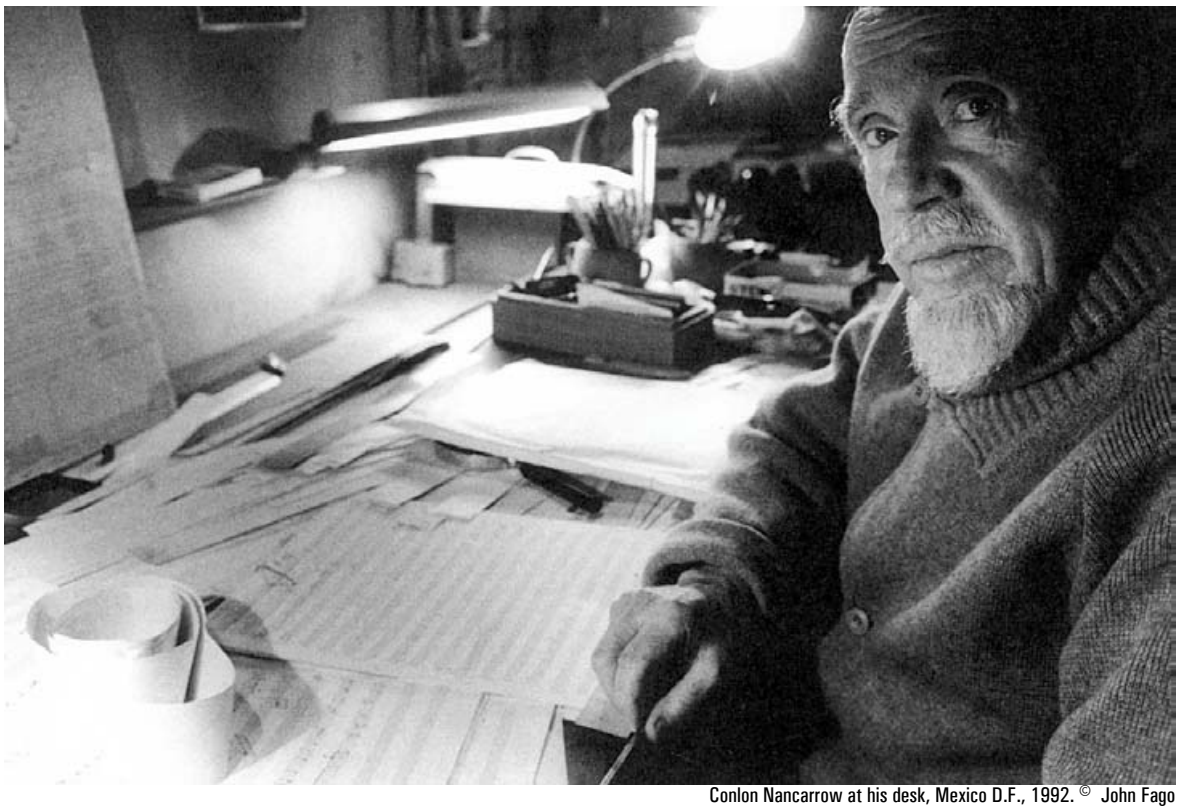

Conlon Nancarrow at his desk, Mexico D.F., 1992. © John Fago

"... THE GREATEST DISCOVERY SINCE WEBERN AND IVES...":[1]

AN ANALYSIS AND SOUND TRANSFORMATION OF SEVERAL OF CONLON NANCARROW'S STUDIES FOR PLAYER PIANO

by Martin Schlumpf

The following article deals with the sound transformation of Conlon Nancarrow's Studies for Player Piano. It is conceived as a work report from the field of applied research at upper-level music schools in Switzerland. My research assignment, from the Zurich Academy of Music and Theater, was granted within the framework of large-scale explorations of problems in twentieth-century rhythm and meter. My task was to produce a CD containing new sound transformations of selected Studies, accompanied by a booklet with a work report. The CD, which will appear in the course of this year, is thus a sort of "wordless analysis" of pieces originally confined to the sound of the piano. As a fitting illustration of the topic, this issue of Dissonanz is accompanied by a sample CD containing several original recordings and sound transformations of the pieces discussed in this article.

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1 György Ligeti on Conlon Nancarrow's music, quoted from a letter of 4 January 1981 to Charles Amirkhanian.

Isolation and impact, seclusion and commitment: Conlon Nancarrow's life and music were marked by simultaneous but antithetical extremes. His early years of radical activism were followed by decades of self-imposed isolation. Similar opposites governed his musical output: originally composed for a mechanical instrument far removed from the eminently human world of the music industry, his music became, after its belated discovery, one of the most fertile breeding-grounds of contemporary art music.

Conlon Nancarrow was born in Texarkana, Arkansas, in 1912. After studying briefly at Cincinnati Conservatory he moved in 1934 to Boston, where he studied counterpoint with Roger Sessions, befriended Walter Piston, and was championed by Nicolas Slonimsky. Being at that time what he called a "fiery radical," he joined the Communist Party and, among other things, organized the musical program of a Lenin memorial celebration at Boston Symphony Hall. A trumpeter who had played jazz and popular music since his teenage years, Nancarrow made his first trip to Europe in 1936 as a member of a dance band, staying for several weeks. One year later, he travelled to Spain as a volunteer in the Abraham Lincoln Brigade to take part in the civil war against Franco. As a result, the United States government refused to renew his passport. This caused him to withdraw to Mexico, where he lived and composed from 1940. In 1956 he became a Mexican citizen.

Until the early 1980s Nancarrow's name was famous in informed circles, but hardly anyone from the European scene had met him in person. This situation quickly changed in 1982, when he was feted at the 20th Cabrillo Festival in Aptos, California. A month earlier he had become one of two winners of the MacArthur Award, which temporarily relieved him of financial worries. In the same year, he travelled through various European cities and appeared at West German Radio in Cologne and at IRCAM in Paris, among other places. The University of Mexico devoted a two-day festival to his music in 1990. Longer journeys followed at somewhat greater intervals, particularly one to New York, where his compositions were heard at a week-long festival of American music in 1994. He died in August 1997.

One of the few books that Nancarrow took with him to Mexico was Henry Cowell's New Musical Resources. It was Cowell's belief that complex rhythms would be easier to produce on a player piano than in live performance.[2] This notion must have kindled in Nancarrow the most momentous idea of his career, particularly as he had always been more interested in rhythm than in pitch. For a long time he turned his back on live performance altogether (not until the 1980s did he again begin to compose for human musicians, and every now and then he consented to have his Studies transcribed for live ensembles). Nancarrow’s decision may have been prompted by other factors no longer reconstructable today, one perhaps being the disastrous New York première of his Septet in 1940, when the performance veered utterly out of control.

Whatever the case, in 1947 he took advantage of a small inheritance to return to New York and buy his first player piano as well as a punching machine for the paper rolls. Later he bought a second instrument in Mexico and covered its hammers with metal and leather to obtain a more incisive and percussive attack. This then became the true medium for his series of Studies for Player Piano (for a long time he called them Rhythm Studies). Today some fifty of these studies, dating from 1948 until the early 1990s, have survived with Nancarrow's authorial sanction. They are the prod

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2 Henry Cowell: New Musical Resources (1930). The passage in question is taken from the new edition (Cambridge: Cambridge University Press, 1996), p. 65.

uct of an ingenious single-mindedness that led the composer to discover a completely new and fantastically unreal world of acoustical presentation: a sort of hyper-virtuoso cross-fertilization between compositional complexity and pianistic exactitude that makes listeners feel as if gravity has been suspended.

The truly extraordinary thing about Nancarrow's Studies is their wholly unique way of handling musical time. The mechanical precision and flexibility of the automated piano enabled Nancarrow to invent a form of music whose metrical intricacy and contrapuntal textures advanced into uncharted musical territory. This highly innovative element sometimes contrasts sharply with other parameters of his music, especially melody and harmony, which often seem far more beholden to tradition. This aspect merits attention in light of Nancarrow's curt remark in an interview he granted to Charles Amirkhanian in Mexico City in 1977. Asked why canon was so important to him, he replied that complex time progressions were easier to follow when the melody remained the same everywhere.[3] To which we might also add: when the musical fabric of the parts is not overly complex.

At this point my paper opens with the question of how much, and with what means, such polymetric phenomena can be highlighted in the auditory faculty by enlarging the range of available timbres. The only working instrument that comes to mind is the computer, the sole modern-day machine capable of producing a perfectly accurate rendition of an extremely broad range of mensural relations.[4] My first task was therefore to sift through the vast amount of source material preserved at the Paul Sacher Foundation in Basel and to classify it for my purposes. I then had to find a way to transform it in the computer, as befit my basic idea, into perfect raw-data MIDI files that could serve as starting points for my sound transformations. By "raw data" I mean the specification of pitch inception, pitch duration, pitch level, and a rough system of terrace dynamics.

The stages along this path can be summarized briefly as follows:

- First, I examined the source material at the Sacher Foundation and the fair copies of unpublished or out-of-print Studies that Schott Musik International placed at my disposal in the form of photocopies.

- Then I began to focus on the canonic Studies.

- I decided to obtain my raw data from Nancarrow's musical notation rather than the player-piano rolls.

- I chose a computer sequencer that made it possible to work practically and flexibly with precisely defined but fully independent temporal levels.[5]

For the rest of my article, I will use five Studies (#13, 19, 22, 34, and 41b, all included on the enclosed CD) in order to discuss various types of canon and the vari

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3 "Conlon Nancarrow Speaks with Charles Amirkhanian," recorded in Mexico City in April 1977 and released on the CD Conlon Nancarrow: Lost Works, Last Works (Other Minds, 2000, OM 1002-2).

4 The term "mensuration" refers to the tempo of a voice, i.e. the speed of its basic metrical unit. A "mensuration canon" is a canon whose voices move in contrasting tempos.

5 I am extremely grateful to Ljubo Majstorovic of the Sound Vision Studio for his many insightful suggestions both in this matter and in general questions of studio equipment.

ous problems of transferring them from the written page to the computer, and to comment on their sound transformations. As space is limited, I have had to omit many interesting details. My analysis focuses on questions of mensuration and their clarification on the basis of the musical text.

Accelerando and Ritardando in Mensuration Canons

Study #34,[6] composed between 1965 and 1977[7] (tracks 1 and 2 on the CD). This piece has an interesting subtitle enclosed in parentheses:

$$\textit{Canon} \quad \frac{9}{4/5/6} \Big/ \frac{10}{4/5/6} \Big/ \frac{11}{4/5/6}$$

What secret lurks behind these numbers? We quickly notice that we are dealing with a three-voice canon. Comparing the opening tempos of the three voices (72/80/88), we discover that their mensurations stand in a relation of 9:10:11 in the order of their entrances (from low to middle to high register). Moreover, the diagram in the subtitle tells us that the ratio 4:5:6 must occur in each voice. If we look at the first tempo marks for the bass voice - 72/96/90/106.6/108/120 - we note that the first, third, and fifth numbers (i.e. skipping every other tempo level) actually yield the ratio we are looking for. The few hints suggested by the subtitle already outline the underlying mensural conception of entire Study:

1) Each voice passes through a series of tempo levels derived from a matrix of 29 tempos (see Example 1).

2) The tempos corresponding to the main proportional series 4:5:6:8:10:12 (printed in boldface in Example 1) are emphasized musically by being assigned an unchanging theme consisting of 120 eighth notes. This process is identical in all voices.

3) As mentioned above, these "thematic" tempo levels are separated by a series of tempos extracted from the basic matrix. These tempos do not relate analogously to the voices, nor do they seem to have any strict logic in their individual progression (see Example 2). Melodically these sections are written in canon, but occasionally interspersed with new ideas.

4) Viewed over the entire piece, the tempo progressions form a successively gradated accelerando, beginning initially with relatively small undulations (i.e. brief ritardandi), progressing to larger undulations, and finally reaching a tempo climax just before the end. After this climax, a quick ritardando in strict mensuration canon passes through all ten tempo levels to the end of the piece. This concluding gesture of "retraction" is practically unique in Nancarrow's music.

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6 Conlon Nancarrow: Study #34 for Player Piano (Mainz: Schott Musik International, unpubd.).

7 The most reliable information on Nancarrow's work-list and biography can be found on Kyle Gann's website at http://home.earthlink.net/-kgann/cnworks.html. All the chronological information in my article has been taken from that source.

Example 1

	1.		2.		3.		4.		5.		6.		7.		8.		9.		10.
	10	:	12	:	15	:	16	:	18	:	20	:	24	:	30	:	32	:	36
	2		**:**		**3**			**:**			**4**								
			4	**:**	**5**		**:**		**6**				**8**		**10**		**:**		**12**
			3		**:**		**4**		**:**		**5**								
High voice: 11s	73.3		88		110		117.3		132		146.6		176		220		234.6		264
Middle voice: 10s	66.6		80		100		106.6		120		133.3		160		200		213.3		240
Low voice: 9s	60		72		90		96		108		120		144		180		192		216

Tempo matrix of Study #34, where ".6" refers to two-thirds and ".3" to one-third. It encompasses a total of 29 tempos, i.e. ten levels in three voices ("120" occurs twice), arranged in an initial group of five with the proportions 10:12:15:16:18:(20). Concealed within this group are the proportions 2:3:4, 3:4:5, and the central 4:5:6. A second group of five tempos to the right repeats these proportions multiplied by a factor of 2.

Example 2 shows the actual tempo sequence of the three voices arranged by theme (A) and free interludes (B, C, D, etc.).

Example 2

	A1	**B**	**A2**	**C**	**A3**	**D**	**A4**	**E**	**A5**	**F**
High voice: 11s	88	106.6	110	117.3	132	133.3	176	146.6	220	176
Middle voice: 10s	80	96	100	117.3	120	120	160	146.6	200	160
Low voice: 9s	72	96	90	106.6	108	120	144	133.3	180	144
	A6	**G**	**H**				**A'**			
	264	234.6	220	176	146.3	132	117.3	110	88	73.3
	240	213.3	200	160	133.3	120	106.6	100	80	66.6
	216	192	180	144	120	108	96	90	72	60

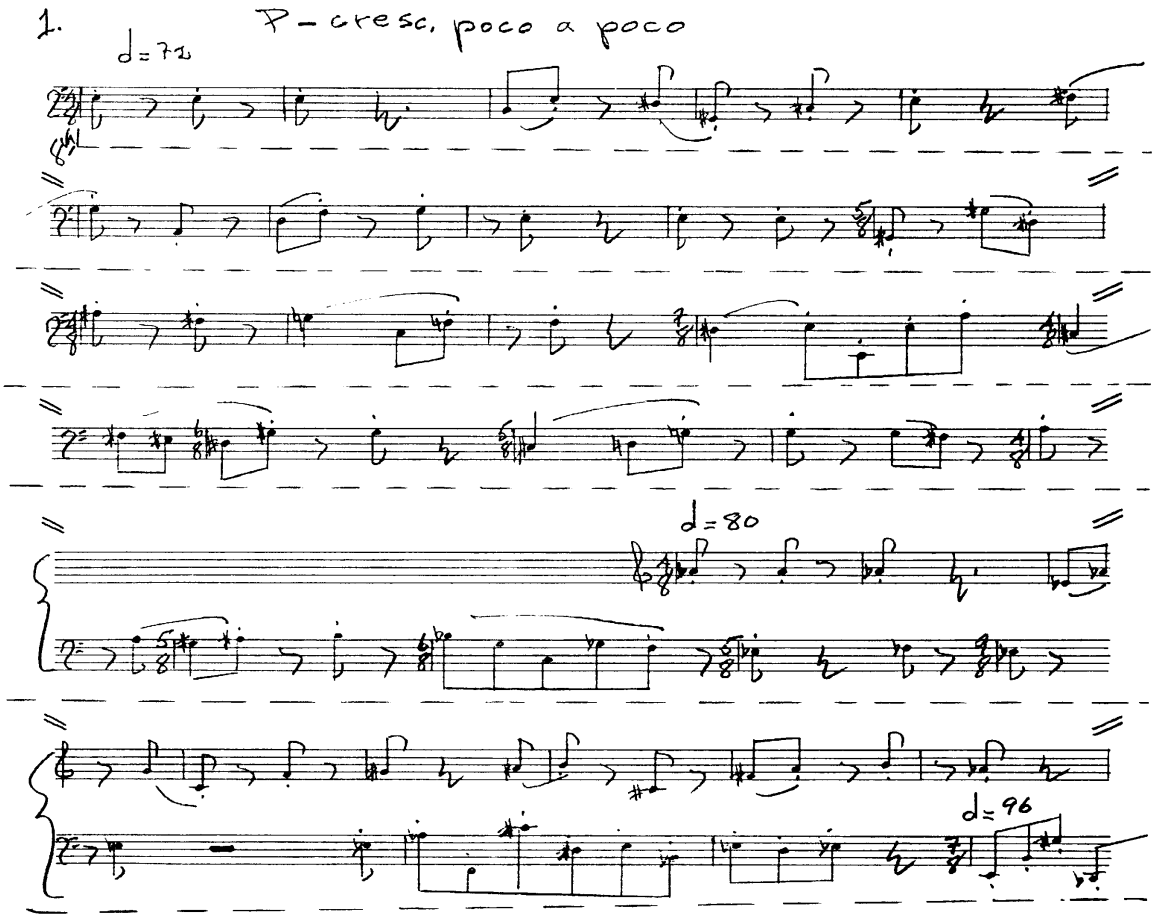
Progression of tempo levels in the three voices of Study #34.[8] Figures appearing vertically superposed in the chart are in fact heard after an intervening interval of time, as is usual in canonic writing.

8 See Kyle Gann: The Music of Conlon Nancarrow (Cambridge: Cambridge University Press, 1995). Gann presents the same table on page 131, but with four mistakes: the tempos given for C, D, and H in the 11s voice are incorrect (because Nancarrow forgot to enter the tempo changes for these passages in his fair copy although they are clearly visible in the proportional notation and the punch master), and the second tempo mark after H is missing (without it there would be no continuous ritardando!). None the less, Gann's book is indispensable for a close study of Nancarrow, offering a multitude of essential analytical observations on all his works.

A close perusal of this table and a comparison with the tempo matrix in Example 1 reveal that the mensural relations fall into a ordered whole. While the A sections, or "refrains" (the voices, after all, are structured in rondo form), accelerate in strict accordance with their proportions, the first four "episodes" interpolate tempo levels 4 and 6 from the matrix (i.e. the non-thematic tempos) in such a way that the slowest tempo occurs twice together with the middle tempo, then the fastest tempo occurs twice together with the middle tempo, after which the whole pattern is then repeated. The result is a moderate sort of acceleration among the non-thematic tempos. Finally, Episode F repeats tempo level 7 (analogous to A4), followed by the tempo climax with A6 in a ratio of 3:2. Tempo level 9 is exclusively set aside for G, which already stands out acoustically by virtue of the octaves, heard here for the first time.

What does the fair copy of this Study look like? Example 3 shows the first page, with refrain theme A1 in the lowest voice and the entrance of the second voice in the middle register occurring on staff 5.

Example 3



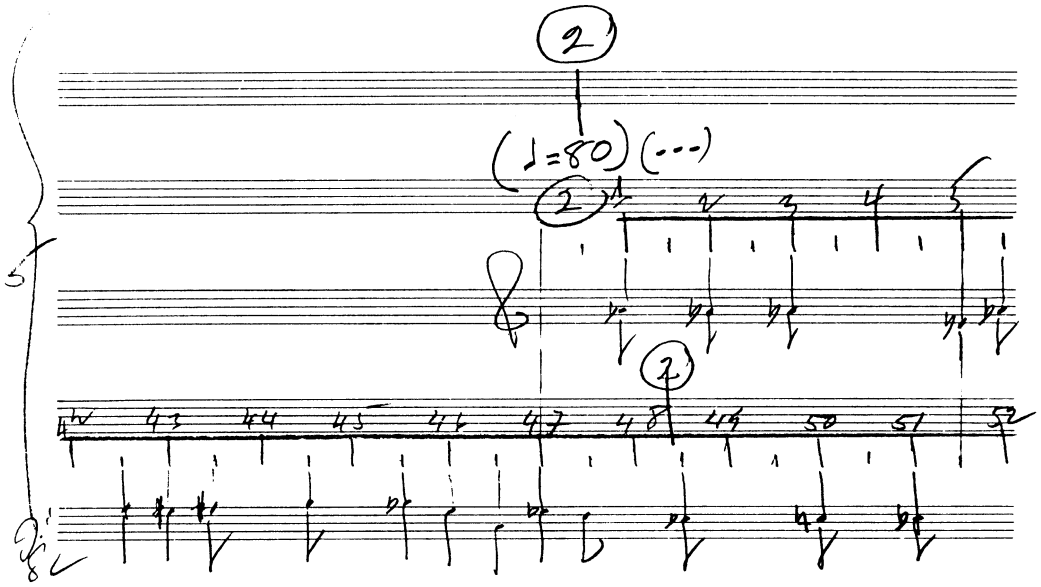
Page 1 from the first fair copy of Study #34.[9]

9 All of the examples from Nancarrow's fair copies and punch masters are taken from the Conlon Nancarrow Collection at the Paul Sacher Foundation in Basel, which kindly granted permission to reproduce them in my article. In particular, I wish to thank Dr. Felix Meyer for

This theme is easy to identify by ear, thanks to its striking opening of regularly reiterated pitches and its distinctive concluding figure of ten eighth notes constructed from the horizontalized quartal sonority F2-Bb2-Eb3-Ab3-Db4 (Ex. 3: bottom staff, before new tempo 96).[10]

When precisely does the second voice enter in relation to the first? Apart from their vertical placement in the manuscript, itself extremely precise for a handwritten score, the fair copy does not give us an exact answer to this question (the two voices never seem to coincide). The key to the answer is found in the punch master, the first stage in Nancarrow's compositional process. Here, in addition to the pitch levels, the mensural relations and the displacement of the voices are exactly indicated on the basis of grid systems. Example 4, a detail from the punch master for Study #34, shows the moment at which the second voice makes its entrance.

Example 4



Detail from page 3 of the punch master for Study #34.

Now everything becomes clear: the mensural relation 9:10 (i.e. the ratio of tempo 72 to tempo 80) starts on the Gb3 in the lower voice, from which point we always hear ten eighth notes for every nine. The first note of the middle voice is not placed at this point of synchronization in the two grid systems. Indeed, it turns out that none of the notes shown on the page in Example 3 exactly coincides with any other.

Now let us measure and compare the durations of the three voices. The result falls fairly precisely into the ratios of 9:10 and 10:11. This is not a trivial conclusion when we recall the conflicting tempo progressions of the first four episodes (Example 2) or the various lengths of rests between sections in the fair copy. In fact, however, Nancarrow has managed to organize all the entrances of the various sections in such a way that they always fall into the ratio 9:10:11, with the voices necessarily entering

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demonstrating Nancarrow's original pianos, for providing material of various sorts, and for carefully reading my manuscript.

10 The pitch levels are identified in American letter notation, where C4 = middle C.

faster and faster the closer they come to the end (the point of synchronization). Moreover, the significance of the refrain theme is further underscored by the fact that it recurs at practically unchanged intervals in each voice, thereby producing more and more space for the episodes as the piece goes on. Indeed, the intervening sections really do expand from B to E, and F, though shorter, is surrounded by longer rests.

The combination of temporal ideas of the sort we find in Study #34 is unique in Nancarrow's oeuvre: three canonic voices, rigorously interrelated in their melodic substance and organized into a rondo form, proceed fairly consistently in the mensural ratio of 9:10:11 while the logical yet flexible "interior tempos" of the voices produce a large-scale gradated accelerando (with occasional interruptions) and a brief, quasi-linear concluding ritardando.

The main point of my sound transformation was to highlight these essential features.

First, as in several other canons, I chose a device that is taken for granted by today's studio engineers: I separated the three voices and placed them in a stereophonic panorama, with the low voice in the middle, the middle voice to the left, and the high voice to the right. This alone makes it much easier to follow the progression of the voices than in the original, although Nancarrow himself provided the key prerequisite by placing the voices in different registers.

The second step was to supply contrasting instrumentation for the "thematic" and the "non-thematic" sections.[11] The refrain theme is assigned to three different pianos, while the sound of the episodes is laid out in a large-scale retrograde arch: B = harp, C = marimba, D = string pizzicato, E = marimba, F = harp. From G the marimba and string pizzicato are combined in octaves. To reinforce the special character of the ending (the section marked A' in Example 2, i.e. the first 18 pitches of A, repeated literally but in a slightly different rhythm), the preceding sound is rejoined in this section by the pianos.

Third, in keeping with the metrical subdivision of the voices (irregularly changing meters; see Example 3), I altered the attack so that the listener perceives a "living" articulation, especially in the pianos. This lends a characteristic feel to each of the themes.

Finally, it turned out that the metronome marks in the fair copy are quite obviously too fast. A comparison with the original recording issued by Wergo makes this apparent:[12] instead of half-note = 72, the piece begins at tempo 48 (!). I have chosen a slightly quicker opening at half-note = 54, i.e. in a 3:4 ratio to the score, as the tempo climax still seemed intelligible to me at this speed. The interesting point is that Episode G has precisely the same tempo in the original recording as in my transformation, i.e. half-note = 144, although the original should actually be half-note = 128 when measured from the beginning. This reveals a familiar phenomenon of player piano music: rather than moving at a constant speed, the paper roll moves

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11 In this context, "instrumentation" means selecting sounds that the computer is capable of "administrating" internally or via the MIDI interface. In my studio, I used three sound expanders from Korg, Roland, and E-Mu and a library of Akai samples controlled by a software sampler.

12 Conlon Nancarrow: Studies for Player Piano Vols. I to V (1988), issued by WERGO Schallplatten GmbH Mainz as WER 6168/69-2 and 60165/66/67-50.

faster toward the end for purely physical reasons![13] As a result, the original and my transformation have an identical tempo climax although they start at different speeds. This allows us to compare the original recording with a computer version containing the time relations Nancarrow actually intended.

Time-Stretching Calibrations

Study #22,[14] composed between 1948 and 1960 (tracks 3 and 4 on the CD). Once again, the essential features of this Study are pointed out in a subtitle:

Canon - 1% / 1½% / 2¼%

What do percentages have to do with music? If we listen to the Study with this question in mind, it will presumably become clear that these numbers govern the finely gradated accelerando and ritardando progressions. But what, for example, is a 1% acceleration (that is how the piece opens)? The answer: nothing but a chain of metrical units whose tempos increase in the ratio of 100% to 101% from one unit to the next, yielding an acceleration coefficient of 1.01. In other words, each tempo figure is multiplied by this factor to produce the next value. This sort of tempo change is known as a "geometrical accelerando" (by analogy with the geometrical series) as apposed to an "arithmetic accelerando" in which a constant duration is subtracted from each adjoining unit.[15] The first study that falls into this "time stretching" category, Study #8, applies various forms of arithmetic accelerando.[16] Study #22 is the first in which Nancarrow applies a geometric progression.

In the opening section, the three voices enter at canonic intervals with identical note values, and hence at the same initial tempo. They then accelerate separately, the first at 1%, the second at 1.5 % and the third at 2.25%. The intervals between entrances have been selected so that all three voices exactly coincide after 96 metrical units. This point of synchronization is indicated by the two arrows placed in the bottom system of Example 5.

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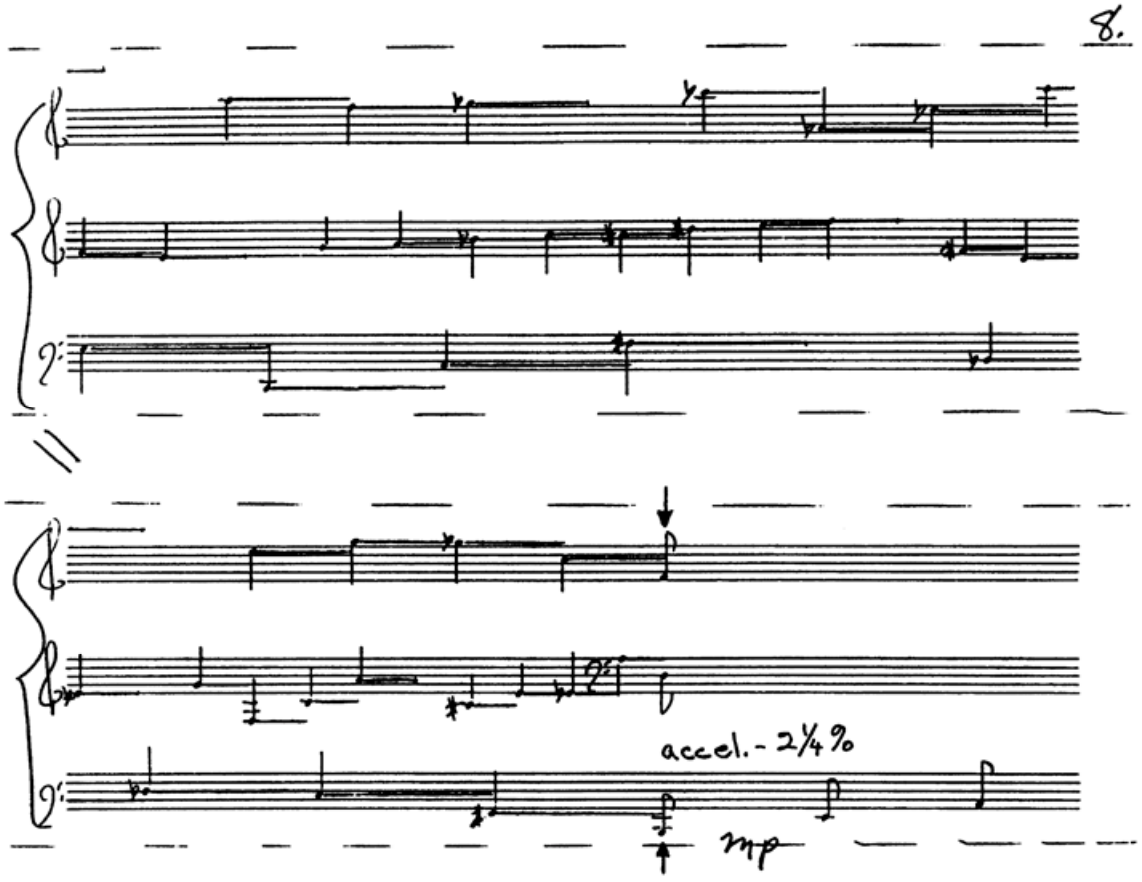
13 First described by Gordon Mumma: "Briefly about Nancarrow," in Conlon Nancarrow: Selected Studies for Player Piano, ed. Peter Garland (Berkeley: Soundings Press, 1977), pp. 1-5.

14 Conlon Nancarrow: Study #22 for Player Piano (Mainz: Schott Musik International, unpubd.).

15 Here I am speaking of accelerando as one form of "time manipulation" for which the opposite form, ritardando, is always implicit. See also K. Gann (note 8), who uses the term "time stretching." Since Gann also discusses examples of arithmetic and geometric progressions in chapter 7, pp. 146-8, I refrain from comparing them here.

16 The punch master for this Study contains highly interesting sketches in which Nancarrow tried out various forms of notation.

Example 5



Detail from page 8 of the fair copy of Study #22 (two arrows entered by author).

In purely graphical terms, it is apparent that just before the point of synchronization the middle voice (the last to enter) is progressing at about twice the speed of the upper voice (the second to enter) and at roughly 3.5 times the speed of the low first voice. The later voices thus catch up with the earlier ones, with all voices reaching approximately the same tempo shortly after the middle of the section (this detracts slightly from the general feeling of accelerando).

Example 5 also clearly illustrates the so-called "proportional notation,"[17] an unbarred form of musical notation fully in keeping with the notion of time stretching. But Study #22 is not only conditioned by this special form of notation: it also presupposes a fundamentally new understanding of time. Whereas all the previous Studies were based on time grids,[18] the music is now conceived in a completely "sliding" time continuum. In other words, to adopt Nancarrow's pragmatic way of thinking, the punching process, which was formerly possible only in tiny unchanging increments, now abandons all restraints and the holes can be punched in infinitesimal gra

17 Proportional notation first occurs (as an isolated instance) in Study #8, followed consistently by #20-23, #25, #27-9, and later #41, #42, #45, and #47-50.

18 Even the predecessor, the famous "Canon X" (Study #21), in which two voices traverse an analogous path in retrograde time-stretching processes, is based on a grid system and occasionally involves subtle leaps of tempo.

dations. It was evidently for this purpose that he had his second punching machine rebuilt in the early Sixties.[19]

To transfer this process to the computer, several invariants have to be observed:

1) the three voices evidently all begin with an identical duration corresponding to an initial tempo of 44-45;

2) they have to reach a clear point of synchronization at the end of the section;

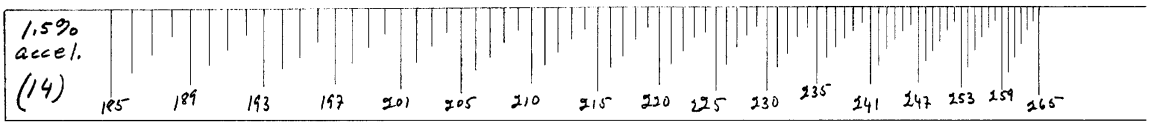
3) the rates of acceleration and the number of metrical units are predefined; and

4) the entrances of the second and third voices can be precisely calculated graphically in the fair copy.

However, an arithmetically exact transcription reveals that not all these conditions can be met at once (apparently Nancarrow made a few little "mistakes"!). If we construct the piece on the basis of the first three conditions, the second and third voices would have to enter roughly two metrical units earlier. This would alter the vertical sonorities to such a degree as to make the transformation unacceptable. Our only alternative is, therefore, to observe the fourth condition at the expense of the first, i.e. to place the entrances roughly as they occur in Nancarrow's original, but at slightly different opening tempos. (The tempos in my adaptation are 44, 45.53 and 46.15.)[20]

But how did Nancarrow bring off these geometrical series in practical terms? The key is found in Example 6.

Example 6



Fourteenth and final master scale for a 1.5 % accelerando. Located at the Paul Sacher Foundation, Basel.

First, he drew a master scale for the calculated time-stretching calibrations in pencil, using several strips of paper roughly 65 x 3.75 cm in size. (This cannot be done by hand with absolute accuracy, of course, and minor errors can easily slip into a series involving several hundred figures.)[21] Then, proceeding from a given starting length, he transferred the remaining values to the paper. Finally, he punched holes at the lo

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19 Jürgen Hocker: "Auf der Suche nach der Präzision," Neue Zeitschrift für Musik (1986), no. 9, p. 29: "The improved machine was used to punch all the studies from no. 22 on." Philip Carlsen (see note 28) also mentions this significance of Study #22 and refers in this context to G. Mumma (see note 13).

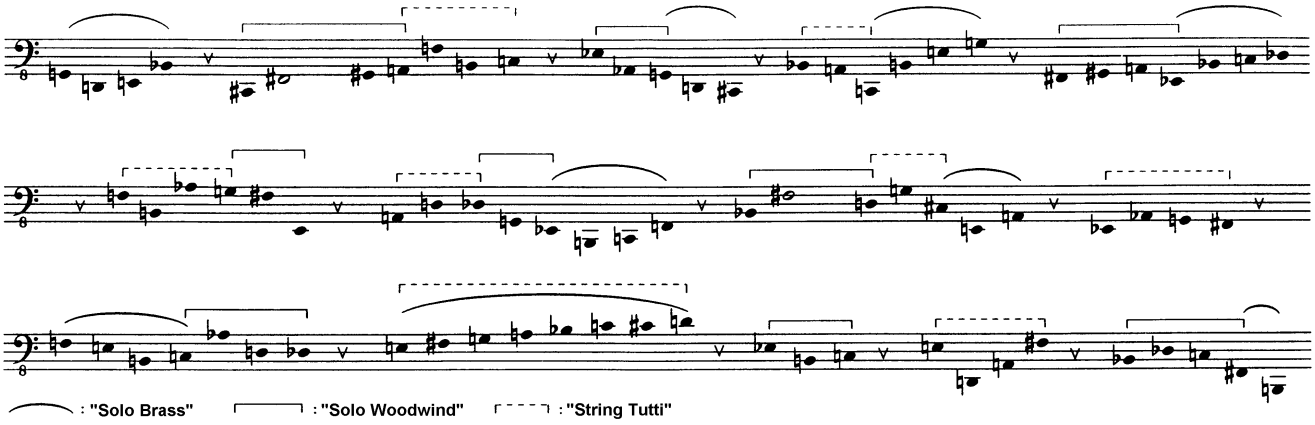
20 As it is, there are minor discrepancies amounting up to roughly one metrical unit. The third voice in particular is always a bit early until just before the end.

21 At the Paul Sacher Foundation, the surviving scales are still preserved in their original cabinet with many small drawers. Interestingly, Nancarrow used scales not only for time-stretching studies but also for others with irrational mensuration ratios, e.g. e:π in Study #40.

cations indicated (once again the possibility of slight irregularities cannot be dismissed).

My sound transformation of this opening section applies a method patterned after the technique that Anton Webern employed in his instrumentation of the Six-Part Ricercar from J. S. Bach's Musical Offering: the use of contrasting timbres to highlight minuscule motivic relations. I subdivided the voices into overlapping three- and four-pitch motifs which I then orchestrated with three groups of timbres: 1) „Solo Brass": tuba, horn and trumpet; 2) „Solo Woodwind": contrabassoon, clarinet and piccolo; and 3) „String Tutti": double basses, violas and violins.[22] Example 7 shows the assignment of motifs to timbral groups in the bass voice:

Example 7



Study #22, low voice, section 1: motivic analysis for sound transformation.

Note the fourth phrase from the end, the only passage with a lengthy stepwise ascending motion. To lend special weight to this passage, I gave all eight pitches a homogenous sound by doubling two timbres. (The listener can easily follow the end of the accelerando process from this phrase on.) In addition to the three timbral groups, there is also a level of what might be called duplicate punctuation: each ascending fourth (or descending fifth) is doubled by string pizzicati, and each tritone by harps. As the occurrence of these intervals is irregular, the primary three-color level receives an additional distinguishing texture.

In listening to the piece, an A-B-A' arch form is readily discernible, with the opening accelerando section counterbalanced by a ritardando conclusion. Indeed, it turns out that Nancarrow has composed a perfect palindrome: the piece runs symmetrically in cancrizans from the middle back to the beginning.[23] The point of reflection is located at the exact middle of the B section, which is thus symmetrical in turn.

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22 One special difficulty in many of the Studies is Nancarrow's radical exploitation of the entire compass of the piano. The choice of acceptable timbres is extremely limited in the top and bottom registers.

23 Slight discrepancies may be explained as deliberate attempts to obtain a consistent form of rhythmic motion.

What is new about the B section are its staccato articulation, the interchanged acceleration coefficients in the middle and low voices, and especially the "fragmentation" of the individual voices: the 99 notes up to the climax of the acceleration are subdivided into groups of 35, 30, 11, 5, 10 and 8 separated by rests of irregular duration.[24] As this formal design, by its very nature, discloses the imitative relations between the motifs far better than the opening section, the goal of my instrumentation is not so much a motivic analysis as to help the listener to perceive the formal process of "fragmentation." Here, too, the regular succession of „Saxophones“ and „Marimbas“ makes it easy to hear the canonic relations between the voices.

Isorhythms

A comparison of Study #13 and Study #19,[25] composed between 1948 and 1960 (tracks 5 to 9 on the CD).

Originally Nancarrow grouped Studies #13-19 under the collective title "Seven Canonic Studies." One cogent reason for doing so is their analogous rhythmic structure, which is based on a bundle of four interrelated isorhythmic strands[26] in accordance with the formula n-1/n/n+1/n:

a) 3 + 4 + 5 + 4 (= 16)

b) 4 + 5 + 6 + 5 (= 20)

c) 5 + 6 + 7 + 6 (= 24)

d) 6 + 7 + 8 + 7 (= 28)

Study #13 and Study #19 are thus united by a minimal four-voice time-stretching process occurring within a fixed grid system for each strand. Yet the notational approach to the two pieces reveals a completely different picture: the patterns can be directly traced in separate staves in Study #13, but they are not detectable at first glance in Study #19. These contrary results from a largely similar starting point, though due entirely to the notation, prompted me to come up with different transformations.

A quick glance at the opening bars of these two pieces will show how this works.

In Study #13 (Example 8), Nancarrow notates the four isorhythmic strands contrapuntally in 4/4, 5/4, 6/4 and 7/4 meter, while all four staves taken together produce

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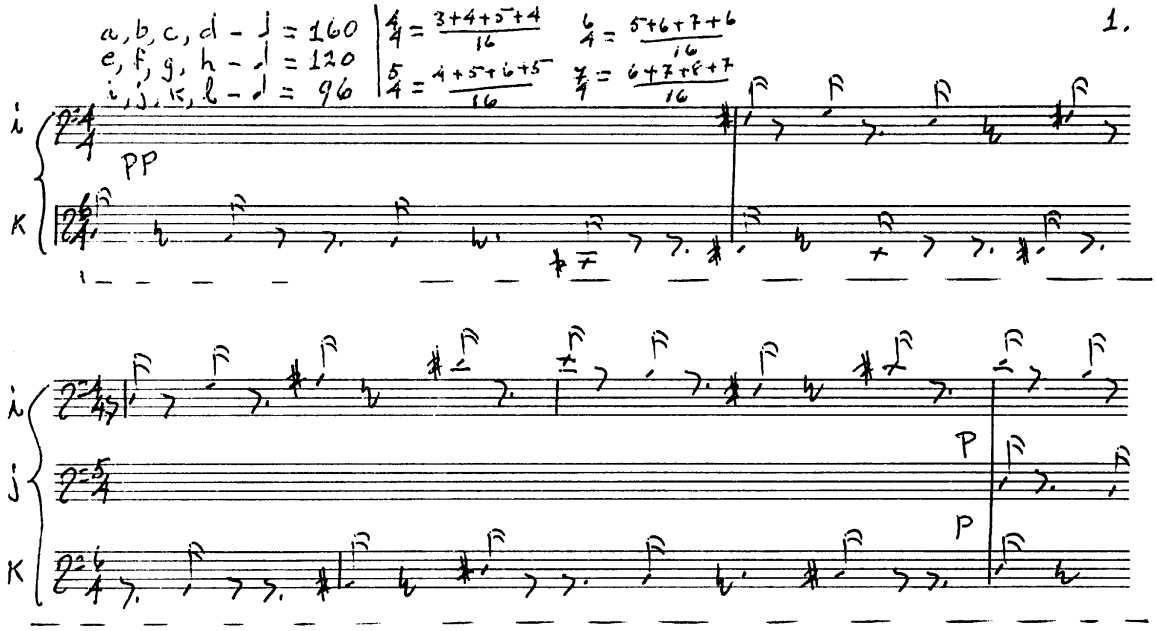
24 Apparently Nancarrow later made a correction in the punch master, where the regular enumeration of the metrical units is suddenly interrupted by a halved number (67 _). The accelerando is indeed interrupted there for the space of one beat, although this is indiscernible at the fast tempos.

25 Conlon Nancarrow: Study #13 for Player Piano (Mainz: Schott Musik International, unpubd.); Conlon Nancarrow: Study #19 for Player Piano, published in Selected Studies for Player Piano, vol. 1 (Berkeley: Soundings Press, 1977), available from Schott Musik International in Mainz since 1988 (currently out of print).

26 Here I use the term "strand" in order to make a strict terminological distinction between micro-voice (strand) and macro-voice (canonic voice).

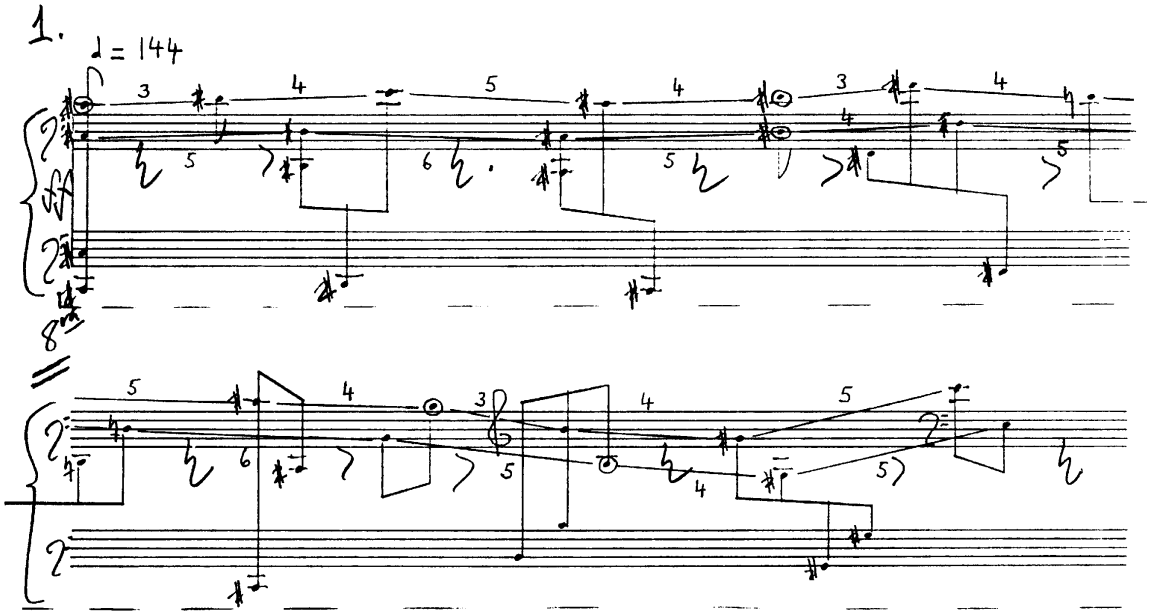
a resultant moving on a particular mensural level.[27] In Study #19 (Example 9), in contrast, we see standard piano notation with groups of eighth-notes separated by rests.

Example 8



Detail from the first page of the fair copy for Study #13

Example 9



27 The term "resultant" is used, for instance, by James Tenney in his essay "Conlon Nancarrow, Studies for Player Piano," in Conlon Nancarrow: Selected Studies for Player Piano, ed. Peter Garland (Berkeley: Soundings Press, 1977), pp. 41-64.

Detail from the first page of the first fair copy of Study #19 (the highlighting in the first and second strands and the interpolated numbers are mine)

In other words, the resultant of the four isorhythms is a more or less homophonous event. To illustrate the structure of the separate isorhythmic strands, I have connected the uppermost and next-to-uppermost strands with guidance lines, entered their isorhythmic values, and placed a circle around the first note of each isorhythm. The reason why the second strand does not begin with the first note of its pattern lies in the overall conception of this Study. All in all, the Study has a total of 337 eighth-notes in each resultant (336 plus the final note). However, 336 is the least common multiple of isorhythms a), c) and d). If we divide 336 by the b) unit, i.e. by 20, we arrive at 16 with a remainder of 16. Nancarrow now logically puts this remainder at the beginning of the second strand (5 + 6 + 5), so that all strands have their point of synchronization on the final note.[28]

Study #13 follows a different approach. Here Nancarrow has the isorhythmic strands enter consecutively in accordance with a strict rule, so that the next strand always begins when the previous ones, taken together, have formed a complete cycle.[29] This yields the structure illustrated in Example 10.

Example 10

a)	-	3	15	15	15	3	-
b)	-	-	12	12	12	-	-
c)	1	2	10	10	10	2	1
Length	*24*	*48*	*240*	*240*	*240*	*48*	*24*

a)	21
b)	(16.8)
c)	14
d)	12
Length	*336*

480 → **SyP** ← ***384***

Formal structure of a single resultant from Study #13. The number of bars per isorhythmic strand (from a to d) is indicated within each section, followed in italics by the length of the section (least common denominator) in sixteenth-note grid units. SyP = point of synchronization.

It is interesting to note, first, that the middle section containing the entrance of the lowest strand (d) encompasses 336 units (i.e. it is exactly as "long" as Study #19 as

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28 Study #19 is analyzed in depth by Philip Carlsen in The Player-Piano Music of Conlon Nancarrow: an Analysis of Selected Studies (Brooklyn, 1988), which also contains analyses of Studies #8, 23, 35 and 36.

29 By "complete cycle" I mean that the openings of the bars in the corresponding voices are again synchronous. In arithmetical terms, this is identical to the least common multiple ("LCM") of the corresponding grid unit.

a whole[30]) and second, that the study's point of synchronization occurs at the exact mid-point of this section. If we calculate the relation of the longer opening section to the shorter concluding section, we arrive at a ratio of 5:4. This is identical to the mensural ratio between the first and second canonic voices,[31] whereas the relation between the third and second is 4:3. This yields 12:15:20 for the overall mensural context of all three canonic voices.

In Study #13 the isorhythmic strands not only enter in succession (Example 10), the resultants are also treated canonically, i.e. with intervening time intervals. The result is a staggered, semi-symmetrical twelve-voice textural crescendo/decrescendo. Study #19, likewise based on the mensurations 12:15:20, merely generates the central 336 unit, arranged canonically in three voices so that the point of synchronization occurs at the end.

Both studies treat the melodic relation among the four isorhythmic strands in exactly the same way. The uppermost and faster strand sets, in a manner of speaking, the "tone" of the piece, while the slower bottom voices move in octaves with a slight rhythmic displacement forward or backward, thereby producing passages of broken octaves (see Example 9). While the broken-octave melodies in Study #19 proceed strictly canonically between the resultants, Study #13 turns out in this respect to be a bogus canon: the "canonic voices" only imitate each other at the beginning and at the end, proceeding freely in the interim.[32]

Although these two studies have an almost identical structure, I have attempted in my transformations to emphasize the differences between them reflected by their appearance on the page (polyphony vs. homophony).

Study #13 reveals a twelve-voice texture of linear counterpoint in which the timbres of the strands in the resultants are treated in a similar way, thereby lending maximum weight to the melodic identity of each voice (insofar as this is possible at all in the multi-voice texture). As a brief glimpse into my analytical workshop, I present two versions in highly contrasting timbres: track 6 on the CD uses percussion and plucked instruments from a "folk music" ambience, whereas track 7 presents the same music with instruments from the traditional symphony orchestra. Here the importance of the "atmosphere" of a sound transformation is plain to hear.

Study #19 first adopts a conventional guise by presenting the three canonic voices en bloc with three acoustic pianos. Soon, however, three wind instruments (english horn, clarinet and piccolo) join the fray in the manner of leitmotifs. These instruments emphasize the same intervallic motifs in each canonic voice (reinforced by pizzicato interpolations to mark the "cadences"), thereby allowing listeners to perceive the continuous temporal foreshortening to the final octave in the ratio 12:15:20.

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30 Since the tempos of the two Studies differ, this statement applies in a purely structural sense. The real tempo relation is #13:#19 = 4:3.

31 Here "canonic voice" refers to the resultant of four isorhythmic strands.

32 A short passage of imitation again results at the entrance of d).

Sound-Mass Canons

Study #41b,[33] composed between 1969 and 1977 (tracks 10 and 11 on the CD):

The complete Study #41 consists of two separate canons (41a and 41b) played simultaneously on two player pianos according to a predefined time scheme.[34] Each of the two canons forms, however, a self-contained composition in its own right.

This Study illustrates yet another dimension to Nancarrow's canonic art: the so-called "sound-mass canon,"[35] in which the canonic voices are formed from a wide range of musical elements. The elements, which may include such timbral features as glissandos, trills, and tremolos, are manipulated by means of highly contrasting compositional devices and textural densities. As the sonic material is far more complex than in the canons discussed above (Studies #13 and 19 form a sort of transition), one separate canon will suffice here as an example.

Two brief analytic remarks are called for here. First, Study #41b is constructed as a two-voice canon with a mensural relation of $\frac{1}{\sqrt[3]{\pi}} : \sqrt[3]{\frac{13}{16}}$. This irrational ratio is nearly equivalent to the fraction 30:41 (or roughly 3:4), with the crucial difference that in this case the metrical units never exactly coincide (thus raising the philosophical question of absolute mathematical precision).[36] Second, the temporal entrance of the second voice is chosen in such a way that the canon's point of synchronization arrives roughly two-thirds of the way through the piece (it is marked by the end of a joint ascending glissando followed by a brief rest). After that, the quicker upper voice comes to an end sooner than the lower one.

A comparison with the original clearly reveals that, in canons with this degree of density, many details can be worked out with far greater clarity using contrasting "colors" and panorama spaces than is possible with a single piano.

I hope that these few examples will kindle an interest in the sound transformations on my CD, which is scheduled to appear within the year. There the reader will find a representative selection from the entire spectrum of Nancarrow's fascinating canonic universe.

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33 Conlon Nancarrow: Study #41 for Player Piano, published in Collected Studies for Player Piano, vol. 2 (Santa Fe: Soundings Press, 1981), available since 1988 from Schott Musik International (ED 7684).

34 Two player pianos are also used in Studies #40, 44 and 48. Whereas the latter likewise combines two different canons, #40 and #44 contrast two identical canons (transposed in #44) in slightly different tempos.

35 The term "sound-mass canon" was coined by K. Gann (see note 8) and also applies to Studies #24, 32, 33, 36, 37, 40, 41, and 48.

36 Nancarrow also worked with irrational mensuration ratios in the following canons: #33 ($2:\sqrt{2}$), #40 (e: π), and #41a ($\frac{1}{\sqrt{\pi}} : \sqrt{\frac{2}{3}}$).