544
Expander/Gate
Operating Manual

Revision 1.5 1 October, 1988

4211 24th Ave. West
Seattle, WA 98199

Telephone (206) 282-2555
Fax (206) 283-5504

FOREWORD

This manual contains all the information you need to operate the 544 Quad Expander/Gate. In addition, there's detailed applications data to help you get started right away, and to illustrate some of the more interesting uses for the 544.

There are seven sections in this manual. The individual parts of each section are labeled first, with the section number, then with the part number. For example, the first part of the first section is labeled 1.1, and the third part of the fourth section is labeled 4.3, and so on. Use the numbers referenced in the Table of Contents to quickly locate the information you need.

If you're going to jump right in and start using the 544 without reading the manual, just take a minute to run through Section 3 - Fast First Time Setup.

Several notation conventions are used to indicate various facets of the 544's features:

SMALL CAPS indicate a marked feature on the 544, like the EXP/GATE switch, or the THRESHOLD control.

italics and **boldface**
are used for emphasis. Words printed in **bold** convey more emphasis than those printed in *italics.*

Some of the text in this manual is set apart by the headings Note, Caution or Warning:

NOTE conveys useful information that's included to make certain functions more obvious, and to supply extra information about processes, techniques, connectors etc.

CAUTION indicates a potential danger to the 544. An example of a CAUTION can be found below.

WARNING is used to point out a potential hazard to the operator. An example of a WARNING can be found in Section 6.1

CAUTION

Save the original box, packing material, and purchase receipt. If ever it's necessary to ship your unit it must be packaged in its original box to prevent damage. (See Section 7)

Table of Contents

Section	Title	Page
1.0	Introduction to Expanders and Gates	1-1
1.1	Defining Dynamic Range	1-1
1.2	Dynamic Range as a Specification	1-1
1.3	Dynamic Range of Sounds and Signals	1-1
1.4	Why Dynamic Range Processors are Necessary	1-2
1.5	The Threshold Concept	1-2
1.6	The Ratio Concept	1-2
1.7	The VCA - Voltage Controlled Amplifier	1-2
1.8	Linear vs. Downward Expanders	1-3
1.9	How Expanders and Gates Increase Dynamic Range	1-3
1.10	Sidechain Processing	1-3
2.0	Using the 544	2-1
2.1	Getting Started	2-1
2.2	A Word About the Controls	2-1
2.3	Block Diagram	2-1
2.4	Connectors	2-2
2.5	Switches	2-3
2.6	Controls	2-3
2.7	Metering	2-3
2.8	Signal Levels	2-3
2.9	Installation	2-4
3.0	Fast First Time Setup	3-1
3.1	Connections	3-1
3.2	Switch Settings	3-1
3.3	Control Settings	3-1
3.4	Meter Readings	3-1
4.0	Applications	4-1
4.1	Noise Elimination	4-2
4.2	Tightening Up Drum Sounds	4-3
4.3	Fattening Up Drum Sounds	4-5
4.4	Gated Reverb	4-7
4.5	Keyed Bass	4-11
4.6	Robot Snare	4-12
4.7	Restoring Dynamics	4-13
4.8	Pseudo Stereo	4-14
4.9	Adding Controlled Room Sound to Existing Dry Tracks	4-15
4.10	Preventing Noise and Feedback Between Sets	4-15
4.11	Expanded/Gated Compressor	4-15
4.12	Non-Critical Companding	4-16
5.0	544 Quad Expander/Gate Specifications	5-1
6.0	Troubleshooting Guide	6-1
6.1	Troubleshooting Table	6-1
7.0	Service Information and Schematic	7-1
7.1	In-Warranty Repairs	7-1
7.2	Out-of-Warranty Repairs	7-1
7.3	Schematic Diagram	7-1
8.0	User's Knob Notes	8-1

Section 1

Introduction to Expanders and Gates

Expanders and gates are the functional opposites of compressors and limiters. Compressors continually *reduce* the dynamic range of signals that are *above* threshold, while expanders continually increase the dynamic range of signals that are *below* threshold. Limiters are really very high ratio compressors, and gates are very high ratio expanders.

To put it another way, compressors are to expanders as limiters are to gates. All four of these devices are included in the family of signal processors called dynamic range processors.

1.1 Defining Dynamic Range

To begin a discussion of dynamic range processors it's necessary to have a working definition of dynamic range. The term is really self-descriptive, but has two distinctly different uses:

1. To describe the *actual* range of signal fluctuations that are going through the equipment, and
2. To define the *maximum allowable* range of signal fluctuations that can be put through the equipment.

The usual unit of measure for audio signals is the decibel (dB).

1.2 Dynamic Range as a Specification

The *maximum usable range of operation* for a particular circuit or piece of gear is the distance in dB between the noise floor and the maximum output level. In this context *dynamic range* is used as an equipment specification.

Noise floor is defined as the *lower* limit of a circuit's operating level, and is a function of its self-generated electrical noise. Very noisy circuits have a high noise floor, quiet circuits have a low noise floor. The maximum output level is the *upper* limit of the operating level, and is the level at which clipping begins.

To put levels in perspective they must be referenced to some nominal operating level, like 0 dBm. That's why noise specs are stated as minus something. For example, the 544's noise spec is -86 dBm, which is 86 dB below 0 dBm. And since maximum output level is usually greater than 0, it's stated as plus something. The 544's maximum output is +19 dBm, which is 19 dB above 0 dBm. The difference between the noise floor and the onset of clipping is the dynamic range. To find the 544's dynamic range, subtract -86 from +19. The dynamic range is 105 dB.

1.3 Dynamic Range of Sounds and Signals

The other definition of dynamic range describes actual level changes, or the *range over which signals fluctuate*. The signals under discussion here are electrical representations of sounds, so it follows that sound has dynamic range.

The dynamic range of the human voice, from a whisper to a shout, is well over 100 dB. So a microphone will convert the sound pressure of a voice going from a whisper to a shout into an electrical output signal with a dynamic range of well over 100 dB.

circuit called the detector, which turns the AC audio signal into a DC control voltage. The control voltage is applied to the VCA under the direction of the ATTACK, RELEASE, RANGE/RATIO and THRESHOLD controls.

1.8 Linear vs. Downward Expanders

Expander operation is easily misunderstood unless it's remembered that what's being expanded is the dynamics, or *changes,* of signals passing through the circuit. Expanders come in two very different types: downward and linear.

Linear expanders increase the dynamic range of *all* signals, no matter what their actual level. The linear expander simply makes all changes greater by some ratio, which is sometimes user adjustable. Of course, clipping occurs when the dynamic range of signals just below maximum output level is expanded.

For instance, a signal 3 dB below clipping that goes up 2 dB won't distort because it's still 1 dB below maximum. But if that same signal is passed through an expander operating at a 1:2 ratio, the resulting level at the expander's output would go up 4 dB and would therefore be 1 dB over maximum, causing distortion. Linear expanders must be used with care because very few audio systems have enough headroom to handle the increased dynamic range.

The kind of processor most commonly referred to as an expander is really a *downward* expander, because it only changes signals below threshold. This gives the operator control over the expander's activities, allowing it to be used to expand the usable dynamic range of the system without using all the available headroom.

1.9 How Expanders and Gates Increase Dynamic Range

It's really quite simple how the dynamic range of a system is effectively increased by downward expansion. The lower limit restriction is the noise floor, which is usually well below the 544's lowest threshold (-40). It's important to keep in mind that while signal levels may change greatly, noise *usually doesn't change very much.* The action of the expander/gate increases the dynamics of all signals below threshold that *do* change. This action increases the apparent loudness of those changing signals, while decreasing the apparent loudness of the noise.

For example, an expander operating at a ratio of 1:2 will cause a signal that falls 10 dB at its input to fall 20 dB at its output. The downward action of the expander reduces the noise floor by the same ratio that was applied to the signal. Since the relationship between the signal and the noise stays the same, the noise is reduced 20 dB by the action of the expander, which is responding to a 10 dB drop in the signal with its 1:2 ratio.

Gates work very much like expanders, but are generally used for more specific control functions. With a ratio of 1:10 (or more) the gate will respond to level changes very definitely. The open or closed nature of the gate makes it useful for strict control of room noise, ambience, mic leakage and crosstalk.

1.10 Sidechain Processing

The term **sidechain** describes a patch point in the *control circuit* of a dynamic range processor, which provides access to the part of the circuitry that tells the VCA what to do. The 544's sidechain is routed through a rear panel connector that allows the control signal to be processed outside the unit.

Section 2
Using the 544

"When all else fails, read the directions."

2.1 Getting Started

This section of your manual will give you all the control and switch settings you need to operate the 544.

If you're going to jump right in and start using the 544 without reading the manual, just take a minute to run through the Fast First Time Set Up - Section 3. Remember, this only needs to be done once to become familiar with the 544's controls - after that it's easy.

2.2 A Word About the Controls

With four fully variable controls on each channel, the 544 can be used effectively in a tremendous variety of situations. For that very reason, the level of performance you are able to extract from the 544 depends entirely on your understanding of those controls.

2.3 Block Diagram

The functional block diagram in Figure 2.1 illustrates the signal flow into, inside of, and out of the 544. The levels and impedances at the INPUTs and OUTPUTs are designed to match all common line level systems (see Section 2.8 - Signal Levels). All connectors are located on the rear panel, all switches and controls are located on the front panel. In the block diagram, control and switch names enclosed with a box.

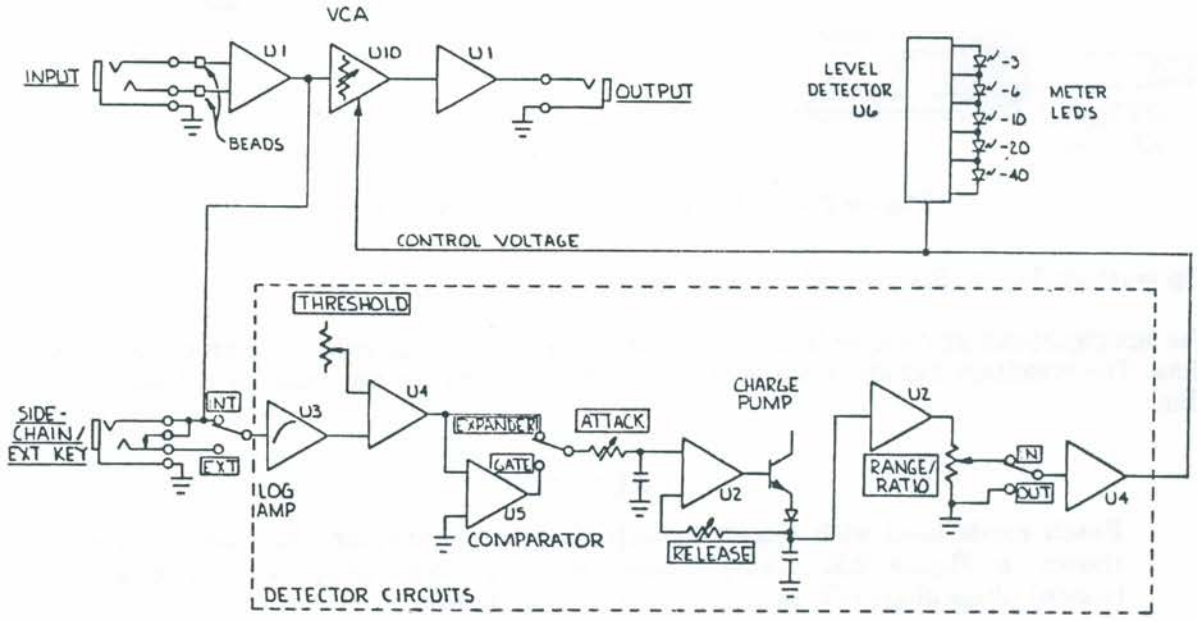


Figure 2.1. 544 Block Diagram.

NOTE

Assembled patch cords are available from Switchcraft. Part numbers are:

1. *981T1 - right angle 3-conductor male TRS connector with about 6' of wire, terminated in 2 2-conductor male (TS) connectors.*
2. *353CP1 - straight 3-conductor male TRS connector with about 6" of wire terminated in 2 2-conductor female (TS) connectors.*

When the SIDECHAIN/EXT KEY connector is used as a send/receive patch point, the 544's activity can be made frequency dependent, or offset in time, because the sidechain provides a signal path for the insertion of equalizers or time delays between the 544's input and its VCA. See Section 3.1 for a description of the sidechain function.

When the SIDECHAIN/EXT KEY connector is used as the key input, the 544's activity becomes a function of a signal other than the signal in the main audio path. The EXT KEY function is enabled with the front panel switch marked INT/EXT.

2.5 Switches

IN/OUT - Switches the 544's control circuitry in or out. Must be depressed, to the "in" position, or nothing will happen.

EXT/INT - Selects INTernal or EXTernal control signal, and functions as an insert switch for devices patched into the SIDECHAIN. In the INTernal position the control signal is taken from the main audio input. In the EXTernal position the control signal is taken from the EXT KEY input.

The SIDECHAIN/EXT KEY connector is normalled - when it is not used, the EXT/INT switch has no effect.

EXP/GATE - Determines whether the 544 is in EXPand mode or GATE mode.

POWER - Switches AC mains on/off.

2.6 Controls

THRESHOLD - Sets the level below which the expander/gate activity is initiated.

RATIO/RANGE - Sets the expander ratio in EXPand mode, or the range of attenuation in GATE mode. Because it determines how much change the 544 makes, nothing will happen if the RATIO/RANGE control is set fully clockwise (MIN).

ATTACK - Determines how quickly the 544 reaches zero attenuation when signals go above threshold.

RELEASE - Determines how quickly the 544 returns to full attenuation when signals fall below threshold.

2.7 Metering

The LED metering arrangement indicates the actual level change being created by the VCA. In the absence of signal, the LED's will be lighted only if the RANGE/RATIO control is set to some value other than MIN.

2.8 Signal Levels

The 544 is designed to be used post-preamp, at a place in the system where the signals have already been amplified to line levels. But, "line level" is a generic term that's been used at one

Section 3
Fast First Time Setup

Follow this sequence to get the 544 up and running:

3.1 Connections

INPUT - Connect to the output of the signal source to be processed.

OUTPUT - Connect to the input of the following device.

SIDECHAIN/EXT KEY - Connect to equalizer, delay, or to triggering audio source (optional).

3.2 Switch Settings

IN/OUT - Push in (puts system in circuit)

INT/EXT - Push in (triggering control signal derived internally)

EXP/GATE - Push in (sets 544 to GATE mode)

3.3 Control Settings

ATTACK - Set the ATTACK control to fast (fully counterclockwise).

RELEASE - Set the RELEASE control to fast (fully counterclockwise).

RATIO/RANGE - Set the RATIO/RANGE control fully counterclockwise.

THRESHOLD - To find a beginning setting for the THRESHOLD control, patch the 544 into your system and feed a normal level signal to its input.

Set the THRESHOLD control fully clockwise, at +20. If you've put the unit in GATE mode, you should hear nothing. Slowly turn the THRESHOLD control counterclockwise until the LEDs flash and you begin to hear something. (What you will hear probably won't sound that good until you fine-tune the ATTACK and RELEASE controls.)

Use this beginning setting as a starting point whenever the 544 is patched into your system at this particular place. For different patch points, repeat the procedure and note the setting of the control.

3.4 Meter Readings

The LED meter on each channel will not be lighted unless the RATIO/RANGE control is set to less than MIN (fully clockwise). The meter is peak reading, and will accurately track the attenuation of the VCA. The LED's will only blink when very short duration signals are processed with very fast release times. Slower ATTACK and RELEASE times will keep the metering LED's lighted longer because they track the control voltage as it's applied to the VCA.

4.1 Noise Elimination

It's assumed here that there's noise on the track or channel that becomes objectionable when not masked by the desired signal. Use GATE mode, with the THRESHOLD set above the background level, but just below the level of the desired signal. The gate closes whenever the signal falls below threshold, so only the desired signals are allowed to pass.

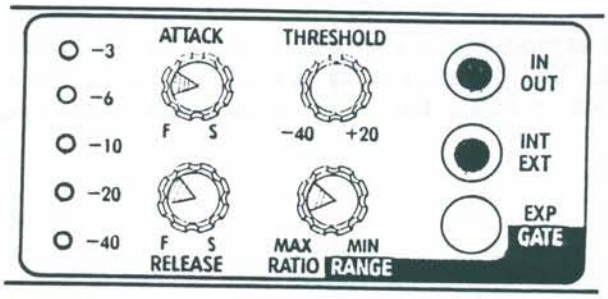


Figure 4.1. Control settings for noise elimination in GATE mode.

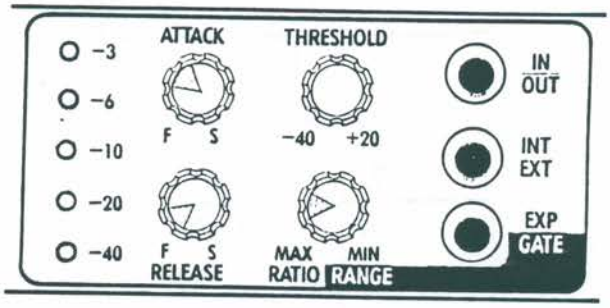


Figure 4.2. Control settings for noise elimination in EXPand mode.

For more general and gentle noise suppression use the EXPand mode, and set the THRESHOLD relatively low (-20 to -40).

NOTE

The ability of the gate/expander to discriminate between wanted and unwanted signals is determined in part by mic technique. Be particularly careful when high frequency instruments are located to the side or rear of a cardioid mic. Most cardioids exhibit a sharply rising off-axis response characteristic at higher frequencies; check the off-axis curve (the lower one) in the manufacturer's literature. If there's only a 2 dB or 3 dB difference between the on-axis and off-axis response in the 5 kHz to 10 kHz region, cymbals may leak like crazy into your tom mics, and you may have hihat all over the snare mic (all of which can be used to advantage, of course). Use the mic's directional pattern to keep other sources as far off-axis as possible. Remember - the idea is to do everything you can to extract all the source-to-source discrimination possible through good mic technique. The sounds picked up by the individual mics have to be primarily the sound of the individual drums, or the gate won't be able to tell the difference.

For tracks already recorded, you can use equalization in the SIDECHAIN to create extra discrimination if the spectral content of the interfering signal is fundamentally different from the desired signal.

For example, if cymbal leakage is causing the gate on the tom track to false-trigger, here are some possibilities:

- Boost the drum's fundamental frequency with an equalizer in the SIDECHAIN and/or cut the high frequencies to which the expander gate is responding.
- Drive the EXT KEY with a signal split from the tom track's direct output from the console. Run the signal through an equalizer, then into the EXT KEY input. Tune the equalizer to boost the frequency of the drum's fundamental, and/or tune it (with a wide bandwidth) to cut the high frequencies from this control signal.

If the drums are somehow out of tune with the room or the track, this same technique can be used to "retune" a drum kit after it's been recorded. To make way for the new sound you'll create when the fattener is added to the original, tune out the bulk of the original sound with the console EQ. Then tune the synthesizer(s) or signal generator(s) so the primary frequency created by the drum beat is in tune. If a synth is used the drum sounds can actually be played right along with the changes. For example, the kick drum can be given the fundamental (or one of the harmonics) of the bass line, while the toms are tuned to work within the inversion played by the primary rhythm instrument.

RT_{60} is the term used to describe reverb decay. Specifically RT_{60} is the length of time required for the reverberation signal to fall 60 dB from its beginning level (whatever that may be).

Figure 4.7 illustrates the varying density vs. time for short, medium and long reverb times, as produced by a typical digital reverberation system. The sound qualities of the various reverb programs shown in Figure 4.7 are really quite different. But when those qualities are tied to an RT_{60} that can't be changed by the operator, their actual usefulness is very restricted. However, the expander/gate can effectively shorten the RT_{60}, allowing the sound qualities developed in the earlier part of the decay to be used without the "mud" that's often associated with a very long decay time.

The drawings in Figure 4.7 show how very different the decays are. Even though some of those longer patterns may sound great, it would be impossible to use those longer reverb times. There's really no way to fit a 4.5 sec RT_{60} into most pop music production, is there? But, the initial 1.5 seconds of that 4.5 second program sound very different from the 1.5 second reverb program the manufacturer built into the reverb. With the 544 the early portion of any length reverb program can be extracted, because the RT_{60} becomes a function of the setting of its controls.

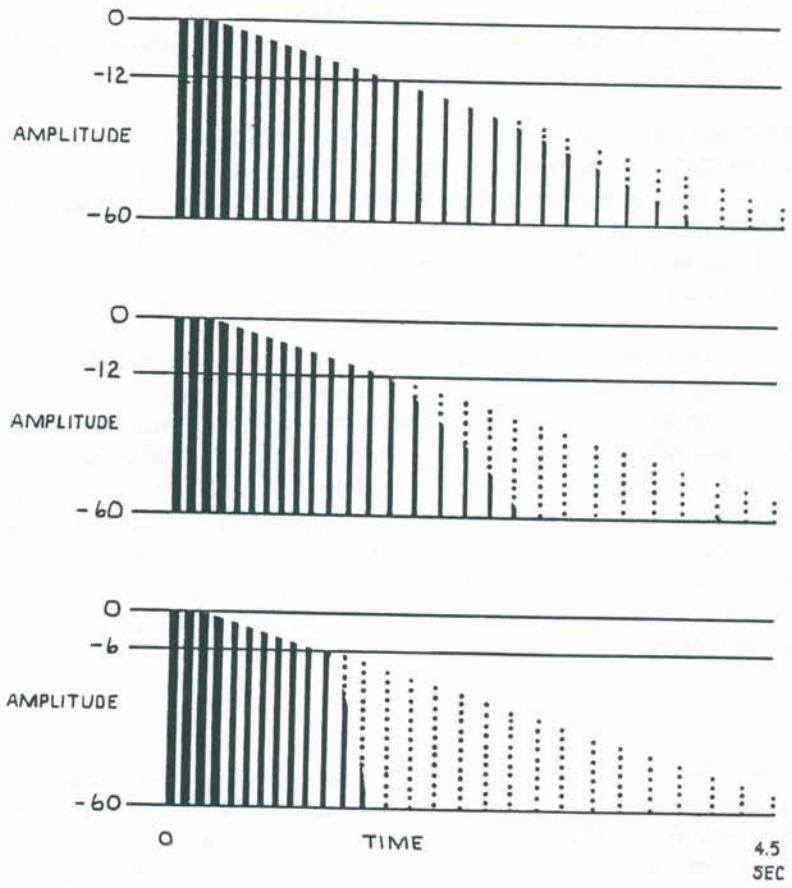


Figure 4.8. Reverb decay as a function of the threshold setting.

Inserting time delay into the SIDECHAIN allows you to place a burst of reverb strategically inside the rhythm and tempo framework. The resulting effect is quite different from the usual pre-delay. Since any delay in the SIDECHAIN offsets the action of the VCA, the combined effect of pre delay and loop delay allows the reverberant signal to be time shifted, so a burst of very intense reverb can be "nested" between beats.

4.6 Robot Snare

As either a special effect or a remedy, the robot snare technique offers a sound not available by any other means. When it's time to mix and you find out the snare track is poorly recorded, use this technique to generate another snare sound from the original. Or, if the existing sound just isn't "big enough," the robot snare can be panned to the opposite channel from the original to create a huge stereo effect.

During mixdown, use a gated output from the snare track to drive a power amp, which in turn drives a speaker. Put the speaker on top of another snare drum - this becomes the "robot." Every time the original snare is played, the robot plays too. The speaker/drum combination is placed in the studio, and miked. The signal from the mic on the robot snare is returned to the console, gated (or expanded), and then combined with the original during mixdown. (A JBL LE-14A fits perfectly inside the rim of most 14" snare drums.)

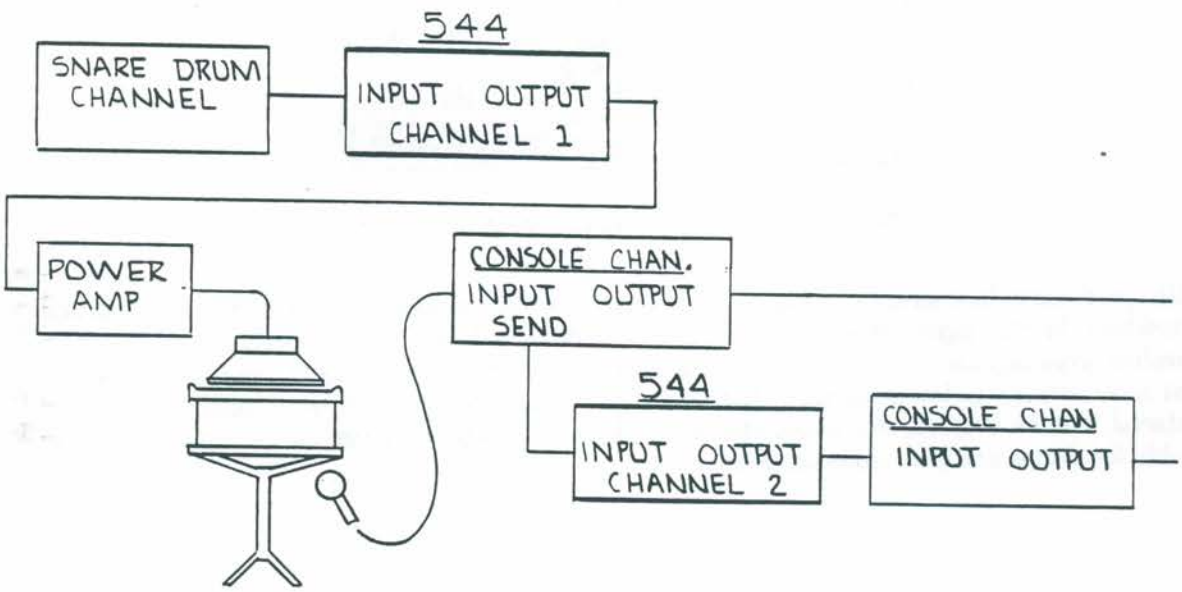


Figure 4.12. Robot snare hookup diagram.

A variation on the robot snare effect can be created by sending the snare signal to a guitar amp (usually the cheaper, smaller ones work best). In most cases the amp sounds so bad it creates another dimension, which sounds great when combined with the original in mixdown.

In both examples above, the signals to the amp and from the mic must be gated, and an equalizer is often needed in the sidechain to clean up the send signal.

4.8 Pseudo Stereo

A usable stereo effect can be created with the 544. There are two techniques:

1. Process a mono signal through one channel of the 544, then pan the original and the processed signal to opposite sides.
2. Process a mono signal through two channels of the 544, and set the controls on each channel differently. The expanded/gated signals are returned to the console, and panned to opposite sides.

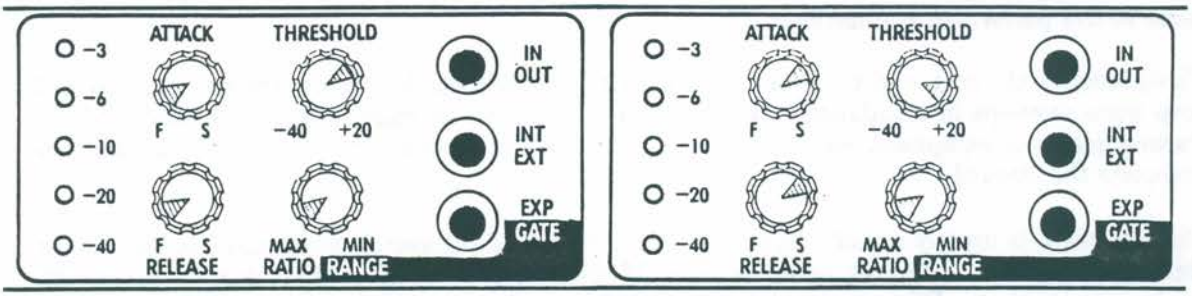


Figure 4.14. Control settings for pseudo stereo effect.

Either of the channel's settings shown above could be used for technique number 1. For number 2, both are used. The controls are set differently on the channels to give each output its own attack and decay characteristics. The outputs are returned to console inputs, and panned to opposite sides. The effect is best with percussive sounds, and better yet if there's a little room sound included in the original mono track.

4.12 Non-Critical Companding

Companding is compression followed by expansion, and is the basis of all modern noise reduction processors. For non-critical noise reduction companding, a low ratio compressor followed by the 544 can be very effective. The linear expansion technique (Section 4.7) is used, with the expander's ratio set the same as the compressor. If the compressor's ratio is 2:1, set the expander at 1:2. If the compressor's ratio is 5:1, set the expander at 1:5. Since control tolerances prevent the compression and subsequent expansion from being **exactly** the same, this technique will not work in critical applications. But, it will give you much better performance from inexpensive reverbs and effects devices. Every attempt must be made to set the ATTACK and RELEASE controls of both devices as nearly alike as possible to eliminate pumping and breathing.

Section 6
Troubleshooting Guide

To isolate a problem you think may be caused by the 544 (or any other unit), check each input, output and sidechain connector *one at a time*. Before you go any further:

- Make sure the unit is plugged in, and the power switch is on, and the pilot LED is lighted.
- Plug headphones directly into the outputs to see if there's any signal.
- Bypass the device in question by connecting the input cable to the output cable using a double-female adaptor. If the signal passes through this direct connection, but not through the unit, it's time to check the unit more closely.
- Check all wires and connectors. Most malfunctions are wire or connector related.

6.1 Troubleshooting Table

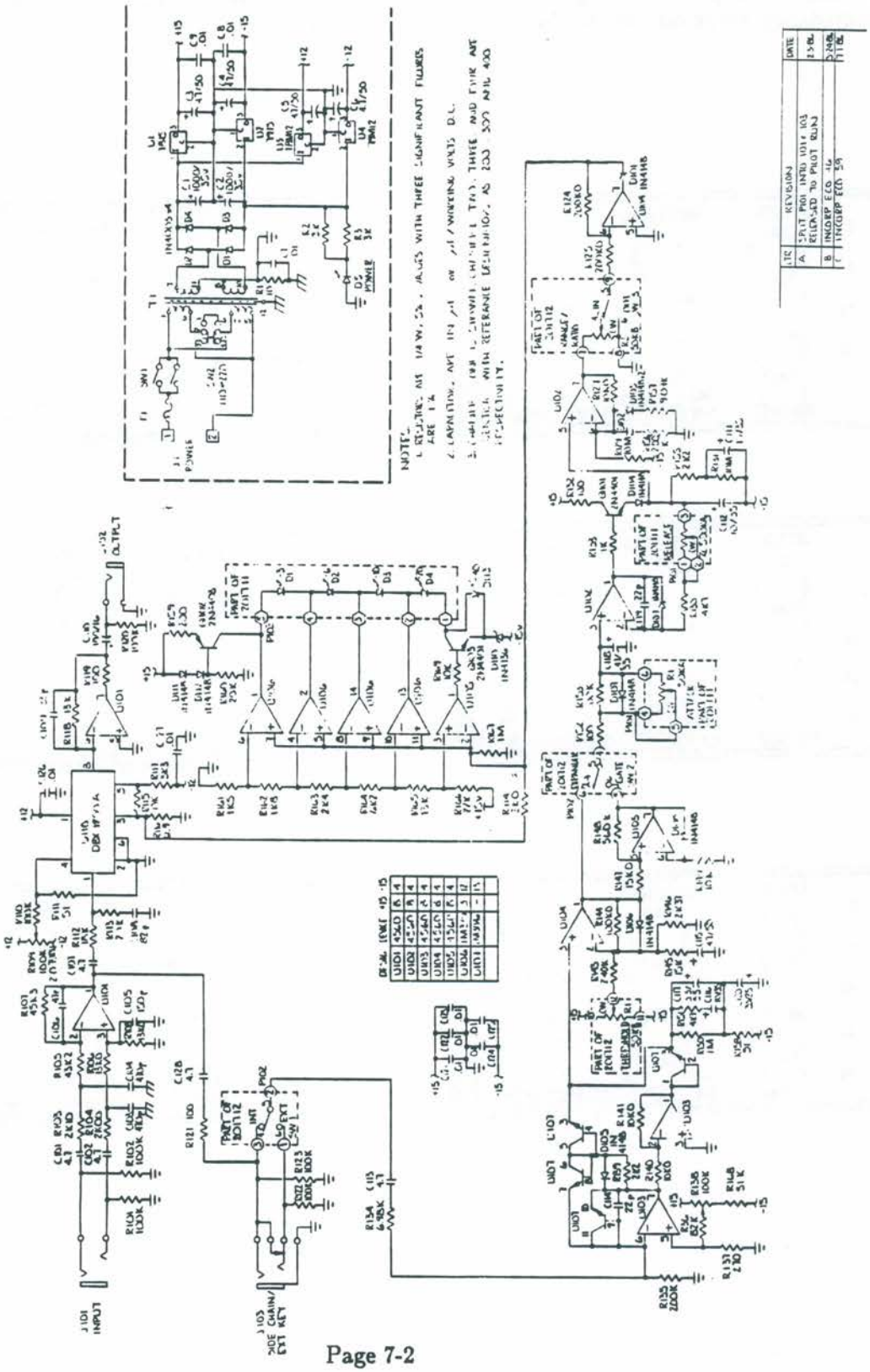
Use the following table to analyze difficulties before calling Symetrix or a technician for help. You may be surprised at how easy it is to solve problems, and you may save us both some time and money. Thanks.

Problem	What to check - what to do
No expand/gate action	Is the IN/OUT switch in? Is the INT/EXT switch in? Is there something in the SIDECHAIN that's not turned on? Is there a 2-conductor (mono) plug in the SIDECHAIN/EXT KEY? Is the RATIO/RANGE control set below MIN? Is the THRESHOLD set low enough for the present signal level?
Low or distorted output	Be sure gear patched into the SIDECHAIN is turned on. Check input, output and SIDECHAIN connectors for shorts. Is something patched into the signal chain before or after the 544? Is the 544 powered up?
Distortion or crackling sound at output	Try slower ATTACK or RELEASE times. Check level and signal at input: Is it too high? Is is distorted?

If you cannot isolate or cure the problem call Symetrix or a *qualified* audio electronics service technician. For service information turn to Section 7.

7.3 Schematic Diagram

The schematic diagram is to be used by qualified service technicians only. No license to use this information for anything other than normal repairs is implied or given by the inclusion of proprietary information in the schematic diagram.



LIMITED WARRANTY

The Symetrix 544 is designed and manufactured for use in professional and studio audio systems. Symetrix, Inc., warrants that the 544 manufactured by Symetrix, when properly installed, used and maintained in accordance with instructions contained in the manufacturer's operator's manual, will perform according to the specifications set forth in the operator's manual.

Symetrix expressly warrants that 544 will be free from defects in material and workmanship for one (1) year. Symetrix' obligations under this warranty will be limited to repairing and replacing, at Symetrix' option, the part or parts of the 544 which prove defective in material or workmanship within one (1) year from the date of purchase, provided that the Buyer gives Symetrix prompt notice of any defect or failure and satisfactory proof thereof. Products may be returned by Buyer only after a Return Authorization number (RA) has been obtained from Symetrix and Buyer will prepay all freight charges to return any products to the Symetrix factory. Symetrix reserves the right to inspect any products which may be the subject of any warranty claim before repair or replacement is carried out. Symetrix may, at its option, require proof of the original date of purchase (dated copy of original retail dealer's invoice). Final determination of warranty coverage lies solely with Symetrix. Products repaired under warranty will be returned freight prepaid via United Parcel Service by Symetrix, to any location within the Continental United States. Outside the Continental United States, products will be returned freight collect.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, WHETHER ORAL, WRITTEN, EXPRESS, IMPLIED OR STATUTORY. SYMETRIX, INC. EXPRESSLY DISCLAIMS ANY IMPLIED WARRANTIES, INCLUDING FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY. SYMETRIX, INC.'S WARRANTY OBLIGATION AND BUYER'S REMEDIES HEREUNDER ARE SOLELY AND EXCLUSIVELY AS STATED HEREIN.

The Symetrix 544 is designed and manufactured for use in professional and studio audio systems and is not intended for other usage. With respect to products purchased by consumers for personal, family or household use, Symetrix **EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

This limited warranty, with all terms, conditions, limitations and disclaimers set forth herein, shall extend to the original purchaser and anyone who purchases the product within the specified warranty period.

Warranty Registration must be completed and mailed to Symetrix, Inc. within thirty (30) days of the date of purchase.

Symetrix does not authorize any third party, including any dealer or sales representative, to assume any liability or make any additional warranties or representation regarding this product performance on behalf of Symetrix.

This limited warranty gives the buyer certain rights. You may have additional rights provided by applicable law.

LIMITATION OF LIABILITY

The total liability of Symetrix, Inc. on any claim, whether in contract, tort (including negligence) or otherwise arising out of, connected with, or resulting from the manufacture, sale delivery, resale, repair, replacement or use of any product will not exceed the price allocable to the product or part thereof which gives rise to the claim. In no event will Symetrix, Inc. be liable for any incidental or consequential damages including but not limited to damage for loss of revenue, cost of capital, claims of customers for service interruptions or failure to supply, and costs and expenses incurred in connection with labor, overhead, transportation, installation or removal of products or substitute facilities or supply sources.