serve as such, but when it did not, he edited the material.

The musical result of the CD recording is much the same as conceived in our hypothetical analysis. The short period durations and systematic structure support the unfolding of a perceivable development: tension builds gradually, musical expectations flourish, and overall, the cycle appeals to a listener's sense of form. As with the hypothetical example, period structure is ambiguous at first, but later on in the cycle it strengthens due to the reappearance of recognizable musical material and the L/R diffusion pattern.

Cycle E

For this cycle, I will provide only a very brief aural analysis of the CD recording, highlighting some of its salient features. Cycle E is an Interrupted Cyclical Canon (Group 4 Layer Density Pattern); the source page (page 6) should be interpreted with the following page (page 2); 'elements' that are the 'same' should alternate with 'elements' that are 'different'; use 'relatively long pauses'; and the acoustic entry pattern is *Blöcke*.

The opening of cycle E is very striking: a movement from the 11 layer accumulation structure of D11 to solo acoustic sound in E1 (the choice of musical material plays a role in the striking effect here, i.e. higher register held note). These facts punctuate cycle E as a new section of form, and the Cadential Chordal Block which follows in E1 further strengthens this perception. (Stockhausen edits the Chordal Block here as well.)

As in cycle B, the material is sparse due to the inclusion of pauses (the medium length pauses of cycle B, with a period duration of 45.6s, are roughly equivalent to the long pauses of cycle E, with a period durations of 32s). However, cycle E takes on a musically more coherent form and feels less random than cycle B due to the use of the *Blöcke* entry pattern, which is aurally apparent here. The simultaneous appearance of musical material points to some form of musical organization, as opposed to the seemingly haphazard overlapping material of Cycle B.

Cycle F

Again, I will provide a brief aural analysis of the CD recording, which is approximately 4 seconds longer than its specified length. This fact complicates analysis because it means periods are difficult to define precisely. Cycle F is a Mixed Pattern (Group 1 Layer Density Pattern); the source is page 2 and only this page is interpreted; 'elements' and 'parts' that are 'contrary to one another' are to be interpreted; and the entry patterns are *Polyphon* and *Akkorde*.

Once more, the P1 Cadential Chordal Block functions as an important marker of form (again, Stockhausen processes the Chordal Block here, possibly adding to its structural importance). The electronic structure of V5F, which consists of a P1–6 Interrupted Accumulation Pattern, followed by Deaccumulation and ending with a Chordal Block, largely defines the form. The P2 drone, for which Stockhausen has again chosen a held note which overlaps periods (same process as in V5C), also plays a unifying role in defining the structure. The break in texture caused by Deaccumulation in P7 is significant. Overall, this cycle shares many of the qualities of the other Mixed patterns: a wandering sense of form and a collage of musical material.

Page Structure of Version V

The allocation of note pages to cycles (carried out by the instrumentalist) influences form and the resulting texture of each cycle, and the confluence of note page allocation with Stockhausen's page interpretation instructions[41] creates another hierarchical level of form and functions as a meta-layer of (acoustic) 'feedback'. The page structure for the Wiesner flute recording (V5) is as follows: 1, 4/5/1, 1/5, 3, 6/2, and 2. It is important to note that Stockhausen considered each note page thematically linked: "every note page presents a particular aspect of approximate sameness of systems, parts, and elements."[42] The first 3 cycles of V5 interconnect because they share common pages: cycles A and B share a common page, B and C share two common pages, but A and C do not share common pages. Thus, there is a gradual progression of material from cycle A to C. Cycle D is unique because it is the only cycle in V5 which does link with another cycle. Furthermore, the page structure of V5 incorporates 2 separate arch forms: from the perspective of the number of pages used per cycle,

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[41] I will refer to this confluence as 'page structure'.

[42] Stockhausen, "Solo für Melodieinstrument mit Rückkopplung," 14.

V5 manifests the following structure: 1/3/2/1/2/1. Therefore, cycles A–D display an overall arch in terms of diversity of musical material, moving from a narrow range of musical material to a diverse range and then back down again. From cycles D to F, the process repeats on a smaller scale. We can also argue a correlation between page structure and superimposition patterns: the Strict Interrupted Accumulation Pattern in cycle D acts as an appropriate climax to complete the arch structure and its placement in the middle of the composition acts as a climatic element. Thus, page structure involves a number of interconnected processes that function to create a hierarchical level of form (superior to cycle-level) and maintain unity throughout *Solo*.

Conclusion

Although musical analysis of a Version (or Versions) of *Solo* is by no means capable of providing an exhaustive understanding of form and content, it does yield insight into the multi-layered processes at play. Most importantly, the musical analysis here supports many of the claims I put forth in Part II regarding the subordinate function of micro-formal elements. Musical content affects form to varying degrees, ranging from negligible to significant; however, in no instances does musical content define form to the degree which electronic superimpositions do. In fact, Stockhausen, in his choice of musical content, seems to select material that supports and complements the predetermined framework of electronic superimpositions. The role of acoustic rests remains paramount: they carry out a subtractive operation in regard to superimposition patterns which must be considered in an understanding of form. The role of acoustic entry patterns, however, is mitigated by the fact that the instrumentalist must adhere to a broad set of (sometimes conflicting) instructions in the preparation of the performance score and at times is not able to fully effectuate these patterns. This means that acoustic entry patterns generally do not have a significant impact on overall form; they do, however, create and alter the perception of texture to varying degrees. In addition, a number of other micro-formal elements, including perforations, period structure, textural counterpoint, acoustic timbral transformation, and the diffusion of sound, influence form. Thus, electronic superimpositions establish the foundations of structure and create form at a macro-level, while micro-formal elements carry out processes of subtraction and variation, shaping, but not undermining, the structural paradigm of superimpositions and imparting a uniqueness to Versions.

Stockhausen systematically allocates a set of logically and musically conceived superimposition patterns across Versions, and these patterns, along with a range of superimposition techniques, generate the subdivisions of form within *Solo*. Complete Cycle Superimpositions patterns, which include Accumulation, Cyclical Canons, and Drones, formally define cycles; Cadential Chordal Blocks and electronic rests punctuate these formal boundaries, while both Structural and Cadential Chordal Blocks carry out the function of densely recapitulating material; and superimposition techniques, including Partial Cycle Superimposition Patterns, Deaccumulation, static layer density, delayed canons, and various non-recurring techniques, act to unify cycles and delineate further subdivisions of form. Finally, page structure, functioning at a hierarchical level superior to that of cycles, binds these processes into a unified whole.

Stockhausen abandons the traditional exposition/development/recapitulation paradigm for a new conception of form, a 'memory' form involving an interaction of acoustic and electronic feedback. *Solo* could be considered thematically non-developmental, but I contend that Stockhausen achieves a different type of development: a development through structure, texture, and diffusion which amalgamates these traditional elements of form, thus creating a continuous, temporally displaced exposition/development/recapitulation paradigm. Stockhausen strove for, and achieved, 'something new' in the composition of *Solo*; although his original intentions underwent a transformation in which the idea of a 'structure formation' takes on a new meaning, the kernel of Stockhausen's idea persists in the manifestation of electronic superimpositions. Today, *Solo* occupies a seminal position in the repertoire of live electronic music involving the recording, playback, and processing of sound from an instrumentalist(s) during concert performance.

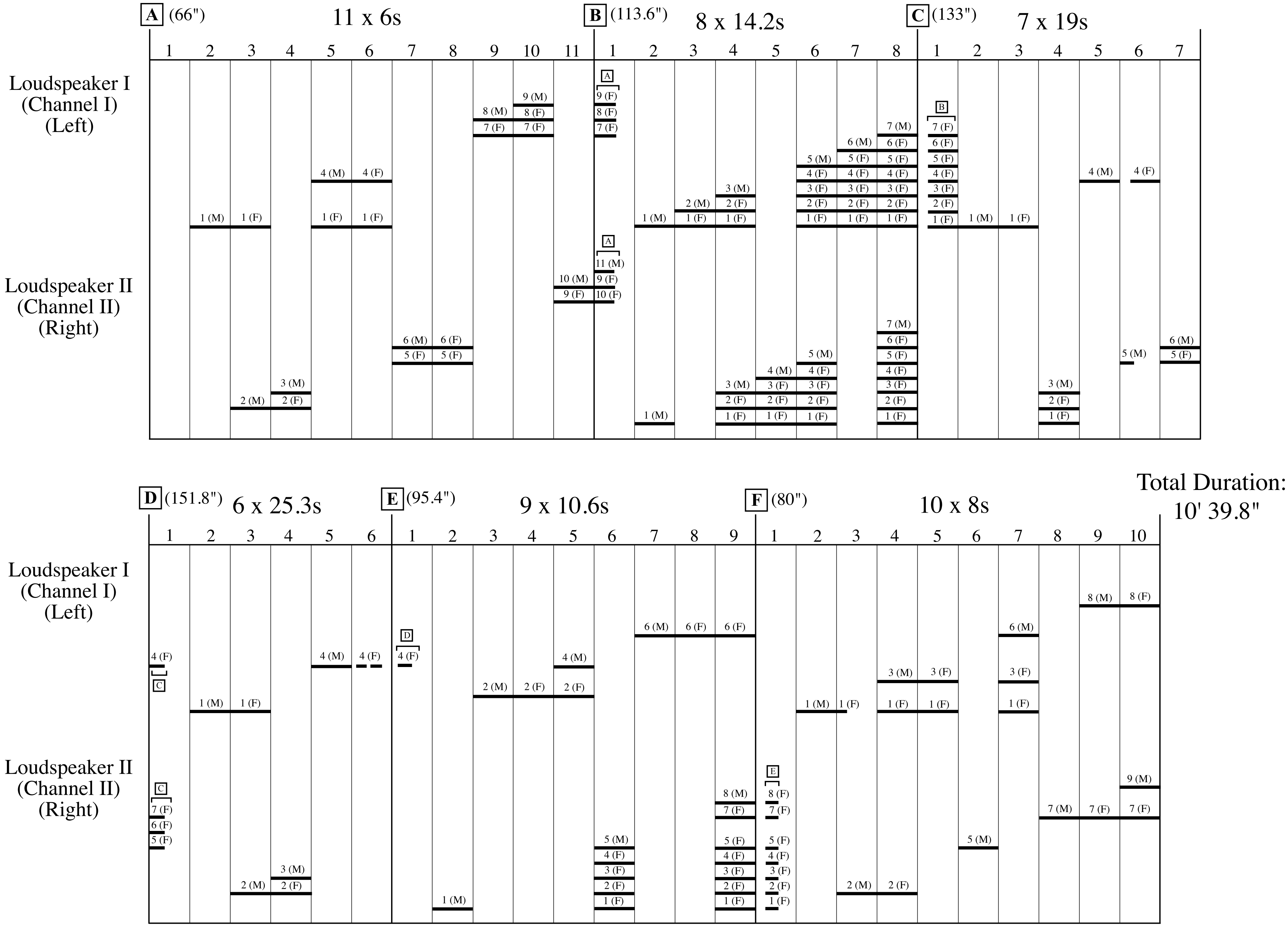
Appendix I
Electronic Superimpositions Graphs

Abbreviations:

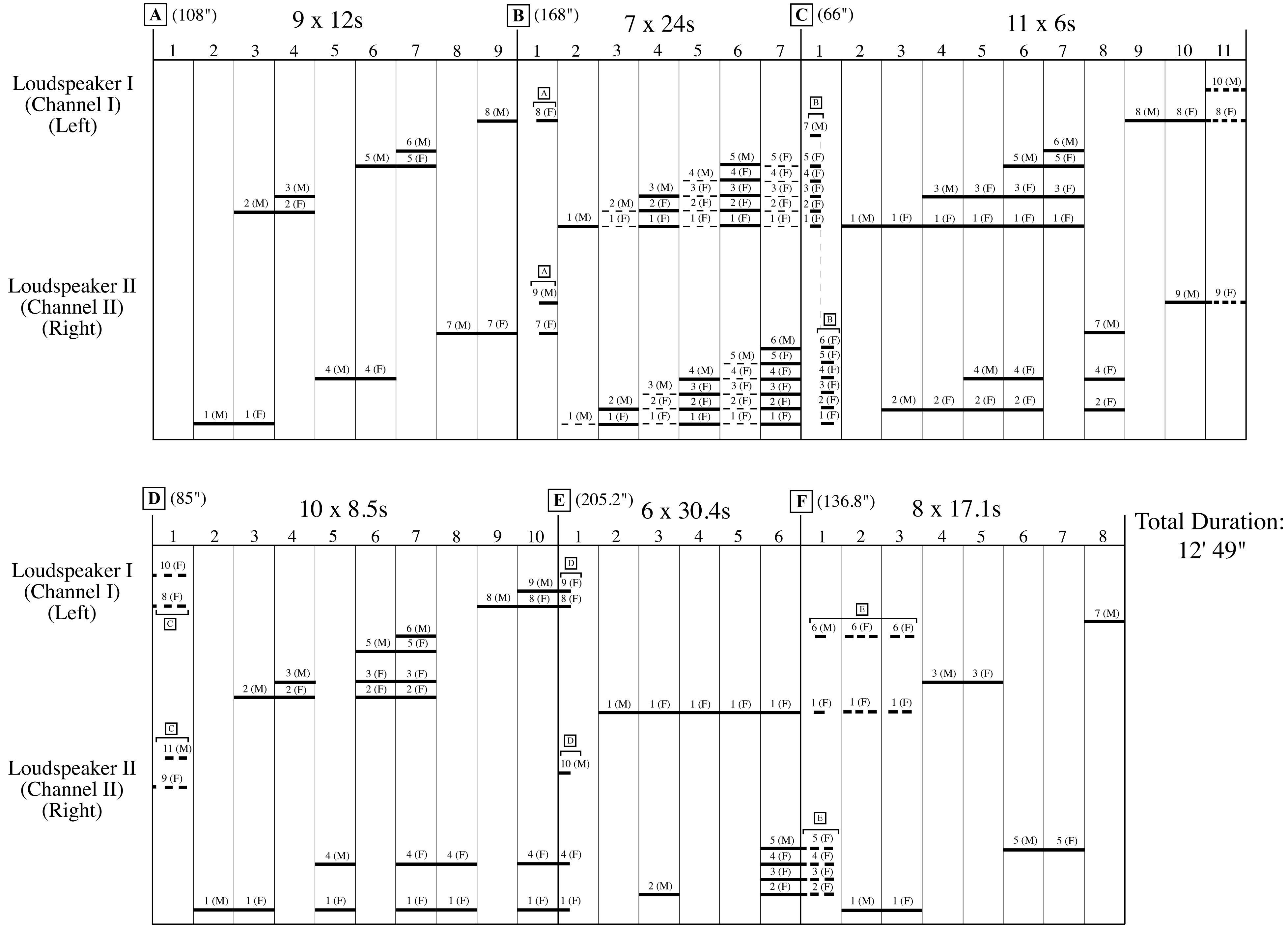
M = Microphone (Electronic Superimpositions that originate from tape delay)

F = Feedback (Electronic Superimpositions that originate from the feedback circuit)

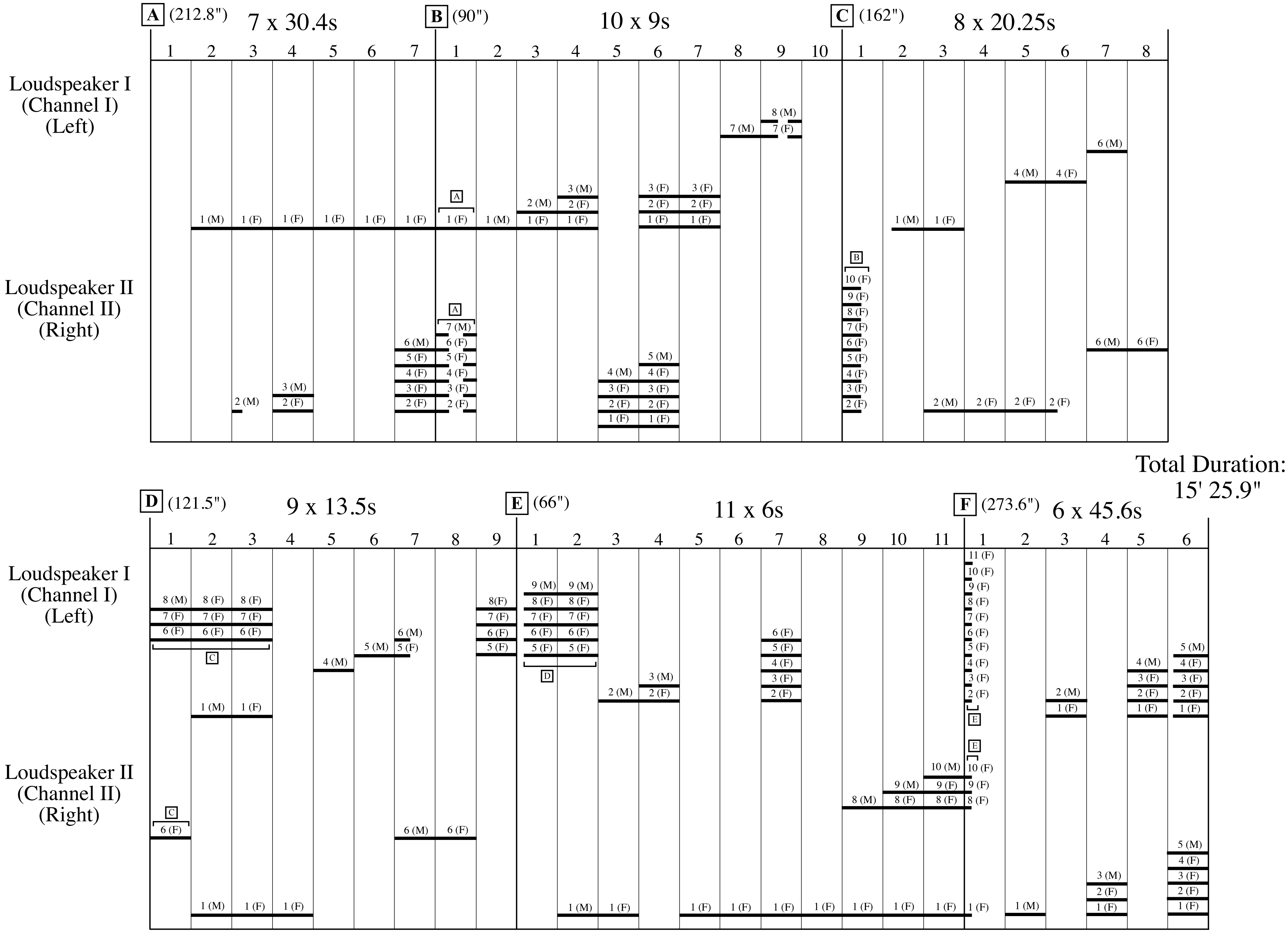
Electronic Superimposition Graph: Form Scheme Version I



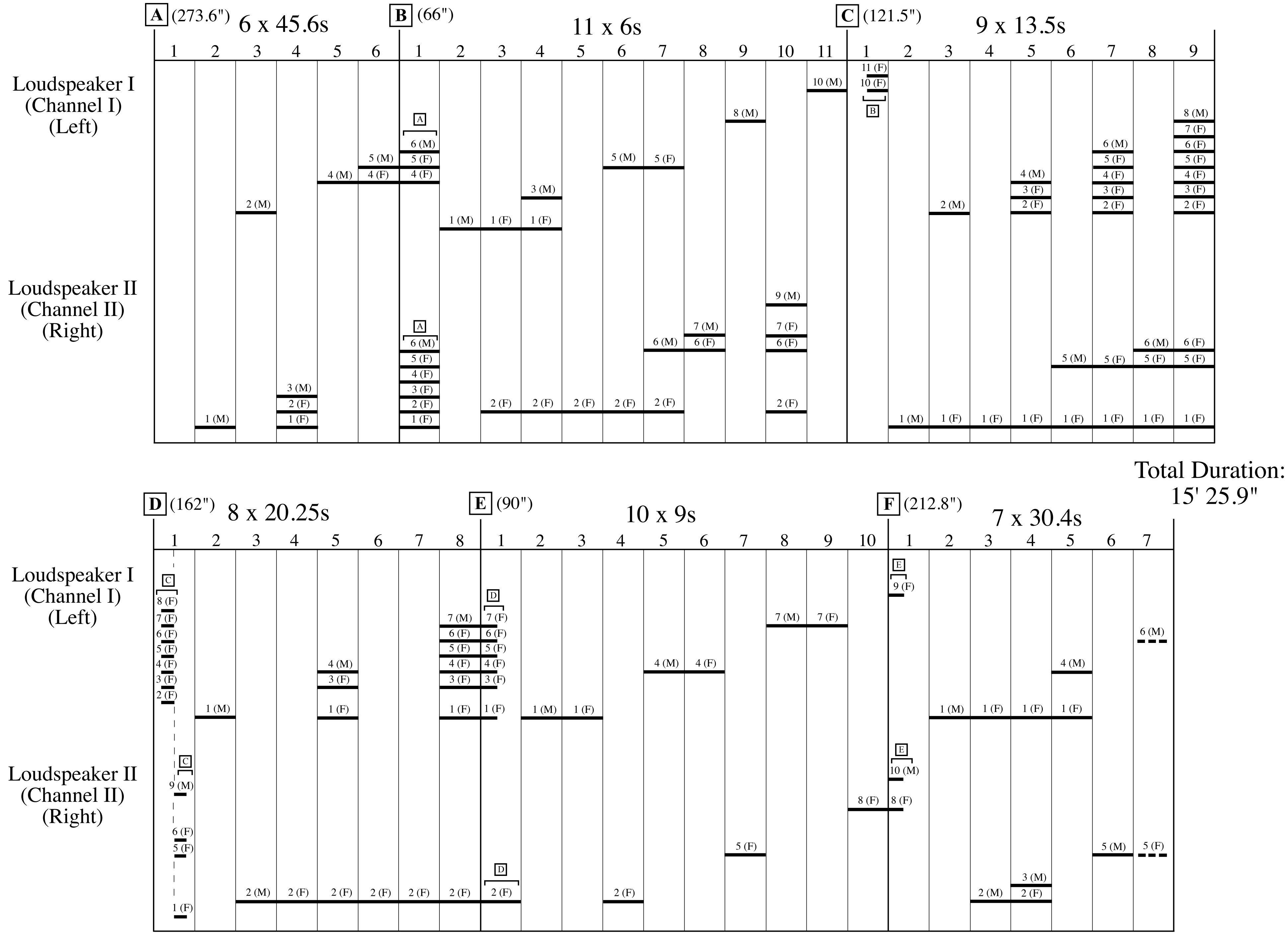
Electronic Superimposition Graph: Form Scheme Version II



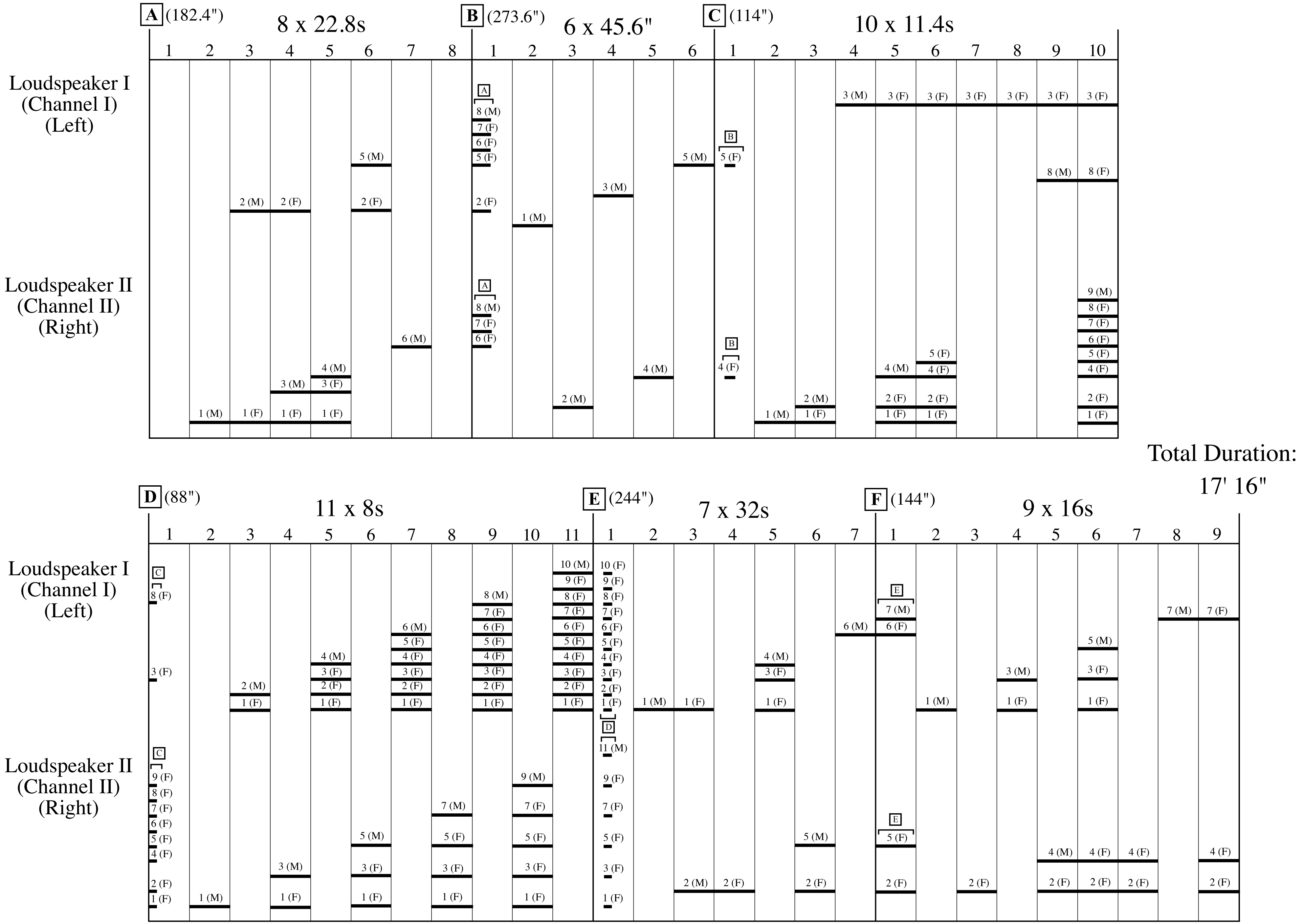
Electronic Superimposition Graph: Form Scheme Version III



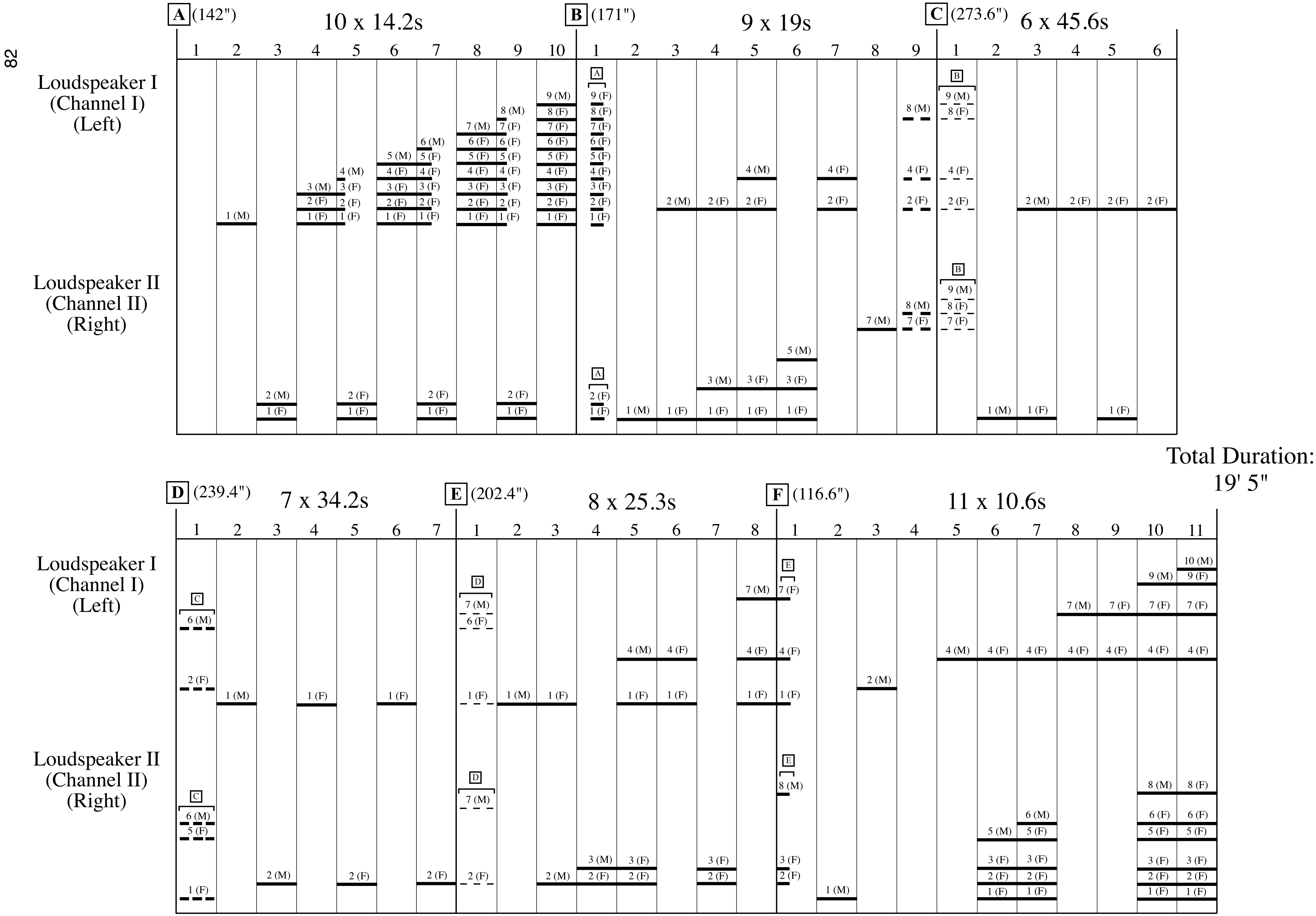
Electronic Superimposition Graph: Form Scheme Version IV



Electronic Superimposition Graph: Form Scheme Version V



Electronic Superimposition Graph: Form Scheme Version VI



Appendix II
Acoustic/Electronic Superimpositions Graphs

<u>Abbreviations:</u>

A = Acoustic (Live sound of the instrumentalist)

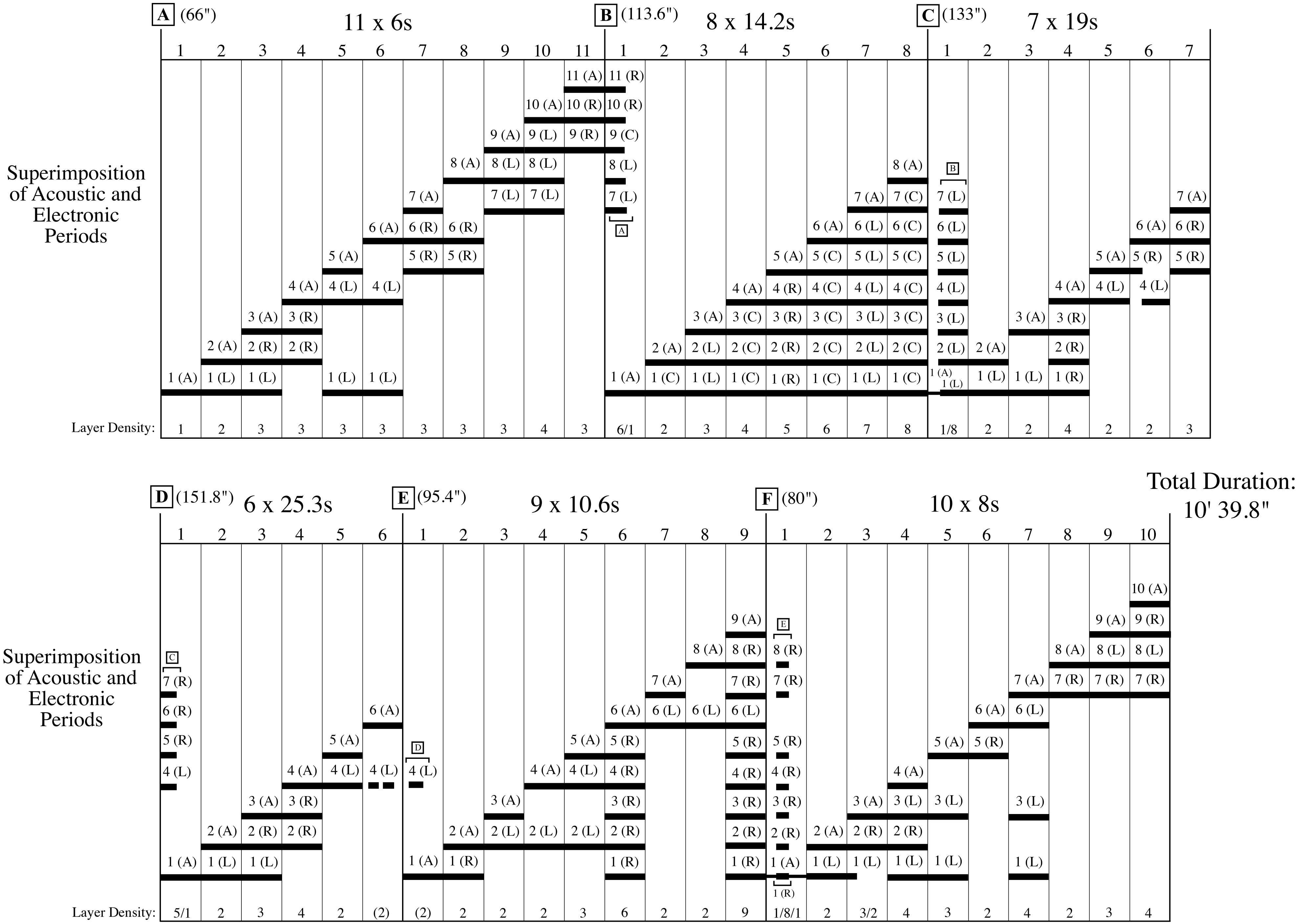
L = Left (Electronic Superimposition originating from Channel I)

R = Right (Electronic Superimposition originating from Channel II)

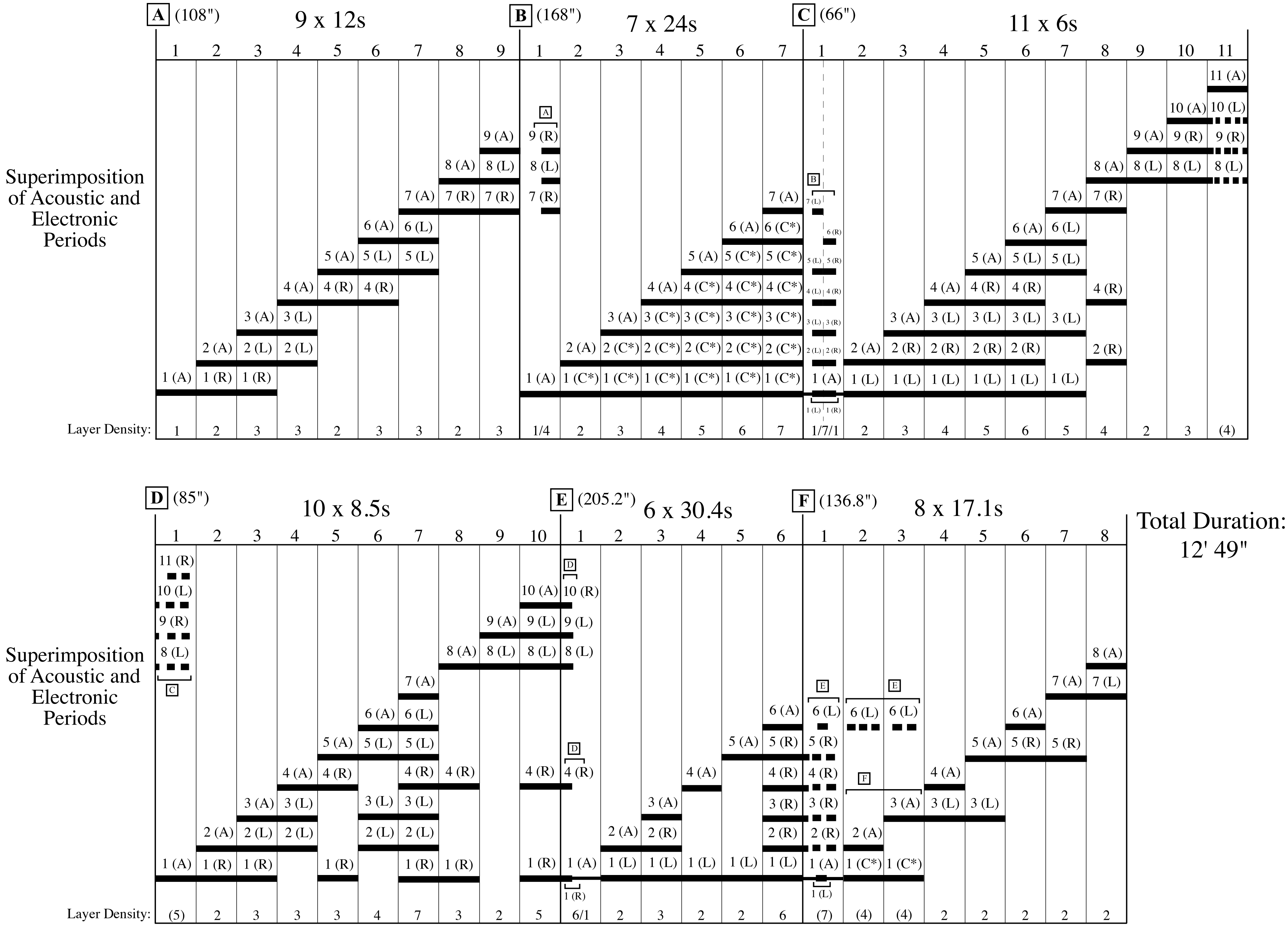
C = Centre (Electronic Superimposition originating from Channel I and II)

C* = Centre (Intermittent output from Channels I and II)

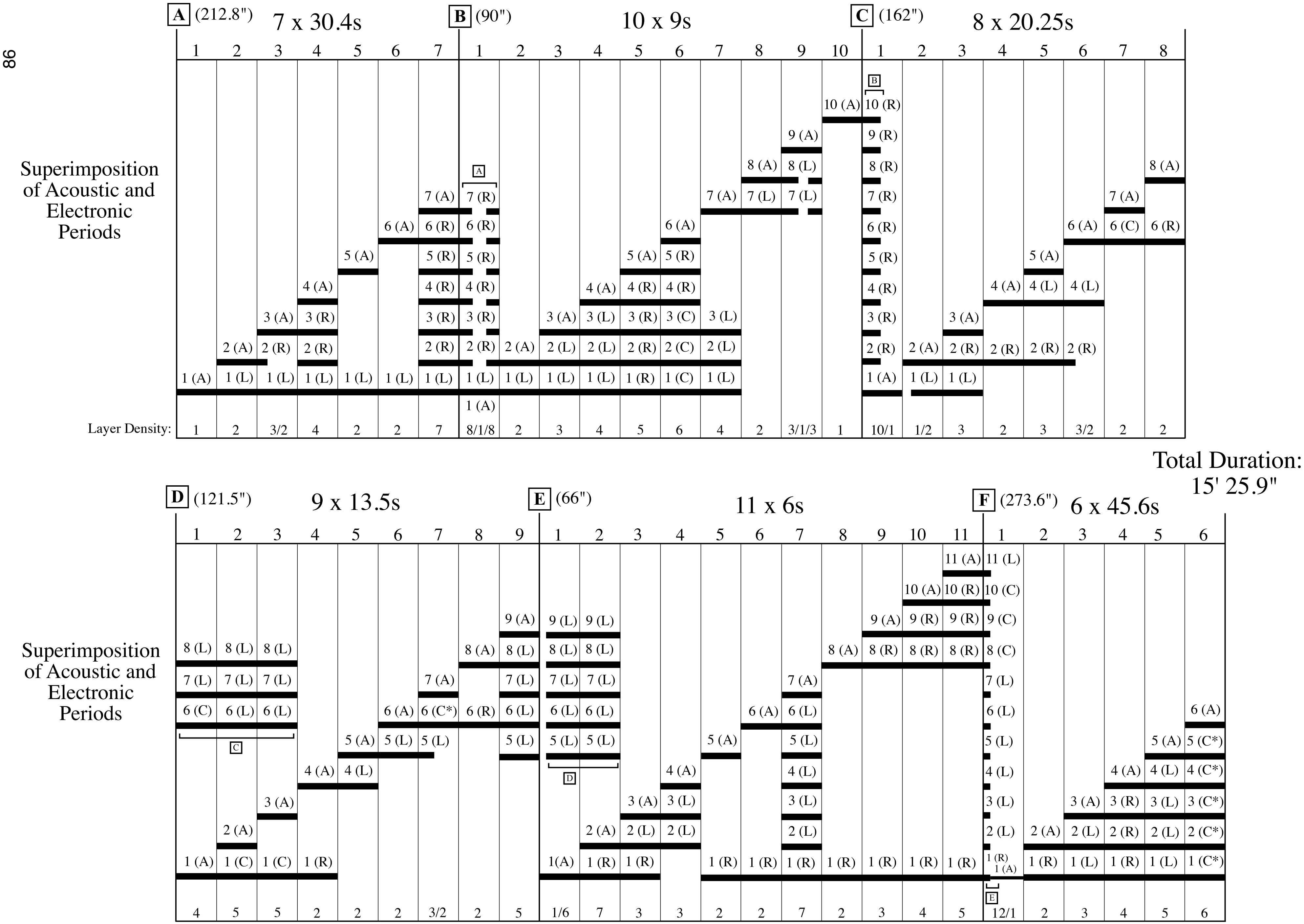
Acoustic/Electronic Superimposition Graph: Form Scheme Version I



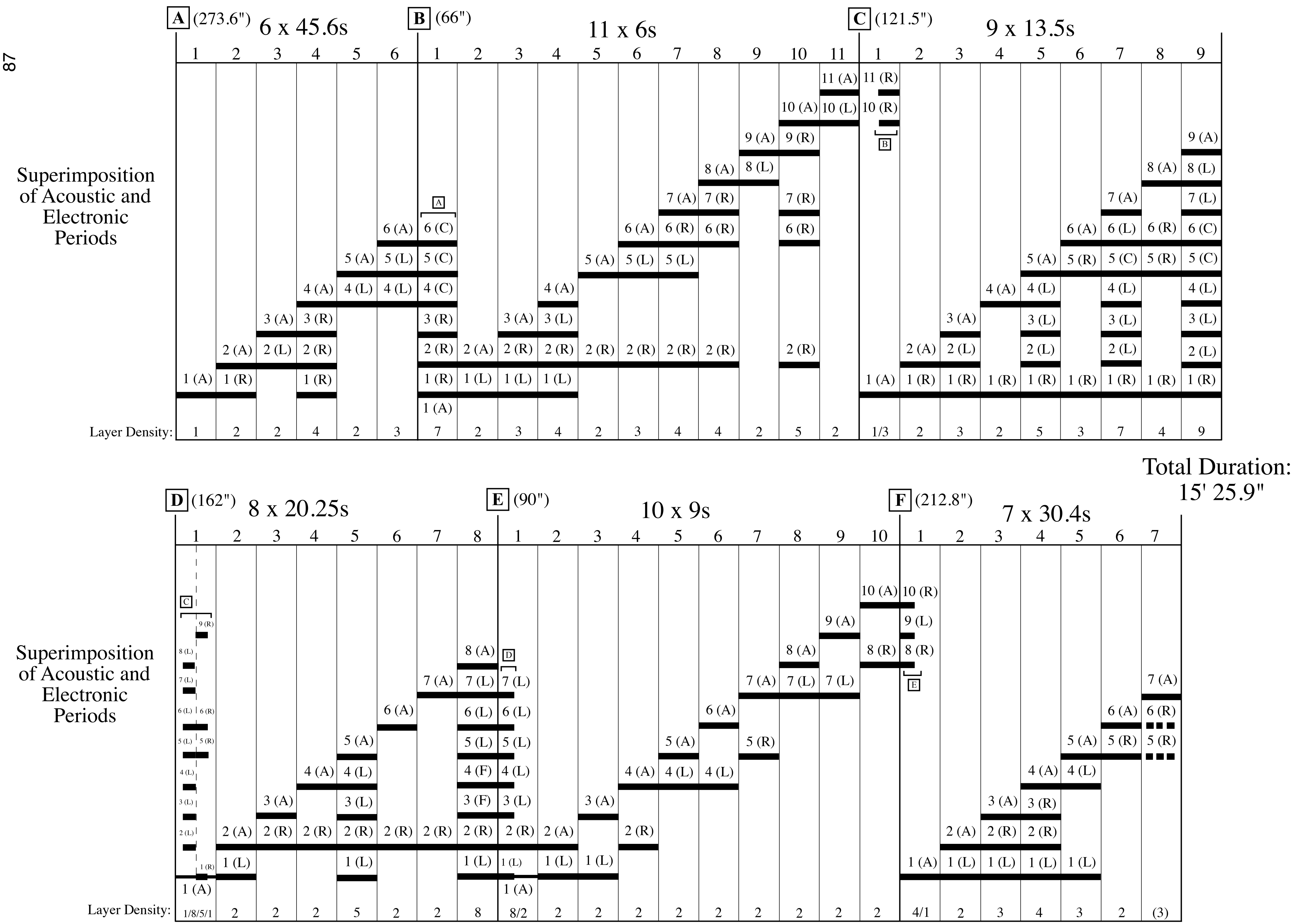
Acoustic/Electronic Superimposition Graph: Form Scheme Version II



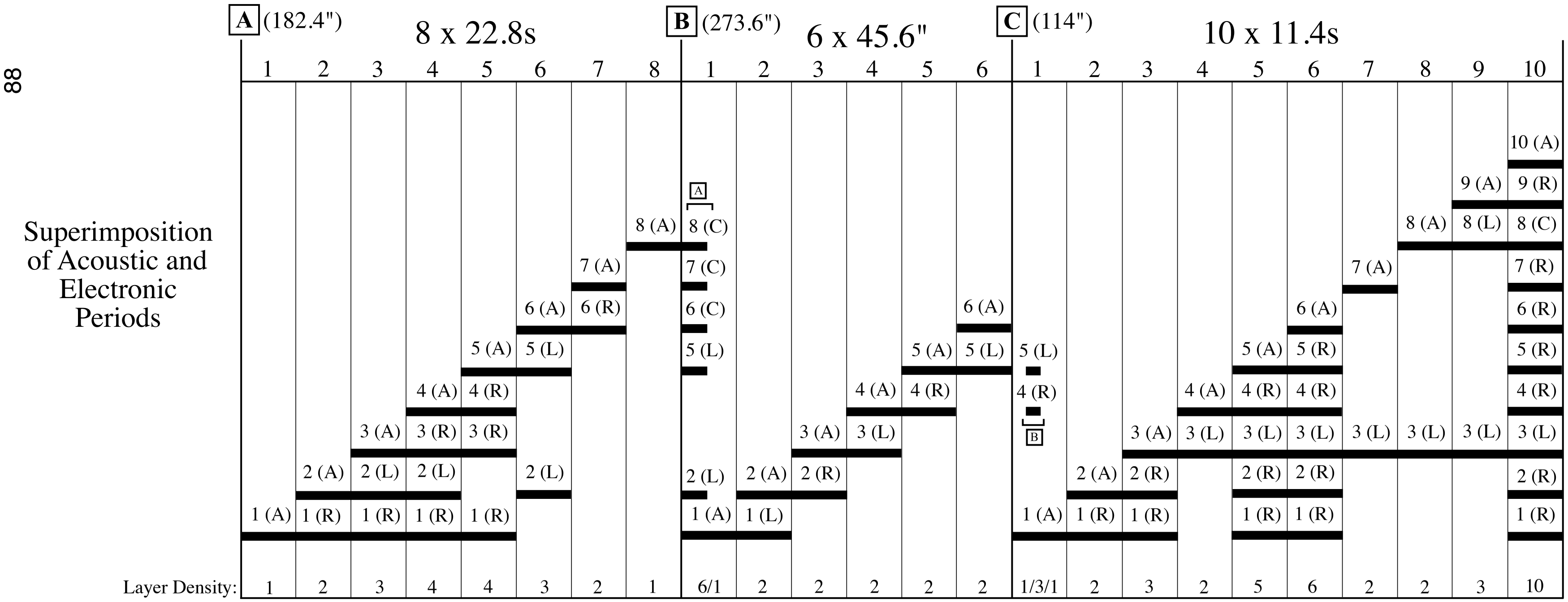
Acoustic/Electronic Superimposition Graph: Form Scheme Version III



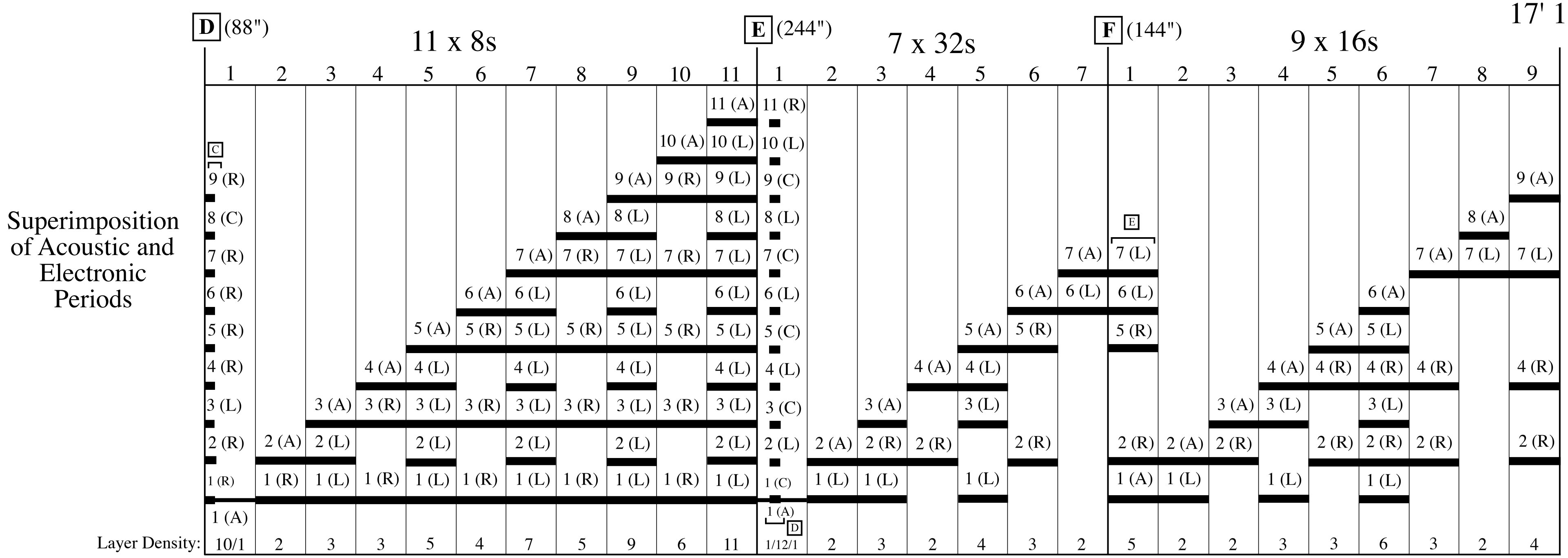
Acoustic/Electronic Superimposition Graph: Form Scheme Version IV



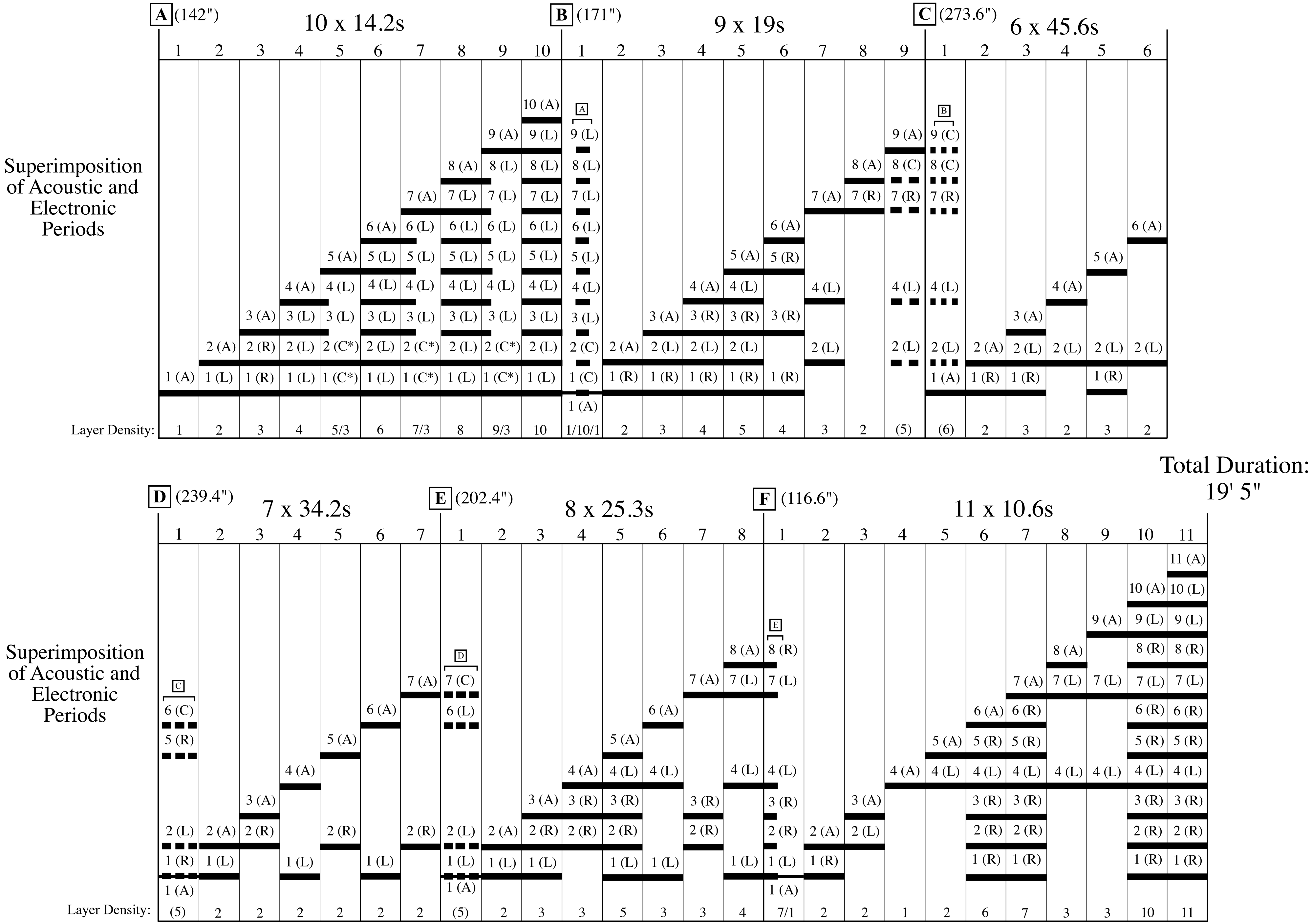
Acoustic/Electronic Superimposition Graph: Form Scheme Version V



Total Duration:
17' 16"



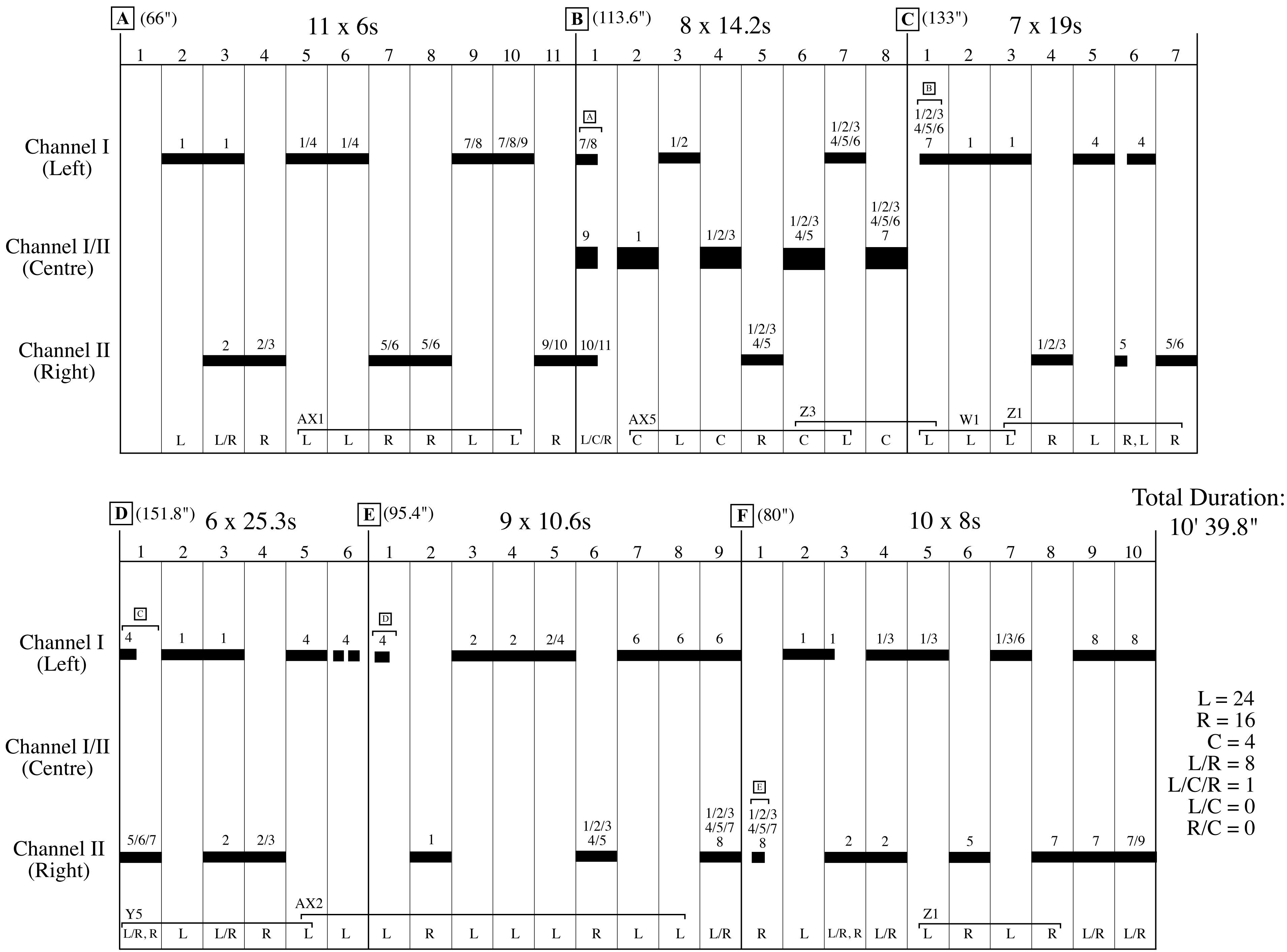
Acoustic/Electronic Superimposition Graph: Form Scheme Version VI



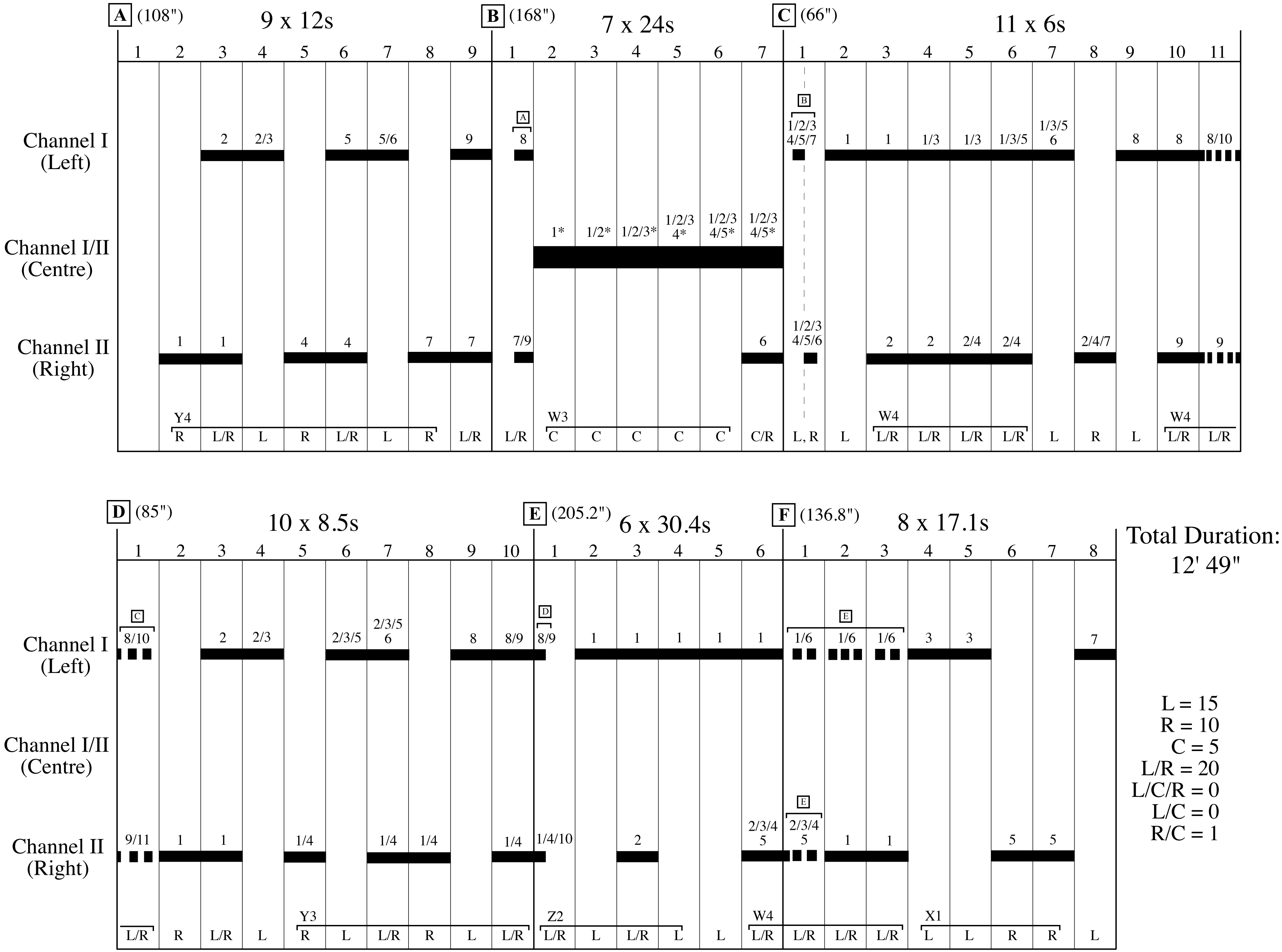
Appendix III

Diffusion Graphs

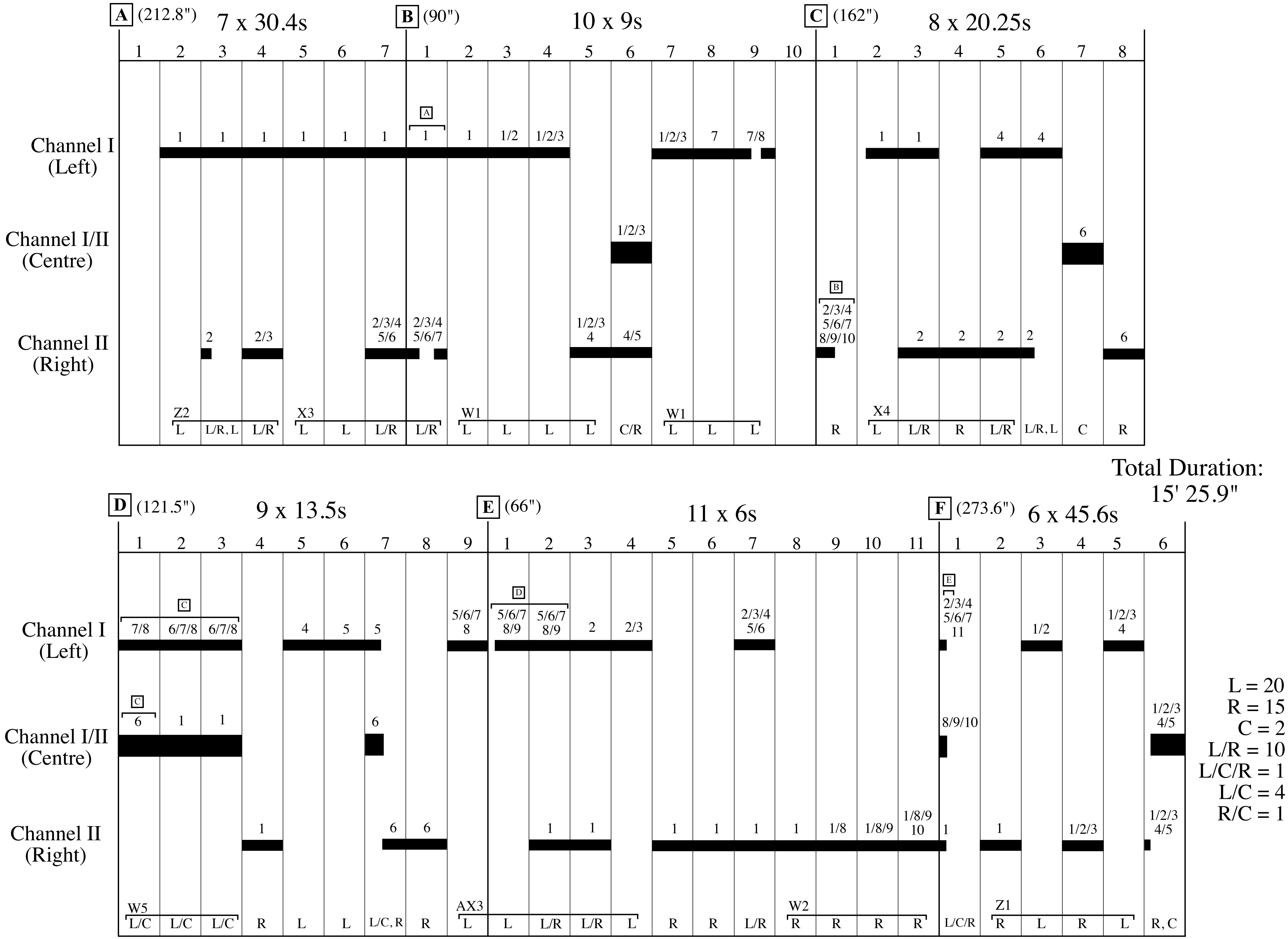
Diffusion Graph: Form Scheme Version I



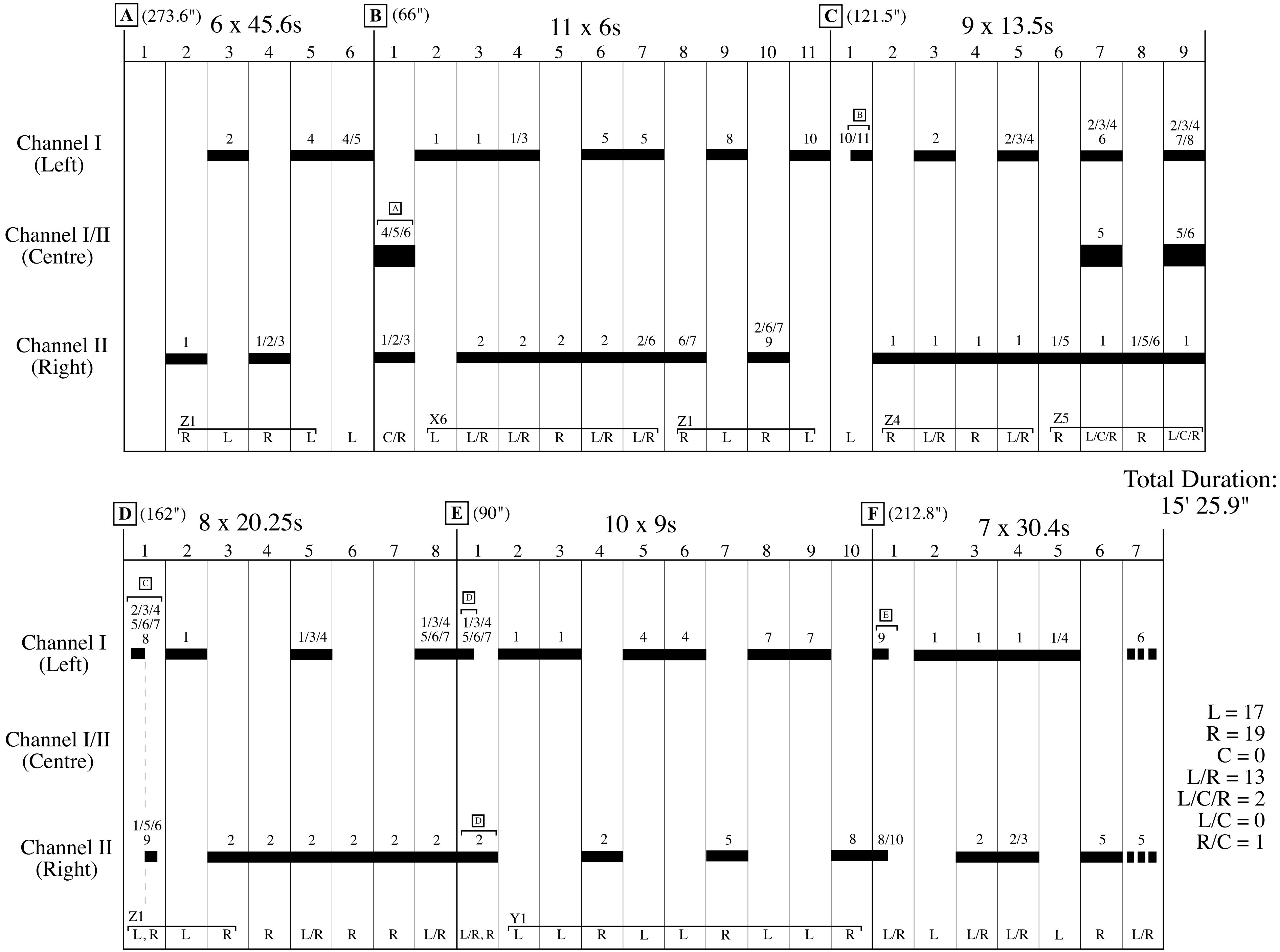
Diffusion Graph: Form Scheme Version II



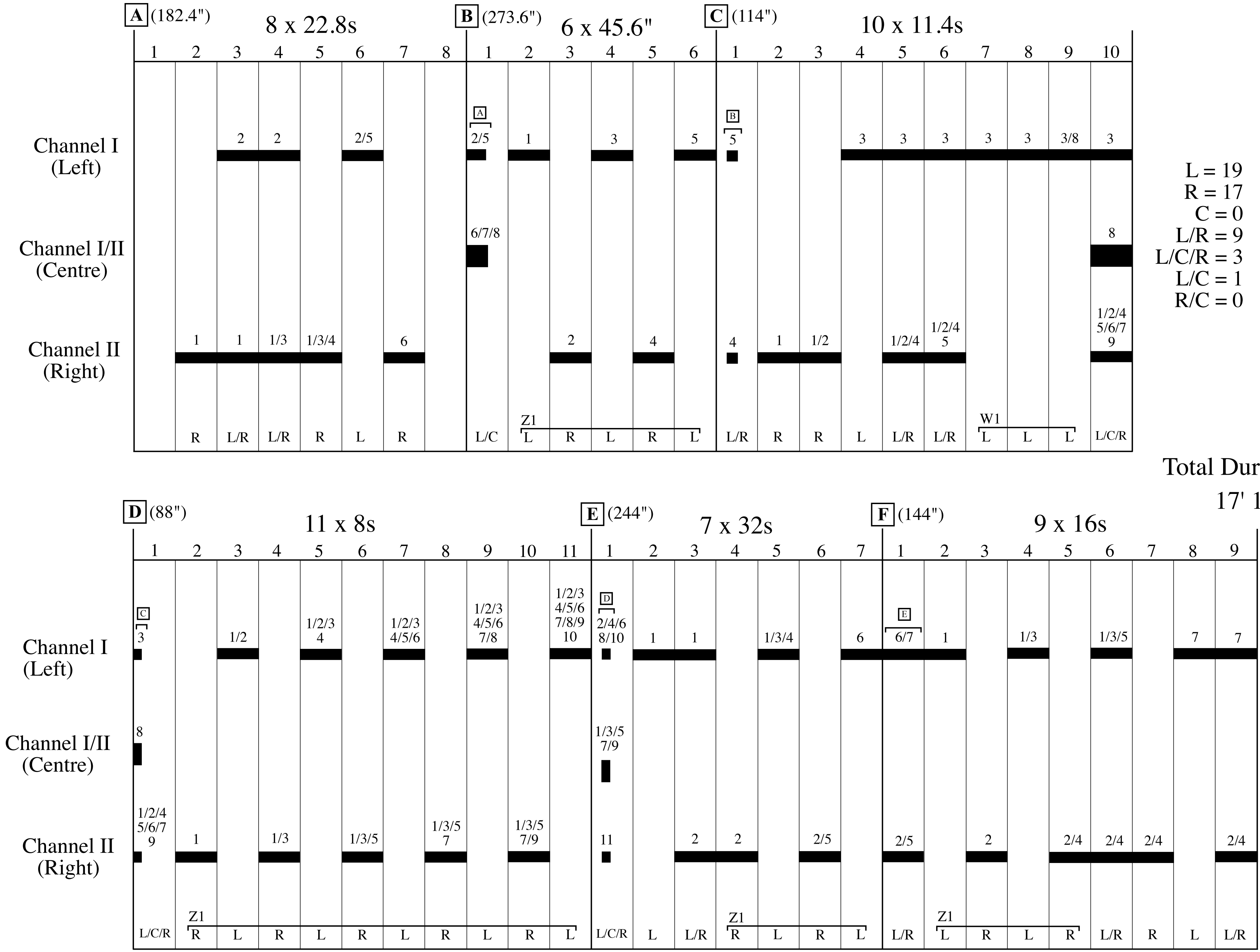
Diffusion Graph: Form Scheme Version III



Diffusion Graph: Form Scheme Version IV



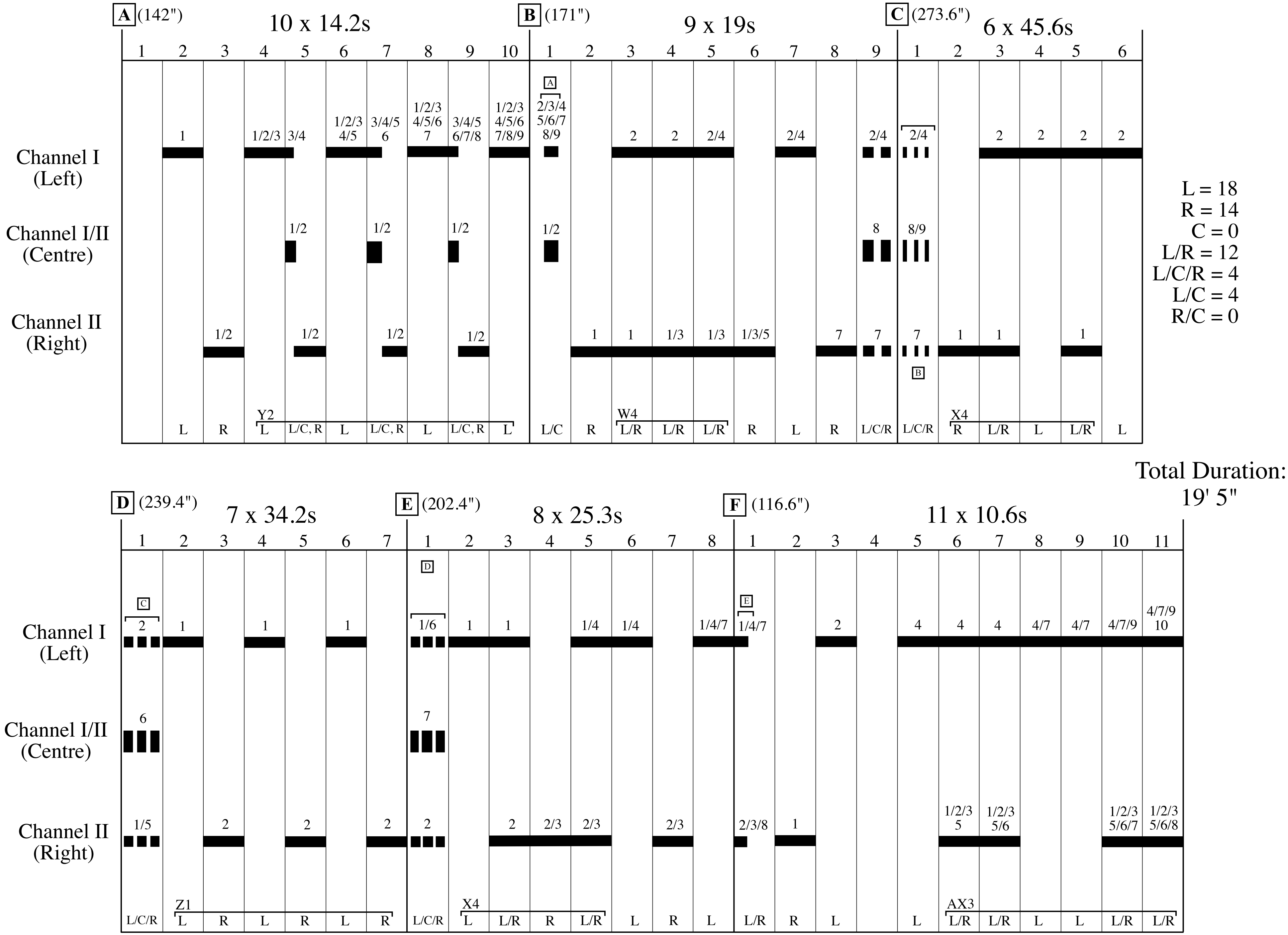
Diffusion Graph: Form Scheme Version V



L = 19
R = 17
C = 0
L/R = 9
L/C/R = 3
L/C = 1
R/C = 0

Total Duration:
17' 16"

Diffusion Graph: Form Scheme Version VI



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