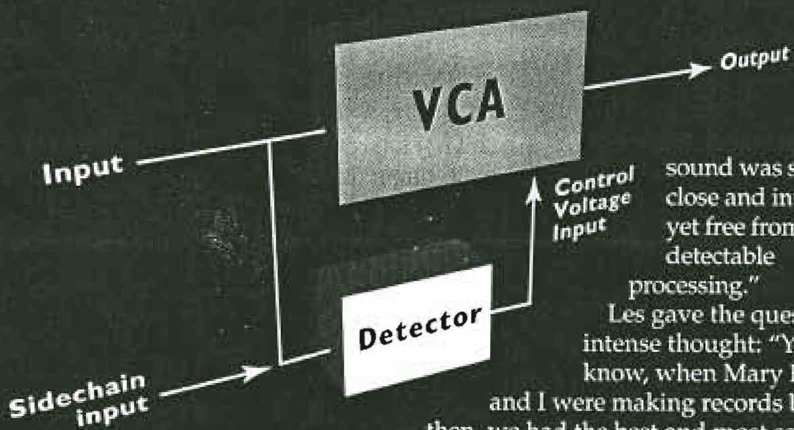
# All about DYNAMICS PROCESSING

## Part 1

*Compressors, gates, expanders, limiters, duckers, and automatic gain controls have more in common than you might think.*

**BY PAUL FREUDENBERG**

Many years ago, I had the unique opportunity to attend an intimate chat with Les Paul, the father of multi-channel recording. "What kind of compressors and limiters did you use back then?" asked a member of the audience. "Your sound was so close and intimate, yet free from any detectable processing."




Les gave the question intense thought: "You know, when Mary Ford and I were making records back then, we had the best and most sophisticated equipment available at the time. The compressors and limiters that we used were state of the art. They were noise free, no distortion, totally automatic adjusting attack and release time, program adaptive, and so on. Nowadays, you engineers still have these available, but they never get used!"

By this point, the engineers in attendance were all on the edges of their seats. Finally, Les Paul pointed to his right eye. "We didn't have any of those types of boxes back then—they hadn't been invented yet! Mary and I used our eyes! We would record everything in the same room with the tape machine and just watch the meters!"

And that's at the heart of all dynamics processing. The difference between doing it by hand and using a machine is that the machine can react much more quickly and precisely. But throughout this 2-part discussion of machines, let's not forget that the old fashioned way does have its advantages, as Les pointed out that day.

Having said that: Dynamics processors include compressors, limiters, gates, expanders, duckers, levelers, and automatic gain controllers (AGC). Very simply, we are modifying the original program envelope by adjusting the gain on signals that go above or below a given level by a specified law, or ratio.

### The nitty gritty

Before getting to the real world, let's look at the theory behind these devices. The workings of most dynamics processors can be explained with very similar block diagrams. At the heart is a gain (level) control device, usually a VCA (voltage controlled amplifier) or sometimes an opto-electronic device such as a photoresistor. A sidechain path branches off, and it goes to a detector that tells the gain control device what to do. Finally, input and output stages are there to interface with other gear.

The basic block diagram to the left, shows an audio input followed by a VCA stage and an output stage. A sidechain path—a branch off the input signal—feeds the detector stage of the dynamics processor. The detector's job is to analyze the input and tell the VCA what to do, based on the front panel settings. Some processors have a side chain input, as illustrated, so the processor can be controlled by a separate signal from the one being processed (we'll explain why you'd want to do that later).

Fig. 1 shows input level relative to output level. A 1:1 ratio setting (no gain change) produces the straight line on the graph. A 1:1 ratio simply means "1dB in, 1dB out"; a 2:1 ratio would mean that the signal is being reduced, since you only get 1dB out for every

2dBs you feed in. The non-linear plots show the effect of various ratio settings, as indicated. Their ratios vary as different levels are fed in.

Since all dynamics processors share very similar block diagrams, you may wonder what the difference is between compression, limiting, and gating. It depends on the setting of the basic controls, and whether the device operates on above-threshold signals (Fig. 2) like a compressor or limiter, or on below-threshold signals like the expander or gate shown in Fig. 2.

**What the controls do**

Continuing our backward journey, let's talk about the buttons and knobs common to most dynamics processors—but because different devices are designed differently, there may be some differences on your unit. Some of these differences are obvious on some units; other units have these parameters, but for the sake of simplicity don't allow them to be adjusted.

The *Threshold* control is the most common on all types of dynamics processors. It is the level at which the change in gain begins to occur. If you have a processor that doesn't have a threshold control, it's been fixed at one level (referenced to the nominal, or average, operating level of the machine), and the control that replaces it is usually called Gain Reduction, Drive, or Input. If that's the case, you're simply adjusting the input level relative to a fixed threshold, rather than adjusting the threshold relative to the input level (which, to confuse matters, can also be adjusted).

Next comes the *Ratio* control, which as we've discussed sets the relationship between input and output. With compression, when the signal exceeds the threshold setting the ratio determines the amount of change. For instance, a 2:1 ratio means that for every 2dB of signal above the threshold, you get out only one. With expanders and gates, the opposite happens. A 1:2 ratio would mean that every dB below the threshold is reduced by an additional dB. This can be confusing because manufacturers often specify this relationship backwards (i.e., 2:1, when they should say 1:2). On many gates, the ratio is fixed at a high setting, such as 1:30.

On gates and expanders, the *Range* (of gain reduction, specified in -dB) control works with Ratio to determine the maximum amount of gain reduction. Remember, all these controls only affect signals that have crossed the threshold.

Then the *Attack* and *Release* times delay the onset of gain change once the signal crosses the threshold. On some program material, very fast attack times may produce undesirable results such as dulling (cutting off the bright attacks), modulation, pumping, or breathing (caused by the gain going up and down uncontrollably— you can prevent that by telling the device not to react so quickly every time the signal crosses the threshold very briefly). Very fast release times result in a very distinctive distortion (particularly on low frequency signals), as the tail of the program envelope modulates rapidly. It is important to select attack and release times with the envelope of the track in mind. For example, a slow release time on a clave track would not be appropriate, since it's a percussion instrument

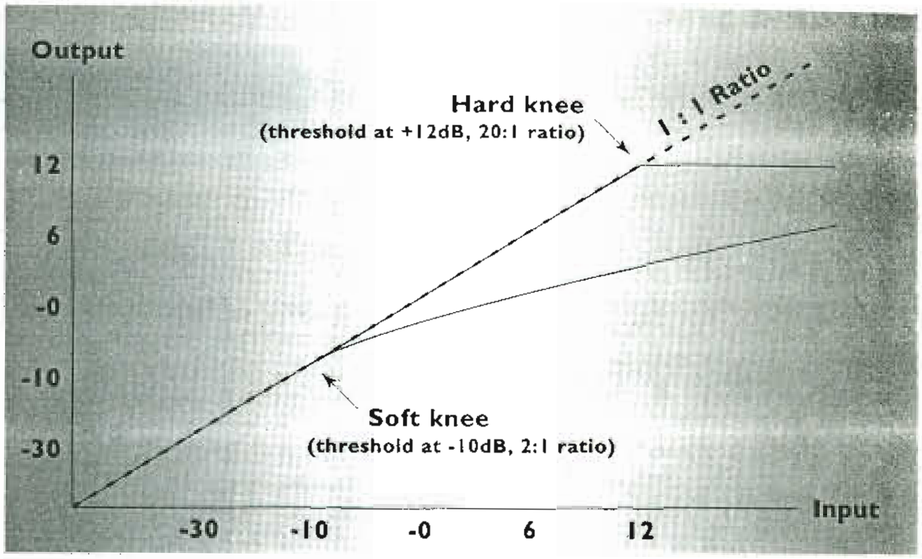



*Figure 2 Compression and Limiting thresholds/ratios*

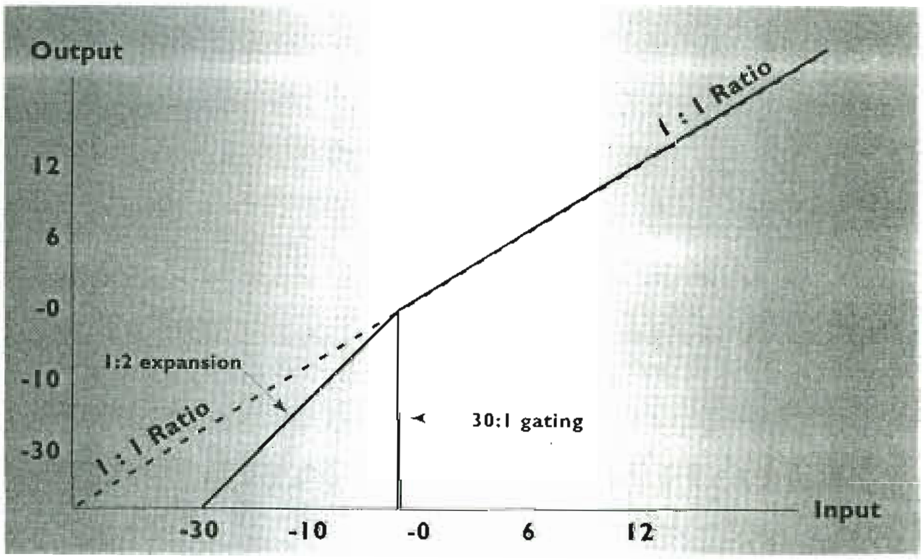



*Figure 3 Expander and Gate thresholds/ratios*

with all peak energy with a very short envelope.

An additional control called *Hold* is found on most high end expanders and gates. This control sets an amount of time that must pass before the gate or expander starts the release portion of its envelope. It may be timed from the moment the signal exceeds the threshold (usually) or the moment it falls below, depending on the unit. If the input signal's level constantly fluctuates across the threshold, the hold control can prevent the gate from closing prematurely. With drums, for example, the hold control could prevent the toms from being gated before the end of their ring.

Compressors usually have a *Gain* control at the end of their signal path. A byproduct of reducing the dynamic range is that the average signal level is lowered, so it has to be brought back up to keep the next device in the chain happy. This is often referred to as 'makeup gain'.

We need to explain two more terms to fully understand how different compressors work. With *hard knee* designs, compression begins exactly when a signal exceeds the threshold. The full ratio is applied all at once. Hard knee designs tend to have more character, and they are useful in situations where you want to contain peaks.

*Soft knee* designs, on the other hand, gradually increase the ratio as you approach the threshold, so the onset of compression is less detectable. It's comparable to fading the signal down instead of suddenly lowering it. Some compressors let you select hard or soft knee, others are preset one way or the other.

**Why use dynamics processing?**

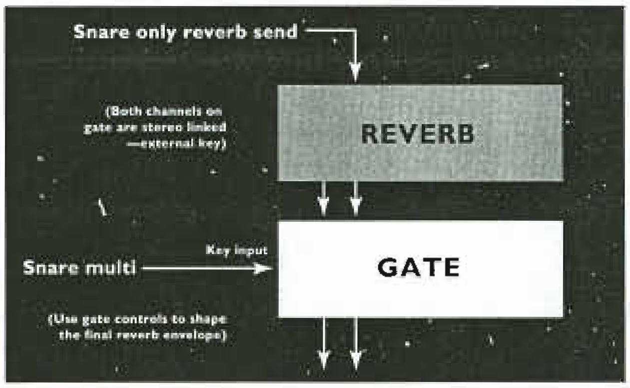
Originally, the sole purposes of dynamics processing were to keep the program level above the noise level (whether the noise was hiss from tape or magnetic film, or ambient noise in the background), or to prevent the signal peaks from getting too high. As you know, the result of a signal that's too hot depends upon where in the chain it's occurring—it can be anything from distortion to smoke to interference with signals broadcasting on neighboring radio frequencies.

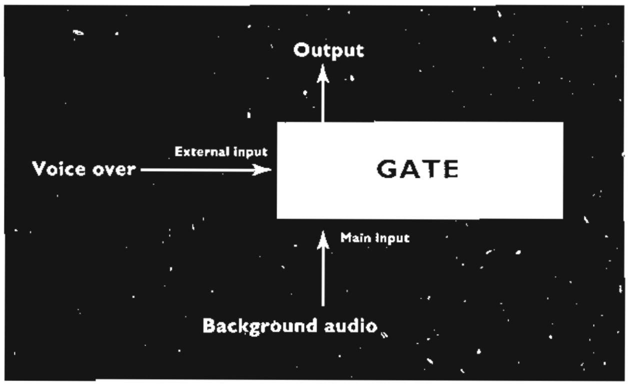
Today, dynamics processing is also being used as a creative tool. It can be thought of as another color. You can affect the amount of sustain, get a more or less punchy sound, increase or decrease dynamics to get a more interesting or smoother sound, and so on.

**The processes**

*Compression* reduces the level of signals that exceed the threshold, but it's helpful to think of it as bringing the softer program dynamics up higher. This may seem contrary to the action of gain reduction, but by definition the response of a compressor is relatively average and the attack and release times are moderate, so a compressor will only have an effect on the average dynamics. There will be little detectable change on the peaks, compared to limiting.

Thus, it's useful to conceive of compression this way: *the amount of gain reduction being applied when the program is at its loudest is the amount you are bringing up the soft signals.* For example, I set my compressor with a -20dB threshold on the guitar track. The Ratio is set at 2:1 (quite subtle), the Attack at 50mS, and the Release at 250mS. I see about 10dB of gain reduction when I play the loudest, so I adjust the Gain to +10dB. When I play softly, my performance is brought up by that 10dB. In other words, my dynamic range has been compressed by 10dB.




*Gated reverb & ducking, block diagrams*

*Limiting*, on the other hand, pushes signals that exceed the threshold down, using high ratio and fast attack and release times. Also, there is no makeup gain, as in the compression example. My settings for a vocal limiter might be like this: Threshold at +12dB, Ratio 20:1, Attack time 10mS, and Release at 100mS. I usually see about 4 to 6dB of peak gain reduction on the meter. I should not see long periods of high gain reduction. If this happens, I raise the threshold so it only operates on dangerous peaks. Limiting is used to protect from overload. Note that the difference between compression and limiting is often just a matter of the settings—there isn't necessarily a hard line between the two. In theory, a limiter would have a ratio of ∞:1, but in practice, ratios of 10:1 or greater are extreme enough to be considered limiting.

AGC (automatic gain control; also called *leveling*) is a less familiar type of processing. It slowly adjusts the gain of the program over the long term. As you'll see in the table that accompanies this article, the threshold is set low and the ratio high. You can expect to see large amounts of gain reduction with these settings. However, since the attack and release time are slow (attack 250 - 500mS and release 1.5 - 3S, or so), expect no sudden changes in the program envelope. Leveling is often used to adjust the gain when crossfading from one tune to another. Applied to mixdown, you'd use leveling to even up an entire mix when the overall level is uneven, but the balance between tracks is fine. Some engineers who are paid for this type of manual dynamics control refer to the task as "fader riding."

*Clipping* is another form of gain control found on some processors, although it may be referred to by a different term, such as Peak stop. This process is exactly what it says: above a certain threshold, the signal is just clipped off. As you can imagine, the result will be raspy distortion if the threshold is not high enough. Used in small amounts, however, clipping limiters can provide protection without changing any of the dynamics below the threshold.

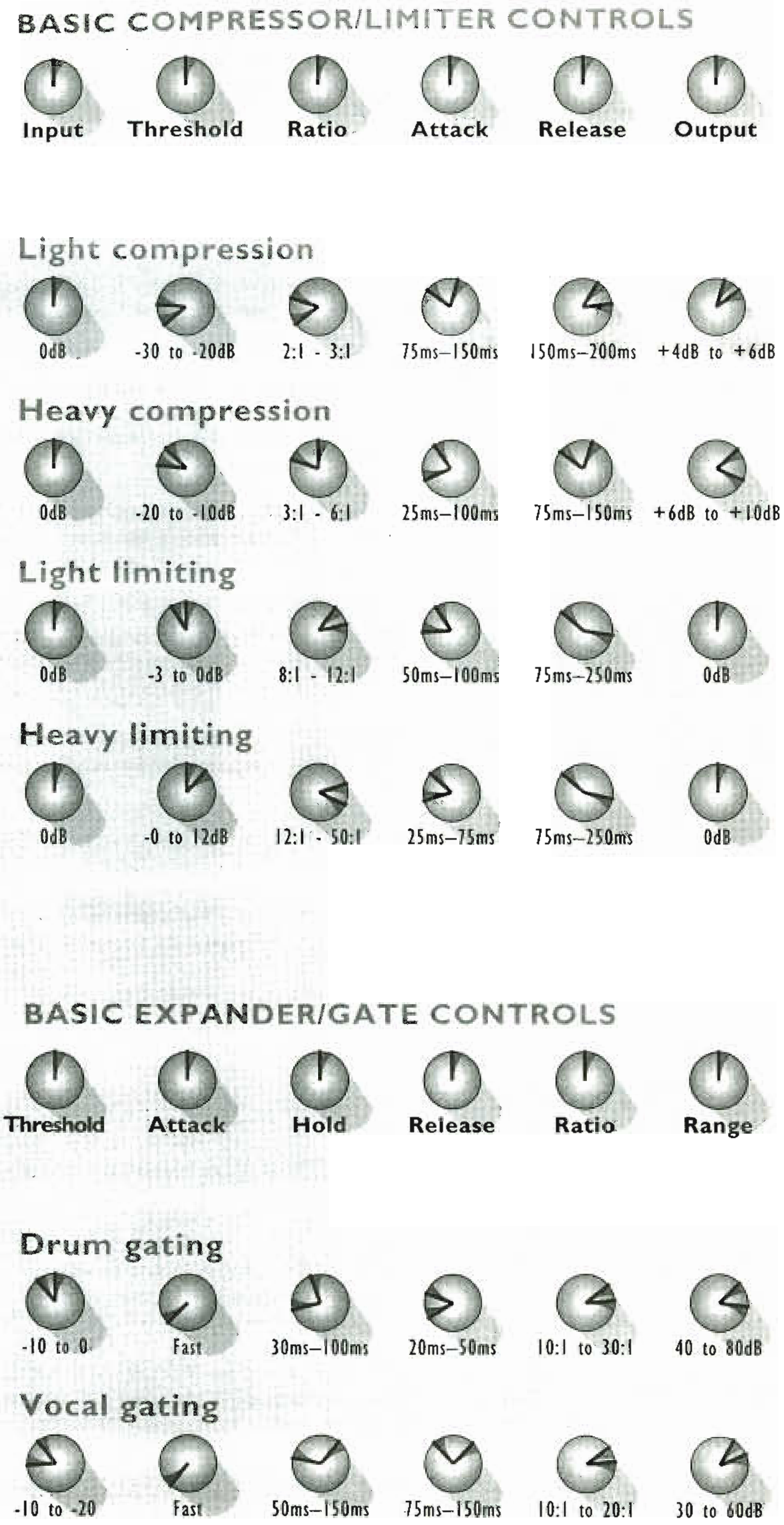
*Expansion* and *Gating* affect levels that fall below the threshold. Noise gating (as it's also commonly called, because of its primary function) tends to be a little more stiff-sounding because of its high ratio (around 30:1). It is like a switch: on or off. The signal falls below the threshold, the gates closes; the signal exceeds the threshold, the gate opens. Gating is good for muting tracks when they're not in use, or for cutting down leakage into a mic from surrounding instruments (such as in a drum set, when you don't want the bass drum to leak into the snare mic, for example).

**The overall character of the track also dictates what type of processing to use. For example, a soft string synth pad with little peak energy would not need a limiter**

Expansion, on the other hand, is more gentle. It can be used to add dynamics to a part, including the effect of too much compression. To expand the dynamic range, you'd want to use a fairly subtle ratio, such as 1:1.5 (and a fairly low range), and also set a high threshold so most or all of the signal is affected. Setting too low a threshold for this application will sound funny—the peaks will be quite high, while below-threshold signals will be very low. You can also use expansion as a more subtle gate, by setting a low threshold and large amount of gain reduction.

The difference between expansion and gating is that expanders reduce below-threshold signals, rather than simply shutting them off. This is a function of the different ratios—expansion begins at a 1.2:1 ratio, while gating in usually fixed at around 30:1. Again, expansion is like fading down the signal, while gating shuts it off.

*Ducking* uses an expander or gate to lower the level of a signal (often a music bed) whenever an external signal (such as a voiceover) exceeds the threshold. You could also use subtle ducking to



lower the band when the guitar solo comes in, or to lower the acoustic guitar accompaniment when the singer starts singing. This is where the side chain, or key input, is used. You'd feed the accompanying tracks into the regular audio inputs and outputs, and the lead into the key input. The dynamics processor now listens for its cues from the sidechain signal, not the signal to be processed.

> If the desired effect is a fat drum sound, try a limiter setting

**What to use**

The important question to ask yourself while recording or mixing is, What does this track need? For example, if the vocal tends to fall below the instrumental mix (which is pretty stable in level), then use compression to boost the low level vocal dynamics. However, if the vocal peaks (like screams or expressive "yelps" or "ows") are giving you trouble, use limiting on the track.

The overall character of the track also dictates what type of processing to use. For example, a soft string synth pad with little peak energy would not need a limiter. Although you could find a setting to get some effect, it probably would not be the sound you were trying to get. A compressor or leveler would be good for adding further control over the dynamics changes in that part.

Drums can vary from small tight drums that have mostly peak energy to large toms that have much more sustain, and therefore more average energy. If the desired effect is a fat drum sound, try a limiter setting. If a more natural drum sound that just has less dynamic change is appropriate, try a compressor setting. If noise or microphone crosstalk is giving you problem, use a noise gate.

**Setups**

Try the setups on p.22, then modify them to satisfy your own ear.

**Conclusion**

In Part 2 next month, we'll discuss de-essing, where to apply dynamics, how dynamics apply to digital audio, shopping for processors, and what to look forward to in future processors.