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View From the Top: Line Arrays

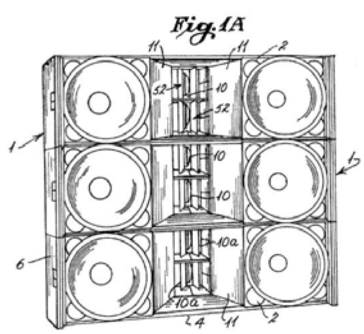
By Brock Adamson

On January 29th,2002, United States Patent #6,343,133B1 was issued to Adamson in the field of line arrays. *Titled "Axially Propagating Mid and High Loudspeaker Systems", this patent describes in detail the inner workings of Adamson's Y-Axis loudspeakers. But more on that a little later. Fig 1. (Patent Fig 1A.)*

There is little to say generally about line arrays that hasn't already been said. The benefits of excellent coupling and controlled vertical coverage angle; the predictability of the array and the software utilities used to set them, and; the significantly better direct-to-reflected ratios and the horizontally uniform sound field are all known and accepted by the faithful. The few remaining naysayers protest that they don't-work, can't-work, and won't-work, while the manufacturers continue to hammer out more sausage-shaped boxes.

The Historical Line Source vs. the Line Array

The historical *line source* and its limitations were defined in the 'fifties by Olsen. The limitations are found in the very geometry that makes them work: a vertical row of close-coupled devices, operating in the same bandwidth, spaced at less than a wavelength of their upper useable frequency.



Since the wavelengths of the highest audio frequencies are much shorter than any driver's diameter a high frequency "fix" is obviously needed. But it is unacceptable to rely on direct radiators for midrange, since the upper-mid wavelengths are nearly the dimension of an average mid speaker. The problems are apparent in the far field.

New Line Arrays: Not all "Fixes" are Created Equal

New *line arrays*, multi-way loudspeakers that hang vertically in a "J" shape, offer a variety of approximate "fixes" for the high frequency problem, but in most cases completely ignore, or deal badly with the mid frequencies.

There are three critical questions of the new designs that must be answered:

- Does the curvature of the wavefront match the enclosure angle?
- How continuous is the radiating surface of the "line"?
- Are *horizontal* driver placement rules obeyed?

Curvature

In a correctly designed trapezoid-enclosure line array, the wavefront must be curved precisely to match the enclosure angle (Adamson Y-Axis). An isophase wavefront emanating from a curved slot can be defined mathematically with prolate spheroidal coordinates.

In a correctly designed rectangular-enclosure line array, where the upper and lower walls are parallel, the wavefront must be planar (V-Dosc). An isophase wavefront emanating from a planar slot can be defined mathematically with cylindrical coordinates.

On the other hand, simple horns with narrow rectangular exits can be found in some line arrays. Wavefronts from these systems have too much curvature to match the vertical coverage angle of the enclosures in the array. Two major problems result: Reflections from cabinet surfaces above and below the slots corrupt the wave form; and enormous vertical overlap in the listening field dramatically increases time smear, restricting clarity and long throw performance.

Continuity

Research by Professor Marcel Urban and Christian Heil has shown that planar rectangular (and consequently curved) radiating sources should occupy at least 80% of the frontal area of the section of the array devoted to that frequency band in order to perform properly. This is apparent where the operating wavelengths are a fraction of the length of the radiating surface in the high frequency section. However, in the case of mids operating to 2k (wavelength approx. 6.7") the rule is still very valid.

For example, where mids are paired vertically in enclosures 15" to 20" in height, the rule *must* be obeyed. Consider what two 7" mids do in a 15 ½" line array enclosure. Fig. 2.

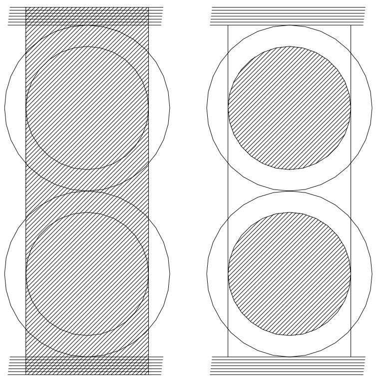


Fig 2.

The 5.2" diaphragms are 42.5 square inches. But the rectangular space is 80.6 square inches. This means that the radiating area of the diaphragms is only 52.7% of the vertical strip of space representing the midrange. It's simply not good enough.

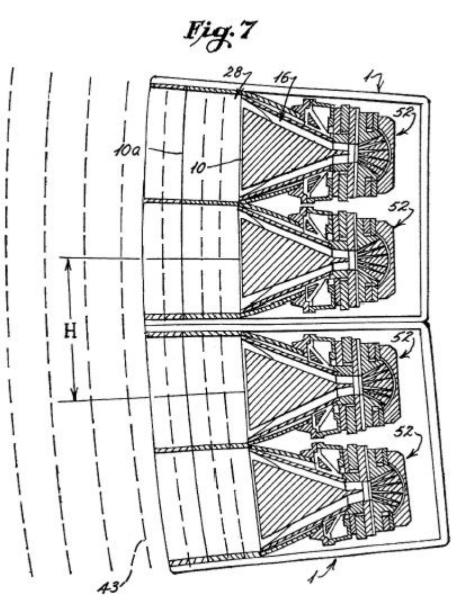
The result in the far field is that the mid disappears while the highs continue further, assuming of course, that the highs are designed properly.

While the numbers may be a subject for debate, it is obvious to the naked eye that the high frequency slot source has a totally different characteristic than the midrange direct radiator source. So what's to be done?

The Y-Axis Systems

The new technology in our systems is like no other system in the world. The US Patent 6,343,133 outlines this quite clearly but I'll try to summarize a couple of highlights here.

(The high frequency sound chamber illustrated in the patent is not found in any Y-Axis system. An improved sound chamber is used, featuring unequal pathlengths, a rectangular entrance and a rectangular exit that reduces the curvature of the typical wavefront found at the exit of a CD horn throat. This sound chamber is the subject of a number of patent applications here and in Europe.) Fig 3. (Pat Fig 7.)



We start with a co-axial mid and high driver combination comprised of extremely high performance drivers. We pass the high frequencies through the pole-piece of the mid driver and place the high frequency sound chamber in front of the mid driver. This acts like a phase plug for the mid device.

Then we wrap the midrange sound chamber around the high sound chamber forming two parallel slots where the mid energy can exit on either side of the high frequency slot. All three slots extend the full height of the enclosure creating mid and high acoustic sources of similar radiating characteristics.

If you are familiar with acoustics, you will notice that there is potential for a 180-degree cancellation in the throat of the waveguide from the two mid slots. You can also imagine that there might be a problem with the high frequencies passing the mid slots. True on both counts.

The solution is found in limiting the physical dimensions of the sound chambers and waveguide to control the location of the interference frequencies. Once this is achieved, the mid and high processing is set for sufficient overlap so that the three slots are all energized at these frequencies. The interference is thus eradicated. (A further US patent on the signal processing is pending.)

Horizontal Spacing: the Same Rules Apply

It is convenient to forget that the placement of drivers in the horizontal axis is as important as vertical placement. Remember that we listen up to 50 degrees off axis horizontally but we stay in a narrow vertical window, essentially on axis for at least one enclosure.

Two things are important in the horizontal plane: symmetry and spacing. The Adamson Y-Axis obeys both rules, resulting in phenomenally smooth coverage over a 100° listening window, the widest in the industry.

When you combine the superlative coverage of Y-Axis systems with Adamson's Y-Axis Shooter program, you can design the optimal Y-Axis array for the given venue in a matter of moments. Then, Adamson's unique flying system allows you to realize the array minutes later.

Conclusion

When you design an array with the Y-Axis "Shooter" software, you'll hear how precise and predictable our systems are and how much more audience can be covered perfectly. That's proof that when you obey all the design rules, you get results. Our growing list of clients agree: the proof is in the product.