UNIVERSITY OF CALIFORNIA

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AARDVARKS IV: A Real-time Electronic Music Performance Machine

A thesis submitted in partial satisfaction of the requirements for the degree Master of Arts in Music

by

Warren Arnold Burt

Committee in charge:

Professor Kenneth Gaburo, Chairman
Professor Thomas Nee
Professor Moira Roth

1975

The thesis of Warren Arnold Burt is approved:

Committee Chairman

University of California, San Diego

1975

DEDICATION

This thesis is warmly dedicated to the two finest tchatchka-fanatics in San Diego:

David Dean Dunn

and

Ronald Al Robboy

whose unfailing hysteria helped formulate these three noble principles, a guiding light for all who choose to follow:

1. Tho' totally effete, we, the sissy bourgeoisie, shall harp and grouse 'til bitter denouement.
2. Actually, none of these pieces are musical compositions.

   So don't be fooled.

   You know better.

   We know better.

   Your first impression was the right one.

   You turkey.
3. Nuthin' could be finah' than bad idea taken to tasteless extremes and then rammed mercilessly into the ground.

Dedicated with love.

June 1975

Warren Arnold Burt

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A project such as this could not be accomplished without the help of many persons. Therefore, I would like to give thanks to the many wonderful people who helped me in this endeavor. For initial help in formulating compositional and technical procedural models, I would like to thank Joel Chadabe and Randy Cohen. For technical help above and beyond the call of duty, warm thanks go to Ed Kobrin, Robert Gross and Serge Tcherepnin. I would also like to thank Serge for his gift of two of the voltage controlled filters which I used in the machine, and likewise thank Joseph Pinzarrone for his gift of two bandpass filters which also were installed. Donna Dunn is to be thanked for photographing the Food Co-op piece, and I would also like to thank my aunt, Mrs. Betty Farkas, for her generous financial assistance which enabled me to start this project. I would also like to thank the members of my committee, Moira Roth and Thomas Nee, for their valiant eleventh-hour performances, and warm thanks go to my chairman, Kenneth Gaburo, for hours of sweat and agony above and beyond the call of etc.

ABSTRACT OF THE THESIS

AARDVARKS IV: A Real-time Electronic Music Performance Machine

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Warren Arnold Burt

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University of California, San Diego, 1975

Professor Kenneth Gaburo, Chairman

This thesis describes AARDVARKS IV, a real-time electronic music performance machine constructed during 1973-75. Volume I describes the technical aspects of the machine and the various aesthetic positions that led to its building. It then describes two compositional models and two compositions exemplifying those models which use the machine. Appendix 1 consists of circuit diagrams and engineering drawings. Appendix 2 consists of 20 color transparencies of internal and external views of the machine. Appendix 3 consists of 18 color transparencies photographically documenting one of the two compositions realized in Volume 2.

Volume 2 consists of tapes of two compositions realized using AARDVARKS IV. This first, a solo composition, is called "On the Natural Structural Superiority of Pink African Nocturnal Mammals Over Small Hispanic Plastoid Aquatic Beings." The second, a group effort, composed jointly with David Dunn and Ronald Al Robboy, is a tape documentation of an activity called "YCMA 6: Three Music Boxes for the Golden Hills Food Co-op."

I. INTRODUCTION

During 1973-75, while I was a Fellow in the Center for Music Experiment, UCSD, I designed and built AARDVARKS IV, a real-time, live-performance, digitally controlled analog wave-form assembly synthesizer. This machine was conceived as a modular system, with each module designed to allow for great flexibility in the real-time generation and performance of electronic music compositional structures. The performance of these structures in real time falls into three classes:

ONE: Performance before the fact, where the automated controls of the machine are set up by the composer beforehand in such a way that the machine performs the music without human assistance. This may involve indeterminate procedures quite heavily, so that once set in motion, the general limits and not the moment-to-moment details of the composition are under the control of the composer. This form of indeterminate automation seems to imply that the composer using it must deal with the logic of automated processes, and the fairly unpredictable working out of their own intrinsic natures.

TWO: Performance during the fact, where, by way of the live manipulation of an array of dials, switches, joysticks and the like, the composer makes moment-to-moment decisions about both the nature of the immediate sonic details and the long-term structural elements of the music.

This, the most traditional form of live electronic performance, seems very similar to improvisation with acoustic instruments, where all decisions regarding the immediate nature of the sound are made in a direct one-to-one manner, with one manipulation of one control (key, valve, or knob), producing one change in the sound.

THREE: Recursive, almost after the fact, performance, where the composer, having set up an automated program beforehand, proceeds, during the course of performance, to alter certain controls such that the previously programmed process is subjected to critical judgments and shaped accordingly. This shaping may explore all facets of a given sound thoroughly, or it may explore several radically different sound types. In either case, however, this form of performance implies a desire on the composer's part to impose one form of logic on another, and a desire to interact with already active, partially sentient systems.

As a composer, my personal interests lie in exploring the first and third types of performance discussed here, utilizing the second type mainly as a tool for the better realization of the third. My machine was designed and built as a vehicle to serve these ends.

II. TECHNICAL DESCRIPTION

A. AN OVERVIEW

To implement these compositional procedures, a number of approaches were possible, such as completely digital systems, large-scale analog systems with digital switching arrays, or general purpose computer systems. However, the economical and reasonably quick implementation of a personal machine for performance, given any of the compositional procedures outlined above, suggested to me the design and construction of a patchcord-operated digitally controlled analog machine. I simply felt more comfortable working with sound as shape, rather than a series of numbers, hence the final analog approach. A modular system seemed necessary to economically realize the number of different musics I had in mind, and patchcords seemed more flexible than pin matrices and more immediately practical than still-to-be-developed microprocessor switching arrays for the interconnection of the modules in such a system. Yet at the same time, because of economy and ease of assembly, digital and CMOS digital logic seemed to be the way to realize many of the individual modules. The end result of these considerations was a personal, inexpensive hybrid machine, with the hybrid slightly more heavily weighted toward the analog than the digital end.

B. A PERSONAL WORKING METHOD

One of my chief interests in the compositional procedures discussed above is working with waveforms which constantly change timbre. One way of achieving such a result is through an analog waveform assembly process which allows the composer to have access to a number of these electronically generated waveforms. This process, which is a central consideration in the design and construction of this machine, consists of pre-setting a number of fixed or time-varying voltage levels and sampling them at a fixed rate. This process produces a rather more complex sound than is available from standard electronic equipment. The basic implementation of this process consists of various random voltage sources and fixed sequencer levels mixed and gated in a specific way, as shown in Figure 1. In this figure, two random voltage sources with slowly gliding random voltages are being alternated on the first and second pulses of a three pulse sequence with a frequency of three milliseconds per pulse. The output of this gating is then mixed with a third voltage, a three step sequence of 0 volts, 1 volt and 4 volts moving at the same clock rate of three milliseconds per pulse. The steady gating pulse results in a pitch of stable frequency, the sliding voltages gradually change timbre continuously in a non-abrupt manner. The sequencer gives the wave an alement of timbral stability. By using stepped random voltages instead of slewed ones, and by having either these stepped random voltages or the sequencer asynchronous with the gating pulse, sharp timbral discontinuities can be introduced into the waveform, such as sudden poppings in and out of various elements of the spectrum of the waveform, or various types of noisy modulations of the waveform. By varying the frequency of the gating pulse at audio or near-audio frequencies, interesting frequency modulation effects occur, and if the gating pulse is frequency modulated by another similarly assembled waveform, complex arrays of glissandi result from the interaction of all the assembled voltages upon one another. If a further operation of halting the waveform at any particular level for either regular or irregular intervals is made, variations of the timbre, from intermittent silences to complex noiseband modulations, will occur. A further operation, namely a filtering routine of some sort, is usually carried out at this point. This is done for one of two purposes: first, these assembled waves, because of the many sharp edges in their forms, tend to sound rather like square waves. So some sort of filtering is usually desirable to reduce the concentration of higher partials in the sound. Second, these filters can be used to effect further radical timbre transformations upon an already continuously changing sound by either modulations or partial samplings of a very rich sound spectrum.

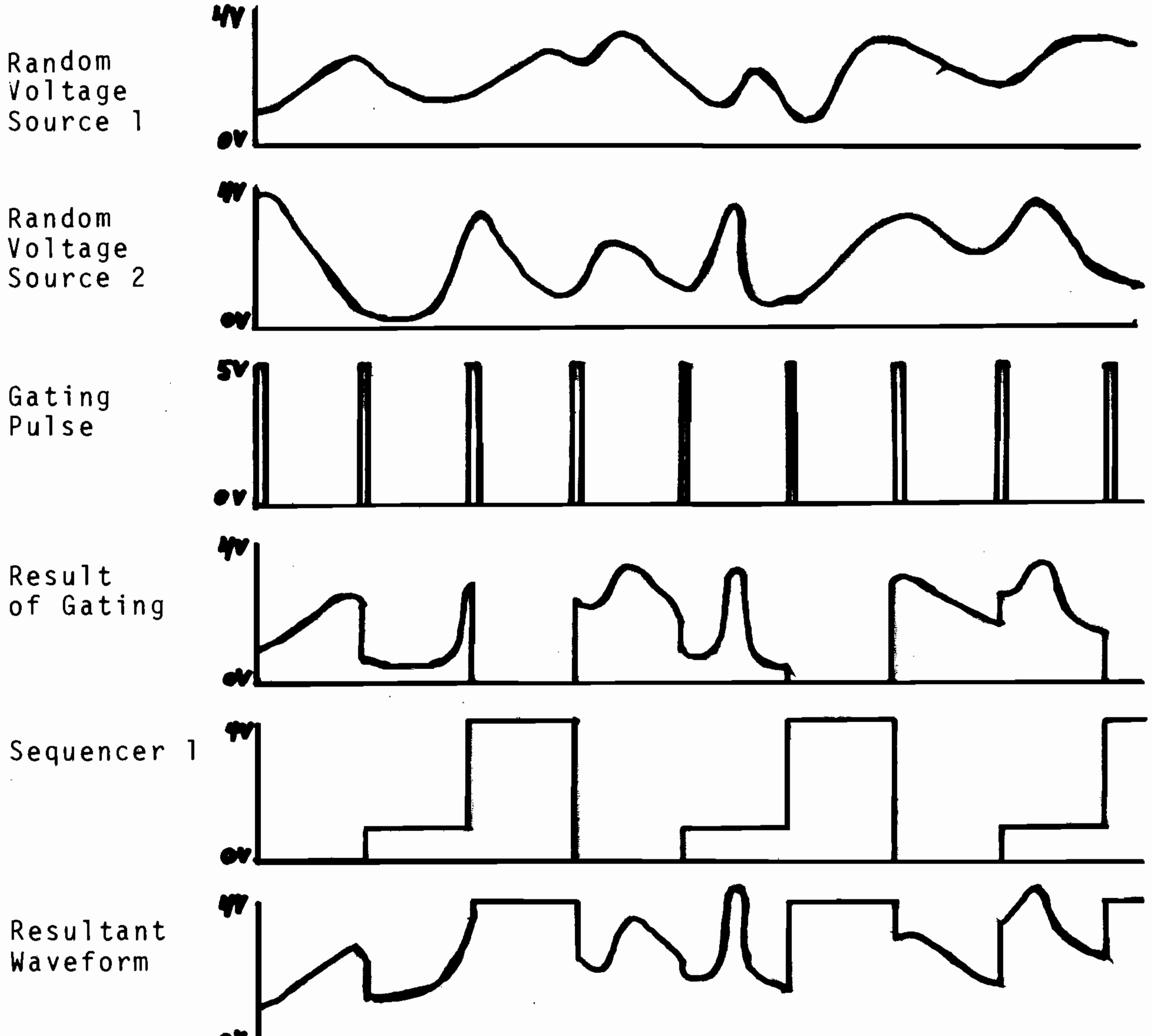

Figure 1: Analog Waveform Assembly

In September 1972, when I first conceived of treating waveforms in this manner, I attempted to set up this process on the Buchla Series 100 synthesizer at UCSD. Although I achieved only limited success in this venture, this and further researches carried out with Joel Chadabe, Serge Tcherepnin and Randy Cohen helped me develop the specific configurations of equipment necessary for carrying out this process. Considerable research led to the following basic list of components:

16 random control voltage sources
2 sequential voltage and pulse sources
2 sequential pulse sources
16 voltage controlled gates
4 unity gain mixers (6 in- dual outs)
4 audio mixers (4 in- dual outs with unity gain input)
2 standard variable state voltage controlled filters
2 special purpose narrow band-pass voltage controlled filters
2 high-gain amplifiers and internal speakers

The internal amplifiers and speakers, though not strictly necessary for the waveform assembly process, were considered necessary for the machine's self-sufficiency in live situations. Having developed this list of modules, design, prototyping and construction of them commenced. A detailed technical description of each of the completed modules now follows.

C. COMPONENT DESCRIPTION

1. RANDOM VOLTAGE GENERATOR

By far the most important modules in the machine are 16 identical random voltage generators. These units sample values of a 400 KHz 8 bit digital random number generator at a particular frequency determined by a voltage controlled clock. This voltage is then routed through either a six to eight bit digital to analog converter, after which it may be offset by an external potentiometer by as much as + or -15 volts, and/or routed through a portamento circuit, and/or limited by an external gain control. The concept involved in the design of this module is to have a fairly complex array of internal shaping for the random voltages. External switches and potentiometers enable one to perform various functions (rate, clarity of resolution, sliding or stepped voltages) while the generator is in operation, adding an element of live performance to what is essentially an automated module. Figure 2 shows the faceplate layout of the random voltage source.

The clock (Fig. 2a,b,c) is a voltage controlled oscillator with two outputs, a pulse train and a sawtooth wave (Fig. 2a). It operates over two ranges which are selected by a switch (Fig. 2b). The low range goes from approximately 1/10th Hz to 20 Hz. The high range is approximately 50 Hz to 15 KHz. An auxiliary bypass input (Fig. 2b) allows the module to be clocked by an external

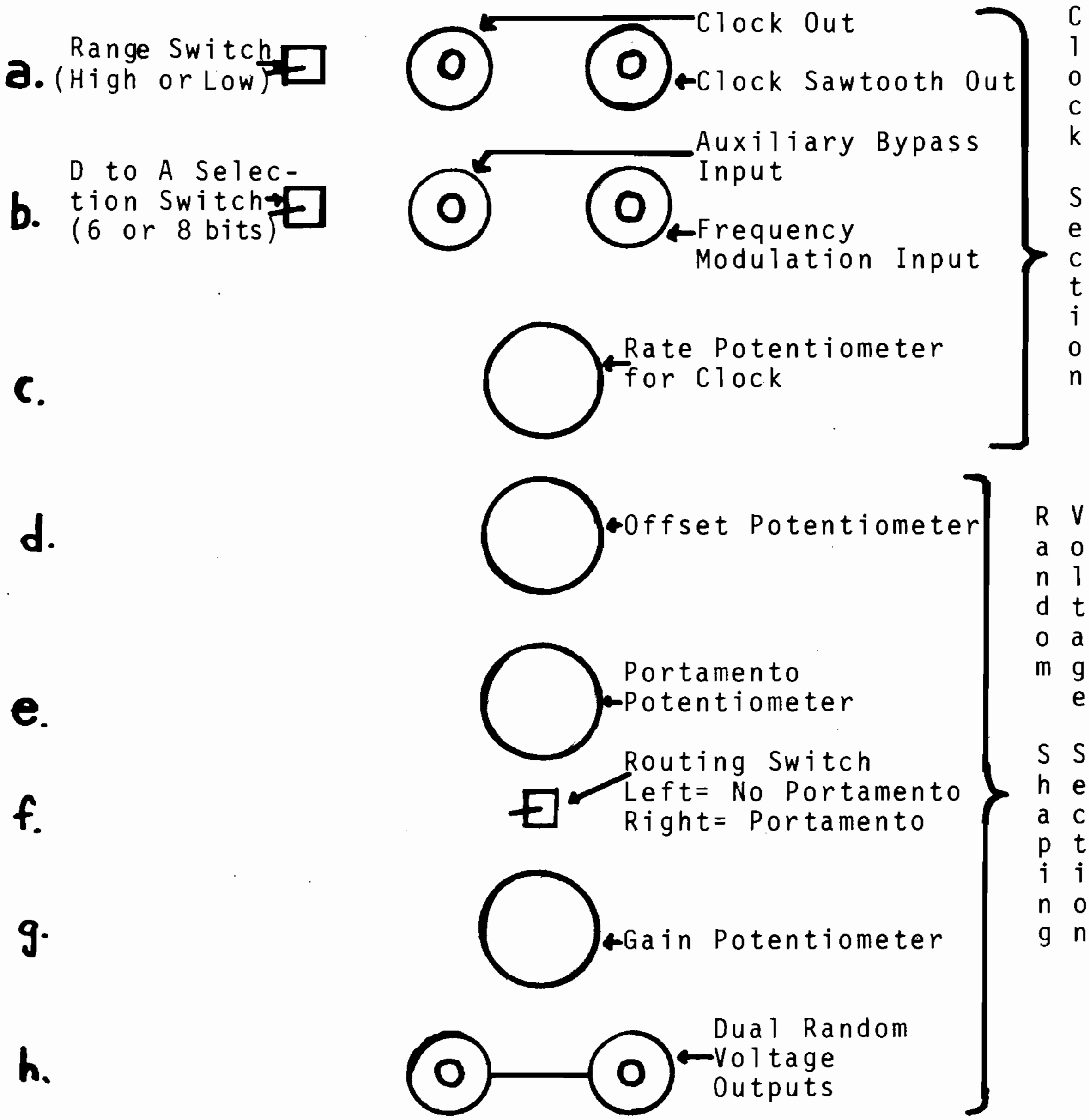

Figure 2: Random Voltage Source Faceplate

clock source, instead of the internal clock. This is useful in that it allows several generators to be clocked synchronously. When a signal is connected to this input, the internal clock is disconnected, and the auxiliary clock input is also routed to the clock out (Fig. 2a). This allows a common clock pulse to be routed to more than one random voltage source without the need for multiples or Y-connectors. A frequency modulation input (Fig. 2b) allows the internal clock to be modulated over approximately a 10:1 range from the base frequency, which is set by the rate potentiometer (Fig. 2c).

This clock is then internally routed to an 8 bit binary latch which samples the input from the common random number generator. Every time this latch receives a pulse, a new random 8 bit binary number is sampled and held. The output from this latch is then routed to a homemade resistor-ladder network digital to analog converter, the two central bits of which (bits 3 and 4) may be disconnected by an external switch (Fig. 2b) thus giving an effective choice between 8 bit (256 different levels) and 6 bit (64 different levels) resolution. The external offset potentiometer (Fig. 2g) attenuates the output if an output range of less than 10 volts is desired. As a further option, a switch (Fig. 2f) is installed which allows this stepped random voltage to be routed through a portamento unit. This unit is a very low frequency low-pass filter which slews between incoming changes in voltage level at any given rate between 1/30th Hz and 4Hz. The precise rate of this slewing is set by the portamento potentiometer (Fig. 2a). The voltages generated in this manner can then be used as control voltages for any of the modules in the system, or as components of the waveform assembly routine, or as sound sources in themselves. In the latter case, the output is colored noise, the frequency component of which is heavily weighted towards the frequency of the random voltage source's internal clock.

2. SEQUENTIAL VOLTAGE AND PULSE SOURCES

a. Sequencer

This is a module which gives out 10 sequential pulses at a given clock rate of 1 per pulse. Each of these sequential pulses attains and holds a level of 5 volts for the duration of 1 incoming clock pulse. These sequential pulses can also be attenuated to produce a series of discrete voltage levels. This module is basically the same as a standard synthesizer sequencer. It consists of two sections, a voltage controlled clock, as in the random voltage source, and a RCA COS/MOS CD 4017 AE chip. The chip is a complete divide-by-ten counter in a single package, with all the functions necessary for a sequencer self-contained, except for an external clock, three 22K resistors for grounding various control inputs, and a series of potentiometers for attenuating the pulse outputs into differing discrete levels. On AARDVARKS IV, the sequencer is arrayed as in Figure 3.

To use a 10 stage sequencer as an audio generator, the low range of the clock should be about 10 times the lowest audio frequency desired. The two ranges of the sequencer clock, then, are much higher than those of the random voltage sources. The low range is 200 Hz to ca. 18 Hz, and the high range is 5 KHz to ca. 50 KHz. In all other details except range, this is exactly the same clock as was discussed in the random voltage source section.

The sequencer, in addition to giving out 10 sequential pulses or adjustable voltages, has two functions which are useful in a wide variety of circumstances. One is the reset function: When a pulse (5 volts) is applied to the input of this function, either externally or through an internal pushbutton, the sequencer immediately resets itself to its initial stage, but continues to cycle normally until another pulse is detected at the reset input. The result of this function is that sequences of less than 10 steps can be easily obtained, as well as sequences of random lengths. This function is also extremely useful when the sequencer is being used as a divide-by-n counter for precise frequency division.

The second useful features is the hold function: Quite simply, whenever a voltage of 5 or more volts is applied to this function, the sequencer stops, wherever it

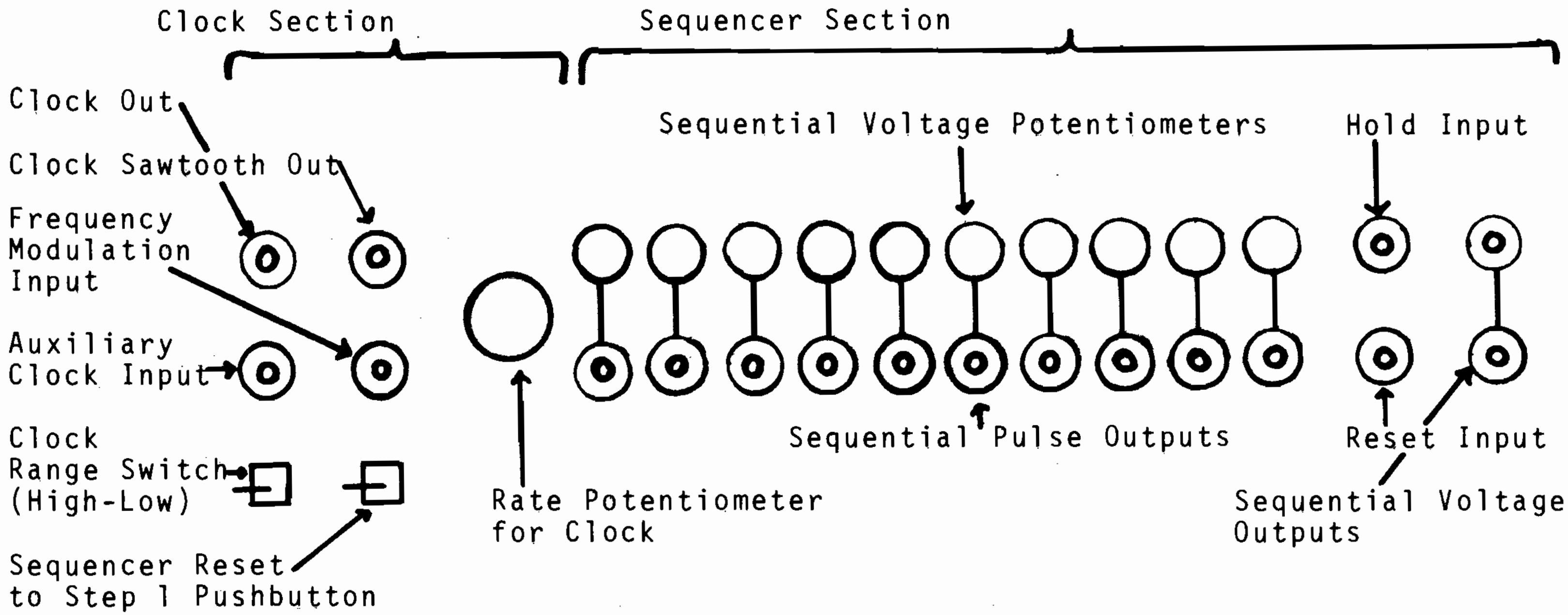

Figure 3: Sequential Voltage and Pulse Source Faceplate

is in its cycle, and remains stopped at that point, until the hold input voltage is low again. If this function is then clocked with a fairly rapid series of regular or random pulses, extremely complex noiseband modulations will result from the regular or irregular breakup of the waveform.

b. Sequential Pulse Source

On AARDVARKS IV, there are two sequencers arranged as in Figure 3. Another two sequential modules are arranged in a similar manner, but with one important exception. These two modules do not have a sequential voltage output, but instead, only give out sequential pulses. The row of sequential voltage potentiometers is therefore missing, being replaced by dual, as opposed to single, sequential pulse outputs. These two, in addition to functioning in the waveform assembly routine, are also useful in a number of dividing-down and clocking functions.

3. VOLTAGE CONTROLLED GATES

This is a very simple on-off analog switch, which, nevertheless, performs one of the most important functions of the waveform assembly process. When the control signal goes high (more than 2 volts, usually a 5 volt pulse), the gate immediately and cleanly turns on and passes the input signal. The output of this gate can be used in a number of ways: First, if a number of such gates are ganged together and clocked sequentially by one of the sequencers and the outputs of the gates mixed, the inputs into the gate will be assembled into a new sequence. Second, if the inputs to the gates are all random voltages of the sort shown in Figure 1, and the sequential clocking of the gates is of an audio frequency, a waveform of changing nature will have been synthesized. Third, if such a sequential gating scheme is clocked slowly, and the resultant output used as a control voltage in the domain of, say, pitch, a multilayered structuring of pitch materials can be achieved very easily. Externally, the gates each consist of three jacks arranged vertically, as shown in Figure 4, Page 15. The top jack is the output; the middle, the signal input; and the bottom, the control voltage input.

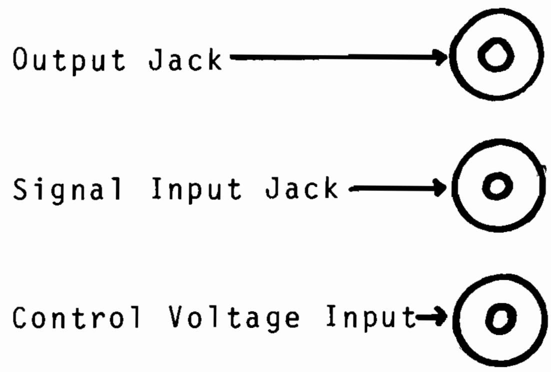

Figure 4: Voltage Controlled Gate Faceplate

4. MIXERS

Eight mixers are included in this machine. Four are simple unity-gain mixers which are normally used as the final mixing stage of the waveform assembly process, and four are standard audio mixers with attenuators on each of the inputs. The unit-gain mixers each mix up to six inputs and the output is available through a dual output. The audio mixers have four inputs, each of which may be individually attenuated. A fifth input, a unity-gain input, allows a fifth signal to be passively mixed with the output of the other four. This is also useful in ganging mixers together for larger mixing systems.

5. FILTERS

Due to the complexity of design necessary for a really high-quality audio filter, and further, due to the large expenditure of funds necessary for the development of such filters, I decided to use commercially available filters in the design of this machine. For this purpose, two variable-state voltage controlled filters developed by Serge Tcherepnin at California Institute of the Arts, and two voltage-controlled multi-bandpass filters developed by Joseph Pinzaronne at the University of Illinois were generously donated by their respective designers.

The Tcherepnin filters have three simultaneous outputs, a high-pass, a band-pass and a low-pass. The cut-off rate on each of these is 12 db/octave when the Q control is at its lowest position. The Q can be manually increased to the point of oscillation. The cut-off frequency can be either adjusted manually by a potentiometer, or can be controlled over its entire range by a control voltage of 0 to 5 volts.

The Pinzaronne filter divides an input signal among six different third-octave band-pass filters, each of which may be individually voltage controlled. The outputs from these filters are each available separately, or ganged to a common output. In the common mixed mode, the center-frequency control voltage of each filter also acts to attenuate the output of that filter into the overall mix. In the separate mode the control voltage only acts to shift the center frequency of the individual band by a very large minor third. The exact ranges of these bands are set by a series of internal capacitors which can be chosen and replaced by the composer at will. For this particular occasion, one filter was fitted with roughly contiguous bands ranging from ca. 200Hz to 1 KHz, and another with non-contiguous bands within the spectrum from 100 Hz to 2 KHz.

6. INTERNAL AMPLIFIERS AND SPEAKERS

Although the modules discussed above constitute the minimum equipment required for the waveform assembly process, one other module was considered necessary. This module, two internal amplifiers and loud-speakers, was necessary because the desire existed to use the machine in a variety of situations not always determined by the economic availability of external loudspeaker systems. These loudspeakers, because of their extremely small size and the limited amplification available (ca. 4 inches in diameter) are useless if the machine is trying to fill even any moderately sized space with sound, but do prove extremely useful both in the installation of the machine in rather intimate situations, and in personal monitoring of sound before it is put into larger speaker systems.

III. AESTHETIC POSITION

A. NECESSITIES

From October 1972 until April 1975, I was involved in the design and building of AARDVARKS IV. Such a large-scale project was dictated and shaped not only by technical and compositional desires but by aesthetic views as well. This chapter presents the ideas which led to the building of the machine, and two compositional uses for which it was intended.

Early in 1972 Joel Chadabe first suggested to me the idea of assembling waveforms as an alternative to more traditional methods of analog sound synthesis. At the time, the conception was simple: One "brute force" drives a sequencer through its cycle at audio speeds and then somehow continually changes the voltage level of one of the stages of the sequencer to get a variation in timbre. From this early point, our researches led in two very different directions. Joel, along with light sculptor-electrical engineer John Roy, went on to develop a very elegant voltage controlled sequencer unit, the PWG-2, which he then used to explore the many changes in timbre available on a single tone, or group of tones. My researches led me to explore the possibilities available in programming a sequential series of sampling gates, and the sounds available from the noisy modulations of such a series. These researches were carried out on the Buchla Series-100 synthesizer at UCSD in October and November of 1972. The sounds obtained were dirty, rasping, raw, uncontrollable and more exciting and alive than any other sounds I had heard to that date. Despite the extremely arresting nature of the sounds produced in this manner by the Buchla, shaping them to my compositional ends proved extremely difficult, because the Buchla, a general purpose machine, was not capable of providing either the specific speeds of sequencing and gating, or the particular types of automated control necessary. Thus, it seemed apparent that another source of equipment would have to be found. A number of equipment alternatives were investigated, but all proved impractical for the kind of intensive and intimate work with sounds that I desired. It was at this point that the need for a personal machine, one that I would design, build, and own, impressed itself upon me. The advantages such a machine would afford me seemed so compelling that I immediately plunged into work on its design and construction. Among the chief advantages might be mentioned:

ONE: Accessibility. A personally owned machine is available when the composer wants to work with it, for however long the composer wants to work with it, and, if properly designed, where the composer wants to work with it.

TWO: Uniqueness. A machine with its own set of idiosyncrasies cannot help but have a unique sound, and demand unique methods of working with those sounds. And, if the composer is designing the machine, he can assure that the idiosyncrasies inherent in the machine match his own peculiar set of compositional whimsies.

THREE: By building the machine himself, the composer acquires an intimate knowledge of the method of the production of a sound. Such intimate knowledge is almost essential if one wishes to shape the sound in an intelligent manner. Therefore, this building becomes as important a compositional procedure as any other.

FOUR: Economy. If relatively little original design research is required, sound synthesis and control machines can be assembled by relatively competent people for a fraction of their commercial value. For example, the total cost of AARDVARKS IV was around $900, while an equivalent amount of commercial equipment would have cost between $5000 and $8000.

FIVE: Political freedom. Despite a continuing reliance on academic and other institutions for personal income, the composer can at least free himself from reliance upon them for the very means of producing his art. A personal machine means no copyright struggles, no equipment scheduling struggles, and, above all, freedom for the composer to use his equipment in any manner he sees fit.

B. MANIFESTATIONS

Therefore, to fulfill my desires to work intensely, intimately and freely with sounds that interested me, I built my own machine. I envisioned two uses for the machine. These were what I termed the construction of monuments and the making of Muzak. These two activities will now be discussed.

1. MONUMENTS

One compositional idea that appealed greatly to my sense of whimsy was the construction of sonic monuments. These I viewed as large-scale, long works which, as in traditional Western Art Music, aimed at a certain high quality and continual interest, and which thus created their own potential to endure. The monument then was seen as formal music, designed to be presented in formalized contexts. The technical aspect of the monument was to take automated processes and through manipulating controls during performance, gradually shape them and the sound output in a continuously changing directional manner so that over a long period of time both micro and macro changes of sound type would be explored. The waveform assembly process provided me with an incredibly complex array of sounds generated by one basic equipment configuration, and these sounds seemed to have more inner life, and thus, more moment-to-moment interest than other electronically generated sounds. Therefore, the structural ideal of this recursive form of performance was to use the waveform assembly process to provide rich sounds of continuous timbral interest, thus shaping the micro-temporal level, while automation of certain basic functions would provide continuous indeterminate shaping on a middle temporal level. Live manipulation of certain controls would impose an ideal of continuous directional evolution upon this shaping, thus sustaining interest on a long-term scale.

2. MUZAK

Another idea, and one which appealed to me more strongly on the political level, was the concept of Muzak. For my purposes, I defined Muzak as the installation of pre-programmed sonic environments, that is, backgrounds, for various events, such as art gallery openings, Sunday afternoons in the park, or daily supermarket operations. This was seen as a non-formal music, that is, a music designed for presentation in non-formalized contexts. The technical aspect of Muzak was to take automated music machines and install them, usually fairly unobtrusively, but never anonymously as in traditional commercial Muzak. The audience could then be regarded in a passive manner (e.g., as in commercial Muzak, which aimed at producing a specific commercially-viable state of consciousness), or in an active manner, (e.g., invited to respond to the sound with comments, questions, or even manipulations). In either case, however, the non-formalized listening mode, that is, the sound primarily treated as background, was viewed as the key feature of this activity.

IV. TWO COMPOSITIONS REALIZED USING AARDVARKS IV

Having completed construction of the machine, I proceeded to realize each of the two compositional types discussed above. The first, a solo composition, was called "On the Natural Structural Superiority of Pink African Nocturnal Mammals Over Small Hispanic Plastoid Aquatic Beings." The second, a group effort composed jointly with David Dunn and Ronald Al Robboy, was an installation/event called "Three Music Boxes for the Golden Hills Food Co-op." A brief description of each follows:

A. ON THE NATURAL STRUCTURAL SUPERIORITY OF PINK AFRICAN NOCTURNAL MAMMALS OVER SMALL HISPANIC PLASTOID AQUATIC BEINGS

This is a composition for 4-channel magnetic tape realized with the completed machine at the Center for Music Experiment, UCSD, on April 17-19, 1975. It is, in many senses, the culmination of my experiments in producing long, continually changing sonic monuments. Though a tape piece, it serves as a model for the type of live-performance real-time composition the machine is capable of. The piece was realized in four successive passes, with great care being given to careful matching of the timbres at the end of each section to those at the beginning of the next section. In the final mixing, the last minute of each pass was then gradually faded into the first minute of the next. This was done in order to keep the evolution set-up in each pass intact, to discourage the notion of a sectional composition, and to have one continuous structural drive for the duration of the piece. The technical reason for doing four successive passes was to make slight changes in the equipment configuration which, in live performance, would be made by a specially built series of selector switches. During the final mix, the mono or stereo master tapes were then also routed into four channels in much the same manner as they would be during a live performance.

The completed composition lasts 72 minutes. It progresses from an opening drone where the basic assembled waves of the piece carry out their slow timbre changes unmodulated. Two waveforms are heard here. One, fairly low, is clocked by a very stable clock. The other, several octaves and a minor third above the first, is driven by a fairly noisy, unstable one, which results in the higher elements of the sound having an almost bell-like shimmer. After eight minutes, modulations are gradually introduced into the lower waveform, and these increase until the once stable wave glides over a range of about a fourth. At thirteen minutes into the piece, the hold function on the sequencer assembling the low wave is activated, and the drone becomes a sliding colored noiseband. The higher waveform is then transformed into a high band of hiss. This hiss then fades into the next pass of the composition.

The second pass uses basically the same equipment patch as the first, but some extra filtering is added, and the clocks are set at new frequencies. It begins with the same high filtered hissing that ended the first section. A gradual progression into broad noisebands with sharp attacks, whining, sliding glissandi, and fast filter sweeps explore the many varieties of noiseband modulation available on the machine. This section ends with a very raspy "burble" resulting from modulating the filters with a fast, unslewed random control voltage. This "burble" allows transition to the third section.

Here, after some initial noise, the assembled waves modulating the final wave are suddenly slowed to a fraction of their original frequency by using the rate switch on the random control voltage generators. This frequency change results in the sudden jarring substitution of a series of very rapid notes of incredibly banal timbre for the elegantly textured noisebands previously heard. These noisebands and notes alternate freely until the notes begin moving at such a rapid rate that they turn into a series of very rapid tremolos. When these tremolos slow into painfully trite melodies, the transition to the fourth section begins.

In this final section, the steady steps of the sequencer assembling the final waveforms are tuned to the pitches of a minor ninth chord, and these waves themselves are then slowed to subaudio frequencies and used as control voltages for a series of sine waves obtained through feeding the filters back on themselves. After reintroducing a few reminiscences of the noisebands, the composition concludes with a final slow, soft burst of ninth-chord melody.

B. YCMA 6: THREE MUSIC BOXES FOR THE GOLDEN HILLS FOOD CO-OP

If abstract structural concerns are central to the previous composition, social concerns were central to the group composition "Three Music Boxes for the Golden Hills Food Co-op." Eighteen slides taken by Donna Dunn and a fifteen-minute tape recorded by myself document this activity, a sonic environment installed by David Dunn, Ronald Al Robboy and myself at the Golden Hills Food Co-op on May 1st through 3rd, 1975. Three very different electronic music installations were provided for the Co-op, a three-room store front on Beech Street in San Diego. The set-up suggested by the layout of the Co-op was one machine per room, with the open nature of the interior allowing for each sound to permeate the space of the others. It was decided in conference between ourselves and the Co-op managers that Ron's installation, a Customusic background music machine with a complete set of atmosphere tapes, many of which were recorded at the wrong speed, were warped, or exhibited distortion in some way, would go in the produce and staples room. David's contribution, a ring modulator with a public-access microphone, oscillator input, and loudspeaker, would go in the meeting and cashier's room. My part in the display, AARDVARKS IV automated to play a Muzak of whines, whooshes and burbles tuned to match the hum of the refrigerators, would be placed on a table in the cheeses and oils room. The following document was circulated in the Co-op's weekly newsletter to inform shoppers of the nature of the event. In addition, one of us was constantly in attendance to answer questions and, in as unobtrusive a manner as possible, mother-hen the equipment.

> THREE MUSIC BOXES FOR THE GOLDEN HILLS FOOD CO-OP
> The installation in the meeting room was brought here by David Dunn; he calls it Public Sound, with these instructions: Place one microphone in a public location. Utilize the signal from the microphone as the program input to a ring modulator, and the signal from a sine oscillator as the carrier input. The output signal from the ring modulator is to be amplified and heard through a single loudspeaker. Allow public access to all materials and provide information that anyone may perform the system by changing the oscillator frequency.
>
> The CUSTOMUSIC box in the produce and staples room was brought by Ron Robboy, to whom it was a gift. 'I like my music box because it helps us keep perspective on the many dimensions of capalist whimsy. If you don't specifically recognize a song, you have the sense that you just as easily could, and nothing would be different. Because all the songs are in one standardized musical language, they act as furniture in standard consumer environments. There is no beginning or end, but rather just a music installation.'
>
> The shiny box in the cheese room is from Warren Burt; the installation is called 'Alone and Afloat Amongst the Cheeses'. 'I started building my machine as an alternative to the stranglehold, both economic and spiritual, that institutions and the electronics industry hold over those of us interested in making music with machines. I also built it out of a desire to provide a music that would serve a real, useful, social purpose. It seems that one of the more useful things I can do is to decorate the aether with delightful burbly sounds that make people smile and talk to each other.'

David, Ron and Warren invite comments and criticism from Co-op members. The clipboard posted by the work sign-in board is there for you to speak your mind.

The written comments received were sparse, and are reproduced in full here:

"Sounds like muzak UGH!"

"Ditto" "Do Do"

"I like cheese music best."

"The atmosphere machine is cerebral filler, sheer intrusion."

"  very, very nice  "

The verbal comments and the events resulting from the interaction of machines and people were much more numerous, however. Expressions of delight and puzzlement gave way to either shaking heads or smiles when people finally figured out what was going on, or else asked, and were told. One of the more amazing incidents occurred on Saturday morning, about two hours before the Co-op closed, when a group of small children, four to eight years old, discovered David's ring modulator installation and began to really explore it. They quickly discovered the wonderful result of the sound of a microphone smashed into the floor modulated by a 20 KHz sine wave. Their exploratory zeal, in fact, eventually proved fatal to the microphone, but since it cost less than $10, we considered that there was no harm done.

The tape and slides document many of the interactions that took place during the installation. Notice, for example, that no sooner had I set up the microphone and turned on the tape recorder to document our ambiance, than a man approached and asked me some questions. A few seconds later, the two rather inebriated store clerks discovered David's ring modulator setup and proceeded to give full voice to a series of beloved favorites of yesteryear. At about the middle of the tape, two shoppers indulged in what first seemed like a conversation about the installation, but which instead proved to be a quite didactic discussion on the nature of blue cheeses. Through it all, Ron's Customusic machine kept playing its wonderful tunes, and AARDVARKS IV made a valiant attempt to compete with the sounds of the refrigerators and cheese-shoppers. However, the internal loudspeakers could not play very loudly, so only those sounds of very high frequency could be heard over the rumbles of the cooling units. Just before the end of the tape, Ron's machine began playing one of its distorted tapes. Shortly after that, the refrigeration shut off (!) as did Ron's machine (it was changing tape cartridges) allowing my whining little box a brief soliloquy before the final conversational coda.

The photographs show the installations and some reactions. Note especially the expressions, ranging from bemusement to extreme involvement, on people's faces as they deal with David's installation, and the cleverly unobtrusive installation of Ron's machine between the honey and gluten flour. Note also how good an unlettered bare-metal faceplate looks across a sea of cheeses, and the stoic, almost saintly calm of the pineapples, leeks, rhubarb and artichokes as they await purchase surrounded by the sounds of the event.

Appendix 1: Circuit Diagrams

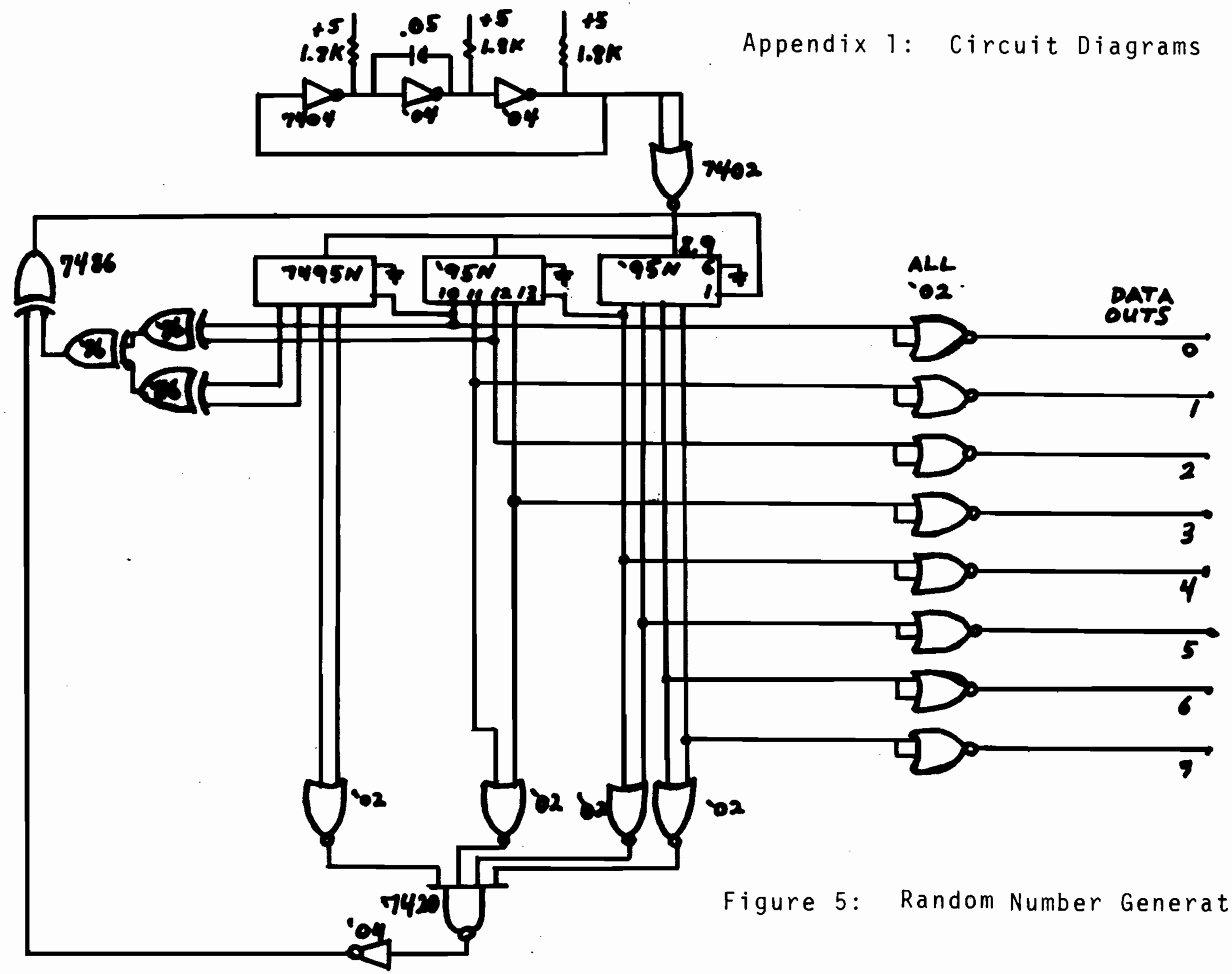

Figure 5: Random Number Generator

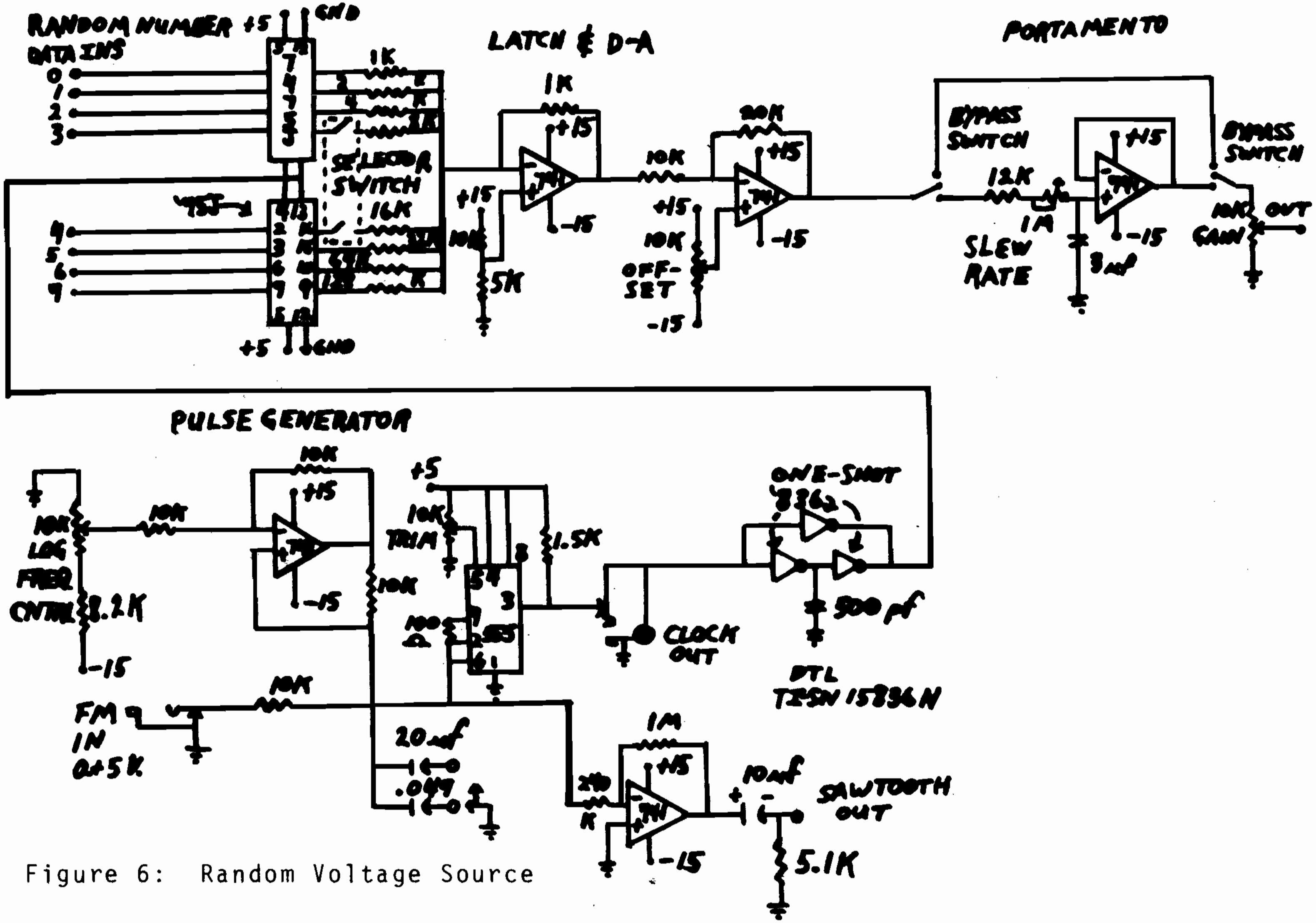

Figure 6: Random Voltage Source

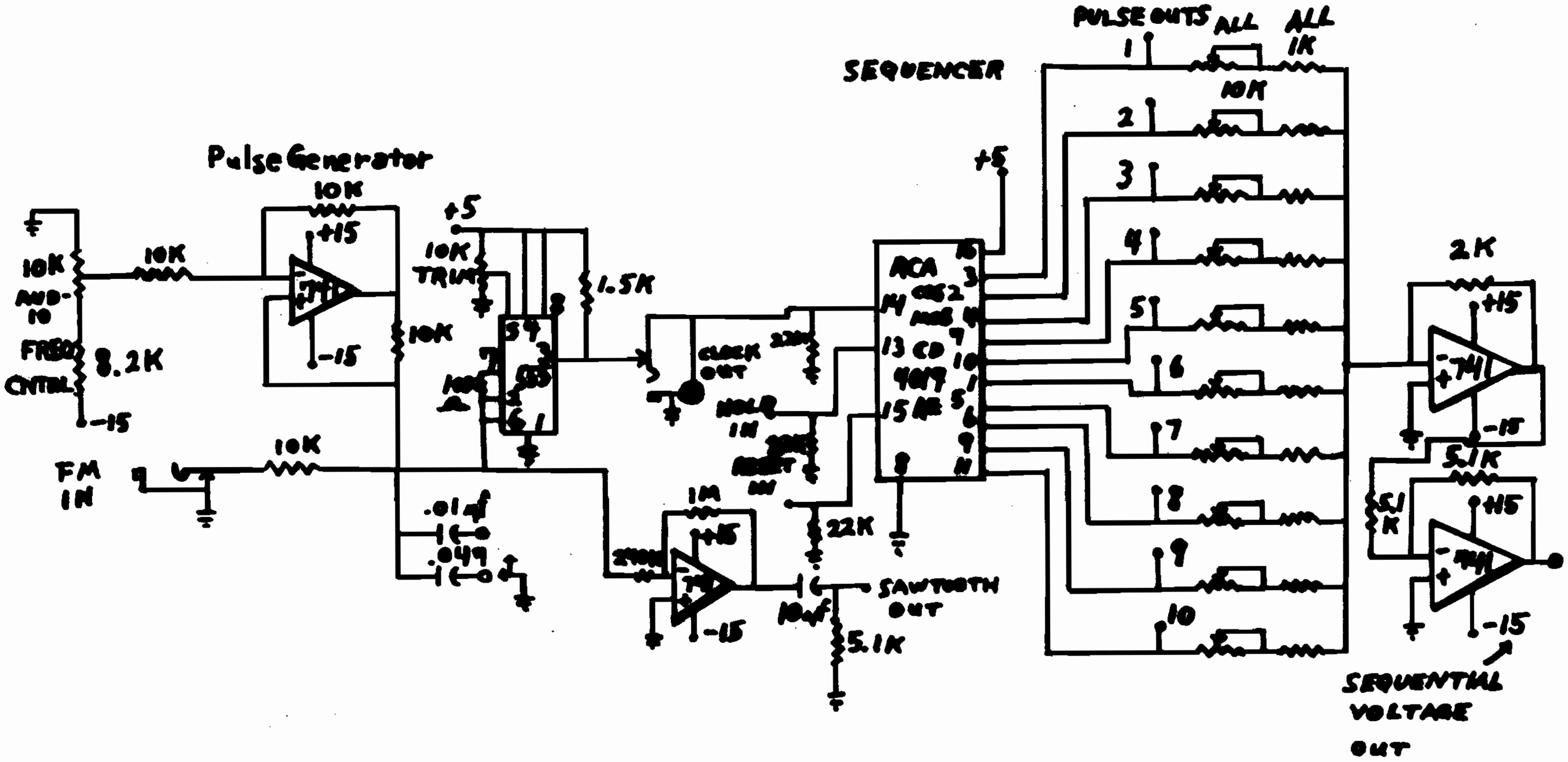

Figure 7: Sequential Voltage and Pulse Source

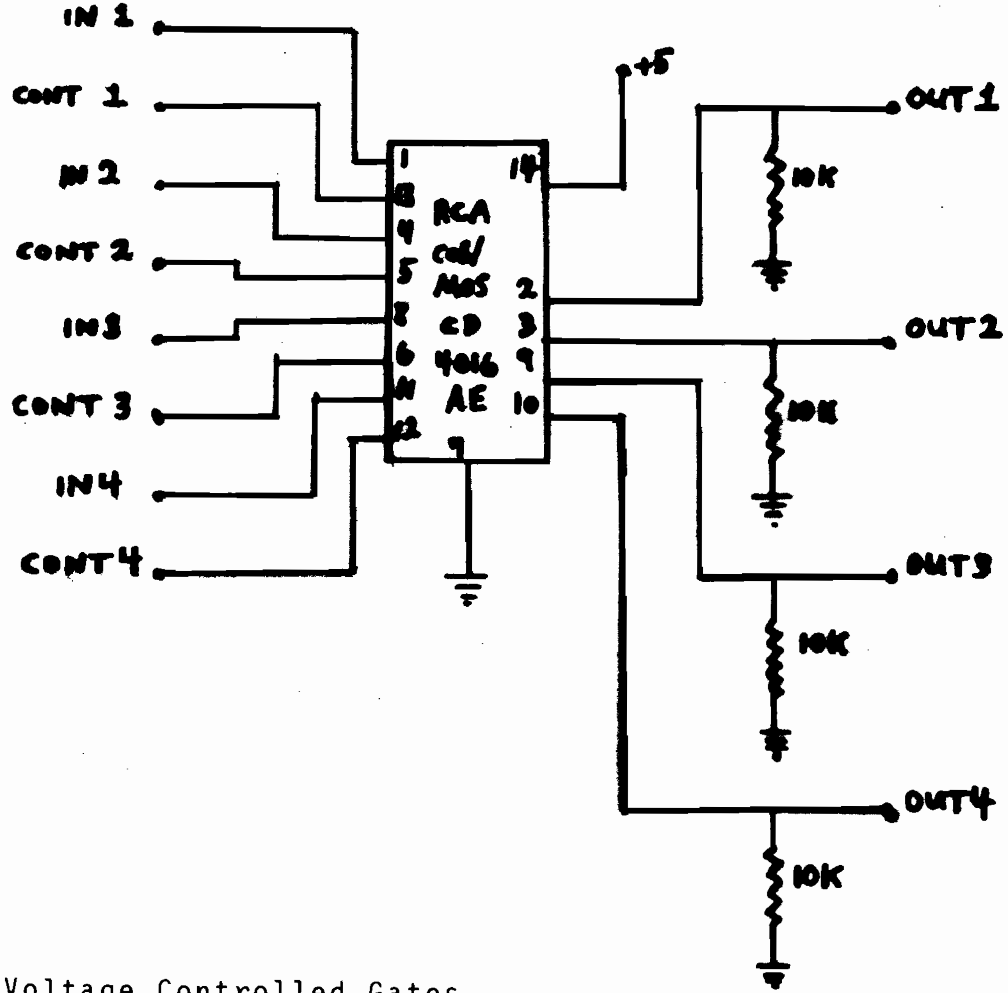

Figure 8: Voltage Controlled Gates

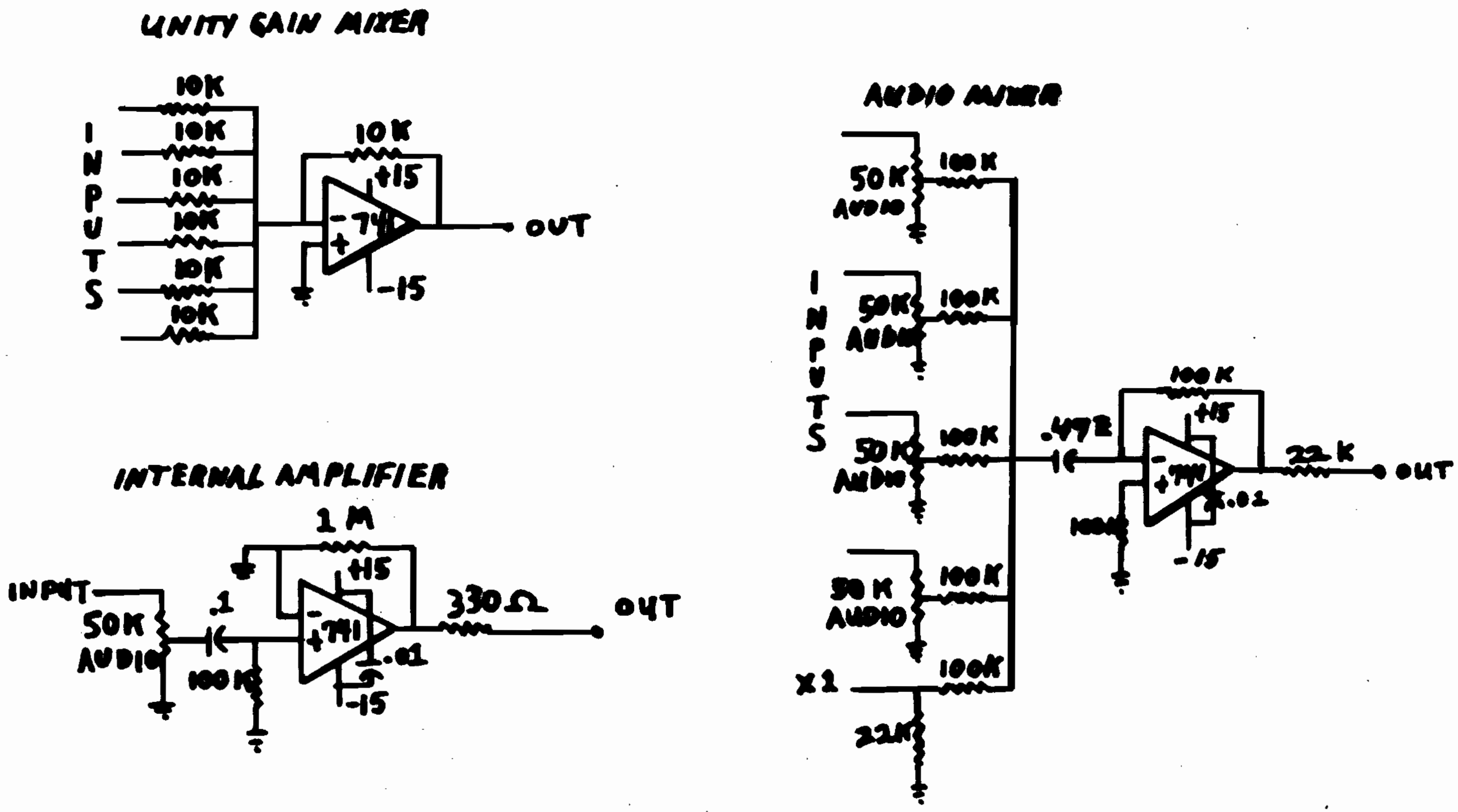

Figure 9: Mixers and Internal Amplifier