Pumping Gain:
Understanding Dynamics Processors

Like a boa constrictor, a linear accelerator, or a surgeon's scalpel, a dynamics processor in the wrong hands is a dangerous thing.

Dangerous? You bet. Dynamics processors—compressors, limiters, expanders, and gates—are the most misunderstood of all signal processors. And they can be touchy: Mishandle a compressor, for instance, and it'll squash the life out of a good recording.

But don't be scared. Dynamics processors are easy to use, once you understand them, and they can make the difference between a good recording and a great one. They're wonderful problem-solvers, and fantastic for effects. In informed hands, a dynamics processor is a powerful thing.

DYNAMICS PROCESSING, MORE OR LESS

Dynamics is the rise and fall in sound level, and it's responsible for much of the drama and impact in music and sound. *Dynamics processors* (not to be confused with dynamically controlled effects processors) change audio signals by altering the relationship of the loud parts to the soft parts. Changing the dynamics of a sound can profoundly alter its effect on the listener. As it happens, it also can dramatically affect how the sound can be recorded and reproduced.

Dynamic range is the amplitude difference between the quiet and loud passages of a sound or signal. Not all things are created equal, in this respect. A symphony orchestra, for example, is capable of fantastic dynamic range: more than 70 decibels between its quietest and loudest levels. A harpsichord, on the other hand, has a much smaller dynamic range; there isn't a great deal of difference between a key pressed lightly and one played with force. When you want to increase or decrease dynamic range, subtly or overtly, dynamics processors come into play.

Compressors and limiters are the best-known dynamics processors. They, along with two variants known as de-essers and duckers, are used to *reduce* a signal's dynamic range. On the other side are expanders and gates, which *increase* dynamic range. When should they be used? How do they differ? Let's find out.

BY BRENT HURTIG

COMPRESSORS

Vocalists are capable of tremendous dynamic range, from a whisper to a scream. That's great. But if you've ever tried recording vocals, you've probably found it necessary to "ride" the faders; that is, to adjust the vocal fader up and down as levels change to prevent overload and overcome tape hiss and other background noise.

The ideal result is a more evenly balanced, smoother-sounding vocal track, but there are two problems with "gain riding." First, it's inefficient. You've got better

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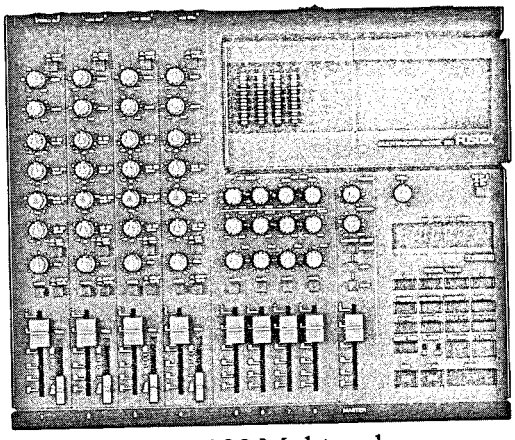

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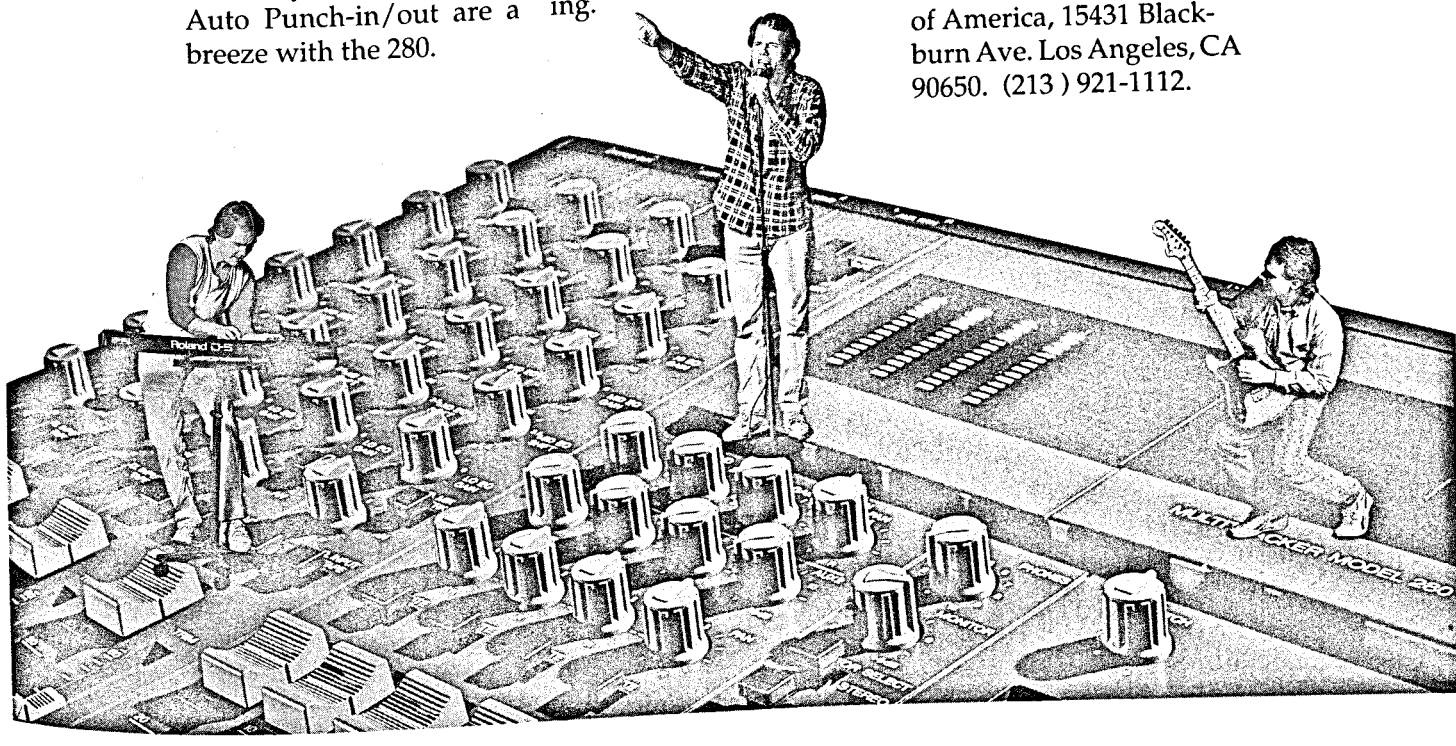

things to do than worry about a single fader. The second shortcoming is that you're human; try as you might, there's no way you can react to a sudden peak fast enough to prevent overload.

A compressor can free you from gain riding by acting like an automated gain control. Compressors let you set a predetermined *threshold*. Signals below that threshold pass through the compressor unaffected. When signals cross above the threshold, however, the compressor kicks in and reduces their level. A compressor can help "average" a singer or instrument for consistent, more professional results (see **Figs. 1** and **2**).

A common misconception is that compressors make loud passages quieter, and quiet passages louder. Here's what really happens: Since loud signals *are* reduced, the total range between the loudest and quietest passages is reduced; quiet passages *seem* louder, even though they're not processed. Engineers use this effect to increase the sustain of instruments, since decaying notes seem louder when peak attacks are compressed. Unfortunately, buzzing, background hiss, and other low-level signals may also sound louder. It's usually better to compress a signal before it goes to tape.

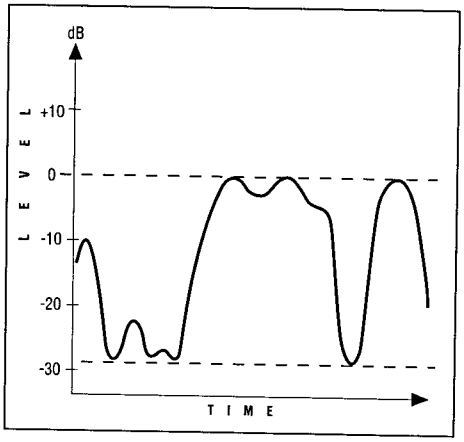

FIG. 1: The amplitude envelope of an unprocessed audio signal.

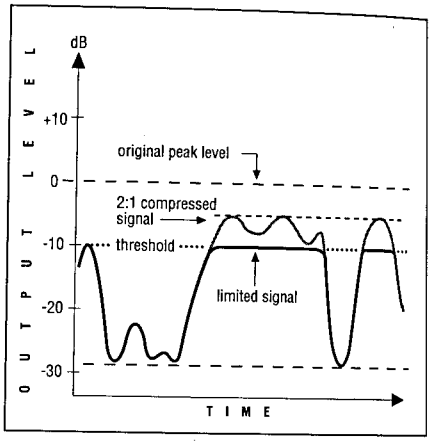

FIG. 2: The same signal envelope, illustrating compression at a 2:1 ratio, and limiting (infinite compression). The threshold in each case is set at 10 dB below the uncompressed peak.

Most of the time, you should use just enough compression to do the job; extreme settings can make the signal sound "pumped" or "squashed." There are times, though, when an extreme is just what the doctor ordered.

LIMITERS

Limiting is an extreme form of compression: Levels that exceed the threshold are effectively stopped from getting any louder. A good limiter can let you set an absolute maximum level.

Generally, limiters are used as safety devices. For instance, anyone who has played in a garage band knows it's easy for a singer or a kick drum to produce a peak capable of destroying a loudspeaker. Every professional P.A. system

should be equipped with limiters of some sort, typically wired between the mixer (or active crossover) and the power amps.

In the studio, limiters are used to prevent overload at the tape machine. Typically, they're used with vocalists and drums, though any source with a quick, unpredictably loud attack is a candidate for a "safety" limiter.

DE-ESSERS AND DUCKERS

Condenser mikes sound wonderful, especially for vocals. Unfortunately, many of them accentuate *sibilant* sounds, those "sss," "sshhh," and "tsch" sounds. You can throw in an equalizer and cut the offending frequencies (around 1 to 7 kHz), but it will reduce those frequencies by a fixed amount. The professional solution is to use a de-esser, a device that gradually compresses sibilant frequencies as they get louder.

Often, it's necessary to sing or talk over music, particularly in radio or jingles. There are two ways to handle this. The first is to "ride gain," lowering the level of the music as the voice comes in and raising the music as the voice leaves. The other way is to automatically "duck" the music when the announcer speaks. A ducker is a compressor with a *side-chain*. The music is put through the compressor, and the announcer's voice is routed to the side-chain input. When the announcer speaks, the level of the music is reduced in proportion to the level of the voice.

EXPANDERS

When you need to increase dynamic range, call in an expander. Unlike a compressor, which kicks in when signals exceed the preset threshold, an expander kicks in when signals drop *below* the threshold setting.

There are four main uses for an expander. The first is to restore lifelike dynamic range. (Some people use stereo expanders on their home stereo to increase the limited dynamic range of tapes and LP records.) The second is a noise reduction system; used carefully, an expander can make quiet background noise even quieter. Since a compressor may raise the apparent level of background noise, it's common to run a compressor's output into an expander, to reduce noise while "averaging" a signal's peaks (see **Fig. 3**).

• PUMPING GAIN

The third use is for cleaning up tracks and minimizing crosstalk. Certain sounds may "bleed" between tape tracks, or a microphone can pick up nearby instruments. Since these extraneous sounds are usually low-level, an expander can make them even quieter (without the "clipping" effect induced by most gates, as we'll see).

Finally, an expander is great for "tightening up" the sound of sustained instruments: A tom drum might sound great struck on its own, but when you play the rest of the set, it may ring too long. A cleverly tweaked expander reduces sustain as soon as the signal drops below the threshold by "pushing down" the decaying signal even further.

GATES

Just as limiting is a form of maximum compression, gating is expansion taken to its most extreme. With expansion, signals that drop below a certain threshold are made even quieter. With gating, once a signal drops below the threshold, it's completely silenced; only when the incoming signal rises

MASTERING THE CONTROLS

Threshold: Determines the level at which processing kicks in. With compressors and limiters, signals that cross above the threshold level get processed; with expanders and gates, only signals below the threshold get the treatment.

To help in setting the threshold, better processors have a gain-reduction meter. Simpler boxes may have an LED that illuminates whenever the input signal crosses the threshold.

Ratio: The ratio between a change in input level and the corresponding change in output.

Ratio range depends upon the job at hand. Compression calls for ratios of 2:1 to 10:1. Once you approach 8:1 or greater, audio begins to sound more than just a little "squashed."

Limiting implies very high compression ratios: 10:1, 20:1, or even ∞:1. At these ratios, input level increases result in just tiny output level increases.

For expanders, opposite ratios are the way to think: A 3:1 ratio setting on the box should really be thought of as a 1:3 setting, since a 1 dB drop in input level will be expanded to a 3 dB drop in output level (once the signal drops below threshold). Expansion ratios range from 1:2 to about 1:10.

A gate is like an extreme expander. Since gates are usually "open" or "closed," however, and not somewhere in between, their ratio is 1:∞. This means that once the input level drops below threshold, there is an infinite amount of gating—in other words, silence.

Attack and Release: The attack control determines how quickly processing kicks in once a signal has crossed threshold, from microseconds to a second or longer. There are times when it's necessary to limit a signal instantly. A more moderate attack setting sounds better for processing an "average" of signals, rather than just peaks.

A release control lets you set how much time passes before the processing stops, once the signal crosses back under (or over, in the case of an expander or gate) the threshold. Quick releases are best for peak control, and moderate or longer release times are better for "average," natural-sounding processing.

Input and Output: An input-gain control sets the processor's sensitivity. Changing the input level will have an effect on the device's threshold setting.

Dynamics processing, whether it's compression or expansion, often causes a reduction in the device's overall output level. Output-level controls "compensate" for lost gain. If your processor lacks an output control, you can increase the level of the compressed signal at your mixer.

Gain-Reduction Meter: This shows how much processing is taking place and usually is calibrated in dB. Once signals cross the threshold, LED gain-reduction meters begin to light up. Some older processors have mechanical meters that start at "0 dB" and begin to drop to "-3 dB" and further as processing starts. Some boxes just have a single LED that illuminates when processing starts.

Side-Chain In, or Key In: This switch engages the external side-chain return so that external signals control the VCA (see sidebar "Of VCAs and Side-Chains"). Not all processors with side-chains have these front panel switches, in which case anything plugged into a rear-panel side-chain input will control the VCA automatically.

Slave: Dual-channel, or stereo, processors usually sport a slave switch on the second (or right) channel. Push this in, and the slave channel will be controlled by the master channel (usually channel one, or the left channel). The slave channel's controls have no effect once the channel is slaved to the master.

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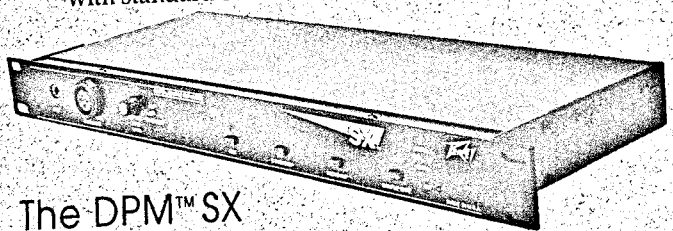

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above the threshold level does the gate "reopen" and allow the signal to be heard.

Gates are perfect for eliminating hum and buzz, something for which guitar setups, on stage and in the studio, are notorious. Gates also can be used to shut out background noise (such as lip-smacks and pages turning) from any microphone. The key to success, as with any of these dynamics processors, is careful adjustment: An improper setting can "clip" the attack off sounds or cause "stuttering" if a signal waivers around the threshold level.

It's difficult to listen to much popular radio these days without hearing the ubiquitous, Phil Collins-like "gated reverb" effect on drums. I present the full technique for this already overused sound on p. 68 of this month's issue.

THE RIGHT TOOL FOR THE JOB

Dynamics processors come in a wide variety of devices. Most are designed as "outboard," rack-mount gear. If you spend time in professional studios, you may come across certain mixing consoles with complete dynamics processors built into each channel. In mid-size P.A. gear, you'll find compression and limiter circuits built into power amps and mixers (most notably from Peavey), though these are designed primarily to prevent overload and usually aren't adjustable.

At the other end of the scale are compressor and gate footpedals. While some of the studio techniques described below can be applied to "stomp" boxes, noise and mediocre frequency response generally limit them to stage use.

Compressors and limiters are usually combined into a "comp/limiter" device, as the difference between a compressor and a limiter is largely a difference in *attack* and *ratio* amounts (see sidebar "Mastering the Controls"). Some comp/limiters do compression *or* limiting; others have separate limiter circuits for simultaneous comp/limiting. Comp/limiters with a side-chain input (see sidebar "Of VCAs and Side-Chains") also can be configured to function as de-essers or duckers.

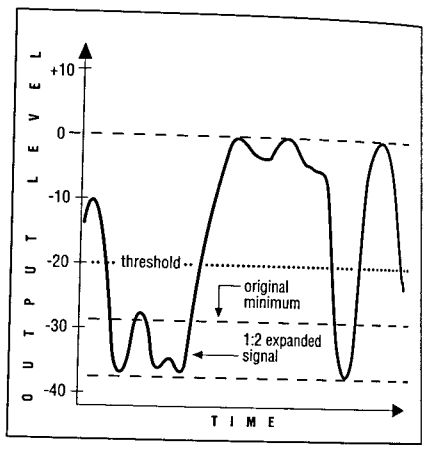

FIG. 3: Our lovely model signal, this time expanded at a ratio of 1:2 with a threshold 20 dB below peak.

Gates are usually found on their own as single- or multi-channel gates (Symetrix, Furman, and others offer 4-channel gates). Several gates (notably from Klark-Teknik, Studiomaster, and Drawmer) include MIDI control; this allows the gate to open, for instance, when a particular MIDI note number comes in. Certain comp/limiters also throw in a simple gate circuit, suitable for many gating purposes.

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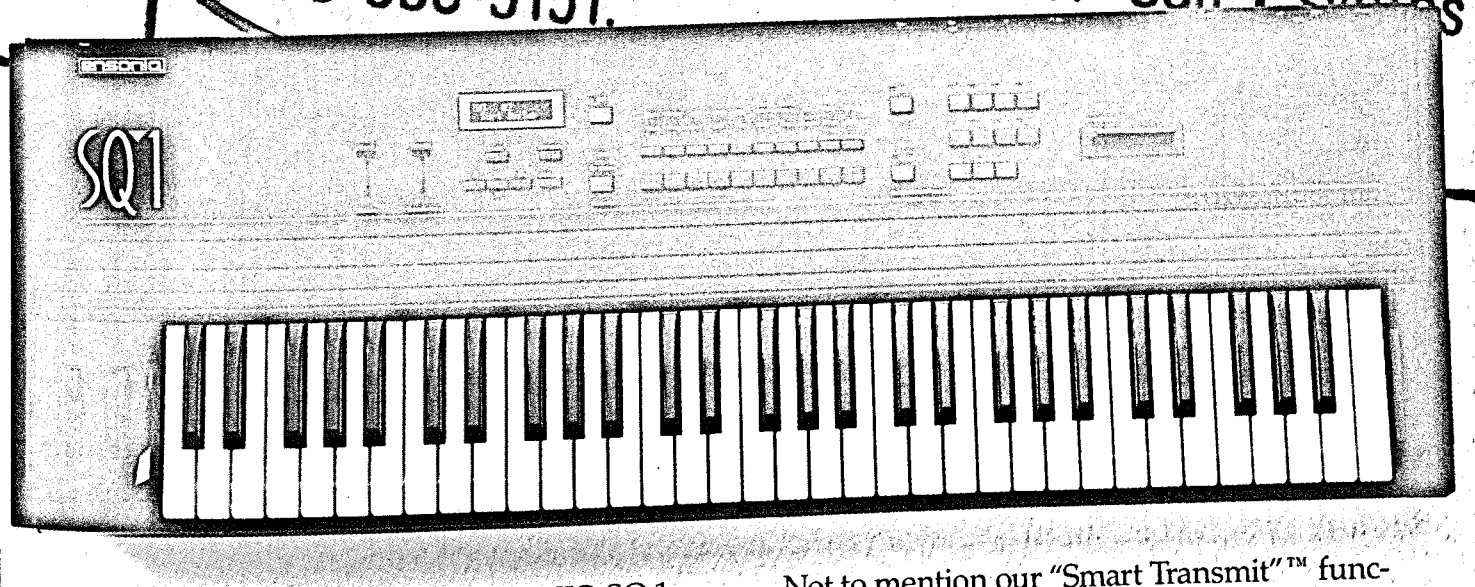

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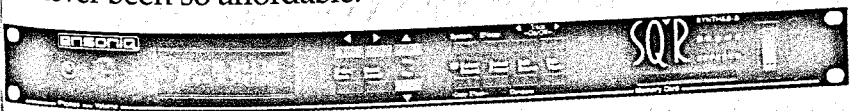

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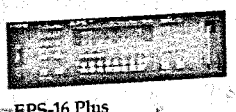
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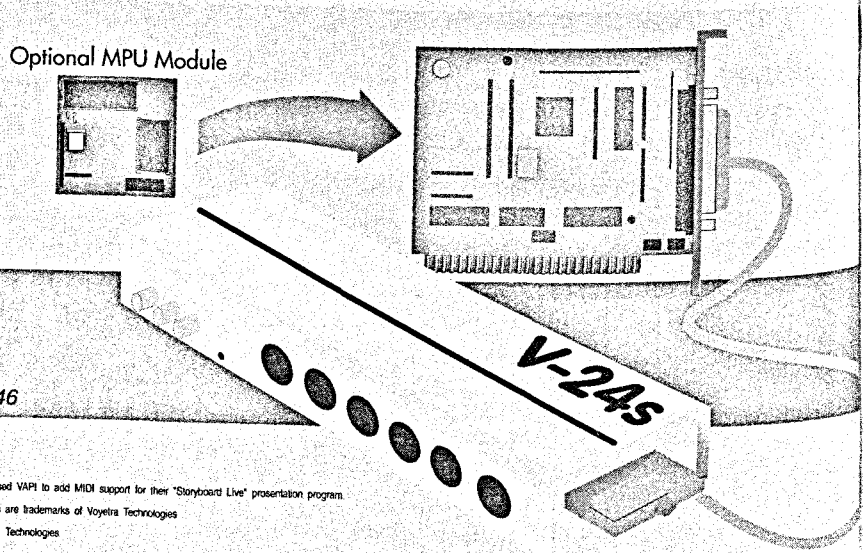

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Stand-alone expanders are uncommon. Some gates can do double duty as expanders, if they have an adjustable ratio control. But for the most part, look for true expander circuits in some of the more professional (and expensive) multi-purpose dynamics processors from Drawmer, Symetrix, and others.

Thankfully, it doesn't cost an arm and a leg to move up from a stomp box to a quality, outboard dynamics processor. Gates, compressors, and even comp/limiters with simple gates are available for under $200. A $500 investment will bring you a pro-grade, 1- or 2-channel processor with a broad palette of controls. Above $1,000, you get into the land of MIDI-controlled gates (BSS, Drawmer); digitally controlled and programmable, multi-purpose boxes (Drawmer, Studiomaster); and esoteric vacuum tube and solid-state compressors and limiters (Summit, Pultec, GML, and others).

A few words of warning: Be sure your dynamics processor choice is compatible with your existing setup. Whether you have a -10 dBV, "semi-pro" mixer (or 4-track ministudio), or are using a professional-level, +4 dBm mixer, make sure the dynamics processor has level-compatible inputs and outputs.

Secondly, there are a lot of do-everything digital effects boxes on the market, with great reverb, delay, and more. Many sport, as an extra feature, digital "compressor/limiter" functions. While these sections may work okay, chances are the box won't provide any indication when a signal exceeds or drops below the threshold level, nor provide a meter showing how much dynamic processing is happening. Consequently, these functions are not a replacement for a real dynamics proccessor.

Finally, a word about connection: Unlike using a reverb—where a mixer's effects send feeds some of the signal to the effect, and an effects return or input channel is used for the effect's output—dynamics processors usually are connected at *insert* loops. (Most mixers and many 4-track ministudios feature insert, or *send/receive*, loops on their channel inputs.) This is because normally, you process the entire signal. Alternately, a dynamics processor can be connected at a mixer's group outputs, between a group and the multitrack deck (or the crossovers or power amps, in the case of a P.A. system).

So don't be scared. Dynamics processors are easy to use, now that you understand them. They're wonderful problem-solvers and fantastic for effects. In your informed hands, a dynamics processor is a powerful and versatile tool.

Based in San Francisco, **Brent Hurtig** *is the author of* Multi-Track Recording For Musicians *(GPI/Alfred), the editor of over ten books, and was founding editor of* EQ *magazine. He is now lucky to be qualified and crazed enough to work as a creative and technical consultant to the recording industry.*

OF VCAS AND SIDE-CHAINS

Central to most dynamics processors is a small circuit known as a ***voltage-controlled amplifier*** (VCA). Each channel has its own VCA.

Once incoming signals cross the threshold level, however, the VCA kicks in and begins to attenuate (reduce) levels. The amount and rate of reduction depends upon the type of processor and its various control settings; see sidebar "Mastering The Controls." Remember, with compressors and limiters, overall dynamic range is reduced as high-level signals are attenuated. With gates and expanders, overall dynamic range is increased as low-level signals are attenuated even further.

Normally, the VCA is controlled by whatever signal is at the processor's input, but not always.

In fact, there is an electronic internal "port" to the VCA known as a ***control input***. Usually, this control input is fed by the incoming audio signal, so, for instance, when you want to gate a bass guitar, the VCA gates the signal once the level of the bass drops below the gate's threshold.

Many processors allow you to "access" the VCA's control input via an external ***side-chain*** (some boxes call it a ***detector***, ***key***, ***control***, or ***trigger*** input). Once you connect something to the side-chain input, that external source controls how much dynamic processing occurs and when it starts (see Fig. 4).

Let's return to our gated bass guitar setup. The VCA is normally controlled by the bass guitar's level changes. But if we were to connect a drum machine's kick drum to the side-chain input, then the level of the kick will control the VCA, in turn controlling how and when the bass is gated. In this way, the kick could turn the bass "off and on" with each kick.

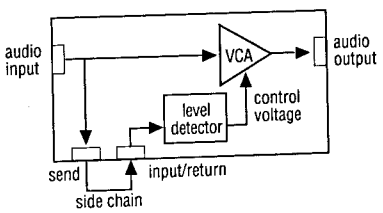

FIG. 4: Block diagram of a generic dynamics processor with side chain.

Keep in mind that side-chain signals are not fed to the outputs of the dynamics processor; they only control how the incoming audio is processed. Unless we simultaneously feed the kick drum's signal to the mixer, ***we won't hear any kick.***

Aside from this sort of "gate trigger" control, the side-chain can be used for ***frequency-dependent*** dynamics processing. Sometimes it's necessary to process certain frequencies and not others. De-essing is a type of frequency-dependent compression.

Frequency-dependent gating and expansion are also techniques to try, particularly for reducing noise at certain frequencies. The big difference with these processors is that you ***cut***, rather than boost, the frequencies you want to process.