MACHINE DESIGN

AUGUST 23, 2007
www.machinedesign.com
A PENTON PUBLICATION

GOOD VIBRATIONS

Rotary woofer wows audiophiles, page 52

Periodicals
USPS 100 Approved Poly

Tune in to *engineeringtv.com*

GOOD VIBRATIONS

Innovations in turntables and loudspeakers didn't end with the breakup of The Beatles. Even today, some audiophiles will shell out 3,000 clams for a tonearm that gently caresses grooves laid down by the likes of Billie, Frank, Miles, and the Fab Four.

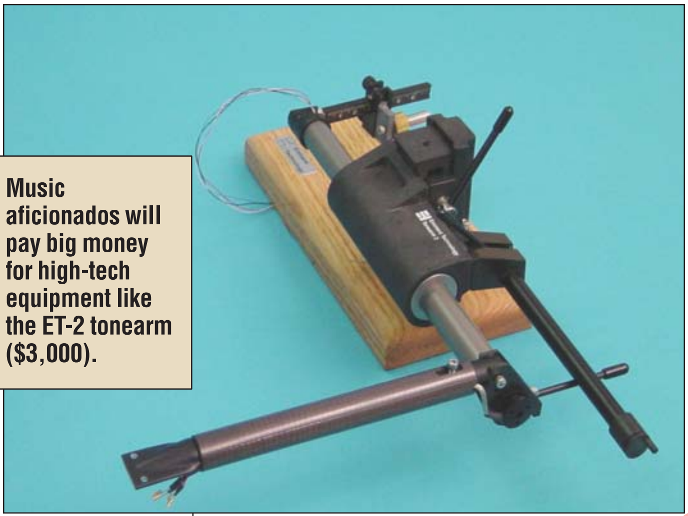
Bruce Thigpen
President
Eminent Technology Inc.
Tallahassee, Fla.

My lifelong fascination with audio and sound reproduction resulted in the start-up of **Eminent Technology** in 1982. Unfortunately, 1982 was also the year the compact-disc player came along. And so it appeared that our first product, a high-end, air-bearing phonograph tonearm, wasn't going to keep the lights on indefinitely. Still, the demand for high-tech, high-end record players never disappeared entirely.

An air bearing is more than a series of holes that direct air to the surface of the bearing. An efficient air-bearing tonearm must use a minimum of air. The smaller the air pump, the better. A pressure cavity in a manifold provides the air pressure, and a series of tiny holes, or capillaries, restrict the flow of air to the bearing surface.

Engineers at Eminent Technology use a sound-pressure-level meter to measure ac-voltage input from audio amplifiers (above). The TRW-17 rotary woofer, which can produce sounds below 1 Hz, retails for $12,900 (left).

Edited by Patrick Mahoney



Music aficionados will pay big money for high-tech equipment like the ET-2 tonearm ($3,000).

Our ET-2 tonearm has a hard-coat anodized-aluminum spindle that floats inside the manifold on a thin layer of air. A small diaphragm air pump consumes about 15 W and delivers 3.5 psi with 120 in.^{3}/min of airflow, as opposed to an industrial-type air bearing which might use a couple horsepower and 80 psi. The spindle floats with a surface pressure that is less than that on the manifold side of the bearing. If the spindle is canted in the manifold bore, the higher pressure in the manifold acts as a centering or restoring force.

LOUDSPEAKERS

We also developed and patented a push/pull version of a planar ribbon loudspeaker that uses ceramic permanent magnets. Planar loudspeakers have polyester diaphragms laminated with aluminum foil about half the thickness of household aluminum foil. Eminent makes these in-house. We silk-screen a conductor pattern onto the foil with an ink resist. Then, an etchant removes the foil around the resist. After the ink is removed, a conductor pattern remains.

The polyester diaphragm is tensioned in a frame and terminations are added. When the conductors are in the presence of a magnetic field and current is supplied from an audio amplifier, the diaphragm will move with the audio signal. The disadvantages of this kind of loudspeaker are low efficiency and low-frequency capability. The advantages are low distortion and transient capability.

Dipole (bipolar) loudspeakers operate without a box. In traditional front-radiator-type (monopole) speakers, sound usually emanates from only one side, in phase. A dipole loudspeaker radiates sound from two sides (usually opposite each other). The energy radiated from the front is 180° out of phase with the energy coming from the rear. There is a loss of bass in a dipole because wavelengths are long at low frequencies. The out-of-phase components come together around the speaker and cancel out (short circuit), which results in little or no output at those frequencies.

High frequencies are more directional and don't come around and cancel out. Dipoles are usually either electrostatic or planar magnetic, but some cone-type speakers have been used as dipoles. The planar magnetic panels have restricted diaphragm displacement that limits low-frequency sound output. To overcome the problem, the diaphragm needs a larger area than that of a conventional cone loudspeaker mounted in a box.

At low frequencies, conventional cone loudspeakers have an impedance mismatch with the air. In theory, for each halving of frequency, a cone woofer must move four times as far to maintain the same output. The impedance mismatch starts where the wavelength of the sound matches the dimensions of the cone (a fairly high frequency). The upshot is that cones are very inefficient loudspeaker

This high-end tonearm bearing uses a small (15-W) air pump for quiet operation.

Rotating blades solve impedance mismatch with the air.

transducers, only converting about 1% of electrical energy into sound.

Loudspeakers can be built into horn-shaped enclosures or use horns. Most often the higher-frequency elements, such as tweeters, use horns. Acoustic diffraction lenses can spread the sound waves in a horizontal pattern, at ear-level. An audio driver (e.g., a speaker cone or dome) mounts at the small, inner end. Horn speakers are highly efficient, but they can have a sharp cutoff frequency, with little sound output below that point. Bass sounds are usually produced by conventional speaker cones, since a straight or folded horn sufficient to reproduce a low audible frequency (20 Hz) can be about 12-ft long, unless a building, ground surface, or the room itself is considered part of the horn.

ROTARY WOOFERS

The company's latest product is a new type of loudspeaker called a rotary woofer. Four years in development, the rotary woofer solves the impedance mismatch with the air by rotating a set of blades. Sound represents very small changes in air pressure. As the blades rotate at a constant speed, the pitch follows the signal from the audio amplifier, changing the pressure of the air just as a cone loudspeaker does. The blades have no pitch when there is no audio signal. The rotation of the blades grabs the air far more effectively than a cone and enables high sound levels with a far better conversion of energy. At extremely low frequencies, the rotary woofer has acoustic output equivalent to many cone woofers combined.

The rotary woofer can produce sounds below 1 Hz, generating controversy among some audio professionals who believe frequencies below 20 Hz are beyond the range of human hearing. This probably dates back to the hearing studies of Fletcher and Munson in 1933. More recent studies suggest we can hear sounds down to a few hertz. Eminent conducted tests that showed people can perceive tones as low as 4 Hz. But conventional audio systems with cone subwoofers are usually limited to 20 Hz, making the loudspeakers a high pass filter to sound.

Modern digital audio-recording systems have no low-frequency limitations. And almost 30% of modern movie sound tracks have content down to a few hertz. Conventional loudspeakers in movie theaters and homes do not reproduce these sounds. Our rotary woofer is gaining acceptance in high-end home theaters and theme parks. **MD**

Eminent Technology, Inc.
225 East Palmer Street
Tallahassee, FL 32301
Phone: (850)575-5655
FAX: (850)224-5999
E-Mail: info@eminent-tech.com