EXTENTS AND LIMITS OF SERIAL TECHNIQUES

By ERNST KRENEK

The Title

THE propensity of present musical theory for terminology originally belonging to mathematics and physics is characteristic of a style of thinking essentially different from earlier ways of viewing the subject matter. Although some of this language sounds merely pretentious, it has nevertheless added useful terms to musical discussion. One of these is the concept of "parameter." It was introduced into recent music theory by Dr. Meyer-Eppler, of the Institute of Communication Theory at the University of Bonn, who was associated with the work of the electronic laboratory of the West German Radio at Cologne. It is borrowed from mathematics, where it means "a variable entering into the mathematical form of any distribution such that the possible values of the variable correspond to different distributions."[1]

Serial organization of a certain number of parameters of a musical process causes a certain number of other parameters to be left uncontrolled. A detailed study of the relationships of these two areas was the purpose of the seminar. The title did not, as was surmised by some, hint at a discrimination between accomplishments and shortcomings of serial thinking.

Definition

Serial music was defined as a method of composition that has been developed as a sequel of the twelve-tone technique inaugurated by Arnold Schoenberg around 1923. While the serial concept in that technique was embodied in the twelve-tone series, i.e. an ordering of the pitches to be adhered to throughout the course of the composition, the new idea of

[1] *American College Dictionary*, New York, 1948, p. 879.

serialism encompasses all aspects (or "parameters") of the musical process, such as timbre, dynamics, articulation, and above all, time, i.e. duration of the individual sounding elements and their mutual relationships in time, subordinating all these aspects to premeditated serial statements. In this view the twelve-tone technique appears to be a special, or limiting, case of serial music, similar to an interpretation of Newtonian mechanics as a limiting expression of the Special Theory of Relativity, which in turn has been explained as a limiting expression of that General Theory.

Method

Anton Webern and Olivier Messiaen were mentioned as the best-known generators of the new way of serial thinking, the former because of the extraordinary impact his work has exercised during the last twenty years or so, the latter above all through his experiments with "rhythmic rows" (or "modes") and his immediate influence on such composers as Boulez and Stockhausen. The discussion then turned to the significance and consequence of the gradual expansion of the musical area that was subjected to premeditated organization. It was recognized that serial ordering of the factor of time (i.e. premeditated fixation of points of entrance and duration of the individual musical elements) caused fundamental changes in the structure, appearance, perceptibility, and meaning of music. Therefore the larger part of the investigation was devoted to the methods of organizing serially the parameter of time. The discourse was mainly based on my own work in the serial style because my intimate knowledge of this work allowed succinct presentation of the relevant details, whereas the few available analyses of other composers' serial works are frequently ambiguous and far from enlightening.

The Principle of "Rotation"

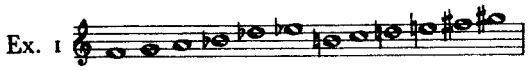
By rotation we understand a procedure in which the elements of a given series systematically and progressively change their relative positions according to a plan which in itself is serially conceived in that the changes occur in regular phases.[2]

I applied this principle for the first time in a large choral work,

[2] In his book, *Die Komposition mit zwölf Tönen,* Berlin, 1952, p. 113 ff. and *passim,* Josef Rufer points out that Arnold Schoenberg occasionally let neighboring tones of his rows exchange places, or groups of tones change their positions within the row. Rufer's discourse and the examples quoted show that this was done sporadically and mainly in order to create a musical context that would not have been served as well by adhering to the premeditated succession of pitches.

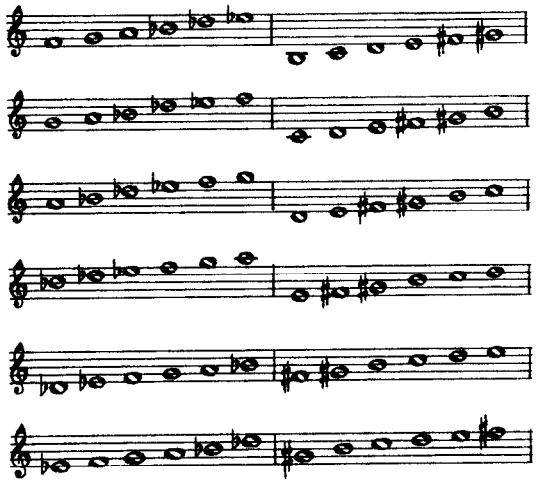
Lamentatio Jeremiae Prophetae,[3] written in 1940 and 1941. The twelve-tone series of this work reads thus:

Ex. 1



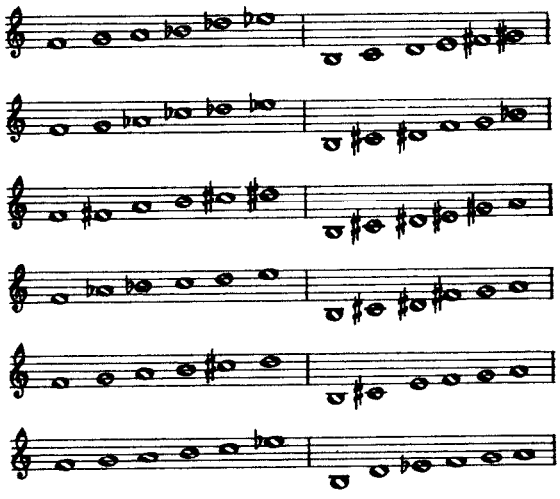
Each of its two constituent six-tone groups is progressively modified by making the first tone the last:

Ex. 2



The patterns thus obtained may be called "diatonic" since they contain the same six tones. The roster of patterns is doubled by transposing all those of the left column of Ex. 2 to begin on F, all those of the right column to begin on B.

Ex. 3

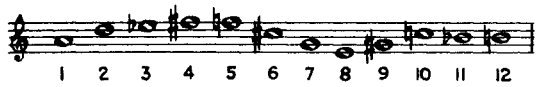


[3] Bärenreiter-Verlag, Kassel.

These new patterns are "chromatic" because they eventually include all twelve tones. The rotation taking place was inspired by the construction of the Greek modal scales and their transposition into one "characteristic" octave. The purpose of the operation was not so much to make the serial design stricter, but rather to relax it, insofar as the wide variety of available six-tone patterns made it possible to remain within the frame of reference of the twelve-tone serial technique without constantly having to use complete twelve-tone rows. Thus it became possible to give various areas of the composition distinctive harmonic flavors. At that time no attempt was made to organize serially the selection and succession of the rotational patterns.

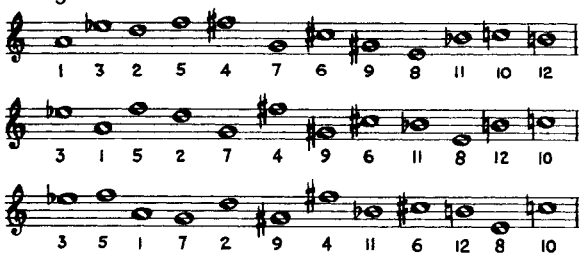
A more consistent and systematic application of the principle of rotation may be found in my orchestral work, *Circle, Chain and Mirror,*[4] written in 1956 and 1957 for the Basel Kammerorchester. The tone-row of this work reads as follows:

Ex. 4



In the course of the composition twenty-four derivative forms of this row are employed. The principle of derivation may easily be apprehended by comparing the original row with its first three derivative forms (the tones in their original succession are numbered from 1 to 12):

Ex. 5



The rotation taking place here consists in forming a retrograde succession of each pair of two adjacent tones. After eleven such operations one arrives at the complete retrograde form of the original statement. The twelve following derivates represent the retrograde forms of the first twelve, and the twenty-fifth transformation is identical with the original. The same procedure was applied to the inverted form of the original series (see Ex. 6). This arrangement suggested the "circle" part of the title of the work.

[4] Original German title: *Kette, Kreis und Spiegel.* Bärenreiter-Verlag, Kassel.

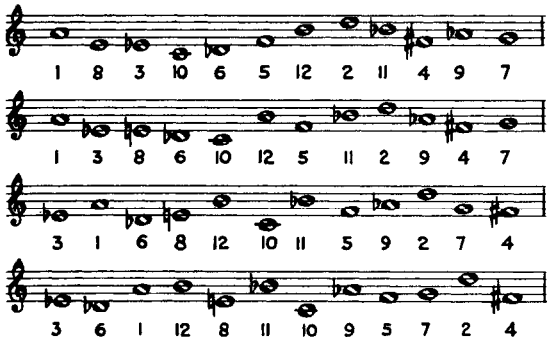
The sequence in which the forty-eight rows thus obtained were used in the work was determined by the decision to have each original form followed by the second of the two forms of the inversion which would have for their first tones the last tone of the preceding original, while this inversion in turn would be followed by an original form beginning with the last tone of the preceding inversion. This interlocking arrangement is meant by the term "chain" in the title. The sequence of rows obtained through this operation may be partially seen in the following table (O=original, I=inversion, R=retrograde, RI=retrograde inversion):

O	I	R	RI
1			
	8		
6			
			12
10			
			4
4			
			10
12			
			6
		8	
			2
	1		
8			
	6		
		12	
	10		
		4	
	4		
		10	
	12		
		6	
			8
		2	
2			
	7		
5			
			11
9			
			3
3			

etc.

The symmetry resulting from this organization is obvious: The sequence 1, 6, 10, 4, 12 in lines 1 to 9 of the O column is identical with the sequence 1, 6, 10, 4, 12 in lines 13 to 21 of the I column. The same relation obtains as regards the sequences 12, 4, 10, 6, 2 in lines 4 to 12 of RI and 16 to 24 of R. The positions of I8 between O1 and 6 and of O8 between I1 and 6 are equally symmetrical and correspond to the positions of the 8s in R and RI between 2 and 6 of RI and R respectively.

Ex. 6



The term "mirror" finally refers to the fact that the musical configuration that opens the work and is expressed in terms of the row O1 returns in inverted form when the serial "conveyor belt" produces the form I 1, in retrograde inverted form when the row RI 1 appears (not shown in the above table), and at the very end of the work in terms of the form R 1. The remaining areas of the music are not any longer occupied by thematic statement, development, recapitulation, and the like. Whatever morphological kinship may be detected between adjacent sections is a result of similarities of intervallic shapes that may occur in neighboring forms of the tone-row, the vicinity of which, however, is a consequence of the premeditated serial arrangement outlined above and not dictated by requirements of a so-called musical nature.

In this composition no other parameter beside the succession of tones was serially ordered. In this respect it belongs to the province of "classical" twelve-tone music. It transcends that province in that it allows its structure to arise from the serial arrangement of the rotational derivatives of its tone-row.

The principle of rotation, which, as may be seen here, I discovered and utilized for reasons not relevant to the evolution of pan-parametrical organization, turned out to be of far-reaching significance when I became

interested in that kind of organization. The point is that the notion of invariancy inherent by definition to the concept of the series, if applied to all parameters, leads to a uniformity of configurations that eliminates the last traces of unpredictability, or surprise. But unpredictability appears to be not only especially characteristic of so-called "atonal" music, but desirable, or necessary, in any work of art. That the composers who have made the most consistent attempts at "total determinacy" are aware of this need transpires from this utterance of Pierre Boulez: "L'inattendu, encore: il n'y a de création que dans l'imprévisible devenant nécessité."[5]

Combination of the various configurations that result from rotational procedure with constant (non-rotating) serial elements means that the principle of order that governs one set is applied to another, unrelated set (as if one, for instance, would order the numbers from 1 to 5 alphabetically: five four one three two). Since this is one of the definitions of randomness, we meet here for the first time the factor of chance, which has attained high significance in recent developments.

Rotation and Time

According to György Ligeti's analysis[6] of Pierre Boulez's *Structures* for two pianos,[7] the composer has interpreted the transpositions of his twelve-tone row to various pitch levels as a form of rotation and has transplanted the results to the parameter of time in order to obtain an analogous sequence of derivative forms of his time series.

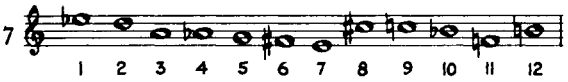
[5] "The unexpected, again: there is no creation except in the unforseeable becoming necessary" (*Revue musicale,* April 1952, p. 119, as quoted in *Die Reihe,* No. 4, Vienna, 1958, p. 71). It is interesting that this statement almost *verbatim* sums up Carl Bricken's brilliant argument about "inevitability and the unexpected" in his analysis of Beethoven's Quartet Op. 18, No. 3 (*Some Analytical Approaches to Musical Criticism,* in *Proceedings of the Music Teachers National Association for 1936,* Oberlin, 1937, p. 262 ff.). In Bricken's discourse the "inevitable" is, of course, represented by those musical processes that appear to be most likely to occur within the framework of tonal harmony so that they constitute a predictable, "normal" set of events. The "unexpected," then, consists of the deviations from the norm introduced by the genius of the individual composer. In the case of serial music the inevitable is what serial premeditation ordains. The unexpected, however, is not a result of the composer's kicking against the self-imposed limitations, but of the built-in surprise mechanism, as we shall see later on. In my article *Is the Twelve-Tone Technique on the Decline?* (in *The Musical Quarterly,* Oct. 1953, p. 523 ff.) I indicated that Boulez in his Second Piano Sonata probably applied the principle of rotation.

[6] *Die Reihe,* No. 4, p. 38 ff.

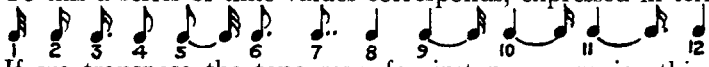
[7] Universal Edition, Vienna.

The elements of the tone series are numbered from 1 to 12:

Ex. 7

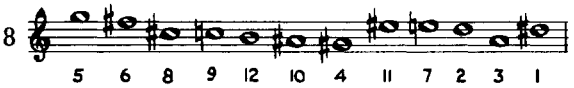


To this a series of time values corresponds, expressed in terms of 𝅘𝅥𝅯 :

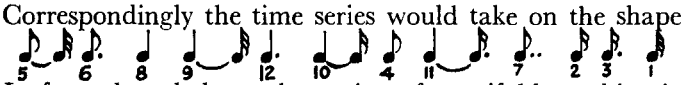


If we transpose the tone row, for instance, a major third higher, the original order of the tones is changed into:

Ex. 8



Correspondingly the time series would take on the shape:



In fact, the whole work consists of manifold combinations of the tone- and time-sets thus obtained.

Serialism in the Electronic Medium

Karlheinz Stockhausen's work described alternatingly as *Komposition 1953 No. 2* and *Elektronische Studie I*[8] is based on a six-tone series which according to the composer's own elaborate analysis[9] is an expression of this series of ratios of frequencies:

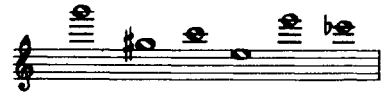
12	4	8	5	5
5	5	5	12	4

Expressed in vibration numbers, or cycles, per second, the first series reads:

1920		800		1000		625		1500		1200
12	:	5		8	:	5		5	:	4
		4	:	5		5	:	12		

In notes it reads approximately:

Ex. 9



Five more series are derived by making the consecutive tones of the first series points of departure for new series identically built (a procedure somewhat reminiscent of my *Lamentatio* rotation):

800	333	417	260	625	500
1000	417	521	325	781	625
625	260	325	203	488	390
1500	625	781	488	1170	937
1200	500	625	390	937	750

[8] Universal Edition, Vienna. Recorded by the Deutsche Grammophon Gesellschaft.

[9] *Technische Hausmitteilungen des Nordwestdeutschen Rundfunks*, Vol. VI, No. 1/2, Cologne, 1954, Item 10, p. 46 ff.

A second set of six series is obtained by making the second line of the first set the top line of the new set, then the third, and so on.

All parameters are serially ordered in terms of some variants of the numerical sequence 1 to 6. For instance, the combinations of the above frequencies follow from the series 4 5 3 6 2 1 in that the first tone-combination (*"Tongemisch"*) has four tones, the second five, and so on. There are four such *"Gemische"* in "sequence 1" (a "sequence" being a grouping of consecutive elements), and four "sequences" in the first "structure," which is the next higher compound, "horizontal" or "vertical." (It does not become quite clear on what grounds one or the other of these two dimensions was chosen.) There are six dynamic levels which are assigned to the various frequencies in proportion to their relative positions in the groups and columns of the entire system. The series that orders the succession of dynamic levels within this frame of reference is 3 4 2 1 6 5. Finally, the time factor is determined by relating the durations of the individual sounding elements to the pitch levels and degrees of loudness of those elements as ordered by the previous rules. The governing series in this parameter is 2 4 6 3 5 1.

The details of this organization are far more complex than what we are able to indicate here in an abridged sketch. Unfortunately the presentation by the author is not always felicitous, so that some of the intricacies of his work remain obscure. At any rate, the character of his reasoning seems to reveal a desire to derive the rules of serial organization from the nature of the chosen material and its intervallic texture. In this respect Stockhausen differs somewhat from Boulez, who has a rather mechanistic approach in assigning numerical values to the various magnitudes manipulated in his work. While this procedure of Boulez's has been criticized as "anorganic,"[10] it has nevertheless produced a fascinating piece of music. On the other hand, Stockhausen's *Studie,* although much shorter than the *Structures,* suffers from considerable monotony of harmonic flavor, which is due to the prevalence of augmented triads in the original series (see Ex. 9). The extraordinary subtleties of combinations of dynamic shadings, time values, echo effects, and the like cannot overcome this initial handicap.

The objection was raised that music here becomes the victim of an abstract numbers game which is contrary to the nature of music. While there undoubtedly is room for more than one definition of the nature of music, we did not extend our inquiry into this field. The numbers used

[10] Ligeti, *loc. cit.,* p. 41.

in the ordering of the parameters of serial music are almost always derived from proportions and measurements of the basic musical substance. Of course, these numbers detach themselves from the objects with which they were associated and take on a life of their own in the various operations performed. The results of these operations are, however, retranslated into musical terms and applied to the sounding material. In this relation of number and reality one may see a vague analogy to the connection of contemporary mathematics and physics.

Premeditated, but Unpredictable

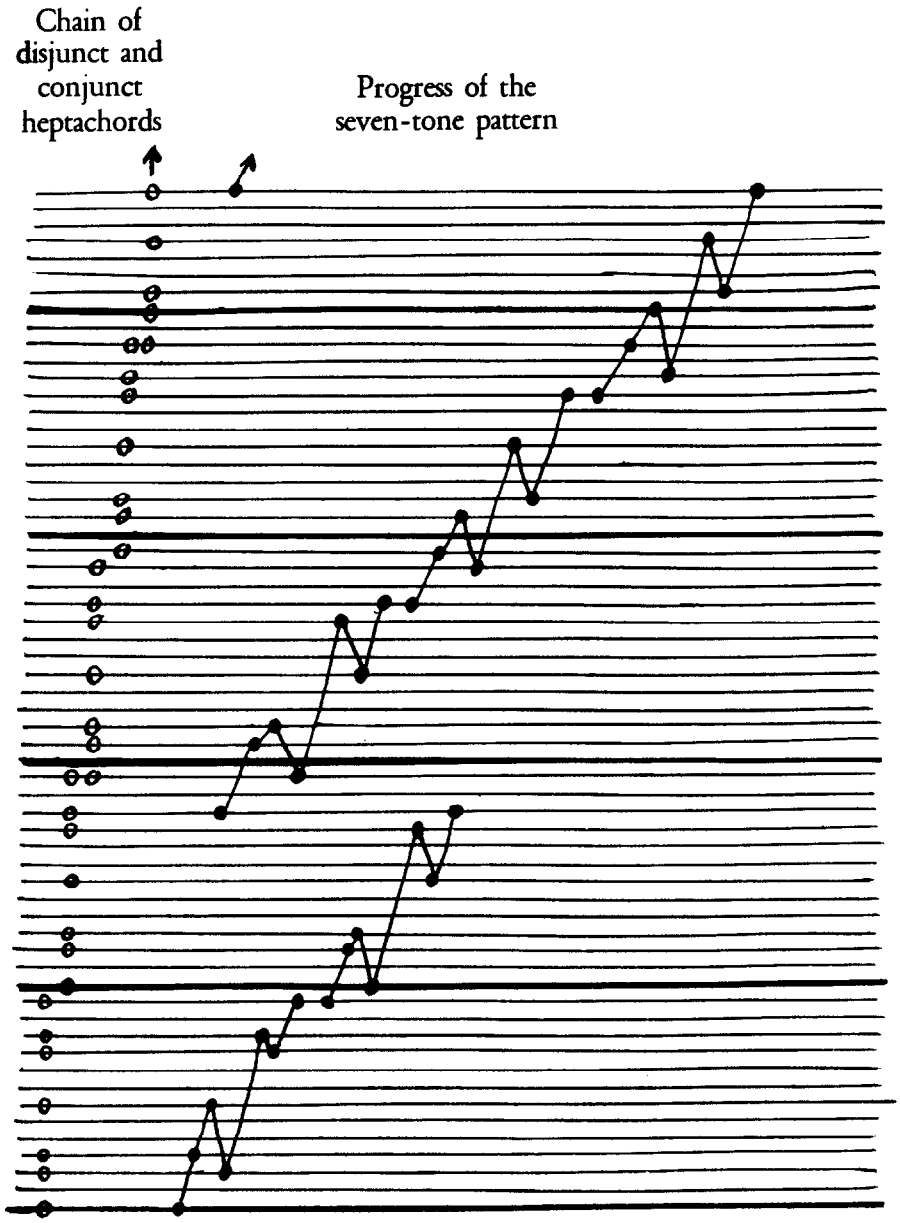
In my oratorio for voices and electronic sounds, *Spiritus intelligentiae, sanctus,*[11] there is a section without voices (so to speak an "instrumental" interlude). The material of this section is a tempered scale of thirteen tones. From the continuum of this scale, groups of tones were selected to form alternatingly disjunct and conjunct heptachords of equal and symmetrical structure (see left side of Diagram 1). A seven-tone pattern (seven-tone row) meanders through this system of pitches constantly retaining its principle of progress: from any tone on which it starts it goes up to the third and fourth, then back to the second, up to the sixth, back to the fifth, and it stops on the seventh tone of the network of pitches. Since the pattern always progresses conjunctly (which means that the first tone of its next appearance is identical with the last of the preceding) while the pitch system is based on the alternation of conjunct and disjunct shapes, the internal intervallic configuration of the pattern is always different, although its general outline remains the same (see right side of Diagram 1). After thirteen appearances the pattern lands again on the tone from which it started, and the "rotation" has come to an end.

The interlude in question may technically be called a double canon. One of the two elements subject to imitation is a tone-line consisting of the chain of the thirteen possible variants of the seven-tone pattern just described, the other is an analogous line presenting the chain of the inverted forms of the pattern. The first tone-line is so designed that it begins on the central tone of the entire gamut (330 cycles), rises to its highest level (4754 c) in the first third of its length, returns to the center in the second third, and descends to the lowest level (26 c) in its last portion. The second line begins on the lowest point when the first reaches its apex, rises to cross the first line where it passes on its descent the central tone, goes up to its own high point which it reaches approximately when the first line ends, and returns to the center.

[11] Recorded by the Deutsche Grammophon Gesellschaft (LP 16134 Hi-Fi).

Diagram 1

Read from bottom up
Heavy lines indicate octaves

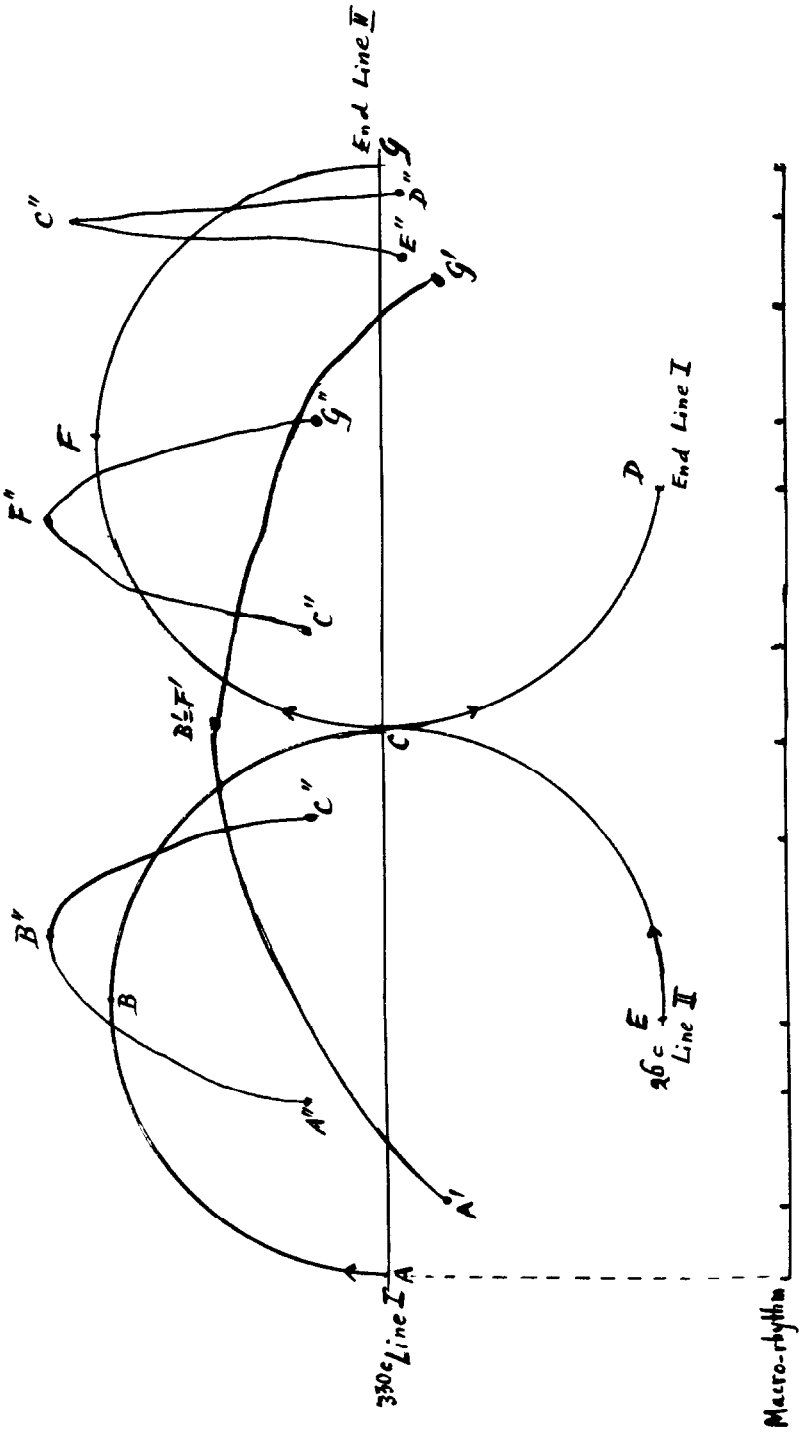


The canonic imitations were obtained by rerecording the original material at a higher and a lower speed, in which procedure the pitch level of the original tape was automatically raised or lowered in the same proportion. These imitations were so synchronized with the original lines that the slowed-down version of the ascending branch of the first tone-line would reach its highest point (proportionately lower than the summit of the original) when the original line had returned to the center. It was followed by the slowed-down imitation of the descending branch of the second line. The above-center arcs of both lines were imitated in accelerated versions reaching their (proportionately higher) apices shortly after or before those of the original lines. Finally, a very highly accelerated imitation of the below-center branches of both lines was inserted shortly before the end of the section.

To determine the time values of the single elements the whole expanse of the piece was viewed as one unit. Through measuring the linear distances of the important points of articulation — entrances of imitations, turning points and such — a series of eleven spans was established, a sort of macro-rhythm articulating the over-all structure. It was reduced in scale to a micro-rhythm in order to determine the durations of the individual tones in each tone-line. Since each line takes approximately three quarters of the entire length of the piece and each line contains ninety-one tones (seven times thirteen), the micro-rhythm of eleven values has to be repeated eight times, leaving three tones free at the end. This concept determined the ratio by which the macro-rhythm had to be reduced. Since the rhythmic series thus established has eleven terms whereas the tone-series has only seven tones, it follows that the last four terms of the first time series will apply to the first four tones of the second tone series, and so forth, so that here again mechanical repetition is avoided while uniformity in a higher sense is maintained. (See Diagram 2.)

It may be stated that whatever occurs in this piece at any given point is premeditated and therefore technically predictable. However, while the preparation and the layout of the material as well as the operations performed therein are the consequence of serial premeditation, the audible results of these procedures were not visualized as the purpose of the procedures. Seen from this angle, the results are incidental. They are also practically unpredictable because the simultaneous progress of highly complex rhythmic patterns at various relative speeds together with the corresponding transpositions of equally complex pitch patterns creates situations that defy precise visualization.

Diagram 2


End Line II
G
D"
E"
C"
G'
G"
F
F"
C"
B≠F'
C
C"
B'
B
A"
A'
330c Line I A
96c Line II E
D
End Line I
Macro-rhythm

The Time Mechanism of My "Sestina"[12]

The *Sestina* is one of the poetic forms developed by the Provençal poets of the twelfth century, its original specimen being ascribed to Arnaut Daniel. It may well be called a serial form of poetry, and its essential formative principle is rotation.

The poem consists of six stanzas of six blank verses each. It hinges upon six keywords which appear at the endings of the individual lines. If in the first stanza the order of these words is 1 2 3 4 5 6, the words will appear in the second stanza in the order 6 1 5 2 4 3. The principle of rotation which is applied here consists in switching the position of every two keywords equidistant from the center of the series, proceeding from the end toward the middle. According to the same principle, the positions of the keywords in the subsequent stanzas are 3 6 4 1 2 5; 5 3 2 6 1 4; 4 5 1 3 6 2; 2 4 6 5 3 1. The process ends here, since the next rotation would produce the original series. The six stanzas are followed by a *Tornada* of three lines in which the keywords, one of each pair in the middle and the other at the end of the line, appear in the order 2 5, 4 3, 6 1.

The content of the *Sestina* which I wrote (in German) as text for the present composition is a contemplation of the implications of the idea governing the musical construction of the work.[13]

The first two stanzas may suffice to indicate the character and form of the poem:

1. Vergangen Klang und Klage, sanfter Strom.
   Die Schwingung der Sekunde wird zum Mass.
   Was in Geschichte lebt, war's nur ein Zufall?
   Verfall, Verhall, zerronnene Gestalt?
   Die Stunde zeitigt Wandel, wendet Zeit.
   Das Vorgeschrittne ordnet sich der Zahl.

2. In Schritten vorgeordnet durch die Zahl
   gestaltet sich Gedanke, doch zum Strom
   wird strenge Teilung, uhr-genaue Zeit.
   Ist es vermessen, solches Mass von Mass
   dem Leben aufzuzwingen, der Gestalt?
   Der Zwang zerrinnt, erzeugt den neuen Zufall.[14]

[12] Bärenreiter-Verlag, Kassel. Epic Records, LC 3509.

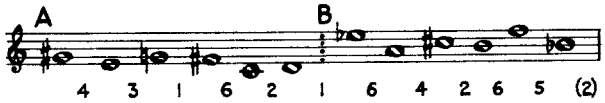
[13] Quoted from my notes on the jacket of the record cited in note 12.

[14] In a nearly literal translation which reproduces the positions of the key words:

Bygone are sound and mourning, tender stream.
Vibration of the second becomes the measure.
What lives in history, was it only chance?
Decline, fading sound, vanished shape?
The hour causes change, turns the time.
What looks ahead subordinates itself to number.

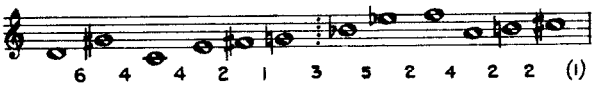
The music of my *Sestina* is based on a twelve-tone row divided into two groups of six tones each:

Ex. 10



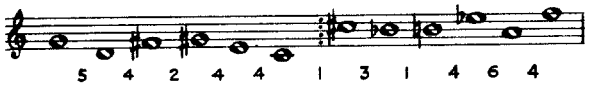
The figures indicate the size of the intervals measured in half-steps. These tone-rows are rotated according to the principle of the sestina so that the second A- and B-groups read:

Ex. 11



The third line is:

Ex. 12



and so forth. The tones are always placed so that they will not exceed the ambitus of the original row and the intervals (indicated by the numbers below the staff) are so measured up or down that their magnitudes will not exceed the figure 6. Obviously the sequence of these intervallic magnitudes constantly changes as a result of the rotation of the tones prescribed by the sestina pattern, but these changes are of a different order.

The durations of the tones of the whole composition are derived from these magnitudes in the following manner: each intervallic magnitude corresponds to a time segment which contains as many basic time units as the interval figure indicates. Consequently the first time segment has four units, the second three, etc. Each segment has as many tones as it has units (4, 3, etc.). The duration of the individual tones is determined by a subdivision based on the same serial sequence of magnitudes. If the first segment contains four units and four tones, its subdivision is based on the first four values of the original series: 4 3 1 6. The sum of these being 14, the subdivision unit within the first segment is 4/14. The durations of the individual tones within the first segment are determined by multiplying 4/14 consecutively by 4, 3, 1, and 6. The

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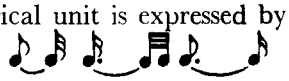
In stages preordained by number
thought takes shape, but a stream
is (the result of) strict division, of clocklike, precise time.
Is it presuming to force such an extent of measure
on life, on shape?
Force vanishes, brings forth new chance.

durations, then, are 16/14, 12/14, and 24/14, or 8/7, 6/7, 2/7, and 12/7 of the basic value.

Actually the determination of the durations is due to much more complicated computation because it is influenced by serial organization of other parameters. In order to achieve higher rhythmic diversity, the concept of "internal speed" was introduced. It is derived from the assumption that in every group of six tones one to five tones might be sounded an octave higher so that the magnitude of the affected intervals would be augmented by twelve. The succession of "internal speeds" is derived from the position of the tones in group B (see Ex. 10). The lowest (A) is designated as 1, the highest (F) as 6. The initial row of internal speeds is therefore 5 1 4 3 6 2. The first segment, then, has the internal speed 5 so that 12 is added to five out of six subdivision numbers. Thus these numbers read 16 15 13 18 14 instead of 4 3 1 6 2. The following number — 1 — remains unaltered. The sum of the numbers attached to the first segment is therefore 62, instead of 14. Consequently the durations of the individual tones will be considerably shorter than if the "internal speed" were, for instance, 1 or 2.

To facilitate computations each basic unit is assumed to contain ten micro-units. We arrive at the subdivision of the first segment by dividing 40 (four times ten) by 62. The result is 0.645. This number is multiplied consecutively by 4, 3, 1, 6. The results are 2.58, 1.935, 0.645, 3.87. If the work had been realized by electronic means on tape, these values could be produced with utmost accuracy. Since it was conceived for conventional manners of rendition, the time values had to be adjusted as follows: 2.5, 2, 0.5, 4. If the smallest numerical unit is expressed by  , the rhythmic shape of the first four tones is  = 9/16.

"Density" is the next parameter to be determined serially. There are six degrees of density whose succession is determined by the position of the pitches in group A (Ex. 10). Again the lowest (C) is called 1, the highest (G♯) 6. Consequently the initial series of densities is 6 3 5 4 1 2. In "density 1" the two tone-groups A and B run off simultaneously in a sort of two-part setting in which the duration of the individual tones is determined by the mechanism described above. In "density 2" the first and second time segments of group A run concurrently with the first segment of group B. In "density 3" two segments of each group are developed simultaneously, and so forth, until in "density 6" six segments of each group, i.e. twelve all together, run off at the same time.

Another parameter is the location of the tones within the gamut of six octaves designated as the ambitus of the work. The serial statement adopted for this area reads that the tones of each segment should run through as many octaves as there are tones. The direction of the motion is determined by the direction of the corresponding interval in the original series. Since many segments contain less than six tones, they cover less than six octaves and therefore could extend over various bands of the complete ambitus. This, too, is regulated by special serial statements. Needless to say that all these serial organisms are subject to rotation according to the sestina pattern, which is the supreme law governing every move of every variable within the whole composition.

The structural layout is designed to combine each "rotated" version of any six-tone group with every other. Thus the music of the first stanza is based on the first statement of the A-group, in each consecutive line of the poem combined with one of the forms of the B-group rotated from B 1 to B 6. The second stanza has A 2, combined again with all six B-groups, but now in a different sequence, according to the sestina pattern: B 6, B 1, B 5, B 2, B 4, B 3.

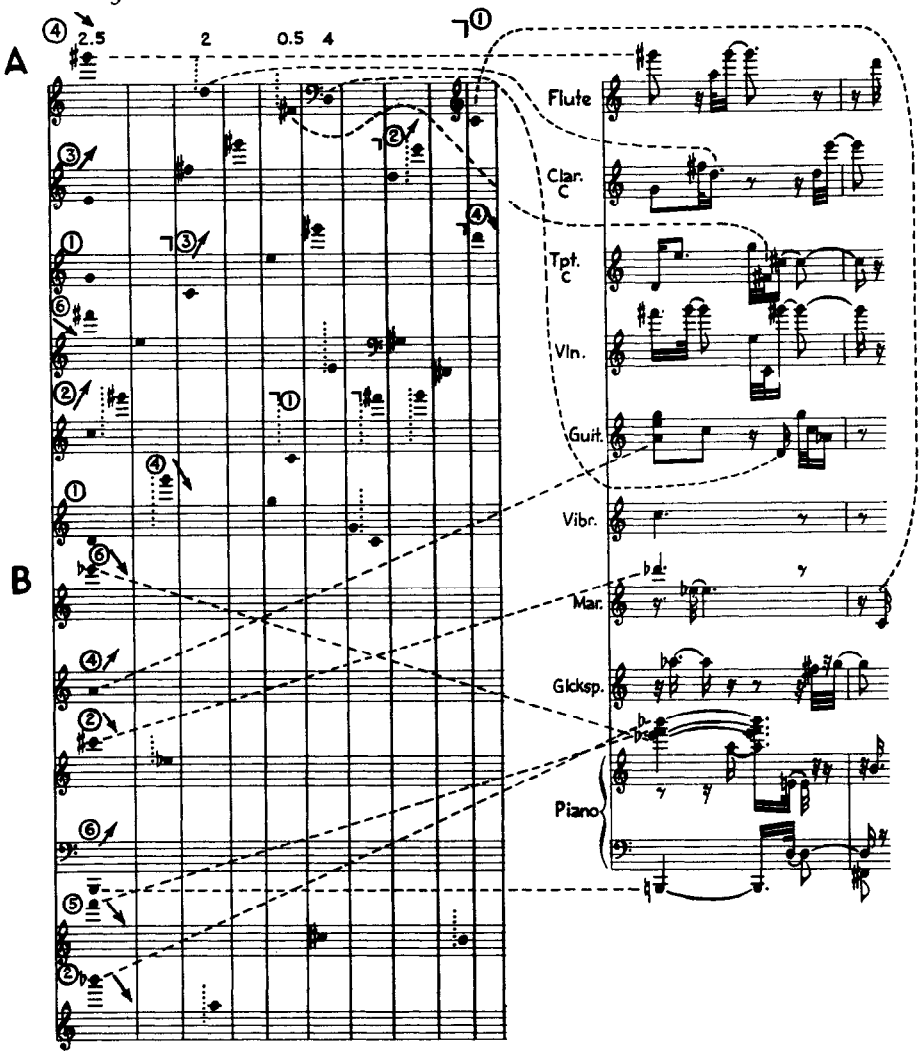
Paralleling the arrangement of the key words in the *tornada,* the tone series assigned to it reads 2 5 4 3 6 1. The music of the tornada consists of six sections, the first four and the last of which are given over to the instruments alone. While the tone row of the tornada undergoes the now familiar six sestina transformations, the density increases from 1 to 6 so that in the first section of the tornada only one each of the A- and B-rows are employed, while in the last section six of each, that is twelve, or all available forms are used simultaneously.

The parameter of "external speed" has six steps also, the lowest being M ♪ = 90, the highest ♪ = 180. The former is associated with the highest degree of density, the latter with the lowest.

Example 13 shows the first ten sixteenths (micro-units) which form the first basic time unit of the *Sestina.* On the left side one may see the distribution of the tones of the A- and B-groups over the twelve layers (density 6) of simultaneously progressing time segments, each tone entering at the point assigned to it by the time mechanism explained above. The tones occupy their places from top to bottom layer in their order of succession in the row. The "internal speed" for the A-layers (top six) is 5, for the B-layers (bottom six) 1 (no acceleration). Encircled numbers indicate the number of tones allotted to the particular segments. Arrows indicate the direction of the tone lines. The figures above the

top staff give the durations of the first four tones in 𝅘𝅥𝅯, as computed on p. 225. The right side of the example shows how these tones are represented in the actual score, and a few connecting lines were drawn to demonstrate where some particular tones may be found.

Ex. 13



It is easy to see that the parameter of timbre lies beyond the limits of the present serial arrangement. If this parameter too were organized serially and this procedure would, for instance, require the first tone of the top layer (G♯) to be played by the trumpet, it would obviously be

at variance with the octave register demanded by the serial regulation of spacing, since the trumpet cannot play the G♯ in question.

The Element of Chance

Other parameters may be affected in the same way. If the succession of tones is determined by serial regulation (as is the case in the classical twelve-tone technique) and, in addition to this, the timing of the entrance into the musical process of these tones is also predetermined by serial calculation (as, for example, in the case of the *Sestina*), it is no longer possible to decide freely (that is, by "inspiration") which tones should sound simultaneously at any given point. In other words, the so-called harmonic aspect of the piece will be entirely the result of operations performed on premises that have nothing to do with concepts of "harmony," be it on the assumption of tonality or atonality or anything else. Whatever happens at any given point is a product of the preconceived serial organization, but by the same token it is a chance occurrence because it is as such not anticipated by the mind that invented the mechanism and set it in motion.

Generally and traditionally "inspiration" is held in great respect as the most distinguished source of the creative process in art. It should be remembered that inspiration by definition is closely related to chance, for it is the very thing that cannot be controlled, manufactured, or premeditated in any way. It is what falls into the mind (according to the German term *Einfall*), unsolicited, unprepared, unrehearsed, coming from nowhere. This obviously answers the definition of chance as "the absence of any known reason why an event should turn out one way rather than another."[15] Actually the composer has come to distrust his inspiration because it is not really as innocent as it was supposed to be, but rather conditioned by a tremendous body of recollection, tradition, training, and experience. In order to avoid the dictations of such ghosts, he prefers to set up an impersonal mechanism which will furnish, according to premeditated patterns, unpredictable situations. Ligeti characterizes this state of affairs very well: "We stand in front of a row of slot machines ["*Automaten*"] and we can choose freely into which one we want to drop our coin, but at the same time we are forced to choose one of them. One constructs his own prison according to his wishes and is afterwards equally freely active within those walls — that is: not entirely free, but not totally constrained either. Thus automation does not function as the opposite of free decision: rather free selection and

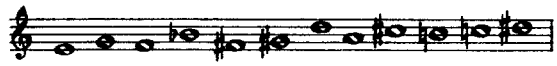
[15] *The American College Dictionary,* New York and London, 1948, p. 200.

mechanization are united in the process of selecting the mechanism."[16] In other words, the creative act takes place in an area in which it has so far been entirely unsuspected, namely in setting up the serial statements (selecting the slot machines). What happens afterwards is predetermined by the selection of the mechanism, but not premeditated except as an unconscious result of the predetermined operations. The unexpected happens by necessity. The surprise is built in.

Layers and Densities

A later serial work of mine is a set of six piano pieces, called *Sechs Vermessene.* This German title is a play on words, since *vermessen* in German means "completely measured" as well as "presuming," a pun that cannot be reproduced in English. While the time mechanism is similar to that of the *Sestina,* the construction differs from it in that for the first three pieces a system of five layers is set up in which the first has "density 1" (i.e. one tone at a time), the next has two tones together, the third three, the fourth four, and the fifth six tones. The time measurements for the various layers are a result of summing up the interval magnitudes involved in the consecutive tone combinations. For example, the tone series of this composition being:

Ex. 14



the first combination of tones in "density 2" is:

Ex. 15

The numerical values derived from this progression are 3 (a minor third from G to B♭) and 1 (a half-step from E to F). Consequently the first time segment of the first layer has three units, the first of the second has four (3 + 1). As the density of the layers increases, the number of simultaneously sounding intervals and thus the numerical values of their sums become higher. Therefore the time segments become longer, which means that the chords, or tone-clusters, with increasing thickness are spaced farther apart, while the single tones of the first layer follow each other more rapidly. Computations of this kind form the basis of the whole composition.

As explained before, phenomena in the parameter of harmony must be accepted as results of the operations in the sectors of pitch succession and time. In the fourth of the piano pieces an attempt was made to

[16] *Loc. cit.,* p. 38 (translated from the German by this writer).

begin with a selection of sound elements. From the tone row we developed twelve sets of four elements each (consisting of one, or of two, three, or four tones played simultaneously) plus two six-tone chords. These fifty elements were numbered from 1 to 50 and their succession was determined by progressing along this series by the distances indicated in the numerical values of the intervals of the basic row:

series of elements:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15 ...
intervals of the tone row:	3			2		5					4				...
selected elements:	1			4		6					11				15 ...

In the fifth piece the five degrees of thicknesses (see above) are distributed over five layers which progress at various speeds so that the time measurements of the slowest layer are reduced to 1/2 in the second, to 1/3 in the third, to 1/4 in the fourth, and to 1/6 in the fastest layer.

Progressively Varying Series

In the field of serial music one may observe a tendency towards using series of magnitudes that progressively vary according to some serial ordering of their own. The speed levels of the *Sestina* are an example. Another time series of this nature was established for the voice line of this work. It is based on the succession of 1 2 3 5 7 and 10 ♪ for the accented syllables. The opening succession is 2 3 10 5 7 1 and the following forms are obtained through the sestina rotation. Since each line of the poem has only five accented syllables, interesting situations of overlaps occur.

It may be seen that the series here applied is a modification of the so-called Fibonacci series in which each term is equal to the sum of the two preceding terms: 1 2 3 5 8 13 21 34 55 etc.[17] Luigi Nono has used the first six terms of this series as factors with which he multiplies the basic time values of his *Il Canto sospeso* in order to obtain the actual durations of the individual tones.[18] I have used the terms of the Fibonacci series from 2 to 21 to determine the speed zones in a recent orchestral composition entitled *Quaestio temporis* (*A Question of Time*). This work is based on a twelve-tone row that contains all eleven intervals in this order (measured in half-steps):

3 8 5 10 11 6 1 2 7 4 9

The entire expanse of the composition is thought of as consisting of 66

[17] Cf. Matila Ghyka, *The Geometry of Art and Life,* New York, 1946, p. 13 f.

[18] Cf. Karlheinz Stockhausen's analysis of the work in *Darmstädter Beiträge zur neuen Musik,* Mainz, 1958, p. 70.

time units (the sum of the above figures), which form eleven sections of varying lengths according to the magnitudes of the basic series. To these sections six different speeds are assigned:

M ♩ = 20, 30, 50, 80, 130, and 210

The Concept of Density Generalized

It appears that density is a function of speed and thickness of texture. If the latter may be called the vertical component of density because it depends on how many layers are in operation at the same time, speed is the horizontal component of density since the tones follow each other more closely the faster the tempo of the music is. If both parameters approach maximum values, a degree of saturation is reached at which accurate computations of time points and durations become irrelevant. When in the final section of *Quaestio* twelve layers (maximum vertical density) progress at a speed of ♩ = 210 per minute, the tones come so close together that nearly every sixteenth is sounded, frequently by several tones simultaneously. The velocity of the music causes 14 ♪ to run off per second. At this rate even the succession of pitches is not any longer of great significance. It seems sufficient to determine by experiment within a limited area the average number of time units needed for running through the twelve-tone series. The results of this statistical examination are then used in order to fill this area of highest density with actual musical sounds.

What Does Serial Music "Mean," if Anything?

One of the parameters that obviously cannot be controlled by premeditation when those so far discussed are subjected to serial ordering is the expressive, or communicative, aspect of music. If a serial composer were concerned with this problem, he would have to set up a series of "moods," or "ideas," or something of this sort, to begin with, and then let the other parameters fall in line. It so happens that serial composers are not thinking in such terms.

In a more pessimistic attitude than he now seems to entertain, the German composer and philosopher, T. W. Adorno, has criticized the recent developments of serial music[19] because in these the (according to him) deep-rooted and essential analogy and affinity of music and speech is abandoned. While it may be true that music from the time of plainchant has been oriented towards speech-like articulation, diction, and over-all structure, and while especially the exploits of Expressionism and

[19] *Das Altern der neuen Musik,* in *Der Monat,* May 1955.

atonality point to a very close association with the free articulation of prose, we have to face the fact that under the influence of the constructive rigor that was the very consequence of Expressionistic roaming serial music has turned away from its rhetorical past. Since whatever music seems to communicate is not so much the supposed content of the audible matter as it is the product of the listener's reaction touched off by his auditory experience, there is no reason to assume that the nature of serial music excludes the possibility of interpreting it as a medium of some sort of communication. The interest it may evoke is similar to that elicited by the process of life, to which serial music is related in the paradox of the chaotic appearance of totally and systematically traceable causality. It may mean as much or as little as life itself.