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Recently I read a music critic who praised the courage of a young composer who dared to make use of ordinary triads. Are we to infer from this that the application of the serial technique probably means cowardice and electronic music no less than fraud? The informative function of music appears to be in great confusion. The instrument itself is endowed with aesthetic and ethical value; but that which it formulates is neither linguistically conceived, nor as a result of this, linguistically comprehended.

Now I do not believe that we are living in a time of crisis. On the contrary: we are extremely privileged to take part in the productive processes of regeneration of dormant forces, and it is only too understandable that this tremendous task should lead to errors and missteps. None of us is completely sure of the ground—though the philosophy of art may, here and there, shed light on obscurity. All in all the outcome is determined by the unique nature of the organism. This organism develops itself by trial and error. Attentive listening and practical results will bring us further than the careful separation of science and art which is a *contradictio in adjecto*, since there exists no true science without human values and these again are formed by the awareness of underlying facts. Here then is the point of departure for my theme. As for practice, several points may be taken for discussion.

The technical possibilities of the slowly evolving electronic musical instrument lead the imagination of the composer into new ways. These are as different from the traditional paths as perhaps Debussy's musical style is from early polyphonal vocal music. Every composer of electronic music has from his own, as well as from the experience of others, gathered valuable material and this may be the reason for the somewhat over-hasty theorizing and, on the other hand, for the delays in sorting and organizing. I have a strong

feeling that now is the time to organize the sequel to Gioseffe Zarlino's *Istitutioni Armoniche*—an *Istitutioni della Musica Elettronica*. That is, we must systematically establish combinations of apparent importance, accept, separate, alter, and develop them. Then we shall set up symbols for the chosen formulae and in this way again prepare a sure basis on which future generations may build further without wasting time on polemics. Here follow a few chosen examples for observation as a stimulus for such systematic preparatory work:

In a choreographical composition I had to represent the nervous and hurried flight of a multitude. I renounced every melodic suggestion, and chose in their stead four different timbres (to which I will return again) and, by cutting and repiecing in accordance with more or less well known rules, constructed a fugue, similar to the well-organized representation of disorder on the stage. In this example the effect of the density of time is particularly to be noticed. This is a musical-linguistic phenomenon that comes to its full effect only with the help of tape-cutting. Tone-density is a familiar concept to us, both from the building up of a chord and also from the instrumentation of an orchestral *tutti*. For this latter we have created our traditional symbols after systematic examination. As regards time-density, hitherto only the factors involved in its reproduction have been measured; the phenomenon itself, however, radiates in several directions.

Beethoven has made use to a great extent of active, silent time as opposed to voiced time. We have set up for these mute times the false symbol known as the "pause." The function of these so-called pauses is to linearize time relations. This is based on the recurrence of pauses during linear time. In addition, we are now able to produce electronically the most rapid variations in time with a precision which has hitherto been unobtainable. These are added to the timbre characteristic of the basic tone and produce finally, by a combination of vertical and horizontal relationships, a frequency structure where individual organisms are absorbed into serving the whole.

It follows from this suggestion that a systematic number of experiments may lead to a formulation of ideas from which the composer may choose and elaborate suitable tone material. Such a sound, coming in this way from a number of sources, is indeed to be found in every score of a Ravel and indeed, based on this tradition, we should gain sufficient knowledge and confidence to be able to

find our way in a more or less intelligent manner in the new area of electronic music.

In one of my works I bring the human voice into contact with the electronic apparatus. It is known that we are able to change the voice until it is unrecognizable, in the hope that we may derive new qualities from it. The words of biblical text, recited in litany, are as follows:

*And the Lord went before them by day in a pillar of a cloud,  
to lead them the way; and by night in a pillar of fire,  
to give them light; to go by day and night:  
He took not away the pillar of the cloud by day, nor the  
pillar of fire by night, from before the people.*

To the words "cloud" and "fire" I have given a musical interpretation which, for the word "cloud," adds to the reciting voice an oriental micro-tone-structure with the help of mechanical time-extension; and for the word "fire," transposed and cut curves of the singing voice. I am quite aware of the fact that I have discovered nothing new in this. But on the other hand exercises in composition in this direction may develop an electronic choir passage which may introduce organic and electronic possibilities to counterpoint.

We may consider the extremely important question of electronic tone-production. Since tones are produced with oscillators in a simple manner and are easily controllable by metering, it is also easy to modify electronically recorded tones of mechanical instruments. With these, the composer may come upon some very interesting surprises, often to be proved only afterward upon analysis. I have, by placing a pick-up upon the sound boxes of various musical instruments and recording the resultant tone with a microphone, achieved certain sounds, the synchronous recording of which produces a minor triad as a result of the specific overtone dynamics. But the resultant tone is dependent on so many coincidences that I could not perform the experiment a second time without achieving totally different results. With sine-tones and combinations thereof one is on safe ground. This convenience, however, means a total rejection of undetermined elements. Schopenhauer said that justice is like that chemical substance which can never be made in the completely pure state, but only alloyed with some impurity. I believe that this is also valid here.

We must ask ourselves what we chiefly demand from an electronic

tone. We can make a religion of the purity of the sine-tone, we can use "white noise" as a counterpart, but we cannot shut our ears to the fact that, compared with conventional tone material, as the bearer of sound content, electronic tone material is inherently narrower and more rigid; indeed it has the characteristics of synthetic material. This acknowledgement brings us to a delicate situation. For naturally the sound of conventional instruments may be synthesized electronically with tremendously complex machinery. But it has been justly stated that this is not the function of electronic music. However, there is not nearly enough tone material at our disposal for electronic music for us to dispose of the conventional. Therefore there came quite early the ideologically distorted necessity of searching for the new, the never-heard, the originality *à tout prix* that always leads rapidly to complete sterility.

Not so very long ago this voracity for the new in the modern orchestral palette so misled the composer as to preclude him from devising an instrumental theme which could also be played on other instruments. Then again the instrument was considered an end in itself. I find in an essay by Donald Francis Tovey an extremely applicable statement: "This is as much as to argue that no gentleman should say anything that could possibly be said by a lady and no lady should say anything that could possibly be said by a gentleman."

We know very well that this thirst after originality includes all parameters. If we are to pursue our course in peace, our elementary concern in the production of electronic tones must be in the realm of the possibility of controlling the individual components with financially feasible and aesthetically satisfying projects. Should, in addition, similarities with the known tones of other instruments appear, I for one will not be distressed, so long as these tones are necessary for the creation of the composition and represent points of departure for further electronic development. Such imitation of sound appears in altogether new relationships in specific recording techniques which cannot be accomplished with conventional playing (here I refer particularly to Dr. Hugh LeCaine's "Creative Tape Recorder"). On the basis of such considerations, our engineer, Mr. Fred Goldwater, was commissioned to build a tone generator, working on the well-known principle of the optical siren, but providing, in its details, specific possibilities for electronic composition. Here is Mr. Goldwater's description of the instrument:

“Some of the requirements for the ideal artificial (electronic) musical tone generator may be easily summarized. The instrument should be capable of generating musical tones of continuously varying pitch, easily adjustable: the number and harmonic relationship of the overtones should be as flexible as possible and the level of each overtone variable; the output level of the complete tone should be subject to direct control; and the entire instrument should be suitable for the production of various tones with a minimum of simple, straightforward and repeatable readjustments.

“Before the construction of the instrument, some of the many possible methods of generating tones were considered with reference to the foregoing requirements. These included: the phonic wheel, the use of oscillators tuned individually to the required harmonic frequencies, a “saw-tooth” or other oscillator rich in harmonic content from which the individual harmonics could be abstracted by filters, and simultaneous generation of all desired overtones by some electro-mechanical method. The phonic wheel, involving the design of a ‘wave-form pattern’ for each tone, was rejected as lacking flexibility. Oscillators to be tuned individually to harmonic frequencies would require the utmost refinement in design and the use of stable precision components. The difficulty of tuning such oscillators would preclude simple, rapid changes both in frequency and in tone structure. The saw-tooth oscillator, to be used with filters, would require a complex of expensive electronic components and would also require considerable manipulation when changing either the frequency or structure of the tone.

“The simplest form of an electro-mechanical method for the simultaneous generation of all overtones—based on the interruption of the light falling upon phototubes—was therefore selected.

“Let me describe the operation of the instrument. Several rows of different numbers of holes are provided in a disc rotated by a variable speed meter. For each row of holes there is a lamp and phototube combination. The electrical impulse generated by interruption of the light falling on the phototube is amplified—a separate amplifier with individual gain control and an electronic phase shifter allowing nearly 360° of phase angle adjustment being provided for each phototube. These features allow adjustment of the magnitude and the phase angle for each component of the complete tone, independently and simply. Ordinary pointer knobs and dials indicate the settings so that any previously developed tone may be reproduced at will.

“The electrical signals from each channel are mixed together electronically and, in addition to a master gain control, several additional features are provided to allow the generation of tones whose output level varies in accordance with a preset pattern. This is accomplished by means of a keyed amplifier, the gain of which is controlled by two one-shot multivibrators in association with various resistance-capacitance networks. These elements make possible a tone which builds up from silence to a predetermined initial ‘attack’ level at a controllable rate; continues at this level a definite length of time; decays to a lower, continuous “tone” level at a present rate; continues at this level a further interval of time; and then decays in silence. Each of the characteristics of this tone-build-up time, ‘attack’ level, ‘attack’ time, decay time to ‘tone’ level, ‘tone’ duration, and final decay to silence is individually controllable, allowing complete manipulation of the various aspects of the tone and repetition whenever desired.”

There is no doubt these are but the raw beginnings, comparable to the “zinks” of the sixteenth century. We must nevertheless keep our vision unclouded so as not to fall into the net of pseudo-science, where all the aliveness of indeterminacy will be lost. It must be the musician who demands from the designer the instrument he requires. And when these instruments are built, the Gordian knots of all art philosophies of electronic music will naturally come untied.