

# The Boston Globe

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## Health | Science

### Now hear this – and only this

New speaker aims sound at a single person without bothering others



Joe Pompei, an MIT researcher, holds a part of his invention – the “Audio Spotlight” – which is designed to focus sound on one spot.

By Eric Niller  
GLOBE CORRESPONDENT

It's almost a cliché of family life: Mom, dad, sister and brother all like different music – or no music at all – on long drives. So, unless everyone has headphones, the radio dial becomes a battleground of conflicting requests for hip-hop or classical, classic rock or news.

But passengers in MAXXcab, a new experimental four-passenger pickup truck from Daimler-Chrysler, need never have radio wars. Using an invention by a researcher at the Massachusetts Institute of Technology in Cambridge, each rider is bathed in a “spotlight” of sound, audible to them but not to the person sitting just 2 feet

away.

“It’s a concept right now, but it’s a brilliant concept,” said Daimler-Chrysler spokesman Sjoerd Dijkstra from Detroit. “It treats sound like light.”

In a world increasingly awash in electronic sound, Joe Pompei of MIT, the 27-year-old inventor of the “Audio Spotlight,” may be onto something.

Focusing sound in the same way that a flashlight creates a beam of light allows music, speaker phones, movies and other information to reach its target audience with laser-like precision.

Car stereos are just the beginning of possible uses for sound beams, now under development by several companies:

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#### Making a ‘beam’ of sound

The “Audio spotlight” creates a beam of sound similar to a flashlight beam

Music is fed into the spotlight, which acts like a filter, turning sounds into ultrasound waves

AUDIO SPOTLIGHT

ULTRASOUND WAVES

The narrow beam of ultrasound waves is initially too small for humans to hear

AUDIBLE WAVES

The air distorts and lengthens the waves, revealing the sounds that were encoded in the ultrasound

300 FEET

## Experimental speaker aims sound at a single listener

### ► SOUND

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Amusement parks want sound beams to beef up rides with weird sound effects. Television makers want speakers that trick the listener into thinking something is sneaking up from behind.

Sound beams also have a host of possible military applications. Troops could confuse enemies with projected sounds of artillery fire, they could detonate mines with sound triggers or talk to each other without having their radio communications picked up by eavesdroppers.

The new sound beam technology simply takes advantage of the physical properties of sound. Audible sound waves are big – a single wave can be several feet wide – and normal speakers broadcast them radially, like ripples from a pond. As a result, sound waves spread in all directions, filling the space.

It is possible to focus big sound waves into a small space using ordinary speakers. But, ironically, the speakers need to be very large because the size of a sound wave is inversely proportional to the size of the source. To create a narrow beam like the one from the Audio Spotlight, a conventional speaker would have to be 150 feet wide, Pompei estimates.

But researchers have found a way around that problem – ultrasound the same waves that obstetricians use to make images of fetuses.

Ultrasound operates at a frequency so

small that our ears can't detect it, like a dog whistle. Researchers in the 1960s discovered that ultrasound interacts with the air in an unusual, nonlinear way to produce audible sound that seems to come out of nowhere. As the 1-millimeter-wide ultrasound waves travel through the air, the air itself lengthens and distorts them, making some long enough for humans to hear.

To the listener, it's as if the air acts as its own speaker.

The hard part for researchers has been finding a way to take advantage of ultrasound's odd behavior because the sound produced has a high level of distortion. And the louder the sound, the more difficult it is to understand the information being broadcast. Thus, the real trick is reducing distortion.

“So far, it's been pretty tough to do,” said David Blackstock, professor emeritus of mechanical engineering at the University of Texas, and an expert on audio technology. “But I'm less skeptical now than I was several years ago.”

Japanese researchers at Ricoh and Matsushita tried without success in the late 1980s to develop a distortion-free ultrasonic speaker. Researchers at Ricoh thought they could use the same acoustic technique that makes AM, or amplitude modulation, radio possible. But they also were unable to eliminate distortion that grew with volume.

But Pompei, a graduate student at

**‘I had to develop mathematical algorithms and then a physical system of reproducing those ultrasound waves accurately.’**

JOE POMPEI

Inventor of the “Audio Spotlight”

MIT's Media Lab, knew that the air acts on ultrasound in a predictable way, so he set about to create a mathematical model of how air alters ultrasound. Once he knew that, he could develop a speaker that produced ultrasound waves designed to become audible music or other sounds after the air distorts them.

“I had to develop mathematical algorithms and then a physical system of reproducing those ultrasound waves accurately,” said Pompei, who grew up in Wayland and was, at 16, the youngest engineer at Bose Corp.'s laboratories. “The combination allowed me to [create a] high-performance loudspeaker.”

The result, Audio Spotlight, is a flat, round speaker that projects a beam of ultrasound waves that becomes audible in the air and travel up to 300 feet. Stand inside the beam and you hear the sounds;

step outside and you hear nothing.

Most important, Pompei said he has reduced the distortion rate from 50 percent of the soundwaves to 5 percent. The best conventional speakers have about 1 percent distortion.

But Pompei is not the only one hot on the trail of a commercially valuable sound beam, which some believe could eventually grab a slice of the \$11 billion speaker market. San Diego-based American Technology Corp. announced in 1996 that it had developed an ultrasound speaker that combined certain algorithms with a digital processor that appeared to work.

Last August, the company delivered several speakers to General Dynamics' Bath Iron Works, which will install them on a new Aegis-class Navy destroyer under construction. The idea is to allow radio operators to focus on their own communications while still listening to ambient noises in a ship's control room.

The firm is also talking to a French electronics manufacturer about installing its sound beam speaker into new flat-screen televisions. Sound effects could then be bounced off the back wall of a living room, giving the impression of sound coming from behind.

“We're at the birth of a new technology,” said Robert Putnam, American Technology's vice president for investor relations.

At MIT, Pompei said he believes his speaker is more powerful and more clear-sounding than American Technology's device.

“Mine is the only one to demonstrate high performance and low distortion output,” Pompei said.

At Daimler-Chrysler, officials say the Audio Spotlight is still two or three years away from commercialization, and is still experimental. The first model, MAXXcab, announced last June, can only divide music into two zones, front and back seat, while future applications are expected to create four distinct sound beams. But company officials say Audio Spotlight could be the way of the future for American motor vehicles.

“The variety of sound sources is only going to increase with the availability of voice-enabled navigation, e-mail, cell phones, video games and movies in your future vehicle,” said Steve Buckley, electrical product innovation manager at Daimler-Chrysler.

But David Blackstock of the University of Texas is not yet convinced that the world needs sound beams. After all, many of the same uses – such as secure or individualized sound – can be accomplished with the use of headphones. “The big question is: Are there some schemes out there that you can't do any other way?”

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