

WORKINGKNOWLEDGE

DIRECTIONAL SOUND

Psst ... Hey, You

You are walking down a quiet grocery store aisle when suddenly a voice says: "Thirsty? Buy me." You stop in front of the soda display, but no one is next to you, and shoppers a few feet away do not seem to hear a thing.

At that moment, you are standing in a cylinder of sound. Whereas a loudspeaker broadcasts sound in all directions, the way a lightbulb radiates light, a directional speaker shines a beam of waves akin to a spotlight. The beam consists of ultrasound waves, which humans cannot hear, but which can emit audible tones as they interact with air. By describing these interactions mathematically, engineers can coax a beam to exude voice, music or any other sound.

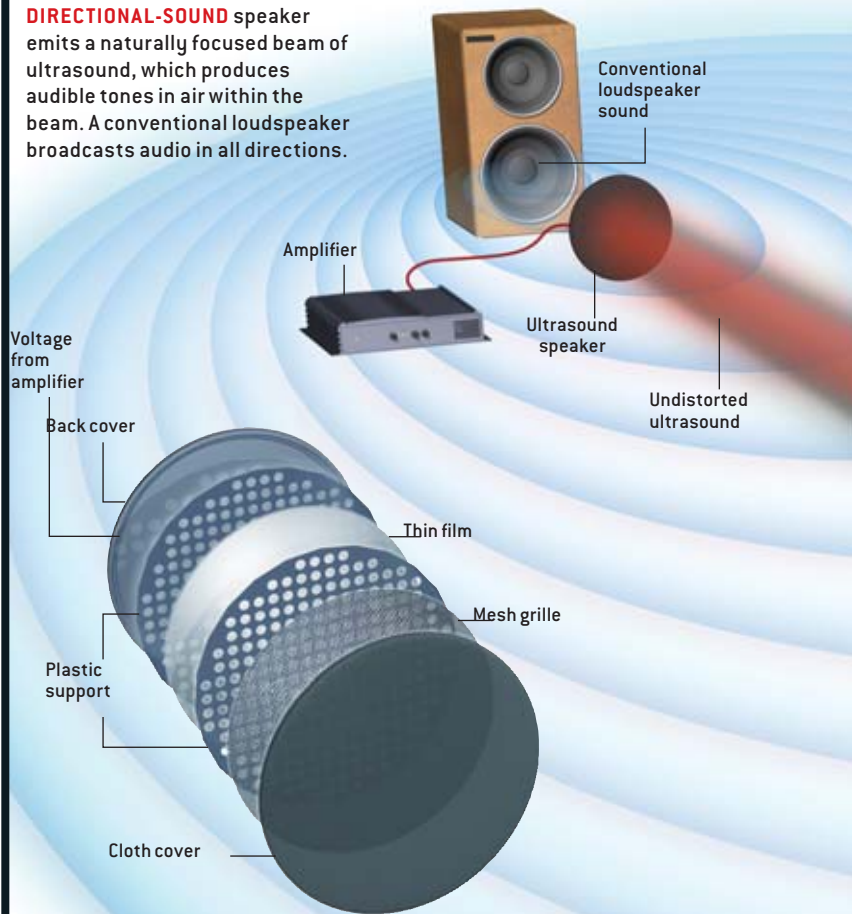
Military and sonar researchers tried to harness the phenomenon as far back as the 1960s but only managed to generate highly distorted audible signals. In 1998 Joseph Pompei, then at the Massachusetts Institute of Technology, published algorithms that cut the distortion to only a few percent. He then designed an amplifier, electronics and speakers to produce ultrasound "that is clean enough to generate clean audio," Pompei says. He trademarked the technology Audio Spotlight and started Holosonics, Inc., in Watertown, Mass., in 1999.

Pompei's speakers are installed in company lobbies, and above exhibits at the Boston Museum of Fine Arts and Walt Disney World's Epcot Center, among other locations. Narrations inform visitors standing in front of artifacts or video screens without filling the rooms with noise. Department stores have tried the arrangement for retail displays, and automakers are experimenting with them so passengers can hear only their own music or movies. A speaker above a recliner in the living room would allow Dad to hear the television while other family members read on the couch in peace.

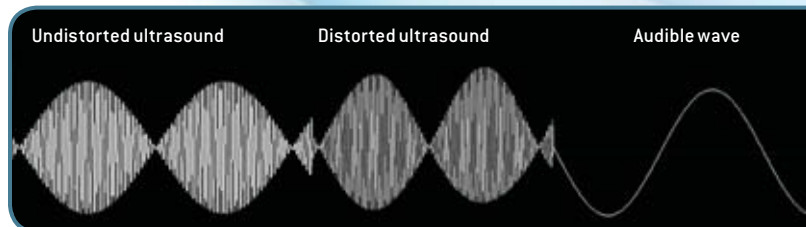
Detractors say that in certain situations headphones can provide similar benefits, and note random problems, such as unwanted reflections off a car seat. But the primary obstacle to wider deployment is cost: systems run from \$600 to \$1,000 or more. If the price drops, consumers are more likely to consider buying the gear ... or encounter it while shopping.

—Mark Fischetti

DIRECTIONAL-SOUND speaker emits a naturally focused beam of ultrasound, which produces audible tones in air within the beam. A conventional loudspeaker broadcasts audio in all directions.



SPEAKER, only half an inch thick, is driven by an amplifier that sends voltage to a metal-polymer film. The film vibrates at 60,000 cycles per second or more, generating ultrasound waves.



UNIFORM ULTRASOUND waves (left) produce density fluctuations in air, which distort the waves (center), causing them to emit an audible tone (right).

PHOTOGRAPH BY JEFFREY M. HARRIS FOR SCIENTIFIC AMERICAN, INC. (photograph)

DID YOU KNOW...

▣ **BOUNCED:** Ultrasound waves remain in a tight column when they reflect off a hard, smooth surface. Police teams could bounce a beam off a building at the end of an alley or off a distant window inside a warehouse to flush out suspects, who would run away from the sound—and right into the officers' waiting arms.

▣ **BATS NOT DOGS:** Certain animals can detect the ultrasound noise behind audible directed sound. The ultrasound speakers emit frequencies from 40,000 to 80,000 cycles a second, or hertz [Hz]. Humans typically hear frequencies between 20 and 20,000 Hz. Dogs can hear up to 40,000 Hz or so, mice up to 90,000, and bats, porpoises and beluga whales up to 100,000 Hz or higher.

▣ **BONUS:** Middle ear bones limit human hearing to below 20,000 Hz. But researchers have applied ultrasound up to 200,000 Hz to the skulls of volunteers, some of whom report "hearing" sounds; the skull may be distorting vibrations that reach the cochlea.

▣ **MURDERER:** Last November, Court TV used Audio Spotlight in major bookstores to market its new *Murder by the Book* television series. When a patron, milling about, unwittingly stepped near a poster about the show, a voice from nowhere whispered, "Hey, you—over here. Don't turn around. Do you hear me? Do you ever think about murder? Committing the ultimate crime? I do. All the time. I get paid to think about it. I'm a best-selling crime writer..."



INDIVIDUALS at the New York Public Library can hear audio from overhead speakers when they are in the "spotlight." All other space remains quiet.

Distorted
ultrasound

Audible
sound

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