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BUCHLA SYNTHESIZER USER GUIDE

Daniel J. Scheidt

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## OVERVIEW

This manual is designed to serve as a basic user's guide for the Buchla analog synthesizer in the U.VIC. electronic music studio. It is presented as an instruction manual complete with diagrams for the first-time user. For regular users it is sectionalized to facilitate use as a reference text. It assumes a basic understanding of synthesis techniques and terms, and tends to focus on special features of the Buchla.

The first chapter covers basic features of the instrument. It answers such fundamental questions as, "Where is the power switch?". The next four chapters cover each module of the synthesizer in detail under the headings; Signal Generators, Control Voltage Generators, Signal Processors, and Control Voltage Processors.

## 1. INTRODUCTION

The primary role of the Buchla in the studio is that of a signal processor. It is intended to complement the NEW ENGLAND DIGITAL SYNTHESIZER which is, of course, only capable of generating signals and control voltages. Therefore the Buchla has been equipped with only four oscillators but numerous signal processing devices.

Another feature of this synthesizer is its suitability for live performance. Its two mixers allow for a number of simultaneous patches and its many LED's are very useful in keeping track of what is going on. The "keyboard" has a number of features which make it capable of subtle nuance not usually associated with keyboard instruments.

The Buchla is also well equipped for interfacing with live instruments. It has two microphone inputs and three envelope followers capable of extracting pulses and control voltages from a live signal. The PROGRAMMABLE SPECTRAL PROCESSOR is also capable of analyzing signals and has a number of possible outputs.

Part of the Buchla's flexibility comes from the fact that the synthesizer is broken up into separate modules with very little "pre-patching" done for you. Also almost every aspect of the instrument can be voltage controlled (there are 80 control voltage inputs). But don't be confused by the large number of jacks, switches, and pots. Everything is clearly (if not elaborately) labeled and things soon start to make sense if you pay attention to and become familiar with these labels. While the modular nature of this synthesizer makes possible a myriad of different configurations, by studying each module individually and understanding clearly its own functions, it becomes easy to construct complicated patches and still be in control of the sounds being produced. Part of the key to this is being aware of the path the signal is taking and what is affecting it along the way. Block diagrams and flowcharts are very useful for visualizing this sort of thing.

## 2. BASIC FEATURES

The following chapter describes some basic features of the synthesizer which are essential to its operation. It covers how to turn it on, the use of patchcords, and how to get a signal out to the studio so you can start listening right away.

First, a couple of points about the physical construction of the instrument. The Buchla is designed to be portable, and to facilitate this the upright section folds down over the base. It is not locked in place and will fold forward if you just pull (or accidentally lean) on it. Even though the Buchla is fairly sturdy in its construction, pots, sliders, and switches should be gripped lightly and moved gently. Patchcords must be inserted and removed holding the plastic base of the plug, NOT by pulling on the cord. Lastly, the keyboard is mounted on a "floating" bracket (see how it moves?) and is very delicate. Be careful not to lean elbows on it while working elsewhere on the machine.

### 2.1 SIGNAL VS CONTROL

The Buchla synthesizer makes a complete distinction between signals and control voltages. They are two separate electrical systems and cannot be mixed or interchanged. Each even has its own type of patchcords and jacks.

#### 2.1.1 Signals

All signals are AC voltages and are associated with mini-phone-plug jacks and patchcords. These are the grey patchcords and metal mounted jacks. All signal input and output is through these jacks and they are all clearly labeled as to which are inputs and which are outputs. Care should be taken NOT to plug inputs into inputs or outputs into outputs because it leads to unpredictable results (ie. the synthesizer may blowup).

### 2.1.2 Control Voltages

Control voltages, on the other hand, are all DC voltages and use the coloured banana-plug patchcords and jacks. The jacks are colour coded as follows:

1. Black jacks are inputs (with the exception of the outputs of the VOLTAGE PROCESSORS).
2. Blue or purple jacks are outputs. There is no difference between blue or purple.
3. Red jacks are for pulses and are labeled as inputs or outputs.

Again, inputs cannot be connected to inputs and outputs cannot be connected to outputs. The banana cords can be stacked together allowing distribution of one output to a number of inputs, but a number of outputs cannot be connected to one input.

It is important to realize, with all control voltage inputs, that the pot associated with whatever is being voltage controlled is still functional. The voltage indicated by the setting of the pot is always being added to whatever control voltage is present.

### 2.2 POWER SWITCH

The power switch is located on the back of the synthesizer in the lower left-hand corner. It is an unlabeled silver switch (up is "on", down is "off"). Best to go around and have a look for it the first time. When reaching around from the front be careful not to disrupt any of the wires connected near there.

### 2.3 OUTPUT

Now that you know where the power switch is you probably want to know how to get a signal out of the Buchla. Rather than covering the final output stages of the synthesizer now, (it would be rather boring with nothing to put through them) here is a quick way to get a signal out to the jacks labeled "Buchla Outputs" on the patchbay.

The Buchla has four output channels. These are most easily accessed through the jacks, labeled INPUTS NORMALED TO,

located just below the eight blue sliders in the middle of the top panel. These jacks form two sets of inputs to the four output amplifier channels. (Ignore the "NORMALED TO" part for now.) The blue sliders are attenuators for each input and the red knob to the right of these, labeled PROGRAM LEVEL, is the master output level control. In order for the meters to function properly the eight switches in the top right-hand corner, labeled MONITOR SELECT, should all be in the down position.

#### 2.4 THE MISSING COMPUTER

The Buchla 200 series synthesizer is designed to be interfaced with a special computer designed by Buchla. Since U.Vic. does not have one of these computers there are a few things on the synthesizer which have no function at this time. There are 4 switches in various locations labeled CONTROL with three positions; REMOTE, BOTH, and LOCAL. These must be kept in the lowest, or LOCAL, position (the LED beside each of them should be off). Otherwise the nonexistent computer will attempt to take control and nothing will happen. The two switches labeled AUTO-TUNE do not function and can be ignored. Lastly, the three rows of jacks in the recessed bands across the synthesizer have no function without computer control and can also be ignored.



### 3. SIGNAL GENERATORS

#### 3.1 OSCILLATORS

The Buchla has four oscillators arranged in two identical pairs. Each pair forms a module labeled PROGRAMMABLE COMPLEX WAVEFORM GENERATOR and they are located just above the keyboard. Each module contains a PRINCIPAL OSC., with various waveshaping controls, and a MODULATION OSC. which has some pre-patched connections to the PRINCIPAL OSC.. Both have signal outputs and control voltage inputs, and the MODULATION OSC. has a control voltage output as well. It is important to realize that both these oscillators can be used completely independently of one another. They can both produce audio and sub-audio frequencies and their roles as "PRINCIPAL" or "MODULATION" oscillators are set up as a convenience and not as a requirement.

#### 3.1.1 Principal Oscillator

##### 3.1.1.1 Outputs

The PRINCIPAL OSC. occupies the right-hand half of each module. It has four signal outputs across the top. The sine and square wave outputs are unaffected by any of the waveshaping controls or inputs from the MODULATION OSC. except pitch modulation. The two FINAL outputs are identical variable waveshape outputs and represent all control voltages influencing the oscillator.

##### 3.1.1.2 Phase lock

The PHASE LOCK jack, just below the signal outputs, is an input with attenuator pot which phase locks the frequency of this oscillator with the frequency of the input signal. If the frequency of the input signal is close to or lower than that of the oscillator it will cause the oscillator to "lock" onto the frequency of the input signal. If the input

has a higher frequency the oscillator will "lock" onto the nearest sub-harmonic of the input frequency. This can be used to eliminate "beating" between two oscillators tuned in unison, octaves or harmonics.

### 3.1.1.3 Frequency control

Beneath the PHASE LOCK input and functionless AUTOTUNE switch are the coarse and fine tuning frequency control pots. The scale on the coarse tuning knob indicates frequency in Hertz and marks off octaves starting from "A"=27.5 Hz. (the lowest "A" on the piano). As indicated by its calibration the coarse tuning pot gives the oscillator a range of about eight octaves but this can be greatly extended with a control voltage. The fine tuning pot has a range of about a fifth. The two LED's beside the pitch control pot on each oscillator are meant for use with the computer and, despite the fact that they occasionally turn on and off, they indicate nothing.

### 3.1.1.4 Pitch modulation

Both the PRINCIPAL and MODULATION oscillators have the same three frequency modulation inputs. These are the jacks just beneath the tuning pots. The jack with attenuator pot on the left accepts an AC signal for frequency modulation. This is one of the few places on the synthesizer where a signal can be used as a control voltage. The banana-jack in the centre has a special attenuator which inverts the input signal if it is turned to the left (-) side. This pot, and others like it elsewhere on the machine, are extremely sensitive and give a very wide range of voltage control. The jack on the right, labeled KEYBOARD has a fixed sensitivity of 2.4 volts per octave which is the same as the output of the keyboard. In other words, if you want the keyboard to play recognizable intervals, this is the jack to use.

### 3.1.1.5 Waveshape controls

Along the right-hand side of the PRINCIPAL OSC. are some fairly elaborate waveshaping controls. These are split into two sections labeled HARMONICS and TIMBRE. It is worth noting that these controls are labeled according to the audible effect they produce and not the changes in waveshape they

cause. These changes are quite complex and are best observed on an oscilloscope for those who are interested. It is quite sufficient just to associate these controls with their audible effect.

The HARMONICS section consists of two controls, each with an unattenuated control voltage input. The top pot, labeled SYMMETRY, determines the mix of odd and even harmonics in the final output. The LED indicator will get brighter as the odd harmonics get stronger. The ORDER control emphasizes either low or high harmonics. Its indicator gets brighter as more high harmonics are added. This determines the relative "brightness" of the sound.

The bottom section labeled TIMBRE simply determines the strength of the harmonics present in the final output. With the TIMBRE pot turned all the way to the left the final output is almost a sine wave. As the pot is turned to the right the harmonic content, as determined by the SYMMETRY and ORDER controls, increases. The timbre control has a control voltage input with an inverting attenuator the same as on the pitch modulation input.

These three waveshape controls have a tremendous effect on the final output signal and should be experimented with to discover the wide range of timbres this oscillator can produce before any signal processing.

### 3.1.2 Modulation Oscillator

#### 3.1.2.1 Outputs

The MODULATION OSCILLATOR, on the left side of the oscillator module, also has four outputs across the top much like the PRINCIPAL OSC.. From left to right: a triangle wave output, a control voltage output, and two identical signal outputs. The waveshape for all but the triangle wave output is selected by the three position switch just below the outputs on the right labeled WAVESHAPE. The waveforms are as indicated; sawtooth, square, or triangle. (Note: The saw-

tooth output is actually the reverse of what the label shows. It has a short rise time and a long decay.)

### 3.1.2.2 Frequency control

To the left of the WAVESHAPE switch is a RANGE switch which sets the frequency range of this oscillator. It has two positions, (HIGH and LOW), with a difference between them of about six octaves plus a tritone. The AUTOTUNE position, of course, has no function. (One wonders what sort of melodies AUTO-TUNE might play.)

The coarse and fine tuning pots and the frequency modulation inputs are all exactly the same as on the PRINCIPAL OSC.. The scale on the coarse tuning knob indicates frequencies (in Hz) for the LOW and HIGH ranges and, in its HIGH range, is calibrated the same as the PRINCIPAL OSC.. This knob then, gives a range of about eight octaves in each of its two ranges. With a control voltage the frequency of this oscillator can be driven up over 20,000 Hz and down to .0003 Hz. (One cycle every two and a half hours.) Be aware that the scales on these pots are only a rough guide and it's best to use a frequency counter or your ear to do accurate tuning.

### 3.1.3 Pre-Patched Connections

Between each pair of oscillators are the switches and pots which control the "pre-patched" connections between the MODULATION OSC. and the PRINCIPAL OSC.. The switches are "on" to the left and "off" to the right. The appropriate LED will light to indicate a connection is made.

The top switch is a phase lock FRCM the PRINCIPAL OSC. TO the MODULATION OSC. as the arrow indicates. This is primarily intended to be used to prevent "beating" between the two oscillators when they are tuned to a unison or in harmonics but can be used for other effects as well.

The remaining controls are all from the MODULATION OSC. to the PRINCIPAL OSC.. The second switch down is for amplitude modulation of the PRINCIPAL OSC.. The next switch is for pitch modulation and the bottom switch is for timbre modulation. The modulating signal is an AC signal the waveshape of which is selected by the WAVESHAPE switch.

The pot labeled MOD. INDEX controls the **degree** of modulation. One of the advantage of these pre-patched connections is that the MOD. INDEX is voltage controllable (by means of the control voltage input with inverting attenuator pot). This allows voltage control of the degree of amplitude, pitch, or timbre modulation between these two oscillators. There are other ways to do this (see DUAL VOLTAGE PROCESSORS) but the pre-patched connections make it very simple.

All these controls may be used together or in any combination but the modulation INDEX is the same for all of them at any one time. (Note: Even with all the modulation switches "off", if the MODULATION INDEX is turned up high, some of the signal from the MODULATION OSC. leaks through to the PRINCIPAL OSC.. If no modulation is desired the MOD. INDEX should be turned down, as well as turning off the modulation switches.)

### 3.2 NOISE GENERATOR

The only other signal generator on the Buchla is the NOISE SOURCE. It is located at the top of the SOURCE OF UNCERTANTY module which is just to the right of the oscillators. This noise generator consists of three different outputs labeled -3dB, FLAT, and +3dB. Each output has two identical jacks. The FLAT output is known as "pink noise" which is defined as random frequencies and amplitudes with equal energy per octave. The +3dB output is a "white noise" source. White noise has equal energy at any frequency. The -3dB output is just a minus 3dB per octave noise source.

## 4. CONTROL VOLTAGE GENERATORS

### 4.1 ENVELOPE GENERATORS

The QUAD FUNCTION GENERATOR, located on the left-hand side of the third panel down, contains four identical envelope generators (A, B, C, and D). Each can generate two or three segment envelopes with voltage controllable attack and decay rates. The outputs of these are usually patched directly into the voltage controlled amplifiers beside them by means of the black plastic "shorting bar" plugs. While these connectors are very useful, it is important to realize they can be removed and the two modules will function completely independently.

#### 4.1.1 Pulse Input

In the top left corner of each envelope generator is a pulse input allowing external pulses to trigger the envelope. Beside it is a trigger mode select switch. In its top position the envelope generator will repeatedly trigger itself at the end of each envelope. In the lowest two positions an external pulse is required to trigger the envelope. In the middle position the envelope will trigger and complete its cycle upon receipt of any pulse voltage. In the bottom position the envelope will trigger and remain at its peak level (+10 volts) for the duration of the pulse. The decay cycle will only begin when the pulse releases. This is best demonstrated by using the pulse output from the keyboard and experimenting with the difference between these two lower positions.

#### 4.1.2 Voltage Control

Beneath the pulse input are the control voltage inputs for attack and decay rates. As the control voltage increases so do attack or decay times. The two pots on each generator are for manually setting attack and decay rates. The scale on these pots indicates seconds and is more or less accurate. (Actually the maximum attack or decay time without voltage control is about 9 seconds.)

NOTE: At the time of writing there are a few "quirks" in this module. The maximum attack and decay times are not the

same for all of the envelope generators. Generators "A" and "P" seem to establish the "norm" with maximum attack or decay times of 9 seconds without voltage control and just over 4 minutes with a control voltage of +14 volts (maximum output of the voltage processor). Envelope generator "C" also has 9 sec. rates without voltage control but its attack time can only be extended up to 1 min. 20 sec.. With a maximum setting on the decay pot and a +14 volt control voltage the envelope will not release! It remains at its peak level until the control voltage is turned down. Envelope generator "B" is the oddest of the lot. Its maximum attack time without voltage control is only about 6 seconds but its decay time is about 15 sec.. With a control voltage its attack time can only be increased to 21 seconds and, like generator "C", its decay cycle won't function under maximum voltage control. For the most part these differences won't be of concern but be aware of them if particularly accurate envelopes are required.

#### 4.1.3 Outputs

Each envelope generator has two outputs on the right. The red output generates a pulse at the end of each envelope. The blue output is the envelope control voltage output (0 to +10v). The red LED fades on and off to indicate the relative level of the output voltage.

#### 4.1.4 Quadrature

The yellow LED's come on to indicate when two generators are in QUADRATURE mode. The yellow switches in the bottom left-hand corner of the module link two envelope generators (A and B or C and D) in a "quadrature" relationship. This means that if the TRIG A switch is "on" (up) envelope generator "B" will be triggered, regardless of the position of the trigger select switch, whenever envelope generator "A" reaches the peak of its cycle. (The end of its attack segment.) The TRIG B switch creates the same situation between envelope generators "C" and "D". (Granted, this labeling is a little confusing.)

#### 4.1.5 Or Outputs

To the right of the QUADRATURE switches, beyond the CONTROL switch, are two control voltage outputs labeled OR'S. These outputs represent two "logical or" circuits which "or" the "A" and "B" envelope outputs and the "C" and "D" envelope outputs. This means the top jack represents either the "A" envelope output voltage or the "B" envelope output voltage whichever is greatest at any given time. The pot is an attenuator on the "B" voltage so with it turned all the way down (to the left) the output will be exactly the same as the "A" generator output. With it turned all the way up (to the right) the output is as stated..."A" or "B". The bottom pot and jack perform the same function with the "C" and "D" envelope generators. Both the OR outputs and the QUADRATURE switches can be used to create complex multi-segment envelopes.

#### 4.2 ENVELOPE FOLLOWER

##### 4.2.1 Outputs

The TRIPLE ENVELOPE FOLLOWER module, located in the middle of the third panel, consists of three envelope followers arranged vertically. At the top each has two identical control voltage outputs which represent the amplitude of the input signal. (The higher the amplitude the greater the output voltage.) Below these are PULSE OUTPUTS which can be set to trigger either just at the beginning of each envelope or also with each small peak in amplitude. The LED beside each PULSE OUTPUT will flash with each pulse. Beneath the SIGNAL INPUTS are the PULSE RESPONSE switches. In the SUSTAINED position a pulse will be triggered and remain "on" whenever the input signal is above a certain amplitude. In the TRANSIENT position the PULSE OUTPUT is always a short pulse triggered by any amplitude peak in the input signal.

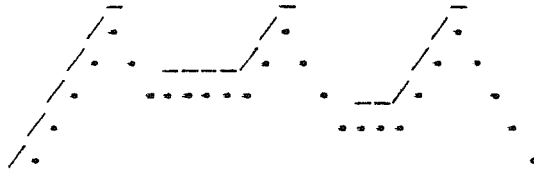
##### 4.2.2 Decay Time

The DECAY TIME pots, labeled in seconds from .1 to 5, are used to increase the decay time of the control voltage outputs. They also affect the PULSE OUTPUTS by increasing the pulse length when in SUSTAINED mode and by preventing re-triggering until the decay time has elapsed when in the TRANSIENT mode. In addition to adding decay time to single envelopes these pots can be used to "smooth out" an irregular envelope as shown below:

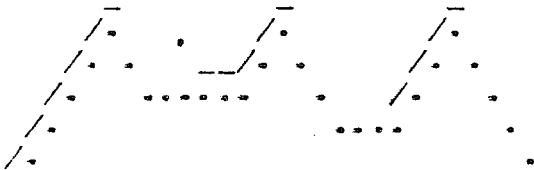


ENVELOPE FOLLOWER OUTPUT

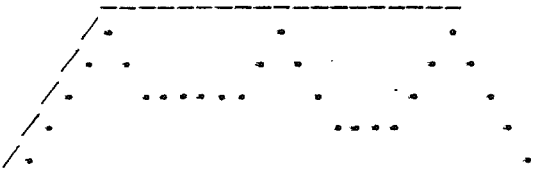
... = amplitude of input signal  
--- = control voltage output



DECAY TIME SET TO .1 SEC.



DECAY TIME SET TO 2 SEC.



DECAY TIME SET TO 5 SEC.

### 4.2.3 Sensitivity

The SENSITIVITY pots, at the bottom of this module, determine just what one might expect; the sensitivity of the envelope follower to the input signal. They establish what input level is required to trigger the PULSE OUTPUTS and also set the relative control voltage output level.

Both the SENSITIVITY and DECAY TIME controls require precise adjustment and it usually takes some experimenting with them in order to achieve the desired results. In its TRANSIENT position, the PULSE RESPONSE switch increases the sensitivity of the envelope follower and often needs to be compensated for if the PULSE RESPONSE is changed.

### 4.3 RANDOM VOLTAGE GENERATORS

The Buchla has three different "random" control voltage generators, contained in the SOURCE OF UNCERTAINTY module, located just to the right of the oscillators. All have inputs on the left and outputs on the right. The LED beside each output indicates the relative strength of that output voltage.

#### 4.3.1 Fluctuating Random Voltages

The FLUCTUATING RANDOM VOLTAGES module supplies two separate, but similar, control voltages. Each generates a gradually changing random voltage. Both the voltage itself and the rate of change are constantly changing but the "probable rate of change" can be set using the pot beside each output. The scales on these pots don't have too much meaning because, despite the fact that they are the same, the lower output actually varies at a considerably faster rate than the top output even when the pots are at the same setting. The "probable rate of change" can be voltage controlled through the control voltage input beside each pot.

#### 4.3.2 Quantized Random Voltages

The QUANTIZED RANDOM VOLTAGES module offers two distinct but related outputs. Both outputs generate "stepped" random voltages meaning their output changes from one voltage to another in discrete steps. Each change must be triggered by a pulse presented to the pulse input jack on the right. An input pulse will cause both outputs to change to another voltage. (It is possible the next voltage chosen might be the same as the last voltage in which case no change would be noticed.)

The QUANTIZATION pot, which is voltage controllable through the input beside it, determines the value of "N" in each of the short equations beside the outputs. Under voltage control the value of "N" increases from where the pot is set as the control voltage increases. The top output offers "2 to the Nth" possible voltages ("states") for output. If the pot is in its lowest position, ("1"), the output will change back and forth between two different voltages. In its highest position sixty four different voltages, (between 0 and +10 volts), can be generated. With each input pulse one of these voltages is selected, at random, for output. The lower output offers "N + 1" different voltages.

The DISTRIBUTION graph beside each output indicates the "weighting" of the random choice. For the top output there is equal probability that the next voltage will be any one of the possible states. The graph for the lower output indicates that there is a greater probability that the next voltage will be in the middle range and less chance that it will be a high or low voltage.

NOTE: There seem to be very small places between each different setting of the QUANTIZATION pot where the output changes from distinct voltages into garbage. If you are getting a static filled "noise-like" signal, when you don't expect it, this could be the cause.

#### 4.3.3 Stored Random Voltages

Similar to the QUANTIZED RANDOM VOLTAGES, the STORED RANDOM VOLTAGES also require a pulse to change voltages but they generate completely "random" voltages. The DISTRIBUTION graphs again indicate probability distribution. From the top output there is equal probability that the next voltage could be anywhere between 0 and +10 volts. The probability

distribution of the bottom output is determined by the pot and control voltage input. At its LOW setting the output will contain mostly low voltages and in its HIGH position mostly high voltages.

#### 4.4 KEYBOARD

The Buchla's KINESTHETIC INPUT PORT provides a variety of useful control voltages in addition to the standard keyboard voltages. The keyboard itself is a digital keyboard which has its own digital to analog converters in order to generate DC control voltages. Because of this the keyboard must be "woken up" each time the synthesizer is turned on by flipping the RESET switch in the left hand corner of the keyboard module. The keyboard outputs will generate garbage as the switch is held up but will function properly once released. It is important **not** to touch any keys while doing this because the RESET switch actually establishes the "norm" condition of the keyboard and if a key is being touched while resetting the keyboard that key will not function when touched later. (This can be useful for creating "fool-proof" scales or arpeggios.)

The keyboard is designed with computer interfacing in mind and, as a result, some controls don't function at this time. The eighteen square touch sensitive "keys" that run across the middle of the panel, the two leftmost CURSER CONTROL keys on the right-hand side, and the CLOCK UP knob under the RESET switch all have no function.

##### 4.4.1 Keyboard Voltages

The next section to the right of the RESET switch contains all the keyboard activated control voltage sources. From left to right these function as follows:

1. The pulse output generates a 3 volt pulse whenever a key is touched and **continues** to output 3 volts for as long as the key is touched.
2. The PRESSURE output offers a voltage representing pressure on the keyboard at any given time. The range of this output can be adjusted using the SENSITIVITY pot just below the pulse output. The keyboard must be reset after any change in the SENSITIVITY setting.

3. Below the PRESSURE output is the BEND output. This provides a voltage corresponding to the side to side motion of the "floating" keyboard. It generates a positive voltage as the keyboard is moved to the right and a negative voltage as it is moved to the left.
4. The next unlabeled output is the plain keyboard voltage. It outputs a voltage corresponding to the last key touched. (Based on 2.4 volts per octave.)
5. The next output provides, as labeled, the sum of the keyboard voltage plus the BEND voltage. In other words its just another keyboard voltage output with the added PITCH BEND feature. The degree of PITCH BEND is set by the pot labeled BEND which is an attenuator on the amount of BEND voltage mixed in with the keyboard voltage. The BEND pot does not affect the straight BEND output.
6. The last output is the same as the previous except it includes portamento. The rate of portamento is set by the PORTAMENTO pot and is voltage controllable through the input beside the pot. Think of this pot as an attenuator on the degree of portamento with its farthest left position being minimum attenuation (maximum portamento) and its farthest right position being maximum attenuation (no portamento).

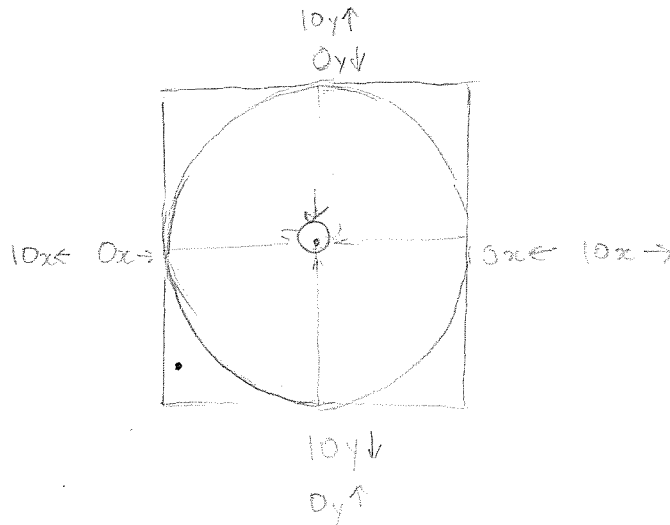
#### 4.4.2 Preset Voltages

There are four "constant" voltage sources, labeled PRESET VOLTAGE SOURCE, each with a possible range of 0 to +10 volts. These are set with the pots below each output. The output labeled PRESET OUT gives the voltage of whichever preset is indicated by the LED's. The presets are selected by touching one of the square "keys", labeled MOD SELECT, in the right-hand corner. The top three "keys" correspond to the first three presets and the farthest right in the second row to the fourth.

The KEYBOARD VOLTAGE SHIFT switch allows for upward transpositions of the keyboard voltage. In the middle position the keyboard is in its normal range. In the OCTAVE position the keyboard will be transposed up by one or more octaves depending on which preset is selected with the MOD SELECT keys. (The keyboard is transposed up one octave for each preset move to the right.) In the PRESET position the keyboard is transposed up by the setting of whichever preset is selected.

### 4.4.3 Joystick

The 2D VOLTAGE SOURCE is a "joystick" device which generates 0 to +10 volt voltages as indicated by the arrows and determined by the position of the stick. If the stick is in the lower right-hand corner the outputs will be as follows: (left to right) X to the left = 0v, X to the right = +10v, Y up = 0v, and Y down = +10v. As the stick is moved up the right-hand side the "X" voltages do not change but the "Y up" will gradually increase and the "Y down" will gradually decrease.



## 5. SIGNAL PROCESSORS

### 5.1 FINAL OUTPUTS

As mentioned previously, the Buchla has four output channels. All access to these is through the top panel on the synthesizer. Across the top are VU meters which indicate the output level for each channel.

#### 5.1.1 Inputs

Below the left-hand meters are four identical input modules which offer tone controls, reverb, and voltage controlled output channel assignment. Despite the fact that these inputs are numbered 1 through 4, each one can send a signal to any of the four output channels. These input modules act much like a "4 in, 4 out" mixer.

At the top of each input are BASS and TREBLE tone controls. Be careful of these! They are easy to forget about and yet can have considerable effect on the output signal. Beneath these, on the right, is a REVERB send pot which determines the level of signal from each input being sent to the reverb generator. With this pot turned "up" the signal is sent to all reverb channels regardless of which output the signal is assigned to. This allows the main signal to be present in only one or two speakers and still have the reverberated signal in the other speakers. This kind of setup can create some reasonably realistic acoustic environments.

Beside the REVERB pot is the ASSIGN control which determines to which output channel(s) the signal will be sent. The LED's around this pot indicate the strength of signal going to each output channel ("A" through "D" going clockwise from the lower left-hand corner. Channel assignment can be voltage controlled from the two inputs at the bottom of each input channel. The "X" input controls panning from side to side (as the voltage increases the signal pans from channel "A" to "D" and from channel "B" to "C"). The Y input controls panning from front to rear (as the control voltage increases the signal pans from A to B and from D to C).

The large red knob on each input channel is the attenuator on the input signal. As with the inputs controlled by the blue slider attenuators, the master output level is

controlled by the pot on the far right labeled PROGRAM LEVEL.

### 5.1.2 Reverb

The REVERB RETURN pots, just to the left of the PROGRAM LEVEL pot, determine the amount of reverb signal present in the final outputs. The two pots allow separate control over reverb in the front two channels (B and C) and the rear two channels (A and D). Unfortunately, reverberation is one of the few aspects of this machine which is not voltage controllable.

### 5.1.3 Headset Monitoring

In the top right-hand corner are controls for monitoring Buchla output with headphones. Just above the PROGRAM LEVEL pot is the headset output jack which takes a standard stereo phone plug. The switch beside it selects for output either the "front" two channels or the "rear" two channels or a mix of all four. The two pots to the left are volume controls for right and left sides. The red MONITOR LEVEL pot is the master volume control for the headset output.

The eight switches labelled MONITOR SELECT determine the source of the headset signal. With all eight switches in the down (off) position the MONITOR output is the same as the Program output. If one or more switches are in the up (on) position then the MONITOR signal is only from whichever switches are "on". The TAPE 1 and TAPE 2 switches present to the monitor the signals from the "Synthesizer Patchbay" input jacks on the studio patchbay. The REVERB switch selects the reverb signal for output to the monitor. It is not affected by the REVERB RETURN pots only by the reverb send pots on each input channel. The SYS switch has no function except to cut off the PROGRAM signal to the headphones. The four red switches correspond to the four main input channels. There are LED's which light to indicate which of these possible sources are being sent to the monitor output.

The signals from the "Synthesizer Patchbay" inputs on the studio patchbay can be accessed on the synthesizer from the jacks labeled TAPE 1 OUTPUTS and TAPE 2 OUTPUTS located below the eight blue sliders. The first four inputs are connected to TAPE 1, the last four to TAPE 2. The TAPE outputs are normaled to the inputs directly above them which are at-



tenuated by the blue sliders. This means any signal presented to the "Synthesizer Patchbay" inputs can be fed into the Buchla outputs just by lifting the appropriate slider.

Note: The normaled connections within the synthesizer are not reliable and it might be best to patch from the TAPE outputs into the inputs above them if you need to use this setup.

The jacks labeled AUXILIARY OUTPUTS in the lower right-hand corner have no function in the studio but, with a special edge connector, these can be used as outputs when the synthesizer is out of the studio. Below these, the jacks labeled MULTIPLE CONNECTIONS are two sets of four jacks wired together to allow splitting of a signal for distribution to more than one place. These should not be used for mixing two or more signals together.

## 5.2 MIXERS

The Buchla has two identical mixers located in the centre of the second panel down. Each has six inputs and two main outputs as well as a monitor output. At the bottom of each mixer is a microphone input with preamplifier. The microphone input jack takes a phono plug. Beside it is a switch for selecting "high" or "low" impedance according to the microphone to be used. To the right of the IMPEDANCE switch are a switch and pot which set the gain of the preamp. The switch has three different ranges but most microphone signals need to be boosted the maximum amount. The microphone input can also be used for a signal from some other source such as an electric guitar or electric piano.

Just above the preamp are the six signal input jacks ("A" through "F"). Above these are six yellow MONITOR switches. Putting any of these switches in the up position sends the signal from that input to the MONITOR output on the mixer. The six blue switches, when up, send the respective signal to the main SIGNAL outputs. The sliders are attenuators on the input signals going to the SIGNAL outputs. They have no effect on any signal going to the MONITOR output.

Above the four centre sliders are ASSIGNMENT pots which pan the signal between the "right" and "left" outputs. The input channels on either side of each mixer ("A" and "F") feature voltage controlled assign. Without any control voltage channel "A" is assigned to the left output and channel "F" goes to the right output. As a control voltage increas-

es the signal pans to the other output channel. The two LED's below each control voltage input indicate which channel the signal is going to.

Across the top of each mixer, going from right to left, are two "right" channel output jacks, two "left" channel outputs, the MONITOR output, and two EXPANSION IN jacks. These last two jacks are actually a pair of inputs without attenuators, assign control, or access to the MONITOR output. The jack on the right goes directly to the "right" output and the left jack goes to the "left" output. These inputs can be used to link the two mixers to form one "12 in, 2 out" mixer. To do this simply patch the outputs of one mixer into the EXPANSION IN inputs of the other.

### 5.3 VOLTAGE CONTROLLED AMPLIFIERS

The Buchla's four voltage controlled amplifiers are located in the QUAD LOPASS GATE module just beside the envelope generators. The labeling refers to the fact that these VCA's can function as "lop-pass" filters, signal "gates" (VCA's), or a combination of the two. The switches at the bottom of this module, determine what mode each amplifier/filter is in. The four pots running diagonally across the module are the gain controls for each amplifier. They also set the filter cutoff frequency when in LOPASS mode.

The signal inputs are across the bottom of the module and the control voltage inputs run up the left-hand side. These are usually connected directly to the envelope generator outputs with a "shorting bar". Remember that these bars are removable and it is worthwhile to experiment using control voltages from other than the envelope generators. Note that the "shorting bar" must be removed in order to apply any other control voltage to a VCA. A control voltage cannot be plugged into the right-hand side of a "shorting bar" because this would mix two control voltages together.

Across the top of this module are the signal outputs. There are two identical outputs for each signal input plus one jack which is a mix of all four VCA outputs.

## 5.4 VOLTAGE CONTROLLED FILTERS

The Buchla has two voltage controlled filters contained in the DUAL VOLTAGE CONTROLLED FILTER module to the right of the mixer. Both are variable width bandpass filters featuring voltage controllable bandwidth. Each has inputs across the top and two signal output jacks on the right.

Leftmost is the signal input jack. Beside it is the bandwidth control voltage input (with inverting attenuator pot below it). The bandwidth adjust pot is in the lower left hand corner. In the centre of each filter is an FM input which allows centre frequency modulation with an AC signal. The pot below it is an attenuator on the amount of FM. This input is very similar to the FM input on the oscillators. To the right is the control voltage input for centre frequency control. It also has an inverting attenuator on the input voltage. The CENTRE FREQUENCY pot, in the lower right-hand corner, manually sets the centre frequency and offers a range from 30 Hz to 15 KHz. Of course, this can be extended with a control voltage. The small "Q" control knob determines the "Q" or "resonance" of the filter. (Watch out for this pot because it is impossible to tell where it is set by looking at it.)

## 5.5 PROGRAMMABLE SPECTRAL PROCESSOR

The PROGRAMMABLE SPECTRAL PROCESSOR is an elaborate set of filters with a number of different outputs and special functions. Perhaps its most obvious function is that of a sixteen band "graphic equalizer". The sixteen bands are labeled in hex (0 through F) at the top and bottom of the module and the centre frequency of each band is indicated above each slider attenuator.

### 5.5.1 Attenuator Outputs

The signal input jacks, in the centre beneath the sliders, offer the choice of putting a signal into the eight even numbered bands, all sixteen bands, or the eight odd bands. (Note that these are just the even or odd numbered bands on the equalizer and have no correspondence to even or odd harmonics.) The ATTENUATOR OUTPUTS at the top of the module also offer "even", "odd", or "all" signal outputs. With a signal patched into the "ALL" signal input and taken out through the "ALL" attenuator output the module functions just as a sixteen band graphic equalizer. Note on the scale

for the attenuators that 0 dB is just below the top range of the sliders and that a slider at the very top is actually giving a 6 dB boost to frequencies in that band. An attenuator at the very bottom will completely cut off any signal in that frequency band.

The signal output jacks directly above each attenuator offer the signal present within that frequency band. These outputs are not affected by the attenuator's positions. The COMB FILTER outputs offer the signals from either all the "even" or all the "odd" bands and are also unaffected by the attenuators.

### 5.5.2 Control Voltage Outputs

The control voltage outputs labeled ENVELOPE OUTPUTS are envelope follower outputs for each frequency band. In other words, the voltage from these outputs represents the amplitude of the signal present within each band. The switch in the upper left-hand corner selects "long" or "short" envelope decay times. These outputs are not affected by the positions of the attenuators.

### 5.5.3 Programmed Outputs

The SPECTRAL PROCESSOR can be voltage controlled in a variety of ways. The results of any control voltage manipulation are presented to the PROGRAMMED signal outputs. It is possible to "sweep" through the various frequency bands (much like a bandpass filter can "sweep" the frequency spectrum) using the pot on the far left of the PROGRAM CONTROL section. This pot can be voltage controlled through the control voltage input labeled FREQ.. The small knob beside the input is an inverting attenuator the same as others on the synthesizer. On the right is a WIDTH control pot which determines the widths of the sixteen frequency bands. The labeling above each attenuator indicates the approximate centre frequency of each band. Notice that as the bandwidth gets very narrow "gaps" appear between each band and then the bands disappear completely and no signal is passed. At the MAX setting each band is so wide as to encompass the entire frequency spectrum and the FREQ control will have no effect. This pot can be voltage controlled but it has no attenuator on the control voltage.

The LOCAL PROGRAM INPUTS allow individual voltage control of the signal level in each frequency band. With no control voltage the signal for that band is cut off. As a control voltage increases the signal is gradually unattenuated.

#### 5.5.4 Spectral Bias

The pair of knobs and switches labeled SPECTRAL BIAS have a function often associated with a "vocoder" circuit. Unfortunately the labeling on these controls has no relationship to their function and should be ignored. (They were originally intended for a different purpose.) The left switch, when up, patches each "even" envelope follower output into its neighboring "odd" control voltage input. In effect this causes the SPECTRAL PROCESSOR to analyze the signal present at the "even" input and to duplicate its frequency spectrum in the "odd" bands. If the signal presented to the "odd" input has a broad enough frequency spectrum itself the "odd" PROGRAMMED OUTPUTS will match timbres with the "even" signal. The right switch performs the same function going from "odd" to "even". (NOTE: Despite the fact that this is a three position switch, only the top and bottom positions have any function.)

If a microphone signal is the signal being analyzed, a harmonically rich signal from an oscillator can be made to duplicate vowel sounds in speech. (This is known as a "vocoder" patch.) For this to work best the input signal requires special equalization. This is the purpose of the two knobs. When turned to the right they boost the treble range of the "even" and "odd" input signals respectively. Since they affect both the ATTENUATOR and PROGRAMMED outputs they should be turned down (to the left) unless setting up a "vocoder" patch.

Be aware that the BANDWIDTH and FREQUENCY controls are still in effect when using these switches. For best results in a "vocoder" patch, BANDWIDTH should be set fairly narrow and FREQUENCY set to about the same range as the output signal.

## 5.6 FREQUENCY SHIFTER

The panel to the right of the ENVELOPE FOLLOWERS contains a FREQUENCY SHIFTER and a BALANCED (or ring) MODULATOR. Both require two input signals; a carrier or SIGNAL input and a modulating or REFERENCE signal. Both modules employ a form of amplitude modulation to create sidebands which represent the sum of and/or difference between the two input signal's frequencies.

The FREQUENCY SHIFTER has input jacks for carrier and REFERENCE signals but it can also generate its own internal reference signal. In the "down" position the switch connects an internal oscillator for use as the REFERENCE signal. The frequency of this oscillator can be set with the centre pot. It has a range from 0 Hz. to 1000 Hz.. The frequency of this oscillator can be voltage controlled through the CONTROL input with inverting attenuator below it. The internal oscillator also has an AC signal input for FREQUENCY MODULATION. The pot below the MOD. input sets the modulation index. There are two jacks for the SUM output signal and two for the DIFFERENCE signal.

## 5.7 RING MODULATOR

The ring or BALANCED modulator, like the frequency shifter, requires a carrier or SIGNAL input as well as a REFERENCE input. The RING outputs represent the sum of and difference between the two input frequencies. The VARIABLE outputs allow control of the amplitude of the REFERENCE signal or "modulation index". With the AMPLITUDE pot set to "0" the carrier signal will pass unaffected. As the pot is turned to RING sidebands are created and the carrier signal is suppressed. AMPLITUDE can be voltage controlled through the CONTROL input (with inverting attenuator) to the left.

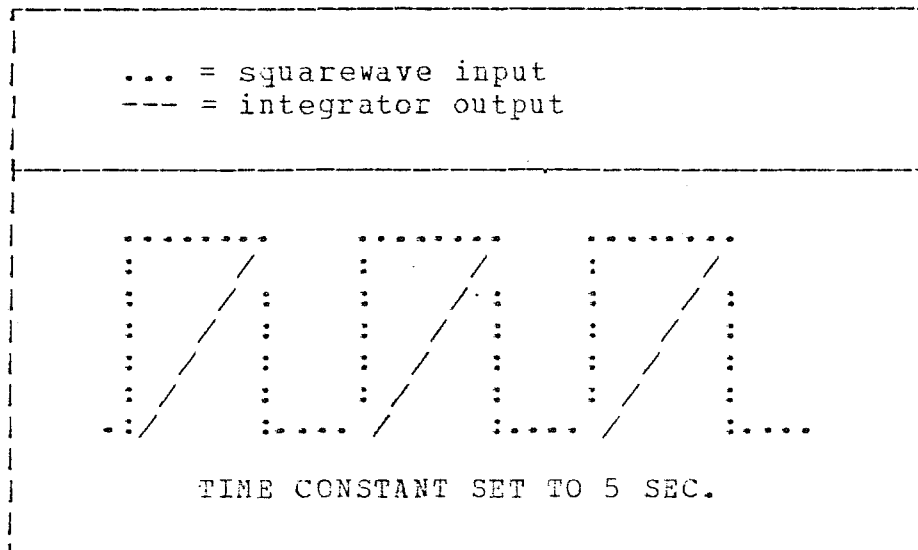
## 6. CONTROL VOLTAGE PROCESSORS

The Buchla has three different devices devoted to control voltage processing. These are the INTEGRATOR, the SAMPLE AND HOLD circuit, and the DUAL VOLTAGE PROCESSORS.

### 6.1 INTEGRATOR

The INTEGRATOR and the SAMPLE AND HOLD modules are located at the bottom of the SOURCE OF UNCERTAINTY panel. The INTEGRATOR integrates between different voltage levels of a "stepped" voltage. For example, it can turn a square wave control voltage into a triangle wave or change a series of stepped random voltages into a gradually fluctuating voltage. It could be used to create portamento between different keys on the keyboard (but the keyboard can do that itself). It accepts a voltage input in the top left jack and the output is the top right jack. The TIME CONSTANT pot determines the rate of integration from .01 of a second to about 10 seconds. This pot can be voltage controlled through the input to the left of it.

#### INTEGRATOR OUTPUT



## 6.2 SAMPLE AND HOLD

The SAMPLE AND HOLD module is very simple and straight-forward. The voltage to be sampled goes in the black CV input in the centre. The pulse input in the lower left-hand corner determines the sampling times. The output voltage is present at the CV OUT jack. The ALT (alternating) control voltage outputs offer every other change in output voltage and the pulse ALT jacks are output pulses corresponding to every other input pulse.

## 6.3 DUAL VOLTAGE PROCESSORS

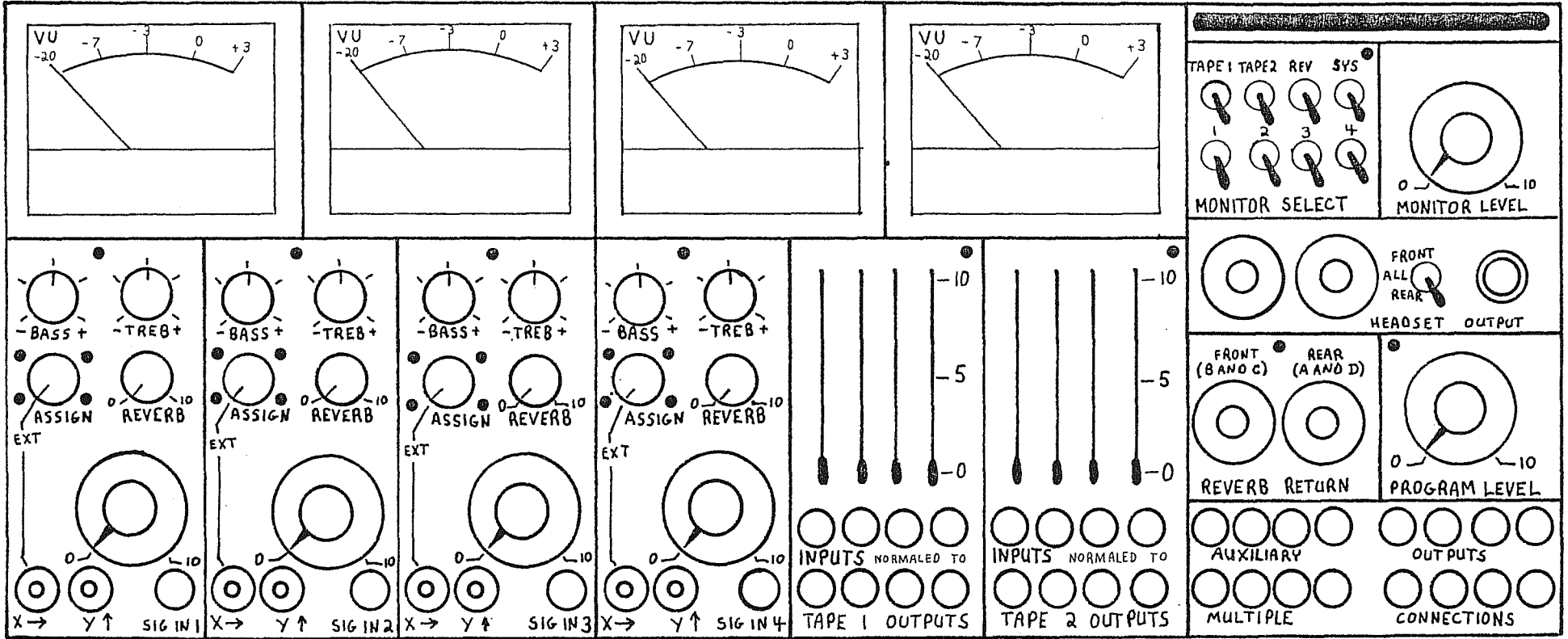
The DUAL VOLTAGE PROCESSOR module consists of two identical control voltage processors. These function something like the control voltage equivalent of a mixer. They can be used in a number of different ways but the equation indicated on the labeling describes what functions they can perform. They accept up to four inputs which combine to produce one final output voltage.

Voltages "Va", "Vb", and "Vc" can be supplied for processing through the control voltage inputs just below their position in the equation. The final voltage output is on the right and its relative strength is indicated by the LED beside it. (Although it is possible to generate negative voltages, the LED just remains "out" below 0 volts.)

As indicated at the beginning of the equation, voltage "a" is multiplied by constant "K". The value of "K" is determined by the first pot and has a range from -1 to +1. In other words this pot can: pass unaffected, attenuate, or invert any voltage present at the "Va" input. The next pot supplies the variable "M" and has a range from 0 to 1. Since voltage "c" is multiplied by "M" and voltage "b" is multiplied by the compliment of "M", when "M" equals 0 voltage "b" is added to the output voltage and voltage "c" is ignored. If "M" equals 1 voltage "c" is added and voltage "b" is cutoff. Inbetween those two values a mix of both voltages is passed to the final output. The value of "M" can be voltage controlled through the jack between the "Vb" and "Vc" inputs.

The final pot adds an "offset" voltage between 0 and +14 volts to the final output. This "offset" will generate a voltage without any other voltage inputs. The "+.5" switch generates a 6 volt voltage to be used as voltage "b" if no





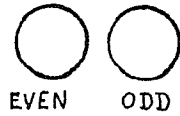
PROGRAMMABLE SPECTRAL PROCESSOR

ENVELOPE  
DECAY  
TIME

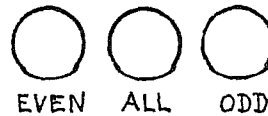


SHORT  
COMBO  
LONG

COMB  
FILTER  
OUTPUTS



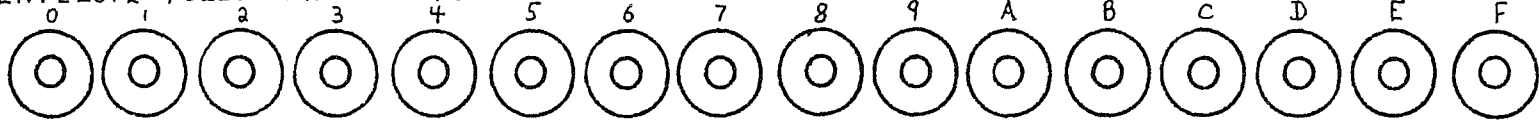
ATTEN-  
UATOR  
OUTPUTS



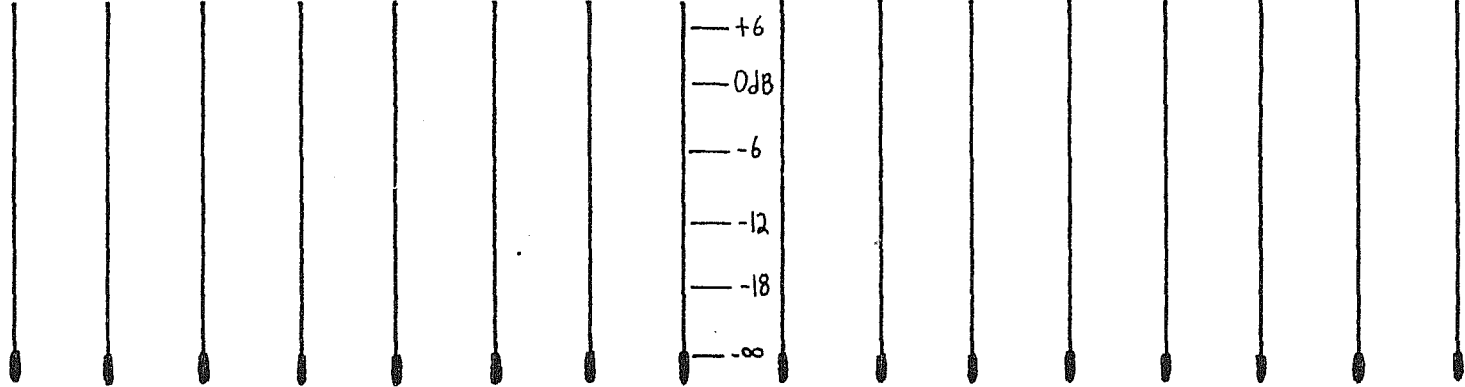
PRO-  
GRAMMED  
OUTPUTS



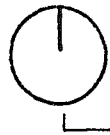
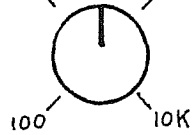
ENVELOPE FOLLOWER OUTPUTS



< 100 150 250 350 500 630 800 1K 1.3K 1.6K 2K 2.6K 3.5K 5K 8K >10K



630 2K PROGRAM CONTROL

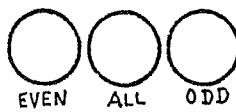


FREQUENCY

WIDTH



SIGNAL INPUTS



LOCAL PROGRAM INPUTS

