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The Single-Ended Triode Paradox

"One of the worst-kept secrets in audio engineering is that what we hear does not always correlate with what we measure."
—Richard Heyser

"Whenever connoisseurship is found operating within science or technology we may assume that it persists only because it has not been possible to replace it by a measurable grading." —Michael Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy*

There's no greater paradox in audio than that of the single-ended triode (SET) amplifier. Ask an engineer to describe an amplifier's ideal technical characteristics and he'll describe everything an SET is *not*: low distortion and noise, high output power, high damping factor, low output impedance, ability to deliver current to low-impedance loads, generous dynamic headroom, wide bandwidth—the list could go on. So how can some of these amplifiers that are the antithesis of good textbook engineering sound so magical?

The SET's very existence calls into question fundamental beliefs and assumptions we routinely make about technical performance, sound quality, and the correlation between them. These amplifiers expose a crack in the edifice of audio engineering theory that is based on the conviction an amplifier can be judged by its technical specifications or measured performance. To the "meter readers," who reject the listening experience and instead believe that nothing more can be known about an audio component beyond its technical performance, a modern amplifier with 18W of output power at 3% distortion is a joke. But put that 18W SET in a system with an appropriate-load loudspeaker and the sound will melt the heart of even the most hardened objectivist.

This paradox arises because the technical measurements that attempt to quantify amplifier performance are simply inadequate and incomplete. Each element of an amplifier's performance description (bandwidth, THD, for examples) is a static two-dimensional sliver of information that, when combined with all the other limited two-dimensional slivers (noise, damping factor, TIM, etc.), attempts to completely characterize what is in fact a highly complex, multi-faceted, three-dimensional dynamic system. In addition, that complex system interacts with a vastly more complex system—the human brain. Predicting an amplifier's sound quality, or judging it to be good or bad, based on existing criteria is like looking at a few still images from a movie and then attempting to discern from those static photos the movie's plot, characterizations, dramatic arc, and meaning.

The SET exposes the fact that certain aspects of amplifier performance are not quantified by the traditional measurement arsenal. In what data-set do we find an amplifier's directness of expression—that feeling of the musicians being present in the room making music contemporaneously? What spec tells us if the amplifier reproduces timbre with such realism that we get goosebumps? What graph plots musicality along one of its axes? The vexing problem is not so much that traditional measurements fail to describe these qualities. Rather, the real quandary is that an SET, an amplifier that exhibits such grossly flawed performance according to established criterion for "goodness," can sound so wonderful. How can an amplifier that is so "wrong" sound so right?

Some will suggest that listeners are merely responding to the SET euphonic distortion—that the SET sounds good *because* of its distortion rather than *in spite* of it. There's no question that the largely second-harmonic distortion component of an SET is much more sonically benign than the upper-order distortion components of Class AB solid-state amplifiers. But a first-rate SET amplifier's magical qualities go far beyond this simplistic interpretation. The SET's resolution of inner detail that, singularly, conjures up a strikingly vivid picture of the instrument creating the sound is certainly not merely a euphonic second-harmonic distortion artifact.

This essay is neither a renunciation of all amplifiers other than SETs nor an evangelical campaign for the world to embrace the single-ended triode amplifier. They are limited in the loudspeakers they can drive, exhibit other practical drawbacks, and are certainly not for every listener. Moreover, only a very few of them are uncolored enough to be used as a reference. But when I listen to music through a pair of Lamm ML2.2s, I can't help but question whether nearly a century of conventional wisdom about what makes an amplifier "good" has led us down the wrong path.

Robert Harley

AMPLIFIER DESIGNER ROUNDTABLE

How have amplifiers improved over the last decade? What is the state of audio amplification today? Have tube sound and transistor sound become more alike? What innovations will the future bring?

To gain some insight into these and other issues, I posed the same set of questions to nine of the world's top amplifier designers. Each of these internationally recognized engineers has produced world-class preamplifiers and power amplifiers, and each takes a different approach to the challenge of creating cutting-edge audio electronics—in some cases, radically so.

—Robert Harley

BOB CARVER / Bob Carver LLC

JOHN CURL / Parasound, Constellation

CYRILL HAMMER / Soulution

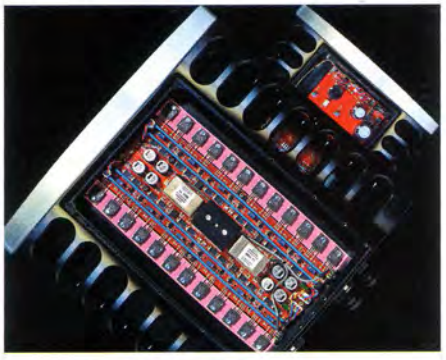
LEW JOHNSON / conrad-johnson design

VLADIMIR LAMM / Lamm Industries

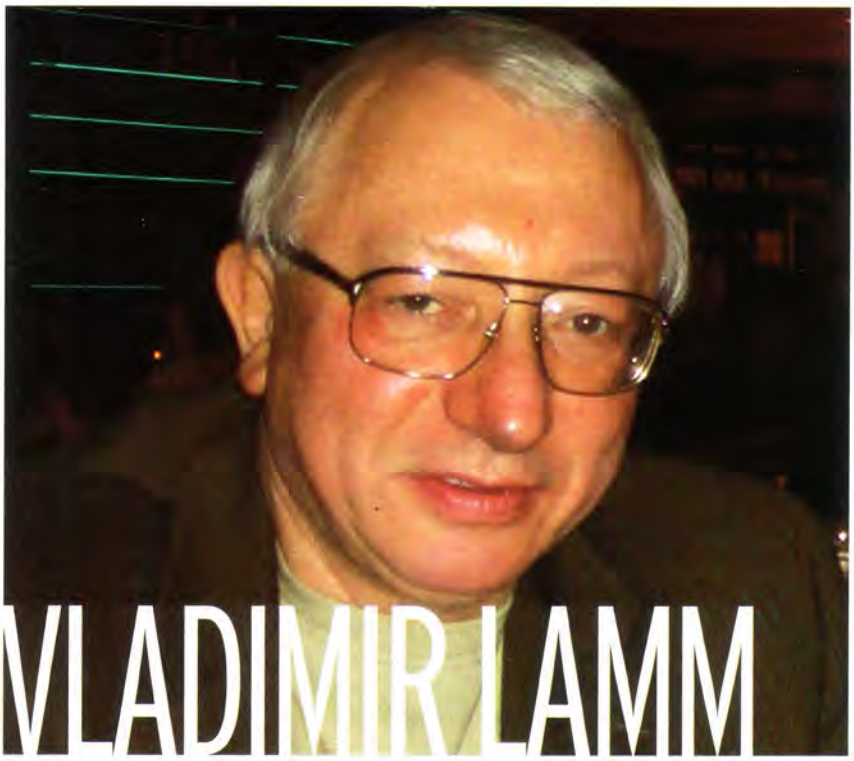
FUMIO OHASHI / BAlabo

NELSON PASS / Pass Labs

JÜRGEN REIS / MBL



JEFF ROWLAND / Jeff Rowland Design



VLADIMIR LAMM

The advantage of single-ended topology using triodes lies in the real possibility of achieving the level of sound reproduction that closely approximates the actual sound of live instruments in space.

Vladimir Lamm was born in the former Soviet Union and holds an M.S. in Electronics and Solid-State Physics. He was a professional table-tennis player; for many years played in a symphony orchestra; was involved in the Russian Space Program; studied psychoacoustics in depth; developed a theory called Absolute Linearity of the System, on which his audio designs are based with predefined and predictable parameters (eliminating the need for a trial-and-error approach to design). Founded Lamm Industries, Inc. in 1993.

How much have preamplifiers and power amplifiers improved over the past decade, and why?

I believe that I have dealt with this question to some extent in my answers to questions 2 and 5. I would just like to note that in light of a very rapid growth marked by the proliferation of increasingly affordable digital technologies, audio equipment has been enriched with various features, the implementation of which would've been quite problematic as recently as 15–20 years ago due to price and overall dimensions.

Have the sounds of tubed and solid-state electronics converged toward a common neutrality in the past 20 years? If so, what accounts for this trend?

Partially. The improvements that have been made on this path are in generally related to a couple of aspects: (1) a growing understanding of the necessity to re-examine the role of feedback in the audio path, with such awareness itself already providing an opportunity to scratch at least the tip of the iceberg; and (2) a gradual realization by the engineering community that the interaction between a man and a sound-reproducing system takes place on many levels—those that have already been studied and supposedly understood, as well as those that are largely unknown and mostly hidden from us for the time being.

You choose to work primarily in tubes, but you have produced single-ended tube and solid-state Class AB designs. What are the advantages you see to each of these technologies?

I am working with tube, solid-state, and hybrid technologies utilizing single-ended (Class A) and push-pull (Class A and Class AB) topologies. However, my personal preference is for the single-ended topology that employs vacuum triodes in the output stage. The advantage lies in the real possibility of achieving the level of sound reproduction that closely approximates the actual sound of live instruments in space.

Is Class D competitive with linear designs in sound quality, and if not, will it ever be?

No, it is not. And I would like to respond to the second part of this question with an allegory. Any field of human activity defines a number of requirements which, when properly implemented, guarantee a positive outcome. For example, the basic requirement in the army and sports is an able-bodied individual. So, it would be quite natural to concentrate on searching for such an individual (especially as we know where to find him). However, out of the blue we decide to choose a feeble-

bodied person who, on top of that, is encumbered by various diseases. Having made this decision (which is *a priori* improper) we start justifying it to ourselves and others by citing the great state of our medicine, which is capable of curing many ailments.

Of course, this allegory illustrates the utilization of Class D topology in high-end audio only. There are many technical applications in which implementation of high-efficiency power amplifiers is not just very desirable but sometimes *the* only reasonable solution.

Has amplifier design reached its zenith where further improvements are marginal, or will the next decade produce even better-sounding preamplifiers and power amplifiers?

For the sake of brevity, I will once again use an allegory. We know the names of great masters—Amati, Guarneri, Stainer, Stradivari, etc.—who became universally known and respected for their unparalleled creations of bowed string instruments. These instruments have passed the test of time, which is generally a determining factor in evaluating the real worth of any object and/or idea. In this day and age, while possessing very impressive scientific and mathematical knowledge, along with access to powerful technologies, we nonetheless can only approach the previously accomplished mastery level when producing the same type of instruments.

Please note that whether we are talking about musical instruments or electronic audio equipment, we are dealing with devices that interact with the human structure itself—in all its complexity. I think that if future research in the field of high-end audio will take this—and all related factors—into consideration, and begins work in this vein, we can expect very interesting and serious results.