THE URSA MAJOR 323

OWNER'S MANUAL

CORPORATE STATEMENT

URSA MAJOR is dedicated to producing useful, lasting products of superior value for professional audio users, and to building a satisfying, equitable workplace for its people.

ACKNOWLEDGEMENT

Any product such as the 323 StarGate is the work of more than one person. I would like to thank each of the URSA "MAJORETTES" for their active and supportive involvement in making the 323 a reality.

In particular, I would like to thank Mark Bruckner for his contributions to digital design, documentation, and testing; and Charles Anderson for his work on breadboarding, testing, and above all, software optimization (tuning the Rooms).

Christopher Moore

StarGate 323
Digital Reverberator

Owner's Manual

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March 1984

WARRANTY REGISTRATION & T-SHIRT OFFER

We are pleased and grateful that you have chosen an URSA MAJOR product for your use. We stand behind each of our products, and hope they serve you well. Please fill out this form completely to register your StarGate 323 for its one year warranty (refer to the Owner's Manual for warranty details). The information you provide is confidential, and will help us serve you better. When we receive this completed form from you, we will send you a complimentary URSA MAJOR T-shirt. They're 100% cotton, and have our sleeping bear logo and name on the front.

Specify T-shirt size:

Small_____Medium_____
Large_____X-Large____

Where do we send the shirt?
Name:_____
Company Name:_____
Street Address:_____
City/State/Zip:_____
Country:_____

Serial Number of your Unit:

_____

Dealer Name:_____
Street Address:_____
City/State/Zip:_____
Country:_____

How did you first hear about the StarGate 323?_____
_____
What's your application? recording_____broadcast_____
live performance_____sound reinforcement_____home_____
other_____
Describe in a few words how you use it_____
_____
_____
With what sources?_____
_____
What do you like about the StarGate 323?_____
_____
_____
Any suggestions for other products?_____
_____
_____

Please mail the completed form to:

URSA MAJOR, Inc.
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USA

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I. Introduction

A Warranty Registration Form has been included in the front of this manual. Please fill it out and return within 2 weeks of receiving your 323. The warranty for your unit is only valid if we receive this completed form promptly.

IMPORTANT!

IN ORDER TO KEEP YOU INFORMED OF POSSIBLE CHANGES OR IMPROVEMENTS OR UPDATES TO THE 323 IN THE YEARS AHEAD, WE MUST HAVE THE WARRANTY FORM IN OUR FILE!

II. Specifications

Bandwidth: 15kHz, all Rooms, all Decay Times

Sampling Rate: 32kHz

Noise: 15 bit linear PCM conversion for 80dB dynamic range

Programs: 8 Room Simulations

Pre-Delay: from 0 to 320ms, in 16 steps

Decay Time: from 0 to 10 seconds in 8 steps, Room Dependent

HF and LF Decay: continuously adjustable controls

Mixing: Built in Stereo Direct and Stereo Reverb Mix Controls

Override Functions: Three special functions controlled by push buttons or external foot pedals

Input Mute
Dry Only
Reverb Clear

Input: Stereo inputs, electronically balanced (differential amplifier). Pin 3 high (21K ohms), Pin 2 low (11K ohms), and Pin 1 ground. Recommended source impedance is 600 ohms or less. Maximum source voltage before input stage overload is 7v rms. Minimum input for operation of "0 LED" (Input Level control at maximum, input frequency 100Hz, one input only driven, Decay Time 0 seconds) is -10dBV (.316 volts rms) nominal. If both inputs are driven in phase, sensitivity rises to -16dBV (.159 volts rms). Connectors are XLR-3 female.

Output: Stereo outputs, active differential circuit. Pin 3 is high (100 ohm source resistance), Pin 2 is low (100 ohm source resistance), and Pin 1 is ground. Minimum recommended load impedance is 600 ohms. Maximum output level (Input driven so that "0 LED" flashes occasionally, Decay Time maximum, Reverb Mix full cw, and Direct Mix full ccw) is +10dBV nominal. Connectors are XLR-3 male.

Size: Rack mount, 2 units high (19" (48cm) wide, 3.5" (8.7cm) high), and 15.5" (39.4cm) deep, excluding XLR connector protrusion. Weight, fully boxed for shipment, approximately 12 lbs (5.5kg).

Power: 115 or 230VAC nominal voltage (switch selectable via internal switch). Supplies maintain regulation down to approximately 95VAC (182VAC). Consult with factory about special version with transformer for 100/200VAC supply. Unit operates with 60 or 50Hz power line frequency. Power consumption approximately 30 watts. Detachable IEC Standard power cord.

Power Supply Safeguards: Internal fuse for mains, and for +5VDC supply. All supplies are current and power limited.

Environment: 10-50 degrees C operating, 0-70 degrees C storage. RH up to 95% non-condensing.

III. Installation

UNPACKING: As soon as you receive the carton containing your 323, inspect it carefully for signs of shipping damage. Report any shipping damage to the carrier immediately and file a claim. Although in most cases, we insure our shipments, it is the con-signee's (ie., your) responsibility to initiate a claim for shipping damage. Save the carton and all packing material in case return to the factory is ever necessary.

POWER: The Model 323 operates on 115/230VAC, 50/60Hz. A sticker on the rear panel indicates how your unit was set at the factory.

IF YOU HAVE ANY DOUBTS AS TO THE INTERNAL VOLTAGE SETTING AND ARE ABOUT TO PLUG THE 323 INTO 230VAC, DON'T! OPERATION OF A 323 SET TO 115VAC ON A 230VAC SUPPLY MAY DAMAGE THE UNIT. REMOVE THE AC CORD, UNSCREW 11 SCREWS HOLDING THE TOP COVER IN PLACE, AND CHECK THE SETTING OF THE INTERNAL VOLTAGE SELECTOR SWITCH. CORRECT IF NECESSARY AND REINSTALL THE TOP COVER.

If you must change the power cord plug to suit the standard in your country, be sure to connect the green wire to the ground pin of your plug. The 3rd pin is a safety feature, designed to connect the 323 chassis to power ground. Do not defeat this feature!

INSTALLATION: The Model 323 should be rack mounted (height is 3.5" (8.9cm)). Be sure to maintain adequate clearance for air flow at the sides and top of the unit. An inch (2.5cm) all around is recommended. We do not recommend installing the 323 directly above a high power rack mount component such as a power amplifier.

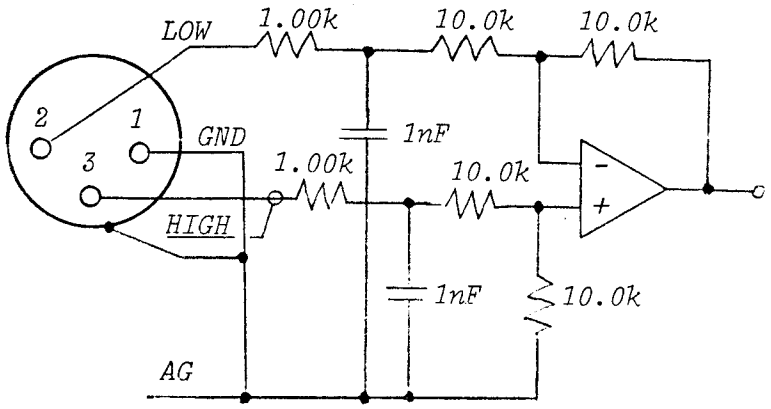
The 323 may be operated on a table or bench-top, as there are no ventilation holes in its underside.

If the 323 is to be installed in a mobile van, we recommend that you purchase from your dealer or URSA MAJOR a pair of optional reinforced steel supporting channels. These screw into the rack frame and then cradle the 323, giving it extra support.

IV. Connections to the Unit

A. Inputs

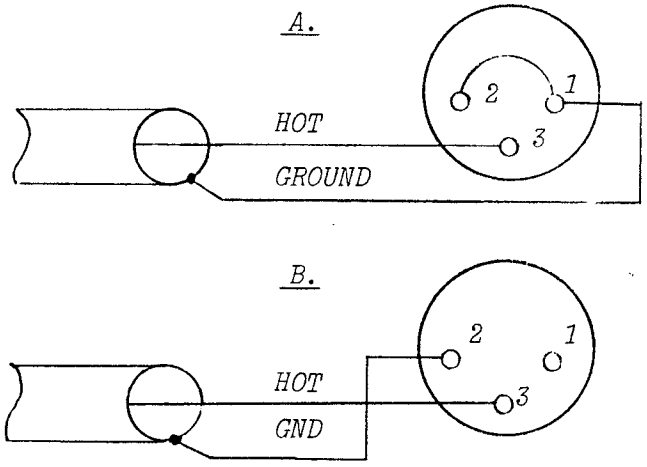
Feed the 323 Inputs from either balanced (preferable) or unbalanced sources of 600 ohm or less impedance. Maximum signal level is 7Vrms, while minimum signal for normal operation is -10dBV (316mV). If both inputs are driven with mono or in-phase stereo components, the sensitivity increases to about -16dBV. Input impedance of pin 3 is 11K ohms, while pin 2 is 21K ohms.



Detailed Schematic
323 Input Stage

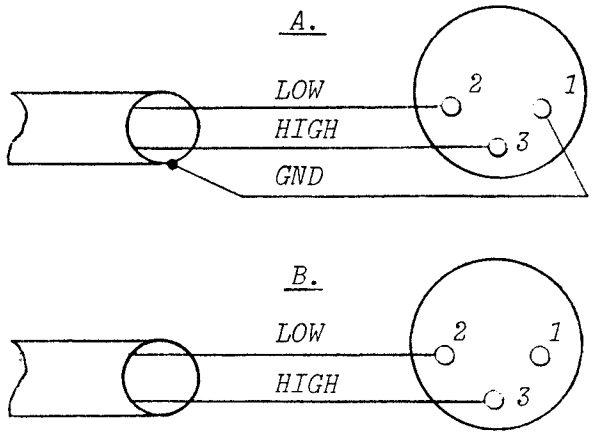
Connection to Unbalanced Source

There are two diagrams at left. You should use A if your external source and load do not share a common ground, or if you are unsure about this. If you're sure of the common ground (ie., you've connected the 323 to a console echo send/receive circuit), then B may offer some advantages in reducing potential ground loop problems.



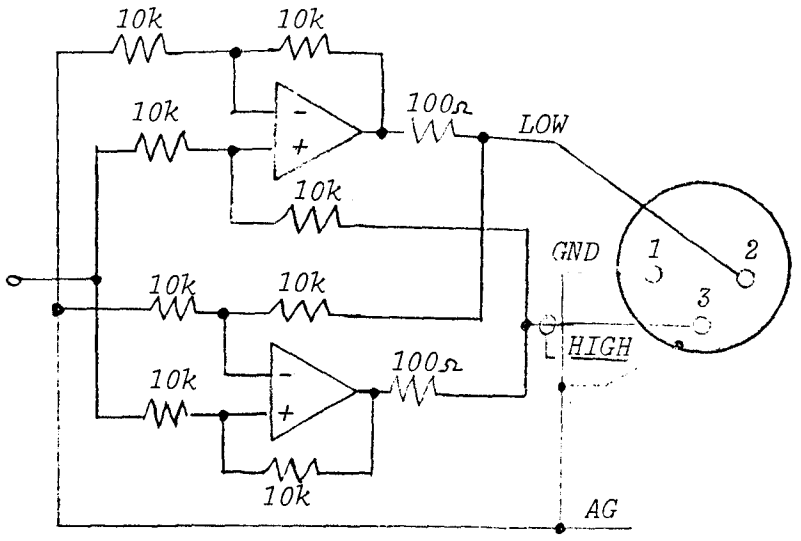
Connection to Balanced Source

A is the normal connection, but B may offer some advantages in dealing with ground loops.



B. Outputs

Send the 323 outputs to balanced (preferable) or unbalanced inputs. Do not tie the left and right outputs directly together to form a mono sum signal. The 323 output stage is an active differential design, with 100 ohm source impedance of each output pin, and will drive inputs with 600 ohm or (preferable) higher impedance.

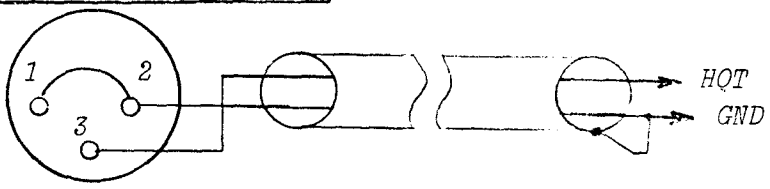


Detailed Schematic
323 Output Stage

IMPORTANT: IF 323 OUTPUT MUST FEED AN UNBALANCED INPUT, CONNECT HOT LEAD TO PIN 3, AND TIE PIN 2 TO PIN 1 INSIDE SHELL OF XLR PLUG GOING INTO 323 CONNECTOR. CONNECT GROUND LEAD TO PIN 1. FAILURE TO GROUND PIN 2 AT ALL, OR GROUNDING AT THE FAR END OF THE CABLE MAY LEAD TO WEAK OR DISTORTED OUTPUT, OR TO OUTPUT STAGE OSCILLATION.

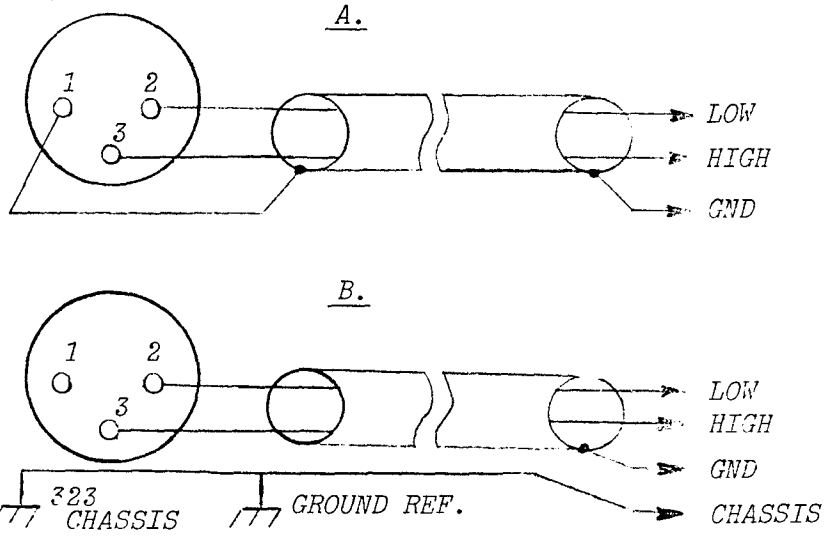
Connection to Unbalanced Load

Use two conductor shielded cable wired as shown at right. Note that the connection from pin 2 to pin 1 must be made inside the shell of the XLR-3 plug going into the 323 output connector. See the note just above.



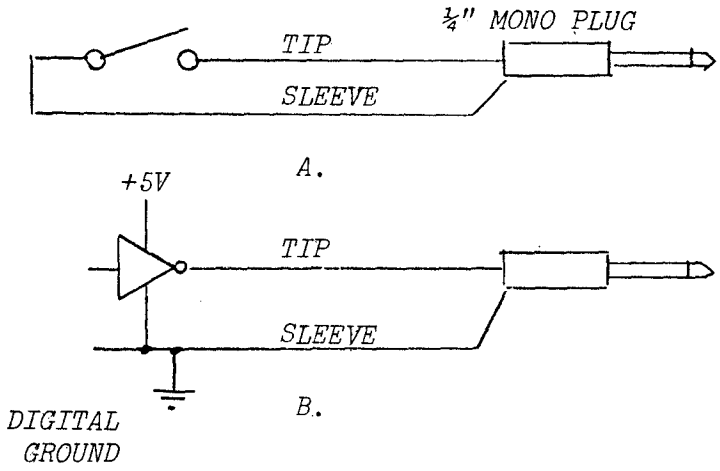
Connection to Balanced Load

A is the straightforward connection, but B may offer advantages in dealing with possible system ground loops. In B both the 323 and the load chassis are grounded to a good system reference, and there is no direct connection via the output cables. This prevents ground currents from flowing in the cable shields.



C. Override Jacks

These three jacks allow remote control of the Input Mute, Dry Only, and Reverb Clear functions. The sleeve of the 1/4" jacks connects to ground, while the tip goes to an LSTTL logic input pulled up by a 3.3K ohm resistor to +5VDC. To activate the function, connect a 1/4" mono (two circuit) plug to either a switch, normally open, as shown in A, or to the output of a LSTTL gate, as shown in B. The gate should be capable of sinking 1.5mA at 0.4V or less.



NOTE: These jacks and the front panel buttons are "OR'd"; that is, activating one or the other enables the function. If the front panel button is in, then the rear panel jack will seemingly have no effect, and vice versa.

D. AC Connector

Standard IEC detachable line cord AC receptacle, with 3 pins. The center pin is tied to the 323 chassis for electrical safety reasons. A nearby sticker shows the factory setting of an internal slide switch at the time of shipment. This switch straps the transformer primaries for 115V operation (windings in parallel) or for 230V operation (windings in series). Also inside are a fuse for the mains (US type 3AG SLO BLO .75A, 1-1/4 x 1/4"), and a fuse for the +10 and +5VDC supplies (US type 8AG 2.5A fast blow, 1 x 1/4").

V. Control Descriptions

INPUT LEVEL: This dual potentiometer is an overall level control that operates on the stereo inputs to compensate for differing source loudness. Adjust so yellow -6 LED flashes frequently, yellow -3 LED occasionally, and red 0 LED flashes only rarely.

PEAK LEVEL DISPLAY: These 8 LED's show the true instantaneous peak signal level in the digital domain, with peak hold to capture even the shortest peaks. All circuits in the 323 operate with good headroom and slew rate reserve when this indicator never reaches red.

LF & HF DECAY: These potentiometers control 6dB/octave low and high pass filters in the reverberation processor to reduce the low and high frequency decay times relative to the mid-band decay time. The LF -3dB corner adjusts from 14Hz at max to 480Hz at min. The HF -3dB corner adjusts from 48kHz at max to 3kHz at min.

The 323 has a bandwidth to 15kHz when the HF Decay control is full clockwise. Generally, in nature anyway, reverberation does not extend to such high frequencies, due to air and wall absorption effects. You will find it preferable to reduce the HF Decay for many kinds of music and reverberant effects. Unless you do so, occasional sibilants, especially in the larger rooms, will hang on for longer than desirable.

The LF Decay control will be used less often. If you'd like a harder sound, or to not have bass information muddy up the reverb, you can try reducing LF Decay.

DIRECT MIX: This dual potentiometer adjusts the level of the left and right input signals that feed "directly" into the stereo output. If the 323 is used with a mixing console in the echo send/receive loop, this control will normally be left at 0, since the Direct signal is mixed at the console.

REVERB MIX: This dual potentiometer adjusts the level of the stereo reverberation signal mixed into the stereo output. If the 323 is used in a console echo send/receive loop, this control should normally be left at 10.

The two mix controls can be used, of course, to balance the proportion of reverb and direct sound going to the 323 outputs--that is their primary function. You can also use them to adjust the overall output level of the 323 for cases where a lower than normal signal level is needed by the equipment following the 323. This may be the case with equipment intended for nominal "-10dB" levels. Simply adjust the controls so that neither one is at maximum, and each is contributing the right balance of its signal.

ROOM: This rotary switch selects one of 8 rooms. Each Room simulates a different kind of reverberation environment, from plate reverberators to large concert halls. Each Room has its own preset early reflection pattern, and set of decay time options. When operated, this switch changes many parameters inside the 323, including delays and gains. If the Decay Time is set to zero, or Reverb Clear is engaged, there will be only an instanteous glitch, and even then only if there is sound going into the 323. At higher Decay Times, however, the glitch resulting from a Room change will itself be reverberated. It is best to wait for a pause in the music if you would like a silent change of Room. In fact, you actually need to wait until any reverberation in process has died out to ensure a silent change.

Refer to Section VI.A and the three tables there for some application ideas to help in selecting the best room to use.

PRE-DELAY: This rotary switch selects one of 16 pre-delay values, from 0 to 320ms, providing additional delay before the onset of reverberation. If there is sound coming through the 323's Reverb Mix control, there will be a glitch in the output due to changing Pre-Delay; but the glitch will not be reverberated. (We distinguish between the more benign glitches which occur in an instant and are done with, and the glitches that can also go on and be reverberated).

The earliest reverberation sound provided by the 323 comes from a series of left and right early reflections. The delay time of the shortest of these taps is displayed as the "pre-delay" time in ms on the front panel. However, just as in a plate reverb or concert hall, the true, high density reverberation process develops after an inherent delay related to the size of the environment, so too in the 323. Table II shows the approximate inherent pre-delay time between the first reflection and the development of dense reverberation. You may take it into consideration when adjusting Pre-Delay in the different Rooms. Unlike the Pre-Delay value, which is adjustable from the front panel, the inherent pre-delay is an unalterable aspect of each Room's sound.

The history of "pre-delay" in sound recording is an interesting one. Traditional artificial reverberators of the 50's-70's used springs or plates. These devices inherently responded very rapidly to incoming audio, and began reverberating within 10 or 20ms or so. While this was often great with drums, it was poor for more natural, concert hall effects. In a concert hall, there is always an initial period when the reverb is building up and there are only a few early reflections. This gap helps music sound clearer and more natural, and contributes to our perception of the size of the hall.

In order to make their plates and springs sound more natural, recording engineers developed the practice of inserting a tape delay (later, digital delay units) ahead of the drive to the spring or plate: hence the term pre-delay. In a modern digital reverberator like the 323, there is already an inherent pre-delay in each room, which scales from short to long as the room size is increased. Although there is, therefore, less need for pre-delay, you may add more pre-delay with this control. In fact, the range of pre-delay (up to 320ms) is so large that a distinct echo can be heard when reverb begins. This can be useful for special effects.

You should note that when the pre-delay is set to 0, and a high proportion of reverb is put in the mix, you may hear some comb filter frequency response effects, due to the interaction of the direct signal and the first few taps. Increasing the pre-delay to 10 or 20ms will eliminate this.

DECAY TIME: This rotary switch selects one of 8 decay times. The display shows the "RT60," or time for the reverberant energy to decay to -60dB relative to its initial value. Each Room has its own menu of 8 decay times, ranging from 0 to a maximum value (2 to 10 sec). With the decay time set to 0 all that is heard is the early reflections. Operating this control while sound is coming through the reverberator will rarely result in an audible glitch, with the exception of going from zero to maximum decay time (turning the control counterclockwise one position from the maximum setting). Then the glitch will be similar to the one discussed under "Reverb Clear".

Decay time is one of the most important parameters that determine the sense of ambience of a recording. As a guideline when seeking a natural acoustic environment for a sound, pick shorter decay times for small ensembles, and longer decay times for large orchestras, space music, and pipe organs. There is also a close relationship between decay time and how rapidly a sound source is changing. Rapid speech or fast musical passages with articulated detail cannot tolerate long decay times or the temporal detail gets lost. On the other hand, slow music can benefit from the extra feeling of space that comes from longer decay times.

OVERRIDE BUTTONS: Three special features of the 323 enhance the ability of musicians and engineers to "play" with the reverberation process during performance or recording, and are especially useful with longer decay times. An LED directly above each switch flashes as long as the function is activated, whether by the front panel switch or by the rear panel jack.

INPUT MUTE: This push button switch mutes the input signal, preventing it from reaching the Direct Mix control and the reverberation processor. Any reverberating sound in the processor continues to decay naturally. The function is duplicated via a rear panel jack. Although this function is electrically quiet, it may produce a glitch, and the glitch can reverberate, if there is sound entering the 323's input at the moment the switch is activated on or off. It is best to operate the switch only during pauses of the incoming sound.

Input Mute can be used in several ways. With a very long decay time, such as 8 or 10 seconds, you can wait until a note or sound is reverberating and hit Input Mute. Now only the sound that was reverberating will continue as it dies out naturally. Or you can use it to disable the 323 during times in a performance or mixdown when you no longer want reverberation.

DRY ONLY: This push button switch mutes the Reverb Mix signal, leaving only the Direct Mix signal in the output. Incoming sound continues to enter the processor and to reverberate naturally, but is not heard at the output. This function is duplicated via a rear panel jack. Although this function is electrically quiet, when engaged it will abruptly interrupt any sound coming from the reverberator. This interruption may result in an audible transient.

You can use this feature to eliminate reverb sound from the mix, while still allowing the direct sound through. The reverberator is still reverberating: you just can't hear it. When you next release this button, you will "rejoin the reverb in progress." Note that if the Direct Mix control is at zero, no sound whatsoever will appear at the outputs.

REVERB CLEAR: This push button switch forces a decay time of "0" regardless of the displayed Decay Time. This clears any reverberant decay that may be in process and disables reverberation. This function is duplicated via a rear panel jack. When pushed in, reverberation recirculation is immediately interrupted, leaving only the "early reflection" sound to reach the output. The transient from this may be audible, depending upon the program material. When the button is released, reverberation is enabled again, and the transient so caused may be audible and may be reverberated. It is best to release this button after a slight pause in the incoming sound.

Reverb Clear is useful with long decay times to create moments with no reverberant decay, when only the early reflection sound reaches the output. When you release this button, reverb will immediately begin to build up normally.

VI. Room Characteristics

A. The 8 Rooms

The 323 has one basic algorithm, very flexible and broadly conceived, that can simulate a wide variety of reverberant spaces or devices. Changing the time delays and the gains used thoughout the algorithm results in dramatically different rooms, ranging from small, fast-diffusing plates appropriate for percussion, to large echoing spaces.

Once you become accustomed to the controls, it will be easy to appreciate the uses and distinctive qualities of each of the rooms. The basic difference from room to room is the increasing time delays used (moving from Room 1 to Room 8). This is, of course, true to nature, where small spaces have short sound paths and large halls quite long paths. Each of the rooms has a distinctly different character, useful for a variety of program material, instruments, and creative effects. Table I will give you some idea of the differences between the 8 Rooms. Refer to the Glossary of Reverberation Terms in Section VII.C if any of these terms are new to you.

TABLE I: ROOM CHARACTERISTICS

CHARACTERISTIC	ROOM 1	2	3	4	5	6	7	8
ACOUSTIC ANALOG	Plate	Plate	Chamber	Small Hall	Hall	Large Hall	Cathedral	Canyon
DIFFUSION	Fastest							Slowest
COLORATION	Greatest							Least
PERCUSSIVE SOUNDS	Best	Good						Worst
SPACIOUSNESS	Least							Most
INTELLIGI-BILITY	Greatest							Least
INHERENT PRE-DELAY (ms)	16	24	40	64	88	120	160	200
MAX DECAY TIME (sec)	2.0	3.0	4.0	5.0	6.0	7.0	8.0	10.0

Table II gives a rough range of suggested settings for you to try with your 323. There is such a broad range of taste and musical style that a table such as this can only be thought of as a starting point. Please don't read this table as a rigid guide; rather, give free rein to your creativity, and experiment!

TABLE II: SUGGESTED SETTINGS FOR VARIOUS SOURCES

SOURCE	LF DECAY	HF DECAY	ROOM	PRE-DELAY (ms)	DECAY TIME (sec)
PERCUSSION, SNARE DRUM			1-3	0-70	0-4.0
VOCALS			2-4	0-100	0-4.0
PIANO			3-6	0-120	0-4.0
CHAMBER MUSIC			3-5	0-60	1.5-3.0
SYMPHONIC MUSIC			3-6	0-170	2.0-4.0
NARRATION			1-4	0-30	0-2.0
SYNTHESIZER			3-8	0-240	0-6.0
SPACE EFFECTS			6-8	0-320	3.5-10.0

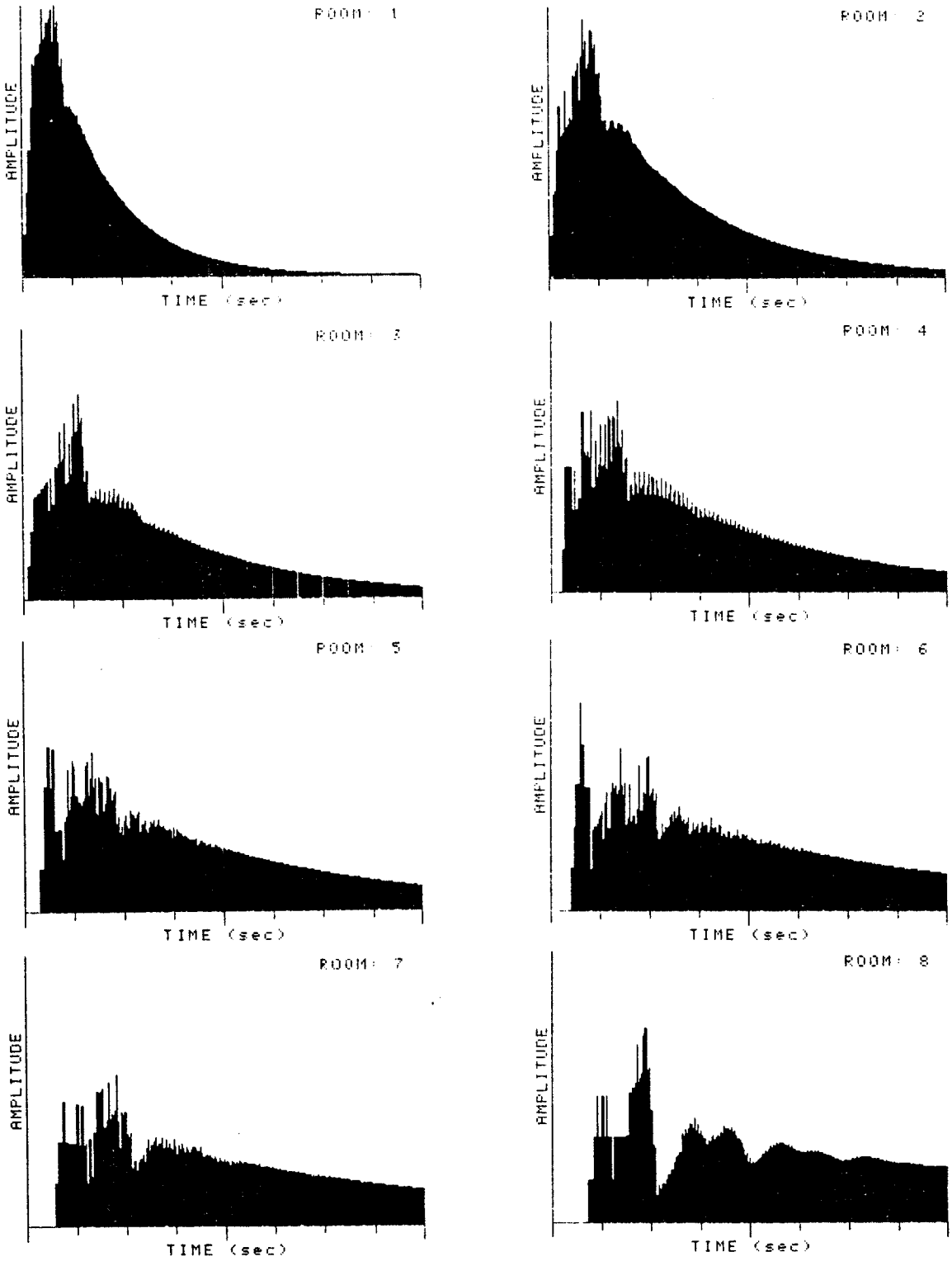
TABLE III: AVAILABLE DECAY TIMES (sec)

ROOM								
1	.0	.4	.7	1.0	1.3	1.6	1.8	2.0
2	.0	.5	1.0	1.5	2.0	2.4	2.7	3.0
3	.0	.8	1.5	2.0	2.5	3.0	3.5	4.0
4	.0	1.0	1.8	2.5	3.2	3.8	4.4	5.0
5	.0	1.2	2.2	3.0	3.8	4.6	5.4	6.0
6	.0	1.5	2.5	3.5	4.5	5.4	6.2	7.0
7	.0	1.8	3.0	4.0	5.0	6.0	7.0	8.0
8	.0	2.0	3.5	5.0	6.5	8.0	9.0	10.0

B. Computer Room Simulations

We made extensive use of computer modelling of the 323 algorithm during the tuning process. The impulse response decay curves on the next page were computer generated during the tuning process. Literally hundreds of such curves were generated, examined visually, and, if promising, auditioned with a variety of challenging program material on studio monitors.

Each curve represents the response of the 323 to a short impulse, as seen at the output with 50ms averaging interval. To simplify the curves, the early reflections resulting from the taps pick up of the incoming direct sound is suppressed in these curves. The total time covered by each curve is two seconds (horizontal axis). The vertical scale is relative amplitude, in linear units (not dB). The decay time for each curve was chosen to permit good examination of the first 2 seconds of decay. We provide the curves merely to give you some feel for the 8 rooms. Note the rise of each curve: the smaller rooms build rapidly to their peak, and thus fuse the early sound well with the source, making them best for drums. The larger rooms take longer to build up, and leave more of an "open space" that allows the direct sound to be heard more clearly.



Computer Simulations of 8 Rooms

C. Other Applications of the 323

i. Mono to Stereo Conversion

The 323 uses a group of left and a group of right taps to "audition" the contents of the reverberation processor. They also, of course, audition the incoming direct sound. When you select a decay time of zero, or activate Reverb Clear, the reverberation processor is disabled, and all that remains is the audition taps. They are placed at precise time and amplitude values that yield an uncolored (ie., almost flat frequency response) version of the direct sound. The left and right tap groups are also arranged to give a stereo pickup of the direct and reverberant signals, with a spacious, uncorrelated sound (look at the outputs on an X-Y scope display!).

Furthermore, the two groups are arranged to not only be uncolored by themselves, but to remain uncolored when summed to mono. This makes them ideal for mono-to-stereo synthesis. The output will transform a center image mono signal into a pleasingly spacious, natural stereo signal that retains full compatibility in mono.

We recommend that, in this instance, you use no direct signal, but only the Reverb Mix signal. You most likely will want to keep the Pre-Delay at zero to keep the pseudo-stereo signal in sync with any other material in the mix. And you would, strictly speaking, keep the Decay Time at zero. But if the material you are spreading into stereo is also very dry, you could sneak the Decay Time up to the first or second non-zero value and see how you like it that way. There is no reason to reduce the HF and LF Decay controls from full clockwise, unless you would like to equalize the pseudo-stereo signal a little.

We recommend that you keep to the smaller rooms-- 1, 2, or 3--for this effect. The audition tap time delay patterns get longer in the larger Rooms, and you will begin to hear discrete repetitions of the source.

Rooms 1 or 2 are nice to use with an announcer's voice in an on-air broadcast application. The mono, boxy voice is projected into a little space, without the annoying 2 or 3 second decay time of a spring or plate reverb. In addition, the perceived loudness is boosted somewhat-- more than the VU meter would tend to make you think. This is because the ear integrates the delayed versions of the direct sound and hears it as louder, even though the peak value may not change so much.

In multi-track mixdown, this is a nice technique to use with closely-miked mono pickups of drums or any other instruments or voice. It helps save tracks on the multi-track, too, because you know at mixdown that you can derive a stereo signal from a track. Set the 323 as suggested in the earlier paragraphs, and try it

this way. You'll get a pleasing stereo sound, spacious and hard to localize. If you do use some dry signal in the mix, you might try increasing the Pre-Delay to 10 or 20ms (otherwise you may hear some comb filtering occur from direct/pseudo-stereo signal interactions).

ii. Fattening and Doubling

Over the years, doubling has come to mean the technique of mixing a signal from a VCO'd delay line with the dry signal. The delayed signal is typically set to 15-35ms or so, and the VCO slowly sweeps the delay up and down about 50% of the nominal time, resulting in a second "voice" with both "random" time delay and pitch variations. Well, doubling can be a little different....

The kind of doubling described above is the only one most studio people know of, because virtually all delay products are limited to one or, rarely, two taps of time delay. We introduced the SPACE STATION SST-282 some years back, and gave it 8 taps for auditioning the processor and more than 12 other taps for reverberation. In the 323, also, we have a lot of taps and can bring this powerful technique to bear on doubling: actually, what we deliver is quintupling (direct + 4 taps). Try using the 323's "Reverb" output with a zero decay time on drums, vocals: anything you'd like to fatten up or spread out. There is no time variation on this signal, as there would be with a VCO'd delay line, but that may be to the good with instruments like piano and guitar where you're after a second voice and not a detuning of the instrument.

iii. Chorus

Chorus has a fuzzier meaning in the audio industry. Often, "chorus" is just another name for doubling, stemming from the idea that we can turn one singer or a few singers into a chorus by replicating them with a delay line. As discussed above, the 323 can provide 4 extra voices, so it's also a chorusing device. Now as long as you have a zero Decay Time set in your 323, the sound from the Reverb signal is just pure time delays. But as you advance the Decay Time control, the contribution of the reverberation processor comes into play. The reverberation signal is subjected to a slow randomization process, so that the sound does acquire a time and frequency response variation. Try this with slow, spacious music, like synthesizer, in one of the large rooms, like 6 or 7, and with a longish decay time (4 seconds or more). The reverb will shimmer and give an enhanced, living sound to otherwise sterile instruments.

D. Is the 323 a Stereo Reverberator?

Although the 323 has stereo inputs, internally it is a one input, two output reverberation processor. Unlike some spring reverbs, it is not two separate and independent reverberators in one box. The 323 design is intended to create a natural, spatially correct stereo reverberation field from its direct inputs. It sums the left and right inputs internally before sending them into the processor, and makes no spatial distinction between its two inputs in developing stereo reverb. The Direct signal path is provided in full stereo as a convenience for situations in which a stereo feed must be carried through the 323 and combined with stereo reverb. If you have a mono source and need mono reverb, simply use the left input and the left output of the 323. If you have a mono source and want stereo reverb, with the mono direct signal coming through the 323 into both output channels in mono, you must make up a "Y" connector with two male XLR plugs wired in parallel to couple your mono source into both of the 323's inputs.

E. Tremolo Sound

At high decay times, you may hear a "tremolo" character to the reverberation signal. This is normal, and is due to the background operation of a randomizing circuit in the 323.

In a room or concert hall, sound freely roams around in a three dimensional volume, and experiences an infinitude of different time delays between reflections, resulting in an extremely complex and rich reverberation sound. Any electronic box created by mere mortals is far simpler than a concert hall, because it can only provide a relatively small number of delay times. In the 323, a randomizing circuit is constantly changing the time delays to new values, so that during the reverberant decay process, a sound experiences thousands of different delay times. A side effect of this technique is that the frequency response is a complex, time-varying function. A similar phenomenon occurs in real concert halls due to the closely spaced resonant peaks in the hall's frequency response. As a musical note shifts slightly in pitch it moves in and out of the various hall resonances (or "modes") and experiences amplitude changes.

As discussed in the section on Chorus, the "tremolo" effect can be used to good advantage with some musical material. Sounds that are nearly steady and close to pure tone, in the 100 to 300Hz range, are the most susceptible to this "tremolo" (piano, certain vocal or acoustic guitar passages, and sustained synthesizer notes). If you want to minimize the tremolo when working with such sounds, follow these guidelines:

1. Use larger Rooms: the tremolo is progressively less audible as the Room gets larger.

2. Keep the Input Level up so that the -6 and -3 yellow LED's flash on peaks. The tremolo is less with high signal levels.

3. Where possible, use short Decay Times, as the tremolo effect is less with shorter Decay Times (gone, in fact, at zero).

VII. Reverberation Tutorial

A. Reverberation and Algorithms

An algorithm is the definition of a process, the sequence of operations that must be carried out to accomplish a desired result. In our case, the desired result is to synthesize reverberation from the source input signal ("dry" or "direct" sound). Shortly we will discuss how this is accomplished in the 323 and, in the process, learn something about its algorithm. But first let's investigate the "algorithm" for natural reverberation. How can we describe the process whereby an acoustic space transforms the sound from a source into reverberation?

To begin, there are some rules. Sound is the phenomenon of wave motion in air, so all the laws of physical acoustics describing sound propagation and absorption in an enclosure apply. The following five principles are relevant to our description of natural reverberation:

1. Sound is radiated from its source as a wave, extending in a straight line in every direction (subject, of course, to the source's directivity pattern).

2. As sound travels through the air, some of its energy is lost due to collisions with air molecules, resulting in attenuation of the sound with increasing distance, especially at high frequencies.

3. Sound travels relatively slowly--about one foot per millisecond (1/1000th second). This results in a sequence of closely-spaced echoes that unfolds in time.

4. By the very nature of an enclosure, the travelling sound wave will eventually reach a boundary. When it does, the angle at which the sound is reflected from the wall will equal the angle at which the sound hit the wall.

5. When the sound wave encounters a boundary and is reflected, it loses some energy: only a portion of the sound is reflected. Sound will be attenuated every time it reflects off a boundary.

Armed with these basic principles, we can outline the algorithm for reverberation in an enclosure. The source emits sound which radiates in straight lines, getting weaker because of air absorption, until it eventually encounters boundaries. The sound is reflected, losing further energy, and travels again through the air, again encounters another boundary, etc. As time goes by, the reflections build up and occur with such temporal and spatial density that all distinctions between individual reflections are lost. It is a pretty simple process to conceptualize this way.

Although the process can be described simply, the result is complex. In a concert hall the sound wave emitted by an instrument on stage travels in many directions and encounters various boundaries many different times. The sound reflects off each boundary that it encounters, so that the process results in an increasingly dense pattern of reflections, which eventually approach the listener from all angles, and at the rate of thousands of echoes per second.

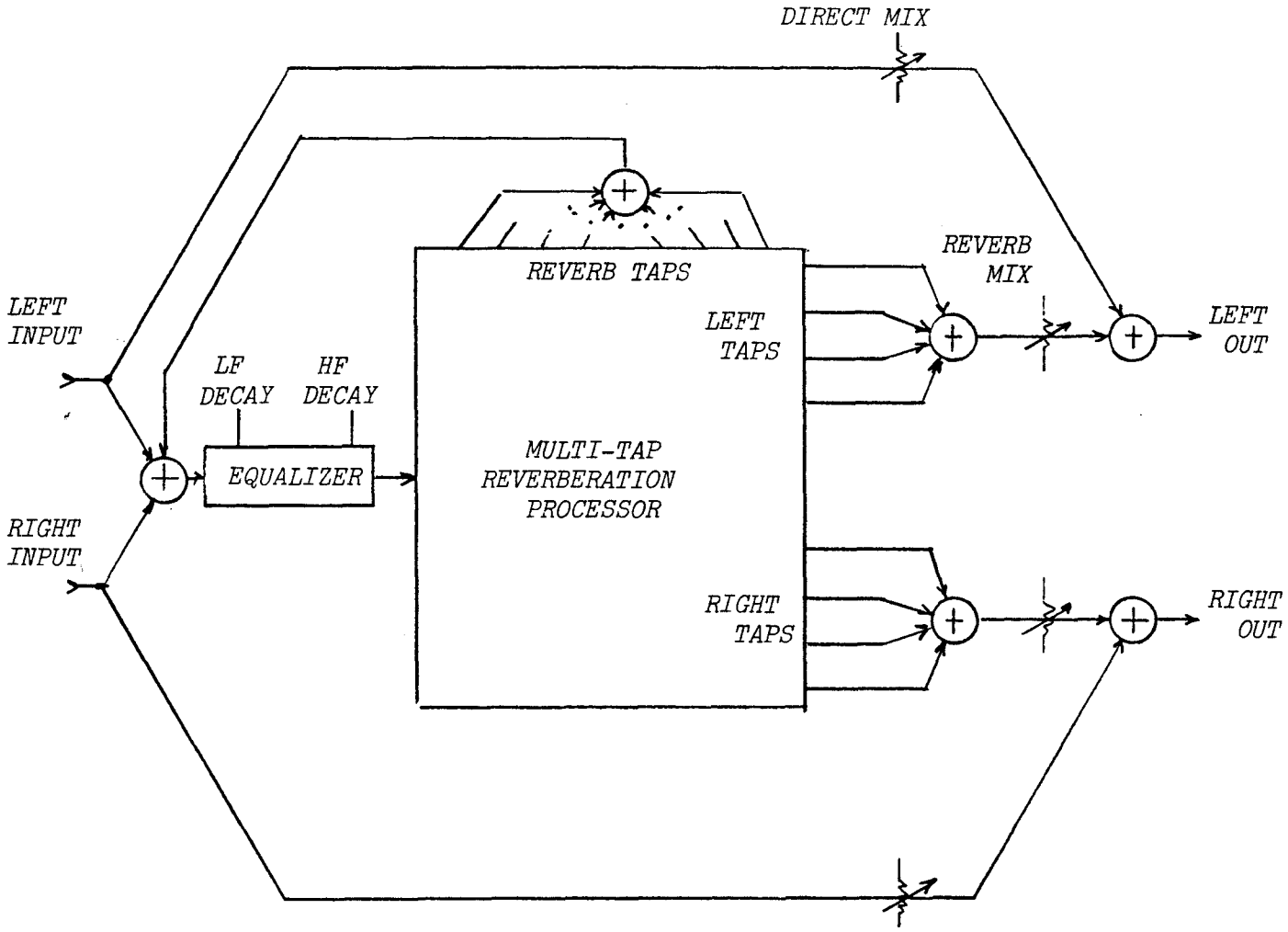
Acoustic spaces are three-dimensional, making it extremely difficult to duplicate with a simple piece of electronic equipment-- or even with a complex piece of equipment, for that matter. In fact, it has been observed that it is theoretically impossible to exactly synthesize reverberation with an electronic system. A natural acoustic environment is three-dimensional, whereas a piece of electronic equipment can never exceed one dimension-- but that is an issue too complex for us to explore here.

What we need to do in our reverberator is to come up with a convincing replica of natural reverberation. The listener automatically, and largely unconsciously, subjects any synthetic reverberation to psychoacoustic tests, comparing it to a deep memory of natural reverberation. The output of our digital reverberator needs to pass these tests: not exactly duplicate the real thing.

B. The 323 Reverberation Algorithm

The 323 uses an algorithm proprietary to URSA MAJOR, called "Multi-Tap Digital Delay." In this algorithm there is a large digital audio memory (realized in RAM, Random Access Memory), with one input and many output taps. The stereo direct signal entering the 323 is split into two paths: one goes through the Direct Mix control to the overall 323 outputs, while the other goes through a mixer. The resultant mono signal passes through an adjustable high and low frequency equalizer (LF and HF Decay) and is written into the RAM audio memory.

Off of the RAM memory are 23 read taps. Each extracts sound from the memory with its own particular delay, gain, and phase. The taps are arranged in 3 groups: left, right, and reverberation. The left and right tap groups are fed to the overall 323 outputs via the Reverb Mix control. The reverberation taps are returned to the input mixer to be reinjected into the RAM.



323 Algorithm Block Diagram

The left and right taps first pick up delayed versions of the incoming direct sound and thus provide a simulation of the so-called "early reflections." The reverb taps (the largest group of taps), pick up many delayed versions of the incoming sound, much as the multiplicity of reflecting wall surfaces in a concert hall would, and reinject them into the "hall." The left and right taps continue to pick up the reverberation dying out in memory after the incoming sound has stopped. They are thus like pick-up mikes in a concert hall.

Since all sound entering the RAM passes through the equalizer, the equalizer will affect the reverberating signal in every one of its recirculating passes. This means that the controls not only equalize the entering direct sound, but the decaying reverberation. This distinction is important, as it means that these controls allow you to shape the spectral character of the reverberant decay. By reducing HF Decay, you can make the reverberation warmer, more like a concert hall. Reducing LF Decay will make the reverb harder, more artificial sounding.

The Room control selects 8 different reverberant spaces. Each Room brings with it its own set of time delay, gain, and phase values for the three tap groups. These parameters have been carefully tuned by an exhaustive process to create a set of 8 rooms, in a logical progression from very small to very large, each with its own character. Each room has its own menu of eight decay times, and can be given a variable pre-delay in 16 steps, from "zero" to 320ms.

In order to enhance stability, to reduce any tendency to ring, and to increase the density of echoes and resonant modes, we subject the reverberation taps to a proprietary randomization process. This constantly changes their delay and gain so that, over the period of reverberant decay, the sound experiences literally thousands of different reflective paths. This ensures an extremely high echo density after the build-up period, and a very random reverberation. A side effect of this process is a time-varying frequency respone of the reverberation, which can be heard as amplitude variations of steady tones in the reverberator. This is a normal characteristic of the 323.

C. Glossary of Reverberation Terms

DIFFUSION describes the ability of a reverberator to build up a high echo density, and how quickly it builds this density. The greater the diffusion of a reverberator, the more quickly it takes an input sound and produces a large number of echoes. Good reverberation calls for an eventual diffusion to at least 1000 echoes per second. In the studio world, a plate has very high diffusion, an echo chamber somewhat less, and a hall or large space the least. Diffusion is an important parameter to consider with percussive material. A percussive sound, such as a wood block, can be close to an impulse (an engineering term for a loud, extremely short duration sound, like a gun shot or electrical spark discharge). Such impulsive sounds easily reveal the diffusion of the particular reverberator in use. In order not to hear a succession of discrete echoes after the impulse, a reverberator needs high diffusion. But with less impulsive material, such as a string section or pipe organ, or even vocals, we do not care so much about high diffusion because it simply will not be revealed due to the slowly changing nature of the program material.

COLORATION describes the tendency of any reverberant situation to emphasize some parts of the frequency spectrum over others. All reverberators have wildly varying frequency responses with countless peaks and valleys. The broader and higher these resonant peaks are, the more we would hear coloration.

Coloration can distort the balance of different tones in the input signal; for example, as a flute rises and falls in pitch, some notes may leap out while others vanish. Coloration tends to increase in small acoustic spaces (like your favorite tiled shower) where diffusion is the greatest. If you seek the lowest coloration, choose the Hall or Space programs. Of course, in all the 323 programs, coloration has been reduced to the minimum regardless of the diffusion; nevertheless, it is the least in the larger Rooms.

SPACIOUSNESS describes the ability of a reverberator to psychoacoustically convey the listener into another space. The reverberation algorithm is crucial to establishing a feeling for the space and its size by setting time delays, reflection patterns, decay time, decay frequency response, etc.

INTELLIGIBILITY involves our ability to still hear temporal detail of a sound in a reverberant environment. Our ability to understand speech depends upon maintaining enough temporal clarity--intelligibility--to separate syllables. Of course, we never listen just to the reverberation by itself, but if we were to do so, we would find that intelligibility is greatest in Room 1, where delays are short and fuse closely with the source. In Room 4, on the other hand, the long delays and gaps between delays allow confusing repetitions of sounds.

Intelligibility can be related to diffusion: fast diffusion tends to keep the temporal detail of the source fused with the reverberation, retaining clarity. This is why we would prefer a fast diffusing program for percussion, but would not care about diffusion with legato, slow-changing sound sources. In the larger rooms, the delays and gaps are long enough so that we can actually hear the discrete echoes if we excite the 323 with short impulses.

VIII. In Case of Difficulty

A. Servicing

USER SERVICING: There are no user servicable parts in the 323 except for the two fuses, and they are extremely unlikely themselves to be the cause of a failure.

If the unit is totally dead--no lights, doesn't get warm, and emits absolutely no sound (not even background noise)-- check the power cord at both ends for good contacts, and try another one if possible. Verify that the electrical outlet can operate another piece of equipment. If the power cord and outlet check out OK, remove the power cord from its connector at the rear of the 323. Remove the top cover of the 323 (11 screws) and locate the AC line fuse (it's at the front right edge of the PC board, near the power switch, under a a protective cover). If the fuse appears to be OK visually, it would still be thorough to remove the protective cover and check the fuse for continuity with an ohmmeter. If the fuse is open circuit, replace it with a fuse of exactly the same type and value, restore the protective cover and then the top cover, and try again. If your 323 is still inoperative, refer servicing to a qualified technician.

If the 323 seems warm, and there is some circuit noise in the output, but all the display LED's and digits are blank, check the fuse for the +10 and +5VDC supplies. Remove the power cord from its connector at the rear of the 323, and then remove the top cover. Locate this fuse at the right rear of the PC board, to the left of the power transformer. Look closely for evidence that the fuse opened. If it appears OK, use an ohmmeter to check for continuity, and replace if necessary, being sure to use exactly the same type. Reinstall the top cover, and try the 323 again.

IMPORTANT: IF YOU MUST REPLACE A FUSE, YOU MUST USE EXACTLY THE SAME TYPE AND VALUE IN ORDER TO NOT CREATE A SAFETY HAZARD. REPLACING A FUSE BY A SHORT CIRCUIT MAY PERMANENTLY DAMAGE THE UNIT OR CAUSE A FIRE HAZARD!

There are roughly 100 IC's in the 323, so servicing is not feasible for the typical owner. Please consult with your dealer or with URSA MAJOR if you have a service problem. We will do our best to quickly resolve the problem.

SHIPPING INSTRUCTIONS: Should your 323 require service, return it with a note, placed inside the carton on top of the unit, that tells us:

1. Exactly what's wrong--any symptoms you observed, how the unit is connected to other equipment, whether the problem is always present or only intermittent, whether the unit was OK originally and then developed the problem, or whether it was always defective. If possible, include a cassette recording of the the unit's sound when exhibiting the failure.

2. When and where you purchased the unit if you believe it to be still under the one year warranty.

3. The name and phone number of someone we can call if we have a question, or difficulty duplicating your symptoms.

4. The full name and street address we should use when returning the unit to you.

Hopefully, you have saved the original carton and will reuse it when shipping to us. If not, you may obtain another carton from us for a nominal charge, or you may pack it yourself. If you pack it yourself in your own materials, be sure the 323 is completely surrounded by at least 3 inches of padding on all surfaces, and that the box is strong. We recommend that you insure your 323 shipment to us because, of course, otherwise it is completely uninsured against damage or loss. You must bear the cost of shipping to us even if the unit is in warranty still.

After warranty repairs, the unit will be returned with postage prepaid. On out-of-warranty repairs in the United States, and some other countries, the unit will be returned COD (covering shipping and service charges).

The shipping address for URSA MAJOR is, at the time of writing (March 1984):

URSA MAJOR, Inc.
50 Trapelo Rd.
Belmont MA 02178
USA

It would be wise to check with us to be sure that the address above is still current if you are returning a unit in 1985 or later. Our mailing and telephone addresses are:

URSA MAJOR, Inc.
Box 18
Belmont MA 02178
USA
telephone: 617 489 0303
telex: 921405 URSAMAJOR BELM

B. Warranty Information

LIMITED ONE YEAR WARRANTY: URSA MAJOR, Inc. warrants each Model 323 to be free from defects in materials and workmanship, under normal use and service, for one year. This warranty begins on the date of delivery to the purchaser or his authorized agent or carrier. If you sell your unit or give it as a gift, the warranty is automatically transferred to the new owner and remains in effect for the original one year period. During the warranty period, we will repair, or, at our option, replace at no charge, components that prove to be defective, provided that the equipment is returned, shipping prepaid, to the factory or a designated service facility.

This warranty is null and void under any of the following conditions:

a. Abuse, neglect, alteration, or repair by unauthorized personnel.

b. Damage caused by improper use, or operation from an incorrect power source.

c. Damage caused by accident, act of God, war or civil insurrection.

No other express warranty is given. The repair or replacement of a product is your exclusive remedy. ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE ONE-YEAR DURATION OF THIS WRITTEN WARRANTY. Some states, provinces, or countries do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. IN NO EVENT SHALL URSA MAJOR, INC., BE LIABLE FOR CONSEQUENTIAL DAMAGES. Some states, provinces, or countries do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, province to province, or country to country.

OBLIGATION TO MAKE CHANGES: Products are sold on the basis of specifications applicable at the time of manufacture. URSA MAJOR, Inc., reserves the right to make changes or improvements in the design of the machine without obligation to make such changes or improvements in purchaser's machine.

SERVICE WARRANTY: Any out-of-warranty repairs are warranted against defects in materials and workmanship for a period of 90 days from date of service.