Remarks on Composition Theory

0 INTRODUCTION

The subject of this introduction to composition theory is not the technical equipment of the studio, neither are details of production methods to be dealt with. However, discussion of aesthetic questions can only provide stimulation, for there is no cut-and-dried system of instruction for electronic music.

0.0.1 Aesthetics deal with perception, and thus more with the listener than the composer, who, however, during discussions with colleagues and listeners, when reading criticisms of concerts, listening to his own works, is within a feedback circuit, so that perception, both his own and that of others, affects his composing. This causes aesthetic experience to become transformed into the rules of compositional craft. We can only deal with aesthetic questions if they are reflected in the technique of composition (also in the realisation of music).

1 THE EXTREMES

Since the late forties, the following two directions in compositional practice are to be distinguished: systematic composing and composing with chance. Although most works cannot be said to adhere rigorously to either one of these principles, problems of compositional technique can be discussed at the extremes with more success when the extremes meet.

1.1 System Composition

I have selected this term because it applies to two things:
(a) the composing of the system itself,
(b) composing within (according to the rules of) the system.
The greater the continuity with which the system itself is planned, the less remains to be composed in the system. The various systems invented by composers secretly tend to be continuous, which is why we shall refer to them as *Utopian systems*. The gap separating the systems from *Utopia* is filled by the composer's reactions, which are determined by traditional aesthetics. The *serial system* may serve as an example of the various systematic departures.

1.1.1 The Utopian system could be said to be mathematical formalism completely describing in two directions each instant of the work:
(a) the sum of what has already occurred (a sort of *balance*),
(b) the conditions for future events; these conditions permit aleatoric decisions.
This *time-section*, in the form of index numbers for the individual parameters, would describe the "form level" of every single instant; each new tone is added to or subtracted from the level, which is thereby altered; the sequence of the *time-sections* results in the *envelope of the form*. The position of the level indicates how strict the conditions of the further course of events are, to what extent the development presses towards consequences. When the level is zero, the piece is finished.

1.1.2 The serial technique is no less ambitious. But although it claims to organise music as a time-flow, the organisation itself must be completed before the piece is written down. The linking together of series for the individual parameters is fixed, and leads to unforeseeable consequences.

1.1.3 In this connection we occasionally speak of chance, which is then said to cause the situation to come into being. Strictly speaking, these situations are actually fixed in the linking scheme, even if they do not appear until the composition is written down, thus becoming

known. On the other hand, an event ought to be called *chance* only if its premises were unknown or as such of no interest to the composer.

1.1.4 There are various techniques of avoiding the difficulty in serial technique of foreseeing all situations. They are based on dividing the work into several sections for each of which new combination rules are set; in their turn, the rules for the sections can adhere to a system. The degree of alteration deserves attention. This prescribes for each section by how many degrees the parameter structure is to be altered with regard to the previous section. The degrees of alteration form together a series.

1.1.5 If serial rules of combination are only valid for a short period (for sections), their effect is easily foreseeen. Each new section occurs so early as to be able to have, if necessary, a corrective effect during the course of the form; this correction – in an *editorial* capacity would otherwise have been meant for the old section. The difficulty of perceiving musical form as being rational becomes clear whenever the composer's powers of appraisal improve editorially. The division into as small sections as possible having their own rules is a contradiction of system composition.

1.2 Chance Composition

This designation, too, indicates two different things:

(a) composing chance itself; or, put in another way: giving chance the opportunity of becoming musically fertile,

(b) composing in consciousness of the fact that not all details of a work are felt to be necessary, that different sequences of the same values can fulfill the musical sense; or again: to let chance operate where a rule would merely simulate necessity.

The more opportunities chance is afforded of determining – within given limits – the form, the smaller is the extent to which it has a determining influence in detail. There are as yet no systems of chance composing, although we are always waiting for chance in the merely suggested actions of the interpreter or in the form of dice on the composer's desk. In any case, composing with chance tends to be just as systematic as systematic composing is interspersed with chance elements.

1.2.1 Musical meaning is not a scientific term. The more one feels that the further development of a work is necessary, there is said to be sense in it; the very readiness of the listener to let himself be led aids apperception. On the other hand, the composer may believe that a particular constellation of acoustical elements is a guarantee of musical meaning which introduces itself either spontaneously, or not until after being heard several times, or not at all.

Musical meaning could be said to come into existence on the plane of communication between composer and listener, modified of course by the latter's musical education. On this plane it is simultaneously subjected to the transformations of the musical material and the attitude of the audience. These, however, are merely the coordinates of the communication plane.

The composer surely has an insufficient idea of what the listener really hears, and vice versa. It would be desirable to examine this difference with regard to a selection of compositions which the audience feels it understands, whether spontaneously or with difficulty. As far as the way in which the composer listens is concerned, we can surely say that he is capable of following systematic compositions as well as of, let us say, composing on the spot works using chance operations.

System compositions usually expose their rule-character to such an extent as to permit the listening composer to perceive the individual structures as the steps of a structure-parameter. – The form idea is developed; the listener recognizes the idea in the development.

Chance compositions do not lead us to expect serially controlled relationships, but rather to observe closely neighbouring musical events, each of which react to one another in their own way. – The development completes itself, thereby becoming the form; the listener recognizes that development was its idea.

2 SYSTEM COMPOSITION

In systematical composing (serial system), three work-processes can be distinguished:
(a) he division of the sound into its characteristics (parameters),
(b) the arrangement of the parameter values (sequence),
(c) the alteration of the arrangement (permutation).

2.0.1 In instrumental music, the work-processes can be said to be theoretical. The composer can name the characteristics of the sound by note-names (C, C sharp, D etc.). metrical values and metronome tempi (quarter-note at tempo 60), dynamic indications (p, f) and instruments (violin, piano, trumpet etc.). For the location of the tone, instructions can be given as to the disposition of the players on the stage or in the concert hall. – The composer arranges the parameter values by writing them down in the desired sequence. – There are no limits to the alterations of the sequence, which are also achieved by writing them down.

2.0.2 In electronic music, the work-processes must be *translated* into technical procedures of realisation. Each sound characteristic corresponds to a different piece of apparatus and thus to a different action (generator, cutting the tape, potentiometer, modulator, registration for the parameters mentioned under instrumental music). – The arrangement of the parameter values is achieved by the composer's producing them in the desired sequence (e.g. pitches, timbres) or programming mechanical media (tape) or electronic circuits in such a way as to cause them to store a particular sequence of parameter values (durations, dynamics). The alteration of such sequences is more difficult than in instrumental music; we must either tamper with a mechanical medium (unsticking gummed tape), or re-program an electronic circuit.

2.1 Division of the sound into its characteristics

If we divide the sound into its characteristics, the following chiefly appear:
(a) pitch,
(b) duration,
(c) volume,
(d) timbre,
(e) location.

The term *pitch* (rather than *frequency*) has been chosen in order to place the accent on the perception value; when dealing with the other parameters we also chiefly mean perception, although (timbre excepted) measuring units are always available. – Time determinations also include the *entry delay*, which, however, will not be separately dealt with here because its technical production in the studio does not differ from the duration (but compare sound synchronisation). – The *attack* is a component of the timbre; for details see below.

2.1.1 Pitch. This characteristic can be just as much perceived in electronic sounds as in instrumental ones. It is produced by means of a sine-wave generator, by spectra with clearly recognisable basic or central tones, by filtering noise or noise-like structures, by transposition. Neither as frequency nor as perception is pitch always unambiguous; but the area between sinus tone and white noise can be divided into several steps, so that the degree of perception can be operated with as a further parameter. (The possibility of perception, the limited unambiguity and the parameter of the degree of perception are also valid for the other parameters.)

The serial system does not only divide the sound into its characteristics but furthermore demands that each characteristic can be altered independently of the others. This demand can

hardly be fulfilled in instrumental music, as at least the timbre depends on the pitch. The same difficulty appears in electronic music. The independence of sound characteristics can only be guaranteed to a limited extent.

2.1.2 Duration. The duration of an electronic sound is realised either by cutting the tape or by electronic switches. In instrumental music, too, practically any duration is feasible by the combination of metrical duration and metronome tempo. The difference is in the practical possibilities of realisation. This is why similar durations or groups of durations in instrumental music are repeated until it is possible to change the tempo or the beat.

Tape, however, can be cut into practically any lengths. But the shorter a sound becomes, the less exact is its pitch.

2.1.3 Volume. Using a potentiometer, we can realise a large scale of various dynamics. The advantage over instrumental music is that in contrast to vague indications such as forte or piano, a physical scale (dB-scale) is available. This measurement does not give information, however, about the degree of perception (*loudness*). The volume of electronic sounds can change as rapidly as desired and can be set or altered not only by hand (potentiometer) but also by means of electronic circuits (amplitude modulator).

A keyboard responding to pressure is a connecting member between instrumental and electronic music; with it, the composer can perform alterations in volume as does an instrumentalist.

2.1.4 Timbre. This parameter permits hardly any analogies to instrumental music, in which the timbres are fixed according to the construction of the instruments which have developed unsystematically in the course of time. The instrumental timbres are important distinguishing marks in polyphonic music and acquire a language-like significance because of the music written for them. In electronic music, by contrast, timbre is simply the way in which that which sounds appears, not a property of the sound that has as yet no timbre, but more that which results from amplitude/time relationships and the context. So far timbre is the aim of a composition and at the same time its medium.

There are many ways of producing timbre; the most important are:
combining individual partial vibrations to make a spectrum,
filtering white noise,
modulation and very rapid dissolution in time.
For the last method, further technical development is awaited (variable function generators, computer).

In instrumental music, attack is of great significance. Attempts to imitate attacks in the studio have not met with success. The attack characteristic for each instrument presents the greatest obstacle in the way of making timbre variable. In electronic music, by contrast, the way in which the sound is altered is important (*transients*).

2.1.5 Location. There are hardly any correspondences to this parameter in instrumental music, although here the instruments can be spatially distributed. In electronic music, the possibility of altering the location of the sound at will is new. The technique of four-track recording is only a beginning. For the future of this development, it seems to be less important to use the mere direction of the sound as a parameter than to evaluate the actual movement of the sound compositorially (the listener is surrounded by sound, this sound-space is variable).

2.1.6 One could ask if it is important to be able to produce parameters separately in electronic music, if after all the artistic aim is their fusion into timbre as the medium of electronic music. However, two points seem to make it reasonable to isolate the parameters first.

(1) Electronic music developed simultaneously with serial compositional technique, and received its first impulses from the latter. This accounts for the pseudo-instrumental character of the first electronic pieces. Attempts were made to draw all conceivable consequences from the tendencies of instrumental music of that time. All later changes in sound production and of the theoretical positions stand historically on this basis.

(2) Specific parameter-combinations can only ensue if the parameters can be produced individually. As in the serial compositional system, they are only isolated in the studio in order to be put together again at will. This viewpoint will always move into the foreground whenever complex sounds have a definable "content" and moreover are to be reproducible (sound production with computer).

2.2 Arrangement of the parameter values

The sequence of the parameter values was the starting point of dodecaphony ("series") and was binding for all parameters in the serial system. If we are to compose systematically in the electronic studio, the question arises as to the technical possibilities of producing or storing (program) the sequence of parameter values.

2.2.1 Pitch. Various pitches are placed in a particular sequence by means of successively recording sinus tones on tape. This provides us with a catalogue. Instead of sinus tones, of course, spectra, filtered noise, other already produced sounds or those recorded with a microphone can be stored, as long as we merely have a sequence of the sounds according to their various pitches.

The sequence of various frequencies can also be electronically stored in the form of various voltage values which then control a voltage-controlled generator.

2.2.2 Duration. Durations are stored by cutting corresponding lengths of tape. These pieces of tape can be kept in the form of loops or – with intermittent pieces of non-magnetic tape – stuck together to form one tape as *passepartout*. These *empty durations* can later be used to record various sounds.

Durations, too, can be stored as various voltage values, to control an amplitude modulator.

2.2.3 Volume. Attempts have been made to cut dynamic curves out of tape. This method is not to be recommended, because when the tape is halved, the volume of a recorded sounds falls by 6 dB. This makes the field of small volumes practically unrealisable.

Another method makes use of a blank film strip which is covered with black material (ink, paper, etc.) in the form of the desired dynamic curves (or levels of constant volume). The photo-electric scanning of the film provides the control voltages for an amplitude modulator (*Hamograph*). The control voltages can also be stored electronically.

If such aids are not available, the envelopes must be individually made by hand, so that a particular sequence can not be stored.

2.2.4 Timbre. Various sounds can be arranged according to the viewpoint of timbre, and stored in the form of a *catalogue* (as pitches or durations). Work processes such as filtering, reverberation or modulation, which give previously produced sounds a particular timbre, can only be stored with control systems switching the above-mentioned apparatus on and off (punched tape, impulse control).

2.2.5 Location. The direction of the sound can only be fixed by recording on multi-track tape. Impulse storage controlling a switch is necessary for storing a sequence of various directions.

2.2.6 The setting-up of catalogues (or passepartouts) serves the purpose of combining the sequence of one parameter with the sequence of another one, thus enabling any desired combinations. In other words: the storage as well as the use of a sequence of any parameter can occur at any time, i.e. independently of the time taken and the time of performance. This – together with the arbitrary combination of various parameters – indicates the programmatic aspect of electronic sound production. It would be desirable to extend the technical possibilities of storage of all parameters, including exact synchronisation. The consequence of this demand is the use of a computer for sound production.

2.3 Alteration of the arrangement

The serial system demands constant alterations. Once the sequence of elements has been established, it must be permutated, just as the first sequence was already a permutation of the elements (*stockpile*).

2.3.1 It is expedient to distinguish between position, term and element. Terms are all the elements occurring in a series, whether they are similar or different. They occupy positions, from position 1 to position n. Elements are various quantities; a series can therefore contain more terms than elements (repetition of elements).

Permutation means: to establish a new arrangement, new with regard to the intended schematic list (starting point for the arrangement of parameter values), new also with regard to an already given arrangement (alteration of the arrangement). For the first production of a sequence it was necessary to compose a catalogue or a passepartout by cutting tape. It would be a waste of time to use this method for each new permutation.

position: 1	2	3	4	...	n	= n terms
E_1	E_2	E_3	E_4	...	E_n	original series
E_{n-3}	E_2	E_n	E_{n-1}	...	E_7	permutation

The numbering of the positions (index) is constant. Examples for permutations:

Examples for permutations:

position:	1	2	3	4	
permutation n	3	2	4	1	
permutation n+1	4	3	1	2	transposition
permutation n+2	1	4	2	3	"
...	...				

position:	1	2	3	4	
permutation n	3	2	4	1	
permutation n+1	1	3	2	4	cyclic exchange
permutation n+2	4	1	3	2	"
...	...				

Note that we have always to do with an alteration of the arrangement and never with an alteration of the elements themselves.

2.3.2 Permutations are derivations; can we find a technical equivalent of the musical relationship to one another of two derivations?

2.3.3 The simplest method consists of running the tape backwards: this gives us the retrograde of the previous sequence.

2.3.4 Cyclic exchange is also simple: we only need to remove the last (or first) element and to put it back at the beginning (or end). Of course this brings about only a small alteration of the sequence.

2.3.5 For transposition, it would be necessary to dismantle the entire catalogue. In order to avoid this, we can use the transposing machine, on condition, however, that all the elements belong to a system of similar intervals. If we then transpose (i.e. increase or diminish the tape-speed) by this uniform interval (or a whole-numbered multiple), each element occupies the place of the next higher (or lower) element. The disadvantage of this method is that elements are discarded and new elements appear belonging, it is true, to the same interval system, but not to the original series.

2.3.6 By means of compositional artifice we can overcome this difficulty: we define more elements than should occur in a series, and we determine that the number of terms in a series shall be a compositional quantity (a parameter). The following example uses 10 equidistant elements; the series encompasses 6 elements.

positions:	1	2	3	4	5	6	7	8	9	10		transposition
elements:			4	7	3	5	8	6				
					6	9	5	7	10	8		2 intervals upwards
		3	6	2	4	7	5					3 intervals downwards

2.3.7 In this manner, it is possible to have transposition of the duration passepartout. The unoccupied durations are lengthened or shortened by the same factor by transposition.

2.3.8 Another method of easily altering the sequence consists in dividing into sub-groups. While each individual sub-group can be altered by reversal or cyclic exchange of the elements, the sequence of the sub-groups, too, can also vary according to this principle.

As an example, here is a series of 10 elements divided into 3 sub-groups with 2, 3 and 5 elements.

series:	3	9	6	1	4		8	10		5	2	7
exchange of the sub-groups	5	2	7		3	9	6	1	4		8	10
exchange in group 2	5	2	7		9	6	1	4	3		8	10
retrograde of the series	10	8		3	4	1	6	9		7	2	5
original subdivision	10	8	3	4	1		6	9		7	2	5
exchange in group 3	10	8	3	4	1		6	9		2	5	7
exchange of the sub-groups	6	9		2	5	7		10	8	3	4	1

2.3.9 Basically, no elements are lost when permutating, no new ones occur. (Exception: transposition, but here the rule mentioned for the *stockpile* of elements applies; from the *stockpile* a selection is made for the series which is then to be permutated – the transpositions of the selection restore the *stockpile* without exceeding it.)

We can call it a hermetic principle, for all other methods of altering given elements (whether in the sequence or their consistency) make use of chance principles or at least of mixed forms.

3 CHANCE COMPOSITION

The introduction of chance into musical composition is often regarded as being a counteraction to serial composing, to system composition. This is correct inasmuch as in serial technique, special significance is attached to the sequence of the individual elements and also to the alteration of the sequence which ensues according to general principles. In chance composition, the sequence of the elements and thus the principles of their alteration, too, are neglected. We can distinguish between two methods of dealing with chance: the introduction of chance during the composition and the effect of chance during the realisation in the studio.

3.1 Composition

At his desk, the composer throws a die to determine all the data of the work: total duration, number and duration of the sections, pitches, dynamics, durations, entry delays and timbres of the elements, their density (superposition), transformations, sequences etc. The practical work in the studio is then limited to realising these data individually; there is thus no difference from the realisation of a systematically composed score.

3.2 Realisation

The composer concedes to chance an influence on the production of the sounds and their synchronisation.

3.2.1 Sound generation. By arbitrary settings of the generator, arbitrary sequences of pitches or impulses are produced. By arbitrary settings of the filter, noise-bands of arbitrary width and frequency are produced. (For arbitrary sound generation, microphone recordings of arbitrary sounds or the use of damaged apparatus could be considered.)

3.2.2 Sound transformation. Arbitrarily selected material can be subjected to arbitrary transformations: the direction of the tape, transposition, ring modulation, filtering, reverberation etc.

3.2.3 Sound synchronisation. Arbitrarily selected results of transformation are arbitrarily composed to form "layers" and are superposed with arbitrary entry delays. These results can be subjected to further arbitrary transformations and finally arbitrarily distributed among four tape-tracks, unless an arbitrary distribution among four loudspeakers during performance is preferred.

3.2.4 Chance is conceded yet another influence if several collaborators, independently using the various switching and control apparatus of the studio, participate in sound production and transformation (possibly in one work process). The course of the piece is completely incalculable unless there is a general scheme for all actions permitting a certain amount of prediction within statistic limits.

3.2.5 This chance principle, as we know, is usually applied by John Cage for instrumental music (electronic example: *Fontana Mix*).

Another example, which really belongs in the next chapter, is *Artikulation* by Gyorgy Ligeti. The material (pitches, durations, pauses, timbres, density) was produced according to tables (which were based on serial considerations). The individual pieces of tape were thoroughly mixed in a cardboard box and stuck together in an arbitrary order. This resulted in sound fields with a previously defined *content*, although the time structure of this content was left to chance.

4 FIELD COMPOSITION

Strict system composition is hardly ever employed nowadays; not because it is out of date but because the development has shifted the systematic aspect of the *point* via the *group* towards the *field*.

Consistent chance composition seems to belong to Cage's individual style; it is easy to distinguish his music from that of his imitators because of the musical quality of his works. Moreover, most composers who approve of chance or at least want to try it out tend towards field determinations which limit chance to such an extent as to make the field limits – as systematical quantities – clear.

4.0.1 If we summarise the observations on system composition, we see that the composer composes the system and that he then composes within the system (according to the rules). Within the system, a certain amount of freedom is available to him, on the extent of which depends whether we can still talk about systematic composition. I do not mean the freedom which suspends the system, but that which is inherent to the system and without the use of which the system is not fulfilled (e.g. composing with degrees of alteration).

4.0.2 If we summarise the observations on chance composition, we see that the composer leaves the production and arrangement of the acoustic element to chance; this leads to

constellations which the composer would not be able to produce systematically. Moreover, the tones are not equally important in their characteristics to the composer (i.e. he does not require a hermetic principle to guarantee their equal rights); he rather believes that chance, which is always being extended to previously selected material and is uttered within the framework of a selected rule, does not confuse the musical idea, but expresses it.

4.0.3 In both cases we can speak of permutations in order to include system and chance in a common viewpoint: in the system, a particular series is permutated; in the sphere of chance, each arrangement of the elements refers to a list containing the elements that are permutated. In the former case, the permutation is systematic because the hermetic principle would otherwise not be guaranteed; in the second case, the permutation is aleatoric because no principal conditions (completeness, non-repeatability) are attached to the selection. To emphasise the difference terminologically, we could call systematic permutation an order, and aleatoric permutation an arrangement.

4.0.4 We obtain yet another difference if we observe the relationship of composition and realisation (also performance, interpretation). In system composition the elements are arranged at the desk, the technical execution takes place in the studio. In chance composition there are two possibilities: arrangement of the elements at the desk, execution in the studio – or: fixing conditions and rules at the desk, arrangement during the technical work process in the studio. The latter case is more important for us.

4.0.5 This confrontation gives us an inkling that system and chance have at least one third factor in common: the composer, whom nobody forces to use exclusively either one way or the other. The system in systematic composing, which according to the above definition is the subject of compositional considerations, can hardly be cogently derived from still earlier circumstances; it is arbitrary as are the rules of chance.

4.1 Unarbitrary fields

During the realisation of an electronic score composed according to a systematical conception, *unarbitrary fields* frequently occur. The processes of production and transformation are admitted into the systematical concept as *ideal*, the fact being ignored that the influence exerted on the sound by the electronic circuits displaces the original system in a transformation field. Even if this is evident to the composer and he also calculates the transformations, he cannot avoid deviations from his system.

4.1.1 During the transposition of electronic sounds, spectral parts are displaced against the frequency characteristics of the transmission links, but also against the curves of equal loudness level. In some circumstances the audible range is exceeded at either end. In this way there is an unintentional spectral modulation.

4.1.2 Filtering involves alterations which are difficult to control – and hardly to be placed in a system. According to the attenuation of the filter, spectral parts outside the compositionally fixed frequency limits are still let through. Steep filter flanks result in audible distortion.

4.1.3 In reverberation, not only do statistical modulations of the original sound occur, but also the characteristics of the reverberation system. This frequently causes reverberated sounds to acquire a new amplitude curve.

4.1.4 The composer finds the situation when using the ring modulator especially obscure. The original spectrum is practically completely lost, while the rhythm is unaffected. If sounds having their own envelopes and time structures are modulated with each other, new amplitude and rhythmic curves occur that can hardly be previously calculated. (NB: They could be previously calculated if the sounds to be modulated were known in all details. The result of modulation could then even be produced without the modulator. However, as long as the

modulator is to be used for structural transformation, i.e. as long as transformation functions as a parameter, the analysis is superfluous.)

4.1.5 We must also be prepared for surprises when dealing with the superposition of sounds, because synchronism is only certain within limits in tape technique. Moreover there are additions of the amplitudes and various degrees of coalescence of the sounds because of their

4.1.6 permeability. Sound processes intended to be independent can be absorbed by each other, while desired coalescenc~occasionally do not occur. This, too, results in an alteration or the form of the sound, to be sought within the field of possible transformations.

Summarising, we can say that the compositional system of the composer is imposed upon by a technical system whose characteristics are known and calculable to differing extents. The systematic data are always unarbitrarily displaced within a field.

4.2 Arbitrary fields

It is of course possible when composing to take into account the unarbitrary influence exerted on the sound by the technical media of realisation in such a way that the punctual system is replaced by a system consisting of fields.

4.2.1 It is apparent that unarbitrarily arranged elements are less exposed to the influence of unarbitrary transformations. When composing, we can define fields and arrange the individual elements so as to make clear not only the fields limits but also other characteristics (density, aperiodicity, etc.) by spreading within a framework. These characteristics are either not influenced at all, or influenced in an easily predictable manner by the unarbitrary transformations.

4.2.2 Scattering within a framework defines the latter's structural content. This could be put in the position of the punctual definition, whether in a systematical method of composition or in one permeated by aleatoric decisions.

4.2.3 Arbitrary fields can have similar structure contents, resulting in common characteristics. These, too, are fairly insensitive to the unarbitrary transformations, especially when the common characteristics are limited to a few or only one parameter.

4.3 Supplement: two kinds of chance

The *unarbitrary transformations* could be calculable and thus not random if the circumstances were more exactly known (characteristics of the material, of the transformation medium and all other transmission links). As the composer does not know these premises, and as knowing them would be of no use to him in most cases, the results assume a random character for him, they remain uncalculated.

If the premises can only be known as statistic values and within known limits, so that the sequence of the individual values can principally not be predicted, we are dealing with chance in the more limited sense (e.g. white noise). In this case the events are incalculable.

Chance composition proceeds from incalculable sequences of events and constellations. System composition tries to avoid chance but must be prepared for uncalculated results, in instrumental music as well as in electronic music.

5 COMPOSITION-THEORETICAL CONSEQUENCES

As unarbitrary transformations are frequent and frequently unavoidable in the sphere of electronic sound production, but the compositorial plans often proceed from systematic premises, compositional technique must be adapted to production technique. The same applies to the case where an aleatorically composed piece makes use of production methods which,

at the same level of unarbitrary transformations, establish uniform characteristics which contradict the a1eatorica1 premises. Here, too, compositiona1 technique can counteract the undesired influences, whereas production technique may not remain indifferent to the conception. We shall consider the consequences again under the viewpoints of system composition and chance composition.

5.1 System composition

In principle, serial compositions are in one movement, the principle thus governing the entire work. The serial principle quantifies the sound with regard to its characteristics. Each parameter can only be subjected to the system individually. From these premises result the parameter presentation and the tendency to large form-units.

5.1.1 Parameter-presentation has two meanings:
(1) that the sound appears as the sum of its parameter values (pitch, timbre, volume, duration),
(2) that the serial principle is respectively extended to one parameter (sequence, permutation).
For only under these conditions can the musical process be quantified, and the sequence of the individual quantities incorporated in perceptible arrangement. The greater the extent to which parameters adhere to certain arrangements and the greater the extent to which musical meaning is to depend on the perception of these arrangements, the more unpredictable, *random*, are the effects of one parameter on the other: the various characteristics coalesce to *sounds* whose order is unequivocally defined neither by the course of an individual parameter nor by the polyphony of all of them. So far, the addition of the parameters to form the sound belongs to the *unarbitrary transformations* which introduce a random element.

5.1.2 The serial overall form arises in principle by as many series' (permutations') being run through for each parameter as are necessary to reach the end of the work. In order to avoid *blocks* in which all parameter series begin and end simultaneously, series of varying lengths are made, or the parameters are made to adhere to various duration series. This leads to multifarious overlappings which the composer can calculate but not hear in advance or visualise for each instant of the work. A kind of temporal compression occurs: while the *classical* composer composes his work moment for moment and can relate the moments to each other with his ear, the *serial* composer casts a relating net over the duration of the work. Its junctions are not heard until the performance, but at the earliest after the entire score has been written.

5.1.3 To avoid the constructional difficulties of the serial overall form, it is first divided into sections; the order of these sections is itself a series. What was said in the last paragraph then applies to each individual section, so that when one section has been *listened* to, the data of the following one can be fixed.
The sections can again be divided into subsections, so that the unarbitrary transformations to which the growth of the sections into the overall form is subjected can be more and more restricted. By dividing still further, we can finally reach the single tone, the *point*.

5.1.4 Another way to the overall form begins with the *point*. Several points unite to form serial groups which in their turn can be combined to form group formations. While the courses of the parameters can still be controlled within a group, this group acquires another characteristic: the group characteristic. It is more important to arrange these group characteristics serially in the group formation than the permutations of the individual parameters running through all groups. It is of course difficult to establish a group characteristic as a serial quantity whose variants constitute the group formation.
Several group formations result in the next highest form unit. Strictly speaking, the group formation must also crystallise a common characteristic which can be varied in the next form unit. The difficulties increase in proportion to the size of the work – whereas the division of

the serial overall form revoked the difficulties as the form element to which serial control has to apply became more punctual.

Section and group are serial form elements which are brought about by mechanical (obeying series) division or accumulation. The unarbitrary transformations increase with growing complexity (even of the duration) of the form and call special attention to properties which result from the transformations and which can be emphasised by the composer at will.

5.1.5 On these characteristics (actually definitions of uncertainty) is based the term structure. It combines the individual elements in such a way that form parameters such as density, aperiodicity, tendency, contrast and others like them can be articulated. At the same time, serial mastery over parameters and their permutations relaxes, without being able to instal comparable systems in these form parameters. Of course, structure characters are less exposed to unarbitrary interpretation by the listener than is the division of an overall form into sections.

5.1.6 Structural characteristics are uniform features which come to the fore all the more clearly when they occur in few parameters. Uniform features occur in electronic music – as far as they were not already fixed in elementary sound structures – by means of electronic transformation processes. They are in a manner of speaking the other side of the picture of the *unarbitrary transformations*.

It will be clear that system composition in its ideal form can hardly be realised because of the multi-dimensionality of music which must leave it to the listener to direct his attention at will to one or another dimension or to perceive an always receding sum of all dimensions, as it were, *diagonally*. The more the composer forces the listener to hear in a certain direction, the less capable he is of composing in detail the system in all parameters, not to mention presenting this to the listener. Whatever systematic contents stand out are mediated by the transformation process which displaces the acoustical data in a chance field finding its correspondence in the transformation inherent to the psychology of listening to music.

5.1.7 This defines the limits of the system and at the same time possibilities of protecting the systematic character from chance or at least of prevailing over it. Chance composition is not only a countermove to systematic composition but rather the attempt to rationalise obvious contradictions of the latter and to base a proper system – the aleatoric principle – on them.

5.2 Chance composition

This principle does not aim at particular form types or form units because chance – according to how it is interpreted – is absolutely not capable of forming form, or it leaves forms in its wake wherever and to whatever extent it operates. (That is what was meant by the definition of chance composition: the composer gives chance the opportunity of becoming musically fruitful.)

5.2.1 Chance composition, too, requires parameter presentation if it: is not desired to put random quantities, regardless of their parametrica1 definition, into random arrangements. As however the random order within a parameter does not create clear form contours which could lose pregnancy by the coincidence with the arrangements in other parameters, there is not the danger of coalescence to *sounds* which system composition can hardly escape; for *sounds* occur in any case, and their order will be just as random as the sequences within a parameter.

5.2.2 The division of the overall form, whether into sections or by accumulation to form groups, contributes nothing to the articulation of the form as long as no uniform features are created or uniform features arise by chance to which the composer reacts by intentional definition of deviating uniform features. It is more a question of the method of composition, as to whether the work is conceived and performed as a whole or in sections.

Mongrel forms are more frequent than the extremes; the work governed throughout by chance may appear unarticu1ated to the composer.

5.2.3 More plastic formations are brought about by the articulation of structures. However, this presupposes that various structures have various characters in order to be distinguished from one another. The qualification of structures tends to the system:

(a) of structural types as musical units,

(b) of parameter values and their permutations constituting the respective structure type.

Whereas the structure functions as a definition of uncertainty in system composition it defines the degree of sharpness of an as yet blurred agglomeration.

5.2.4 Structure characteristics are also here uniform features insulating the structures against each other. As in system composition, uniform features also arise in chance composition by means of transposition processes in the electronic studio: the random arrangements of the parameter values are unformly reverberated or filtered or modulated, which causes them to combine to form a form unit which could be said to *absorb* its individual elements.

5.2.5 This makes the limits of chance clear, too: even the slightest pressure towards form, i.e. towards differing units, towards transitions, contrasts or tendencies, attacks the free play of chance and effects the appearance of planned actions. The *unarbitrary transformations* now displace the unarbitrary elements in readable relationships, they work like force fields, which, because their particles arrange themselves, recognise the forces working in them.

5.3 Fields with variable content

Practical conclusions can be arrived at from the compositio-theoretical consequences formed up to now. *Fields* are limits between which the horizontal and vertical division (time, pitch), as well as the permutations of the elements, are dictated from readable systems, non-readable systems (unarbitrary transformation) or random principles. Division and permutation are variable quantities.

5.3.1 Form is sequence – at least in the serial system, certainly in chance composition. The sequence imparts particulars about the meaning of the most recent events. Experiments have been made with form sections whose sequence could be altered so as to give them new significance. But it becomes apparent that the more often one hears the work, the greater is the extent to which the form sections make themselves independent: the alteration of the sequence, and not of the meaning, is heard. The sequence's ability to construct forms is a kind of *first performance* effect; expectations are still fresh and reactions spontaneous. This experience must be all the more forceful, the smaller the extent to which a first form section nurtures specific expectations with regard to the second: fields which can be full of inner tensions, but which remove these tensions to a great extent so that what remains is the necessity for progression, but not for one particular progression.

If fields succeed one another, they form relationships; these relationships are all the more easily comprehensible, the greater the extent to which related elements are manifest or suggested. Fields with variable content are more variable; families of similar – or contrasting – fields can easily be established.

5.3.2 Related fields reveal their degrees of relationship and thus systematic contents – or those which can be systemised. Fields are actually *open* forms, not only with regard to apperception, but especially for the composer: their content can depend on chance or on system, and systematic thought (form tendency) can be formed in their order, too, or a random whim be expressed.

5.3.3 The field content (similar to the structure content) consists of the sum of what has been musically and structurally invested; not merely of the amount of acoustical elements themselves but of their characteristic sequence, of distribution of recurrences, leaps, transitions, coalescences, of neighbouring relationships or contrasts. Such characteristics result from systematic manipulations which, because of their complexity, are subject to *unarbitrary transformations*, or they result from random manipulations within such narrow limits that they

protrude like punctual quantities, thus forming a scaffolding by which the listener can orientate himself. According to whether this unarbitrary transformation is entered because of increasing complexity, or whether the limits of chance are gradually drawn together, the field can be granted degrees of transparency or coherence which, of course, could hardly be subordinated to any system. Decreasing entropy (little complexity, narrow chance limits) creates circumstances which can be quantified.

In electronic music, field contents are brought about during the phase of production (recording, splicing, superposition) but also by means of transformation processes which displace to a greater or lesser extent the result of the production phase in the field of the *unarbitrary transformations* and grant the results an additional characteristic. Such transformation processes can be systemised: the same transformation can operate in various degrees, various transformations can be coupled with one another.

5.3.4 Systematic transformations can moreover alter the result of the production phase in such a way that only certain characteristics (such as the pitch flow or rhythm) are retained, but that others by contrast are altered to the point of unrecognisability.

By *structure* we define a piece of music complete in itself, i.e. an articulated duration. Structure is accordingly a formal term. By *field*, on the other hand, we define a sound context complete in itself, i.e. an articulated relationship of durations, but also other parameter values. Field is accordingly a sound term in the broadest sense. The field becomes structure if it fills a form section on its own as articulated duration.

5.3.5 In many cases, fields are superposed to form structures (the superpositions can of course be placed on one another in such a manner that no caesural structures occur). As – corresponding to the field concept – the superposition, too, need only be fixed within limits (in time limits), it is important that the fields be susceptible to one another. Susceptibility is a compositional quantity, a field characteristic. It means that the internal relationships constituting the field do not simultaneously seal it off from the outside, but are rather *open* in such a manner that the presence of another field causes a kind of contact, one might almost say: communication. Several fields can also permeate to the point of complete coalescence.

6 FINAL REMARKS

We have proceeded from the extremes of system composition and chance composition to arrive finally at the field as a mongrel form in which systematic and random components are crossed. From the beginning it was clear that when strict system composition is at all complex, it leads to unpredictable mutual influences which, as definitions of uncertainty, belong to a field of probable relations rather than that they occupy calculable places in the system. Similarly, we could not ignore the fact that chance composition leads to constellations which can more easily be attached to a flexible or incomplete system than heard as contextless points.

6.0.1 Although instrumental and electronic music have the same objective: that of making an imagined construction audible, they differ basically in the technique of realisation. This difference comes especially to light when the formation of variants (of a sound, a field, a structure) is effected by electronic transformation media. This causes the acoustical event as a whole to be subjected to one and the same transformation. At this point, the compositional technique of electronic music branches off, too: sounds or structures must be articulated in such a way that not only the uniform feature that frequently occurs but also the variant is more copiously articulated than the initial material.

6.0.2 The discussion of the extremes has shown that in the electronic studio systematic constructions are possible, although always in danger of being displaced in the realm of chance; that, on the other hand, technical consequences could be acted upon in order to retain the systematic character of a composition throughout all realisation processes. On the other

hand, chance manipulations easily acquire systematic features which can not be avoided so easily, not at any rate by merely developing suitable studio equipment.

6.0.3 The discussion of the extremes has also shown that where the system character or that of chance cannot be retained, aesthetic consequences are to be acted upon. They amount to assimilating the *unarbitrary transformations* into the systematic conception, in other words, to defining degrees of unambiguity (or degrees of probability), and then employing the transformation media in such a way that the sound characteristics either are displaced or remain unchanged in the range of greater or lesser probability. – In chance composition, the limits should be drawn together so tightly that punctual events still appear as limit values of chance without fixing expectation in unambiguous connections.

6.0.4 Finally, a conception of musical fields might be feasible in which static elements are from the very beginning related to each other in such a way as to represent various degrees of presence; the acoustic appearance of the material and in it the refraction encountered there by the musical idea become present.