THE CONSTRUCTION OF SOUND

In the following text I might be accused of not keeping the promise made in the title. There are no indications as to how instrumental or electronic sounds ape constructed, nor is there a classification of known or imaginable categories of sound. The text, written in 1963, therefore contains no mention of sound analysis as nowadays performed by computers. I might also be reproached with -referring more to instrumental music and the formal arrangement of electronic sounds in the context of musical form than to electronic sounds and formal tendencies inherent to this medium. I should therefore like to remark that in this text I have attempted to transfer to electronic music that which in serial theory transcends the classic formal canon. The guiding aspect resulted from the programmability of musical structures, for which instrumental music provided by far more leads than electronic music. The compositional technique apostrophised in the last chapter as "aleatoric mixtures" has since been realised in the form of a computer, programme ("PROJECT 1", 1964/66).

As the text demonstrates. it is not only a matter of transferring the serial theorems of the fifties to electronic music. The implicit question rather arises as to how instrumental experience in macro-time (rhythmic relationships among parameter values) could be transferred to micro-time (timbre formation laws). The sparse empiric material for this scarcely permits conclusions to be drawn, let alone indications as to craftsmanship. Consciousness of fundamental experience in both instrumental and electronic music can aid the construction of models which when executed by computers will smooth the path to analytical sound description. That is what this text is about.

1. General

The characteristics of every sound depend on the way in which the sound was produced. Each art-form exploits its special production methods in order to endow the phenomena with unmistakable characteristics. Artistic economy demands that the means be appropriate to the end, and that the exploitation of the means be an end in itself.

Instrumental music is produced on mechanical instruments which are influenced more by instrument-builders than by composers. Operation of these instruments depends on physical prowess; the sounds which are produced depend on the way in which the instrument is constructed. This results in the homogenous, continuous sounds of limited lengths in instrumental music. One might say that all classic categories of melodic formation, counterpoint, harmony, form and instrumentation have their origins in this manner of production. What is also extremely characteristic is the joint productive result in smaller or larger ensembles. All rhythmic and metric formations can be regarded as the consequence.

Electronic music is produced on electrical equipment. Here, too, the engineer's contribution is of greater influence than the composer's. The operation of the machines does not greatly depend on manual skill; but the sounds which are produced do depend on the equipment's construction. The joint productive result for performance purposes is replaced by the production of individual sounds; this can occur in any order and take any length of time. The length of electronically produced sounds is theoretically unlimited; the apparatus is simply switched on and off. The classic categories thus do not apply to electronic music; at any rate they do not have their origins in the new material and the way in which it is produced.

The electronically produced sound does not have to be homogenous and continuous. In its capacity of structured field it is variable in all directions. Its length is only determined according to compositional considerations, and a piece could conceivably consist of one single sound.

In instrumental music, the smallest musical structure consists of several tones. Their pitches (simultaneous or in succession), their volume, the time-lag between their onsets (entry delays) and their durations form mutual relationships. These relationships are the means by which form is made. – In electronic music, one complete sound can consist of several individual components whose determinants may change in the next sound. In this manner the individual sound becomes data storage with references both to itself and to the next sound. The sound is a closed unit and becomes the means of formation; each sound characteristic (the course of its pitch, loudness, timbre) becomes a formal event. Instrumental music composes "with" sounds, electronic music composes sounds.

The electronically produced sound is thus both a form-section and an acoustico-musical "unit", a quantum. The reciprocal play between the characteristics constitutes electronic formal theory and also its aesthetics.

Analysis of the musical sound into its "parameters" – in instrumental music theoretically more preached than practised – is in electronic music a fact by virtue of its production method. Pitch, loudness and duration are "set" on independent pieces of equipment. "Timbre", however, the result of compositionally linking parameters or individual sound-components, is in electronic music not a parameter but its "dimension", a reference system as is the two-dimensional plane in Euclidean geometry. Although a reference system, "timbre" is not static. One might describe an electronic work as white noise from which the undesired components have been removed. One might say that in instrumental music time is articulated, in electronic music the "sound" is articulated, for "sound" as a kind of timeless sounding of particular "material" is alien to instrumental music, individual sounds being produced manually under the conditions already described. These sounds interrupt the silence of time. The individually formed sound is alien to electronic music; this sound is already present in the form of raw material, so to say, before a piece is started, and has no time-limit.

The internal time-structure of the electronic sound can always make the transition from an inarticulate flow to rhythmic formations. At such instants the "classic" characteristics predominate: duration or pitch relationships that can be grasped rationally, situations that can be observed, comparable to a stopped cinema film. Constellations like this do not necessarily have to arouse associations with instrumental music, but should be used with caution.

All in all the electronic sound should be seen as what is advocated in instrumental music with regard to its meaning and its position in the syntactical context: the part and the whole in one. The element of this is the movement, the fluctuation, the imperceptible transition, the variation already in a particle which as such is to be placed in variable constellations.

2. Fundamentals of serial decision

Although our attention is directed towards the electronically produced sound, the methods of describing sound also partly apply to instrumental music. In instrumental terms, but even more so in electronic terms, "sound" is not ust an acoustic concept but a formal one too. Where the description of sounds in instrumental music can still be separated from compositorial processes to a fair extent, in electronic music it terminates in formal analysis. – The question is: can serial categories be applied to electronic sound production?

The term "serial" requires explanation. As a further development of dodetaphony, serial technique started by operating with "series", the elements being subjected to a strict repetition prohibition. Entire series were permutated, all the parameters of a work were articulated where possible with one single basic series (or at least with series derived from it). This procedure was meant to unify, and to differentiate under control. Whilst many composers soon tired of standardisation, differentiation is still possible without strictest serial treatment. Since then serial ideas have been based less on the series and more on the concept of difference. An example: a superior duration is to be divided into five parts – the parts must have different lengths. The easiest way of ensuring that they really will be of different lengths is by the use of simple numerical relationships. Such a sequence of numbers will basically serve the same purpose as a fundamental series which is prescribed for the entire piece and from which all form-sections are to be derived. The aspect of various quantities causes the stringency of early serial music to be relaxed. The composer can decide in each individual case whether to make serial relationships or not. He will of course consequently have to check all observable states as to their quantities, and in this way his serial experience will increase and not atrophy. – The "serial" concept is to be understood in this sense in the following.

The series, as an instrument of quantification, penetrates electronic music more deeply than instrumental music. In the latter it is an essential means of formation, regulating complete phenomena such as instrumental tones and typically instrumental aspects of behaviour (of composer or musician). There are no such instruments in electronic music, just generators whose elementary oscillations must first be put together to form musically usable sounds. Such procedures can be described quantitatively, i.e. serially. If two sound events can be controlled quantitatively in themselves, they can also be made to refer to each other quantitatively.

Serial compositional technique has its origins in dodecaphony, on which a particular number was imposed: the number 12, corresponding to the 12 semitones of the octave. The strong influence of this number on composers' ideas can be seen in the fact that all parameters of a piece basically either consisted of 12 individual values or at least of series whose elements were in a harmonic relation to 12 (6, 4, 3).

In mathematics, incidentally, "series" means the sequence of values in ordered succession, or at least the sequence directly resulting from the rules used to form the series. In this sense the chromatic scale is actually the twelve-tone series. A distinction should be made between the actual "series" and the selected "sequence".

For present purposes we shall regard the series (or scale) as a container for the various states which the pitch parameter can assume. (This also applies to all other parameters.) This explains the nonrepeatability of elements; every possible state is marked once. The series shows what basically is"possible", but not what actually should or may occur in a piece.

The series is complete in itself; it contains its own total potential. Any extension or subdivision of its values would require an additional series containing in its turn all the factors with which the first series could be modified. The series grants the composer only one liberty: the order of its elements (permutation).

Taking the twelve-tone series as a basis without modification of the number of tones (which, at least at the beginning, was forbidden for harmonic reasons), the number of tones of a serial twelve-tone piece would have to be divisible by twelve. Since each tone must be given a degree of loudness, a duration, a timbre, an octave register, etc., this results for the other parameters in a total number of elements which must be divisible by 12 or one of its divisors. This is why, for instance, 12 various degrees of loudness were required, although historically - in contrast to the pitches - they had by no means evolved. It is advisable to regard the series as a cycle, because once its elements have been run through, the same elements are repeated although in a different order. When several cycles are to be simultaneously linked, it is easier to survey the situation if they agree, that is if the shorter cycle goes into the longer one once, twice or three times (compare the hands of a watch). If the longer cycle is not divisible by the shorter one, the smallest common multiple must be used: if the shorter one has 5 elements, and the longer one 7, the short one must run seven times and the longer one five times until they meet again at the start, i.e. so that the general serial rule that all values must occur equally often is not broken. Subdividing a series *does* thus make the system more flexible, but does not free it from the fundamental limitations. Possible subdivisions resulting in cyclic overlapping are

6 + 6
5 + 7
4 + 8 etc. or
3 + 4 + 5
2 + 3 + 7 etc.

If twelve pitches, then, were combined with seven degrees of loudness, the result would be 84 tones or a whole-number multiple of this number.

If we apply these principles to electronic music, the harmonic problems recede. On the one hand the construction of spectra does not conform to harmonic aspects but to those of timbre – which ultimately provokes harmonic relations again; and on the other hand electronic music is not handcuffed to dodecaphonically tuned instruments. The composer is free to divide the octave up into any number of tones he wants. However, this does not solve the twelve-tone problem, it merely puts it in a different light. A series in electronic music is still a series of something, a container of various parameter states. As far as distinct parameters are still defined, consisting of various states so that the parameter definitions meet each time in one point – the single tone or sound, the numerical quantities must harmonise with one another; the result here is also a smallest common multiple which determines the minimum number of elements of a closed serial structure. The more "pointillist" parameters there are, and the smaller the extent to which the cycles are divisible, the more copiously the series of the individual parameter must be permutated until all the parameters are back at the starting-point. This mechanical run-through until an aesthetic balance is recovered will take all the longer, the more differentiated the individual conditions are; it can be modified only by complicated additional rules which threaten to overstep the limits of actual serialism.

In the early years of electronic music, a trick helped composers out of this dilemma. It resulted from the consideration about the significance which an element of a series, written as a number, can assume. This element can be understood as a particular pitch, duration, loudness etc., but also as a particular amount of similar elements.

The sequence 3 1 4 5 2 could regulate 5 different degrees of loudness, for example; the permutation 4 2 5 1 3 might indicate amounts of similar elements (multiplication series). The result is:

4 x loudness 3
2 x loudness 1
5 x loudness 4
1 x loudness 5
3 x loudness 2

Loudness 5 would be at a great disadvantage here, since it only occurs once. It could subsequently be multiplied 2, 3, 4 and 5 times. The same applies to the other values. In this fashion, "groups" are formed. The parameter being multiplied is the group characteristic. The following distinction could be made between sequence and group:

(a) the sequence refers to one parameter;
(b) the group refers to at least two parameters, one of which contains similar values.

Example: Pitches: 3 2 5 4 1, Durations: 3 3 3 3 3 (element: 3; factor: 5). It is sufficient for only one parameter to be fixed (by multiplication) in a group in which several parameters are involved. According to what parameter is selected for characterisation purposes, the group character will appear more or less clearly. The more parameters are fixed, the more pointed the group character will be.

The above-mentioned difficulty in numerical conformity is however not completely alleviated by group mechanism. The system merely becomes more flexible, especially if more general indications such as "many", "few", livery few" are used instead of numbers.

Up to now the remarks on serial technique have referred to constellations which are still accessible to instrumental music: coarse textures, as it were, whose individual threads attract so much attention that the plastic articulation of larger form-sections must resort to compositional artifices such as group technique. In electronic music, however, we have structures which pass by quickly, consisting of individual elements, and which consequently can be defined individually (serially), but whose details still coalesce to form a totality. Here the group character is formed mechanically, for instance by accelerating the tape. Glissandi of all kinds, too (in the dynamic or frequency range, changes in spatial depth), combine a number of single aspects into form-units - groups - without unity being restored by means of group-series. In such cases where overall modifications which can scarcely be expressed serially again characterise the numerically calculated structures as a whole, the original group treatment fails. These modifications are recommended universally as a simple means of forming formal units, but they exceed the framework of serial considerations. But even in such roughly characterised groups, there are numerically definable parameters which should be articulated all the more carefully, the more "blurred" the enveloping parameter is.

Serial technique takes each parameter into consideration separately, potentially for the whole piece, which is then formed by the superposition of all the parameters, conforming thus to a polyphonic principle, so to speak. Groups, on the other hand, are shut off from their surroundings; events occurring in them have precedence over those running through all the others. Groups follow each other in succession, thus representing a homophonic principle. Transitions occur where groups are unambiguously strung together, or in pointillist serial music where the parameters are treated in such a way that caesurae occur naturally, thus separating fields of uniform texture from one another.

Fundamentals of aleatoric decision

The serial method had shown that it perpetually led to situations of constraint. The so-called series, the selected order of the values of a selected parameter, only exists in its entirety. Once a sequence of numbers has been established, it can be applied to various parameters, and is thus not peculiar to any one of them. The series is therefore only characterised by its own properties; the rules governing its occurrence – even the morality which prescribes the use of these rules to some composers – are invulnerable. The series, together with its permutations, which we shall discuss presently, represents a closed system. The moment the series becomes audible, its most characteristic aspects – its arrangement, the regularity of its variations – no longer come into their own. It would not be surprising if the only enjoyment of serial composers were the constellations on paper. But if in order not to lose contact with "practice", with what actually sounds, the composer wanted to subordinate the arrangement and treatment of the series completely to the respective purpose, the character of the parameter, the series' purity and transparence would be sacrificed to an external purpose which would affect its best characteristics. Serial construction as a means to an end, for producing musical arrangements and relationships, for articulating the form whose criteria developed historically outside serialism, is a kind of self-deceit; the composer must be prepared to find aesthetic pleasure in the serial system as such, even when it tends to be unperformable.

We have considered the series as a "container" for the states which "can,' be assumed by a parameter. That is not accurate. The parameter "must" exhibit the states in which it may exist. That little word "can" is more indicative of the transition to aleatoric states. Whilst in a series a value may not be repeated, and its order is also prescribed, it thus being possible to express the serial condition as a general repetition prohibition, this prohibition is gradually lifted in the aleatoric field. The order of the values is also free. – However, before discussing details of the aleatoric field, we shall make a few more observations on permutation. A superficial examination shows that the series forces its values into a particular order, which however is broken up again when the values are permutated. It accordingly seems to be only a small step towards aleatoric treatment, the principle of which is perpetual permutation, and where consequently the idea of a basic series from which everything is derived is abandoned.

Permutation of parameter states is necessary because the series can not go on being repeated in the once-selected arrangement of its elements. Variation of the order should however be governed by a rule; first because serial aesthetics will not tolerate irrelation, and secondly because the relationship of the permutations to each other, once the elements of the series have been arranged, should, as superior arrangement, govern the form of the work throughout.

The most simple rules for permutating, say, a twelve-tone series are known: making it run backwards (retrograde) and forming its complement (inversion). Retrograde-inversion is the combination of these two. From dodecaphony however we also know transposition, which does not-change anything in the properties of inversion or retrograde. The permutations of serial music have really only generalised these premises. Whilst the four classic modes still occur, as does transposition, they are joined by the new "axis rotation" (cyclic exchange). Here are a few examples, using the basic series 3 1 4 5 2:

Original:	3 1 4 5 2
Retrograde:	2 5 4 1 3
Inversion:	3 5 2 1 4
Retrograde-Inversion:	4 1 2 5 3
Transpositions:	3 1 4 5 2
	4 2 5 1 3
	5 3 1 2 4
	1 4 2 3 5
	2 5 3 1 4
Axis rotation:	3 1 4 5 2
	1 4 5 2 3
	4 5 2 3 1
	5 2 3 1 4
	2 3 1 4 5

Use of the modes permits only four different forms of the series, regardless of the number of elements. Transposition and axis rotation result in as many series as the series has elements. Of course it is possible to subject each transposition to cyclic exchange or to derive the other modes from it. The material is much more abundant if the elements of the series are shifted cyclically by using the elements of the series them7 selves. For instance, in the series 3 1 4 5 2 , which contains five places which can be occupied by numbers, the number 3 can be shifted 3 places further, but also 1, 4, 5 and 2 places. (I became acquainted with this manner of forming permutations under the name of "module permutation".) If for example we shift the numbers the same number of places as their own size ("3" 3 places, "1" 1 place, etc.), the result is:

Original:	3	1	4	5	2
Permutation:	-	42	1	35	-

(Note that the numbers are shifted cyclically as if the start were the direct continuation of the end.) Some places are empty here, others are occupied by more than one number. In the same manner we can shift the numbers by the amount of their adjacent elements, thus gaining a total of 5 permutations besides the basic series. The results can also be treated in the same way. The numbers keep the places which they received from the previous permutation. – Shifting of the above result by the amount of the adjacent value:

Last permutation:	-	42	1	35	-
New result:	1	-	25	43	-

The original order of the values is altered even more pronouncedly by module permutation than by transposition or axis rotation. In this manner the principles of permutation – and thus those of formation to the extent in which it is brought about by permutation – become obscure. The resulting series can no longer be seen to have any relation to a variation principle; they appear to be aleatoric. Since according to serial methods neither series nor elements in a series should be repeated, the series, which originally had a quasi-thematic function, turns into a permutation programme. It is true that permutation is used to link all, or as many as possible, parameters together, but in practice the abundance of links can not be exploited. Even a series of 5 elements permits 120 permutations altogether, which means 600 individual values. All combinations with a second parameter also with 5 states will lead to 3000 links. In view of this abundance of possibilities, the small selection which a composer must make for a serial piece appears to be the result of a totally unserial imagination.

The jump to the multitude of variations not obeying any serial principle or regulated permutation can be made via group technique, in which larger contexts are made by means of group-series. Group characteristics can also be defined without serial criteria. If, for example, seven tones are selected from the 12 of the chromatic scale, the form-section in which only these seven tones occur will differ from other sections for which other combinations of tones are used. It is immaterial whether the seven tones occur in a series or not. Such a selection might be called a "field"; the form-section using only the elements of a field would itself be characterised by the respective field. Changing fields cause changing characteristics. Work with such fields however requires two additional indications:

a) the duration of the form-section, or the total number of elements to be taken from the field;
b) a prohibition limit indicating how many elements at least must occur before one may be repeated.

Two examples:

1) Assuming the number of elements in a field to be 5 (represented by the numbers 1 to 5), and that the field should be run through three times, repetitions being forbidden and the order within a five-group being free:

5 1 4 3 2 / 4 3 1 2 5 / 4 1 2 5 3

2) The number of elements in a field is again 5. The field is to be run through five times; repetitions are forbidden until at least three elements have been used. The order within a three-group is free:

3 1 2 / 1 4 5 / 5 2 1 / 3 2 5 / 4 1 3

In the first example the groups are the same size as the prohibition limit. In the second example there are deviations. If we place the oblique line before a number is repeated, we have the following arrangement:

3 1 2 / 1 4 5 / 5 2 1 3 / 2 5 4 1 3

The groups can never contain fewer than 3 elements, but they can have more, up to and including 5. Only a lower limit, then, is fixed.

In the following example the size of the field is 7; the prohibition limit again applies to 3 elements; 14 groups are required:

461 / 612 / 276 / 643 / 672 / 741 / 724 / 156 / 143 / 412 / 246 / 623 / 142 / 237

Here the "serial" arrangement (groups as large as possible without repetition) gives the following result:

461 / 612 / 276 / 643 / 672 / 741 / 724 / 156 / 143 / 412 / 246 / 623 / 142 / 237

It is only slightly different from the previous example. – All three indications are variable: size of field, prohibition limit and total number.

The counterpart to the repetition prohibition is the repetition command. In this case the maximum number of repetitions is indicated. Example: size of field 6; repetition: max. 4 numbers (the actual number of repetitions is aleatoric); total number 12 groups:

4444 111 55 5555 4 44 55 55 666 333 33 66

We notice that both numbers and quantities are repeated. Special repetition prohibitions could be imagined for this, such as: prohibition limit for numbers = 5, prohibition limit for quantities 3, number of groups = 15:

2222 666 5 4444 33 111 4444 66 333 22 111 3333 666 5 4444

Other arrangements of the last result could be according to two points of view: repetition of a number:

2222 666 5 4444 33 111
4444 66 333 22 111
3333 666 5 4444

repetition of a quantity:

2222 666 5
4444 33 111
4444 66 333
22 111 3333
666 5 4444

The only sense in these arrangements is an analytical one. The musical significance is given in the respective combination of conditions.

The conditions can be taken from "fields", so that they are in individual cases left to chance. – These examples show how strongly serial ideas survive in the aleatoric field; they also show that the serial behaviour of elements is merely a special case of aleatorics. The serial case could therefore be defined as "prohibition limit = size of field".

Pitches

Having indicated the fundamentals of serial or aleatoric decision in composition, we shall now examine individual phenomena.

Instrumental music has at its disposal a certain number of equidistant pitches, grouped in octaves; each octave contains 12 semitones. Arrangements are prescribed in the form of tonality or atonality (dodecaphony), but these arrangements are of a general nature; for special pieces special arrangements must be sought in the general ones (modulation plans, twelve-tone series etc.).

Such arrangements are not prescribed for electronic music. Electronic generators produce an uninterrupted sequence of various pitches; the pitch range is filled continuously. The task in each piece consists of making an arrangement in the continuum, of defining distances, just as it is the task in analysis to recognize arrangements in the continuum.

Division into ranges

All imaginable pitches are in a "space" - the pitch space. The term "space" is justified by the fact that several tones can sound simultaneously, just as in visible space several things can occur simultaneously. If we call space a function of time, time is ambiguous with respect to points in space.

In our search for an arrangement of pitches, we shall first divide the space into "ranges"; these can be of equal or different sizes. We ought also to consider whether the selected division should apply for the entire piece, or whether various form-sections should differ by having different divisions of space. The following, then, are variable:

number of ranges,
size of ranges,
the relative position of variously-sized ranges, alteration of division from one section to the next.

Such ranges can be fairly large. They should facilitate a preliminary survey and articulation. Since a range should if possible not be exceeded in a short form-unit, it must be subdivided. This subdivision corresponds to the first division. Quantities and proportions occurring in this way can be treated serially or aleatorically. However, it is important – and here we see the connection between material and form – for the division of the pitch space to depend on the way in which it is to be used. Whether it is to be divided, how often, when and how subdivision is altered: this can only be decided according to formal aspects, but it has an immediate effect on the character of the material: on harmony, density, chromaticism, etc. The close connection between the texture of the material and formal references boosts both: the one category benefits from what is decided for the other.

We can measure the sizes of ranges with various standards: we can adhere to octave division or to whole-number relationships corresponding to the pure interval; or we can operate according to the principle of geometric series. This does not only affect melody and harmony but also – since the frequencies which we determine by subdivision of the range (limit or single values) are spectral components – the timbre.

Representation of the range

There is only sense in dividing up the pitch space if the range selected for a form-section will be clearly heard. Not only its limits must be audible, but its interior too. Each range can be represented

pointillistically
single pitches (corresponding to the subdivision) are used in such a way that the limits of the range are frequently touched. According to the temporal density (the ratio of the number of tones to the duration) of the tone-points, the range is clear or unclear;

in *planes*
the range is filled as continuously as possible (dense spectrum or noiseband). Regardless of the temporal density (rate of alteration), the range as a whole is clear, since limits and interior are uniformly occupied;

articulated in planes
the entire plane of the range is divided up into changing sections which in their turn can be either pointillist or planes: pointillist as "chords", clusters of various sizes; planes in the form of smaller planes within the larger ones.

Points or planes succeed each other either in leaps or in glissando.

transition
It is a simple matter to have a regular transition from planes to points if the plane is brought about by a rapid sequence of points (superposition of several pointillistic layers): by

a) slowing down the process,
b) reducing the number of layers step by step.

Limits of the range

Occasionally it is awkward to work out clear limits to a range. This is simpler to do for narrow ranges, but it is also more important; it is less urgent but more difficult for wide ranges. Narrow ranges contain fewer tones, which therefore however have to be repeated more frequently, making the limits unambiguous. Demarcation is necessary in order for it to be at all possible for a distinction to be made between adjacent narrow ranges. Wide ranges can easily be distinguished; the large interior means that more tones are there than at the limits. If limit-tones are to be repeated as infrequently as possible, the limits are "indistinct", regardless of whether they may be overstepped (approximate limits) or not.

Limits are indistinct if

a) horizontal density is very slight (this might be called a "statistic deficit");
b) vertical density is very slight (few different pitches in the range); in this case tones adjacent to the limits are fairly far inside the range. The limit is "distinct" towards the exterior, indistinct towards the interior.

In the case of larger ranges matters can be simplified by "bending" the interior: the distance between tones (frequency lattice) gets smaller towards the limits. If there are not enough tones, ranges can scarcely be articulated. For example, three tones of various pitch do not result in a range unless three ranges are intended, each indicated by a single pitch. Even in this extreme case there is a question as to distinctness: individual pitches are indistinct

a) because of too few periods (duration too short);
b) because of aperiodicity of the periods (noise).

Time-structure in the range

Although we are only dealing with pitches here, we must at least touch on the time-structure, since all musical events only occur in time. Pitches or plane-sections representing a range are

pointillist

individual pitches or plane-sections are in calculated intervals (melodic, quasi-melodic). It is easy for a melodic "gesture" to occur, depending on

a) the width of the range,
b) the number of pitch steps.

Time can be articulated by the formation of groups, which are distinguished according to

a) duration of group,
b) number of tones,
c) direction of motion,
d) average speeds.

in fields

Tones or plane-sections succeed rapidly and irregularly, resulting in average values. No "melodies" are formed, but the range does "sway" or "breathe". By "sway" I mean the upward or downward motion of the entire field (its limits move approximately in the same direction); by "breathe" I mean the opposing movements of the limits: the field gets narrower and wider.

Time is again articulated by group formation with the criteria

a) duration of group,
b) directions (sway) or variable width (breath),
c) average values for speed.

Pointillist arrangements and arrangements in fields can alternate or make gradual transitions from one to the other.

Polyphony

Various ranges can be articulated simultaneously. Polyphony occurs

a) spatially: by simultaneous flow of various representations of various ranges;
b) in time: by various ranges overlapping in time, whether they are represented identically, similarly or differently.

It is not expedient to *subdivide* one single range polyphonically. It is better to select narrow ranges instead which can overlap spatially. This is a question of the intelligibility of the representation. Pitch ranges as instrument of composition, of formation, have to be rough in order to guarantee every freedom of articulation in the interior. They might be said to be the containers, and not the contents.

Time

In instrumental music time-division depends on various factors; there is no scale as in the pitch range, but there are the musician's facility, the playability of the instruments, the synchronisability of the musicians (conducting) and historically formed behaviour. For although rhythmic notation is in itself precise, a style of performance has evolved which only pays attention to the prescribed accuracy in larger ranges; detail is characterised by perpetual fluctuation. This interpretation is not a fate which notation suffers meekly, but it is preconceived by the composer. This is what turns performance into interpretation. – In these circumstances, time-division in instrumental music is based either on the multiplication of smallest units or on the periodic division of metres.

In electronic music, neither the musicians' facility nor instruments need be regarded, nor their synchronisability nor habitual behaviour. However, limits are set by audibility and studio technique. Not every rhythm that can be calculated can also be heard and distinguished from other rhythms. Not even every duration can be accomplished by splicing; there is a lower limit. Nonetheless arrangements are still sought in the rhythmic field, similar to those in the pitch field.

Division into ranges

We obviously start by following the pattern of the pitches. All realisable lengths of time are contained in a list of audible and distinguishable quantities. The rules for forming this list can change from one piece to the next. It might be compared to the pitch "space", since it says nothing about the real time-sequence. It could contain time quantities which are separated by either equal or unequal intervals.

Here, as in the case of pitches, the list could also be divided into equal or unequal ranges. The division applies to the whole piece, or changes from one form-section to the next. The variables, then, are:

- the number of ranges,
- the size of the ranges,
- the relative position of variously sized ranges,
- the change in division from one form-section to another.

The ranges should supply a preliminary survey here, too. Since there are many analogies to pitches, the reader is referred to the previous chapter ("division into ranges"). Of course range division affects the material's character and with it the rhythmic dimension: for instance speeds, horizontal density relationships, aperiodicities, etc.

The sizes of the ranges can again be measured according to various standards. The "time-colour" is now affected.

The analogy ends here. Whilst the individual values of the pitch space are distributed regularly or irregularly, whatever the time-structure to which they belong, the individual values in the time-list are not spatial quantities which are put into time-relationships, but themselves time-values. The question we could still ask about the time-structure when treating pitches consequently does not arise here. The difference between pitch space and time-structure of the pitches is now represented as different "division into ranges", according to whether it refers to the "list" or the "time axis". This is clear in the case of equal distances. Equal distances occur in the pitch space as a result of geometric division, as is the case with the time-list: the various time-values are in accordance with a "chromaticism", so that the quotients of adjacent values are equal (regular accelerando or ritardando). Equal distances occur on the time axis when the individual values are equidistant, i.e. when the intervals between them are equal. Instead of a time-structure of "spatial" values we thus have the division of the piece into large sections, i.e. into durations which may be equal or unequal. To this extent the division into ranges applies to the "list"; according to the way in which its individual values are combined, we get more or less regular time-sequences, similar distances or leaps. Periodic sequences result from repetition of a single time-value.

Representation of the range

The treatment is similar to, or the same as that of the pitches. A range is characterised by its size (ambit) and position in the whole "list". The limit values are important for the representation, in other words: the shortest and longest time-values. They ought to be used frequently enough for the selected range to be worked out clearly. Here a rule applies which cannot be used for pitches (or any "spatial" dimension): the individual quantities are not equivalent. Short values will only enter the listener's consciousness clearly if they occur often enough; the number of repetitions (which can be widely scattered) conforms to the average duration of the other values, perhaps to the longest ones: the sum of all the shortest values should counterbalance the longest, and in certain circumstances exceed their duration.

Whilst the individual pitches, regardless of their duration, have a pointillist character, not assuming a plane-like effect until the points are very close together, individual time-values are not point-like in themselves. If however we do not regard the time-values as durations but as distances, we obtain a sequence of entry points at which sounds of any duration can commence. If the durations are shorter than the distances (in order to achieve pointillist effects), they result in duration + rest. Pointillist time sequences also result from durations filling the entire distance, if sounds and rests enjoy equal rights and alternate.

A duration occupying the entire distance can be compared to the pitch glissando: it links, as it were, two different time-points just as the pitch glissando connects two different pitch-points (frequencies). If however we do not define time-points but durations, these correspond to narrow noise-bands (or clusters) instead of distinct pitches. This comparison between duration and glissando only applies of course to the division into ranges; listening experience would prefer to put the glissando on a par with an accelerando or a ritardando. This is justifiable because the pitch glissando occurs as a result of regular alteration of the periods of a tone (or fundamental), i.e. alteration of the distances, thus of the speed; the correspondence is literal in this case.

When the list of time-values (durations) is finally placed on the time axis, so that a sequence of time-points results, these points assume a pointillist character if only the entry points are marked (staccato); plane-like formations result if the distances are filled in (legato). A sound can begin or end at every fixed time-point. Even when sounds are multiply superposed, the time-structure is still (more or less) clear. – The representation of the range, then, is again

pointillist
the time-points are merely marked;

plane-like
the distances between the time-points are occupied by "durations", there only being superpositions and direct connections;

articulated in planes
some durations are replaced by corresponding rests;

transition
a transition from plane-like to pointillist articulation (or vice versa) is conceivable if the planes consist of layers, either

a) by gradual diminution of the durations, or
b) by omission of layers.

Limits of the range

(See the relevant section in the previous chapter for difficulties in making the limits of the range clear.)

The limits are "indistinct" if

a) there are not enough time-values (statistic deficit);
b) the range contains too few subdivisions.

In the case of large ranges, "bending" can help. In certain circumstances, too few values will not result in a range at all. But even a single value (this also applies to pitches or other parameters) can attain the significance of a range if it is repeated often enough.

Combination with a "space"

Multiple structural patterns can be accomplished by combining a spatial range with a time range. Such patterns are between the extremes:

a) plane-like representation of a pitch range, plane-like representation of a time range;
b) pointillist representation of a pitch range, pointillist representation of a time range.

Plane-like articulation occupies a position more or less in the middle.

The patterns are extremely variable if the formal sections which are articulated by various combinations change rapidly and irregularly.

Mixtures like this tend towards polyphony, which occurs

a) in space: various simultaneous representations of different time ranges;

b) in time: by overlapping various time ranges, whether they are represented equally, similarly or differently.

Polyphony in time can moreover be combined with spatial polyphony.

Timbre

Up to now we have attempted to divide each parameter up into ranges for purposes of sound analysis and synthesis; the question was how a range could be represented. In this aspect the pitches were regarded as a "space" which is vertical to time; in the time range a distinction was made between the "list" of time-values and the real "time axis" on which it is placed. We have demonstrated that instrumental music is familiar with preset arrangements and limits for pitches and time-values which only apply conditionally to electronic music and which as a rule must be replaced by other kinds of arrangements and limits. We shall now consider *timbre*.

Owing to the completely different manner of production, we do not know any preset arrangements in instrumental music from which arrangements in electronic music might be derived. The sound possibilities in instrumental music can be said to be familiar; we also know the limits of the traditional orchestra. The limits of sounds which can be electronically produced are however not known (in spite of the optimistic idea, not totally unjustifiable, that any conceivable sound can be produced in the studio); a vast, unknown field stretches out towards these limits.

We are used to speaking of "timbre" in electronic music without being able to say properly what a sound's "timbre" is. Perhaps we should speak of the "sound" or of its inner "structure". In instrumental music we do not actually indicate the "timbre" of a sound but only the "instrument" on which the sound is produced. An instrument's timbre is in fact its only distinguishing characteristic; apart from a few exceptions, melodic models can be performed on all string, wind and percussion instruments (with definite pitch). This is why we have in instrumental music something like an "absolute text" containing only pitches, dynamics and durations, and no description of the sound. Piano reductions of orchestral works testify to this; if we were to omit rhythm or pitch arrangement instead of the sounds, we should not be able to recognise the original. In the course of musical history, it is true, sound has been fixed to an increasing degree; it became emancipated to the extent of Schoenberg's Klangfarbenmelodie, from which however we can see by the indication "Melodie" how classical the aspects were under which the sound was understood. – Even today there are composers who still first compose the absolute text and then "instrument" it; here the sound is merely the medium of representation, a kind of interpretation before performance.

At the beginning of electronic music, timbre was first concentrated on, both in the Paris studio where concrete sounds were analysed, and in Cologne where they were produced in the form of sine-wave spectra. Most instrumental sounds can be reduced to a superposition of periodic oscillations, and there was thus hope that these sounds and many others governed by the same law could be produced synthetically. This resulted in the *first class* of electronic sounds: harmonic spectra. The harmonics are in whole-number relationships to one another, and coalesce to form "timbre", the greatest common divisor of the frequencies appearing as the "fundamental". Fundamental and timbre are independent of each other: the fundamental can be altered without the timbre, or it can be given various timbres.

The *second class* was discovered in white noise. In contrast to the superposition of periodic oscillations, this has a statistic oscillation curve. White noise can be filtered, resulting, according to the filter setting, in coloured noise of various pitch and bandwidth.

Noise-like sounds also occur if sinus tones are combined outside the harmonic system. If only one tone departs from the harmonic spectrum, the spectrum is merely "dimmed"; if the other components gradually leave the harmonic relationship to the fundamental, the result is increasingly noise-like, the fundamental is lost and with it the relationship of the fundamental to the timbre, which is left over as bandwidth and "roughness" similar to real noise.

All sounds between the sinus tone and white noise can come together under the heading:

CATEGORY OF CONTINUOUS SOUNDS

Sound:	(harmonic sound), components coalesce to timbre, fundamental;
sound-noise:	(sound derivative),
	a) veiled sound, fundamental,
	b) noise-like sound, no fundamental;
noise:	(real noise), statistic spectrum, no fundamental.

The third discovery was the impulse, with which we shall open a third *class.* Itis in its nature to be of brief duration, and it has neither timbre nor fundamental. Physically it is characterised by a short current impulse of constant or decreasing voltage (square or sawtooth impulse). It reveals two aspects:

rhythmic aspect: clear articulation of a time-point;

sound aspect: it does not possess any timbre or definite pitch.

The impulse is audible as a musical event:

a) as a rapid sequence of impulses (harmonic spectrum, fundamental corresponding to rate of impulses);

b) if it touches a resonance filter (noise band according to filter bandwidth).

The rapid impulse sequence coalesces to a continuous sound of the first category; the filtered impulse remains discontinuous. Impulse-like effects can be obtained by means of splicing. All sounds whose nature it is to be discontinuous can be assembled under a second heading, the

CATEGORY OF DISCONTINUOUS SOUNDS

Sound, noise and impulse are actually instrumental categories. All orchestral instruments fit into them. They also belong to the family of *stationary sounds*: the sound is complete in itself, existing in its timbre value and in a duration during which it does not change substantially. This duration can be reduced to the shortest rhythmic units: but the timbre always stays constant within the time-values comprising the rhythmic flow. In other words, we have one particular timbre for each "attack".

Electronic music also knows a family of *non-stationary sounds* with a duration, but no constant timbre. They consist of continuous and discontinuous sounds in such a way that only an apparent continuity occurs. They exhibit pointillist character in the smallest time-sections, although they are continuous (or can be) in the range of rhythmic values. They often occur as a result of superposition of continuous but variable sounds. In this *fourth class* I should like to include "sounds with variable time-structure". Their oscillation curve moves between periodic and aleatoric sequences, and between sinoidal and impulse-like wave-forms. Since their "timbre" is not constant, it can be described but not accurately imagined. The movement of the timbre rather follows the compositional processes of the micro-time range. In this way structures are composed instead of timbre. They can be heard as a timbre flow. Future sound research must decide on the categories or classes to which the family of non-stationary sounds should belong.

Degree of alteration

At this point we shall examine a parameter from the extensive catalogue of serial compositional methods referred to with regard to the treatment of "points" and "groups" in the second chapter. The parameter to be dealt with here is one which gives us a bird's-eye view of serial technique: the degree of alteration.

We have defined the series as a "container for parameter states"; since strict serial technique requires that a sequence be run through completely, the parameter is presented in its entirety, the "run" is "saturated", complete in itself. Even sections of series forming clear contrasts to other sections are sealed off. Series or sections of series as building elements of formal articulation and subject of variation are hermetic. The fixed permutation rule according to which serial variants occur ' keeps the individual sequence open; the hermetic state returns with the last sequence of the permutation cycle.

These cycles (sequence, series-section or permutation group) are the smallest building elements of serial technique and are also formal quantities. The first serial run through the values of a parameter expounds these values; permutations behave like variations altering a theme and fixing it in the alteration. The articulation of the form is brought about by elements which are both identical and non-identical; they shut themselves off from one another, but do not lose their ability to form larger formal units with their like. Serial technique has insofar inherited tonal development form, at least according to the letter of the law. Harmonic material, however, whether atonal or dodecaphonic, has forfeited the widely ramified inner structure of tonal harmony, and especially its functionality. Where the slightest alterations of the form could still be accentuated before, the tools are now coarser: since the group as constellation of several parameters is now only roughly defined in its various states, the formal elements now also only correspond in rough degrees. The compositional commandment of clarity prevails en bloc, all serial formal articulation stands and falls with the unmistakable separation of one formal element from another.

In the simplest case this results in *contrast.* If the composer is afraid that form-articulatory groups might not be recognised, he could feel impelled to alter if possible all the group parameters if only for the sake of the repetition prohibition already governing the series. The group, moreover, contrasts even more sharply with neighbouring elements if it is uniform and closed in itself. It tends to become plane-like, and the sequence of groups presents the planes at various levels. Groups as components of higher arrangements (or sub-groups as components of a group) draw closer because of common characteristics, so that the jump from level to level occurs sooner or later according to the dimensions selected for the formal units. What mobility the individual group loses by this is gained by the sequence of groups: they are illuminated, as it were, by changing lighting, resulting in a kaleidoscopic effect. Not unlike the pointillist style: nothing must be repeated, every musical moment is irretrievable; nonetheless a general equilibrium must be achieved - not waiting until the last note but occurring at the shortest possible intervals in time. It was not the desire for comprehensible articulation of the musical flow that led to the group technique, but the need for changing rates of articulation, for rapid movement and pauses, for climax and culmination, for epic breadth of interpretation, for lingering, repose and eruption. This is because it is the group which provided the opportunity to present a uniform state in the breadth of its variation. But fear of heavyweights – here the taboo of tonal centres is still alive – has also placed groups in equilibrium, and, in order to accomplish this, the components of the group too. The sharper the contrast between groups gets, the easier it is to bring about an average state – the consistent mixture when the characters are perpetually changing. This is at least true in theory; in practice the contrasts remain as they are, because one tires of them; subtler variants are not noticed, because one's attention is only guided by the leaps, and by places where there is an unexpected change.

If on the other hand the group is not just supposed to replace the point of the pointillist style by a group of points, but to appear as a universally variable element without however breaking the rule that various groups in serial terms must follow without repetition, an attempt will be made to mediate among the groups. The new group will assume components of a previous one, at the same time referring to ensuing groups. The groups are linked by common characteristics (even if these occur in the form of variants), which finally form their own uniform element that runs throughout the groups. This kind of link may obey a different rule in each parameter, so that a current group refers, through each of its parameters, to a different, previous or later group. The next highest form-unit within whose limits the individual groups refer to one another, is then lifted out of the whole form. like a kind of net whose threads are multifariously knotted together. The groups of a complex like this function as crossing-points, rather like the points of the pointillist style; they become blurred with regard to one another. To compensate, the single element in a group can be formed with all the more care, undisturbed by the requirement that the group as unmistakable building element be provided with uniform characteristics. The entanglement of the characters in the group's superior formal unit ceases because of this very formal unit: the larger formal units are represented as enlarged or superior groups which must again be in mutual serial relationships. This connection may also be felt to be a contrast, so that relationships such as those now existing among the groups are extended to the superior units. In this way the entire work becomes flexible material which absorbs all serial characteristics as technical tools; the listener is not confronted with the kaleidoscope of changing colours, but with a context which is articulated in smallest intervals, coherent, and which is not interrupted by leaps or contrasts. But the greater the extent to which the contrasts wear out, without the form's "developing" teleologically, the more sluggish and opaque the flow becomes. If one stares steadfastly at single elements all the time, attention becomes rigid and is finally distracted. Compensation must therefore be sought, a compromise between careful division into contrasting formal elements and perpetual mediation of all events. Work with degrees of alteration is suitable for this.

The contrast between two groups is defined by the extent to which one group changes with regard to the previous one. The contrast is defined by series of groups running independently through the parameters where contrast is sought, or it is worn down by free formation of the group, which becomes a reaction centre. Undisturbed contrast formation results from random encounters of parameter values; the contrast is thus established as absolute without any special control of its degree. This degree can however become independent if the degree of alteration (of the contrast or decreased contrast) is indicated in serial terms from group to group. From such a series the group-series are detached for the individual parameters. No matter how a group is articulated, it gives birth to a rule indicating the degree by which the next group should differ from it. The composer is free to follow this rule. He cannot do so, however, without first defining the degrees of alteration, parameter for parameter. The parameter states are graduated; the steps do not appear as absolute values which then form a series, but as relative values if only intervals are fixed, which of course must be feasible within the range of the parameter. The step appears as a parameter state - the interval by which it is altered into another, as degree of alteration. If the parameter is represented in seven steps, the greatest degree of alteration is "six"; it can only be reached from step one or step seven. But since a group is defined in several parameters, the degree of alteration can be greater than the size of an individual parameter. The rule is then: alter the individual parameters by as many steps as are needed to make the sum of the intervals equal to the degree of alteration. Repetition of the parameter value corresponds to the degree of alteration "zero".

As we have already stated, the composer is free in his choice of parameters. If he wishes to realise degree of alteration one, all the available parameters are at his disposal; but only one parameter can be used in this case. The greater the degree of alteration becomes, the greater too the number of possible combinations. "Degree of alteration two" can be accomplished by altering two parameters by one step each, or altering one parameter by two steps. "Degree of alteration three" means: alter three parameters by one step each, alter one parameter by one step and another by two steps, alter one parameter by three steps. The premise is of course that alteration by one step is experienced equally strongly in all parameters. It is also a condition that the graduation of the various parameters takes the particular characteristics of individual parameters into account; the steps must correspond to the distinguishability of various steps. Such conditions cannot be formulated with mathematical exactitude. [Not yet, at any rate; sound research, perception research and research into music as a language system ought to pool their efforts in order to demonstrate what perceptions – both with individual sounds and the musical context – are aroused by alteration of the physical structure of the waveform. It is doubtful whether such observations in the sonological field of sound synthesis could be applied to instrumental music.] The actual alteration is not guaranteed by the degree of alteration alone; the point is to distribute the entire degree of alteration over the parameters in such a way that the measure of contrast or similarity really holds good. – Degrees of alteration can be put together in series without repetition, or they can occur as group-series. In the latter case the repetition of a degree of alteration provides an opportunity of interpreting it in different ways, thus expressing what is both different and identical.

The advantage of working with degrees of alteration is obvious. On the one hand it provides a good way of checking the relationship of groups to one another as far this can be expressed quantitatively. On the other hand it leaves the composer free in his "interpretation" of each rule. And in the third place the internal articulation of the group is not affected by the degree of alteration. Of course, the autonomous internal form of a group could greatly diminish the effect of the relationship degree, expressed in the degree of alteration. That is why the degree of alteration is more intended as a supervisory instance than as a controlling quantity which leads with certainty to a predictable alteration in the structure.

The degree of alteration is the last fortress to which serialism, on the flight from its own consequences, retreats – although the degree of alteration is itself one of these consequences. The conclusion that numerical relationships are not always congruent to the language of musical form takes the way of least resistance by separating the numerical quantities as fixed points of the form. Imagination – even if it is schooled in serialism – fills in the spaces. Serialism can start from the beginning there, except that the serial patterns articulate a formal element (a group, for instance), that already has its syntactic function in terms of the degree of alteration and other criteria. The serial idea retreats into the cells after having infiltrated the whole and lost its strength there; it becomes domesticated.

Aleatoric mixtures

After the discussion of the degree of alteration as a generalisation of serial mechanics, we shall now examine the more general features of aleatoric compositional methods. If the use of degrees of alteration is supposed to place variable structures in preconceived relationships, neither the kind of alteration nor the kind of internal form being prescribed, then work with aleatorically defined structures aims at something similar. Here too the inner structure is only defined in terms of a field, whereas the field alters or is used repeatedly from structure to structure. We can characterise this technique by the term "aleatoric mixtures". [In the meantime realized as "Project 1".]

By aleatoric mixtures I mean the combination of several parameters to form a structure, the way in which the individual parameter is treated, the data field and the manner of its evaluation being governed by chance. [In what follows the term data field is used in a double genre: it first means the pre-structured data material with which the composer composes, and secondly the result of composition which it constructs in the listener's ear according to aesthetic aspects. The data field thus tells us nothing about the quality or significance of a composition, but merely describes the physical premises without which significance could not be communicated.] The manner of parameter treatment indicates a general characteristic such as similarity or dissimilarity of elements, degrees of periodicity or aperiodicity, tendency, continuity or discontinuity. The data field is freshly generated each time or prescribed for the whole piece; it is of course also possible to have several fields from which a selection is made each time. Evaluation indicates whether it is to be used as a whole or only in part, whether repetitions are allowed, forbidden or required.

The three processes are interdependent, at least the manner of treatment is a condition for the evaluation of the data field.

When we speak of chance in this connection, we mean either the unpredictability of selection or merely a selection which is liberated from serial rules. In new music one speaks of chance as a contrast to serial constraint. To follow previously established series and schematised permutations is to "arrange" the material, even when the constellations to which serial mechanics lead are unknown before the piece is written down, and only gradually reveal themselves whilst this is happening. Composers who would rather not offend serial morals but still want to make the final decision on the spot, resort to "ticking the register": the order of the parameter values remains open until they are used, and the values which are used are then ticked off so as to avoid repetitions. In this way sequences occur in the serial sense, only the various permutations not adhering to superior rule. This is where aleatoric working methods link up by having a "prohibition register" in which the used values are entered until all have been used up. If the repetition prohibition is relaxed, a general aleatoric state is gradually reached.

Aleatoric mixture also produces a closed structure which contrasts more or less sharply with other structures. The inner form can be strongly affected by the way in which the parameters are treated and by the production and evaluation of the data field. In this way it is possible to have correspondences between the structures. But it is not a matter of making aleatoric mixture approach serial work, such as that with degrees of alteration. The aim is more a generalisation in which serial work appears as a special case. Correspondences between aleatoric structures can (but need not) resemble serial ones. The aleatoric field is virtual in its substance, it reveals one of the possible aspects of a particular musical situation. Each of the possible aspects is typical, neither better nor worse than the others - and thus unique. An aleatoric situation might conceivably be calculated in various versions and a suitable one then selected; for the selection made by personal taste only has equivalent aleatoric results at its disposal which were triggered by this very taste in the form of general formulations. The equivalence of aleatoric mixtures which occurred under similar conditions is however theoretical inasmuch as the conditions under which chance operates are of necessity vague. The stricter they are, the less room there is for chance, and they become equal to serial conditions. If aleatoric equality is not identical to aesthetic equality, it should still be achieved in context. There are languages which are not defined until the moment they are spoken; as long as music does not repeat current idioms but exceeds the canon of what is given, it is such a language. Whether the aleatoric structure satisfies aesthetic standards or not is consequently less a question of the structure itself than of the emphasis with which it is defined by dint of the structural relationships. The isolation of the random product is apparent; chance only works when it is guided, and this guidance places the random data in closest relationships.

A connection with degrees of alteration can be seen in the fact that aleatoric mixtures are usually based on the same data fields, just as serial technique keeps to parameters and their steps during a work. The serial degree of alteration is replaced here by an aleatoric one, the guidance that leads to an aleatoric data selection conforming to statistic principles. Of course multifarious transitions are possible between the serial and aleatoric realm. A pre-calculated data constellation or one of its permutations can at any time take the place of aleatoric data invention. However, the comparison is not particularly rewarding since after all every composition made from structured sections reveals alterations, whether their extents are serial, non-serial, aleatoric, known or not known to the composer.

The concept of aleatoric mixture does not merely mean chance composition. It should indicate that aleatoric constellations are mixed and that the mixture itself can conform to aleatoric procedures. First the composer has to select the parameters which are not "elementary" as are pitch and duration. If for example elements are required to be grouped, the question arises as to the size and characteristic of the group. Not until these have been established can chance come into effect. The same applies to the treatment of the parameters. For this there is a list which only the composer can compile. The data field (for a particular parameter) is compiled by the composer according to non-aleatoric aspects; if it should now and then be produced randomly, the limits must still be set in each case, and this should be done constructively. Finally, evaluation of the data field usually conforms to the rules of parameter treatment and is only aleatoric within these rules. The linking of various structures, their order, the way in which contexts are formed, can only be guided by superior aspects which the composer has established for the work, or at least within the framework of limit~values between which chance can operate. All in all, chance penetrates the rigid construction from below, as it were. Perhaps it will be shown that in what can be referred to as "fringe areas of form". the data and their order will at first be random to the extent in which they articulate the outlines, so that contours can be linked, and not individual data. Such an outline, and also the statistic average values for a parameter in a structure, is not only more general than the specific construction of its data, not only "larger" with regard to the duration and possible number of all individual processes in the piece; it is also inexact because it is caused by a sequence of aleatoric data: individual data and the outline they form are not independent; the possible variations in distribution of data do result in outlines that are similar but not identical; and in this manner the outline, if it is to fulfil all the general conditions which it is set, is expressed by a random result, and is equally vague. Outlines which are caused by a random field correspond less exactly than those consisting of fixed individual values. An attempt will therefore be made to suspend the relationships between several outlines in a similar way. For if the "suspended" data of a random field can be expected to become "fixed" because of gradually combining to form the totality and completely occupying the field which at first only exists in outline, it must also be expected that the order of the outlines which are not yet completely clear as such will gradually become "fixed" to the extent in which the various outlines occupy the field of all outlines which complement one another.

Such consequences are further-reaching. It appears to be difficult, if not impossible, to constitute the total form with different, even contradictory means. In the serial forms the serial elements combine to form a closed figure; the elements, as they gradually appear, aim at this figure, which is achieved step by step, but without the next step ever being a matter of doubt - at least not to the composer. The permutations of a series also adhere to a serial rule, as does the simultaneous linking of several series. Extended series which regulate the overall form take precedence above the series which determine the detail because they are the aim towards which everything strives; nonetheless the serial form achieves a certain completion with each completed series. An aleatoric form on the other hand is always open to the extent in which individual data, and also outlines and larger form-units, have no aim towards which they can strive; they are part of a larger totality – the data field – which finally appears without the size of the field being certain: an occupied field can also be part of a larger one which will be constructed in the course of time. (From this one might form the rule that a data field must be filled so irregularly that no complete field-sections occur, if it were at all possible to follow this process at all times.) Neither do outlines exist for their own sake; from one outline to the next a relationship is formed which is modified by the relationship of the second to the third. In a certain sense such processes are teleologic, it is only the expressly stated goal that is missing. This is made up for by a kind of equilibrium which puts an end to the process. The formation might more fitly be described as entropic. If, then, the order of individual data is left to chance, the characteristic of the outline changes; if aleatorically produced outlines are put together to make larger form-units, the contours of these units are also aleatoric. Serial elements, strictly speaking, would break up this connection, which is not given, but which develops. They would have no part in the vegetable-like substance which puts out feelers in all directions but only grows towards one of them. Whether the entire piece eventually achieves the preconceived equilibrium or not is a different matter. It might be closed in terms of a static form, whose elements are connected and give each other mutual support, or it might remain open if several continuations towards an unknown static state are possible.

The various possibilities of aleatoric compositional methods can be illustrated by three examples.

1. The composition might conceivably be based on a fixed notated text; this text would represent "material" such as a twelve-tone series or a numerical series in the serial field. The notated text would be relatively short and would contain certain structural characteristics which, during the course of the work, would be preserved. or altered. For purposes of alteration, transformations could be defined which would affect the original text to a greater or lesser extent. These transformations would exhibit similarities with electronic sound production methods, because a general alteration of a given structure, which is in itself complex, is brought about. Transformation might alter the time-structure of the text, or the pitch structure (transposition); it could "isolate" registers by omitting all tones which were outside the desired octave; it could change the harmony or the instrumentation or the dynamics. The results of transformation could be combined in the entire work by means of superposition or by chain-like linking, or the results themselves could be subjected to further transformations. This method would combine aleatoric and non-aleatoric procedures if the basic structure were for instance constructed serially and would still prevail in this capacity in spite of transformations. The selection of the respective transformations could be aleatoric, as could the linking of the results of transformation to form the entire piece.

2. The piece could be constructed horizontally or vertically by aleatoric methods alone. "Vertical" would mean that in terms of parameter representation in serial music each parameter would be "produced" for itself and for the whole piece, and that these complete parameters would finally be superposed. The composer might have the idea of representing each parameter in different versions which may not be repeated, so that each parameter shows each of its representational forms once. If the sequence of representational forms thus became "serial", as it were, the superposition of all the parameters would still be aleatoric. The previously mentioned equilibrium would merely be produced within each parameter, but not with regard to the combination of all parameters in each form-section and eventually in the entire piece.

3. "Horizontal" would mean that all successive structures in the piece are produced separately. The aim here would not so much be to treat the parameters equally as to achieve the total effect of the individual structures. The composer would have to consider whether the structure might not be indicated by a significant index in such a way that the sequence of indices would describe the total course. The parameter values would be found aleatorically in a structure. All kinds of superposition (harmony, polyphony, multiple layers) would have to be determined within the structure, and their expansion in time could be considerable. After all, such structures are not produced independently. A structure's characteristics must be registered so that prohibitions or orders can be issued for the next structure according to the entire protocol up to that point. The index referred to would be nothing more than a brief expression for the entire characteristics of a structure and of the reactions which it now contains to everything that has gone before.

These examples are only indications. They are intended to clarify the general conditions under which an aleatoric form might be produced. Only analysis of aleatorically composed pieces would show the restrictions under which chance was allowed to operate and the actual results.

[1963]