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CREATIVE ASPECTS OF LIVE-PERFORMANCE ELECTRONIC MUSIC TECHNOLOGY

by
Gordon Mumma
Cunningham Dance Foundation
New York, New York

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I am a composer and performing musician by profession, with considerable experience in acoustics and electronics, particularly solid-state technology. My work in electronic music began in 1957, with the making of film soundtracks and electronic music for theatre, and within a year I had established an electronic music studio.

Since that time my work with electronic music has evolved from its primacy as a magnetic tape medium to an almost complete preoccupation with live-performance electronic means. I like being a performing musician, I like the sound control possible with electronic technology, and I like to compose electronic music which I can perform live for paying audiences.

My own electronic music equipment is designed as part of the process of composing my music. I am really like the composer who builds his own instruments, though most of my "instruments" are inseparable from the compositions themselves.

My "end-product" is more than a package of electronic hardware, it is a performance of music. Thus, on occasion my technical concerns may be differently oriented than those of the usual electronic engineer. Nonetheless, we are concerned with common ground: the applications of electronic technology to music.

Some differences still exist between the design and human-engineering of electronic music studio equipment and that of live-performance equipment. In the studio the composer doesn't really work in real-time. He works on magnetic tape, without an audience, and can use his studio-time for "reworking". In the live performance an audience is waiting to be entertained, astonished, amused, abused, or whatever, and there is no time for "reworking". Live performance equipment is different from studio equipment if for no other reason than the requirement of portability for the performance equipment.

My decisions about electronic procedures, circuitry, and configurations are strongly influenced by the requirements of my profession as a music maker. This is one reason why I consider that my designing and building of circuits is really "composing". I am simply employing electronic technology in the achievement of my art.

The four musical compositions which I will discuss have at least two aspects in common: conventional musical instruments are used as sound sources for electronic sound processing, and they are all live-performance works. The first three compositions are included to indicate the diversity of configuration possible with very few basic electronic functions. These functions are amplitude modulation, frequency modulation, and frequency filtering. The fourth composition is given in more detail because of its greater complexity, and because it is possible to hear illustrative examples from a recent recording of the work.

Though I may describe my use of certain electronic procedures because they result in certain sounds, these procedures were not always chosen on a cause and effect basis. Sometimes I am after a certain kind of sound modification and I work on various circuits until I have achieved that modification. Other times I may have been casually experimenting with different configurations of circuits and I chance upon some novel sound effect which becomes the germinating idea for a piece of music.

I am concerned with "system-concepts": configurations which include sound sources, electronic modification circuitry, control or logic circuitry, playback apparatus (power amplifiers, loudspeakers, and the auditorium), and even social conditions beyond the confines of technology. I suggest that the most important creative aspect of live-performance electronic music technology is not this or that circuit innovation, but rather the total configuration itself.

Technically, and in conception, the first of these works is the most elementary. Medium Size Mograph 1963 is an eight minute composition for piano with two performers. The piano sound is amplified by way of vibration pickups attached to the soundboard. The inherent dynamic range of the piano sound, from its initial transient through its resonant decay, is greater than that of practical loudspeakers. The function of the electronic circuitry which follows the vibration pickups is to compress the attack transient, spread that energy over into a later portion of the piano envelope, and expand the final part of the envelope. What the audience hears from the loudspeakers is a sound that obviously comes from the piano, but is at best a distant acoustical cousin. This is a special and simple case of amplitude modulation, though it is a bit more complicated than ordinary "automatic volume control".

The second piece is called Hornpipe (1967). This is a composition for solo French Horn. The instrument has been modified and contains a special microphone. A few feet behind the performer is a series of vertical pipes, containing their own microphones and resonant at different frequencies. Further behind is the loudspeaker from which the music is heard. All of the microphones are applied to the sound modifying circuitry, but at different points in the configuration.

The acoustical feedback loop which exists between the French Horn, the resonant pipes, and the loudspeaker, is part of an electronic feedback system which employs amplitude gated frequency translation.

As the performance begins the system is balanced. Sound is produced only when something in the acoustic-electronic feedback-loop system is unbalanced. The initial sounds produced by the French Hornist unbalance parts of the system, some of which rebalance themselves and unbalance other parts of the system. The performer's task is to balance and unbalance the right thing at the right time, in the proper sequence.

The third work I want to cite is titled Diastasis, as in Beer (1966). It is composed for two electric guitars. As the title implies, the two guitars in performance are interdependent but separating in a special way.

Briefly, the pitch (or frequency) of each guitar is determined by the amplitude envelope of the other guitar. The frequency spectrum is shifting continuously rather than discretely (as would ordinarily occur on a fretted instrument). Two special frequency modulators accomplish this task, and the process is complicated because the amplitude-envelope sensor circuitry is purposely frequency sensitive.

The effect poses a challenging musical problem for the guitarists. They must strive to execute their separate parts with accuracy, but their individual efforts seldom produce a direct result--a one to one correspondence. Their attempted pitches do not remain constant, though the conditions of the music require the achievement of specific pitch and rhythmic relationships.

In 1966 I was commissioned, under the auspices of the National Endowment for the Arts and Humanities, to compose music to accompany a new modern dance for the Merce Cunningham Dance Company. I had already been at work on a piece for David Tudor, a musician in the dance company, and decided to modify and finish this project to fulfill the commission for Merce Cunningham.

The title of the piece is MESA. I wanted a predominant character of the music to be of sustained sounds at one level interrupted by sounds of greatly contrasting loudness. I had already given up the idea of a composition on magnetic tape, because the kind of dynamic range I wanted simply isn't possible with tape.

My concept for MESA included the use of an inharmonic frequency spectrum with extremes of sound density. To achieve this, as well as to control aspects of the spatial perception of the audience, and still maintain clarity in the musical continuity, I deploy inharmonically related portions of the sound through different loudspeakers in the auditorium. Thus, the final "processing" of the sound is the mixing of inharmonically related, spatially deployed sounds in each listener's two ears. In contrast to Diastasis, as in Beer, the pitch changes of MESA are discrete rather than continuous.

David Tudor plays the Bandoneon, an accordion-like Argentine instrument, and with it can produce extremely long, sustained sounds over a wide frequency and dynamic range. The Bandoneon became my sound-source for MESA, and the technical problems included, besides extending the dynamic range, frequency-translation and equalization to obtain the desired timbres, and a configuration of logic circuitry to control the continuity of the music.

Extending the dynamic range was the most complicated problem, because a wide range of sound envelope controls had to be included in the same circuitry. These functions are completely automatic in MESA, and are achieved with four VOLTAGE CONTROLLED ATTENUATORS (VCA) developed in collaboration with Dr. William Ribbens in Ann Arbor, Michigan.

The general configuration of MESA is indicated in Figure 1. Six microphones are used, three attached to each side of the Bandoneon. These microphones are each sensitive to different frequency bands. Thus, right at the beginning of this scheme six different channels of sound are being processed. For various reasons, besides thickening the plot, one microphone from each side of the Bandoneon is applied to the circuitry of the other side.

There are four sound processing channels. The two inner channels are of primary importance to the music, the other two channels are outriggers. By means of logic circuitry the control signals (indicated by dashed lines) and program signals (solid lines) are routed from one channel to another during performance. The processed program outputs from the VCA modules are applied directly to power amplifiers and thence to loudspeakers at different points in the auditorium. The outrigger channels are usually heard from behind the audience. Though not indicated in this diagram, voltage amplification at various levels is included in the circuitry wherever necessary.

A closer view of the interrelated sound modification functions can be seen within one of the system blocks. The functions of one of the modifiers are outlined in Figure 2.

The SPECTRUM TRANSFER is a frequency shifter with equalization. The amount of frequency shift is determined either by variable internal control signals or by an external signal derived from the Bandoneon itself. The source and nature of the control signal is determined by the FM LOGIC.

The MULTIPLIER translates portions of the program spectrum by whole integers and equalizes the product.

The PRODUCT VALVE is a combination amplitude and phase modulator, the product of which contains the output of the SPECTRUM TRANSFER plus a new spectrum derived by amplitude gating the SPECTRUM TRANSFER output with part of the MULTIPLIER output.

The MODIFIER ROUTE-GATE LOGIC is an adder with three inputs, two outputs, and a control signal. This control signal comes from an external ROUTE-GATE LOGIC module and determines (1) the proportions of the three inputs (from the SPECTRUM TRANSFER, the MULTIPLIER, and the PRODUCT VALVE), and (2) the balance of the two outputs (to the FORMANT MODULATOR and the outrigger modifier channel).

The FORMANT MODULATOR is a class of voltage-controlled comb-filter. The bandwidths and center frequencies of the several passbands are continuously variable by control signals from the external ROUTE-GATE LOGIC. The passband outputs are added and sent to the VCA.

The VCA, besides accomplishing what its name implies, includes time delay circuitry which shapes the envelope of the program signal. The control voltage is derived both from the original Bandoneon signal and from the external ROUTE-GATE LOGIC.

The kinds of sound delays required for MESA are out of the question by direct electronic manipulation of the program signal. Delays at the controlled, variable speeds which I require are also beyond mechanical means. The solution to this problem is inherent in the concept of MESA itself, since at this point in the system it is the envelope of the otherwise sustained sounds which is to be shaped. This is achieved by subjecting the VCA control signals to frequency-sensitive thermal-delay circuitry. The wide dynamic range of the VCA is due to special bias procedures.

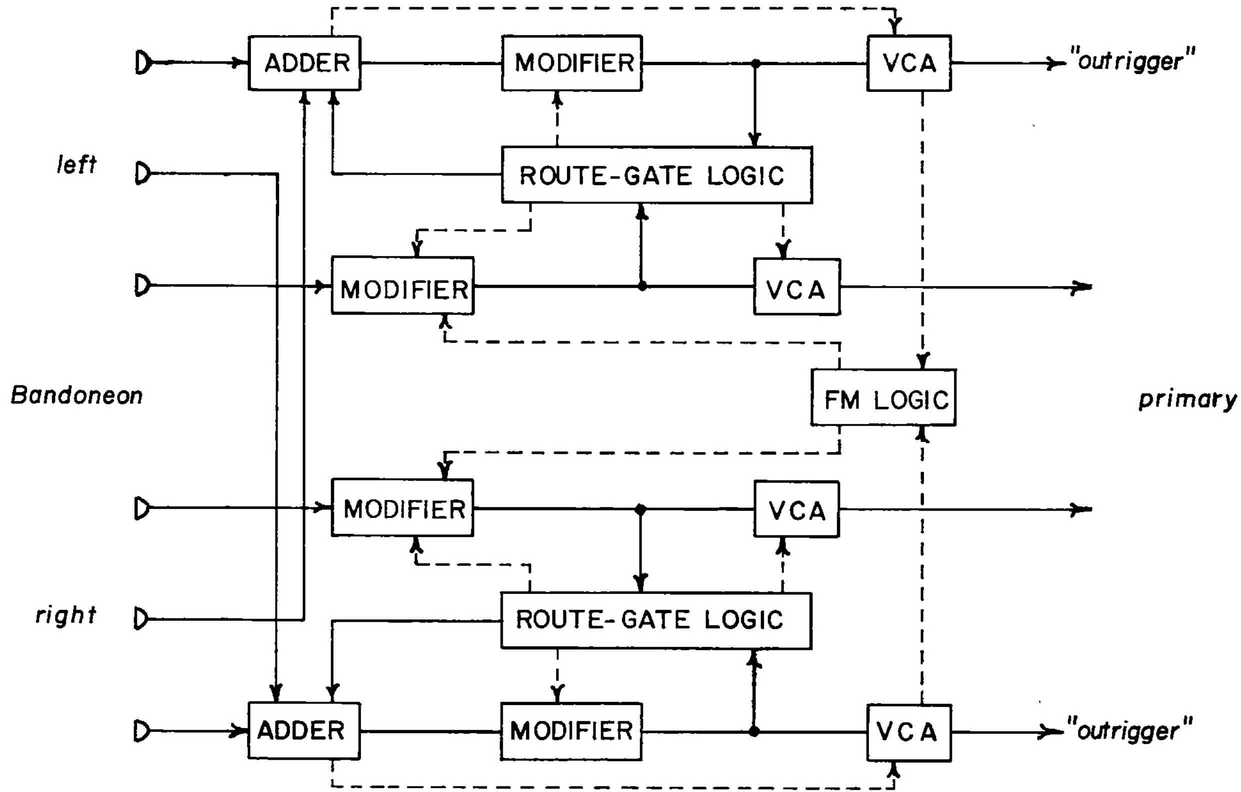
All of the control signals for these sound modification functions are derived from the Bandoneon itself. Some are frequency (or phase) modulated, some are amplitude modulated, and in the VCA module some of the bias is derived from integration of control and program signal sums. Because the control signals are automatically derived from the sound materials themselves, I call the process, and the music, "cybersonic".

The LOGIC modules have two basic functions. The FM LOGIC controls the operation of the SPECTRUM TRANSFERS, determining the amount of program-signal frequency-shift by control signals derived from the outrigger VCAs. The ROUTE-GATE LOGIC modules determine aspects of the sound modification and, in conjunction with the actions of the Bandoneon player, establish the musical continuity.

If these logic modules are operated in their fully automatic modes the most extreme performance situation for MESA is possible: a duo between the Bandoneonist and the electronic circuitry. Most often they are operated semi-automatically, with a second human performer making decisions and overriding parts of the internal logic. Usually this second performer is myself, the composer.

All of the compositions I have cited are my own. During the past decade a substantial repertoire of live-performance electronic music has been made by other composers, in the United States, in Europe, and in Japan. The diversity of this repertoire is already sufficient to support several performing ensembles.

Among other composers of significance in this medium are Robert Ashley, David Behrman, John Cage, Alvin Lucier, and the Japanese composer Toshi Ichiyanagi. Some of their works extend beyond music into the realm of "intermedia", and include theatre, film, and dance. These are works which also integrate their non-musical elements into configurations of electronic manipulation. It is difficult not to be excited about the future of these arts.


ADDER
MODIFIER
VCA
"outrigger"
left
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Bandoneon
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ROUTE-GATE LOGIC
ADDER
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VCA
"outrigger"

Figure 1.

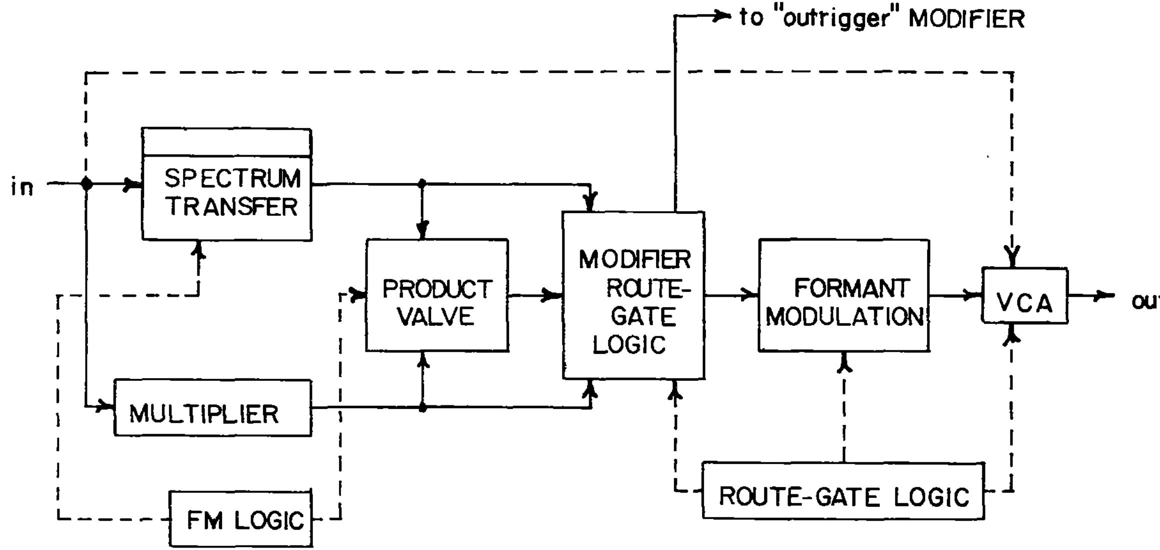
to "outrigger" MODIFIER
in
SPECTRUM TRANSFER
PRODUCT VALVE
MODIFIER ROUTE-GATE LOGIC
FORMANT MODULATION
VCA
out
MULTIPLIER
FM LOGIC
ROUTE-GATE LOGIC

Figure 2.