



An Acoustic Lens by Sausalito Audio Works Aids in Lateral High Frequency Dispersion

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A new approach to the problem of achieving broad high-frequency dispersion is through the use of a novel acoustic lens that, mated to the transducer element, alters the directivity of the transducer. Manny LaCarrubba, of Sausalito Audio Works, has invented such a lens and is currently soliciting potential licensees. At present, he is using the lens in prototypes in service in recording production. The lens is suitable for both tweeter and midrange applications, when properly mated with an appropriate conventional direct-radiating transducer.

A key attribute of loudspeaker driver and system performance is dispersion as a function of frequency. Due to the proportional relationship between wavelength, transducer size and dispersion, and the wide range of wavelengths encountered in the audible spectrum (2/3 inch to 50 feet), any loudspeaker system design must face wavelengths both larger and smaller than the size of the radiating element and its housing. This, in turn, results in propagation tendencies that are broadly dispersive for long wavelengths and quite directional for short wavelengths. In general, this tendency has been tolerated as a "fact of life" and engineering design solutions have concentrated on achieving flat "on-axis" amplitude response performance in preference to flat power response.

The acoustical and psychoacoustical result of this has been a distinct and particular "loudspeaker" behavior characterized by omnidirectional wave propagation at low frequencies, erratic propagation at crossover points, and quite directional propagation at high frequencies. There is wide variability in power and polar response of loudspeaker systems as a function of frequency, particularly as the array of drivers employed becomes more complex.

At the same time, other directional behaviors are possible, behaviors that yield distinct benefits in comparison to conventional loudspeaker behavior. Broad high-frequency dispersion from loudspeakers placed symmetrically in small reverberant rooms yields significant benefits in terms of imaging, depth and musicality of phantom and real images generated by the loudspeakers.

However, high frequency dispersion has always presented a problem in loudspeaker design. To date, transducer topologies that seek to directly control this fundamental quality of loudspeakers have only concentrated on narrowing beamwidth (for sound reinforcement) or controlling and stabilizing high and mid-frequency beamwidth across a solid angle of about 30° (both horizontal and vertical), through the use of horns and waveguides/baffles. Other



than for ribbon transducers, little, if any, design effort has been expended on the development of transducers that, as a function of the topology of the transducer, achieve broad high-frequency dispersion.

Work with prototype omni-directional tweeter arrays in the mid 1980's led the author to the conclusion that wide dispersion of high-frequencies yielded significant benefits in perception of stereophonic sound images (AES preprint 2371). However, double-blind subjective listening tests and objective anechoic measurements at the Canadian National Research Council's facility at Ottawa (under Floyd Toole) in 1991 led to the insight that arrays using multiple transducers to achieve such dispersion were unacceptably difficult and/or expensive to implement for such applications when excellent audio performance was desired.

In 1993, Manny LaCarrubba started work on a novel but simple lens for use with a single transducer that serves a similar function. A patent has been issued for this lens in 1997. Several prototypes have been constructed, and the lens has been incorporated into both high-frequency and mid-frequency systems, in both large full-range speaker systems and so-called "meter-bridge" small 2-way loudspeakers for use in recording studios. Some of these prototypes are being used successfully in full-time audio production services, in both stereophonic and surround music production. A broad range of listeners' comments have been strongly favorable.

The lens itself consists of a single piece that is fastened to the face of the transducer mounting plate. Acoustic output of the transducer is gathered by the lens and re-emitted into space with altered directional characteristics, so that energy at frequencies higher than the frequency whose quarter-wavelength equals the width of the back plate of the lens is dispersed narrowly on the axis passing from front to back through the transducer and widely on the plane whose surface is also the surface of the transducer face plate.

This means that energy is radiated out from the lens at 70° to 90° from the direction the transducer is facing, spread across 180° in the plane of the transducer face plate. Within that range (which may be varied by altering the defining envelope of the lens structure), energy output is approximately constant in all directions and all frequencies above the low-frequency limit mentioned above.

For a conventional application, the transducer is placed facing upwards at a height slightly below the desired listening position, and the lens then causes the sound energy to be dispersed laterally over 180° and vertically over approximately 35° . Physical integration with the transducer is simple. However, acoustical performance of the driver/lens depends on the transducer performance characteristics as well as the specific topology of the lens.

The acoustic performance of the lens yields an array of desirable benefits. Within the coverage angle, the output is remarkably stable in terms of amplitude at all frequencies, free



from lobing in the horizontal plane, and with no significant interference effects due to phase shift and comb filtering. These benefits yield significantly improved timbral quality and phantom images in normal reverberant spaces. At the same time, construction of the lens is simple, materials required are neither critical nor necessarily expensive, and manufacturing problems are minor.

The use of Acoustic Lens Technology is appropriate for loudspeakers in normal stereophonic pairs in normal consumer use, recording production and post-production use (including mastering), home theater arrays – including and perhaps especially surround speakers for multi-channel music playback, where the broad dispersion of the lenses accomplishes much of what the surround dipole for film surround is intended to accomplish while also matching the timbral quality of the front speakers – and similar applications. If properly integrated in installation, Acoustic Lens Technology should prove to be extremely effective in automotive installations as well.

Due to the lens' capability of generating extremely narrow "vertical" dispersion, there may be some sound reinforcement applications where very broad coverage is desired on one axis and extremely narrow dispersion on another axis.