

Lexicon 224

OWNER'S MANUAL

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2.0 BRIEF OPERATING INSTRUCTIONS - VERSION 3 (AND HIGHER)

POWER-ON DIAGNOSTICS:

Digital systems diagnostics are performed at power-on or "RESET". The test begins by illuminating all remote panel LEDs for a few seconds, while displaying a "P" and the software version number. Errors display with an "E" and an error code.

If no errors are found the 224 starts reverberation with program #1 in the "CALL" mode. Recommended parameter settings are automatically loaded and the 224 can be used for reverberation without further adjustment. Notice that program buttons #7 and #8 are normally illuminated. See "Mode Enhancement" and "Decay Optimization".

TO "CALL" A REVERBERATION PROGRAM:

Press the "CALL" button to enter "CALL" mode, and then press the desired program button. Recommended slider settings will load automatically.

Example: "CALL" + "PROGRAM #3" = "Large Concert Hall - B" with recommended slider settings

TO MODIFY INITIAL SLIDER SETTINGS ("CALL" or "SET" modes)

Move the desired slider to or through the preset position. The slider will become active. The preset or active position can be viewed on the digital display by pushing the button below each slider.

TO ACTIVATE ALL SLIDERS - (bypassing the recommended settings)

Press "IMMEDIATE"

TO "CALL" A MAIN REGISTER:

Press "CALL" to enter the "CALL" mode, and then the desired register button. The previously stored program and slider positions will be loaded. Sliders can be activated to modify the presets.

Example: "CALL" + "REGISTER A" = setup previously stored in register "A"

TO STORE A MAIN REGISTER:

Press "SET" to enter the "SET" mode. Then push the desired register button.

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SLIDERS:

- "BASS" Reverb Time below the crossover frequency
display reads in seconds
- "MID" Reverb Time above the crossover frequency
display reads in seconds
- "CROSSOVER" Sets the Crossover frequency between "BASS" and "MID"
display reads in Hertz and kiloHertz
- "TREBLE DECAY" Sets a FREQUENCY above which decay is very rapid
display reads in Hertz and kiloHertz
- "DEPTH" Sets the effective distance between the source and the reverberation
display reads in arbitrary units from 0 to 71
- "PRE-DELAY" Sets the delay before the onset of reverb
display reads in milliseconds

INPUTS:

Stereo feed to the "LEFT" and "RIGHT" inputs as marked. Reduced separation may be useful.

Mono feed should be bridged to both inputs.

OUTPUTS:

The main stereo outputs are outputs "A" and "C", the jacks just below the input jacks. Outputs "B" and "D" are chiefly used for mixing with the front channels in Quad operation. They are not recommended for stereo.

For mono use, it is best to mix "A" and "C", but either can be used alone.

PHASE:

Be sure there is no phase reversal between any of the inputs or the outputs of the 224.

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2.1 DETAILED OPERATING INSTRUCTIONS

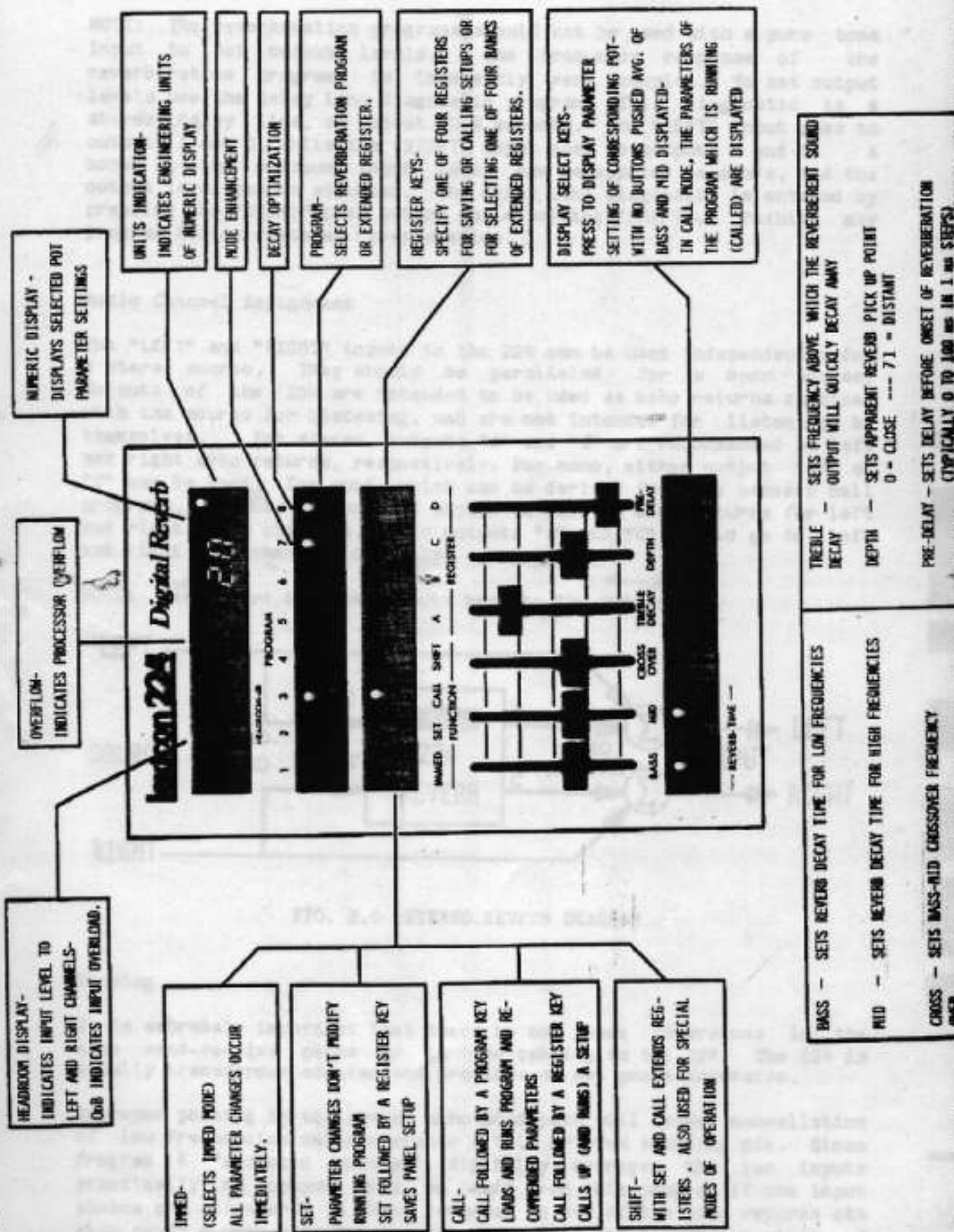
After the Model 224 is installed (section 1), power up at the mainframe. The on/off button applies power to the entire system, lighting the power-on indicator immediately. The remote control panel will take a few seconds to activate while built-in diagnostic procedures verify proper machine operation. As part of the built-in digital diagnostics all LED displays on the front panel are illuminated, while the numeric display shows a triple dash (Version 2) or a capital P (Version 3 and higher) followed by the software version number. The display will then go blank for a few seconds as diagnostics are completed. Machines with Version 2 software activate program 1 in the immediate mode after diagnostics. Machines with Version 3 (or higher) software activate program 1 in the "call" mode. With Version 3 (or higher) software the slider settings Lexicon recommends as a starting point for that program are automatically entered, and the Model 224 can be used without further adjustment. If a different program is desired, simply push the appropriate program button. Again the proper parameters will be loaded. If the optional memory board is installed, the program and slider settings last used in the 224 will be loaded after diagnostics.

If after several seconds the remote panel display fails to log on, or if the display comes on but makes no sense, check the remote cable connections or try pushing the "RESET" button on the mainframe. The reset button should be pushed whenever displays or output signals appear to be garbled. In normal operation this problem should rarely, if ever, be encountered.

Should the diagnostics routine locate a problem, the remote panel display will indicate an error by displaying an "E" followed by a two digit code number. The code can be read by consulting the diagnostics table in section 6. Pushing "PROGRAM 1" will continue diagnostics to the next test. If the 224 must be used despite the indicated malfunction, it is possible to defeat the diagnostics by pressing the "PROGRAM 2" button while powering up the unit at the mainframe or while pushing reset.

LEVEL ADJUSTMENT

Input and output level adjustments can be made with a small screwdriver through access holes in the mainframe front panel. The input levels should be set so that the peak input amplitude falls just short of illuminating the 0dB indicator on the remote control unit headroom display (see section 2.2). The maximum input levels can be adjusted from less than +8dBm to greater than +18dBm. The output levels should be set for the convenience of the user. Maximum output levels range from less than +8dBm to greater than +18dBm peak output depending upon the setting of the output level pots. The input and output adjustments come factory set for unity gain at a level of +12dBm.



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NOTE: The reverberation programs should not be used with a pure tone input to set output levels. The frequency response of the reverberation programs is inherently very complex. To set output levels use the delay line diagnostic program. This diagnostic is a stereo delay line of about 0.4 seconds. The "LEFT" input goes to outputs A and D, while the "RIGHT" input goes to outputs B and C. A tone at the maximum input level can be applied as above, and the output level can be adjusted. The delay line diagnostic is entered by pressing the "DELAY" push button while holding "SHIFT". Pushing any program button restores reverberation.

Audio Channel Assignment

The "LEFT" and "RIGHT" inputs to the 224 can be used independently for a stereo source. They should be paralleled for a mono source. Outputs of the 224 are intended to be used as echo returns combined with the source for listening, and are not intended for listening by themselves. For stereo, outputs "A" and "C" are recommended as left and right echo returns, respectively. For mono, either output "A" or "C" can be used. For quad, which can be derived from the concert hall programs, outputs "B" and "D" should be used as echo returns for left and right front channels, while outputs "A" and "C" should go to left and right rear channels directly.

NOTE: Never feed the 224 outputs back to the 224 inputs.

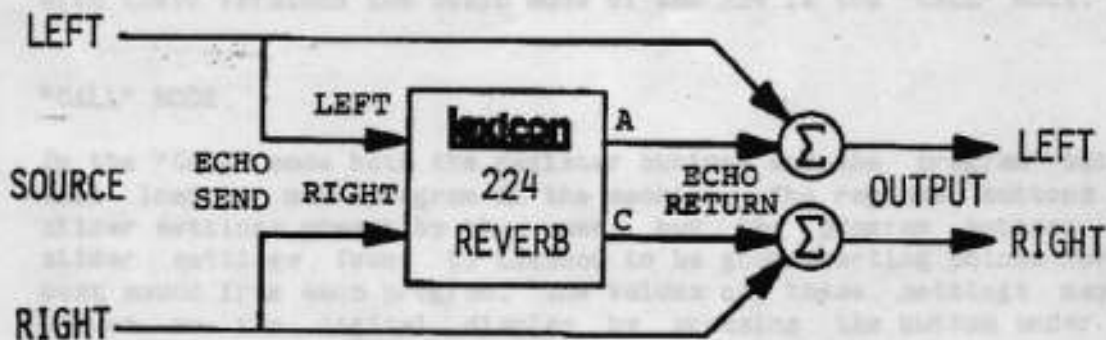


FIG. 2.0 STEREO REVERB DIAGRAM

Phasing

It is extremely important that there be no phase inversions in the echo send-receive paths or in the cabling to the 224. The 224 is totally transformer coupled and provides no net phase inversion.

Improper phasing in the stereo echo send path will cause cancellation of low frequencies and can create a thin or weak sounding mix. Since Program 4 "acoustic chamber" digitally averages the two inputs practically no output will be heard from this program if the input phases are different. A phase reversal in one of the echo returns can also cause a weak mix, but it may also change the apparent width of the reverb on some material. On percussive material an overall phase

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inversion between the inputs and the outputs of the 224 can be easily heard - experimentation with these effects is encouraged.

Mix Ratio

The mix ratio of the reverberant returned to the dry feed is basically up to the user to decide. It is recommended that the returns from the chamber and plate programs be used with restraint, but some material can benefit from a large amount of the concert hall programs.

Bridging of Inputs

It is usually recommended that mono sources be bridged to both "Left" and "Right" inputs - refer to individual program descriptions in Section 3 for specific recommendations.

Program Selection and Use

The 224 allows the user great flexibility in program selection and parameter setting. Software versions beginning with Version 4 have been designed to make obtaining a natural sound as easy as possible. With these versions the basic mode of the 224 is the "CALL" mode.

"CALL" MODE

In the "CALL" mode both the register buttons and the program buttons will load a new program in the machine. The register buttons load slider settings preset by the user, but the program buttons load slider settings found by Lexicon to be good starting points for the best sound from each program. The values of these settings may be viewed on the digital display by pressing the button under each slider.

Once a program has been called the sliders on the panel are initially inactive. The sliders can be individually activated by pushing them to or through the preset position. To change the reverb time for example, one need only push the BASS and MID sliders up or down until the display indicates they have become active, and then set them for the desired sound. "CROSSOVER", "TREBLE DECAY", "DEPTH", and "PRE-DELAY" will all remain at their preset values. The preset values may be restored by simply pushing the program button again. In practice a flick of a control is sufficient to activate it. Modified programs can be saved in the registers for later use or modification by pressing the "SET" button and a register button. A loaded register button in the call mode behaves identically to a program button, except that the preset parameters have been set by the user. Calls to unloaded registers are ignored.

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"IMMEDIATE" MODE

The "IMMEDIATE" mode activates all sliders. If a program button is pushed in the immediate mode the actual parameter settings given by the slider positions will be loaded into the machine with the new program.

"SET" MODE

The "SET" function allows the user to store programs and parameter settings for later use. It also allows the user to modify parameters or call new programs without affecting the audio. If a new program button is pushed while in the "SET" mode the recommended parameters for that program will be displayed. This new program can be modified and run, or it can be stored in a register without affecting the running program. The new program can be run in the 224 by pushing either "CALL", which will run the displayed parameters, or "IMMEDIATE", which will set all the parameters to the actual slider positions.

To store a new set-up in a main register, simply push one of the four "REGISTER" buttons while in the "SET" mode. The program and settings which are currently being displayed will be stored in that register. Once stored, the set-up can be recalled from the "CALL" mode by simply pushing the register button.

All the set-ups stored in the registers, as well as the current operating state of the machine are retained when the power is off if the optional memory board is installed.

EXTENDED REGISTER STORAGE:

Version 3 allows 32 extra program settings to be stored in four banks. The "REGISTER" buttons select the bank, and the "PROGRAM" buttons select the register within the bank. These registers are reached by adding "SHIFT" to either "CALL" or "SET". To store a setting in an extended register, for example register "A1", enter "SET" mode and push "SHIFT". Both "SET" and "SHIFT" should be illuminated. If you now push register "A" AND HOLD IT, followed by program button #1 the current setting will be stored in extended register "A1". The contents of register "A" will be undisturbed. In the "SET" - "SHIFT" mode the program buttons and the register buttons are inactive unless one of each is down at the same time. The display will blink when the settings are correctly stored.

To call an extra register, push "CALL", "SHIFT", and the desired register bank button. All three LEDs should be illuminated. The program buttons will now call any register in that bank with a single keystroke. The display will blink when registers which have been previously loaded with programs and settings are called. Program buttons corresponding to empty registers will be ignored. The "CALL" - "SHIFT" mode allows complicated scene or mood changes to be made quickly. Pushing any "FUNCTION" button restores normal operation.

"MODE ENHANCEMENT" and "DECAY OPTIMIZATION" (SUBPROGRAMS #7 AND #8)

"MODE ENHANCEMENT" is a subprogram which increases the effective density of modes in the 224. It greatly improves the naturalness of the sound of the 224, both in the decay and as the music is running. The improvement is similar to the effect of "DECAY OPTIMIZATION", but the two work by entirely different techniques, and complement each other. If the two subprograms are tried separately, "MODE ENHANCEMENT" is more effective at controlling the coloration at the end of the 224 decay, and it also produces a noticeably warmer sound in speech or continuous music.

"MODE ENHANCEMENT" works by altering some of the internal parameters in the 224 continuously. Since the coefficients must change in discrete steps, an increase in the background noise of the 224 may be noticeable with pure test tones of very low or very high frequency when "MODE ENHANCEMENT" is running. "MODE ENHANCEMENT" is not necessary with such inputs, and it can be turned off by pushing button #7. This change can be stored in the registers. The amount the internal parameters are changed by "MODE ENHANCEMENT" is adjusted differently for each program, and for certain specialized applications it may be useful for the user to use more or less than the preset value. See "ADVANCED FEATURES OF VERSION 3".

"DECAY OPTIMIZATION" improves the naturalness of the decay from the 224. It alters internal parameters in response to changes in level at the input. This subprogram was first introduced with Version 2 software, and has been very successful with users. With version 3 (and higher) software the level detection algorithm has been made much more sophisticated. The 224 can now tell the difference between drums and vocals and adjusts "DECAY OPTIMIZATION" correctly for each. The amount of "DECAY OPTIMIZATION" used is set by each program when it is called and can be adjusted by the user for certain specialized applications. See "ADVANCED FEATURES OF VERSION 3". "DECAY OPTIMIZATION" increases the clarity and reduces the coloration of the decay from the 224. However, it can also make the decay more uneven on some material. If the decay is noticeably uneven, "DECAY OPTIMIZATION" can be turned off with button #8, and this change can be stored in the registers. "DECAY OPTIMIZATION" can cause an increase in noise with low frequency pure tones which vary in amplitude. You may want to turn it off when using the 224 with this material.

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2.2 REMOTE CONTROL PANEL DISPLAY

Numeric Display

The Model 224 control panel displays three digits which indicate a variety of parameters depending upon the function chosen. Quantities from 0 to 999 can be displayed as well as decimals such as 2.8 with the use of a decimal point. In addition, some letters can be displayed such as "E" which indicates an error.

Units

Displayed units are seconds ("sec"), milliseconds ("ms"), Hertz ("Hz"), and kilohertz ("kHz") which are indicated by an LED lamp lighting adjacent to the appropriate symbol. Units are determined automatically depending upon which parameter is selected. For example, "2.8 sec" is a typical value for a reverberation time parameter.

Overflow

Under certain conditions of high input signal levels and/or program parameter settings, the arithmetic processor can overflow much as a calculator that attempts to produce a sum or product that exceeds the range of the instrument. When this happens, the "ovfl" indicator will light indicating the need to reduce one or more of the following: input signal amplitudes, reverberation time settings, "CROSSOVER" setting, or the "TREBLE DECAY" setting.

Headroom

Headroom indicators are provided for both left ("L") and right ("R") input channels; Peak signal levels are displayed on sequential arrays of LED's indicating from 24dB below limit to 0dB (limit) in 6dB intervals. When the 12dB LED first comes on, for example, there is 12dB of dynamic range left before limit, i.e., 12dB of headroom. Proper setting is with both the zero db and overflow LEDs off.

Parameters

The reverberation parameters were chosen primarily to emulate those characteristics of real rooms and halls which most effectively determine the acoustics. For instance, the complex frequency characteristics and the "liveness" of real halls can be approximated with the "CROSSOVER" and "TREBLE DECAY" controls. The size of a hall can be approximated with the "REVERB-TIME" controls. And one's apparent position in a hall can be altered with the "DEPTH" control.

The "PRE-DELAY" control is provided for the common studio practice of inserting some delay time before going to chambers and plates. But because the reverb programs were written with some pre-delay already

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GENERAL OPERATING INSTRUCTIONS

in them, the "PRE-DELAY" control will not be required in many situations.

In order to display a given slide pot parameter, the corresponding control button must be held down. The parameter control pots will be active, however, even if they are not being displayed. When none of the parameter buttons are being held down, the display will indicate an average of the "BASS" and "MID" reverb time parameters.

REVERB TIME

The reverberation time refers to the time it takes for the programmed reverberation to die away following a momentary excitation. The reverberation time is broken down into two bands, the "BASS" and "MID" bands, which are separated at a frequency determined by the "CROSSOVER" control.

BASS

Holding down the "BASS" button causes the bass reverb time to be displayed in seconds as long as the button remains pressed. The reverb time ranges to 70 seconds in coarse increments.

MID

Similarly, holding down the "MID" button causes the mid frequency reverb time to be displayed to a maximum of 70 seconds.

CROSSOVER

The frequency which divides the "BASS" band from the "MID" band is controlled by moving the "CROSSOVER" slide control. When the corresponding button is held down, the crossover frequency is displayed ranging from 100Hz to 10.9kHz.

TREBLE DECAY

The "TREBLE DECAY" refers to the frequency above which reverberation falls off. It is controlled by the "TREBLE DECAY" slide pot, displayed when the button is held down, and ranges from 100Hz to 10.9kHz.

DEPTH

"DEPTH" is a non-dimensional parameter and is displayed (when holding the "DEPTH" button down) on an arbitrary scale from 0 to 7 (software versions 1 and 2) or from 0 to 71 (software versions greater than version 3). In concert hall programs the function of the "DEPTH" control is to simulate reverberation at varying distances from the sound source in a hall. As the control is moved up, the displayed number increases, and the apparent distance from the source increases.

PRE-DELAY

The "PRE-DELAY" parameter produces a delay between the sound source

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and the onset of reverberation from the 224. With the "PRE-DELAY" slider all the way down the displayed delay value will be that value inherent in the particular delay program being used. Refer to Section 3 for the specifics of each program.

SHIFT CONTROL

The "SHIFT" function has been reserved for diagnostics and special functions which will become available to 224 users as they are developed.

2.3 ADVANCED FEATURES OF VERSION 3 (AND HIGHER)

Version 3 (and higher) software allows the interested user to adjust the two subprograms "MODE ENHANCEMENT" and "DECAY OPTIMIZATION". Both subprograms work by altering some of the reverberation parameters as the music is playing. The rate and the amount these parameters are altered are preset by each program when it is loaded, and can be adjusted by the user. "MODE ENHANCEMENT" is set normally with a rate parameter value of 2. This setting produces excellent reverberation while keeping the induced noise low. Slightly more natural sound can be obtained (at the expense of more interaction noise) by setting this parameter to 1. Setting the parameter to 3 or higher reduces the amount of alteration. The parameter is adjusted by using the "SHIFT" button.

To change the parameter, enter the "CALL" mode and select the desired program. Now push AND HOLD both "SHIFT" and program button #7. If you now move the "PRE-DELAY" slider while holding the two buttons the alteration parameter can be set from 1 to 16. The digital display will show the value set. Notice the control must be actually moved to set the parameter. Pushing any of the buttons under the sliders will restore the normal display.

Once the parameter has been changed the new value can be stored along with the program and the slider settings in a register for later use. Calling a register always sets these parameters to the values previously stored. However, pushing the running program button again does not restore the original settings of either "MODE ENHANCEMENT" or "DECAY OPTIMIZATION". The recommended settings are only loaded when a different program is loaded, or if button 7 is switched off and then on. To compare your modified settings with the original it is best to store both an un-modified and a modified version of the program in the registers.

Setting this parameter has been deliberately made difficult. It is not recommended that users adjust "MODE ENHANCEMENT" or "DECAY OPTIMIZATION" unless they are willing to devote considerable time listening for the results.

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The "DECAY OPTIMIZATION" parameter is normally 5 for the concert hall programs and 7 for the plates. Again higher parameter values mean less alteration. To set this parameter use the same procedure as for "MODE ENHANCEMENT", except hold button #8 instead of #7. Once again the changed program can be stored in a register for later use or comparison. Small values of the parameter tend to make the program sound clearer and less colored in the decay, but at the expense of the evenness. When the parameter is too small there can be a noticeable left-right shifting of the decayed sound, especially with a strong input in one channel only. This effect is reduced by the new level detecting algorithm, which can differentiate between strong bursts of sound and continuous music which stops suddenly. Once again, the "DECAY OPTIMIZATION" parameter has been deliberately made difficult to adjust. Users should not attempt to adjust this parameter without careful listening.

2.4 OPTIONAL MEMORY BOARD

Version 3 (and higher) software supports a memory board which plugs into the option slot on the 224. This board (available fall 1980) allows additional reverberation programs, permanent storage of registers preset by the user, and the restoration of the current operating state after the power has been turned off or has failed. See Section 5 for a complete description of this board.

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PROGRAMS

3.0 PROGRAMS

3.1 INTRODUCTION TO PROGRAM OPTIONS

The Model 224 may be ordered with or retrofitted with several different programs.

Each program has characteristics which optimize it for particular applications. Although adjustment of front panel controls can change the sound of a program it can not change the basic character of a program eg. change a chamber to a plate.

It is strongly recommended that the user carefully study the descriptions of each program to select those programs which suit his needs. Development of new programs and revision of old ones is ongoing at Lexicon so that a substantial program library (including programs for special effects) is anticipated. Of course new programs and revisions of old ones will be available to every 224 owner.

In order to receive new and updated programs, it will be necessary to ship the program circuit board (SBC board) module back to Lexicon. Or, if the 224 must remain in operation, it will be possible to either purchase a new module with the new programs installed or to purchase a new set of 2716 Music Program ROM IC's for field installation. Refer to section 6.5.1 for procedures required to install the ROM's. Extra modules can also be purchased in the event that more than eight programs are desired. See section 6.5, Module Exchange Program, for instructions on removing, refitting and shipping the program module.

3.2 OPERATING SYSTEMS

In order to co-ordinate and maintain numerous programs and revisions of programs each different set of programs is assigned an "operating system" identification number. This number has the following format:

V X . Y

where X is the unique number or letter of each operating system and Y is the revision level.

The initial operating system in production is V 1.1. This number will uniquely define what programs are installed in a 224, what revision level they are and what program number on the front panel "calls" a given program.

New Music Programs Added:

In addition, several entirely new programs were introduced with VERSION 2. (See the program lists below and the program description section of the manual.) The new programs and the improvements to the old ones represent a major improvement in the sound of VERSION 2 and VERSION 3 over the original VERSION 1. Lexicon recommends that owners of machines with the original operating systems upgrade them to VERSION 2 or higher software.

Field Hardware ECO Needed for VERSION 2 and higher software:

Upgrades from the original VERSION 1.1 and 1.2 software require a simple field ECO. Refer to section 6.5.2 for details.

TABLE 3.1

TABLE 3.1 is supplied with two programs. They are:

PROGRAM #	PROGRAM	PART #
1	SMALL CONCERT HALL - B	OTS-0180
2	PERCUSSION PLATE - A	OTS-0181
(1,1)	NEW ENHANCEMENT (all programs)	
(1,2)	DELAY OPTIMIZATION (all programs)	

TABLE 3.2

3.3

TABLE 3.1 is supplied with four programs. They are:

PROGRAM #	PROGRAM	PART #
1	SMALL CONCERT HALL - B	OTS-0180
2	LARGE CONCERT HALL - B	OTS-0181
3	ACOUSTIC CHAMBER	OTS-0182
(1,1)	PERCUSSION PLATE - A	OTS-0183
(1,2)	NEW ENHANCEMENT (all programs)	
(1,3)	DELAY OPTIMIZATION (all programs)	

TABLE 3.3

TABLE 3.2 is supplied with six programs. They are:

PROGRAM #	PROGRAM	PART #
1	SMALL CONCERT HALL - B	OTS-0180
2	YOUNG PLANK	OTS-0181
3	LARGE CONCERT HALL - B	OTS-0182
4	ACOUSTIC CHAMBER	OTS-0183
(1,1)	PERCUSSION PLATE - A	OTS-0184
(1,2)	SMALL CONCERT HALL - A	OTS-0185
(1,3)	NEW ENHANCEMENT (all programs)	
(1,4)	DELAY OPTIMIZATION (all programs)	

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VERSION 3 DESCRIPTION (all Rev. Levels)

VERSION 3 software offers easier operation, 32 more storage registers for preset effects, and the new subprogram "MODE ENHANCEMENT". (See section 2 of this manual for descriptions of these new features.)

Upgrades from VERSION 1 should perform the hardware ECO described in section 6.5.2

V3.0 DESCRIPTION

V3.0 is supplied with two programs. They are:

<u>PROGRAM #</u>	<u>PROGRAM</u>	<u>PART #</u>
1.	SMALL CONCERT HALL - B	075-01846
5.	PERCUSSION PLATE - A	075-01794
(7.)	MODE ENHANCEMENT (all programs)	
(8.)	DECAY OPTIMIZATION (all programs)	

V3.1 DESCRIPTION

V3.1 is supplied with four programs. They are:

<u>PROGRAM #</u>	<u>PROGRAM</u>	<u>PART #</u>
1.	SMALL CONCERT HALL - B	075-01846
3.	LARGE CONCERT HALL - B	075-01847
4.	ACOUSTIC CHAMBER	075-01793
5.	PERCUSSION PLATE - A	075-01794
(7.)	MODE ENHANCEMENT (all programs)	
(8.)	DECAY OPTIMIZATION (all programs)	

V3.2 DESCRIPTION

V3.2 is supplied with six programs. They are:

<u>PROGRAM #</u>	<u>PROGRAM</u>	<u>PART #</u>
1.	SMALL CONCERT HALL - B	075-01846
2.	VOCAL PLATE	075-01791
3.	LARGE CONCERT HALL - B	075-01847
4.	ACOUSTIC CHAMBER	075-01793
5.	PERCUSSION PLATE - A	075-01794
6.	SMALL CONCERT HALL - A	075-01790
(7.)	MODE ENHANCEMENT (all programs)	
(8.)	DECAY OPTIMIZATION (all programs)	

3.4 INTRODUCTION TO THE PROGRAM DESCRIPTIONS

Programs in the Lexicon 224 are mathematical algorithms which simulate the sounds of reverberation. Because the time available for computation is finite, it is not possible to exactly duplicate the properties of natural reverberation. The programs differ greatly in both the type of natural acoustics they try to simulate, and in the ways they differ from the ideal. Standard acoustical terminology is not always accurate in describing the sound from the 224. In this section we define the terms we use in the program descriptions both as they apply to natural acoustics and to the 224.

3.4.1 Reverberation Time and Decay

The decay is the reverberation which is heard when the music stops. It is also called stopped reverberation. The reverberation time controls on the 224 set the rate of decay. Decay is usually assumed to be at a constant rate, a certain number of decibels per second. However, in most buildings the initial rate of decay is much faster than the final rate. Churches, where many fine recordings are made, frequently show this type of non-uniform decay. A slower final rate of decay gives a sense of space and depth in a recording, while a quick initial decay can keep the music from becoming muddy. The numbers displayed with the reverberation controls on the 224 usually indicate the effective reverberation time of the first 20 decibels of decay. Lexicon 224 programs differ in the amount of difference between the initial and final rate of decay, and in how the difference varies with the reverberation time setting. The "DECAY OPTIMIZATION" and "MODE ENHANCEMENT" options available with Version 2 and higher software operating systems make the decay rate more uniform on all the programs.

3.4.2 Sound heard before steady decay, or "Initial Sound"

In a concert hall the first sound to reach the listener is the direct sound, followed closely by reflections from the stage floor and walls. Somewhat later the hall walls, floor, and ceiling contribute their reflections. Finally the reflections from the back wall arrive. During all this time it is meaningless to speak of "smooth decay". The smoothness of these initial sounds depends on the size and shape of the hall and the position of the listener. Steady decay is reached only after sound has had time to bounce through the hall several times. Small rooms or chambers achieve even decay much sooner, and the ear perceives these rooms as smaller. The duration and the smoothness of the initial sound is vital to creating a sense of being in a specific acoustic location. The duration of the initial sound is built into the various 224 programs. It can be as long as 200ms in the concert hall programs and less than 50ms in the plate programs. The initial sound is also very important in determining the character of the "running reverberation", or reverberation which is heard while the music is playing.

MODEL 224 OWNER'S MANUAL

PROGRAMS

SMALL CONCERT HALL - B: (PART NO. 075-01846) REV. 0

Initial sound: Hall-like - uneven for 200ms
 Decay: Moderately non-uniform
 Initial Diffusion: Moderate - some clicking on an impulse
 Coloration: Low

INPUTS MONO: both "LEFT" and "RIGHT" in parallel
 STEREO: left "LEFT" right "RIGHT"
 OUTPUTS MONO: either "A" or "C" (plus source)
 STEREO: left "A", right "C" (plus source)
 QUAD: left front "B", right front "D" (plus source)
 left rear "A", right rear "C"
 REVERB TIME BASS: 0.6-70 sec
 REVERB TIME MID: 0.6-70 sec
 CROSSOVER FREQ: 100Hz-10.9kHz
 TREBLE DECAY FREQ: 100Hz-10.9kHz
 DEPTH: 0-71
 PRE-DELAY: 24-152 ms

This program is basically a modification of "SMALL CONCERT HALL - A". In the old program the "TREBLE DECAY" control affected the sound only after the first 300ms. In "SMALL CONCERT HALL - B" "TREBLE DECAY" affects the early sound too, and reduces the decay more rapidly. It mimics the effects of air absorption better than "SMALL CONCERT HALL - A" and sounds more natural.

The "SMALL CONCERT HALL - B" is useful whenever a sense of space and depth needs to be added to music. It is best on classical music or on popular music which has already been mixed, although it can be used to fill-out a vocal or drum track if clicking is not too apparent. All the concert hall programs are intended to put their sound behind the music, not with it. This program produces best results with reverb time settings of 1.5 to 5 seconds. Program 3, "LARGE CONCERT HALL - B" has less coloration and is recommended for long reverb times.

Recommended Settings

When used with "Mode Enhancement" and/or "Decay Optimization" "SMALL CONCERT HALL - B" sounds most natural if the "BASS" and "MID" control are relatively close to the same setting. "BASS" should be usually set somewhat higher than "MID". The "CROSSOVER" control is useful over the entire range. If it is set to 200Hz, the "BASS" will tend to be emphasized. If it is set to 1.5kHz it can be used to change the character of the high frequencies. When the subprograms are not used "BASS" should be set about a factor of two higher than "MID". When neither subprogram is used the setting of the "TREBLE DECAY" control is very important to achieving a natural sound, but the correct position depends strongly on the type of music and the desired reverb time. With chamber music, or for film sound, a short reverb time (1.5 to 1.7 sec.) is useful, and the "TREBLE DECAY" might sound best at 3.0 kHz. A longer reverb time might sound best with a "TREBLE DECAY" of 4.4kHz or higher. If reverb times longer than 3 seconds

As new programs are developed at Lexicon they will be made available for installation in operating systems 2 and 3. Up to seven different programs can be installed on the SBC/BLC board along with the VERSION 2. VERSION 3 holds 6 programs along with the two subprograms on buttons #7 and #8. If more than six programs are desired an extra read only memory board is available which fits in the option slot on the 224 mainframe, providing storage for an almost unlimited number of programs. This board also contains a battery back-up memory to retain the register storage when power is off. The extra programs are called by pushing two program buttons at once (double-digit program numbers.) Only the program buttons which correspond to programs actually installed in the machine respond when they are pushed. All others are inactive. The non-volatile register storage is activated automatically when the optional memory is installed. For more about the option board, see section 5.

... of a disk from an irregularly shaped wall. Very high diffusion causes a disk to be covered with a wash of sound. Low diffusion causes a more grainy sound, and low diffusion has peaks at obvious points of discrete disks. Contrary to popular opinion, high diffusion is not always desirable, at least for the first 100ms or so after an impulsive input. In concert halls the floor and stage walls are usually not very irregular. In halls diffusion is a function of time. As sound bounces around the room diffusion builds up. Low diffusion is the initial arrival contributed to a very clear uncolored sound. Small rooms and good chambers are designed to produce high diffusion initially, and very well on impulsive material. Some computer rooms are designed to be quiet. The sound is so quiet as to give a low level. Later sound. All late-onset DSP programs have high diffusion after the reverberation has built up, but they have different degrees of initial diffusion. Synthesis, music sounds best with low initial diffusion, vocals with moderate diffusion, and drums with high diffusion.

3.3.3 Coloration

The word coloration can be used to describe almost anything. We will use it in the program descriptions to refer to a "texturally" quality which tends to color whenever the initial diffusion is high. Programs with low initial diffusion are usually uncolored, although coloration can become noticeable at the very end of the decay unless "ROOM ENHANCEMENT" or "DRUMS OPTIMIZATION" is used.

3.5 Control Settings

Frequently the program will have most controls only within a subset of the possible settings of the DSP controls. In general there is no good way to set these controls from a knowledge of acoustical theory. Different types of music may require very different settings of the controls. The settings given with program descriptions (which load automatically with version 3) and higher references are only a starting point.

The Lexicon 224 varies the time dependence of the initial sound with the depth control. Low depth emphasizes the early parts of the initial sound, simulating a close listening position. Higher positions of the depth control tend to increase the running reverberation without changing the amount of reverberation when the music is stopped. In programs which simulate small environments such as a chamber or plate, "depth" controls the explosiveness of the initial sound by compressing it or stretching it out.

3.4.3 Diffusion

Diffusion is the ability of an acoustic chamber or the 224 to spread a single pulse input into a very closely spaced series of pulses. The best acoustic example is the reflection of a click from an irregularly shaped wall. Very high diffusion causes a click to be spread into a swish of sound. Less diffusion causes a more grainy sound, and low diffusion can produce an obvious series of discrete clicks. Contrary to popular opinion, high diffusion is not always desirable, at least for the first 200ms or so after an impulsive input. In concert halls the floor and stage walls are usually not very irregular. In halls diffusion is a function of time. As sound bounces around the room diffusion builds up. Low diffusion in the initial arrivals contributes to a very clear uncolored sound. Small rooms and echo chambers are designed to produce high diffusion initially, and work well on impulsive material. Such reverberation tends to spread out and color the sound it is applied to, giving it a louder, fatter sound. All Lexicon 224 programs have high diffusion after the reverberation has built up, but they have different degrees of initial diffusion. Symphonic music sounds best with low initial diffusion, vocals with moderate diffusion, and drums with high diffusion.

3.4.4 Coloration

The word coloration can be used to describe almost anything. We will use it in the program descriptions to refer to a "bathroom-y" quality which tends to occur whenever the initial diffusion is high. Programs with low initial diffusion are usually uncolored, although coloration can become noticeable at the very end of the decay unless "MODE ENHANCEMENT" or "DECAY OPTIMIZATION" is used.

3.5 Control Settings

Frequently the programs will sound most natural only within a subset of the possible settings of the 224 controls. In general there is no good way to set these controls from a knowledge of acoustical theory. Different types of music may require very different settings of the controls. The settings given with program descriptions (which load automatically with version 3 and higher software) are only a starting point.

are desired, "LARGE CONCERT HALL - B" might give a more natural sound.

We have also found that equalizing the return from the 224 (adding about +3dB below 200 Hz) can add to the richness and naturalness of the reverb. This effect cannot be achieved with the reverb time controls. Boosting the reverb time of the "BASS" excessively makes the bass reverberate too long without increasing richness.

The pre-delay display reads a minimum of 24 ms with this program. Actually there is some output before this time, building to a peak at about 27 ms in the left channel and 20 ms in the right. The time difference in the pre-delay for the two channels can make a pleasant spread in the sound of a mono source. However, with a mono feed solo instruments or voice will sound stronger on the right. If the soloist appears on the left in the mix it may sound more natural to reverse the returns from the 224.

- BASS: 3.0 sec
- MID: 2.0 sec
- CROSS OVER: 540 Hz
- TREBLE DECAY: 4.4 kHz
- DEPTH: 10 to 40
- PRE-DELAY: 24 to 60 ms

In both stereo and quad the feeling of spaciousness is enhanced by using a stereo feed, either similar in placement to the source or reversed. Reversing the returns may decrease the apparent width of the reverb. In stereo or mono operation the outputs "A" and/or "C" should be used as the main echo returns and summed with the source (through a mixer). For quad operation outputs "A" and "C" should be sent directly to the rear, not the front. The "DEPTH" control affects only outputs "A" and "C" and should be set from 0 to 10 for Quad, providing a strong early delay to the rear channels. The outputs "B" and "D" should then be summed with the source at the front.

NOTE: Outputs "B" and "D" are not as satisfactory as "A" and "C" for purposes other than quad.

PROGRAM #	PROGRAM	PAGE #
1	SMALL CONCERT HALL - A	875-0178
2	VOCAL PLATE	875-0179

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PROGRAMS

3.3 OPERATING SYSTEMS LIST

V1.1 DESCRIPTION

V1.1 is the original operating system released by Lexicon in April 1979. It consists of four music programs in the following order:

<u>PROGRAM #</u>	<u>PROGRAM</u>	<u>PART #</u>
1.	SMALL CONCERT HALL - A	075-01790
2.	VOCAL PLATE	075-01791
3.	LARGE CONCERT HALL - A	075-01792
4.	ACOUSTIC CHAMBER	075-01793

Pre-delay inherent in each program is not displayed so that the "PRE-DELAY" display only shows the amount of pre-delay added to the inherent pre-delay of each program. This operating system contains no diagnostics. Changes to pre-delay occur in 1 ms steps and will create some artifacts if modified during use.

V1.2 DESCRIPTION

V1.2 contains the same four music programs as V1.1 but with some minor changes in operating characteristics.

The displayed pre-delay is the actual amount used rather than the incremental value as in V1.1.

Changes in pre-delay will cause a controlled sweep from the original delay setting to the new one selected. This "sweep" through time will cause pitch shift to be heard while delay is changing.

V1.3 DESCRIPTION

V1.3 is identical to V1.2 with the exception that two music programs are provided instead of four - they are:

<u>PROGRAM #</u>	<u>PROGRAM</u>	<u>PART #</u>
1.	SMALL CONCERT HALL - A	075-01790
2.	VOCAL PLATE	075-01791

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V2.0 DESCRIPTION

V2.0 is supplied with two programs. They are:

<u>PROGRAM #</u>	<u>PROGRAM</u>	<u>PART #</u>
1.	SMALL CONCERT HALL - B	075-01846
5.	PERCUSSION PLATE - A	075-01794
(8.)	DECAY OPTIMIZATION (all programs)	

V2.1 DESCRIPTION

V2.1 is supplied with four programs. They are:

<u>PROGRAM #</u>	<u>PROGRAM</u>	<u>PART #</u>
1.	SMALL CONCERT HALL - B	075-01846
3.	LARGE CONCERT HALL - B	075-01847
4.	ACOUSTIC CHAMBER	075-01793
5.	PERCUSSION PLATE - A	075-01794
(8.)	DECAY OPTIMIZATION (all programs)	

V2.2 DESCRIPTION

V2.2 is supplied with six programs. They are:

<u>PROGRAM #</u>	<u>PROGRAM</u>	<u>PART #</u>
1.	SMALL CONCERT HALL - B	075-01846
2.	VOCAL PLATE	075-01791
3.	LARGE CONCERT HALL - B	075-01847
4.	ACOUSTIC CHAMBER	075-01793
5.	PERCUSSION PLATE - A	075-01794
6.	SMALL CONCERT HALL - A	075-01790
(8.)	DECAY OPTIMIZATION (all programs)	

PLATE: (PART NO. 075-01791) REV. 1

(The original "PLATE PROGRAM" - now called "VOCAL PLATE")

Initial sound:	Explosive - decay starts within 50ms
Decay:	Uniformity depends on Reverb Time settings
Initial diffusion:	Moderate to high - good for vocals
Coloration:	Low to moderate
INPUTS	MONO: both "LEFT" and "RIGHT" in parallel
	STEREO: left "LEFT" right "RIGHT"
OUTPUTS	MONO: mix "A" and "C" equally (plus source)
	STEREO: left "A" or "D", right "C" or "B" (plus source)
REVERB TIME BASS:	set by ear - display only for reference
REVERB TIME MID:	0.6-70 sec
CROSSOVER FREQ:	100Hz-10.9kHz
TREBLE DECAY FREQ:	100Hz-10.9kHz
DEPTH:	0-71
PRE-DELAY:	20-127 ms

The "VOCAL PLATE" sounds like a plate, but with less initial diffusion. As a consequence it has a clearer, brighter sound. It is useful for most popular music, but it can sound slightly grainy on drums. Again the "BASS" can be set higher than the "MID" if the two subprograms are not desired. Some plates emphasize the treble, and you may want to experiment with that. You may also want to try equalizing the return for more high treble. The "VOCAL PLATE" is not as good as the percussion plates at very low decay settings, and is not as good as the hall programs at very long settings. Try:

BASS:	2.0 sec
MID:	2.0 sec
CROSS OVER:	1.0 kHz
TREBLE DECAY:	8.8 kHz to 10.9 kHz
DEPTH:	0 to 30
PRE-DELAY:	to taste

The indicated reverb time for "BASS" is not accurate in this program so that users should rely on their ears more than the panel settings when adjusting the "BASS" parameter. Note that it is possible to cause internal feedback by setting the "BASS" control much higher or lower than "MID". The "DEPTH" control affects the first "reflection" in settings 0-40, making it progressively less pronounced. In settings 50-71 it progressively emphasizes later "reflections". The outputs of this program are identical pairs: "A" is the same as "D" and "C" is the same as "B". This program is recommended for use with stereo inputs since the reverb is more natural and interesting than it is in mono. However sharp transients will sound best if panned to the middle. With stereo input the apparent width of the reverb may be altered on some material by reversing the 224 outputs so that "C" goes left and "A" goes right.

PERCUSSION PLATE - A: (PART NO. 075-01794) REV. 0

Initial sound: Explosive
 Decay: Moderately non-uniform
 Initial diffusion: Extremely high - becomes rapidly very dense
 Coloration: Moderate

INPUTS MONO: both "LEFT" and "RIGHT" in parallel
 STEREO: left "LEFT" right "RIGHT"

OUTPUTS MONO: mix "A" and "C" equally (plus source)
 STEREO: left "A" or "D", right "C" or "B" (plus source)

REVERB TIME BASS: set by ear - display only for reference
 REVERB TIME MID: 0.6-70 sec
 CROSSOVER FREQ: 100Hz-10.9kHz
 TREBLE DECAY FREQ: 100Hz-10.9kHz
 DEPTH: 0-71
 PRE-DELAY: 0-107 ms

"PERCUSSION PLATE - A" is ideal for adding to drums and vocals at short reverberation times. It has very high initial diffusion, and a very smooth sound on transient material. Coloration is noticeably greater than the vocals plate, although this sound can be desirable. Coloration increases at the end of the decay unless "MODE ENHANCEMENT" or "DECAY OPTIMIZATION" are used. As with the "VOCAL PLATE" a stereo input is provided, and may be interesting on some material. For best diffusion the two inputs should be driven in parallel. It may also be useful to equalize the return for more brilliance on drums. Try:

BASS: 2.0 sec
 MID: 2.0 sec
 CROSS OVER: 1.0 kHz
 TREBLE DECAY: 8.8 kHz to 10.7 kHz
 DEPTH: 0 to 30
 PRE-DELAY: to taste

The indicated reverb time for "BASS" is not accurate in this program so that users should rely on their ears more than the panel settings when adjusting the "BASS" parameter. Note that it is possible to cause internal feedback by setting the "BASS" control much higher or lower than "MID". The "DEPTH" control affects the first "reflection" in settings 0-40, making it progressively less pronounced. In settings 50-71 it progressively emphasizes later "reflections". The outputs of this program are identical pairs: "A" is the same as "D" and "C" is the same as "B". This program is recommended for use with stereo inputs since the reverb is more natural and interesting than it is in mono. However sharp transients will sound best if panned to the middle. With stereo input the apparent width of the reverb may be altered on some material by reversing the 224 outputs so that "C" goes left and "A" goes right.

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PROGRAMS

LARGE CONCERT HALL - B: (PART NO. 075-01847) REV. 0

This program replaces "LARGE CONCERT HALL - A" on all systems V2 and later.

Initial Sound: Hall-like - uneven for 200ms
 Decay: Much longer final rate than initial rate
 Initial Diffusion: Very low - obvious clicking on transients
 Coloration: Very Low

INPUTS MONO: both "LEFT" and "RIGHT" in parallel
 STEREO: left "LEFT" right "RIGHT"
 OUTPUTS MONO: either "A" or "C" (plus source)
 STEREO: left "A", right "C" (plus source)
 QUAD: left front "B", right front "D" (plus source)
 left rear "A", right rear "C"
 REVERB TIME BASS: 0.6-70 sec
 REVERB TIME MID: 0.6-70 sec
 CROSSOVER FREQ: 100Hz-10.9kHz
 TREBLE DECAY FREQ: 100Hz-10.9kHz
 DEPTH: 0-71
 PRE-DELAY: 24-152 ms

This program is basically a modification of "LARGE CONCERT HALL - A". In the old program the "TREBLE DECAY" control affected the sound only after the first 300ms. In "LARGE CONCERT HALL - B" "TREBLE DECAY" affects the early sound too, and reduces the decay more rapidly. It mimics the effects of air absorption better than "LARGE CONCERT HALL - A" and sounds more natural.

This is not the program to use with material containing bold transients! Its very low coloration is terrific on symphonic music, organ music, or any smooth music. The final rate of decay is much longer than the initial rate. This program is excellent whenever a very long reverb time is needed. It will sustain a guitar or flute tone beautifully.

Recommended Settings

When used with "Mode Enhancement" and/or "Decay Optimization" "LARGE CONCERT HALL - B" sounds most natural if the "BASS" and "MID" control are relatively close to the same setting. "BASS" should be usually set somewhat higher than "MID". The "CROSSOVER" control is useful over the entire range. If it is set to 200Hz, the "BASS" will tend to be emphasized. If it is set to 1.5kHz it can be used to change the character of the high frequencies. When the subprograms are not used "BASS" should be set about a factor of two higher than "MID". When neither subprogram is used the setting of the "TREBLE DECAY" control is very important to achieving a natural sound, but the correct position depends strongly on the type of music and the desired reverb time. With chamber music, or for film sound, a short reverb time (1.5 to 1.7 sec.) is useful, and the "TREBLE DECAY" might sound best at 3.0 kHz. A longer reverb time might sound best with a "TREBLE DECAY" of 4.4kHz or higher. If reverb times shorter than 2 seconds are desired, "SMALL CONCERT HALL - B" might give a more natural sound.

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PROGRAMS

ACOUSTIC CHAMBER: (PART NO. 075-01793) REV. 1

Initial sound: Gradual - flat for 150ms, then decays
 Decay: Moderately non-uniform
 Initial diffusion: Moderate
 Coloration: Moderate

INPUTS MONO: both "LEFT" and "RIGHT" in parallel
 STEREO: left "LEFT" right "RIGHT"
 OUTPUTS MONO: mix "A" and "C" equally (plus source)
 STEREO: left "A" or "D", right "C" or "B" (plus source)

REVERB TIME BASS: 0.6-70 sec
 REVERB TIME MID: 0.6-70 sec
 CROSSOVER FREQ: 100Hz-10.9kHz
 TREBLE DECAY FREQ: 100Hz-10.9kHz
 DEPTH: 0-71
 PRE-DELAY: 25-255 ms

The "ACOUSTIC CHAMBER" sounds like a chamber, but with less initial diffusion. It is good on many types of popular music. It sounds very different from the "PLATE", mostly due to its very different initial sound, and the way the diffusion builds somewhat slower. It is not very good at very long reverb times, but short times may be interesting. Try:

BASS: 2.8 sec
 MID: 2.2 sec
 CROSS OVER: 1.0 kHz
 TREBLE DECAY: 4 kHz to 10.7 kHz
 DEPTH: 0 to 20
 PRE-DELAY: to taste

The chamber program digitally averages the two inputs to mono. If only one input feed is available, it should be bridged to both inputs. The main outputs are "A" and "C". It should be noted that there is less inherent pre-delay in output "A" than output "C", a difference which can be distinguished on some material. Outputs "B" and "D", which are derived from "A" and "C" through a form of time delay matrixing, do not differ in their inherent pre-delays. Thus outputs "B" and "D" may be used instead of "A" and "C" for better timing characteristics but at the expense of marked coloration from output "D". For a single (mono) output "D" should not be used because of its coloration.

The best guide for using this program is to keep the reverb time between 2 and 5 seconds. The most chamber-like sound is achieved with the "DEPTH" at 0. Beware that if the "MID" reverb time is long compared to the "BASS" reverb time, and if the "TREBLE DECAY" frequency is high, then the machine is apt to feed back internally. This condition will be readily apparent and can be useful as a special effect. It can be defeated by raising the "BASS" or lowering the "TREBLE DECAY" controls.

FROM :

PHONE NO. :

MODEL 224 OWNER'S MANUAL

PROGRAMS

We have also found that equalizing the return from the 224 (adding about +3dB below 200 Hz) can add to the richness and naturalness of the reverb. This effect cannot be achieved with the reverb time controls. Boosting the reverb time of the "BASS" excessively makes the bass reverberate too long without increasing richness.

The pre-delay display reads a minimum of 24 ms with this program. Actually there is a strong single reflection at 27 ms on the left and at 20 ms on the right. The time difference in the pre-delay for the two channels can make a pleasant spread in the sound of a mono source. However, with a mono feed solo instruments or voice will sound stronger on the right. If the soloist appears on the left in the mix it may sound more natural to reverse the returns from the 224.

- BASS: 3.4 sec
- MID: 2.6 sec
- CROSS OVER: 540 Hz
- TREBLE DECAY: 4.0 kHz
- DEPTH: 10 to 40
- PRE-DELAY: 24 to 60 ms

In both stereo and quad the feeling of spaciousness is enhanced by using a stereo feed, either similar in placement to the source or reversed. Reversing the returns may decrease the apparent width of the reverb. In stereo or mono operation the outputs "A" and/or "C" should be used as the main echo returns and summed with the source (through a mixer). For quad operation outputs "A" and "C" should be sent directly to the rear, not the front. The "DEPTH" control affects only outputs "A" and "C" and should be set from 0 to 10 for Quad, providing a strong early delay to the rear channels. The outputs "B" and "D" should then be summed with the source at the front.

NOTE: Outputs "B" and "D" are not as satisfactory as "A" and "C" for purposes other than quad.

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PROGRAMS

SMALL CONCERT HALL - A: (PART NO. 075-01790) REV. 1

Initial sound: Hall-like - uneven for 200ms
 Decay: Moderately non-uniform
 Initial Diffusion: Moderate - some clicking on an impulse
 Coloration: Low

INPUTS MONO: both "LEFT" and "RIGHT" in parallel
 STEREO: left "LEFT" right "RIGHT"
 OUTPUTS MONO: either "A" or "C" (plus source)
 STEREO: left "A", right "C" (plus source)
 QUAD: left front "B", right front "D" (plus source)
 left rear "A", right rear "C"
 REVERB TIME BASS: 0.6-70 sec
 REVERB TIME MID: 0.6-70 sec
 CROSSOVER FREQ: 100Hz-10.9kHz
 TREBLE DECAY FREQ: 100Hz-10.9kHz
 DEPTH: 0-71
 PRE-DELAY: 24-152 ms

The "SMALL CONCERT HALL - A" is useful whenever a sense of space and depth needs to be added to music. It is best on popular music which has already been mixed. The initial sound is brighter than "SMALL CONCERT HALL - B", and the "TREBLE DECAY" control is more gentle. This program can be used to fill out a vocal or drum track if clicking is not too apparent. All the concert hall programs are intended to put their sound behind the music, not with it. They do not try to alter a close miked sound. This program produces best results with reverb time settings of 1.5 to 5 seconds. Program 3, "LARGE CONCERT HALL - B" has less coloration and is better for long reverb times.

Recommended Settings

When used with "Mode Enhancement" and/or "Decay Optimization" "SMALL CONCERT HALL - A" sounds most natural if the "BASS" and "MID" control are relatively close to the same setting. "BASS" should be usually set somewhat higher than "MID". The "CROSSOVER" control is useful over the entire range. If it is set to 200Hz, the "BASS" will tend to be emphasized. If it is set to 1.5kHz it can be used to change the character of the high frequencies. When the subprograms are not used "BASS" should be set about a factor of two higher than "MID". When neither subprogram is used the setting of the "TREBLE DECAY" control is very important to achieving a natural sound, but the correct position depends strongly on the type of music and the desired reverb time. With chamber music, or for film sound, a short reverb time (1.5 to 1.7 sec.) is useful, and the "TREBLE DECAY" might sound best at 3.0 kHz. A longer reverb time might sound best with a "TREBLE DECAY" of 4.4kHz or higher. If reverb times longer than 3 seconds are desired, "LARGE CONCERT HALL - B" might give a more natural sound.

We have also found that equalizing the return from the 224 (adding about +3dB below 200 Hz) can add to the richness and naturalness of the reverb. This effect cannot be achieved with the reverb time controls. Boosting the reverb time of the "BASS" excessively makes

4.0 THEORY OF OPERATION

The 224 is partitioned into 9 major functional blocks (not including the option module). They are:

1. Single Board Computer - SBC/BLC
2. Data Memory - D-MEM
3. Timing and Control - T & C
4. Arithmetic Unit - ARU
5. Floating Point Converter - FPC
6. Audio Input - A-IN
7. Audio Output - A-OUT
8. Remote Panel
9. Power Supply - PS1, PS2 and PS3

4.1 SBC SINGLE BOARD COMPUTER

The single board computer controls all functions of the front panel such as reading switches, slide pots and display of data. The SBC also contains the 224 music software which is used to control the "Digital Processor". These programs are stored in Read Only Memories, "ROM's". It is these ROM's which have to be re-programmed whenever software is updated.

An RS232 interface is also provided on the SBC board to allow automation interface as well as diagnostic procedures to be executed with no additional hardware. This interface may be set to any data rate between 9600 and 110 baud.

4.2 INPUT/OUTPUT SIGNAL PATHS

Input analog signals are transformer coupled, gain conditioned and filtered prior to digitization. The input digitizer sequentially converts each analog signal into a digital representation which the FPC card transfers to the digital processor as a 16 bit offset binary word.

The FPC card is also used to process output data to the output DAC. The output DAC circuitry reconstructs the analog information which is then low pass filtered and transformer coupled to the output channels.

4.2.1 Self Test

In the event of operating difficulties it is possible to determine proper operation of the Input, Output and FPC cards by enabling self test mode. This mode is a reasonably good test of Audio and FPC subsystems. Additional information about self test is obtained in Section 6 of this manual. Self test mode is enabled by loosening the D-MEM, T&C and ARU boards. When these cards are loose a control signal to the FPC card is allowed to fly high placing it in self test

MODEL 224 OWNER'S MANUAL

PROGRAMS

the bass reverberate too long without increasing richness.

The pre-delay display reads a minimum of 24 ms with this program. Actually there is some output before this time, building to a peak at about 27 ms in the left channel and 20 ms in the right. The time difference in the pre-delay for the two channels can make a pleasant spread in the sound of a mono source. However, with a mono feed solo instruments or voice will sound stronger on the right. If the soloist appears on the left in the mix it may sound more natural to reverse the returns from the 224.

BASS: 3.0 sec
 MID: 2.0 sec
 CROSS OVER: 540 Hz
 TREBLE DECAY: 4.4 kHz
 DEPTH: 10 to 40
 PRE-DELAY: 24 to 60 ms

In both stereo and quad the feeling of spaciousness is enhanced by using a stereo feed, either similar in placement to the source or reversed. Reversing the returns may decrease the apparent width of the reverb. In stereo or mono operation the outputs "A" and/or "C" should be used as the main echo returns and summed with the source (through a mixer). For quad operation outputs "A" and "C" should be sent directly to the rear, not the front. The "DEPTH" control affects only outputs "A" and "C" and should be set from 0 to 10 for Quad, providing a strong early delay to the rear channels. The outputs "B" and "D" should then be summed with the source at the front.

NOTE: Outputs "B" and "D" are not as satisfactory as "A" and "C" for purposes other than quad.

4.1.4 Main Circuit

The main circuit for the 224 uses a fast primary transformer with 115 and 100 Volt taps and a pair of 250V selector switches across the operating voltage. This supply is collected on both sides of the line. A primary fuse is provided on the chassis ahead of the 25V filter unit. For power is maintained at 115 Volts by placing the red wires on one of the 115 Volt primaries.

4.5.2 +12 and -12 Volt Supplies

The + and - 12 Volt supplies are both derived from a single secondary fused in both legs by a pair of 2 amp slo fuses. Refer to Section 6 for fuse locations.

The +12 Volt supply is a LM317K monolithic voltage regulator programmed by a pair of 1% resistors. This supply is both thermal and current protected - it will provide 1.25 amps.

The -12 Volt supply is derived from 7912 monolithic regulator which is thermal and current protected - it will provide 150ma.

It should be noted that the +12 Volt supply is sequenced by the -5 Volt supply so that +12 Volts can not come up until after -5 Volts is available. Should any problems occur with +12 Volts the presence of -5 Volts should also be checked.

4.5.3 +15 and -15 Volt Supplies

The + and - 15 Volt supplies are a tracking design which allows the -15 Volts to track the +15 Volt supply. Both supplies are derived from a single fused secondary. The +15 Volt supply is a LM317 programmed with an adjustable resistor network.

The -15 Volt supply is a 7912 controlled by a 301 op amp which senses the +15 and -15 Volt outputs and forces the -15 Volt output to track the +15 Volts. A balance control is provided to trim the -15 Volt output. It should be noted that the +/-15 Volt supply is not ground referenced to the +/-5 and +/-12 Volt supplies unless the analog boards are installed in the 224 chassis. When measuring voltages it is essential to refer all measurements to the correct ground.

The +/-15 Volt supplies will provide 750ma and are current and thermally protected.

4.5.4 Mains Circuit

The mains circuit for the 224 uses a dual primary transformer with 115 and 100 Volt taps - a pair of DPDT selector switches select the operating voltage. This supply is switched on both sides of the line. A primary fuse is provided on the chassis ahead of the RFI filter unit. Fan power is maintained at 115 Volts by placing the fan across one of the 115 Volt primaries.

mode. It should be noted that the SBC card must be installed simply to provide a clock signal for the FPC board.

4.3 DIGITAL PROCESSOR

The processor unit consists of three cards, D-MEM, ARU and T&C. These cards provide the basic digital processing and data storage capability to allow the 224 to synthesize reverberant sound in either stereo or monophonic formats.

Refer to Section 6 for troubleshooting information should any problems arise.

4.4 REMOTE PANEL

The remote panel interfaces to the main frame via a 25 conductor ribbon cable. 10 Volt AC power is sent to the control head where it is rectified, filtered and regulated to power the control head logic. All data sent to and received from the control head is sent over an 8 bit bidirectional data bus. Address data is sent over a 4 bit address bus for pot selection and digit scan. All slide pots are digitized under software control and converted into an 8 bit word for transmission to the SBC/BLC board.

4.5 POWER SUPPLY

The 224 Power Supply produces six regulated dc voltages and one unregulated ac voltage to power the control head.

4.5.1 +5 and -5 Volt Supplies

The +5 and -5 Volt supplies are both derived from a single secondary winding. The +5 Volt supply consists of a us 723 regulator, current boost transistor and a pair of high current pass transistors. The regulator is a current foldback design which will limit short circuit currents to less than 3 amps.

Over voltage protection is provided by a crowbar circuit and the entire supply is fused by a 15 amp 3AG fuse. This supply is designed to provide a continuous 10 amp - both voltage and current limit are adjustable.

Refer to Section 6 for fuse locations.

The -5 Volt supply is a 7905 monolithic regulator fused at 2.5 amps. This supply is both current limited and thermally protected. It is designed to provide 250ma.

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IN CASE OF DIFFICULTY

6.2.1 Diagnostic Programs (operating system V2 and later only)

Model 224 Resident Diagnostics are run whenever the machine is turned on or reset. They may also be entered by holding the "SHIFT" key and pushing the "PRE-DELAY" button. The diagnostics make a single pass through all testable features of the machine. If the machine passes, it commences normal operation. If an error is detected, an error message is displayed.

During an error display or the panel test display all controls and buttons on the panel are inactive except the program switches. Briefly pressing "PROGRAM 1" will stop the display and go to the next diagnostic test. Pressing "PROGRAM 2" bypasses all further diagnostics and starts the regular system.

A stereo delay line program is provided which can be used for setting output levels, or as a quick test of the machine. This program is reached by pressing "PROGRAM 8" while the remote panel test is running, or by pressing "SHIFT" and "PRE-DELAY" during normal operation. The delay is about 0.4 seconds and is not adjustable.

The diagnostics test the whole machine, including the SBC/BLC computer. To do this they must erase the program numbers and parameters stored in the four registers A through D. These registers must be reset after diagnostics.

Diagnostics make the following tests:

DA	A	MEMOR ^Y	Rom checksum
E00 to E0F			
E10 to E13			Computer RAM test - destroys the contents of all registers unless optional memory card is installed
—			Remote panel test - all LEDs illuminated for 2 seconds and operating system version number displayed
E20 to E49			T&C board tests (may also implicate circuits on DNEM)
E51 to E8F			ARU board tests (T&C failures will usually cause ARU and DNEM errors too)
E91 to E93			Data Memory test (DNEM)

All the diagnostics work by comparing the actual data in some part of the machine to the data which should be there if the machine were working perfectly. The diagnostic programs display the expected data pattern (the "good" data) on the lights in the program buttons. The actual data returned by the machine are displayed on the mode-register lights. Usually an error is displayed when the two patterns do not correspond. The pattern displayed on these lights is vital to interpreting the cause of the error. If errors appear you should write the error numbers and the light patterns in the order in which

* DIAGNOSTICS RUN WHEN:

- 1. MACHINE IS TURNED ON
- 2. RESET BUTTON IS PUSHED
- 3. SHIFT & DEPTH ARE PUSHED

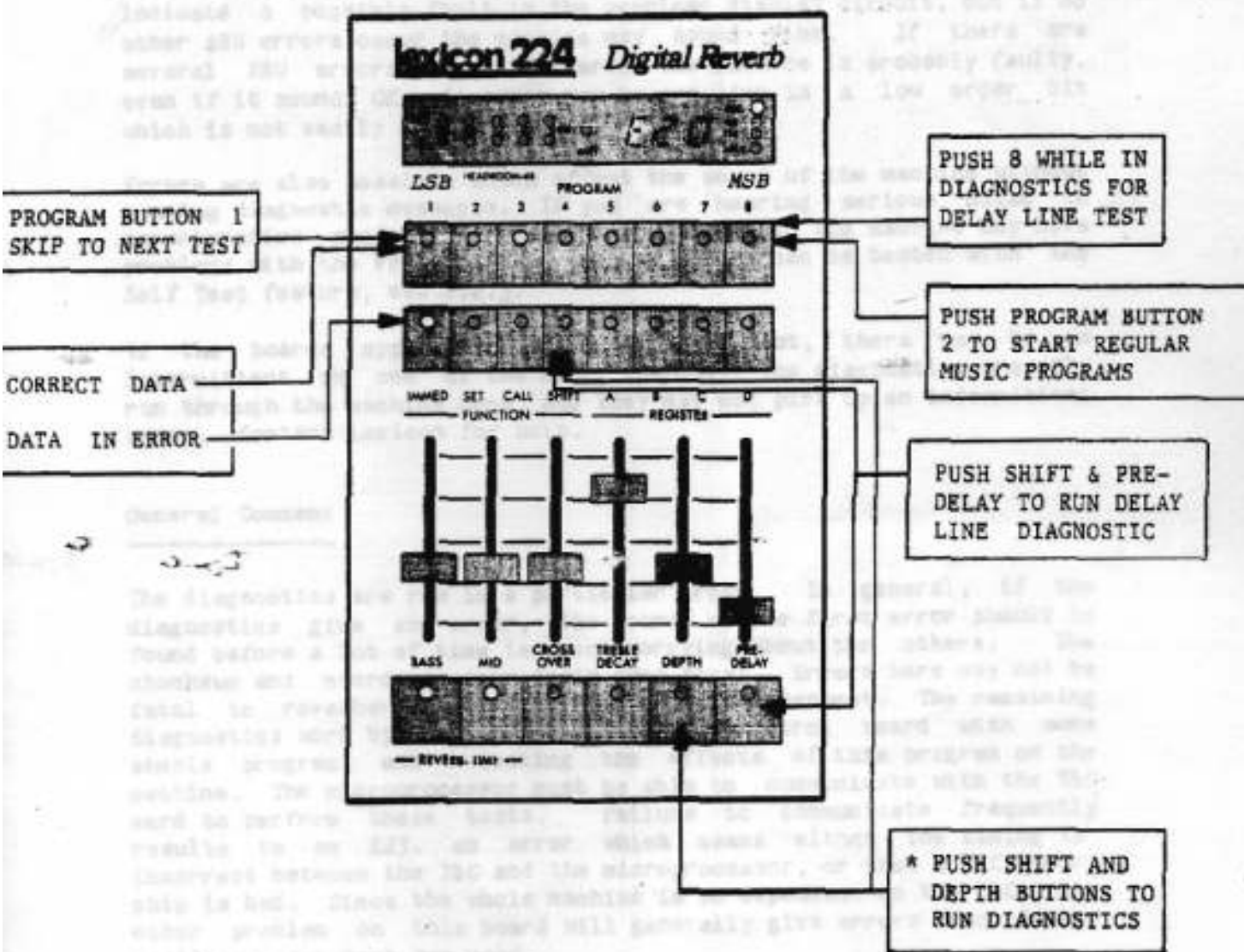


FIG. 6.3 A

ERROR DISPLAY ON CONTROL HEAD

Some other parts of the tests are impossible to separate. All tests of IMM require that the MIC board work at least minimally. None of the microprocessor controlled tests are possible for both TAC and MIC are located on the same board. The only way you can test the TAC test is to test a lot of MICs. The only way you can test a very bad (flashing) MIC is to test a lot of TACs. A short or defective IC on the MIC or TAC can also cause an error which appears to be on TAC. It is sometimes useful to unplug MIC and TAC to see if the error still occurs. The TAC is not testable by the microprocessor, and the machine should pass all diagnostics with TAC unplugged.

What if the machine does not appear to work at all? The cause is the

they occur prior to contacting Lexicon's customer service department.

Error displays may occur which do not indicate a fault in a vital part of the 224. For example, there may be a problem in the error detection circuits themselves. This is especially true if the only errors which display are T&C errors. On the ARU card, E80 would indicate a possible fault in the overload display circuit, but if no other ARU errors occur the machine may sound fine. If there are several ARU errors or a DMEM error the machine is probably faulty, even if it sounds OK. An error may be occurring in a low order bit which is not easily audible.

Errors are also possible which affect the sound of the machine without causing diagnostic messages. If you are hearing serious noise in reverberation and/or the delay line diagnostic the machine may have problems with the FPC or analog boards. These can be tested with the Self Test feature, see 6.2.3.

If the boards appear to work in self test, there may be an intermittent on one of the other boards. The diagnostics are only run through the machine once, and they may not pick up an intermittent error. Contact Lexicon for help.

General Comment

The diagnostics are run in a particular order. In general, if the diagnostics give an error, the source of the first error should be found before a lot of time is spent worrying about the others. The checksum and microprocessor tests come first. Errors here may not be fatal to reverberation, and are easy to interpret. The remaining diagnostics work by loading the timing and control board with some simple program, and testing the effects of this program on the machine. The microprocessor must be able to communicate with the T&C card to perform these tests. Failure to communicate frequently results in an E23, an error which means either the timing is incorrect between the T&C and the microprocessor, or that a T&C memory chip is bad. Since the whole machine is so dependent on the T&C, any other problem on this board will generally give errors even if the sections under test are good.

Some other parts of the tests are impossible to separate. All tests of DMEM require that the ARU board work at least minimally. Much of the microprocessor communication and test circuits for both T&C and ARU are located on the DMEM board. A failure here may make the T&C test take a long time to complete, and may also cause a very odd flashing scan of the front panel. This flashing scan implicates DMEM. A short or defective IC on the ARU or FPC can also cause an error which appears to be on T&C. It is sometimes useful to unplug ARU and FPC to see if the error still occurs. The FPC is not testable by the microprocessor, and the machine should pass all diagnostics with FPC unplugged.

What if the machine does not appear to work at all? The cable to the

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IN CASE OF DIFFICULTY

Remote Panel should be checked first. If there are no diagnostic errors the machine will eventually run reverberation with the remote head unplugged. If the machine does this, the Remote Panel or the cable is faulty. It is however more likely that the transformer plug in the power supply has come loose, or that a power supply fuse has opened. The Self Test mode can be used to check the audio boards and indirectly the power supplies. Self test does not check the +12V or the -5V supply. See section 6.1 for Power Supply test points. Failure of the machine to respond either with diagnostics or reverberation when the power supplies are good probably means that the SBC/BLC board has failed.

2.4 OPTIONAL MEMORY BOARD

Version 3 (and higher) software supports a memory board which plugs into the option slot on the 224. This board (available fall 1980) allows additional reverberation programs, permanent storage of registers preset by the user, and the restoration of the current operating state after the power has been turned off or has failed. See Section 5 for a complete description of this board.