MUSIC AND COMPUTERS

by

PIERRE SCHAEFFER

Mr. Pierre Schaeffer's original paper, which was considerably longer than the other communications presented at the Stockholm Meeting, has been shortened in the following English-language version. Mr. Schaeffer authorized the REVUE MUSICALE to leave out large sections of his original paper dealing, for example, with the projects developed (and explained elsewhere in the present collection) by Mr. Max Mathews.

MUSIC AND NUMBERS

The computer provides contemporary man with a fascinating opportunity of psychological projection. One comes up against the two poles of a contradictory inspiration that haunts our epoch ; the *masculine* principle of power : the computer, absolute arm of knowledge, triumph of deductive logic, of proof by figures ; and on the other hand, the *feminine* principle of submission to a stronger being, religious falling back upon the idol, secret pleasure of finally giving in, and of yielding to this man-made god the sentimental disturbances that the Other God, who is dead, insisted upon in an irrational man, now pleasantly out-of-date.

And so, when the computer makes its entry, most noticeably, upon such and such a scene, it is inevitably followed by strange consequences. As long as the computer is used for what it truly is : an ultra-rapid calculator, there is hardly any risk of misunderstanding : it turns out invoices, pays the employees, etc. Even when the computer, at the height of its capacities, calculates the trajectory of a rocket and enables men to land on the moon (certainly the greatest exploit yet achieved by computers), there is no misunderstanding on the part of the onlookers. This is because a trajectory, launching dates, orbits, firings, etc., all belong to a sector that the man in the street thinks of as lying

outside of humanity, of thought, of language and of beliefs. But when the same apparatus, instead of calculating trips to the moon, is used to decipher a musical score, to decode words or to programme learning, then our ideas are disturbed, and our heads start to swirl. Now these latter projects are infinitely less difficult than those which must be carried out in order to send a rocket to the moon — one might even say less intelligent — and it is a matter of making use of the same logical, if not intellectual, working instrument. Why then does the « mental connection » between the computer and, let's say, music, linguistics, thought, etc., provoke a sort of « bang » which excites some people and disturbs the others ? (Myself included, I must admit.) It is because this connection concerns not so much the arrival of a technique to be used by research workers, but rather the invasion of a myth and of a blind tendancy. In that the computer, as everybody knows, is only capable of calculating (powerful calculations of course, unthinkable without the computer), that means, when one rejoices at the situation, that music, speech, etc., are amenable to calculations, and when one deplores the situation, that the contrary holds... conditioned, in the latter case, by the fear, which always remains in intuitive people, of being mistaken, and of finding even their intuition shaken by an unexpected experience.

The real question concerns neither musical data processing nor computers for making music. Here is the real question : what is the relationship between music and computation ? Can music be resolved by numbers ? It so, then it is obviously intended for computer processing. If not, then computers are going to put music research on to the wrong road for a long time to come. Finally, a still better question : What, in music, can be reduced to computation ? As soon as this question can be answered then it will be possible to know what should be given to computers and what should be left to intuitive human beings.

SIGNS AND SIGNALS

As Saussure has pointed out, there is a difference between the *containing entity* and the *contained entity,* between the *signifying entity* and the *signified entity* ; in other words he pointed out the duality of these inseparable poles which constitute a « sign ».

But the word « sign » (even greater « bridge of asses » than Pythagoras) has a certain property — like electricity also : that of being *single* and *double* at the same time. The *signifying entities* are most noticeable in music, in that they are visibly material : instruments, magnetic tapes, scores. As for the *signified entities,* these are assuredly what we hear, what we understand (?) : all that comports a certain *sense.* There is no way of breaking a magnet into its positive and its negative poles, for each piece immediately recovers the

magnet's initial form. There is no way of obtaining electrons without their being associated somewhere or other with equivalent positive charges. In the same way, there is no way of obtaining *signifying entities* without *signified entities.* Many people — even some of the most intelligent — have failed to realize the implications of this situation.

I pluck a vibrating string and I measure, as an acoustician, the number of periods or decibels. This would appear to be a sign : a *signifying-signified* relationship. Now let's step into a violin class, where a student is striving to produce an exact and well timbred interval of a third by means of similar strings. For each of these sounds (regardless of whether it is well played or not), there will be frequencies, spectra and decibels, but only from time to time will one of these sounds be recognized as a *signifying entity* which can be associated with a *signified entity,* namely the exact, well timbred, well modelled (not modulated) and musical interval of a third. *The physicist's signified entity is therefore adopted by the musician as his signifying entity,* as one might say (1), and the transfer is practically carried out hand-to-hand as in a relay race. This is a very precise and essential distinction which too many people these days try to conceal. The same explanation holds for the signs used in writing. Physical and musical writing would appear to be connected by a convenient equivalence. It is even a simple question of interpretation. The note of music, as it appears in the score, is merely a *symbol.* It can be made use of in two ways, by the physicist and by the musician. The music symbol A, for the physicist, is indeed a « sign » (better still, a *signal*). It indicates to him a certain known relationship between physical and auditive phenomena, brought about by the fact that man is capable of detecting, inside a certain natural (?) range of values, the note A. The physicist's A is in fact a Platonic idea, or, with respect to more recent texts, a « *formal word* » of the musical language, in the sense defined by Saussure, and not a « *spoken word* » of that language, such as one might actually pronounce, having a particular and real existence and creating effects in the psychological and social fields. This same A of the tuning-fork, written on a musician's score, is on the contrary an instruction to put together an A, to translate a symbol which is at one and the same time a *sign* in a score and a performer's *signal,* in order to produce a concrete musical entity, capable of reaching the musical consciousness of other people than the musician (of course this musical entity must first of all reach the musician himself, in that his rôle is obviously divided into two parts, like the poles of a magnet : he is both a craftsman concerning the *signifying entity* and a listener concerning the *signified entity*) (2).

All of this would seem to be leading us away from computers. On the contrary, so many people engaged in musical data processing and so many

(1) The metaphor is used merely as an illustration to facilitate understanding ; the double nature of a *sign* should never in fact be separated into two parts.

(2) Or better still : a craftsman of the signal, and a listener of the sign.

too-eager enthusiasts have neglected these basic reflections that many risks have been taken, bringing about still further confusion in an age characterized by an over-development of equipment and an under-development of thinking.

In order to emphasize the distinction, let us define a *signal* as the relation between a sound and the various physical traces (3) which it leaves on a magnetic tape, or on the dial of an apparatus, etc. These traces are normally measurable, which means that they are amenable to the computer.

If on the other hand we investigate the musical *sign* itself, whose « carrier » is the physical phenomenon, and whose sense is that which man's consciousness (both individual and collective, natural and cultural) has established, then the problem is of a completely different kind, and the suggestion of using a computer in this respect is equivalent to postulating, implicitly yet firmly, that music is merely a question of numbers and configurations of numbers. But what exactly is a configuration of numbers ? Here we come up against the same ambiguity : are we speaking of a mathematical or of a psychological configuration ? In other words, every time we fall back upon computations, that is to say upon the computer, we are implicitly postulating some sort of anthropomorphical identity between man and the computer.

Let's not be burdened by such a troublesome and annoying interpretation, which would surely be denied by many computer users, even by those who are keen on musical data processing. On the contrary the temperament of these people generally incites them to accuse music itself of anthropomorphism, by declaring that it remains at the level of an undefined and obsure correspondance between human beings and numbers. These computer users recommend a scientific approach, and a scientific use of machines, free of sentimentality and of any subjective adherences. Let's not quarrel with them. We are quite prepared to leave out of the discussion their secret or declared motivations, their contemporary approach, and their frequently obvious inspirations.

They have a right to these attitudes. Let's even take off our masks. Those readers who are already thinking up a means of contradicting what I've been saying should at least know that I myself am obviously opposed to the attitudes which I just described. I believe in human instinct rather than even the most powerful calculations carried out by a computer. I must admit that this innate belief is the source of all my inspirations. But I should also admit that this belief has no other basic justification than a personal « inspiration » or an « intuition ». I am completely capable of accepting the idea that my opponents have the right to relate their motivations to a contrary inspiration, and I am in fact obliged to accept this idea. I hope that they will read this text in the same spirit in which I have written it. We should restrain our passions, which are equal and of opposite signs, and we should try to be

(3) Computer people use the more precise adjectif *analog*.

objective (this should be easier for my opponents than for myself, in that they rely upon the physical sciences) in order to avoid the possibility of starting out some sort of religious war centered around computers. Nevertheless I have the feeling, and I *know* in fact, that every reflection on these lines is bound to divide people into different camps, to annoy them at the very moment when they wish to be left alone with their secret desires, and to bring them into conflict. But then I've never denied that machines were better used in « listening » than in producing, and that they were more capable in the discovery of a « sol-fa » than in the synthesis of sounds. I'd be less surprised than anyone if computers came to propose a fundamental opportunity of thinking and of rethinking about music. But my intuition in this case is very clear : if computers force us to think, then it's nevertheless up to us to do the hard work ; they cannot be considered as thinkings machines... in place of ourselves. I also find computers perfidious, and sometimes cynical ; in that they are exceptionally clever, maybe their cleverness covers up our naiveness and excuses our laziness.

THE « LANGUAGE » OF SCIENCE

I'd like to act as the devil's advocate for a few moments, which will give me an opportunity of realizing the difficulty of the problem that I've tackled, as well as putting myself in a situation where I can usefully explain why the scientific attitude is currently so much in fashion. Actually I feel that what I've just been saying about signs and signals is not very easy to understand, and it's quite probable that it won't carry much weight in front of the solid arguments of the devil. After all, the opposition which I've been trying to indicate is subtle, and it is based upon a very delicate distinction between two experiences, two ways of reacting towards things... one might even say two « cultures ». Contemporary scientific culture has brought about a sort of blind faith, and a real belief in causal explanations : that's to say, in logical demonstrations. The distinction between signs and signals, a direct outcome of phenomenology, presupposes a philosophical sensitivity and the sort of doubt which has existed since Descartes up until Husserl, and which is not very widespread these days, even amongst philosophers. People are likely to be surprised when they discover that the field of experience and of knowledge is studded with craters, and that some of these craters are in fact very deep crevices, as in a glacier... and that they are likely to prove mortal for the intrepid person who tries to cross over them on a fragile bridge of brilliant white snow. Let's look into these snow bridges, these mirages conjured up by the Devil.

The most classical music, that which is taught in the conservatories, that which started out with well-tempered harpsichords and *figured* bass (there

you have the word, right from the start), from Pythagoras to Zarlin, has never relented from putting forward numbers, which has always provided the means of joining together both the intuitive and the deductive rank-and-file, no matter how irreconcilable they might appear to be on the surface, in a sort of idolatry cult. Octaves are powers of two. Intervals are simple relationships, starting out with the fifth (whose cycle only repeats itself, one must point out, in virtue of a delicate negociation that our « well-tempered » climate seems to have encouraged). In other words, the Greeks had already discovered all of those things, and when they divided up their vibrating strings they were already behaving in exactly the same way as our friend Helmholtz with his resonators. The Greeks had established the « theme » for which Helmholtz went on to discover the « version » (4).

Fourier, with his famous theorem, only had to point out that every *normal* function, that's to say more or less continuous, could be represented as a series of sinusoidal terms. This theorem, a little dry to say the least, can in fact be put into more literary terms along the following lines : Every relationship between two events (represented by a graph, for example) is equivalent to a concert !

Can I leave off as devil's advocate ? Haven't I sufficiently demolished my personal propositions by these facts, these theories, these precedents... by *traditions* themeslves ? No ! The devil hasn't as yet made use of his most modern and least conventional weapons.

Up until now music has always remained attached to animal tissue. The tomtoms of all the primitive (?) tribes were made out of skin, violin strings were manufactured out of gut, and the skin on the fingertips seemed to be of great importance, for example, in the pianist's « touch » and in the violinist's vibrato. Well, after having proven that all this was fantasy — that electronic tomtoms worked just as well, and that the pianist's « touch » was finally a mere number of pounds — we are in a position to easily affirm the *reciprocal* of Fourier's theorem. Any music whatsoever, no matter how complicated, no matter from what age it dates, and no matter what instruments it uses, can finally be reduced to a two-dimensional graph, that's to say, to the simplest phenomenon imaginable : an elementary time series. Music is therefore nothing more than the instantaneous value of the pressure on our eardrum, or the depth of a track on a disc, or the magnetic intensity recorded on a tape. Funnily enough, it's the analysis developed by our old friend Helmholtz that turns out to be the most difficult to give to a computer, not because it's

(4) Pierre Schaeffer is alluding to the distinction, quite familiar to French students of foreign languages, whereby a translation from one's own language into a foreign language can be thought of as the development, in the terms of the foreign language, of a « theme » which has been proposed in one's proper language, whereas a translation in the opposite sense amounts to providing a familiar « version », in one's native language, of the information gleaned from the foreign text. This attitude is less explicit amongst English-speaking students.

Translator's note.

awkward, but rather because it's expensive. On the other hand, the easiest and relatively least expensive job that can be done by the computer is to work in the opposite direction : that's to say, combine frequencies on a time basis. Who could rightly take it upon himself, in a dictatorial manner, to prevent computer musicians from using an instrument which would appear to be *made for making music* ? Why in fact is the computer so enticing ; why would it appear to *belong* to musicians in such an obvious way ? Simply because, as far as the man/computer dialogue is concerned, man has always been more or less obliged to express himself in words, which has never been very convenient for the machine... whereas the most comfortable language (?) that one can imagine — one that the computer can speak spontaneously — is the language of music. Why ? Simply because the language composed of words, woven out of cultural elements, weighed down by meaning, with its inextricable codes and its confusing and practically unexplored grammars, is far too complex for the computer... and cannot unfortunately be reduced to a Fourier series ! On the other hand, as far as sinusoidal sounds are concerned, that's exactly what is « spoken » by any electronic circuit whatsoever, even without the need of learning. Combining sine waves, that's about the most natural thing in the world for a digital computer. Even without musicians getting in the way. *Quod erat demonstrandum.*

THE « LANGUAGE » OF THE EAR

There you have the devil's statement. *Diabolus in musica,* one should insist : the devil hidden inside the computer. Let's drag him outside so that we can speak with him directly, instead of conversing by the intermediary of the machine (which is after all far too easy for the devil, and far too dangerous for us).

Let's get back to the question of signs and signals. In all this talking about skin, we did nevertheless leave out one rather important skin : our own ! Music is heard by means of the entire surface of the human skin, and particularly by means of a fragile « entry », operating in conjunction with a passage leading to the most obscure antechambers of the brain, to the most amazing labyrinth, to strange organs whose hearing tasks are complicated by other surprising missions, for example the sense of balance. In other words the human ear is itself a sort of computer. And what's more, there is no justification for restricting our investigation to that complex organ, even though we penetrate into its interior... compared with which the eye is a really primitive elementary gadget. We are obliged to recognize that hearing goes beyond the ear and the body and the stomach and the nerves : as for the language of words (although there the « signal » and the « code » are of an exceptional simplicity), hearing involves the memory also, with its subtle

mental connections which are not only poorly determined, or even completely undetermined, but moreover almost unattainable... that's to say, when they are not already forgotten or even denied by the research scholar. Yes, I'm afraid that all I possess, opposed to the devil with his splendid computers, is that poor little human being — ourselves — with his ears, his skin, his brain, his stomach, his memory, and maybe his heart... who knows, this transplantable organ might help me out in a purely symbolical sort of way. And I'll ask you all to accept my apologies...

Here's what I should tell the devil and all those naive people who follow him blindly : No matter how closely together you locate the computer and musical « manipulations » (and we're willing to go along with that tentative as far as you like), you cannot deny that « music is made to be listened to » — according to an unprovable axiom that I've frequently put forward, and whose truth would seem to be so evident that lots of people simply forget its existence.

Yes, it's true that the computer is capable, with prodigious skill, of combining sine waves, of deciphering music, and soon, no doubt, of analyzing sounds one by one, or in groups, according to their appearance in time... but we human beings, how do we stand as far as these various capacities are concerned ?

We come up against something that is amazing in view of its simplicity, something that seems just too unusual, because of its artlessness, to belong to modern thinking. Here it is. When all is said and done, does music concern human beings, or does it only concern itself ? In other words, is musical research an inquiry into meaning or merely into means ? Music is presented to us in the form of compositions, which are in fact distinct both from the composer and from the listener, and these compositions can be analyzed, decomposed, counted, remade, imitated or reinvented (computers have even played a part in such activities in recent years) ; can these compositions be considered as *things,* that's to say as objects which have an existence independant of human beings, which we can know objectively and scientifically ? Aren't there laws concerning music ? And isn't it precisely the lack of a tool such as the computer, capable of carrying out enormous numbers of scalings and combinations on enormous quantities of data, that has been responsible for the stagnation of music... and particularly the stagnation that has become apparent in recent years with the disappearance of that intuition which characterized the great manual computers of past epochs, that's to say the classical composers (Bach, the greatest of them all) ? Since Bach, everything has been attempted in the primary combinatorial domain, including the desperate and yet encouraging efforts of those great pioneers in the field of permutations : our immediate ancestors, the dodecaphonic and serial composers.

But if man is to be the subject of musical research, then how can we start out ? The hesitating approaches adopted throughout the last few decades

would appear to have failed as soon as they reached the limits of successive aesthetical and more or less philosophical pretensions. So-called musical analysis, as it has been practised, would appear to be a sort of discourse having neither content nor form, neither method nor objectives, concerning music about which nobody is capable of speaking... simply because nobody has anything meaningful to say. And if we admit that man is the ultimate goal of this research, isn't it finally through the possibility of being able to offer him fully computed music, at one and the same time objective and founded upon coherent systems and precise hypotheses (or upon models analogous to those which he imagines in space, based upon the logic which he comes up against as the final resort of his thinking process), that one might eventually lay the grounds of a rational, progressive and scientific encounter between physicist and musician ?

TWO USES OF THE COMPUTER

We should begin to answer that enormous question — one might almost say the *only* question (in many other fields besides music) — relating to *man's knowledge of man.* We shall certainly discover all the hesitations, all the misunderstandings and all the subterfuges of modern epistemology. Music would in fact appear to be a last-minute addition and a subsidiary question in the range of this question, although I myself believe, on the contrary, and I have continually put forward the idea, that music, in a strange sort of a way, is situated at the very center of all that is problematical : not so much because music is necessary for mankind (at least I wouldn't set out to defend it from such a point of view), but because it happens that music, on the level of epistemology and, might I say, of learning, occupies a very special place... one might even say a *unique* place.

But before setting out on this question, several words : there's no sense in speaking with people who are deaf, particularly if they're also musicians ! It's not so easy to put and end to the buzzing of so many clear minds, and to modify the faith of so many devoted disciples. It's essential to start out by playing their game... and it's in no way dishonest on my part to start speaking their language (above all in an attempt to put myself at their place), and to become interested in their experiences, not so much in order to prove that they're wrong all the time, but rather to persuade them that they're wrong in adopting one exclusive goal, meanwhile passing alongside of what is essential.

Therefore I now intend to examine, insofar as I'm capable of doing so, the various sorts of music projects making use of computers.

I'm naturally faced with the task of sorting them into their basic categories, and of propounding, both to myself and to the project authors, the prejudicial question : Are they working on the *signal* or on the *sign* ? If

they're working on the signal, it's more or less a matter of the development of musical instruments of a special kind, and we should be persuaded not only to take into account such developments but on the contrary to investigate its possibilities to the fullest possible extent. If on the other hand the project concerns the sign, this means that we'll be making use of these results in order to investigate music itself, either in the sense of *analysis,* or in the sense of *composition.*

There must not be any prejudice on my part either. Why not make use of a computer in order to investigate music itself ? In such cases it's not the computer that worries us, but rather the questions that we give the computer. My only doubts, therefore, concern the sort of questions that people will be *obliged* to formulate.

It can be stated, *a priori,* that the use of a computers in music research can be summarized under two general headings. Under the first heading, the « instrumental rôle » of computers, we recognize, as one might expect, certain pathways that we in Paris have already followed in the field of concrete and electronic music, so we shall be well placed to put forward our point of view. Under the second heading, where a computer is used either for deciphering existing music in order to discover its secrets, or for inventing new music, and for predicting its virtues, I shall certainly be less at ease. On the one hand I'm not so familiar with such procedures (which are often based upon « self-explanatory » technical setups) ; on the other hand, the questions which must be encountered under this second heading represent the very limits at which our own research programme came to a stubborn end. I'd like to emphasize this latter point very firmly. Tedious research work carried me up to the final approach towards the principal mystery in music, and even 20 years was unfortunately insufficient for deciphering a generalized sol-fa, that's to say general enough for encompassing all the possible material in all the possible musics. It's already sufficiently presumptious to claim as much as that, and it would be ridiculous on my part not to warn you, and misleading if I didn't let you know straightforwardly, that I was not capable of going any further. As far as the « very structures » of music are concerned, insofar as they represent the foundations of one or several languages, and insofar as they explain the creation of works, their content and their meaning, I assure you that I have no more knowledge in this respect than any other person in the world. The only claims I can make are that I know the difficulties in this approach, I am capable of imagining the blind alleys, and the misleading short-cuts ; maybe at the very most I might express my doubts concerning the meaning and the current possibilities, if not the interest, of a research programme of this nature. Moreover this is precisely what interests me in the computer tentatives.

In that I generally consider such tentatives as illusory, I naturally consider such failures as instructive, and they can in fact help to define, not my own

thesis, but the general direction of music research, which will eventually become aware of its traditional errors. I naturally do not deny the risks of basic intuitions, as well as the possible errors which might have occured during these 20 years of research work. These failures at least trace out a zig-zag pattern, not unknown in other fields to which computers have been applied, demonstrating the disorder of contemporary research, or at least the lack of solid reflections in connection with problems which have always concerned research, with or without computers.

THE COMPUTER AS A « MUSICOLOGIST » AND « COMPOSER »

Let's begin by the doubtful cases : the use of computers either as « musicologists », when it's a matter of deciphering the secrets of musical language, or as « composers », when they are called upon to replace or assist their « monitors » in the composition of works.

As I already pointed out, I'm not very familiar with these fields, and I have no pretension whatsoever of carrying out an exhaustive examination. I'll limit myself to the consideration of several examples, no so much in order to criticize them, but rather in order to show at what point slips in, implicitly or explicitly, the hypothesis or the point of view on which the *musical aspect* of the project is *founded.* That's the only thing of any importance. Before starting out, let me emphasize once more : I don't have anything whatsoever against computers, but rather against the false confidence which they endow upon a whole generation of young musicians, fascinated by the window-display ; I feel that one should beware of introducing these young musicians to corridors that will soon afterwards be barred by Markoff chains, with the necessity of giving passwords in FORTRAN or ALGOL.

Pierre Barbaud offers us a preliminary statement, without even a vague « sugar-coating » ; the title of the book from which it is taken, « *La musique, discipline scientifique* », already provides a hint as to the spirit of his declaration : « *Whenever Nature provides us with such a basic object as a sound and its resonances, man sets out naturally to make an abstraction of that object ; he removes its epithets, and turns it into an entity capable of entering into set-theoretical relationships with other entities, up to the point where it can in fact be introduced into a set possessing a structure... in other words, to the point where it can be subjected to computations. This tendency was responsible for the blooming of medieval counterpoint, and it's probably true that all music can be attributed to this tendency.* » I have no intention of treating in several lines what it took me 600 pages to explain elsewhere (5) :

(5) *Traité des objets musicaux,* Editions du Seuil, Paris (1966).

viz., the constant flow from the abstract to the concrete in music, a permanent source of enrichment and of renewal in the exploratory evolution of any language. I am therefore not at all inclined to deny the abstract character of music, nor the possibility of discovering set-theoretical relationships in music. But have pity on the poor unfortunates who are blinded from the start, who deprive themselves of the other half of experience, and who imagine along these lines a series of pre-existing structures, « possessed » by these sets... ignoring that man has never ceased to *invent* such structures, varying them, giving them myriad different meanings, themselves changing all the time and yet attached both to geography and history... in other words, to culture itself. It's almost like asking whether such research workers limit the musical universe to several centuries of white civilization.

At a clearly superior level of analysis, in the case of Wilhelm Fucks for example, one can finally distinguish the same postulate, except that his methods of analysis are better implemented from a statistical point of view. Nicole Lachartre has summarized the studies of Professor Fucks concerning « *the distribution of pitch and of intervals, and the distribution of the correlation between two notes that are either adjacent or separated by* n *notes, these distributions being taken from sequences which might be considered as typical of an entire given musical work* » (for example, the first violin part). Fucks has computed in this manner the distribution of the frequency of occurrence of various pitches from Bach to Berg, then the typical pitch separations in 29 works, from 1500 up until 1960, and finally the distribution of frequencies of occurrence of intervals between consecutive sounds for several composers from Bach to Webern. One can only feel sorry for the research scholar harnessed in this way to a study of statistical distributions, for music that is structured *a priori*. There's nothing to be gained from a discussion of the results, which sometimes yield analogous coefficients for Bach and for Webern, along with a numerical explosion to account for the romantic period... So much assiduity in order to continue reading in the dark hardly merits any further investigation.

There is obviously a completely different sort of common sense in the job undertaken by Hiller, who at least starts out from the rules of counterpoint extracted from *Gradus ad Parnassum* (by another Fux, who in 1725 codified the rules of composition employed by Palestrina), permitting him to dictate a program to the computer and get back from it, in exchange, the first movement of the Illiac Suite, so well known in Illinois and other places... The second movement, after random beginnings, reintroduces the same rules, while the third movement generates rhythms governed solely by the tritone. The fourth movement introduces Markoff chain relations, from zero to fourth order, for determining the intervals and principal beats. The University's computer did not actually play the piece, because it had enough work to do

turning out the score... which was in fact played in a quite classical manner by the local Quatuor.

On can smile a little, I feel. Which doesn't prevent us from respecting the colleague or from admiring the achievement. It's certainly to be thought of as a *grande première.* Teaching the computer the rules of counterpoint, introducing random elements as well as constraints, obtaining a result, and then listening to it being played by a string quatuor : there's certainly nothing that shocks me in all that. On the contrary, it's an amazing exploit ! Even though the process is in some ways vague (how could it be otherwise ?), I consider it as an « experiment in hearing », and an honest journey, there-and-back, between what is known and what is unknown, or rather between what is deduced and what is induced ; in other words, it's almost the same journey from « theme » to « version » which remains for us the only means of investigating the unknown aspects of significant events. One also notices the application of relations between the moment of music to come, and the moments which precede it, with the possibility of pushing the Markoff chain order still further in order to take into account a still greater number of pre-existing elements. Finally one is fully aware of the investigator's imagination, and the responsibilities or intelligence of his decisions. Whether one is dealing with the « theme » or with the « version », either you start out with music whose rules are already established, or else you must give the computer a « working hypothesis ». Since the computer, because of its virtuosity, allows the testing of a sufficiently large number of hypotheses (that would not be possible in the span of a single human life), and since it enables the experimental verification of these hypotheses with the help of human listeners, then why not welcome such a system ? What I'm about to say, then, is not so much an analysis, even summarized, of the Illiac experiment as such, nor of its particular beginnings and consequences. I only referred to this experiment out of respect for its historical value — Hiller and his colleague Isaacson being the first investigators in this field — and also in order to point out its simplicity. This project involved a « simulation » of the composer — and even an apprentice composer in the counterpoint classes, who sets out artlessly and stochastically to « test » those notes and chords that are not prohibited by the « Principles of counterpoint »...

The real originality of Hiller is the fact that he turned out to be classical right from his first experiments ; I mean to say that he brought together theme and version right from the start, whereas others set out to *isolate* either the version (law of pre-existing styles) or the theme (law of a preconceived music).

SIMULATION OF THE COMPOSER

It's finally due to a fundamental remark made by Milton Babbitt that I came to see a little light in this field that has remained obscure for such a

long time : « The rules of counterpoint tell us what not to do ; they do not tell us what to do. » Let me put forward Babbitt's remark as a sort of guide for most of what follows.

Let's also make use of the following analogy proposed by William Skyvington. He makes a distinction, for the sake of the explanation, between a sketcher and a sculptor (normally such a distinction would be highly questionable, but it serves our purpose here). On his blank page the sketcher is going to start out by drawing several lines, each of which might in fact be represented by a reasonably elementary mathematical equation (this of course is the last thing in the world that the sketcher himself might imagine). He then continues to « complicate » his drawing up until certain configurations begin to appear from amongst the lines. If the sketcher is an abstract artist, he is likely to emphasize these structures and configurations in order to achieve a balance between a certain order and a certain disorder. A rapid description of this process does not of course *explain* whether the finished drawing possesses a « meaning » or not (just as the same process, adopted in musical composition, would not have any bearing on such a question either). It's up to us to make such an evaluation... and everybody knows to what extent practically anything these days can *acquire,* if not possess, a meaning. If on the other hand the sketcher is a portrait-artist, or if he draws animals, or if he is a caricacturist, his collection of lines will take on another meaning, which might be described as a balance between a certain *permanence* and a certain *variation* ; the degree of permanence in the sketch is more or less a measure of the extent to which the artist's work *conforms* to the general characteristics of his model, whereas the degree of variation indicates the artist's *interpretation* of his subject. The two cases are very different, and one can distinguish various features which I've already suggested in the field of music — which resembles either figurative or non-figurative plastic art insofar as it is based upon *reference structures* or not. But this is not the place for developing such a distinction between two objectives... All that interests us for the present moment is the *process* that consists in assembling a collection of relatively simple elements or isolated obejcts, and forming a complex configuration that has meaning in it, at the same time preserving a certain random aspect.

The other case is that of the sculptor, in which we rediscover the same possible divergence of objectives, but an entirely different working process (we're not speaking of César, who's happiest of all when he's creating packaged automobiles, but rather of Rodin or Picasso, whichever you like). The sculptor starts out with an amorphous stone block (maximum information, as they say ; one might have some doubts !), and he cuts away, little by little, the « disorder », organizing his work in such a way that he finally achieves, like the sketcher, either the abstract configuration or the concrete figuration which he is seeking.

The sketcher then, starting with a sheet of paper and several very geometric lines, adds more and more *disorder* as his creation advances, whereas the sculptor, starting with a rock or a piece of wood that he might have picked up on the sea-shore, adds more and more *order*. The sketcher works away from a situation containing too little information, whereas the sculptor works away from a situation offering too much information.

With the help of this parable, let's set out hand-in-hand with Milton Babbitt, who's going to lead us confidently towards what he considers as the two basics types of simulation of composers. Here they are :

(a) Simulation of *structure* : Isn't this a sort of ridiculous mechanization of the irregularities carried out unintentionally by the human composer ? It's a matter of trying to simulate the composition process.

(b) Simulation of *function* : This is in some ways an analysis procedure carried out in the opposite sense ; the machine decides whether the propositions which it generates do in fact conform to certain pre-established principles.

This has the following meaning : If it's a matter of simulating the composer-sketcher, Babbitt uses the term « simulation of structure » ; the data sent to the computer consists of musical objects (scales, intervals, chords, cadences, rhythms, etc.), and the computer is programmed to produce from this data a structure similar to one that might have been imagined by a human being. It's therefore the composition process that one is attempting to mechanize, including everything that is approximate and « home-made » in the human composer's work.

If it's a matter of simulating the composer-sculptor then Babbitt uses the term « simulation of function » ; this involves use of Monte-Carlo type methods, well known in operations research. The data used by the composition process consists of random musical elements, and the program simply rejects every element that does not subscribe to a set of previously defined hypotheses concerning (and determining) the style of the work. These hypotheses are applied to the random elements in the way of constraints.

It's easy to see why it's simpler to « mechanize » the sculptor's work process than the sketcher's. Suppose that the computer is about to decide what sound it is going to introduce next in the composition : if it's working in the same way as the sketcher, it would probably ask : « Why would a human composer put that sound in the composition at this point ? » ; whereas if it were working in the same way as a sculptor, it would ask : « Why *wouldn't* a human composer put that sound in the composition at this point ? » It's finally more comfortable to play the rôle of devil's advocate than to act as an authentic creator (the sketcher constructs, whereas the sculptor demolishes).

FORMAL MUSICS

Let's now look at two « limiting cases » : the processes (or more exactly the principles of these processes) used by investigators who are determined on employing the computer, outside the range of the complementary directions of « theme » and « version », either as a musicologist — in order to decipher « laws » — or as a composer — in order to provide the computer with *a priori* laws concerning such and such a music. In the first case we're thinking of Forte ; in the second, Xenakis.

A new and interesting idea in Forte's research is that of going beyond Markoff chains, even of a high degree, in order to decipher his laws. He makes use of the idea of a « configuration »... which might even be called a « phrase », if in fact he carried out his investigations upon music that included phrases... Unfortunately, however, atonal music is so far removed from traditional codes that phrases are as little recognizable as words. One is reduced to sequences or segments — the music contained between two rests for example — in order to arrive at countable results. The tendency is nevertheless interesting, although it would appear that this research is being applied to a musical domain that is more than likely to lead the investigator either into the desert or into a blind alley.

As far as Xenakis is concerned, let me emphasize at once that I'd be much more interested in his research if he hadn't set out so obviously to reduce its accessibility and its credibility in a manner which is immediately apparent as soon as you open his book on formal musics.

After several pages of introduction, in which the destiny of music would appear to be settled once and forever (postulate on mathematical music — indeed more profound than Barbaud's — one as spectacular as the other is naive), the reader is suddenly engulfed in algebraic symbols, and he starts searching vainly for the shadow of a doubt... or even a discussion concerning the results. As far as Xenakis is concerned, it's a matter of practically absolute certitudes, of articles in a dogma that he doesn't even take the trouble of presenting, or justifying, or discussing. It's no more possible to reason with him in writing than it is to do so face-to-face (I've often tried to do so, without the slightest success).

Starting out with his text I nevertheless intend to point out in what respects « nothing remains to be discussed ». Whether the final musics be stochastic, strategic or symbolic, the dominating idea is that of a pre-existing and absolute mathematical model, which suddenly becomes the basis of any music whatsoever which fits into its rules. We come across an explanation very similar to Barbaud's : « *Music can be defined as an organization of these elementary operations and relations between sonic entities or functions. The rôle of set theory is understandable, not only for the construction of new works, but also for the analysis and appreciation of past works.* » But Xenakis

goes much further : « *Therefore, even a stochastic construction or a historical investigation carried out with the help of stochastic models cannot be fulfilled without making use of the Queen of Science — and even of Arts : logic, or in its mathematical form, algebra. For everything that is said here concerning music also applies to all the other forms of art (painting, sculpture, architecture, cinema, etc.).* »

Not content with the bringing together of music and mathematics, Xenakis suddenly proposes to subscribe everything to his Queen : from sculpture to cinema... and why not include history while we're about it ?

As for me, I have no intention of getting involved in such a debate (I'm flabbergasted !). It brings back the time when I had the opportunity of initiating Abraham Moles to concrete music : I was equally flabbergasted when this bilingual doctor (philosophy and science) assured me, from his very mouth, that if only we could carefully apply to the world at time t a set of laws making use of the situation and of the movement of all the atoms in the world, then we should be able to deduce the state of the world at time $t + dt$. At that time I wasn't yet aware of Abraham Moles' manner of « sending up » the people he spoke with... but I'm far too convinced of Xenakis' serious nature to believe that he's playing a similar game.

What's making Xenakis « run » ? It's almost obvious in the preceding extract : a blind faith in determinism... reviewed and corrected by indeterminism, of course... with the proviso that both these principles obey the laws of large numbers, as in the kinetic theory of gas. The Greeks are all about the same, and Democritus is not very far away.

« *There is a historical parallelism between European music and the successive attemps to explain the world by reason. The causal and determinist music of antiquity was already strongly influenced by the schools of Pythagoras and Plato. Plato insisted upon the principle of causality, « for it is impossible that anything whatsoever should arise without its cause ». In the 19th century, strict causality incurred a brutal and prolific transformation due to the statistical theories of physics... There is therefore nothing astonishing in the fact that the presence or absence of the causal principle, first of all in philosophy, then in science, should influence musical composition and direct it along apparently diverging lines, which are in fact reabsorbed by the theory of probability, and eventually by multi-valued logics, which are a sort of generalization and enrichment of the causality principle.* »

An attitude as categorical as this leads of course to « a disregard for all inherited conventions and to a fundamental criticism of acts of thought and of their materialization ».

Faced with such self-confidence, one doesn't know whether to speak out or not. I'm therefore going to murmur, in a stage-whisper, my several doubts, in order to have a reasonable chance of being heard, not of course by Xenakis, but rather by those people who are fascinated by the musical talent which he

possesses, « by the way » as one might say (for that's the major stumbling block). I'd like to set out from what I should call a scientific standpoint. I even intend to admit for several moments that music is essentially scientific. Here are my objections :

(a) If I consider myself to be an honest experimenter, then it is in no way clear to me at what level, in which domain, and by means of which pathway, musical man communicates in this way with « causal » formulae, whether or not they be fully determined. Anyone has the right to formulate the various hypotheses of Xenakis (stochastical, strategical, etc.), but these hypotheses still require experimental evidence in order to demonstrate their intelligibility or perceptibility. Any careful experimenter would start out by such preliminaries, and would obviously be motivated by previous experience. Furthermore he would establish simple structures, as soon as possible, in order to test these « pathways ». There is no trace whatsoever of such activities in the case of Xenakis ; in a very deliberate and passionate way, he has chosen the rôle of theoretician and algorithmic poet, rather than that of an experimenter.

(b) Without delving very deeply into advanced mathematics, one can observe a musical preference for numbers even at the level of elementary arithmetic... inevitably for the simplest numbers. The famous dominant fifth, which has despotically governed not only Occidental music, but also a certain number of exotic musics, represents a flagrant historical denial of advanced theories. The atonal adventure, which Xenakis appeals to, at the same time as he goes well beyond it, is an excellent example of the sort of « cultural deviation », or fad, that provokes these enormous leaps into the unknown. If in fact determinism can be applied to music, then the scope of its application has always been quite evident in traditional music. And the ups-and-downs of musicological computer research should persuade Xenakis to be careful. The difficulties which we spoke of in connection with investigators who are as *little* influenced by poetical inspiration as Xenakis is *over* influenced by it, point out eloquently that the whole affair is far from clear. If the mathematical hypotheses were in fact so obvious, then surely one should have already discovered various more or less certain links between music and mathematics. The down-to-earth acknowledgement of what is in fact the case is rather humiliating for our modern age : the link recognized by the Ancient Greeks, of a blinding certainty for Pythagoras, involves simple relationships and the derivations which can be obtained from these relationships. The wild extrapolation carried out by Xenakis is unconvincing ; it appears to be based upon pure fancy, far removed from common sense... a sort of delirious attempt to outbid everybody else in the field.

(c) Whenever experiments are set up, it is usually wise to pay constant attention to the manner in which human beings perceive and interpret the results of the experiments. On page 65 of *Musiques formelles,* psycho-acoustics

is briefly mentioned : « recent studies in audition have produced satisfactory responses concerning certain problems in perception ». Later on there are several definitions inherited from concrete music, such as that of « webs », but these things do not really concern psycho-acoustics. Xenakis has not taken the trouble to verify the relationships which might exist between *mathematical production of sonic objects and their authentic musical perception.* In other words, we are still located exclusively in the field of pure theory and of dreams.

If we could also choose to abandon the equally trite hypothesis of a music which is arbitrarily interwoven with, and indistinguishable from its mathematical genesis, we might well suggest that the field of contemporary knowledge contains other things besides the theory of probability... and that modern linguistics would seem, at first sight, to be much more closely connected with musical language than is the kinetic theory of gas. We could go on to suggest that music contains an undeniable cultural component, whose rôle — less absolute than in language — is obvious to every well-intentioned observer.

Concerning music itself, we might point out the adhesion of all musical cultures, not only towards their instruments — after all ephemeral — but towards their formulae (combinatorial or not), towards their effects (susceptible), and towards their works (so strangely diversified). To deny all of this is equivalent to deliberately choosing to ignore what has happened, which is a sure means of achieving once and for all the status of the soliloquy. Put more concisely, I don't find that denial very « scientific »...

Finally, to return to what we ourselves have found most interesting — that's to say, the very heart of the problem — it remains obvious that without a phenomenology, and without the distinction that Xenakis has never been able to establish between sign and signal, there is no means whatsoever of warding off dreamers who wish to invent combinations of parameters without concern for « characteristic features ».

METHODOLOGY OF MUSICAL RESEARCH

Now that we come to the second use of the computer — as an *instrument* — I should like to propose, as a contrast with respect to the preceding intentions, the point of view of an investigator who has devoted his life towards an authentic research in this field... meanwhile avoiding any temptation to get carried away into unrealism. Let's listen to Knut Wiggen's « preliminary declarations » (Bulletin of the Fylkingen Association, 1969) :

« *Behind all artistic creativity which may rightly bear that name, the common problems of life constantly appear. The source of art is life.*

But the artist needs some sort of material with which to give artistic form to the particular life-problems in which he is interested, regardless of whether

these problems exist for him as an expressed thought, an experience or a feeling. In music, that material is composed of a stock of tonal elements such as pitches, intervals, timbres and envelopes, a set of rules governing the technique of composing, which is applied to building up structures from the elements of the stock of tones; and finally, an instrumentarium for the production and distribution of sound. »

In other words we find ourselves face-to-face with the « complete materials list » for making music, presented moreover with pleasing modesty : component objects, composed structures, and between them, an instrument for producing and assembling these objects. It is no longer question here of « set-theoretic entities », which is at one and the same time an advantage and a disadvantage : an advantage in that music is postulated as « abstract », and a disvantage because nothing is said concerning the nature of these objects and structures... which are to be considered no doubt as self-evident.

Instead of referring to music's intrinsic « essence », Wiggen speaks of objects : that's to say, perceived objects. The structures formed by these objects correspond to the composer's personal « inquiry-concerning-the-world », and are therefore vital in a strict sense. The computer is supposed to contribute the « instrumentarium ». Have I myself sufficiently emphasized what is involved in such an interpretation of an instrument ? It's not only a means of providing the objects, and establishing their identity (which is in fact an authentic causal relationship), but also a means of introducing these objects in sequences, and in trials (here we come upon a most convincing theory of games... *musical* games).

Knut Wiggen continues : « *The three parts of this material — the stock of tones, the rules of composition and the distribution apparatus — are mutually dependant upon one another. No major change can be undertaken in any one of the parts, unless a correspondingly large alteration is made in the others.* » This also is an entirely reasonable point of view, which is sufficiently simple to already justify numerous research combinations. Moreover it clears up something that often remains confused as far as the investigators themselves are concerned. Are they carrying out their research on the material, the rules or the instrument ? Are they retaining classical rules with the use of new material, or are they applying new rules to classical material ? Isn't this tiny mirror an already sufficient means of condemning the greater part of contemporary compositions ? Isn't it even the reason behind the double failure of atonal music and of its immediate successor, synthetic electronic music ? Whenever permutations are applied to a dozen chromatic sounds, isn't the composer sort of falling into a hole ? Such rules, postulated on the basis of traditional material, are possibly quite improper... Inversely, the synthetic sounds derived from the new material ressources may not suit traditional music... Further on Wiggen points out that « *in its more ambitious form — as when it claimed to be the successor to tonal technique — serial technique*

was a failure, because it presupposed a correspondance between physical systems and psychological systems which didn't exist ». Up until this point one might have thought that Knut Wiggen was protecting his project by means of two or three reassuring declarations, whose underlying motivations remained hidden ; one might have considered him to be highly endowed with musical « common sense », but not necessarily aware of the enormous ravine which cuts across the field of music ; maybe he too has set out across the snow bridge provided by enticing new techniques, without paying attention to overhanging rocks... In fact we can be completely reassured by Wiggen's remarks : he in no way ignores the « ravine », and was actually one of the first and only people who has continually echoed my own warnings during the last ten years.

To be completely truthful, probably everybody will end up coming together... for Milton Babbitt himself recently came towards the edge of the ravine ; he gives me the impression nevertheless that he's inclined to continue feeling about, pragmatically, with a blind-man's cane, as if it was merely a matter of some sort of minor technological problem « that we'll end up solving one way or another », probably due to a certain delay rather than to the very nature of human knowledge.

Here is how Babbitt proposes three representations of musical events :

« — *the graphemic (what Michael Kassler calls the « written musical experience »),*

— *the acoustic (Kassler's « produced musical experience »),*

— *the auditory (Kassler's « received musical experience »).*

The absence of a one-to-one relation between any two of these domains and the lack of sufficient knowledge to translate generally and totally from one to another, particularly from the graphemic to the auditory, make it essential that output information be interpreted only in the domain of the input information. The danger of such confusion appears to be particularly great when the investigation involves the extrapolation from a familiar traditional property... (6) »

I did well to underline the « groping » nature of this nevertheless interesting declaration coming from one of those American investigators who up until this point had always been convinced of the connection between the physical and psychological domains by way of Fletcher-type sensation curves. Let's look at Milton Babbitt's conception of psychoacoustical research with the help of a computer... not as a composer, nor as an instrumentalist, but rather as an « assistant research worker » :

« *The actual sonic materials for psychoacoustical research, as well as the lists of such stimuli, could and probably should be prepared by computer. The investigation of the dimensions of so-called « timbre », not in order to*

(6) Perspectives of New Music 3, N° 2 (1965) : « The Use of Computers in Musicological Research ».

« duplicate » timbres, but to test the results of duplicating their dimensionality, this involving analysis by synthesis, is most easily undertaken by the interrelation of the computer as instrument of sound analysis and production... For instance, the dimensions of contextually perceived timbres should be derivable by the method of multidimensional scaling; this method requires only that the subjects be able to arrange three stimuli according to the relation of « more similar than », that is, A is more similar to B than to C, for example... easily and quickly acquirable computer knowledge places one in the position to employ and apply advanced techniques and results derived from a broad inter-disciplinary range without obliging one to undertake the manifestly hopeless task of acquiring more than a passive knowledge of the material of this range. »

We ourselves have sufficiently groped around for long enough to realize the ambiguity and awkwardness of this text proposed by Milton Babbitt. It certainly reflects a certain tendency towards experimental methods : a group of listeners to whom elements are proposed, samples of timbres, for example. But the computer is in on the deal with two functions : first of all for providing the samples, then for analyzing the answers. This represents a double error, to my way of thinking, and I consider the example very valuable for a close mental analysis of the essential faults committed by its author. If in fact my criticism would appear to be unduly severe, then I should hasten to add that this severity must be attributed to the scientific, epistemological and methodological bases of my criticism.

Let's start at the end, which has nothing whatsoever to do with psycho-acoustics, as Babbitt appears to believe, but rather with cultural psycho-sociology. If I interrogate a group of listeners, then I'm going to ask them questions. If I propose a particular question, my question implies, by its very formulation, a *musical intention.* Babbitt suggests (in fashionable binary computer style) questions on resemblances : A resembles B. This sounds as if he's playing the fish. In music nothing resembles anything else, and everything resembles everything. The actual *music* is contained in the subtle variations, concealed right in the middle of all the resemblances : variations of a subtle nature cannot even be established unless the objects are sufficiently resemblant. The implied quantitative reference, concerning equality, or « more than » or « less than », is useless. The right question is : « In what way do they resemble or differ from from each other ? » This « in what way ? » is the very sol-fa of music, based upon the intention to hear this thing rather than that one, and this of course is a matter of the cultural « upbringing » of the subjects. Instead of conversing with the computer, or having themselves stupidly interrogated by the computer, I'm absolutely certain that they'd be much better off talking amongst themselves !

The second fault is less subtle. It comes about through Babbitt's begging the question concerning a tautology in connection with the word *timbre,*

since nobody has taken the trouble — as I've often implored — to define timbre... either in the world of *signs,* or in the world of *signals.* And so, some time back, acousticians told musicians that timbre is a matter of spectra, and musicians — who knew nothing whatsoever about spectra — accepted this as a statement of fact. Nowadays there are no longer many musicians who do not know what a spectrum is, but the belief of which we are speaking has been so widely disseminated by the saintly writings contained in music manuals that nobody would dare to believe that a timbre is not due to a particular spectrum. What's more, there are spectrographs, spectrometers and other sorts of oscilloscopes to prove it. But there we are, since everything is scientific, indeed mathematical, and since everybody continues nevertheless to « discuss such matters », nobody bothers to look into the meaning of words... and of the word *timbre* for example. What do *you* call timbre, one might ask the acoustician ? He'll reply : It's what distinguishes two sounds having the same fundamental frequency, therefore it's a question of spectra. What's timbre, one could question the musician ? It's what distinguishes a good violin from a bad one, a virtuoso from a beginner, or even in the middle of a single concerto, more and less well « timbred » sounds emanating from a single artist. Why do people dare to leave off at the conclusion that « all that » is a matter of spectra ? Is there any common yardstick for these two usages of the same word ?

This definition of the word *timbre,* as well as its various usages, have been largely explored in the work carried out by the Musical Research Group (GRM) (7). It's not the place to study such detailed work here. I might nevertheless mention that this research implied a dissociation between physical magnitudes and musical characteristics. The physicist can be distinguished from the psychologist in that the former sets out to « purify » phenomena in order to be able to extract *parameters,* whereas the latter is only content when he finds himself surrounded by complex objects, containing subtle blends of information, which allow both the eyes and the ears to detect multiple *characteristics.* Perception finally shuns excessively simple events, and has a distaste for what is essential and for that which can be converted into figures. Perception is more concerned with all that is accessory... that's to say, with *anecdotes.* Truly, one is obliged to accept the inevitable, which amounts to paraphrazing Pascal : « The ear has its reasons that physics does not understand... »

Here again, we seem to be a long way away from computers. On the contrary, we're right in the middle of the problem, and my criticism of the American attitude, even when such attitudes are improved, leads directly towards the use of the computer — of the same computer — in a different

(7) See the *Traité des objets musicaux,* chapters XII and XIII (Editions du Seuil, 27, rue Jacob, Paris-6e).

direction. As long as the computer retains a musty smell of behaviorism, and of faith in the absurdly simple stimulus-response chain, we come up against a ridiculous closed dialogue : the *man/machine* dialogue. As soon as we leave all this behind us, the situation opens out on to that indispensable exchange between « theme » and « version » which I have already mentioned. In place of the irresponsible man/computer combination, we reach the man/computer/man conversational loop. This double circuit is unambiguous, and brings to mind the basic rules concerning the use of a machine whose capacity for question-answering is an exclusive function of the information with which it has been previously provided.

We should set out to describe such a mechanism. We should see that it in no way replaces the investigator's responsibilities, whether he be a student of sol-fa, a composer or a musicologist. On the contrary, this mechanism is likely to embarrass all three of its users, in that whilst it can theoretically perform any task whatsoever, it possesses absolutely no axiomatic notions whatsoever, and everything depends upon the suggestions put forward by the users. The mechanism can combine anything and everything, but it contains no automatic « key to success ». It offers the two instrumental infinities : the macro and the microscopic. It is capable of decomposing phenomena that can be broken down infinitely, just as it is capable inversely of recomposing phenomena from their countless fragments. Mute, it is nevertheless capable of saying anything imaginable ; inert, it is nevertheless capable of acting. You only need to give it « instructions ». It's up to us to start the ball rolling.

THE COMPUTER AS AN « INSTRUMENTALIST »

I have neither the intention nor the necessary competences for entering in detail upon a discussion concerning the computer as instrumentalist. Just as I've done so up to now, I shall attempt to bring out the salient features of these systems, either insofar as they put forward a means of « acquiring » experience, or insofar as they constitute an « outlet » for experience.

I think I should however point out, at least for beginners, that the « mystery » of computers can be considerably enlightened by tackling a description of those two famous adjectives : *analog* and *digital*. Anybody at all makes daily use of analog recordings : disk tracks, magnetic tapes, etc. In a centimeter of such a track, or on such a tape, you might imagine an infinitely subtle breakdown corresponding, let's say, to 20 or 30,000 instants per second ; then you might go on to measure, for each of these instants, either the depth of the track, or the magnetic intensity of the tape signal. In this way, nothing prevents us from making use of this enormous collection of measurements in order to replace the material traces of the disk track or of the tape. This is the idea behind « digital representations » ; an entire concert, or an entire

symphony can be memorized by a gigantic number of figures, which are no more complicated than those which indicate the altitudes (yard by yard, for example) of a road in the mountains ; supplied with these figures, one could theoretically rebuild the road. Supplied with similar figures, a computer is capable of taking up a « theme » and of giving back its « version ». It's a simple matter of agitating the membrane of a loudspeaker, or of rerecording a magnetic tape on which all these pressure levels or all these magnetic intensities represent the figures which served as a « memory ». We suddenly realize that a new « leap » has been accomplished, following on the previous one which music incurred with the coming of electroacoustical equipment. Ever since sound recording has existed, people have been able to « act » upon sounds, not at the event level — linked to the instrumental craft — but in working on the « analog » traces that they leave. One was of course obliged to work as a handcraftsman, with scissors, adhesive tape, mixings and editings. Now we come upon a completely new possibility. Music, already astonishing to look at (but not to listen to) when it's stretched out on a gramophone disk or on a tape (but nevertheless still reassuring — in that these supports are material, and remind us of vibrating bodies), can now be converted into something more like a telephone directory. Sounds are then represented as a collection of millions of numbers, like minute beads on an enormously long string.

This mass of figures is assuredly the major trap awaiting the enthusiast in musical data processing. For readers who might not be familiar with these matters, let me repeat that this collection of numbers (20 to 30,000 per second) is a quite reasonable ration for the computer, which considers such a « rhythm » perfectly within its scope ; in other words the computer is capable of computing sufficiently rapidly to « output », every 20 thousandth of a second, the number corresponding to the music program with which it is supplied. Moreover if we add to this situation the fact that digital-to-analog conversion (in order to pass from the numerical basis to an acoustical basis) is quite easily carried out by machines — because of the simplicity (!) of musical « signals » — then we come to understand the short-circuit that continually fascinates investigators, like Xenakis, who are overcome by such opportunities, and by such an obvious indication of the objective nature of the Cosmos.

There are however other things to be said, before looking more closely into the computer as instrumentalist... things which are intended even for the specialists themselves, who often forget that an amateur in the field needs to know and understand certain facts at a very commonplace level. Here's what I should like to say to both these people, located at the two extremes of the scale of competences : When all's said and done, isn't a human being simply a system of numbers ? Isn't it conceivable to define an individual by the situation, if not of each atom, at least of each cell in his body ? And don't we already know that each of these cells carries with it its genetic code ? And

that this code is moreover identical, recorded in each and every one of our cells... not only in the genetic cells, whose function it is to « program » our entire being, but also in all the other cells, even the most humble of all... as if every cell carried our personal signature ? Therefore, more and more *numbers* ! Of course I could make use of this example in order to point out the enormous quantity of data that would have to be processed, as well as the meager knowledge which we have concerning the structural relationships of all these cells. But I don't intend to insist upon such matters. It's of little importance that the computers capable of processing that giant collection of data are not yet born, nor likely to be born in the near future... no more so than a biology sufficiently advanced. The most valuable lesson to be extracted from this analogy consists in noticing how natural it would appear, at least in anatomy, to decompose a human being first of all into macroscopic structures (organs, for example), then into cellular structures (for the various human tissues), before attaining the molecular level (macro-cells), and eventually the purely atomic basis. Who would be ridiculous enough to ask the computer, faced with the task of « counting » a human being, to directly accept one by one the atoms themselves, or even the cells, without passing through the intermediate structural levels ? In fact Xenakis, intending to discover music itself at the level of mathematical entities, commits a similar error. The false rigor of his approach leads to nonsense.

To be completely truthful, this obstinate confusion stems, as I continually try to point out, from the proximity between music and numbers... as well as from the ignorance of musicians — due to the lack of musicologists who merit their title — concerning the « levels » of music. We'll take up this discussion later on ; but in order to fully appreciate a study of the computer's rôle as instrumentalist, especially for those people who are poorly acquainted with data processing, one must keep in mind the following notion : the major difficulties encountered in this domain are brought about by a far too vague conception of what a musical « language » might possibly be. In other words, the computer is naturally gifted for making music, but we still need to know how to use it, and just what sort of music we're going to ask it to play. The electroacoustical studio could very well frighten off the composer used to working with pencils and erasers and lined paper. In the computer's cavern, the stature of the instrument goes far beyond that of its virtuoso.

We know that our ear is able to perceive 10 or 20,000 vibrations per second (often called Herz). This bandwidth guarantees what is usually referred to as « fidelity », particularly in connection with timbres. We notice straightway that if we're going to enumerate the instructions that must be given to the computer so that it can translate the « digital » into « analog », then it will have to operate in real time in such a way that the output voltage issued by the converter attached to an amplifier and loudspeaker system will need to change from a positive to a negative value and back 20,000 times a

second, therefore the computer will have to generate 40,000 positive or negative numbers per second. And this will still remain a pretty vulgar sort of sound-wave : it will in fact correspond to a sawtooth form, and not a lovely round sine wave. Let's suppose then that we stick a « smoothing » filter into the output system, in order to iron out any undesirable irregularities, and let's even suppose that we make do with 20 or 30,000 generated values per second, in sacrificing a little fidelity (that's to say, in keeping within a 10 to 15,000 Herz bandwidth limit). It remains true that the infinitesimal element of sound — the component microsignal — remains of the order of 1/40,000 of a second, that's to say 25 microseconds. Is this a problem ? In other words, is this « atomic signal » necessary and is it sufficient for « making the most general music imaginable »... as we used to say at the beginnings of our own research ? Necessary : yes, certainly, as we've just pointed out, for physical and acoustical reasons (high frequencies of audible treble sounds). Sufficient also, for physiological and psychological reasons ; we never fully and satisfactorily hear sounds that are too short : practically « too short » amounts to less than 20 milliseconds. Between the 25 microseconds necessary and sufficient for producing a microsignal (necessary for the acoustic process) and the 20 milliseconds necessary and sufficient for hearing a microsound (necessary for the perception process), there is a relationship of approximately 1 to 1,000 which appears fundamental. These are the two orders of magnitude which oppose the acoustical microscopic (microsignal) and the sensorial microscopic (microsound). In the same way, if one sets out to analyze a sound, this time musically, then it's tempting to make use of what A. Moles put forward as « sentation bricks » : that's to say, those microscopic pebbles that are calibrated at the level of our physio-psychological thresholds. And so, since traditional notes, for example, are of the order of « 60 crotchets », that's to say one second for the duration of a crotchet (which is about average for musical sounds, including the shortest and the longest that are normally encountered), we can conclude that the crotchet, because it lasts 1,000 milliseconds, would contain 50 of these bricks, whereas a semiquaver, in its more rapid movement, would only contain about 10. This proposal enables us to rediscover, from a purely numerical and psychoacoustical point of view, the levels which I referred to earlier on. And in order to take up the biological example once again, if we're going to think of groups of notes as constituting the « organs » of a composition (motifs, phrases, groups of chords), the note could be thought of as the cell, out of which is constructed the tissues ; the audible fragment would represent the significant element contained in a cell, whereas the atomic signal would be located in a world 1,000 times smaller. In this way the terms « element » (physical), « fragment » (sensorial), « note » (instrumental) and « motif » (musical) could be graded as necessary by someone who was willing to approach the problem intelligently, that's to say qualitatively and not only quantitatively.

Surely everybody would agree upon the necessity of such a project, in that it aims at solving to a certain extent the absurd problem of having to operate upon each of the numbers corresponding to every micro-element in the sound. One has a feeling that these numbers should be grouped or linked together, like the musical elements in a fragment. But this is the point at which uncertainty and conflicting points of view start to appear... which is due to the fact that our analysis, apparently obvious, is still inspired by vaguely mechanical, rather than authentic musicological aspirations.

SONIC OBJECTS

My only advice at this point in the discussion would be to refer the reader to my own reflections on sonic objects... which I was one of the first investigators to define as an « object for human perception » and not as a mathematical or electroacoustical object for synthesis. I'm unable to repeat in several pages the matters which are meticulously discussed at length in the *Traité des objets musicaux,* and which seek their support from throughout the fifty years of phenomenological studies which were motivated by the first discoveries of the *Gestalt.* Let me simply recall two fundamental and exceedingly simple laws ; I might add that I am continually astonished by the fact that these two laws appear to have no impression whatsoever upon minds that seem to prefer that which is complicated to that which is simple... or the inanimate to the living.

First law : A composed structure (such as we perceive it) cannot be deduced from separate perceptions of its component objects ; it constitutes a new experience, of a different quality to its component objects, which are no longer heard individually, but assume specific functions with respect to each other. In other words, sonic objects are incapable both of permutation and of addition. It's easy to understand to what extent such a law is in opposition with all that has been proclaimed and taught by an entire generation of musicians, fascinated by parameters, ever since Schönberg.

Another law can be attached to this first one : every object is defined as a function of the structure to which it belongs and not as a function of the elements out of which it is composed. This law, which is almost insulting to scientists, contradicts a large part of what scientists firmly believe, namely that complex entities can be derived from simple elements. In languages it's the other way round ; phrases make it possible to define words, words enable us to articulate syllables, syllables establish the existence of phonems, and phonems make it finally possible to analyze physical signals in the context of complex relationships... which are hardly *causal,* in the strict sense, because different physical causes can bring about equivalent linguistic phonems. There is a table of experimental correlations, and not causal connections, between

the physical parameters and the significant characteristics or salient features. This is not a personal opinion : it's rather the point of view of four or five generations of phoneticians, phonologists and linguists. When are computer people going to get up to date on such things ?

We're still on the lookout for a « composition brick ». How are we going to group the various elements ? What principle are we going to apply ?

As far as I'm concerned, I'm afraid that such a discussion has no way out. In setting out to approach directly the famous « brick » — even when it's coated over with Gestalt varnish — the investigator is offending against the most solid teachings of experimental psychology. Finally it's not all that astonishing to observe that the search for the « brick » has its most determined supporters in the fatherland of behaviorism, whereas Europe ever since Saussure and Jackobson, has remained more attached to language research. Fortunately Chomsky would seem to have motivated similar work for a young generation of linguistics scholars in America.

Establishing the brick is equivalent to supposing that the problem is already solved ; that's to say, one would need to know, in a very general manner, what possible types of structures can exist in music. As I stated towards the end of the *Traité,* I used to believe in this sort of research, but I finally relinquished such beliefs, after having analyzed the practical impossibility of achieving such results by means of a direct centralized approach. I've often emphasized the need to penetrate into music « by the two extremes » : one concerning musical *material,* and the other musical *compositions.* How is material articulated in order to arrive at compositions, and what are the successive intermediate levels that can be developed ? The problem has hardly been announced, let alone studied... because people continue to believe that music can be produced by processing the bricks, as if you intended to build up a cell starting out with atoms, or an animal body starting out with cells. It should be so obvious to anyone at all that you cannot reach the cellular level without first passing through the macromolecular level, and that the production of an animal body must necessarily imply the construction of organs. But how does one invent macro-molecules ? And tissues ? By synthesis ? By means of preconceived combinations ? Everybody knows that this is untrue... and that if synthesis is in fact plausible, then it can only be carried out after a very long period of *imitation* — more or less skillfully and successively brought to a tentative conclusion — of experimental biology, based upon those models proposed by *life* itself. It's exactly the same thing in music. No matter how mathematical it may appear, it is made and perceived at a *living* level. When people start to understand what living music is all about, then maybe they'll be in a position to start the computer working. This is Knut Wiggen's manner of saying practically the same thing (8) :

(8) Taken from « The Musical Background of Computer Music ». Fylkingen International Bulletin N° 2 (1969).

« There are plenty of composers today who want to have a new arranging apparatus — a new gadget — so that they can be first with a new sound. It doesn't matter whether or not this sound has originated in their own musical fantasy. The electronic sound material is becoming a gimmick. The creation of sound is becoming a result of how the apparatus functions and not of how we want it to sound. The work of composing is becoming an uncomfortable parody on the one-dimensional society — to use Marcuse's terms.

The first treachery against the possibilities of electronic music must have occurred during the last few years of the 1950's, *in the splice between the moments when the first post-war generation « established » itself, and the following generation overtook the continued development. The responsibility for that too early « establishment » must fall upon the musical bureaucracy, which about that time discovered the artistic possibilities of electronic music and its — for that reason — potential political power.*

During the period which followed, in my opinion, one lost musical control over the apparatus which was built. These were either built so that one could play upon them like on a piano, which gave them some purpose, or they were built like small music machines, which produced tone sequences, even if the composers didn't know what was going to happen when they turned the buttons. With such an apparatus, we cannot carry out research in composition. Searching for new sounds becomes, once more, the story of the needle in the haystack.

Those who led electronic music out of that crisis were, without doubt, Schaeffer and his group, as they had employed the interval of waiting in research which led to the system for describing sounds. With the help of the computer, we are suddenly faced with the possibility of being technically able to realize complicated electronic sounds — complicated in the Schaefferian sense, rich in nuances and sonorous dimensions. The technical solution — at least, such as I imagine it to be — is to first set up an analysis/synthesis circuit, so that with the help of the computer, we can analyze a given sound and on the basis of the result of the analysis, synthesize that sound again via a synthesizer. If the result of the synthesizing is in agreement with the sound which we took as starting point, then we have succeeded in the first stage. The second stage is to create, on the basis of the Schaefferian system of description, a computer program with the help of which we can produce many-dimensioned sound scales. These sound scales, we can synthesize, and thereby listen our way further, to the sounds we seek.

Schaeffer has characterized the building of this technically complicated sound synthesizing set-up as an instrument which establishes a synthesis between Musique Concrète and Elektronische Musik. These many-dimensioned scales not only make it possible to search for the electronic musical sounds which are « missing », but on the whole, to synthesize all types of sound and — what is the core and meaning of this whole complicated operation — keep

count of (and thereby have command over and access to) these sounds. The microphone is eliminated, as are the wires of the traditional electronic studio — buttons and technical paraphernalia, which incessantly frustrate the musical fantasy.

Behind all this is a very complicated and expensive electronic music studio which eventually is going to be able to tell us whether we, this time, have succeeded in wresting from the apparatus its command over us, so that we once more can let our fantasy direct our creating. »

THE ARTIST AND THE ENGINEER

We know from experience that for the greater part the problem — one of the most delicate and most important of our age — is evaded... sometimes for very obvious motives, at other times for very secret reasons. The obvious motives (that one often attempts to conceal) are based upon the enormous reciprocal ignorance of the different groups of people working in this field. Two sorts of people are centered around these new machines : on the one hand the musicians, who are confused because they don't understand data processing ; on the other hand, the DP engineers, who are somewhat ashamed to admit their lack of musical skills. The situation is similar to most of the rendez-vous which our modern computer society has proposed with the representatives of traditional society. How can this misunderstanding be translated into comprehensible terms, and how can former failures be explained ? It's about time that people started to have a little confidence in their fellow workers... but not at all like a blind-man who has confidence in a cripple. The ideal situation is quite different. The cripple — let's say the musician — instead of opening his eyes (or rather his ears) imagines that the apparatus is going to turn out music for him. As far as the blind and the deaf are concerned — these experts in the digital domain — they intend to offer their crippled friend such an amazing assortment of combinations that the former artist is likely to suffocate under the weight of so many ressources... for we're speaking of artists who've become accustomed, over the last couple of thousand years, to extracting something out of practically nothing, with the help of prehistoric instruments... whose secrets have nevertheless remained undecipherable. The essential problem, then, consists in proposing a new climate conducive to mutual exchange and assistance between these two sorts of human beings.

Either the musician, once outside his studio, limits himself to describing his musical *intentions,* as is the case in a « classical score », and then it's the technician who sets out to « interpret » this music ; or else the musician must become a technician himself, both for the manipulation of sound generators and for the writing of programs. The range of possibile rôles is therefore quite open and quite unambiguous.

As I've said, it is quite possible to isolate the composer from the « contamination » of the studio, and therefore to consider him for what he really is : that's to say, an initiator of sonic imagination... unable however, as it's always been the case, to immediately materialize his creations. Or else we choose the contrary proposal. In the former case we reinvent the interesting and fruitful notion of two types of creators : those whose job it is to generate « musical ideas », in complete independance, and those who are faced with the task of interpreting these ideas, with an obviously superior degree of liberty than that which has existed up until now. In opposition to Boulez, who has always dreamed of robots for executing his music (I'm speaking of the composer, not of the conductor), I imagine a sort of « disconnection » between conception and realization, as has sometimes been the case, with lots of success (but also without success), in the field of cinema. There are good actors who are bad producers, and there are good producers who are poor script-writers. Between these two situations — that's to say : separating the job into two parts, and doubling up the two roles in one person — there are a number of possible combinations, and I have no doubt whatsoever that future studios will be forced to carry a production team for sharing out the tasks quite differently to the way it's done in a conventional orchestra, particularly as far as the relationship between composer and sound engineer is concerned. It's quite possible that we'll come upon people who are skilful in creating sounds, but less capable when it becomes a matter of assembling these sounds. There'll probably be « combiners » who are not very good craftsmen for producing the basic material, and so on...

Another pair of opposing competences appears in connection with the well-known musical problem of improvisation. In such cases one and the same person is faced with the double task of seeking out sounds or musical formulae, and then organizing them without losing sight of a guiding schema, which may be logical or perceptive, or even instinctive. When Knut Wiggen speaks of installing the composer alongside the computer (with or without a technician, as the former choice remains open) in order to work in real time, that means that he has the right, just as in the early days of concrete music, to « feel around » for his sounds, to test each one out, and only to choose after numerous improvised trials, either logically or haphazardly. In this way the composer rediscovers the piano at his fingertips... with this difference only : that whereas certain composers are ashamed to work with a piano (those who are sufficiently capable prefer to do their writing in their head), in this case it becomes an absolute obligation. In that their piano is now in a position to provide unheard-of sounds, then they need some way of remembering them ! Moreover this same composer can combine such empiricism with a more systematical process, which consists in varying, by means of a program, certain features of a sound which are not yet clearly perceived, but which appear to be « just around the corner ». This enables us to rediscover the two-way approach that

the Musical Research Group has been using for such a long time... except that here the instrument is exceedingly more powerful and subtle than the filters and editing techniques of our electroacoustical studios.

IN SEARCH OF A MUSICAL GRAMMAR

The real problem is to postulate a grammar. Once such a grammar has been found, then the composer would only have to specify forms... that's to say, *write* ! Nothing prevents us from dreaming of the unattainable, as long as we hold on to our common sense... as is the case when we imagine the following extremely relevant dialogue : Composer to machine — « What's music ? » Machine to composer — An interminable series of *examples* of music ! The person who asks such a question *must* be a composer ; nobody else should do so in his place. The most astonishing thing would be for the computer to reply, one of these days : « It's this... », and then to stop dead in its tracks.

Looking for a grammar is more easily said than done. It's nevertheless obviously more interesting than to apply Zipf's law, or to believe that music flows naturally from Carnot's principles, or to consider that music can be written in the form of an icosahedron... lacking even the humor of the person who once suggested « in the form of a pear ». Imagining a grammar brings us back to the idea of research, and is likely to assist that research, instead of offering us recipes tied up with pink ribbons. But this notion involves two questions which go well beyond our present subject, at the same time providing a sort of crowning conclusion : Can the word « grammar » be applied to music ? And, in any case, is such a grammar capable of being discovered ? You can imagine that the first question, with its linguistic overtones, interests us very much. We are unanimous in preferring such a question to any search for mathematical models, in that its possible outcomes are likely to be infinitely more fruitful. On the other hand, our question is merely an analogy, and it encompasses all that is at stake in an inquiry into music : that is, what is music ?

Even if we admit that a grammar, or its equivalent, does in fact exist, the second question remains. We know how to discover the grammar of languages, because these languages are « given ». Even if music resembled a language, how might we consider it as « given » ? In other words, does one invent music starting out with a grammar, just as French litterature is written starting with the French language, or isn't it rather the case that music is first invented at the level of compositions, and that musical grammars, if possible, can only be developed little by little in a retrospective manner.

Maybe it's better to start out with the second question, in that it is both less contestable than the first one, and more useful... for if in fact the invention of musical language precedes any knowledge of its rules, at least we shall avoid having to ask the computer detrimental questions, and this provides us with

a pretext for returning to the previous problem : the one which has been manifest in all musics which have ever existed.

As far as can be imagined — for distant epochs and distant lands — and as far as can be ascertained for the historical period of the Occident, music has continually been constructed without rules, as the outcome of successive movements to and fro, from the concrete instrumental domain to the deciphering of scales, and from the possibilities of instruments to the imagination of musicians. The geographical and historical diversity of music proves that there are as many musics as there are instrumental domains, or cultural backgrounds, or classical styles, and that the same musics do not always bring about the same effects from one point to another : in one place it may be sacred, in another secular, here it may be respected, and there profane, here efficient and there useless, here essential and there a mere accompaniment. Music apparently coincides, in a strange manner, with anthropology ; its problems fall outside of music itself — considered solely as a construction of objects — and are really located on the boundaries of that equally strange relationship between these sets of objects (« sets » in a non-set-theoretic sense) and that larger « set » which they constitute by the inclusion of man and of men, in the astonishingly diversified context of civilizations.

And so we're neither better nor worse off than our ancestors as far as musical means are concerned, except that our instruments would seem to be even a little too powerful for what we're presently capable of doing with them ; they seem to present us with more problems than we'd have wished for... and what's more annoying is that they're not at all *new* problems (as many well-wishing folk might have preferred). It would be marvellous to imagine that somehow or other we'll get around to « using new thinking in order to create archaic sounds » — as long as we don't forget that « archaic » must be taken to mean « primitive »... which means sounds that are related to ourselves and to our over-developed age in the same frugal manner as were related Stone Age man and his granite instruments.

Instead of getting annoyed at the lack of linguistic models and decipherable grammars, maybe it would be more intelligent to rejoice. After all, what does an authentic research worker really need ? A model that can be copied, or a virgin field to be explored... that proposes its own problems ?

Having admitted that music represents a specific problem, for which linguistics is but an analogy, let's return to the first question. I've provided many possible explanations in this respect (9) without receiving the slightest echo. It's strange, to my way of thinkings, that so much attention has been given to secondary matters, and that so much effort has been spent on giving tasks to the machines, whilst so little time has been allotted to the really essential problems. If we can leave aside the possible short-cut leading to

(9) *Traité des objets musicaux*. Books IV and VII.

musical grammars, it might be worthwhile looking into another analogy : that which is represented by language « systems ».

First of all, it's important to remember that a language system rejects — not because it's useless or superfluous, but rather because it's far too difficult and unknown — what you might call « speech », as opposed to « language » ; that is, the material sonic realization of signs, in their particular individuality. The only musics which can therefore be related to language are those which can be reduced to an abstract formalism, or at least those which enable us to apply the same distinction as above, between spoken and formal language. Western music, at its highest pinnacle, would allow such a distinction to be applied ; there is, in fact, a language in Bach's expression, which is practically independant of his particular sonic realisations. But then there are all the other composers...

Finally, even if we remain in the field of language, we can recall the « levels » which start off with physical signals, then phonetic nomenclature and phonological correlations, up until the point at which semantics and syntax appear (quite independantly of their material support). Is it the same thing with music ? Yes and no. I've tried to point out the existence in music of these different levels. But can it be said that musical codes are as arbitrary as in language ? Obviously not. The proof is that the most diversified musics that can be found throughout various different civilizations all possess certain common bases (for example, fifths and octaves). That's to say, there are *non-cultural* features of music which remain permanent from one music to another, as a sort of bridge between Man and Nature. Maybe it's in the vicinity of this mysterious bridge that can best be investigated the magical simplicity of these fifths and octaves that would seem to be so scorned these days.

It's hardly surprising to return, *in fine,* to this *da capo* with which we set out. Indeed, music is mathematical, in a certain way... but in just what way ?

Lots of people would be disturbed to find that contemporary musicians divide themselves so willingly into two camps, each one passionately scientific : those who lean towards mathematical music, and those who want to apply linguistic models. It's an over-simplification. It's far too trivial to explain the situation in this way, and yet the traces of such an apparent disjunction already indicate significant differences in attitudes, knowledge, sensitivities and aspirations. For an age that can reasonably be called scientific, an observer should be enthusiastic when he learns that music is certainly objective in nature, but also subjective : that it enters into relationship with the natural laws (as does man himself to a large extent), but that it depends upon man by offering him a degree of liberty and of signification that can only emanate from his consciousness and language.

All those people who instinctively take position on one or other side of this fictitious barrier are encouraging the naive separation which would appear

to distinguish a scientist from a man of letters, a logician from an artist, or a progressist from a humanist. Worse still is that resolutely modern attitude which consists in refusing obstinately all reflections concerning humanity which cannot immediately be translated into « scientific », numerical language for the computers. On the contrary, we can probably afford to reread the philosophers who have proven their value, and to return to the most traditional sorts of wisdom. One of these fictitious camps is dynamic, realistic, and confident in the future, whereas the other is preoccupied, and incapable, because of its « idealism », of playing other than behind-the-scene rôles. For the fisrt, since God has left the scene, they're working out a new religion... with the help of science. For the others, the frail god which they've fallen back onto, although not yet dead, is certainly dying.

I'd simply like to confront these two sorts of ridiculous beliefs. An authentic science — and an authentic wisdom, which is the highest form of human art — indicate that it has become absolutely necessary to hold on firmly to both ends of the chain. And this chain has never been harder to hold on to than when there's a computer tied to the other end.

PIERRE SCHAEFFER

Translated from French by William Skyvington

PIERRE SCHAEFFER is Director of the Research Service of the ORTF (French radio-television). His pioneering work in the field of « musique concrète » is extensively described in his book TRAITE DES OBJETS MUSICAUX. Composer and novelist, Mr. Schaeffer is also actively engaged in mass-media research, and has recently published the first volume of a trilogy entitled MACHINES A COMMUNIQUER.