Another Tool in the Loudspeaker Tool Bag

We were pleased to have D. B. Keele, Jr. as a guest speaker at the recent Sound Reinforcement for Designers seminar in Louisville, KY. He presented his work on Constant-Beamwidth Transducers (CBT). Much like the Bessel array was used to prevent a vertical line of transducers from forming a tight vertical pattern with increasing frequency, the CBT is a shaded circular-arc curved line array that produces the radiation pattern that one would expect from a large format constant-directivity (CD) horn.

Those considering such a device must understand that it is not intended to produce the non-CD classic straight-line array radiation pattern that (may) continually narrow as frequency increases. The CBT curved-line array is inherently CD and produces a radiation pattern that is essentially independent of frequency and distance. The teachings of the CBT concept dictate that identical drivers be placed around a circular arc and that frequency-independent shading be applied that decreases the level of the drivers the farther they are from the center of the array.

This short introduction is taken from Don's AES paper The Application of Broadband Constant Beamwidth Transducer (CBT) Theory to Loudspeaker Arrays (Sept. 2000) and is intended to familiarize our readers with the concept of the CBT array. We will publish more on the subject in the future, including both measured and predicted data. pb

The holy grail of loudspeakers is a sound source that provides a sound field whose three dimensional radiation pattern is constant over a wide frequency range. This type of source provides an acoustic output whose spectral content does not vary with direction. Particularly challenging is a speaker that couples these characteristics with high directivity. Traditionally, these speakers are called *constant-directivity* or *constant-beamwidth* devices. Various methods have been used in the sound industry to approximate this behavior including horns, omnidirectional sources, and arrays, higher-order sources, etc.

Underwater transducers have much the same problems as in-the-air transducers. Here, one excellent solution to this problem is described in two papers written by authors at the U. S. Navel Research Laboratory (now at the Naval Undersea Warfare Center). This research, which describes spherical transducers with shaded caps, is described in the next section. This paper extends this research to arrays of loudspeakers via computer simulation and prediction of radiation patterns using three-dimensional discrete arrays of point sources.

Rogers and Van Buren, and Buren et. al. describe the theory and experiments of what they call broadband "constant beamwidth transducers" (CBT) for use as underwater projectors and receivers for sonar use. Here the transducer is in the form of a circular spherical cap of arbitrary half angle whose normal surface velocity (or pressure) is shaded with a Legendre function. The Legendre shading is independent of frequency. This transducer provides a broadband symmetrical directional coverage whose beam pattern and directivity is essentially independent of frequency over all frequencies above a certain cutoff frequency, and also change very little with distance from the source. The transducer can be designed to cover any arbitrary coverage angle with a constant beamwidth that extends over an operating bandwidth which is, in theory, virtually unlimited.

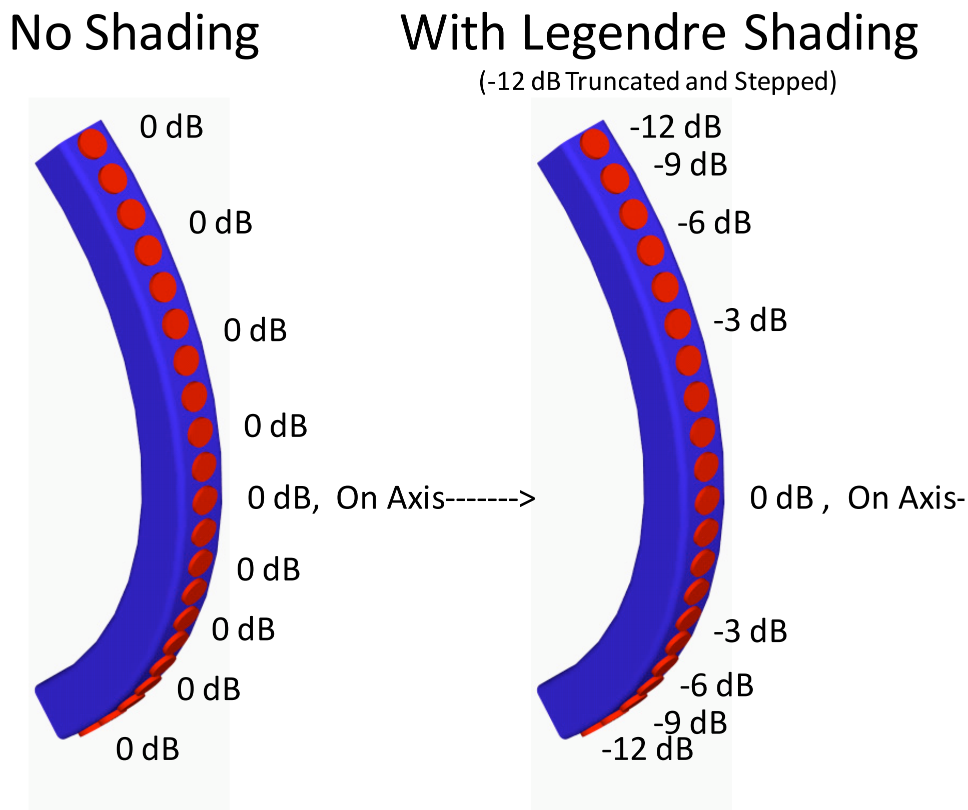
The entire AES paper can be purchased from the AES website.

D. B. Keele, Jr. and a CBT array prototype.

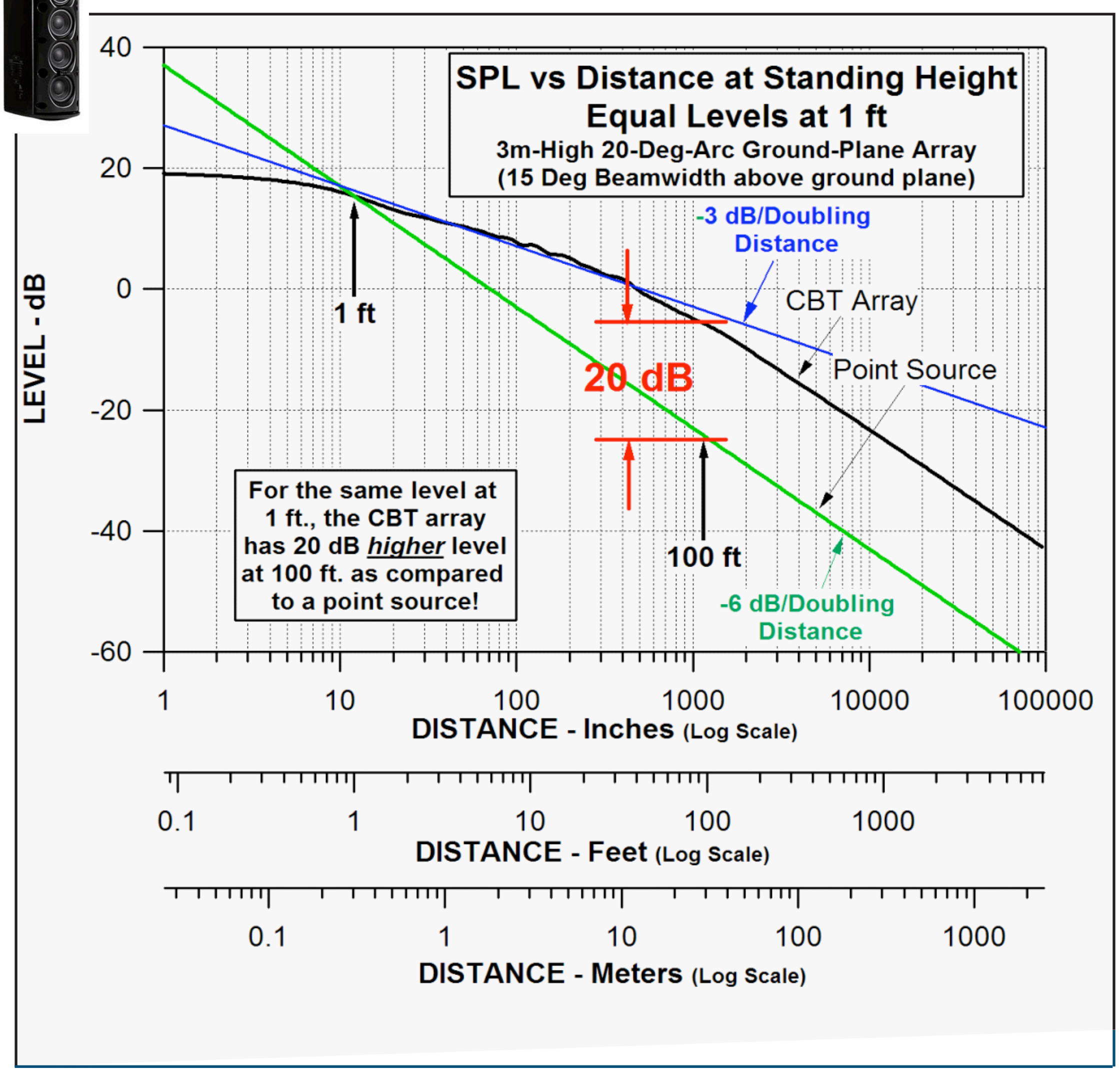
The level shading of the CBT array can be active or passive.

The curvature of the array can be physical or by signal delay.

The signal delay can be implemented actively or with passive all-pass filters.



JBL has produced a line of passive CBT arrays which are mostly straight with the exception of one that has a curved bottom and a straight top.



The CBT array attenuates at $1/r^{1/2}$ in the near field and 1/r in the far field. This allows a CBT array to produce +20dB at 100ft when compared to an ideal point source, if both are producing the same level at 1ft.