THE series 200 ELECTRIC MUSIC BOX

MODEL 248

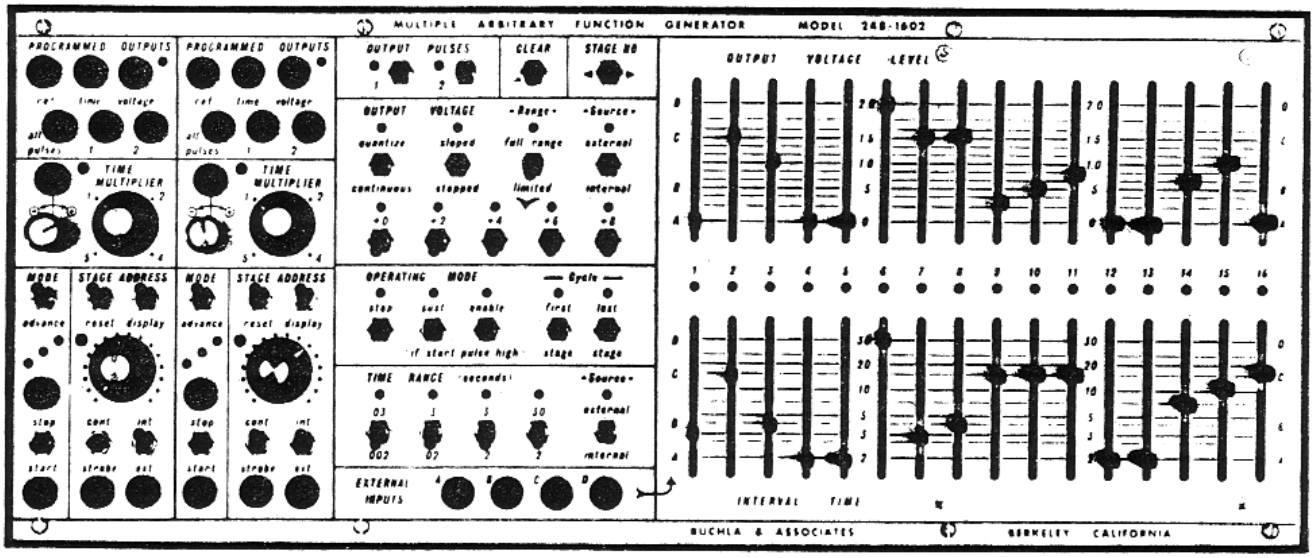
MULTIPLE

ARBITRARY

FUNCTION

GENERATOR

The defining of audio parameters by means of voltages is an important aspect of modern electronic music instrumentation. But the usefulness of this principle is determined by the flexibility and generality of control voltage sources. Since their introduction in 1963, envelope generators and sequencers have comprised the available *programmed* sources of control voltages. Even with a decade of refinement, they possess significant shortcomings. Envelope generators (developed to establish traditional note shapes) produce only a specific class of simple transient functions; sequencers (developed to reduce tape splicing) are limited to stepped functions and rigidly phased outputs. The resultant constraints on our otherwise quite general system led us to conceive this new source of programmed voltages. Unencumbered by engineering expediency or presumed musical asthetics, the model 248 provides the musician with an unprecedented degree of control over the dynamic aspects of his music.



(Version 248-1602 is pictured. Description is on reverse side.)

BUCHLA & ASSOCIATES Berkeley, California

Functions are defined as point-to-point interpolations — the musician enters the voltage and interval time for each segment; the instrument accurately executes the implied interpolation. Times may range from .001 to 120 seconds; maximum number of segments is 16 or 32. Individual segment times and voltages may be governed by external voltages, permitting the implementation of higher ordered modes of voltage control such as indirect analog addressing or voltage control of attack or decay times. Programmed output pulses may accompany the functions in any desired patterns; various additional control modes may be implemented.

Each output section contains a time base multiplier (controlled from the panel or via applied voltages) and the logic necessary to start and stop a local clock via program control, panel switches, or applied pulses. Preset and reset logic is also incorporated; stage selection may be performed manually or by application of control voltages or pulses.

In addition to the main control voltage output, each output section includes a "time" output (voltage proportional to interval time), a "reference" output (descending ramp, with period equal to the interval time), an "all pulse" output (activated for each segment of a function), and two programmed pulse outputs.

The 248 may be regarded as a *memory* with 16 or 32 addressable storage locations, and a number of *output ports*, each of which can output the information contained in any portion of the memory. Each memory location contains the analog and digital information required to define a segment of a time-varying function; an output can produce a function consisting of any desired series of predefined segments. A unique and essential characteristic of the 248 is that it can operate *asynchronously* — that is, different output sections can simultaneously generate identical or dissimilar functions with completely different time scales and/or phase relationships.

The model 248 Multiple Arbitrary Function Generator is offered in several versions, differing in densities but identical in function. Expansion to larger versions may be accomplished at any time.

version number	stages	outputs
248 — 1602	16	2
248 — 1606	16	6
248 — 3206	32	6
248 — 3210	32	10

Version 1602 is recommended for systems that contain other programmable control voltage sources (envelope generators and perhaps sequencers). Larger versions can comprise a system's entire facility for programmed generation of control voltages.

3.16.16 ARBRITRARY FUNCTION GENERATOR

MODEL 248

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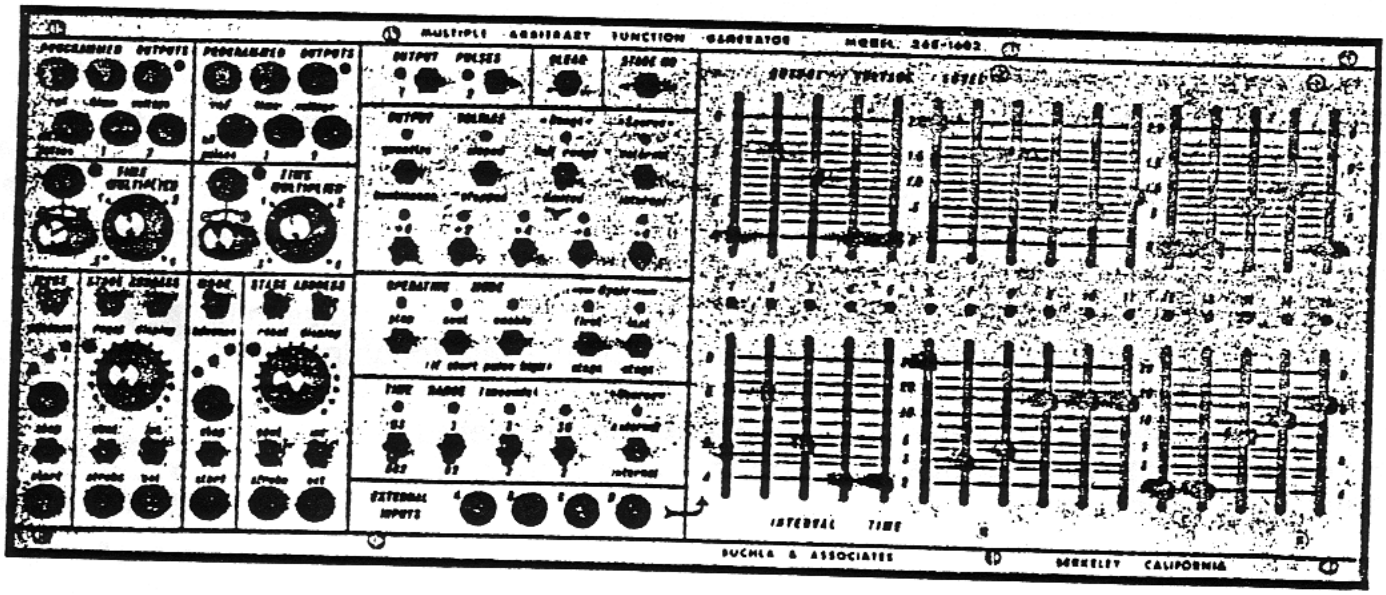

ARBRITRARY FUNCTION GENERATOR 2

Buchla spec sheet

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MODEL 248 MULTIPLE ARBITRARY FUNCTION GENERATOR

Buchla & Associates

Berkeley, California

January 1977

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Version 1602 is recommended for systems that contain other programmable control voltage sources (envelope generators and perhaps sequencers). Larger versions can comprise a system's entire facility for programmed generation of control voltages.

This documentation is in terms of the 248-1602. Models 1606, 3206 and 3210 operate in the same way, the only difference being more stages and outputs. Please read this documentation completely before attempting to operate the 248. Three levels of programming are required to operate the 248. Each level will be described in terms of function and application suggestions. The final section of this documentation gives suggestions on programming procedures which should not be attempted until all operations of the 248 are understood.

2. LEVEL 1 PROGRAMMING

2.a. Output Voltage Levels

Analog control voltages are established by the slide pots. These are initial levels which may be modified by Level 2 digital programming. Access to the voltages are from the Programmed Outputs (Level 3) "voltage" output. The associated LED provides visual monitoring of the output voltage levels.

2.b. Interval Time

These slide pots establish time (period) each stage will be active. Like the Output Voltages, the Interval Times set by these pots may be modified by Level 2 programming. Voltages proportional to Interval Time are available from the "time" outputs on each of the Programmed Outputs.

3. LEVEL 2 PROGRAMMING

This section of the 248 attaches digital commands to the analog voltages set by the slide pots. These commands are given by pushing the spring-loaded switches up; a programmed command will be acknowledged by the associated LED. The command is removed by pushing the same switch down. Each stage of Output Voltage or Interval Time can receive independent sets of commands, which are only attached to that particular stage address.

3.a. Output Pulses

Each time the 248 moves to a new stage, a pulse is sent to the "all pulses" output of each Programmed Output. Pulses may be assigned independently to pulse outputs "1" or "2" by programming Output Pulse command on any

selected stage. If a pulse is to appear at pulse output "1" on a particular stage, that stage is addressed (see section 5) and a pulse command is given. The pulse is then stored at that address and will be activated only when that stage is addressed.

3.b. Output Voltage

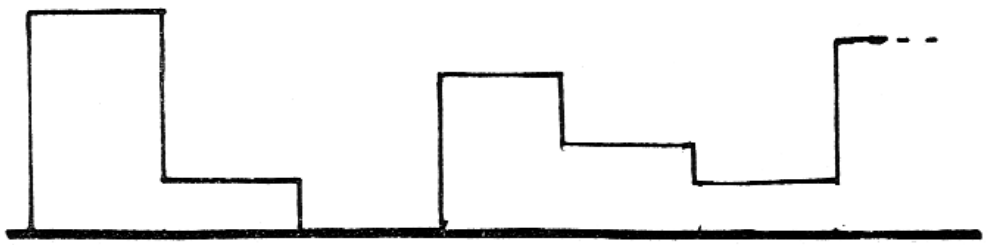
These commands qualify or modify the Output Voltage Levels set by the pots and each stage can carry its own set of commands.

1) "quantize/continuous"

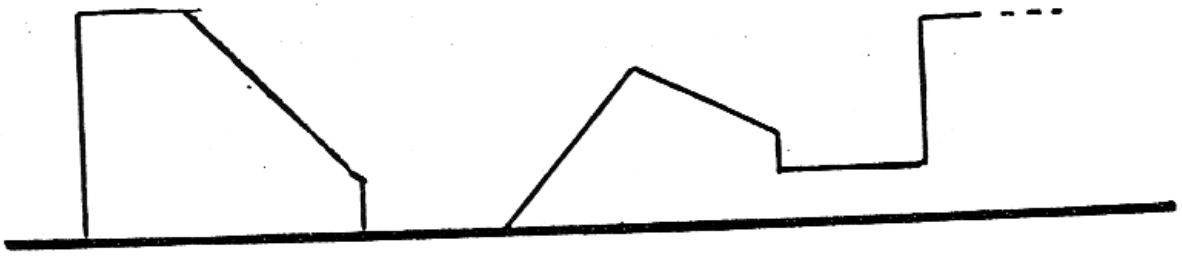
The normal function of each Output Voltage Level pot is to provide an analog sweep normalized between 0 and +10 volts. A "quantize" command will divide the voltage range into twelve equal intervals. Assuming control of frequency, the exact interval to be quantized is determined by further Level 2 programming and by the control voltage processor on the module receiving the output voltage (see section 3.b 3). The command is removed, returning the status to continuous mode, by pushing the switch down.

2) "sloped/stepped"

The 248 output voltages normally step from one voltage level to the next, producing a digital sequence of control voltages:



A "sloped" command integrates the output voltage, enabling the 248 to slope into the established voltage level. The slope time is equal to the programmed Interval Time, reaching the established Output Voltage Level at the end of the period.



Sloped functions are useful for generating envelopes, pitch portamenti, filter sweeps, panning patterns, etc. Sloped and stepped stages may be freely intermixed.

3) Range

The normal range of the Output Voltage Levels (0 to +10) may be compressed to a 2 volt range assigned to a reference offset by the switches marked "+0", "+2", "+4", etc.

"+0" = a stage bearing this command now has a voltage output range of from 0 to +2 volts.
"+2" = +2 to +4 volt output
"+4" = +4 to +6 volts
"+6" = +6 to +8 volts
"+8" = +8 to +10 volts

Full range is re-established by switching the Range Switch up to "full range". The 248 is designed so that if each 2 volt division is processed to equal 1 octave in terms of pitch control, the "Quantize" command will then provide 12 equal tempered divisions

of the octave. The output voltage can, of course, be processed to any desired interval range. Only one range command can be attached to a single stage. For example, a +0 to +4 volt range would have to be accommodated by a 257 Control Voltage Processor or by the processing pots on the module under control.

4) Source

The normal status of this switch is "internal", meaning the initial voltage levels are established by the Output Voltage Level pots. An "external" command ignores the voltage level setting and allows the 248 to accept an externally applied voltage and transfer it to the voltage output port. When the stage carrying this command is addressed, the 248 will accept one of 4 external voltages appearing at the External Input ports marked A, B, C and D. The port to be addressed by a particular stage is selected by setting that Voltage Output Level pot horizontal with the front panel markings A, B, C or D. If the first four stages carry "external" commands, stage 1 set at "A", 2 at "B", 3 at "C" and 4 at "D", the 248 will output the voltages appearing at ports A, B, C, and D in that order, as those stages are addressed. The external voltages may be quantized, sloped or range limited in the same manner as the internal voltage levels. In this mode the 248 can be used as a flexible control voltage processor.

3.c. Operating Mode

These five commands deal with specific operations of the programmed voltages.

1) Cycle

Cycle determines the first and last stage of a sequence. The total number of available stages (16 or 32) can be divided into sub-sequences and each sub-sequence may be addressed manually or by analog address with external voltages (see section 4.a 3, 4 and 5). The beginning and ending stage of each sequence is defined by a "first" and "last" command attached to the appropriate stages. Such commands are removed by pushing the switch down. For example, the 248 could be programmed for several different sequences. A "first" command could be issued on stage 1 and a "last" command might be issued on stage 5. Stage 6 could then carry a "first" command and stage 12 could carry a "last". A final sequence could be established between 13 and 16 in the same

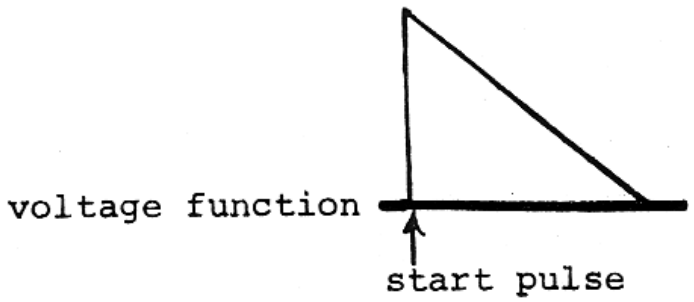
manner. The 248 is then programmed for three sequences. The "last" command tells the 248 to return to the closest numbered "first" command so the various sequences can be independently cycled without overlapping each other.

stage no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
data:	1st				last	1st						last	1st			last

2) "stop"

When a "stop" command is attached to a stage, the sequence will stop and hold that voltage level until a pulse is applied to the "start" input on the Programmed Output. The start command may be manually activated by the "start/stop" switch (see section 3.b 2). Stop commands are required for non-repetitive functions such as pulse activated envelopes. The programming for such a function would be:

stage no.	1	2
voltage level	10	0
data	first	last
		stop
		slope



Time intervals may be set as desired.

Without the "stop" command the 2 stage sequence would continue to cycle. With the "stop" command on stage 2 the envelope will not re-cycle until a start command (manual or pulse) is given.

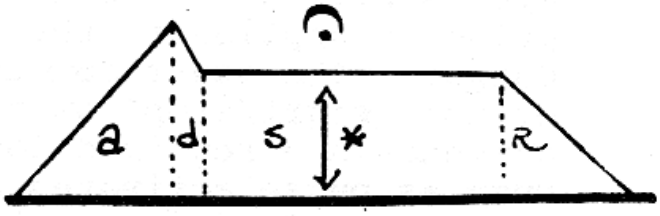
3) "sustain" ("SUST")

The sequence will stop and hold on any stage bearing this command as long as the start pulse is high. When

a start pulse is not present, the sequence will move through that stage, ignoring the sustain command. One obvious application is a sustained envelope.

stage no.	1	2	3
voltage level	10	variable*	0
data	first slope	sus slope	last slope stop

interval time: as desired
voltage function



A start pulse (perhaps from a keyboard) initiates the envelope. Stage 1 determines attack time by programming stage 1 Time Interval to the desired period. Stage 1 also determines the attack amplitude by adjusting the Output Voltage Level. Stage 2 determines the initial decay time and the sustain voltage level (Output Voltage Level). The "sustain" command one stage 2 will hold the envelope at this level until the pulse is released. Stage 3 will then determine the final decay or release time. The "stop" command on stage 3 inhibits re-cycling of the envelope until another start pulse is issued. This function could be expanded to give voltage control of attack time, initial decay time, sustain level and release time by programming "external" voltages in the appropriate stages and addressing the desired External Input ports. Repetitive envelopes can be generated by removing the "stop" command.

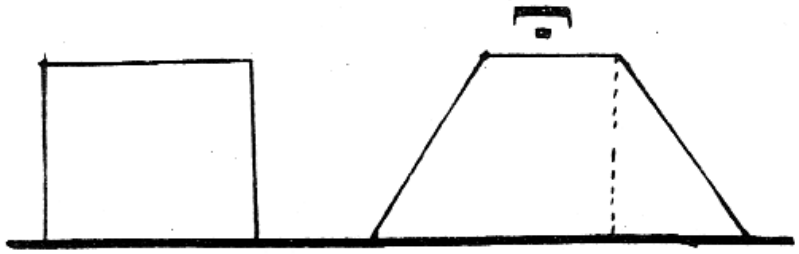
4) "enable"

This command is a "reverse stop". The stage bearing this command will stop unless the start pulse is high. If the start pulse is high, the sequence will continue to run or cycle until the pulse is removed. This is needed for programming dynamic functions that always begin with a specific value and continue for variable lengths of time. For example, suppose one needed to play trilled pitches that always began with

the upper auxilliary note (the standard Baroque ornament). This can be done with square wave FM or a free running 2 stage sequence. There is, however, no guarantee that the beginning of each pitch will coincide with the higher voltage level of the trill program. An "enable" command can solve this problem.

stage no.	1	2	3	4
voltage level	10	0	10	0
data	first	last	first	last
		enable	slope	slope
			sust.	stop

interval time: as desired or externally controlled



Stages 1 and 2 provide the repetitive function for the trill (outputted by Programmed Output 1). Stages 3 and 4 provide a sustained envelope for a Lopass Gate (outputted by Programmed Output 2). When no start pulse is present, the trill function holds on stage 2. As a pulse is applied, the function is enabled and will continue to cycle as long as the pulse is present. The same start pulse takes the envelope function out of the stop mode, stage 3 serving as an attack and hold due to the sustain. When the pulse is released, stage 4 acts as a decay with a stop and the trill stops due to the enable command. (This application is useful when the durations are long enough to let the voltage function cycle to the stage carrying the "enable" command. In other cases analog address techniques [see section 4.a 5] may be more applicable.)

3.d Time Range

These commands modify the Interval Times in the same manner Output Voltage Range commands qualify Output Voltage Levels.

1) Divisions

Each stage has an initial period of 2 to 30 seconds as established by the slide pots. Each Interval Time can be divided by:

10 = a ".2" to "3" second command

10^2 = a ".02" to ".3" second command

10^3 = a ".002" to ".03" second command

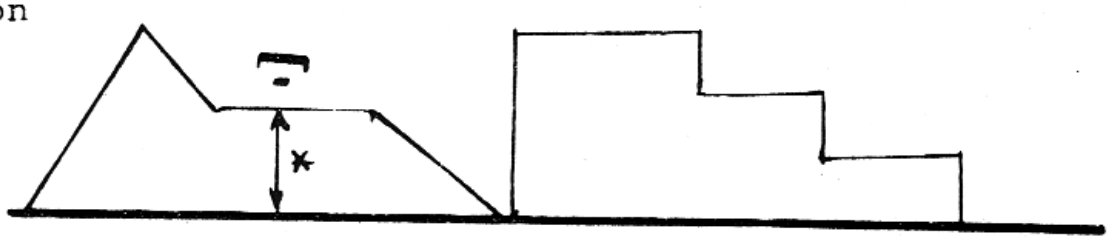
A "2" to "30" command re-establishes the original full time range. Time scale expansion and contraction is facilitated by the Time Multiplier pot (see section 4.c).

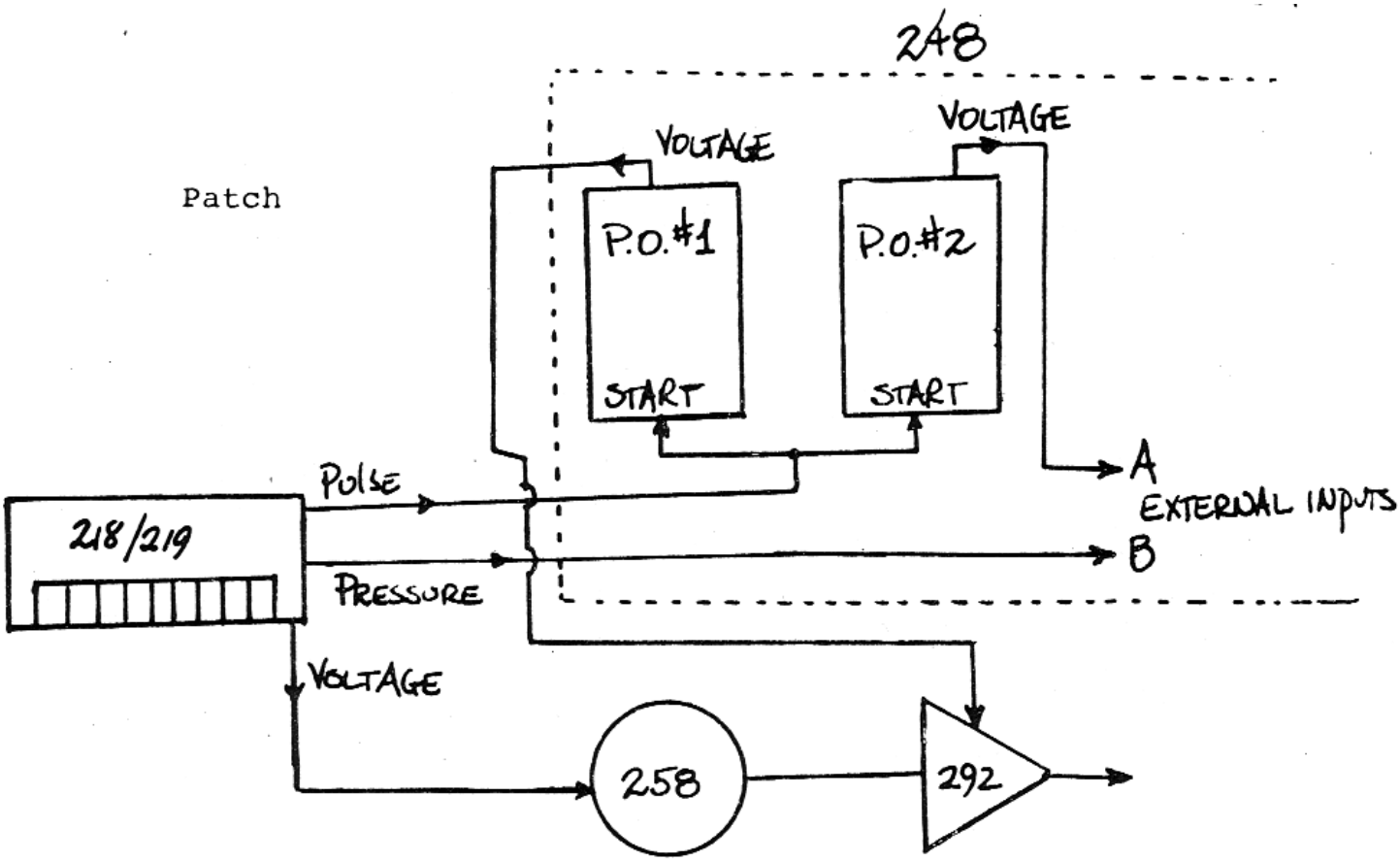
2) Source

The period of any stage may be determined by any voltage applied to the External Inputs. The External Input ports are addressable by moving the Time Interval pot horizontal with the A, B, C, or D panel markings. External voltages used for Interval Times may be processed by the time range divisions. A 10 volt control could equal .03, .3, 3 or 30 seconds, depending on the programmed command. External Time Interval controls can be used to program voltage controlled envelopes. The program used in section 3.b 3 can be expanded to include voltage controlled parameters:

stage no.	1	2	3	4	5	6	7
voltage level data	10 first slope	variable* sust. slope	0 last slope stop	10 first stop	8 stop	5 stop	0 last stop
time interval data	B ext .2-3	5 .2-3	A ext 2-30				

voltage function





A keyboard is used to provide pitch control for an oscillator; a start pulse to two Programmed Outputs and keyboard pressure voltages are applied to External Input B. The Output Voltage from Programmed Output 2 is attached to External Input A. Function 1-3 is an envelope with voltaged controlled attack and decay times. The attack time (stage 1) is controlled by External Input B, pressure voltage from the keyboard. The harder the key is pressed, the longer the attack (up to 3 seconds as programmed by the time divisor). Stage 2 is the initial decay set for 1/2 second into a sustain level which can be manually adjusted as needed. Upon release of the start pulse, stage 3 is activated, determining the final decay time of the envelope. This Interval Time is controlled by External Input port A, which receives a sequence of voltages from functions 4 through 7 from the other Programmed Output. Stage 4 provides a 3 second decay, stage 5 a 2 second decay, stage 6 a .5 second decay and stage 7 a .2 second decay. Each decay time is called up sequentially due to the "stop" command on each stage of this function (see section 4.a 3 and 4 for techniques on non-sequential access to various stages). Interior Times for stages 4 - 7 are not

needed due to the "stop" commands. In this case the period is controlled by the start pulses.

4. LEVEL 3: PROGRAMMED OUTPUTS

The Programmed Outputs are played in real time and used to address the various voltage functions programmed into the 248. Each Programmed Output can independently address and output any programmed function, and visual display of the data being outputted is possible with the "display" switch. In addition, each Programmed Output has its own local clock so it may operate on an independent time base. The programming in Level 1 and 2 then comprises a library of functions called forth synchronously or asynchronously by the different Programmed Outputs.

4.a. Stage Address

This section determines what stage number the Programmed Output will select and also defines the nature of the command used to make the selection.

1) "display"

Activation of this switch displays all of the data of the function being addressed at that moment. The different Programmed Outputs can be displayed at any time to check the address and data and for monitoring before re-programming (see section 5). The large red LED in this section indicates which Program Output is being displayed.

2) "reset"

This switch resets the stage address for that Programmed Output to stage 1 (not especially the first stage of a function).

3) "internal/external"

"int" - the addressing is controlled by the Stage Address pot.

"ext" - the Stage Address pot is defeated and address is governed by an external voltage applied to the Stage Address "ext" input--higher voltages address higher numbered stages.

4) "continuous/strobe"

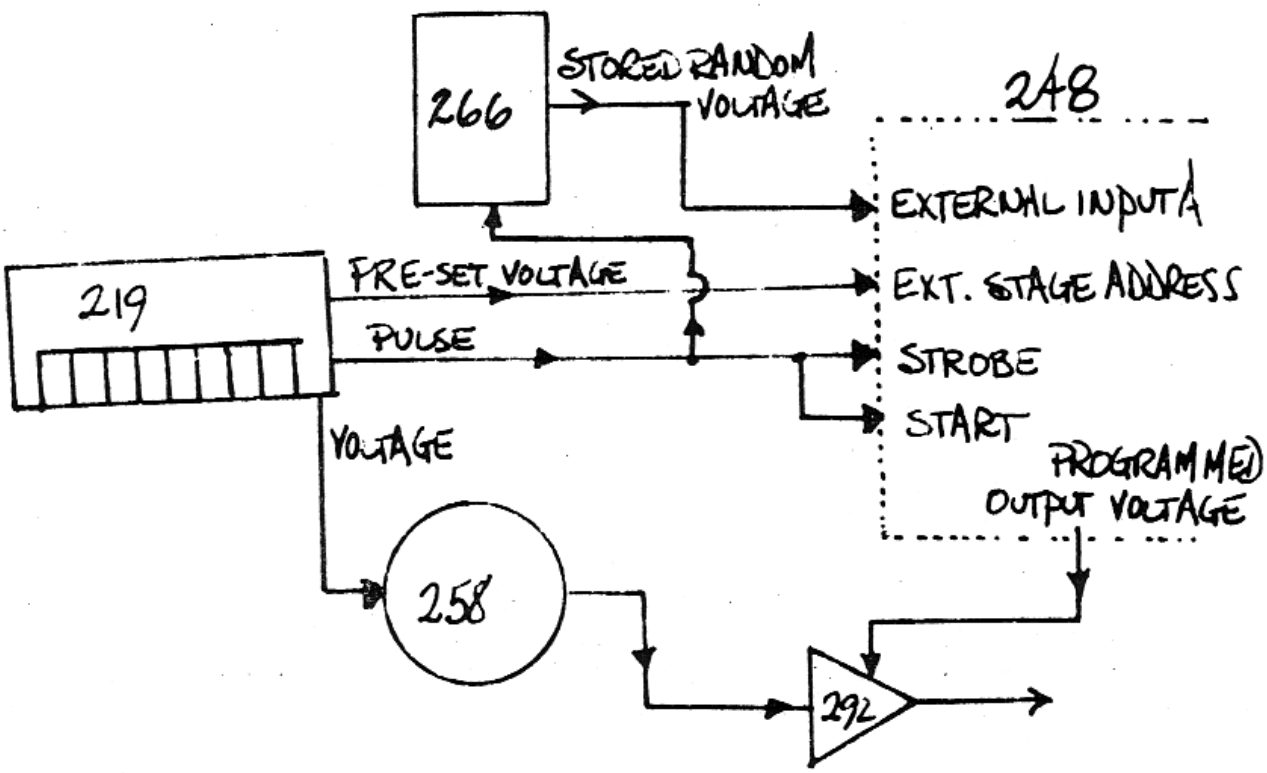
This is a three position switch with the lower pole being spring-loaded with return to the central

position. The "cont" position defeats the local clock making stage address manually selectable if in "int" position, or voltage selectable if in "ext" position. Note that the 248 will not go into the "start" mode if in "cont" mode (see section 4.b 2). "Strobe" is activated by a pulse applied to the "strobe" input or by manual contact with the switch. This can be described as a "stage address sample and hold". With this switch in the middle position a stage can be selected by the Stage Address pot ("int" or by an external voltage--"ext.") and a strobe command (either manual or pulse) will then address that stage. To clarify this function, try the following procedure: set the Stage Address section to "display", "cont." and "int". The various stages can now be dialed up by the pot. Apply a floating random voltage from a 265 Uncertainty Source to the Stage Address "ext" input and set the switch to "ext.". The random voltage will now move the stage address around in a random manner. Set the "cont/strobe" switch to the central position (keeping it in "ext" mode). The Stage Address is still scanning the external input, but it will not react to the input voltage until a strobe command is given. Upon receipt of a manual or pulse strobe command, the Stage Address will register the external voltage present at that point in time and make the appropriate stage selection. In this mode the Programmed Output will react only to an external voltage when a strobe command is given. Once the strobe is issued, if in "start" mode, the 248 will continue to function with the programmed Interval Times and associated data.

5) Two applications of analog address (explained for further clarification)

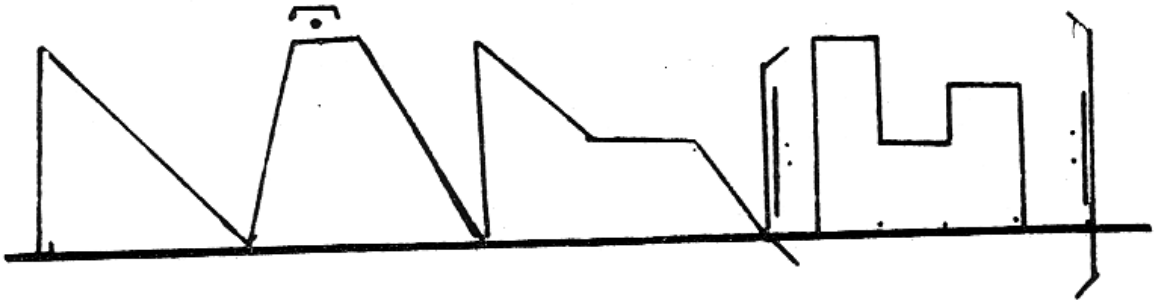
Keyboard Re-tuning: The equal tempered relationships of keyboard voltages may be re-defined by the 248. The key voltages from a 218 or 219 keyboard are attached to the Stage Address external input and the Stage Address switches are set to "cont" and "ext". This turns off the local clock so Interval Time does not function. In this manner the various stages are selected only when a new keyboard voltage is given. The Output Voltage Levels are then tuned to any relationship desired and used to provide pitch logic for an oscillator. It may be convenient to process the output voltages so the various Range commands provide access to different octaves (see section 3.b 3), and these can be manually varied and switched as desired.

Programming Voltage Selectable Envelopes: In this example four different envelopes will be specified and addressed by the Pre-Set Voltages from a 218 or 219 Keyboard. The performer can then select envelopes suitable to the immediate demands of the music. The first three envelopes are one-shot functions dependent on start pulses. Envelope 4 is a cycling function independent of any pulse (except the one used to strobe the address).



Stage Number	1	2	3	4	5	6	7	8	9	10	11
Voltage Level	10	0	10	0	10	5	0	10	5	7	0
Data	1st	last slp stop	1st slp sus	last slp stop	1st		last slp	1st			last
Interval Time	2	1	5	5	2	3	A	2	2	2	2
Data	.03	3	.3	30	.002	.002	ext	.02	.02	.02	.02

Voltage Function



Programmed Output data:

"start" receives the keyboard pulse
"strobe" receives the same keyboard pulse
"ext" receives keyboard Pre-set Voltages
"cont/strobe" switch is in middle position, allowing the clock to function
"int/ext" is in "external" position

External Inputs:

Input A receives the output of a random voltage source. This allows the decay time of envelope 3 to be controlled randomly.

Keyboard Presets:

The Pre-set Voltages select the four programmed envelopes.

To tune these Pre-sets, set the Stage Address in continuous mode and dial Pre-set #1 so it addresses stage 1 of the 248 (the first envelope). Touch Pre-Set #2 and dial it to select stage 3 (the second envelope). Pre-Set #3 selects stage 5 and Pre-Set #4 selects stage 8. There are only three Pre-sets on the 218 keyboard, so eliminate the envelope of least interest (probably function 3-4). Now re-set the "cont/strobe" switch to the middle position. When Pre-Set 1 is activated, the Programmed Output will address stage 1. The Programmed Output will react to that stage address only when it receives a "strobe" command from the keyboard or by manual switching. The envelope will stop on stage 2 and hold until it receives another "start" pulse from the keyboard. Touching Pre-set 2 addresses the second envelope (stage 3) and the "start" pulse also provides sustain information for sustained envelopes. This envelope will also stop at the end of its function and wait for a new "start" pulse. Envelope 3 is selected by Pre-set 3. This is an ADSR function with random voltage determining the final release time. Envelope 4, selected by Pre-Set 4, will continually recycle when addressed as it has no "stop" commands. An "enable" command is not needed in this case as the "strobe" pulse will always address the first segment of the function (stage 8). This same type of patch can be used to address repetitive functions for pitch, filters, location, etc. by

removing the "stop" commands.

4.b. Mode

This section of the Programmed Output allows for manual advance of the Stage Address, receives "stop" and "start" pulses and indicates the clock status.

1) "advance"

When not in "continuous" position, this switch allows the performer to manually read through a function, advancing the Stage Address one position each time the switch is pressed. This is needed for situations where a Programmed Output is defining a set of voltage off-sets (perhaps for a filter, location, pitch transportation) which are to be accessed sequentially. If all of the pulse outputs on the addressing instrument have already been dedicated to other functions, one can use this manual advance to read through the programmed voltages. If an extra pulse is available, the same thing can be accomplished by putting a "stop" command on each stage and addressing the next stage sequentially with a "start" pulse or in variable order with analog address techniques.

2) Status Lights

The three LEDs indicate the clock status of the Programmed Output and are color-coded as follows:

green - the clock is running and the Stage Address will function as programmed.

yellow- this is an interrupt signal meaning that the Programmed Output is waiting for a "start" command. This indicates the presence of a "sustain" or "enable" command. "Continuous" Stage Address also activates the "interrupt" light as this mode also disengages the local clock.

red - indicates a "stop" command either programmed into the voltage function or issued manually by the "stop" switch or a "stop" pulse.

3) "stop/start"

The local clock for the Programmed Output can be stopped or started manually by the switch or by the presence of a pulse at the appropriate input. These

pulse inputs allow one Programmed Output to be turned on and off by programmed Output Pulses from another Programmed Output (or any other pulse source).

Stage No.	1	2	3	4	5	6	7	8
Voltage Level	- - - - - - -			As Desired		- - - - - - -		
Data	1st			last	1st			last
					1	2	1	2 (pulse commands)
	Starts programmed output 1				Stops programmed output 1			
Time Interval Data	2 .02	2 .02	2 .02	2 .02	30 .2	30 .2	30 .2	30 .2

Programmed Output 1 data:

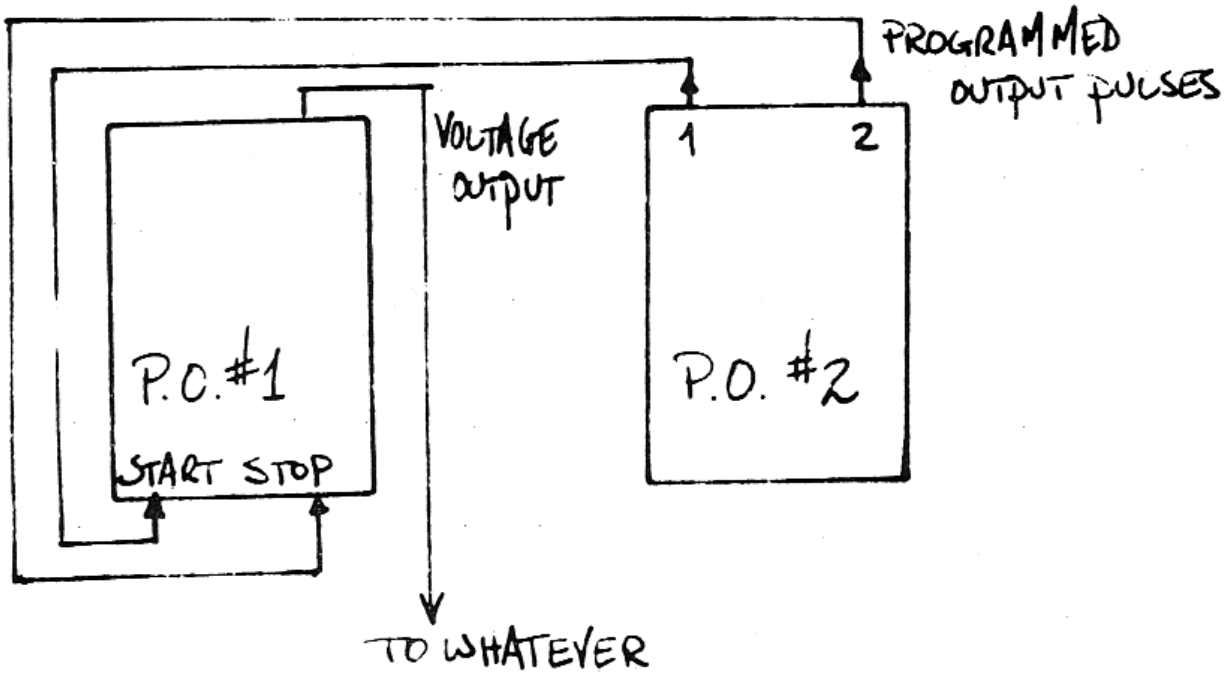
"start" receives a pulse from Programmed Output 2, output pulse 1

"stop" receives a pulse from Programmed Output 2, output pulse 2

Stage Address is "internal" and "cont/strobe" switch is set to middle position.

Programmed Output 2 data:

Output Pulses 1 and 2 attached to Programmed Output 1 as described. Stage Address is "internal" and "cont/strobe" switch is set to "cont" position. Push the "display" switch and use the Stage Address pot to dial to stage 5, the first stage of this sequence. Return the "cont/strobe" switch to middle position and issue a manual "start" command. The stages alternately issue start and stop pulses for Programmed Output 1, so the Time Intervals for stages 5-8 should be sufficiently long to be logical.



Push the "display" button for Programmed Output 1 and gaze in amazement! The Programmed Output will turn on and off at 3 second intervals (the Time Interval of Programmed Output 2).

4.c. Time Multiplier

This control multiplies the programmed Interval Times and their associated data by any value between .5 (twice as fast) and 4 (four times as slow). The multiplication factor can be manually defined by the Time Multiplier pot or by application of control voltages to the Time Multiplier input port. This external voltage may be positively or negatively processed as desired. The pot acts as an offset and the time is voltage controllable in either direction from that reference. Since the Programmed Outputs have local clocks, each can read the same voltage function at different rates by adjustment of the Time Multiplier. This control is also useful for controlling total durations of voltage sequences. A single envelope, sequence, etc. could be programmed with a set of Time Intervals. The entire set of Time Intervals could then be expanded or compressed by various control voltages determining the time multiplication.

4.d. Output Voltage Ports

This section outputs the addressed functions and they may be applied to any voltage controllable parameter.

1) Reference ("ref")

A descending ramp control voltage (+10 to 0) is generated each time a new stage is addressed. This is convenient for use as a simple envelope without taking up any Output Voltage memory or having to use the pulse outputs to trigger an external envelope generator.

2) "time"

This outputs a voltage proportional to the programmed Time Interval of each stage. This can be used for the correlation of time with any other voltage controllable parameter. The "time" voltages can be used as a second dimension of control voltages when the Programmed Output is in external mode. In this mode the local clock is defeated, and time is determined by strobe pulses or manual selection with the pot. The Time Interval voltages then have no effect on period and may be used in the same manner as an Output Voltage.

3) "all pulses"

A pulse is issued with each new stage address.

4) Pulse outputs "1" and "2"

These pulse outputs are program activated by the Output Pulse commands. A pulse is present at each output only when programmed on stages carrying that command (see section 4.b 3 for applications).

5. A SUGGESTED PROGRAMMING PROCEDURE

Each musician will eventually develop a favorite programming technique, depending on applications. Until the 248 is thoroughly understood, it is suggested that the following procedure be used--it may save some confusion.

5.a Programming

Step 1: Turn on the 248 power supply if not already on. The 248 memory is volatile, meaning that when the power supply is turned off, all programming is lost.

Step 2: If not already cleared (indicated by a reset of all commands except "full range" and "2-30" Time Range) press the white "Clear" switch. This removes all previous programming, so don't use this switch unless you really mean it!

If the 248 does not clear, use the Stage Number switch ("STAGE NO") to address a new stage and press clear again.

Step 3: Stage Number. This sequentially addresses the stage numbers to facilitate programming. Held to the right or left, it will count up or down and continue to count until released. Momentary contact will move the address up or down one stage. When this switch is activated, the Programmed Outputs go out of display mode but will not stop. In the first stages of learning to program it is a good idea to stop the Programmed Outputs manually with the "stop/start" switch. After all the Output Voltage Levels, Interval Times and data have been entered, the Programmed Outputs can be activated manually or with "start" pulses.

Step 4: Plan out the desired functions. Some users may find it convenient to use the Programmed Function score supplied at the end of this documentation. Program in all Voltage Levels, Interval Times and data. Some musicians find it logical to completely define each stage before moving on to the next. Others find it more convenient to define the first and last stage for each function, then go back and enter all other data. Conjunct stages with similar commands can easily be programmed by holding down the desired command switch and quickly counting through the stages by holding the stage switch in one position.

Step 5: Display the Programmed Outputs (only one can be displayed at a time) and set them to the first function to be used (refer back to section 4.a 3 and 4).

Step 6: Attach all input and output control voltages.

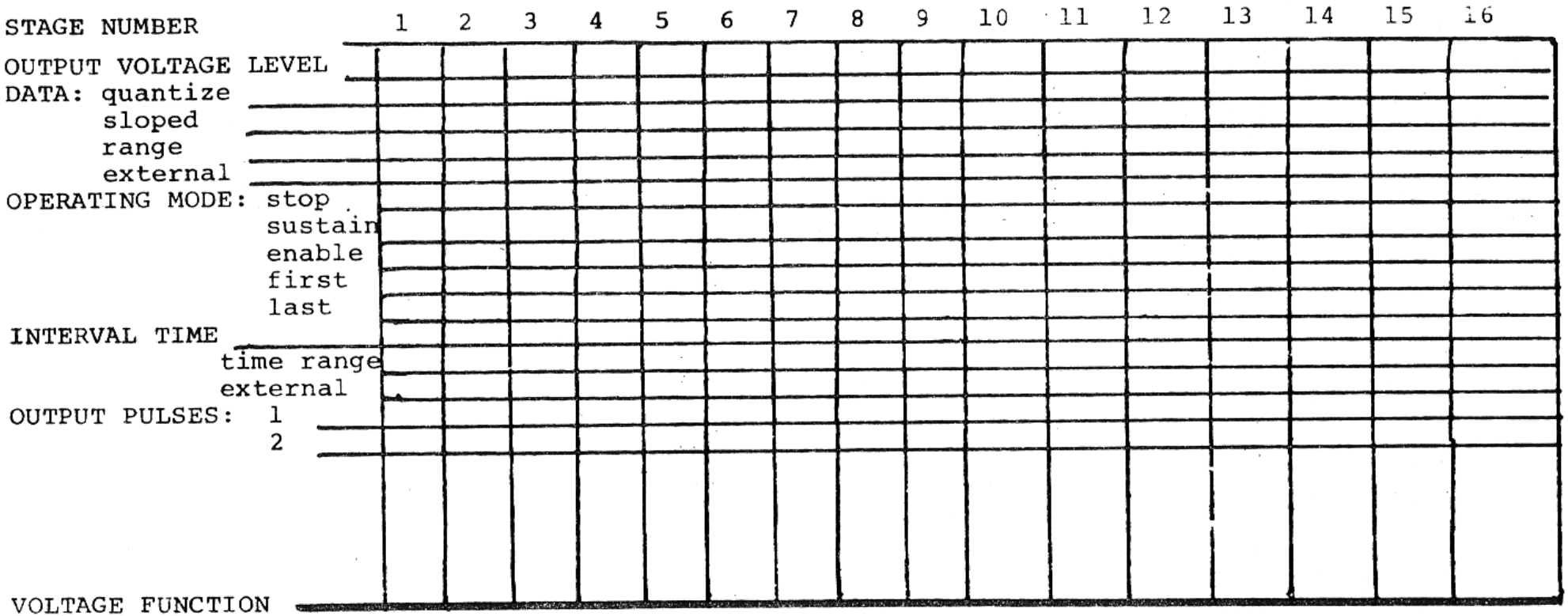
Step 7: Give the Programmed Outputs the appropriate start command, and everything will work as programmed.

5.b. Editing and Re-programming

The 248 need not be stopped in order to alter any Voltages, Times or data. By using the Stage Number switch, any stage can be addressed and new data, voltages, and times can be entered. This will not affect the running of the Programmed Outputs and the data will be updated as soon as it is entered. To re-display a Programmed

Output, press the associated "display" switch. It is also possible to edit any program while it is being displayed. The only problem with this technique is that trying to change any of the data on a particular stage while the program is running is tricky. One must make that change only at the moment that stage is being addressed. It would be possible to stop the program and manually dial through the function, but remember that the results of the editing will be heard in real time. The Stage Number switch allows the function to continue without interruption.

MODEL 248 MULTIPLE ARBITRARY FUNCTION GENERATOR: FUNCTIONS SCORE



EXTERNAL INPUTS A: B: C: D:

PROGRAMMED OUTPUT 1 DATA:

PROGRAMMED OUTPUT 2 DATA:

PROGRAMMED OUTPUT 3 DATA:

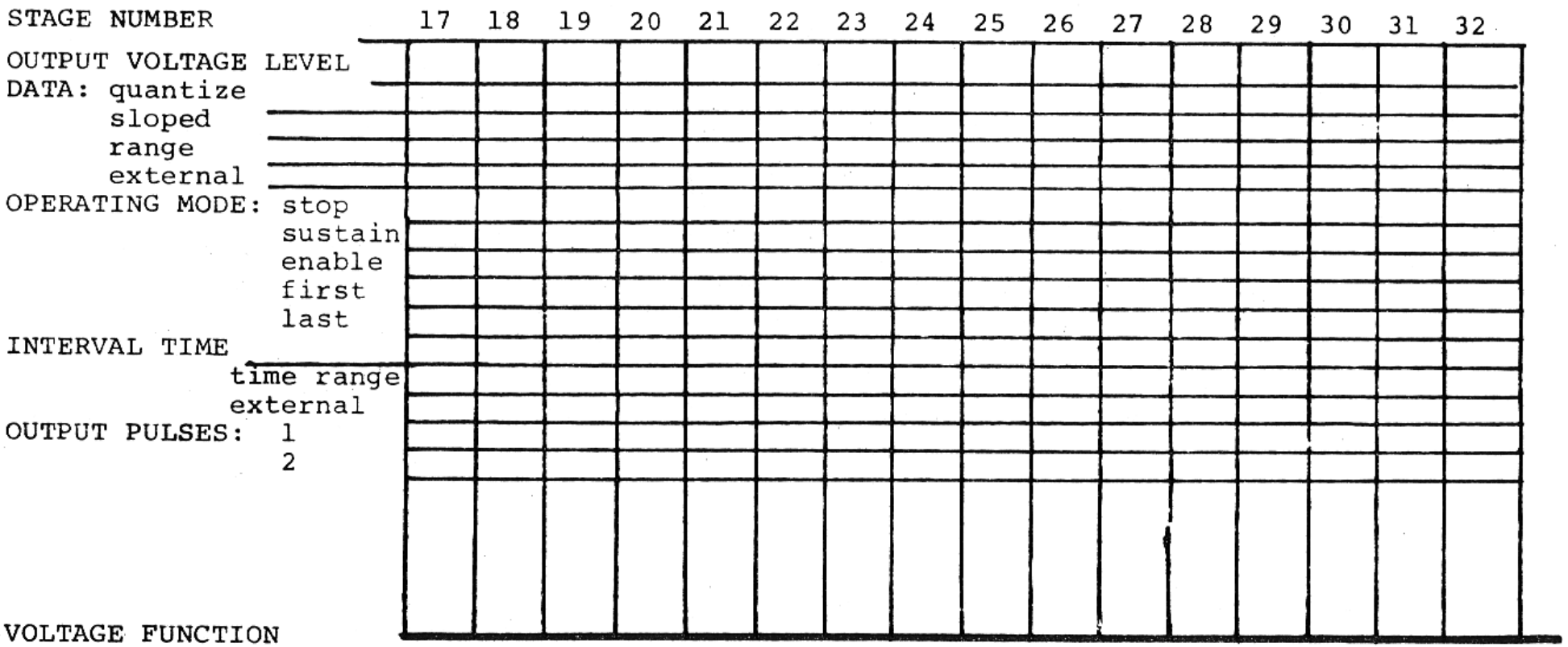
PROGRAMMED OUTPUT 4 DATA:

PROGRAMMED OUTPUT 5 DATA:

PROGRAMMED OUTPUT 6 DATA:

NOTES:

MODEL 248 MULTIPLE ARBITRARY FUNCTION GENERATOR: FUNCTIONS SCORE



PROGRAMMED OUTPUT 7 DATA:

PROGRAMMED OUTPUT 8 DATA:

PROGRAMMED OUTPUT 9 DATA:

PROGRAMMED OUTPUT 10 DATA:

NOTES: