THE COMPUTER AND MUSIC

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CHAPTER II

From Musical Ideas to Computers and Back

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The link between the computer system and the composer of music is *the program*. The composer may think of himself and his mind and his ideas in any way he pleases, until he decides to use the computer as an assistant. From that moment on the composer must envisage himself, his mind, and his ideas as systems, since only systems can be translated into that language, the program, which can generate their analog appearances in the computer. Under control of a program, the computer system will simulate all the processes in and of the particular system which the program represents. The main problem thus appears at the beginning and again at the end of the entire proposition: Can the composer program musical ideas for a computer, and will the output of the computer contain musical ideas?

Another problem, especially for the more philosophically inclined composer, tends to become more acute as his work progresses. If it should be proven that everything is possible, that every sound, every constellation, every logical or random process is available—in short, if everything thinkable *can* be done—why then go ahead and still do it?

In the following pages an attempt is made to deal with some less obvious aspects of such problems and to propose some methods for analyzing them or even solving them.

Musical ideas are defined by composers of music. Not by philosophers, mathematicians, critics, music lovers, and record collectors. Analysts, commentators, and consumers may occasionally, occasionally even frequently, catch on to what the musical idea of a piece of music is or was. But their recognition of a musical idea, their way of calling it names, their behavior and attitude toward their own interpretation of the composer's work do not define the composer's musical

idea. The reaction to a musical creation is a consequence, a product of all the factors which are brought to bear on the moment when the musical idea hits the listener, regardless of this listener's awareness as to what it was that hit him. For most of these factors the listener may be assumed to be responsible. He believes he knows what music is and what music is to be. He is drilled and trained to conceive of certain concepts, to associate certain associations of ideas, to extract from the audible event only what he thinks is worth listening to, and to ignore or even condemn the rest. In theory one might claim that the composer, on the other hand, should be held responsible for the musical idea only. But, as more and more potential listeners have turned composer, such comfortable distinctions will no longer serve, and the best one can do is to state that the composer is responsible for everything *and* the musical idea, while the listener is responsible for everything *but* the musical idea. A composer of music has to be aware of, and to have a penetrating insight into, all the factors which converge to an ideology in the cultural make-up of his contemporaries. He has to come up with an idea, a musical idea, which just passes the accumulated past by not exactly belonging to it, by not conforming to its approved laws, by labeling its claim to eternal validity succinctly as a mere ideology.

Whenever a man finally recognizes and understands the notions and laws that rule his behavior and standards, he will, usually, honor himself for his remarkable insight by claiming eternal validity for these notions and laws, though they be ever so spurious, ever so limited to but temporary relevance. Ideologies flourish on retroactively made-up beliefs which are complacently proclaiming to have found the truth, while skeptics are already busy looking for it again. Under ideological guidance, the desirability of changes of state or law is measured by approved criteria. An idea, on the other hand, usually challenges the adequacy of using approved criteria as standards of measurement, and expressly demonstrates the irrelevance of the *approved* in questions of desirability concerning changes of state or law. It is for this that ideas come under attack; not for being either good or bad, but rather for uncovering the impotence of persisting ideologies. To cover this shame, the ideologically possessed apostle finds himself frequently provoked to advocate indifference, complacency, corruption, or even murder. Often enough, unfortunately, such a defender of an expiring ideology, by proclaiming it to be nature's own law, succeeds in contaminating the more gullible of his opponents, who,

unaware of their defeat, then begin to retaliate in kind. The most contagious disease in our human society is the agony of dying ideologies.

Every man's actions, the reasons for these actions, and the aims he proposes to reach with them, all reflect, among numerous other factors, this man's attitude or attitudes toward the ever-present choice offered: either to cooperate with and affirm ideologies, or to search for and try out ideas; either to make already approved criteria his law or to change the criteria according to the law he makes for himself. The composer's attitude will appear in the music he offers; the listeners' choice will influence their concept of, demand for, and participation in contemporary musical creation.

The criteria by which one thinks and the laws by which one acts function in interdependence. Progressing from temporary relevance to eternal obsolescence, by fits and starts, suspended in state at times, at others moved through a process of change, criteria and laws critically reflect each other. As progress in the two areas lacks synchronization, one is always ahead of, or moving faster than, the other. Their relative positions with respect to an assumed maximum of contemporary relevance vary constantly and may, occasionally, differ so widely that all mutual reflection begins to fade. It is in extreme situations like this that radical changes appear to become necessary. Much depends on how aware a man wants to be of such situations and of possible antidotes. The ideologist usually denies, under pressure at most regrets, the existence of both, whereas ideas begin to thrive on just the most drastic analysis of such problems. Musical ideas could be, more than anything else, seismographic analogies to such fluctuations in function between thought and action, criteria and laws, states and changes, elements and the whole.

In order to test the validity of this statement and its assumed premises, as well as to observe the emergence of unpredicted laws inherent in and consequent to such a test situation, I began work on a project which, written down in 1963, has served, and still is serving, as a general program of procedures, goals, and questions for my research activities at the University of Illinois. The Experimental Music Studio of the School of Music and the Department of Computer Science there offer the opportunity and the equipment, in a combination almost unique in the world, to follow up this kind of theoretical and practical investigation. I proposed to do research on the conditions under which a system of digital and analog computers would assist a composer in

creating music of contemporary relevance and significance. Two parts of the project reflect, in a rather concise fashion, my concepts of why and how work with computers might help toward a temporary immunity against the ideological infections of intentions and languages. There is, to begin with, a list describing some of the experimental steps to be taken, accompanied by brief comments, and then an essay on the speculative tendency of the project and the terminology used.

Plan for Work on the Project

1. Analysis and definition of recent and earlier systems of acoustical elements and events, which were used as musical material.

   Mainly an investigation of the statistical properties of exploited systems for the purpose of comparative studies.

2. Exploration, theoretical and practical, of the acoustical elements and events which today could be produced, controlled, and organized according to defined intentions of the human mind.

   Experiments in synthetic sound production, with a view to using the results as a foundation for planning the construction of a universal sound synthesizer.

3. Development of a code which, based on the scientific analysis of the physical structure of sound, would allow the programming of computers and sound synthesizers.

   In many a sense the core of the project. This code, in order to be useful, has to be capable of expressing in *computer language* not only the structural conditions of sounds that are demanded, but also the conditions for an organization of elements or events in time. Considering the fact that what is generally called sound structure is, to a large extent, actually also a function of time, first attempts at the solution of the code problem will have to be made in the direction of a time code. If found, the application of such a code to fields other than music should offer possibilities of considerable value. It will take some time, however, to coordinate the theoretical concepts, which will create such a code, with the technological systems, which will have to understand and to answer it. On the other hand, it seems fully advisable to start working on this idea while using such information and such equipment as is already available at computer research centers.

4. The speculative definition of an assumed new limited and conditioned system of acoustical elements and events in disorder.

The communication potential of such an artificial system in disorder depends on the condition that its information content does not at the time of speculative definition surpass presumable future human insight. In this project the new factor which has to be considered is that the quantitative content of the system as well as the presumable power of future human insight are to be augmented by the capacities of high-speed digital and analog computers.

5. The gradual organization of a limited and conditioned system of acoustical elements and events in disorder by way of musical composition.

A large program of experiments designed to investigate the following sequence: the composer's musical idea, the computer system's proposals for organization and realization, and the composer's final selection and choice. The recorded progress and the results of the experiments will be submitted to several different methods of analytical and comparative study.

6. Research on whether and how concepts based on the theory of information and communication could be applied to an analysis of the ways in which communicative creations are perceived, understood, described, interpreted, and finally evaluated by individuals or groups of the respective contemporary society.

It is assumed that in the course of such investigations, some clarification may be reached as to the source, the nature, and the quantity of standards necessary for the evaluation of communications which contain a meaning not previously established. With more knowledge on this subject, it should become possible to work out the foundations for a theory of the function of communicative creation in society, which would at least contribute new aspects of hitherto unsolved problems to existing concepts of history and sociology, and especially of the arts. At the most, this new theory would solve the problems and replace or absorb the existing concepts. All predictions, however, as to the results of these investigations must needs be kept rather vague until research is well under way.

7. The composition, realization, and performance of a musical work of contemporary relevance and significance with the assistance of a digital and analog computer system.

> No one can possibly say whether any result of this attempt will correspond to what has, until now, been called a *work of art*, or whether it will define what, from then on, will be called a *work of art*, or whether it will miss altogether that function in society which makes some creative communication a *work of art*. The contemporary relevance and significance of the composition should be achieved, not by appealing to existing means of understanding music, but rather by creating new means for musical understanding. It will not only show noticeable changes in the concept of the acoustical system, not only propose new schemes of organization, but also provoke the creation of new circuits in the listener's mind. This provocation is the aim and purpose of all creative and scientific projects. It is in this sense, that the cooperation of composer and computer is considered for here and now to be a natural idea. Whether it will lead to *music* or to *electronic brains* or to a new aspect of both, is a question fascinating enough to render fascinating all attempts at a satisfactory answer.

The Speculative Tendency of the Project

Man uses the term *chaos* whenever he wishes to ascribe to a quantity of elements or events what he believes to be the quality of disorder. In order to get information out of chaos, the elements and events have to be submitted to a process of organization, whereby order increases and chaos decreases. As soon as the chaos has disappeared, complete order is installed and no further information can be expected. The potential of information inherent in a situation of chaos depends on at least two factors: on the quantity of elements or events which are assumed to belong to the field of disorder, and on the number of possible ways in which they can be organized. If the quantity of elements or events in disorder is a very small one, or if there exists only a small number of ways to organize them, then the potential of information, in this particular situation of chaos, will be small too, and soon exhausted. Usually, though not always, the two factors seem to function in interdependence.

Wherever man observes chaos, he feels tempted, sooner or later, to

apply his powers of organization in order to get information out of this chaos. This temptation is not only an expression of man's untiring curiosity, but also nature's hint at an inevitable necessity. As long as the power of communication of thought is one of the most important pillars of human society, it will be necessary from time to time to renew the sources out of which the means for such communication can be gained. The means for the communication of thought consist of a selection of significant information out of a defined field of original disorder. As soon as this field is fully organized, it cannot yield any more information and thus becomes useless for the generation of communicative means. Established means can be used for the repeated communication of established thought, but, for the communication of a new thought, it is necessary to generate new means. A new thought is naturally, therefore, always in search of a chaos containing an information potential which would render a particular choice of order significant for this particular new thought.

If a system in a situation of total disorder is said to possess a high information content, this usually means that a great number of different possibilities for partial or total organization of the elements or events, in this system, are offered for choice. By making a choice, man extracts information from the system. In order that his choice may be significant and the information carry a meaning, however, the relationship between the chosen and the eliminated possibilities must be perceived.

When a *chaos* is first attacked by an attempt at organization, it is obvious, therefore, that the information gained will carry very little meaning because too little is known about the other possibilities inherent in the chaos. The significance of first choices can thus not be appreciated. This period of first attack may be called the *experimental* stage in the process of reducing chaos to order. Though seemingly uncommunicative, it cannot be avoided if one wishes to attain to higher degrees of order.

The next period could be called the *speculative* stage. By this time, the quantity of information gained allows for a number of statistical hypotheses as to the direction in which further information and the decrease of disorder in the system might be expected to move. In order to attach significance and meaning to the chosen possibilities at this stage, one has to accept as communicative the relationship between information which has actually been gained, and the eliminated possibilities which are only hypothetically assumed.

In due course the system will find itself in a state of order in which the quantity of information gained allows for a correct definition of the whole system, even though not all the possibilities of organization have been applied. Speculation gradually is replaced by variation. This period could be called the *reflective* stage. Communication becomes easier while the store of information runs low. Further attempts at yet untried possibilities of organization tend to result in repeated significance and meaning, demonstrating, thus, the decline in usefulness of the system as a source for the means of communication of new thought.

The transition to the final, the *administrative* stage, during which a system is totally organized, is an almost unnoticeable process. This is due to the fact that the now wholly communicative system at the same time becomes wholly uninformative. Therefore, the information that a system is dead, can only come from another system which is in a higher state of disorder.

Most systems, as they are found in nature, possess an information content which is so enormous that it usually takes thousands of years of human endeavor to show a noticeable decrease of disorder. Thus an enormous quantity of information must be extracted before the experimental stage is passed and the speculative stage, the first communicative period, may be reached. Out of its need for means of thought communication, the human mind has invented a very effective short cut: using its own assumed limits and conditions as a standard, the human mind conceives of artificially limited and conditioned systems. An artificially limited system reduces, by a priori definitions, the quantity of the elements and events that are offered for choice. A conditioned system reduces, by artificial conditions, the quantity of possible ways of organizing the elements and events in a system. The information potential of artificial systems is expected to be lower than that of *natural, physical,* or *universal* systems. The limits and conditions by which the human mind, at a given moment, defines the artificial system through which communication of thought should become possible, reflect on the limits and conditions by which the human mind defines itself at any given moment of its progress from chaos to order.

The success of every human attempt at the presentation and the communication of a new thought depends on whether a system is found in which the nature of the elements or events in disorder has

some bearing on, or affinity with, the nature of the new thought. Not every system will serve all endeavors. It is, furthermore, of utmost importance that the information content of the chosen system does not surpass the limits of presumable future human insight. As a matter of fact, one can say that an essential part of a new thought is the specification of the possible systems in which it proposes to become communicable. Equally, one can deduce from a chosen system some specifications of the thoughts which might be proposed.

A large-scale investigation of the nature of dependence between artificial systems and the human mind would throw light on both.

At least two considerations suggest that such investigation should be conducted with the assistance of computers: (1) limits and conditions are categories which can be expressed in computer programming —the time-saving capacity of the computers could thus be exploited to the full; (2) whereas the human mind, conscious of its conceived purpose, approaches even an artificial system with a selective attitude and so becomes aware of only the preconceived implications of the system, the computers would show the total of the available content. Revealing far more than only the tendencies of the human mind, this nonselective picture of the mind-created system should prove to be of significant importance. It should also be of interest to those engaged in research dealing with the duplication, through electronic devices, of the functions of the human mind.

The research project, meant as a contribution to the pursuance of this aim, would consist of numerous experiments, and should allow for comparative studies of three different but, under the set conditions, interdependent systems: (a) acoustical elements and events; (b) the composer's mind; and (c) the organization potential of digital and analog computers.

If the organization of a system in disorder is attempted with the aim to know all about the system and to render this information communicable, then it may be considered a *scientific project*. Here the system offers not only the means, but also the contents of communication. It speaks for and about itself.

If, on the other hand, this attempt is made in order to mobilize means for the communication of thoughts which transcend the definition of the system, then it may be considered a *creative project*. Here the system offers the means but not the contents of communication. It speaks for, but not about, itself.

All the sciences and all the arts progress in time by way of attacking various systems in various states of disorder with a strategy of interdependence between scientific and creative projects.

Both science and philosophy have suggested that the experience of *time* as an irreversible dimension of movement might be the sensual awareness of a continuous and irreversible replacement of chaos by order, and that, as the beginning of time was total chaos, total order would then be the end of time.

If one uses the terms previously established in this outline, the meaning of the word *music* could be defined as follows:

Music is the result of a continuous attempt to reduce to order the assumed chaos in the system of acoustical elements and events, with the purpose of mobilizing means for the communication of thoughts which transcend the definition of the system [a creative project].

These thoughts, consequently called *musical thoughts,* are the result of a continuous attempt to organize a system, called *composer's mind,* with the aim to know all about the system, and to render the extracted information communicable [a scientific project].

In order to conquer, eventually, the vastness of their respective objects, both attempts have to employ the strategy of probing stepwise into the disordered unknown, with the help of artificial systems. For *music,* the artificial system always consists of a more or less deliberately defined excerpt out of the total mass of possible acoustical elements and events. For *musical thought,* the artificial system consists of a more or less deliberately defined excerpt from the total mass of possible ideas and idea combinations in the composer's mind.

The history of music and of musical thought is the story of such artificial systems, their inception, bloom, and decline, their absorption or replacement by other artificial systems. At the same time, it is a report on the apparent or real progress in reducing to order the chaos in the natural universal system of acoustical elements and events as well as that of the composer's mind.

The idea of composing music, of organizing acoustical events in time with the intent of giving to this time a meaningful variety of movements, is only one of the innumerable attempts of the human mind to repeat, in ever-new ways, the old enjoyable feat of creating order out of chaos. Recent developments in the field of musical composition have shown that the limited and conditioned system of acoustical elements and events, considered *musical material* for several hundred years, has now entered the administrative stage, where

all further possible permutations will no longer possess any new meaning. The degree to which contemporary composers are consciously aware of this fact may vary widely. But equally widely varied are the signs giving evident proof for the growth of at least an intuitive suspicion that the system of well-tempered pitches, harmonic spectrums, and harmonic time periodization has had its day, and has now become so thoroughly organized that nothing unheard and unthought of could possibly find, therein, its communicative equivalent. Research in synthetic sound production by electronic means, as well as the sudden emancipation of percussive instruments in contemporary music, the experiments with random and statistical score and interpretation, as well as the rapid *modernization* of popular music—all these are phenomena accompanying the decline of an exhausted system, and indicating the tentative inception of a new one. A further symptom of this state of affairs may be seen in the fact that the term *new*, which was a word of praise in the musical society of the eighteenth century, now has completely lost its flavor of aesthetical approval, and has adopted instead a connotation of reserved tolerance, implying that the experiment is with the listener, and not with the music. This metamorphosis (within such a word's meaning and social function) shows that comfort is found where everything except a new idea communicates easily, and that fear is felt where a new thought might destroy that comfort.

It is more than probable that observations of this kind, though made in the field of music, should also bear witness to certain more general attitudinal trends in our present-day society. In some way which ought to be investigated and interpreted with infinite care, such observations undoubtedly reflect many aspects of the situation in which the human mind finds itself just now. Once the significance of observations made in a specific field is understood, information on the more general system, which made the observations, will have been gained.

The human mind, out of its desire to know itself, creates artificial systems in order to render this knowledge communicable. If the artificial system in which music was understood is now to be replaced by another or larger artificial system, then it should be of great interest to observe how the human mind meets the demands which it poses. To this end, it is necessary to keep track not only of the results —that is, the music—but also to analyze, to register, and to store for further reference each moment of the working composer's mind. If the

composer would have to program each of his ideas for a computer system, he would have to define as accurately as possible what he is looking for. It is to be expected that the computer system will respond with far greater a quantity of propositions answering the definition than the composer's mind alone is either conscious of, or able to imagine. At the same time, it would provide for an exact, step-by-step record of all the proceedings between initial definition and final choice. The composer's choice from the computer's propositions would still remain a highly personal decision, but would be taken in a field which is not limited by the prejudicial boundaries of the choosing person's imagination.

My contention is that the understanding of the human mind, which goes into the creation of music, will sooner or later communicate to the listener of music. The more valid the initial understanding proves to be, the more the function of music in society will become of importance and of consequence. All music that today is called beautiful, moving, or entertaining, once was the acute representation of a then contemporary vision of truth in the human mind. In order that the music of our day may add beauty, emotion, and entertainment to future times, we should compose it to represent and to be congruent to our contemporary vision of truth in the human mind. So that the search for this vision be a conscientious one, all that the human mind has created up to this day ought to be mobilized. None of its achievements, be they rational or irrational, be they knowledge or speculation, theory or practice, fantastic intuition or technological construction, should be excluded or even neglected, as long as the search goes on.

Since this project was written down, it has been clearly shown, here as well as elsewhere, that a system of analog and digital computers will indeed assist a composer in his attempt at creating music of contemporary relevance and significance, and also in his research on the meaning of these words. The more the composer works with computers, the more he avoids using the equipment as a glorified typewriter, and the more he has it assist him in mental rather than menial work. This development is reflected in some of the concepts through which the composer sees the computer, and by which he is influenced in his choice of procedures, and in the procedures themselves. As soon as the composer recognizes the computer as a very

large and semantically uncommitted system which can adopt any one of the states that its elements and their number allow, he also recognizes how this is an invitation to use this large controllable system as a pseudouniverse in which smaller, artificially limited and conditioned subsystems can be simulated, so that their behavior and structural properties may be registered, recorded, and studied. There are, basically, two ways in which one can accept the invitation. The composer's program may instruct the computer system to simulate a specified subsystem, to operate on it according to specified rules, and to print out (in a convenient, specified code) the resulting states of the subsystem. It largely depends on the specified rules whether the result is predictable or not, whether it represents, unmistakably, the stipulated subsystem and not any other one, whether, as a documentary of the total or implied exploitation of the stipulated subsystem, it shows all the characteristics significant for the composer's intentions, or some, or more, or none. The other way would be that the composer's program defines an initial and a final state of the computer system, and a set of rules, and then instructs the computer system to find and simulate that subsystem, in which these rules will generate an uninterrupted chain of states between the initial and the final state stipulated. Here it will depend on the specified rules whether more than just one subsystem can be found, whether the resultant chain will present a mere record of counting, an exercise in scales, an inventory, or that highly complex progression, facing which the experience of disorder happily meets the knowledge of order.

For some time now it has become possible to use a combination of analog and digital computers and converters for the analysis and synthesis of sound. As such a system will store or transmit information at the rate of 40,000 samples per second, even the most complex waveforms in the audio-frequency range can be scanned and registered or be recorded on audio tape. This not only renders possible the most accurate observation of the nature of sound, but it also allows, at last, the composition *of* timbre, instead of *with* timbre. In a sense, one may call it the continuation of much which has been done in the electronic-music studio, only on a different scale. The composer has the possibility of extending his compositional control down to elements of sound lasting 1/20,000 of a second.

Thus one can say that, potentially, the computer system is a very close approximation to a universal sound synthesizer. If every sound is equally available on order, no particular one carries any significance

by itself. The composer is faced with the problem of how to restrain the availability of sounds noticeably enough and how to make perceptible the range out of which, with various probabilities, a limited number of constellations may be selected for actual appearance, so that each choice attaches that significance to the chosen object which the composer intends it to carry. The composer, having all at his disposal, has to create and to define the subsystem in which he wants his musical idea to expand into a musical event. He has to learn how to think in systems, how to translate ideas and thoughts into network systems of interlocking and mutually conditioning instructions, statements, stipulations and equations. At the same time he will have to open his eyes and ears to the system ruling his social environment, in order to become conscious of the role which his artificially created systems play in that environment. Whether they happen to simulate by affirmative analogy, and by artistic innocence, those ruling systems he actually means to oppose and to criticize, or whether they simulate, still by analogy, and maybe ahead of time, that which he hopes for.