THE PHANTOM IMAGE

So you think the way to position elements in your mix is to reach for the Pan control? Guess again—there's more to it than that.

By Dave Moulton

Stereo sound has proven to be a fabulously successful and effective way to present recorded music to listeners. The senses of spaciousness, realism and you-are-there ambience that come with a good stereo recording (as opposed to a monaural—mono—recording, consisting of a single signal) are both powerful and exciting supports for good musical materials and performances.

The foundation of the stereo effect is the "phantom image," a life-like apparent source of sound hovering in the space between the two loudspeakers of a stereophonic system. Creatively and effectively controlling the quality and placement of that image really improves the quality of a recording. The listener doesn't know *why* the recording sounds better; he or she simply likes it more, finding the music more realistic and enjoyable. It's one of the "magical" aspects of the craft.

The phantom image is the product of some rather elaborate mental operations by the auditory mechanism and the brain. It comes in two versions: mono and stereo. The mono version is the result of an identical signal sent to both loudspeakers. It's interesting that we don't sense the two loudspeakers as the separate sources of energy that they are, but instead as only one imaginary source somewhere in between them.

The stereo phantom is quite similar to the mono one, but it's based on two signals that are not quite identical. Usually, the two signals are derived from two microphones listening to the same source from near each other in the same room. This phantom is more three-dimensional and realistic than the mono phantom, and far more stable in localization. To use it, you usually need to make a true stereo pair of tracks of the instrument you want to have appear in a stereo phantom image, although it's possible to simulate it, as we'll discuss later on.

An effective mix takes advantage of the existence of this phantom image and builds a full, clear comprehensible sound stage around it. Stereo permits us to unclutter the imaginary point in space between the speakers and to creatively control the placement and movement of each track in our mix.

Setting the Soundstage

The basic layout of that soundstage has evolved over time to have the character outlined in Figure 1. This stage is often organized for musical effect and to make the musical impact clearer and more coherent.

We have a tendency to think that the phantom image follows the pan-pot on the mixing console, so that when we turn the pan-pot a little to the left, the phantom moves off to the left as well, hovering closer to the left speaker than the right. That pan-pot, of course, is just two volume controls, one for each of the stereo channels, with one wired in reverse so that its volume goes down as the other one is turned up. The whole effect of panning is done by just varying the relative difference in amplitude between the output channels.

I used to think of mixing as the representation of the band I was recording on an imaginary stage between the speakers. I see my students today at Berklee doing the same thing when they start out. I would (and they do) very carefully set the pan-pots for all my tracks when beginning a mix: lead vocal in the middle (for instance), harmony vocals just a little left and right, the rhythm guitar well off to the left (but not really at the imaginary curtain of that imaginary stage), the lead guitar an equal amount off to the right, the keyboard player maybe a little inboard of the lead guitarist, the tambourine player just outside of the low harmony vocal, etc. It all seems pretty reasonable; my customers seemed to like it at the time, and I never really questioned the whole process.

A little later in my mixing career, I got

into more simple, garage-band music that was intentionally a little raw and crude. In place of any kind of big sound, with the lush ambience of an arena or big stage, the effect we were looking for was very dry and direct, deliberately and obviously recorded in a small room. We used some very hard panning to left and right, and little or no reverb other than some hard slap delays to emphasize that sense of a small room. I noticed that the phantom image really jumped out at me—it became far more palpable and solid.

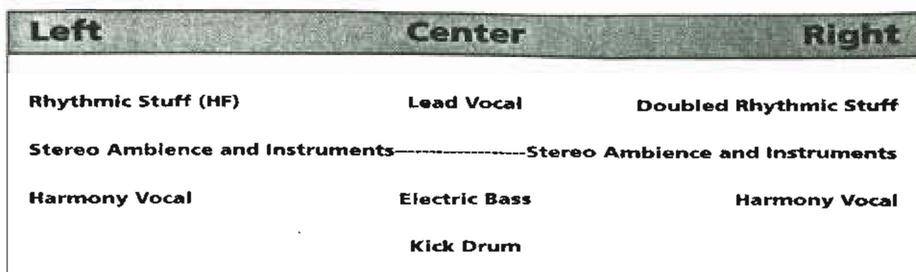

Figure 1. Basic locations of sounds on recorded sound stage, with lead vocal, bass and kick drum occupying the phantom image, rhythmic material panned hard left and right, often with harmony vocals as well. Stereo instruments (like piano, or string pads) often fill in as a sort of "stereo glue" to hold the mix together. Sometimes, the stereo overhead mics from the drum kit do the same thing.

Then, a little later still, I got into some loudspeaker research, and found myself called upon one day to make a research tape, where I recorded a batch of clicks with very carefully documented changes in level between the stereo channels. I figured I knew what was going to happen before I started. Given my golden ears, there just wasn't much doubt that I could hear the image move as soon as I tweaked the pan-pot even a little, so I decided to calibrate the changes to 1/10th of a decibel, so that I'd be able to really pick out the subtle differences in localization that were going to happen when the levels between channels changed.

However, I was very startled to discover that the phantom image didn't seem to move at all even when the levels between channels changed a whole decibel! I became positive I had made a mistake when preparing the tape! A little investigation (well, about three hours, including chasing down all the wiring in the monitoring system) showed that I hadn't. When the dust finally settled, I found out something quite interesting: as long as the difference between channels is less than 3 decibels, the phantom image hovers pretty much in the middle point between the two speakers.

I promptly ran this down to my buddies at the local loudspeaker factory, and we tried it in the anechoic chamber with blindfolds and people pointing at the imaginary phantom. The fact remained true: with up to 3 dB difference between channels (that's half-power, remember!) the image didn't move much, maybe five degrees. With between 3 and 6 decibels difference in levels, the phantom quickly and without much stability migrated to the louder speaker, hovering just inboard of that speaker; once the difference was greater than 7 decibels, the phantom was for all intents and purposes coming from the louder speaker.

Once again, I'd fooled myself, and had some new stuff to learn and think about. The principle of mixing I've evolved from this (which is not very profound, I'm sorry to say) is that there are only three pan-

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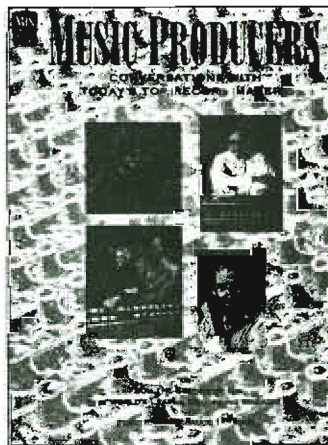

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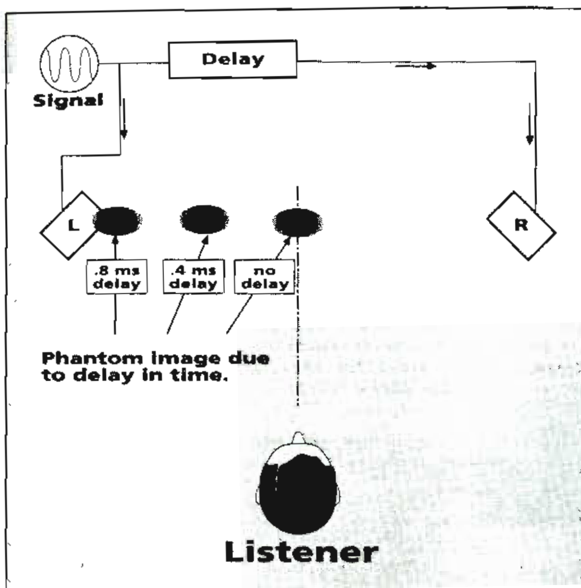

Figure 2. Approximate locations of phantom image for various delay times. With a 1mS delay, the phantom appears to emanate from the earlier speaker. Longer delays yield erratic results, with the phantom emanating from various places, depending on the acoustics of the room and the spectra of the signal, among other things. By 10mS the late signal begins to be heard as an echo, depending on the envelope of the signal.

ning positions: Left, Center and Right. Within those zones, the pan-pot yields a little sense of localization shift, but mostly it isn't stable—moving my head by an inch or so screws it it up. I can't count on that localization detail being there in playback away from the studio.

Panning the Pots

So, you can draw some important conclusions about the pan-pots on a mixing console:

1. They could almost be replaced by a 3-position toggle switch (like the ones available on any decent two-pickup guitar) labeled "Left/Center/Right." Indeed, the first stereo consoles had precisely such switches.

2. The pan-pot, only giving you three choices, isn't the greatest tool for filling up the sound stage between the speakers.

So far, we've been talking about a monaural phantom image, derived from two identical signals coming from each speaker of the stereo pair. The phantom becomes more interesting when we start thinking of it as a stereo image. It becomes stereo as a function of short time delays between the left and right speakers. These delays have a very powerful impact on the phantom's location, and we can exert some rather powerful control (much more so than with a pan-pot) over where the phantom is localized and the stability of that localization. The phantom doesn't even have to be between the speakers—a fact that has led to the development of systems like Q-Sound and the Roland RSS space simulator.

Back in about 1950, Helmut Haas published a paper about the audibility of early echoes that lead to the term "The Haas effect" (also known as "the precedence effect" and "the law of first wavefront"). Basically, we localize a sound based on the angle of arrival of the direct sound, and we ignore the angle of arrival information of all delayed versions of that sound (i.e. room reflections). This means that we don't hear room reflections as such, as long as they arrive quickly enough after the direct sound. The window of time for this is from about 1mS to somewhere between 10 and 50mS, depending on the kind of sound. In nature, you never have the exact same sound coming at you from two directions at exactly the same time; one of the versions is always a reflection. The invention of the loudspeaker changed this.

What this means for stereo is that a

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Delay Time Between Speakers in milliseconds / Localization Effect	
.1 to 1 ms.	Causes phantom image to migrate toward earlier speaker.
1 to 10 ms.	Causes phantom image to appear erratically around the sound stage, often ambiguous.
10ms.	Short sounds begin to be heard as two distinct sounds, original and echo. Long sounds still ambiguous, hard to localize.
50 ms.	Long sounds begin to be heard as two sounds, original and echo.

Figure 3. Impact of delays between left and right speakers for otherwise identical signals.

monaural signal that is undelayed to either speaker is perceived to originate at a point in space compatible with the idea that the sounds from both loudspeakers are reflections (the non-existent direct sound is inferred from these reflections, which is why it is a "phantom" image). A monaural signal that is delayed by less than a millisecond to one of the two loudspeakers implies reflection paths from a different location in the room. It will, as a result, cause the phantom image to shift toward the earlier speaker. The amount of shift in localization is related to the amount of time delay. I've noticed (fooling around with a Yamaha SPX 900, for instance) that the phantom shifts quite reliably in linear increments from the center to the earlier speaker as I step through .1mS delays from .1mS to 1mS. This is consistent with what Haas (and many others) found.

These stereo phantom images are quite realistic and powerful. When coupled with some extra early delays (less than 50mS) sent to left and right speakers, they give a sense of liveness to the recording that is quite remarkable.

So What?

So what does this all mean? How can you use it for fun and profit? There are a number of ways.

First, you should consider your panning layout. As I mentioned, I often see our beginning mixing students meticulously setting their pan pots, making sure that all the performers in the mix are ever so carefully placed on the imaginary soundstage. Of course, then they move their heads a little and it all changes, so if they take the time to notice this fact they have to: a) redo it all, or b) learn to never move their head while they are mixing or listening to music (this latter tendency also often degrades the listening experience in some particularly special interpersonal situations, and I don't recommend it as a general practice).

Conclusions

Don't take the pan-pot settings too seriously. It used to be that we had to worry a lot about disc mastering, so we tried to get as much monaural signal into the recording as possible. Those days are pretty much gone, so I can recommend that you seriously consider doing all of your amplitude panning pretty much hard Left, hard Right and Center, usually reserving the center for lead vocal, kick drum and electric bass, and hardly anything else except maybe an instrumental lead. By de-emphasizing the idea that you are trying to mimic a stage, you can develop recordings that are clearer, punchier and more life-like.

If you have delay lines that you can devote to this aspect of mixing, you can get some truly realistic panning into the zones between Left, Center and Right. You can also hype up the Center phantom as well with delays, but that will be the subject of another article.

Keep in mind that the material in that phantom image is probably the most musically important material in your mix: the lead vocal, and the primary rhythm elements (kick and bass). Get them out in front, with intensity, clarity and impact. Leave some room around them in the mix, and let them both breathe and speak to your listeners. Hopefully, those listeners will line up to hear your message!

So when you mix, continue to map out a full broad sound image between the speakers, but don't try to do it all with the pan-pots. It is the delays that enable you to use those intermediate places between hard Left, Center and hard Right. Isolate each element of the mix and give it is own space, so the listener can find it, hear it, and more easily savor the power of your music.

We'll talk about further enhancements to the stereo image that you can do with EQ and other delay techniques in upcoming articles. In the meantime, happy phantoms!

Dave Moulton is Chairman of the Music Production and Engineering Department at Berklee College of Music. Refer to the December 1991 issue for an interview with him. He was assisted by Berklee students Peter Alhadeff and Alex Hodge for this article.

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