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EXPLORING THE ART AND TECHNOLOGY

The Cutting Edge



The Ultimate system in Bob Nachtigall's home.

MAGICO Ultimate Loudspeaker: The Bugatti Veyron of Hi-Fi

ROBERT HARLEY

A look into a radically different approach to loudspeaker design along with some speculations about why reproduced music doesn't sound like the real thing.

For those of you who don't follow the automotive press, Bugatti's new Veyron 16.4 is an insanely over-the-top supercar with unprecedented performance—and an unprecedented price. The Veyron sports 1000 horsepower, a top speed in excess of 250 mph, and aerodynamic body panels that deploy at high speeds. The price? \$1.2 million.

If there's a parallel to the Veyron in the audio world, surely it is the "Ultimate" loudspeaker system from MAGICO. Like the Veyron, the Ultimate is hand-built in limited numbers, planned without compromise to be the best in the world, extravagant in design and execution, and, at a hair under a quarter of a million dollars, wildly expensive.

MAGICO is a small manufacturer of very-high-end loudspeakers with just three models in its line. The Oakland, California-based company makes the \$22,000-per-pair Mini, a two-way mini-monitor with integral stands. Revered by Japanese audiophiles and the Japanese press (it just won *Stereo Sound's* 2005 Grand Prix Award, as well as the COMPO Grand Prix Award from *Radio Engineering*), the jewel-like Mini makes a statement in itself (a twenty-two-grand mini-monitor?). MAGICO also makes to order the Reference, a \$120,000 system recently chosen by the great mastering engineer Paul Stubblebine for his mastering room. The Reference was the only other model in the MAGICO line until an interesting collaboration developed between MAGICO founder and chief designer Alon Wolf and a small cadre of West-Coast audiophiles including Bob Nachtigall.

A little history sets the stage for what will follow. About ten years ago, Nachtigall walked into a small high-end store in San Francisco and casually explained that he hadn't bought a new "stereo" since his college years and was interested in what "a really good hi-fi sounded like these days." This is Nachtigall's recollection of that moment: "I was encouraged to sit facing a pair of utterly plain, ladies-shoebox-sized, rectangular wooden boxes ridiculously perched as if on impossibly

tiny ballerina tiptoes atop a pair of Stonehenge-class, rough-cast, gun-metal-gray pedestals. Just as I was beginning to wonder if the proprietor had not taken appropriate notice of my Italian-made suit or understood the meaning of my request to hear his 'really good' equipment, he walked over to a stack of brushed aluminum boxes, pushed a couple of buttons, and walked out of the room. Somewhat bemused and certainly not quite comfortable, I followed him with my eyes as he left the room, then turned back to face the diminutive speakers just at the exact instant when the sound of guitars, drums, and bass so immediately, completely, and explosively filled the room that I can only imagine that the sensation would not be unlike witnessing the Big Bang from an infinitely distant vantage point. The astonishingly detailed intensity of the music coincident with the sublime and magical illusion of hearing and 'seeing' a woman's voice suspended in space left me so stunned that I have no recollection of breathing during the entire experience. I remember some time later falteringly staggering out of the room in a disoriented stupor." [*The loudspeakers were Totem Acoustic Model 1s.* —RH]

The number and size of the horns in the Ultimate is set by the laws of physics, not by standard loudspeaker-manufacturing practices.

Needless to say, Nachtigall was hooked on high-end audio. By 2001 he had spent years on the familiar upgrade treadmill but was never quite satisfied with any of the loudspeakers he had owned or auditioned. Purely by chance, Nachtigall was introduced to MAGICO designer Alon Wolf at the time when Wolf was finalizing the design of his all-aluminum, four-way, dynamic-driver Reference. But just when Nachtigall was about to commit to the Reference, Wolf began experimenting with very large horns and compression drivers to satisfy himself that he hadn't overlooked any technology. Immediately, Wolf realized that he was on to something. He demonstrated these radical experimental speakers for Nachtigall, who immediately shared Wolf's enthusiasm for the potential of a massive, horn-loaded system. Nachtigall and a small group of fellow West-Coast audiophiles commissioned Wolf to design and build not just the best loudspeaker in the world, but the best possible loudspeaker that could be created.

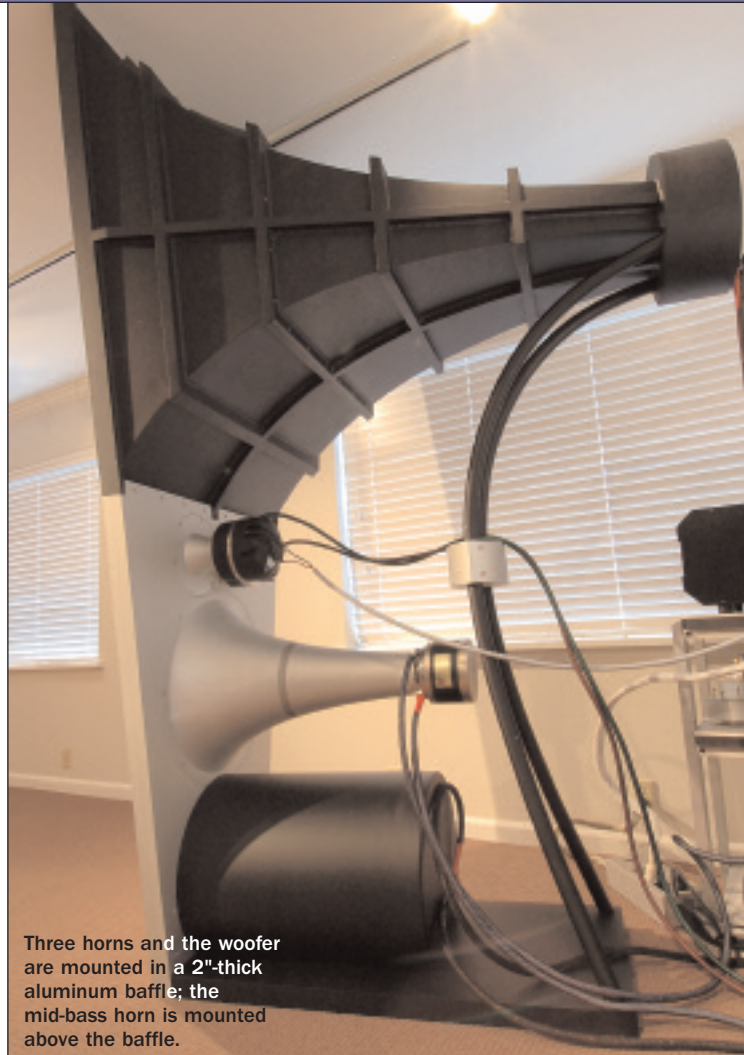
Thus began a four-year project that resulted in the Ultimate. Standing a few inches short of eight-feet tall and weighing more than 800 pounds apiece, the Ultimate is an all-aluminum, five-way horn-loaded system. In the active configuration, each of the Ultimate's four horn drivers must be powered by its own amplifier, with an external active crossover

dividing the frequency spectrum. An additional amplifier channel is required (per side) to drive the direct-radiating woofer. The two midrange horns (8" and 20", respectively) are machined from solid blocks of aircraft-grade aluminum, and then anodized to give them a subtle pearlescent glow. The massive midbass horn, mounted at the top of the system, is made from .25"-aluminum reinforced by 56 machined-aluminum ribs that are hand-welded to the frame. It takes more than two months to construct just one of these devices. The machined parts are so big and intricate that only two machine shops in the country can fabricate them. The woofer and three of the horns (tweeter, upper-midrange, midrange) are mounted in a 2"-thick slab of aluminum that acts as the baffle. The precision with which the horns fit into this panel is remarkable. At the throat of each horn is an ultra-expensive, high-sensitivity compression driver (as high as 115dB 1W/1m). A support structure behind the baffle holds the horns and compression drivers in place. The woofer is a conventional direct-radiating design (a horn-loaded woofer would have been too big) based on a custom Aura 15" driver with a neodymium magnet and 4" edge-wound voice coil, and a peak-to-peak excursion of 2.5".

Why are the horns so big, and why are there so many of them? The horn structure acts as an acoustical impedance-matching device to most efficiently couple the compression driver's tiny diaphragm to the air. This impedance-matching function works only over a narrow range of frequencies, determined by the size of the horn's mouth. In most horn designs, the horn operates over a wider frequency range than is theoretically ideal. This is done to keep the horn size, and number of drivers, reasonable. When the horn is asked to reproduce frequencies above or below the limits imposed by the horn's size, sensitivity drops, non-linearities are introduced, and distortion increases. Below the horn's low-frequency cutoff point (determined by the mouth size), the horn is too small to provide adequate loading and the driver begins to function as a direct radiator, losing the benefits of the horn. But when a large number of horns are used, each can be operated within the linear region of its passband. The massive midbass horn (the uppermost driver in the photos) allows the system to remain horn-loaded down to 120Hz. Frequencies below 120Hz are reproduced by the conventional direct-radiating woofer.

The advantage of a horn is that the diaphragm in the throat is very small, has extremely low mass, and makes only a tiny excursion to produce a high sound-pressure level. Consequently, very little amplifier power is required, and almost no heat is generated in the voice coil. Indeed, the Ultimate's sensitivity is rated at a whopping 110dB 1W/1m for the horns, and 88dB for the woofer.

How much of reproduced music's lack of realism lies at the feet of the microphone and how much at the loudspeaker?



Three horns and the woofer are mounted in a 2"-thick aluminum baffle; the mid-bass horn is mounted above the baffle.

The compression drivers mounted in each horn's throat are unlike conventional dynamic drivers. They feature massive and powerful magnet structures, are built to very tight tolerances, weigh more than 50 pounds each, and cost as much as \$10,000 apiece. The super-light diaphragms have miniscule excursion, always operate in the linear range of the voice-coil travel, and consequently, have almost unmeasurable distortion. These compression drivers would not work without the efficiency-increasing effect of the horn structure to which they are attached. The horn also allows the designer to control the loudspeaker's directivity, decreasing the amount of sidewall- and ceiling/floor-reflected energy.

The Ultimate's fundamental design goal is to capitalize on the horn's inherent strengths while avoiding its traditional limitations. The number and size of the horns in the Ultimate is set by the laws of physics, not by standard loudspeaker-manufacturing practices.

Machining the midrange, upper midrange, and treble

horns from solid blocks of aluminum, and constructing the lower-midrange horn with the elaborate welded framework, overcomes another problem inherent in conventional horns: resonance. Even tiny resonances in the horn are effectively amplified because the horn's acoustic impedance-matching function works just as well for tiny excursions of the horn itself (caused by resonances) as for audio signals generated by the diaphragm. It could be argued that horn resonances are a far greater source of coloration in horn loudspeakers than are cabinet resonances in conventional dynamic box speakers. Controlling resonances is particularly challenging in horns the size of those used in the Ultimate. The large mouth size requires a commensurate depth (the trapezoidal 32" by 46" by 48" mid-bass horn is 60" deep). The larger the panel, the more resonance-prone it is, which is why so much effort and cost has been expended on horn structures machined from aircraft aluminum.

Three crossover options are offered for the Ultimate. The first is a traditional passive crossover that allows the system to be driven by just one amplifier for the upper four drivers,

with a second amplifier driving the direct-radiating woofer. The second option is an active analog crossover that requires ten amplifier channels (for stereo). Eight of these amplifier channels can be low-power, owing to the system's extremely high sensitivity. The amplifier driving the direct-radiating woofer must be of relatively high power. Finally, the Ultimate can be fitted with a digital crossover sourced from DEQX, the Australian company best known for providing the DSP-corrected crossover for the NHT Xd loudspeaker. I can't imagine anyone choosing passive crossovers for the Ultimate. Directly connecting the power amplifier to the drivers' voice coils, with no intervening capacitors and inductors, confers a huge advantage in sound quality.

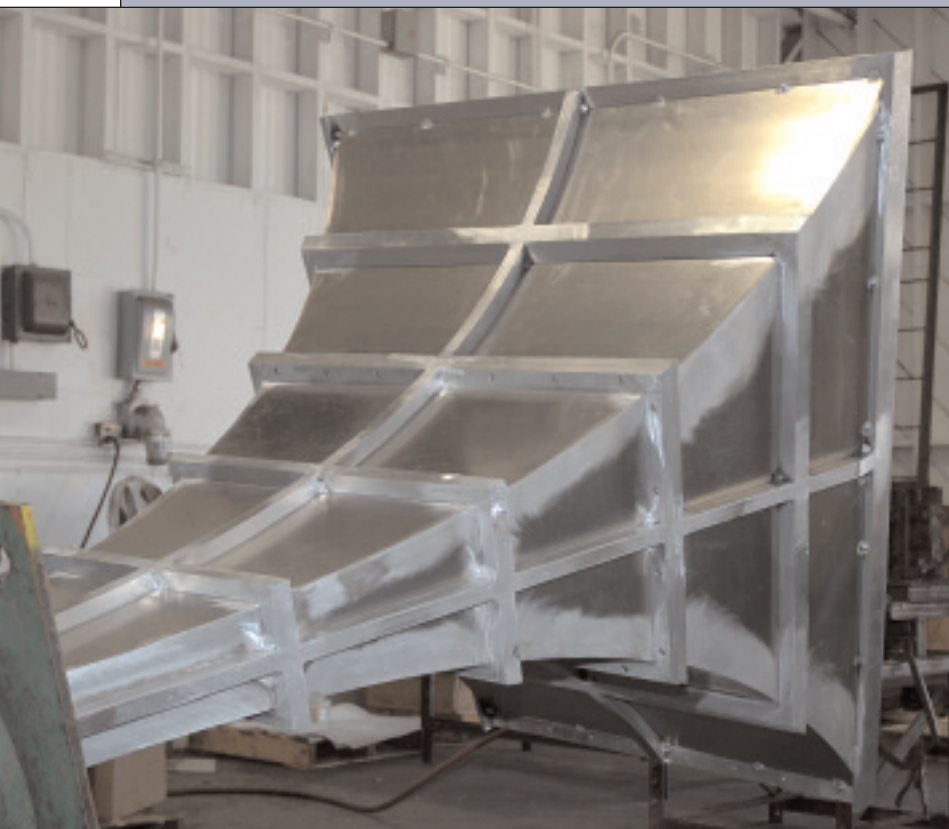
In addition to the system in Bob Nachtigall's home, two other Ultimate systems have been installed so far. MAGICO builds the Ultimate to order, with a four-month lead time and a price of \$229,000, which includes delivery and setup by Wolf.

After Wolf has finished setting up the Ultimate, you can take him out to dinner—in your Bugatti Veyron, of course. 🍷

Robert Harley Listens to the MAGICO Ultimate

I heard Bob Nachtigall's Ultimate-based system on two occasions during visits to San Francisco. The first listen took place just a week after they were installed. The second was two months later after the system was "95%" tweaked in.

In Nachtigall's system, the mid-bass, lower midrange, upper midrange, and tweeter amplifiers are all single-ended-triode monoblocks based on the Western Electric 300 B tube, custom-designed and built by 3 Dimension Audio's Alex Dondysh. The lower midrange, upper midrange, and tweeter amplifiers deliver 9W each, while the midbass amplifier is a 22W push-pull design based on a pair of 300 B power tubes. Each monoblock is split into two chassis—amplifier and power supply. The power supplies employ tube rectification, no electrolytic capacitors, and point-to-point wiring. Each amplifier was custom-tweaked for the driver to which it would be mated, including different output transformers. The com-



The giant mid-bass horn is made from 1/4" aluminum reinforced with 56 hand-welded ribs.

pression drivers' 16-ohm impedance makes an ideal load for a single-ended triode amplifier. The woofer amplifiers are McIntosh MC501 monoblocks, chosen in part for their high power, low distortion, and cool running, but mainly because their relatively-low-damping-factor, transformer-coupled output blends well with an otherwise all-tube system. That's 18 amplifier chassis if you're counting. You can see these rows of amplifiers (except the midbass and woofer amplifiers) in the photograph on page 82.

The active crossover is a Marchand XM44 solid-state unit extensively modified by Mark Eckert with Black Gate and REL caps, Caddock resistors, Bybee filters, and modified Welborne Labs outboard power supplies. Crossover slopes are a very steep 24dB/octave and 48dB/octave. The system's preamps are an Audio Research Reference 3 linestage and Audio Research Reference Phono.

LP playback is via a Basis Debut vacuum 'table and Graham 2.2 tonearm, fitted with a Clearaudio Insider Reference cartridge. The LP front end is mounted on a Vibraplane isolation system. CDs are played on an MBL 1621 transport feeding a Pacific Microsonics Model 2 DAC. The Model 2 is actually a professional HDCD encoder/decoder designed for mastering rooms. It features Keith Johnson's extraordinary DAC and analog output stage. A Sony SCD-777ES player, fitted with the Modwright "Absolute Truth" tubed output stage, spins SACDs. Audio interconnects are Sahuaro Jetstream; loudspeaker cables are Stealth Audio Hybrid MLT; and power cords are FIM Gold. The equipment sits on Billy Bags racks fitted with Dyna-mat treated shelves, with each component (except for the turntable) resting on Brightstar Audio "sandboxes."

The listening room is as elaborate as the rest of the system. The room, a separate area of Nachtigall's home, was gutted to the shell and rebuilt by Alan Goodwin of Goodwin's High-End. With the exception of the Brazilian cherry hardwood floor, every square inch of the room and ceiling is covered with custom acoustic modules and soffits. The Medex modules were CNC-machined from AutoCAD drawings, put together on the East Coast to ensure a precise fit, and then disassembled for shipment to San Francisco. The width, depth, height, and angle of each of the 40 modules that make up the walls and ceiling are derived from acoustical mathematical relationships based on the room's dimensions. The room can be acoustically tuned on-site not only for personal preference, but also for a specific loudspeaker's radiation pattern. The symmetrical placement of these precisely angled and dimensioned hard-surfaced modules

results in a room with no parallel surfaces—one that can control room reflections and modal ringing, and curtail evenly spaced reflection-clusters without resorting to overly damped and absorptive surfaces. The result is a room that gives the impression of a space larger than its 19' x 15' x 11' dimensions would suggest. Low-frequency control is provided by adjustable bass traps built into the corner and ceiling soffits along the bottom of the side-walls.

Finally, the AC power is built around a Toshiba industrial-strength uninterruptible power supply that converts incoming 220V AC to DC, and then regenerates perfectly clean 60Hz, 120V balanced power. The system can run for several hours off the system's 400 pounds of storage batteries. A custom grounding scheme provides an ultra-low impedance path to ground via a continuous run of 10-gauge high-purity copper encased in a mu-metal conduit and terminated in a silver-plated copper bus bar. A massive braid of silver-plated copper was exothermically welded to the bus bar, which is connected to two 10-foot by 2-inch-diameter copper rods sunk into the ground, each surrounded by 100 pounds of electrolytic slurry. The AC power system is built into a walk-in-closet-sized room lined with RF shielding.

It didn't take long in the listening seat to know I was hearing a musical presentation that was in some ways unlike any I had heard before. This system did many things well, but in two qualities, it was revelatory. These two qualities, which were related and reinforced each other, also carried with them many tertiary effects that contributed to the stunning overall presentation.

The most striking aspect of the Ultimate's sound was a palpability and immediacy that went far beyond anything I've previously heard in reproduced music. The illusion of the instrument actually in the listening room was so tangible it was spooky. This wasn't an incremental advance in realism; it was a giant leap. Although apparent on every instrument and every disc, it was particularly stunning on voice. The sense of realism was so palpable that hearing vocals through the system produced an almost eerie feeling that another human presence had suddenly appeared in the room. Surprisingly, every piece of music I played created the impression of hearing real instruments rather than a facsimile of them.

The second quality of the Ultimate that is unprecedented in my experience, and one that no doubt contributed greatly to the stunning sense of realism, was its

reproduction of exceedingly fine detail. This system resolved the finest inner detail of an instrument's harmonic structure, as well as microdynamic nuances. The Ultimate laid bare a wealth of detail that indicated the mechanism by which the instrument produced sound. This ultra-high-resolution presentation was anything but analytical, cold, or clinical. This was resolution beyond any system I've previously heard. Unlike other "high-resolution" presentations that tend to thrust the detail in your face and call attention to itself, the Ultimate's resolving power was much more subtle and profound. The Ultimate's uniqueness is in its ability to reach way down and present the finest, lowest-level aspects of instrumental timbre and microdynamics. For example, brushes on snare drum sounded like individual bristles moving over and striking the rim and drum head rather than a generic, undifferentiated sound.

I should state right now that there was absolutely no hint from the system's sound that the Ultimate was a horn-based loudspeaker. This wasn't a case of forgiving some tonal colorations and enjoying all the other attributes of horns. Rather, the Ultimate had zero horn coloration. Had I heard the system without knowing the technology on which it is based, I would not have guessed it employed horns.

Hearing this system bolstered, in my mind, a long-held speculation about why reproduced music doesn't sound like the real thing. It has seemed to me that the process of converting atmospheric compressions and rarefactions (sound waves) into mechanical motion of the microphone diaphragm, and then into an electrical signal, strips from the original sound the lowest-level components of that sound. These low-level components are fine harmonic nuances, tiny micro-transients, and other microscopic elements of the sound that convey to the listener just how the sound was produced. It could be, for example, the sound of a woodwind's reed making a minute "clicking" noise as it moves back and forth. We don't hear this clicking as a separate component of the sound when hearing the live instrument, or identify its absence in the reproduction, but when it *has* been wiped smooth, we hear the result as an intangible loss of palpability, immediacy, presence, and realism. It's these lowest-level sounds that are most fragile, and the first to be erased in the recording and reproduction process. Complete "erasure" of the low-level components isn't required to produce this effect; a reduction in the steepness of micro-transients' leading edges, for example, is likely to rob the instrument of the characteristics that enable us to instantly distinguish between the live sound and its reproduction.

The microphone diaphragm is the first place this "erasure" occurs, and every circuit the signal must traverse scrubs off just a little more micro-detail, although to a lesser extent. (PCM encoding at 44.1kHz and 16-bit quantization is undoubtedly a larger contributor to this effect than the microphone.) The second place in the recording/reproduction chain where low-level information is obscured is obviously the loudspeaker. Converting an electrical signal to magnetic energy and then using that magnetic energy to push and pull a diaphragm back and forth is a process ripe for acoustic losses.

But how much of reproduced music's lack of realism lies at the feet of the microphone and how much at the loudspeaker? Hearing the Ultimate system suggested to me that conventional loudspeakers contribute more of this erasure (perhaps "blunting" is a more accurate term) of low-level detail than microphone diaphragms. Why? Because over the hundred or so recordings I heard through the Ultimate, there was one constant: the impression of vivid tonal and dynamic realism. We even listened to the Beatles' "Come Together," and it was like hearing a completely different recording of this familiar song. It was as though the session had been secretly recorded by high-resolution gear and delivered by a time machine, and we were now hearing it for the first time. I've used the expression "laid bare" already, but I can't think of a more expressive way of conveying what this system did to "Come Together." Hearing it instantly conjured up a visual image of John, Paul, George, and Ringo in the studio performing. It was human, direct, and real in a way I've never heard in reproduced music.

Clearly, loudspeakers are a major source of detail erasure. It's easy to imagine how large and complex power amplifiers, which must convert a low-level incoming signal to huge voltage swings backed by hefty current delivery, scrub off a bit of the signal's finest information. It's even easier to imagine how the conversion of electron flow in the voice coil into magnetism, the conversion of that magnetism to the large motion of a relatively massive diaphragm, and the motion of the diaphragm itself cause the smallest and most fragile components of the signal to disappear or become attenuated, while the more robust signal components pass through relatively unscathed. But it is precisely these micro-aspects of the signal that contain that last bit of information we need to identify the sound as being live rather than a reproduction.

A musical signal reproduced through a horn-loaded system undergoes an identical process, but on a much smaller scale. The compression drivers'

extremely powerful magnets require only a tiny fraction of the current of direct-radiating drivers to produce their miniscule diaphragm excursions. It seems intuitive that this roughly ten-fold reduction in electrical and dynamic forces allows the process to be performed with higher precision.

Getting back to the Ultimate, the system wasn't a one-trick pony optimized for midrange realism to the exclusion of all else. The sense of resolution, of hearing every iota of information in the music, extended well into the midbass. Acoustic bass was reproduced with a terrific combination of warmth, pitch definition, and extremely articulate reproduction of dynamics. The low bass was very good in terms of extension, dynamics, and definition, but not extraordinary in the way that the rest of the spectrum was reproduced. In spatial presentation, the Ultimate created a closer, more intimate presentation that

avored smaller-scale music. Delineation of individual instruments, and the impression of space between those instruments, was extraordinary. The system was clearly optimized for precise image focus rather than a large and billowy presentation. The Ultimate setup at Wolf's home (with the DEQX crossover) had a more convincing sense of size, space, and depth on large-scale orchestral music.

The MAGICO Ultimate loudspeaker is, in my view, an advancement in the state-of-the-art in music reproduction. Its achievement also suggests something deeper about the mechanisms by which the sounds of instruments are corrupted by the recording and playback process. Perhaps the low-power-amplifier/high-sensitivity horn-loaded loudspeaker approach, realized at the highest level in Bob Nachtigall's system, is the true path toward creating the illusion of live music in our homes.