CONDITION – INSTRUCTION – EXECUTION

Lecture, Firenze 1968

CONDITION – INSTRUCTION – EXECUTION : these are three terms which, in this order, can in future be characteristic for the production of electronic music. Read backwards – execution, instruction, condition – they describe the technical development of electronic music during the last fifteen years. When I say *execution,* I mean any action performed by the composer in the studio aimed at an immediate sounding result; for example, setting a frequency on the generator, filtering a sound, tape montage. All the equipment in the 'classical' studios is intended to be treated in this manner, and the students taking an introductory course of electronic music will not only get to know the apparatus and see how it works, but also how to operate it manually. In a certain sense, this resembles playing an instrument, because the composer has to alter the setting of a piece of equipment during sound production; he thus produces the sound in 'real time' in the same way as an instrumentalist. This has compositional consequences: the composer only prescribes for sound production actions which can be performed manually.

Here, I should like you to hear two excerpts from two compositions produced in our studio in this traditional manner. First here is an excerpt from "Chants de Maldoror" by Rainer Riehn. The second example is from Luctor Ponse's "Concerto No. 1 for Piano and Electronic Music".

By instruction I mean only instructions which can be stored. One of these could be, for instance, to ask a studio technician to produce certain sounds. The technician's memory, or a scrap of paper containing the sound data, is the storage unit. An instruction can also be stored on punched tape, on magnetic tape in the form of control pulses or mechanically by switch positions. It is characteristic of an instruction that it does not have to be carried out immediately. Even if its meaning is disguised by coding, it is better preserved in mechanical, optical or magnetic form than in the memory of a human being. Another characteristic of such an instruction is that it does not depend on any other conditions; it is executed in the same form as it is issued. We could express the relationship to *execution* by calling the instruction *indirect execution* in contrast to *direct execution* which occurs without a delay in time.

Apart from control by punched tape, voltage control is especially suitable for the storage of instructions. Strictly speaking, voltage control simply means that a generator or a filter is operated by a control voltage instead of by hand. In terms of instruction storage, voltage control is therefore useful when the control voltage is recorded on magnetic tape after previously being subjected to frequency-modulation. In the form of a recording it can be transformed in the same way as only audio signals could be transformed up to now: it can be transposed, filtered, used for tape montage, etc. Here, incidentally, we have the most important difference between voltage control and punched tape control; the mechanical code cannot be altered as can the magnetic one – unless a digital computer is employed.

An important question connected with voltage control is: *where does the control voltage come from?* – There would not be much sense in using only sine-wave or square-wave generators as voltage sources. We have therefore developed a variable function generator in

the studio at Utrecht State University. Using fifty potentiometers the composer can set a staircase-formed curve and check it on the oscilloscope. Two built-in filters make it possible to flatten the flanks of this curve. The voltage curve can be scanned at almost any desired speed: slowly if an amplitude modulator is to be controlled, or so rapidly that the curve is transformed into sound. At present we are constructing a second model, which will have a hundred potentiometers and two outputs. The square pulses of the second output can be transformed into sawtooth pulses and added to the first output, causing the upper line of a 'step' so slant. Technical descriptions of this function generator can be obtained from our studio.

As an example of practical work with the variable function generator I should like to play for you an excerpt from "Aspekt", a composition by Konrad Boehmer. The sounds in this piece were nearly all produced with the function generator, but they show only one 'aspect' of it.

In future courses in our studio – the next one begins in October – the participants will have an opportunity of studying the principle of voltage control. The employment of indirect execution resulting from unconditional instructions does, of course, have consequences for the composer. He does not produce audio-signals which he can immediately listen to and correct; he produces control voltages. More than ever he is forced to program his work, to change his ideas about sound into instructions which will then execute the sound. However, this catalog of instructions can at any stage of the work be transformed into sound, checked and corrected. To facilitate work with control voltages, four pieces of auxiliary apparatus are available:

- an oscilloscope which makes the curve set on the function generator visible;
- a storage scope which retains a curve model until it can be reproduced on the function generator;
- an ultra-violet recorder which fixes graphically the flow of a voltage and
- a computer program (including the computer) which calculates the data for setting harmonic spectra with any desired harmonics, amplitudes and phase angles.

Although voltage control in our studio is not yet complete – new equipment is always being built – an attempt has been made to use the available means to produce an electronic composition.

Gottfried Michael Koenig is working on a series of pieces with the collective title 'Functions' to show experimentally the breadth of variation of a fixed basic scheme. A curve was set on the function generator and was used not only as sound material but also to control filtering, reverberation component, and volume; it was also used for ring-modulation. Rhythm was produced with the use of a noise source as a random generator; the overall form was worked out by the computer. Let me play you an excerpt. (Koenig, "Funktion Grün")

Indirect execution consists of unconditional instructions. If we proceed a step further we arrive at the *conditions* on which *instructions* are to be executed. It is better to fix such conditions in the form of a computer program, which is why the sensible further development of the voltage-controlled studio leads to the computer. We should ask ourselves whether this development would be of advantage not only to the composer but to the technique of sound production too. We can assume that this is so in the latter case; for the composer, however, the real sound seems to disappear into the distance; not only would he himself have to produce instructions

instead of sounds, he would instead - or in any case moreover have to produce the conditions on which instructions are made or are obeyed. While the sounds to be performed indirectly - thus with the help of recorded control voltages and voltage-controlled equipment - are still mostly identical with the directly executed sounds, the composer being able to rely on his previous sound experience and only having to learn the technique of issuing instructions, there would not be much sense in using a computer to produce only sounds which can also be made directly or indirectly. The computer reveals the possibility of new sounds, which of course can only be brought into being by means of conditional instructions.

In Utrecht we have given much thought to this problem, and have reached two conclusions:

- for sound production with a computer, standard programs must be developed, just as standard equipment is set up in the electronic studio;
- the sound must be considered as an acoustical occurrence composed in various parameters; preparations must therefore be made for the programming of compositorial procedures.

Allow me to explain in as few words as possible what is being done in Utrecht in this field.

To practise programming compositorial procedures we have written a number of computer programs with names such as ALEA, SERIES, GROUP, PERMUTATION or TENDENCY, which clearly indicate their function. ALEA, for example, is an electronic die, SERIES a die with repetition check (it produces 'series'), TENDENCY composes transitions. We consider these programs to **be** elementary building-stones of modern compositional technique. They do not apply primarily to electronic sounds but to a greater extent to instrumental music, because in the latter the elements are better defined and known. The participants of a special course, parallel to the electronic course, have the opportunity of experimenting with these building-stones. They themselves are not required to write programs, but merely to state their own requirements for each one of these programs, such as the number range for ALEA, or to how many elements the repetition check in SERIES should apply. From such building-stones two larger programs have been compiled, one for rhythm and one for harmony. The rhythm program embraces the parameters STRUCTURE DURATION, ENTRY DELAY, DURATION, REST and TEMPO. The harmony program deals with the parameters PITCH, REGISTER, CHORD, SIZE OF CHORD, SERIES, INTERVAL SEQUENCE and TRANSPOSITION. Finally we also have a comprehensive composing program which, apart from rhythm and harmony, also deals with dynamics and timbre ("Project 2"). This program is also used for composition-theoretical experiments, and I should like to invite any composer here today who is interested in working with it to get in touch with the Utrecht studio. He would then have an opportunity of writing down the required data and having our computer calculate them.

For sound production a primary experimental program has been written, which at present is still being tested ("Sound Synthesis Program – SSP"). It is therefore unfortunately impossible to let you hear practical examples today. The sound production program is based on experience gained from the composing program and is intentionally arranged in such a way as to force the composer to set foot on terra nova. For this purpose we have made a distinction between the terms flank, *segment, sound period and* sound. A flank is a rising or falling section of curve between two inflection points of an oscillation; it is defined by a time value

and an amplitude value. Several flanks form a *segment,* several segments form a sound *period.* Repetitions of the sound period form a sound. With the building-stones already mentioned, the composer can combine time values and amplitude values to form flanks and from the flanks make any desired segments. The segments can be placed in any desired order. Because of the fact that the compilation of the oscillation curve is controlled by selection and permutation programs, the composer can generate perpetually new sounds from given data for time values, amplitude values and the order of the segments, be it in order to derive the sounds of a piece from a single basic principle, be it to find out experimentally the scattering range under given conditions.

It is certain that the experience we shall gain from this experimental program [cf. J. D. Banks, P. Berg, R. Rowe, D. Theriault, "SSP – A Bi-Parametric Approach to Sound Synthesis", Institute for Sonology, Koninklijk Conservatorium, Juliana van Stolberglaan 1, 2595 CA The Hague, Netherlands] will lead to further sound programs; it is also certain that this program will be used for sound research. With this in mind, we have formed a work-group consisting not only of studio staff members but also of perception researchers. Future sound production with a computer will therefore have two sources: on the one hand composition-theoretical knowledge and on the other hand the results of sound research. In the same way we shall include the computer as a sound source in the course program too.

The arrangement of *condition,* instruction and execution shows three steps on which electronic music can be produced. We are not only trying to provide the composer with a multitude of generators, filters and other equipment, but also with the choice between various methods of working. One of these methods is the relationship of musical form to its theory, and this theory leads to research as well as to new production methods. However, the arrangement of condition, instruction and execution would be incomplete without an indication of possible feedbacks.

Everyone is familiar with the feedback during *direct execution:* the composer judges the sound he has produced in order to reject it, to modify it or to assimilate it, unchanged, into a composition. Between direct and indirect execution, that is between execution itself and the instruction, chiefly ywo feedbacks are possible:

- first the correction of an instruction, corresponding to the correction during direct execution; - second the use of the result, the audio-signal thus, as control voltage after amplitude or frequency demodulation.

Between condition and instruction there are two important feedbacks, too:

- the first one is in the character of the condition itself, which is that an instruction will only be executed after the condition has been checked;
- the second one consists of the fact that the instruction structure can modify itself when general form conditions have been fulfilled or have proved not to be accomplishable.

This feedback would also presume that the conditions ae of formal nature and contain alternatives in case condition and instruction partly exclude one another.

Finally there is a third feedback between the conditions and the execution because the conditions, and maybe the instructions too, are changed by the result, which cannot be precisely forseen, if conditions or instructions are interspersed with random actions. For this

an analysis program is necessary; it examines the actual execution and delivers the results of the examination to the part of the program containing the more general conditions for the course of the form. In Utrecht we intend to develop such analysis programs, not only for sound production but also for the composition of instrumental structures. These analysis programs will probably resemble the programs necessary for the evaluation of the test results in sound research.