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White Paper

WP01

The Journey of Sound

Portability creates unique challenges for audio engineers as they develop listening technologies, with Knowles Balanced Armature Micro-Acoustic driver technology providing a high-performance solution.

The "journey of sound" reached a significant milestone in 1877 when legendary American inventor Thomas Edison created the "phonograph" for mechanical recording and reproduction of sound. While others prior to this time produced devices that could record sounds, Edison's phonograph was the first implement that was able to reproduce, or "play back," the recorded sound.

Edison's invention was a landmark because it allowed the listener to hear music or spoken-word performances outside the doors of the opera house, vaudeville emporium or theater stage. It also created a new job description: "audio engineer," or someone who develops new audio/listening technologies in the hopes of advancing the scientific understanding and reproduction of audible sound. The overriding task of the audio engineer: create playback and listening instruments that deliver music in its most authentic, pure form.

While the first sound recordings were etched into steel tubes, by the 1930s, audio engineers had discovered that vinyl was the best medium on which to place recorded sound, whether it be music, a recorded speech or a comedy routine like "Who's on First?" Specifically, the sound would literally be carved into the vinyl disc, and when a "needle" encased in a stylus was placed on the disc's groove, the sound would be reproduced through the phonograph's speakers.

Stereophonic Sound

By the 1950s, the sound-reproduction capabilities of what had come to be known as "record players" or "turntables" had advanced to the point that complete high-fidelity, or "hi-fi," stereo systems with stereophonic sound were being produced and marketed. The advent of stereophonic sound was a major breakthrough, especially for the music-listening experience because it allowed the use of two or more channels of transmission and reproduction so that the reproduced sound seemed to surround the listener and come from more than one source.

The audio engineers' combination of passion and their ability to discover new, creative listening technologies dovetailed with the demands of a new class of listeners—commonly called "audiophiles"—who were determined to experience music in its purest form, absorb every chord and vocal subtlety. As such, a partnership was created between these two groups, the audio engineer reliably advancing listening technology and the audiophile ready to purchase it in the ongoing journey to hear music the way it was meant to sound.

Stereophonic sound allowed the use of two or more channels of transmission and created a listening experience that was closer to a live music performance or soundstage.

This partnership most significantly manifested itself when a new album was released, at which time the audiophiles would gather in anticipation then marvel at the sounds that were reproduced—from the jangly, "Well, it's one for the money, two for the show..." intro to "Blue Suede Shoes" from Elvis Presley's eponymous debut album, to the opening 10 seconds of a pit orchestra warming up and an audience gathering that introduced the title track from the Beatles' seminal *Sgt. Pepper's Lonely Hearts Club Band*, to Robert Plant's plaintive vocal that ignites "Black Dog" on *Led Zeppelin IV*.

Going Mobile

Eventually, listeners began to wish they could take their music and other sound recordings with them. Sure, you could listen to a transistor radio or the radio in your car, but in each case you had no control over what songs you heard and when they were played. With that in mind, the audio engineers went to work and emerged with a string of technologies that would make portable listening readily available, in the process expanding the listening experience through a combination of preferred recordings and mobility:

- **Compact Cassette:** On the heels of 8-Track listening technology came the Compact Cassette, or cassette/audio tape. In vehicles, the cassette tape had one main advantage over the 8-Track—it's smaller size made it easier to store more tapes in the car, which led to a wider range of listening options. Outside of the car, the cassette tape made a further name for itself in the 1980s with the introduction of portable pocket recorders and hi-fi players, the Sony® Walkman™, which was released in late 1979, being the most prominent example. The Walkman was so popular that in the 1980s, for the first time, sales of cassette tapes surpassed those of long-play (LP) records.
- **Compact Discs:** Audio CDs and their players have been commercially available since 1982. CDs had all of the benefits of cassette tapes—small footprint, good sound quality, portability—and the cassette-tape listening technology, i.e. the Walkmans and home/vehicle stereo systems of the world, were easily modified so that they could accommodate CDs.
- **Mobile Devices:** MPEG-1/MPEG-2 Audio Layer III listening technology—known universally as MP3—was standardized

Journey of Sound Timeline

1877: Thomas Edison invents the phonograph

1950s: Stereophonic-sound technology arrives, allowing music to "surround" the listener

1964: 8-Track tape invented, making music mobile

1979: Sony® Walkman™ introduced, cassette tapes become more popular than LPs

- **Stereo 8:** More commonly known as "8-Track Tape," Stereo 8 was invented in 1964 and uses a magnetic tape to record sound. Its popularity peaked from the mid-1960s to late-1970s and was driven by the 8-Track stereo systems that could be installed in vehicles. 8-Track was the first widely popular portable-listening format that enabled listeners to take the phonograph and entire albums wherever they went in their car, and was an attractive alternative to radio and a remedy to the inescapable fact that the listening experience was chosen for you by someone else.

in 1991. The use of the MP3 lossy compression algorithm greatly reduced the amount of data required to represent the audio recording and still sound like a faithful reproduction of the uncompressed audio for most listeners. In other words, MP3 technology meant listeners didn't have to lug around 8-Tracks, CDs or cassette tapes anymore; they could put 10,000 songs in their pocket. The most famous example of portable MP3 technology comes in the form of Apple, Inc.'s iPod, which was released in October 2001.

While ready access to recordings has reached phenomenal levels, this quest for portability did have an effect on the sound quality that was produced. A souped-up vehicle or home sound system can feature large speakers and other components that can recreate the "in-studio" sound quality and clarity that is hoped for, but when out for a walk, working out at the gym, or sitting in an office cubicle it is inconvenient, at best, or impossible, at worst, for high-end speaker systems to be used to reproduce studio-quality sound.

That has been the tradeoff with the advent of portable listening devices – some level of sound quality for enhanced mobility. However, ongoing advancements in broadband streaming audio, which holds the promise of stunningly articulated sound with no perceptible digital degradation, means that even the smallest listening device is now capable of producing better sound quality, or moving back toward the sound quality that is reached by a vinyl recording.

Thankfully for both the audio engineer and the listener, the increased viability and adoption of higher-resolution audio data formats that is taking place today, supported by leaps forward in the cost and size of storage media, is driving the development of high-quality listening devices that parallel the trend toward audio formats with better sound clarity. This so-called "re-evolution" of listening technology is improving the level of sound reproduction.

Knowles Corporation, Itasca, IL, is at the leading edge of optimizing the listening experience through the creation of Balanced Armature Micro-Acoustic drivers that can be placed in in-ear listening devices (earphones/earbuds) that are commonly used in conjunction with today's mobile devices and computers, creating an intersection where the audio engineer can help technology and purity of sound successfully merge. Balanced Armature technology enables the design of compact listening components with high power output that can be finely tuned to meet specific receiver and speaker

1982: Compact disc technology becomes commercially available

1991: MP3 digital-listening technology standardized

1994: Bluetooth® wireless technology is invented

2001: Apple, Inc. releases the iPod

The "Re-Evolution" Of Sound

While audio engineers have done a magnificent job of creating technologies that give recordings the utmost level of portability, they have also been charged with designing equipment that delivers that best listening experience. While it's great that an iPod can put thousands of songs or speeches at the touch of the listener's fingertips, where's the benefit if the quality of the sound reproduction is substandard?

applications. Audio engineers in the employ of listening-device OEMs can now create standard-setting listening experiences for their customers.

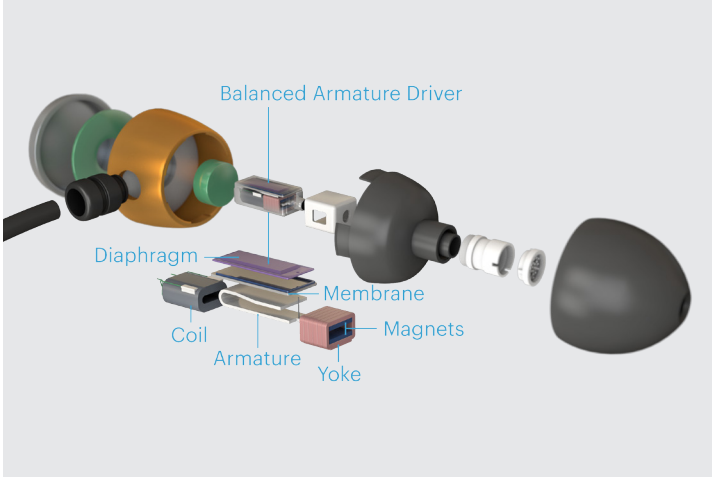
Enhancing the sound reproduction of music and other sound recordings, while being the most prominent examples, are not the only way that balanced Armature technology can optimize the listening experience. Balanced Armature drivers

can be placed into in-ear communication components, such as Bluetooth® headsets, or earphones that can be plugged into cellphones to enable hands-free calling.

Knowles developed Balanced Armature driver technology more than 70 years ago and first placed it in earphones in 1991. High-fidelity sound is produced through the incorporation of a reed that is balanced in the static magnetic field between two magnets within the driver's outer shell. The alternating-current (AC) signal in the static coil creates an AC magnetic flux in the reed, which imbalances it and causes AC motion at the tip, in the process producing sound that is purer in quality and clarity than that that is produced by other earphone-component technologies.

Other features and benefits of incorporating Balanced Armature driver technology in earphones include:

- Precision crafting for clear, immersive, high-fidelity audio
- Low-mass diaphragm for fast and precise sound reproduction
- Specialized reeds that enable true-to-recording sound, regardless of music type
- Small in-ear footprint (smaller than a push pin) for unlimited design flexibility
- Ability to use multiple Balanced Armature drivers in an individual earphone, with each driver tuned to a specific range of music
- Pronounced separation of instruments for a concert-hall or vinyl-record listening experience
- More output per cubic millimeter (mm^3)
- Very low power consumption



In response to the request for ever-improving sound quality and comfort for the portable audio experience, Knowles has made a decades-long commitment to creating listening solutions that can marry high sound quality with the demands of portability.

Conclusion

In response to the inherent tradeoff of compromised earphone sound quality for greater sound portability, Knowles has made a decades-long commitment to creating listening solutions that can marry high sound quality with the demands of portability. This has been a boon for the industry's audio engineers, who now have the tools and technology necessary to create an in-ear listening experience that most closely replicates the audio-replication purity of legacy technologies like vinyl LPs. The committed use of Balanced Armature Micro-Acoustic driver technology is the next developmental stage for the audio engineer to ensure that today's earphone technologies deliver the purity of sound that audiophiles demand and of which more casual listeners can also experience.

ABOUT THE AUTHOR: Tim Wickstrom is the Global Application Engineering Manager, Specialty Products for Knowles Corporation. He can be reached at tim.wickstrom@knowles.com. Knowles is a global supplier of advanced micro-acoustic, specialty components and human-interface solutions, including hearing-aid components, MEMS microphones, speakers, receivers, transducers, capacitors and oscillators, for use in the mobile communications, consumer electronics, medical technology, military/space and other industrial end-markets. Headquartered in Itasca, IL, USA, Knowles also operates satellite facilities in Denmark, the United Kingdom, Japan, South Korea, Taiwan and Malaysia.

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Phone: (630) 250-5100
Fax: (630) 250-0575
sales@knowles.com

Knowles
1151 Maplewood Drive
Itasca, Illinois 60143