www.nytimes.com
The New York Times ON THE WEB

May 15, 2001

An Audio Spotlight Creates a Personal Wall of Sound

By JENNIFER 8. LEE

A person hears a voice in her ear, turns around and sees nobody there. No one else has heard it. Or she hears footsteps in a room, the product of an invisible presence. Is her mind playing tricks on her?

Or is it a jokester, F. Joseph Pompei? A 28-year-old graduate student who is part scientist and part showman, Mr. Pompei has invented a device that projects a discrete beam of sound in much the same way a spotlight projects a beam of light.

The audio spotlight — as Mr. Pompei has dubbed it — emits a column of sound enveloped by silence, the way the glow of a spotlight is enveloped by darkness. Someone standing inside the beam emitted from his flat black disk hears the sound loud and clear. Outside the beam one hears silence or, if there are surfaces nearby, faint murmurs from the reflected sound waves. The beams can also bounce off walls to create an impression of the source of the sound.

Companies are already dreaming up commercial applications for the beam. Supermarkets and retail stores may beam product enticements at customers. Vending machines may soon talk as people pass by. Dance clubs could divide up a single room into different music zones. DaimlerChrysler is looking into installing sound beams in a truck so that passengers can listen to their own music. The military could use it to confuse enemy troops.

American Technology Corporation, a San Diego-based company that makes a similar product, has already sent out evaluations to military contractors, consumer electronic manufacturers and entertainment companies. It has signed a deal with the shipbuilder Bath Iron Works to install the sound beams on the deck of a new Aegis-class Navy destroyer as a optional substitute for radio operators' headsets. As for consumers, Terry Conrad, president of ATC, estimates they will start being hit by sound beams within two years.

Mr. Pompei's audio spotlight, the engineering for which is awaiting patent approval, is the product of a childhood fascination for acoustics and his eight-year obsession with the idea that sound could "dance." He said he encountered resistance to the idea in his graduate school applications, but he found a warm reception at the M.I.T. Media Lab. "I had so many people tell me so many times that it wouldn't work," he said. "My response always was that this was too cool not to work."

An audio spotlight is counterintuitive. Within the human range of hearing, sound tends to travel in all directions, as does a candle's light, and resists being focused in a beam.

The smaller the sound waves, the less they spread out. But if the waves are too small, they lie outside the range of human hearing. For example, the tight waves of ultrasound are focused enough to use in medicine, but they cannot be heard by human ears.

The magic combination is to merge the beamlike nature of ultrasound with the qualities of audible sound.

Ultrasound frequencies are distorted by air in a way that can be captured by complex but well-defined mathematical equations. Mr. Pompei's insight was to use this air distortion to his advantage: start with the desired audible sound and work backward through the distortion to determine the original ultrasound source.

Analogously, if someone with 20/20 vision put on a pair of prescription glasses, he would get a distorted view of the world. But for someone with the right level of bad eyesight, the eyeglasses will result in a clear view. The eyeglasses are similar to the distortion caused by the air, and the original bad eyesight is analogous to the inaudible ultrasound.

Air distortion of sound waves happens all the time, but it is usually negligible, so it wasn't experimentally observed until the early 1970's when David Blackstock, a professor at the University of Texas, and one of his students, Mary Beth Bennett, were first able to create audible sounds by combining different frequencies of ultrasound. The resulting high-pitched chirps were significant, but not very practical.

It wasn't until a decade later that a Japanese research team tried to adapt that breakthrough to produce music,

speech and other sound. Masahide Yoneyama of Ricoh and colleagues at several other Japanese electronics firms in the early 1980's combined audible sound waves with ultrasound waves in a technique called amplitude modulation, or AM, often used in radio transmission.

As the new hybrid wave traveled through the air, it self-demodulated — that is, the audible sound "unraveled" from the ultrasound. But their sound beam was grossly distorted. The high cost and the poor reliability caused the team to abandon the research.

What eluded the Japanese team were the right equations to match the distortion. Mr. Pompei looked to sonar research from the 1960's for inspiration. Dr. Peter J. Westervelt, a Brown physicist, and Dr. Orhan Berktay, a British acoustician, had done seminal work in describing the distortion of ultrasound under water. Mr. Pompei took Dr. Berktay's equations, modified them for the air and engineered the design.

The result is that the audio spotlight doesn't directly generate the audible sound. It generates a beam of ultrasound that acts like a long, thin loudspeaker and releases audible sound — a secondary effect. It's as though Pompei created a hologram of a lamp that then could be turned on to generate light. The ultrasound is the lamp, the audible sound is the light.

Professor Blackstock, who has seen the American Technology Corporation product, still considers audio beams a novelty item since many of their uses could be accomplished through use of headphones. "It looks like a hard sell," he said. "Most of the uses of sound involve spreading it around."

That's true, and that is the reason the audio spotlights may be the most radical technological development in acoustics since the coil loudspeaker was invented in 1925. The real revolution of the acoustic beams lies not in the circuit boards, but in the mind. The audio spotlight will force people to rethink their relationship with sound, as the arrivals of the phonograph, the telephone and the Walkman have done before. An occasional cathedral or dome delights us with acoustic tricks played by the architecture when sounds from far away seem to originate nearby. But those are isolated effects.

With the exception of Walkmans and headsets, sound is public, a shared phenomenon. We are skeptical of those who claim to hear sounds and voices that we can't hear. Humans are immersed in a world of overlying spheres of sound. We can close our eyes, but can't shut off our ears. Darkness is common, but pure silence is difficult. A hum or a rustle breaks that purity.

Now sound can be personal without any apparatus shielding our ears. Mr. Pompei gets letters and e-mail messages from around the world from people convinced that his audio spotlight is being used on them as a mind control device. "Absolutely not," he said, laughing. But Mr. Pompei is too fun-loving not to play a few mind tricks of his own. Among his favorites is to stand on the balcony near his fourth-floor office and emit sounds of breaking glass toward caterers below. The confused caterers nearly always stop to look at the floor. "Eventually they look up or they hear us laughing," he said. Now the caterers are used to it.

People have written Mr. Pompei asking for devices to shield them from the audio spotlight's insidious mind control uses. He has toyed with the idea of selling audio-spotlight earplugs on his Web page to meet the demand. Of course, since the audible sounds generated by his device are normal sound waves, the product would simply be ordinary earplugs adorned with his logo. But if it gives people peace of mind, he says it may be worth it.