In Support of a Systems Theoretical Approach to Art Media

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Today we seem faced with a cataclysmic schism. A schism between those artists who still remain allied with and believe in the use of technology as a predominant force in their modes of expression and those who have become alienated from it due to its obvious and unfortunate associations with enormous amounts of money and the military industrial complex. More than ever before I encounter composers who have thrown up their hands, left their synthesizers at home and are heading for an agrarian commune, back to the earth. I believe multi-media has taught us that we need to gear ourselves to doing less rather than more these days.

It is easy to understand their disenchantment. "Back in 1927, to us now a relatively staticized age, the celebrated British novelist, E.M. Forster, struck a singularly prophetic note when he suggested that it is science's proclivity for allying itself with the needs and demands of power that gives it such a potency for effecting change. There is little doubt that many of the fantastic technical and social transformations in the Western world of the last two decades are directly or indirectly a by-product of the Cold War; and it is imagination-staggering to try to conceive of the likely transformations ensuing from the race for space, which now increasingly absorbs the best energies and national substances of both East and West. Such pessimists as Lewis Mumford warn that though each new invention may respond to a human need and may awaken a fresh human potentiality, that it immediately becomes part of an 'articulated totalitarian system…whose power must be increased, whose prosperity is essential to all existence, and whose operations, however irrational or compulsive cannot be challenged, still less modified.'"[1] If to any significant degree true, then technology in its impact must now be regarded as anti-human, an enemy of man.

Now our culture is involved in a quest to try to regain the wholeness of its natural being. Man has continually been faced with the struggle for a balance between the supposedly technology-art dichotomy, ever since leaving his wholly natural animal state. The great fourth century B.C. media expert, Plato, points out our early sunderance. Aristophanes, talking with his friends Socrates, Eryzimachus and others, told how originally "men were supposed to have four legs, four arms, two heads, etc. and how in time these men began to think they were something and dared to try to scale heaven and lay hands even upon the gods; and how, instead of annihilating them, Zeus finally hit upon the idea of humbling them by splitting them in two – since when, in their loneliness the two halves have longed and searched for one another continuously" – the scientist and the humanist.[2]

Albert Einstein once said, "The cosmic religious experience is the strongest and noblest mainspring of scientific research. The most beautiful and profound emotion we can experience is the sensation of the mystical. It is the power of all true science. He to whom this emotion is a stranger, who can no longer wonder and stand rapt in awe, is as good as dead. To know that what is impenetrable to us really exists, manifesting itself as the highest wisdom and the most radiant beauty which our dull faculties can comprehend only in their most primitive forms – this knowledge, this feeling, is at the center of true religiousness."

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[1] Rosenboom, D: A Systems Theoretical Approach to Art Media, full-length book in preparation.

[2] Internal reports, research records, Neurona Company, New York, 1969.

Similarly, Shelly asserted,

"Every grain
Is sentient both in unity and part,
And the minutest atom comprehends
A world of loves and hatreds."

I don't give up on technology, for in it I see potential for having the most direct embodiment of nature of all in a very universal and cosmic sense. A recent advertisement for NEU-RONA COMPANY reads, "For the last several million years we've been in training. Mother Nature, believing we're ready as we'll ever be, is slowly handing over the controls of the Earth to us. *It is now our responsibility to make it work!* We need technology to do it and for this reason it must be made accessible." Thus, I want to make all the juxtapositions I can between technology and nature, to confront the scientist and artist with each other.

Last year I embarked on a project of building a computer-synthesizer that could be packed in a briefcase and played on the beach. After presenting it in a lecture at the Conference on Computers and the Arts at Simon Fraser University I submitted an application to NASA to be allowed to become the first resident composer on the moon. I am preparing for the premier of my new work, *ECOLOGY OF THE SKIN*, commissioned by the INTERMEDIA INSTITUTE at Automation House and supported by the American Foundation on Automation and Employment in New York, in which I will attach electrodes not only to myself but to my audience as well, allowing electrical information extracted by computer from what have until now been termed autonomic nervous system functions, to control the environmental space. I said "until now" because recent research projects in which I have participated have shown that man can bring these, previously thought uncontrollable responses, seen in his electroencephalogram, electrocardiogram, blood pressure, electromyographic information and in a host of other visceral phenomena, even possibly including the rate of cell death in the body which controls aging, and may tell us how to facilitate hibernation states needed for long space voyages, under conscious control.

From the other side of things, latest developments in artificial intelligence have produced a computer affectionately named the wandering tortoise and classified "machina speculatrix." Machina speculatrix is an exploring machine that learns characteristics of its environment and how to extricate itself from precarious situations and how to find an electrical outlet on the wall when its batteries need recharging. Another is machina spora, which looks after its own comfort. It behaves as a fireside cat or dog that only stirs when disturbed and then methodically finds a comfortable place to sleep again.

Actually it is merely a rig of electronic circuits similar to the reflex arcs within the spinal cord of an animal. What these pieces of complicated electrical circuitry attempt to do is to simulate mental activity of the brain, that is, its thinking process, in a rudimentary manner by substituting wire in place of nerve fiber, hardware in place of flesh, and electromagnetic wave in place of the data transmission pulses in living nerve fiber.

I used to be called a multi-media composer but my musical reaction to all this has caused me to be returning from lavish "Rube Goldberg" productions to more purified music and performance systems with extremely integrated media and the inclusion of ritual. Everyone keeps asking me what is my instrument and I can never find an answer with which I can feel comfortable. So, I now say simply that it is my mind.

We must all regain some consciousness, taking the appropriate lessons from the Easterns, of the oneness or the integratedness of the universe and our part in it. There is a rising belief, for instance, that the idea of consciousness is not something specifically attributable to the particular arrangement of bulk mass and energy that is the human animal, but exists on a more basic, macro-micro, level and that the universe may have an all prevailing consciousness of itself, of which we are a part. According to all present definitions of life one would be perfectly correct in holding up a common stone as an example of living matter whose life processes and cycles are merely too slow for us to perceive. It is life's music recorded on a record that makes only one revolution every ten thousand years.

It is not significant that it has taken the rise of a drug culture to shock us into knowing this. On the one hand it has allowed us to focus our perceptions, not on a fantastically dense array of many things at once, but on a single concept for a long period of time in which we can examine very carefully each minute thing, understanding it and the whole much better; on the other, it delimits compendia. In any case, I believe that all these things must come together, and perhaps best of all the heart of the cosmos represents a union of both eucastrophe and evangelium.

In the light of all this I think that it is necessary for us to develop new ways of looking at systems. We need them now more than ever before, but for different reasons. We must make meaningful relationships among man, his natural environment, and the entire energy-information web. This will lead us away from uses of technology in art whose realizations are mere kinetic gadgetry to charm the galleries or scientific patterns and motifs to bemuse the concert halls and toward a taking up of the phenomenon of technology itself in its role as an extension of human facility.

Until the present, rapport between art and technology in the schools has come about through the employment of the Bauhaus pedagogical methods, which are characterized by product design through the use of abstract motifs. This idea of "making objects" – either for aesthetic purposes or for use as industrial prototypes – has too long dominated design thinking. A systems grasp of technology and its problems appears to be much more relevant to our contemporary situation.

We are at last beginning to realize the potential in the system itself as a work of art. Once the theory of systems is mastered it will be realized that we no longer need to fear systems as demonic, static, hard to change frameworks. We will have the ability to generate them at will, keep them around as long as they demonstrate usefulness, then discard them for something new. We need not even keep any remnants of old systems around. Their reconstruction, for purposes of record, for example, is a simple matter.

We now face the stupendous possibility of taking into hand control of our own evolutionary development. Cybernetics teaches us that it is possible for a grossly inefficient system to create a nearly 100% efficient system. Assuming man to be that grossly inefficient system, where do we go from here?

I would like to proceed by way of example, describing briefly a machine whose design objectives were motivated by the comprehensive systems concerns discussed above, and whose realization was intended to serve optimally for live performance. Neurona Company undertook three major stages in this development process. First, the selection of a set of derived modular mathematical relationships in wave and sequence generation best assimilable by musicians and artist; second, design of hardware for live performance-a kind of human engineering; and third, of course, reduction of cost and size factors. The best of those we've achieved is size. We're still working on cost.

We've tried to derive a set of modular mathematical wave descriptions that correspond to the way in which musicians think modularly, for example, about melodic patterns. These apply more directly to linear functions than to anything else, and to what I will, in a minute, describe to you as the analog portion of this system. To make the analogy more clear, consider a violinist who learns to play a large set of modular patterns, going through exercise book after exercise book, which really contains permutations in seemingly infinite order of various kinds of modular and scalar patterns. When he combines them together later on, he produces sonatas and concerti, etc. The same kind of approach can be applied to a way of generating waves with computer techniques. I am convinced such an approach may yield a fruitful teaching method for electronic music, when combined with concepts from information theory and the basic tenets of Shannon (1), (2). Time limits prevent my going into it here, so I will proceed with a description of the modules.

There are four basic modules. The first is a small module, which takes its inspiration from Fourier. Any complex stationary wave (which, of course, does not exist in nature), can be described by a sum of simple sines. In Fourier's theorem there are four parameters to be concerned with: amplitude, frequency, phase relationships and the principle of summation. So, we have a module, which has three sections. The first section, which you see on top (see Figure 1), is familiar to you because it is a standard oscillator-type section. Let me make it clear that there is very little distinction made between control voltages and signal voltages in this system. Everything is considered a program relationship between voltage and time. It deals with both positive-and negative-going control voltages (Figure 1).

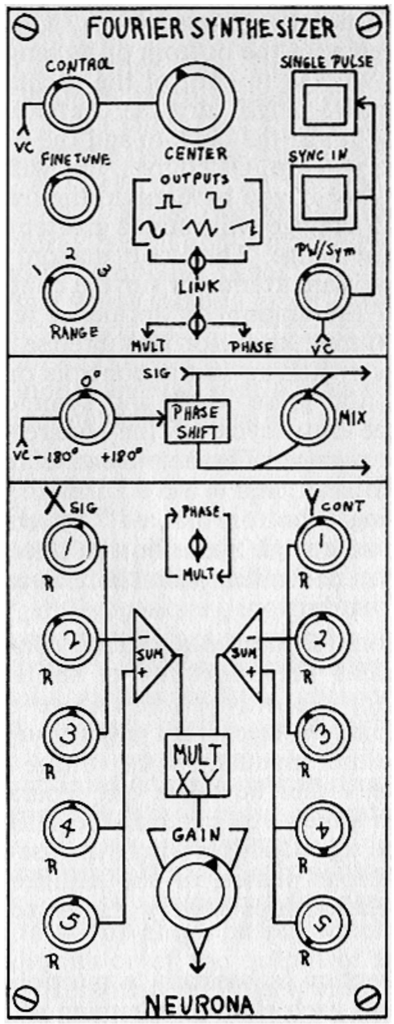

Figure 1

The oscillator section works as follows. The big knob in the center, which is marked "Center," controls the center frequency of the oscillator, also determined by the range switch in the lower left corner. There are three ranges for general purposes: sub-audio, audio, and super-audio. This section controls all periodic functions in the system. The five waveforms that you see there: pulse, square, sine, triangle, and ramp are available simultaneously. What is meant by "Center Frequency" can be seen in that if a positive-going control voltage is applied, it will control the oscillator from the center frequency to the bottom of its range. So, if you want a positive-going voltage to control the oscillator in the normal manner for its entire range, turn the center frequency knob all the way down so it's at the bottom and the positive voltage will control it all the way up. Of course, you will have compressed the range of control if you have raised the frequency. That is, a smaller change in voltage will cause a greater change in pitch, as if you narrow the range. The knob marked "Control" in the upper left corner is an attenuator for the control voltage so that you can control the amount of influence it has on the signal. There is a fine tuning knob for very precise adjustment of the pitch. Also, now switching to the controls on the right side of the top section, the pulse width and symmetry of the square wave, that is, the duty cycle of the square wave, can be controlled also by voltage. Those two waveforms can also be synchronized with an input waveform of an asynchronous nature by pressing a button marked “Synch In.” Single pulse output operates as a single pulse button does on Buchla equipment, I think you’re familiar with that. You get a single pulse when you push that button.

Now, the second section is a voltage controlled phase-shift section. It contains the possibility of shifting a signal either positively 180º for a positive-going voltage or negatively 180º for a negative-going voltage. That gives you a full 360º swing. It can be done either manually or by voltage control. Then, the shifted signal can either be taken out separately or there is a second output in which you can mix the shifted signal with the original unshifted signal. This is where the use of the addition of sine waves of various phases, or the addition of any waves of various phase relationships is very handy to have. That’s the second variable.

The bottom section is basically a multiplier. It has, as you see, five inputs on each side for summing of signals. There are three inputs on the negative side of the summing amplifiers and two on the positive side which means, of course, that you would be adding 1, 2, and 3 together, and 4 and 5 together, but those sums would subtract. The same is true on the Y side and there’s a master gain knob. Any process in which you need the function of multiplication can be facilitated by this module. It will include the company’s published description of this module here for the sake of brevity.

“FOURIER SYNTHESIZER, Model OM1100110, is composed of three sections:
A – Voltage controlled oscillator with manually variable center frequency. As the magnitude of the control voltage increases, the pitch rises above (if the control voltage is positive) or falls below (if negative) the center note. The section has five output waveforms: sine, triangle, ramp, square, and pulse, all simultaneously available. Pulse width and square wave symmetry is voltage controlled and the oscillator can be synchronized with an outside signal. A single pulse can be generated manually.
B – Full -180º to +180º voltage controlled phase shifter with two outputs: the shifted signal and a manually variable mix of the shifted signal with the original signal.
C – Multiplier/Summer, which can be a mixer, a voltage controlled amplifier, a balanced modulator, a frequency summer, and other functions. This section has five X inputs and five Y inputs; the sum of the X inputs and the sum of the Y inputs are multiplied yielding the product as the output.”

The portion of the system in which one could make use of the earlier described modular wave description is the following analog module. (Figure 2)

“ANALOG COMPUTER, Model OM1101000, contains eight computing sections each featuring addition, subtraction, multiplication, division, differentiation, integration, logrithmic processing, antilogrithmic processing, comparator function, sample-hold function, and functions obtained via the connections of eternal operational amplifier feedback components. Hardware has been designed to enhance the needs of live performance media. Cycling of the differentiation and integration functions is accomplished by an internal pulse operated analog switch. The unit can thus be controlled by a pulse generator or any digital device. The status of each computing section is revealed by four color-coded indicator lamps. Each section contains a potentiometer, which can be connected to internal positive or negative 10 vdc or to the op amp’s output, which permits control of the initial conditions, or of the output of the section. Also included are two differential amplifiers, which can be used in conjunction with the computing sections or by themselves to produce additional functions. Complex impedance’s are switchable on both inputs and feedback circuitry in the amplifier.”

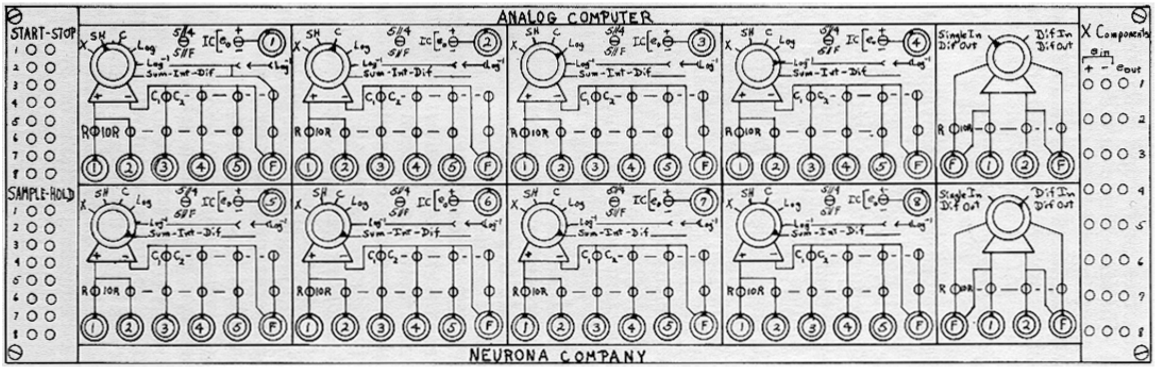

Figure 2

One could, for example, use this to produce an envelope-generating signal by programming a rising-falling voltage in the way in which it is needed. The log and anti-log transfer functions are useful for processing of control voltages; one can convert from linear to exponential or logarithmic modes, for example. All functions in each computing section are easily switchable for quick reprogramming of live operations. The indicator lights respond to the start and stop of time-based functions such as integration; there is a sample-hold indicator for both sample and hold-since those are pulse operated functions, you want to know when you are in each of those modes.

Then quickly to the digital section-what the digital section of this system comprises is basically a special purpose computer with a memory and the ability of storing complex sequences of very large numbers of notes. (Figure 3)

“DIGITAL CONTROLLER, Model OM1100111, is a special purpose digital computer optimally designed for live performance. It is possible to program any sequence of up to 320 notes in any rhythmic combinations. After setting up the sequence it is possible to change notes anywhere within it without affecting the others. There are four output registers operable separately allowing four types of sequences to run at once. There are both numeric and binary read-outs. Each position in the binary read-out is associated with a potentiometer, a precision resistor, and a pulse output; these permit the association of each position with a desired voltage and an outside unit activated by a pulse, and also perform the D/A conversion through addition, subtraction, or integration. There is a DIVIDE mode, which divides the output registers into smaller sequence units. During performance it is possible to start, to hold, to skip portions of the sequence, or to divide it, manually or automatically, through the keyboard or by an outside digital device through the “external command interface.” The sequence can be started, stopped, held, skipped, or divided by external control. The unit also has an A/D converter and a V/F converter. There is also a clock input, which determines the timing of the computer. It is possible to tune the computer and a flat keyboard makes possible rapid entries of numbers.”

One must be careful not to be confused by the output register. Think of it not necessarily as a sequencer which must go from left to right, but as something that can give a sequence of binary numbers. What that means is one is not limited to having one position in the sequence on at a time. You can go from any combination of positions on to another combination of them on; all of those combinations are stored in a memory.

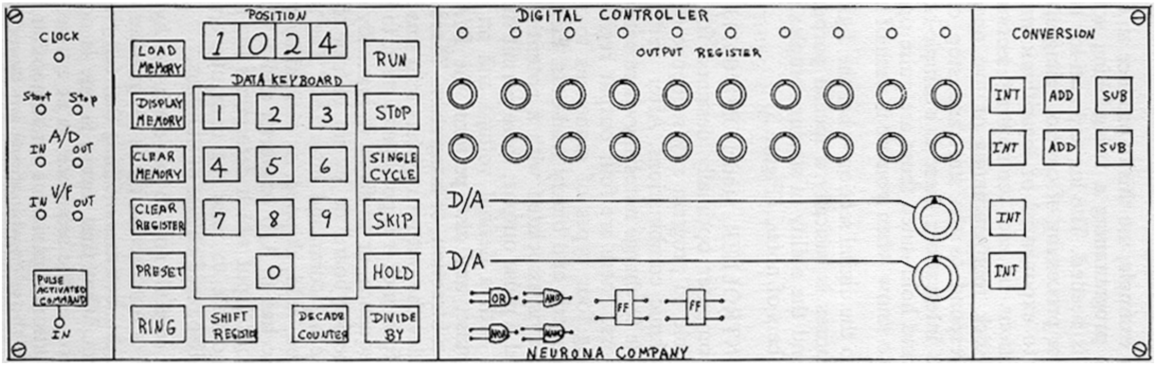

Figure 3

In the center, there is a flat piece of acetate. On that acetate are printed numbers that function like a keyboard, except that it's flat, there are no buttons and you can move your finger across it very rapidly. It's just like a push-button telephone. I'll give you a new example of a way in which you might use it to control a complex sequence. You punch a button in the upper left corner there that says "Load Memory." That prepares the memory to accept information. Then, you punch a number into the data keyboard, which refers to the position in the sequence that you want to talk about—let's say, for example, you punch 25. Now, as this is shown here, it can handle up to 1,024 positions in a sequence. It can be made with various sizes of memory to allow larger or smaller numbers in the sequence according to cost, but for purposes of discussion, I'll use the 1024 number. So if you want, say, position twenty-five in the sequence, you have to always punch four digits, so you'd punch zero, zero, two, five. Then, the next number you would punch would be the voltage you want to appear at that point. Now, what would happen is that the number would be translated into a ten-bit digital word, which is stored at a memory address in the digital unit. Then on **read out**, that word would appear in parallel **read-out** in the output register, and would be translated into a voltage, through a ladder network of pots or precision resistors.

Then, there's a third number which you can punch in, and that number refers to the number of clock pulses you want that voltage to stay on. For example, if you were feeding in, say a 300hz clock frequency, you could punch in the first one to stay on for ten clock pulses, the next one to stay on for thirty clock pulses and the next one to stay on for thirty clock pulses and, of course, you would have set up a rhythmic relationship. So, you have a maximum number of positions of 1024 and you can fill them up with as many voltages as you like. For example, when you punch for it to stay on for ten clock pulses, you use up ten positions in a sequence. You could punch two notes and have one note stay on for 512 and the next one stay on for 512 and you would use up the entire memory.

The other functions are fairly self-explanatory. RUN, of course, starts the machine. STOP stops it. SINGLE CYCLE allows it to run through whatever you programmed once and it stops. SKIP functions with a button over here called PRESET. You can punch that button and it will hold information that you put into the keyboard for use in an instantaneous situation. For example, if you want to say "skip" in a sequence from the position you're on, to position 100, you can punch "preset", and then punch 100, and then when you're ready, punch "**Skip**" and it will skip to that position. HOLD functions the same way; you can put it into "hold" on a particular spot. DIVIDE BY allows you to divide the sequence up into smaller sequence units. For example, if you divide the ten position sequencer by three, you will obviously get four little sequencers, three of which have three positions in them, with one left over. RING COUNT, in the lower left there, is a convenience item, which allows you to get standard sequential ring count as you do in a normal sequencer. SHIFT REGISTER, which would be better described as “binary count,” gives you an ascending binary count. DECADE COUNTER is no longer in the machine. PULSE ACTIVATED COMMAND over here allows you to preset a command, and then when a pulse goes into that pulse-activated input, it will command it to do what you have punched in. The unit has D to A conversion, through networks of pots for special applications, or resistors in standard D/A configuration with scale factor pots. There are various conversion modes which can be selected. For example, when you have more than one position on at a time, you have the option of either adding those voltages together, or subtracting those voltages from each other, or integrating the sequence to smooth it out. This, of course, is another way of generating complex waveforms.

The last module is an inexpensive, miniature special purpose unit with the following operating modes:

A – Subharmonic Generator. Many octave subharmonic series built fundamental tone of external oscillator. Individual tones selected by control voltage.
B – Wave Shaper-Analog Gate. Input waves “drawn” into other shapes by additive harmonic control. Gating and shaping simultaneously voltage controlled.
C – Voltage controlled Pulse Oscillator
D – Schmitt Trigger

The above-described system comprises the basis of the author’s composing studio.

References

1. Kamarck, Edward L., “Confrontation between Art and Technology,” Arts in Society, Vol. VI, No. 2, University of Wisconsin, 1969.
2. Kilby, Clyde, S., The Lost Myth, Arts In Society, Vol. VI, No. 2, University of Wisconsin, 1969.

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