The Tymphany Linear Array Transducer

An Alternative Form-Factor Loudspeaker

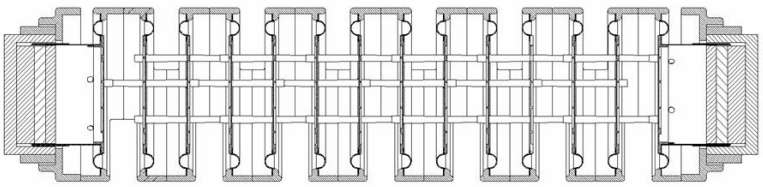
A Technology White Paper

Overview

The Tymphany Linear Array Transducer (LAT) is the culmination of a long and sophisticated research effort. It was developed specifically to solve a very real problem, one that loudspeaker design engineers have struggled with for many years: How do you pack real, powerful bass into very constrained spaces?

It's obvious at first glance that the Tymphany LAT is a very different kind of loudspeaker driver, sharing its root with more conventional electrodynamic drivers, but departing in significant ways. Long and cylindrical, it contains not one "cone" but many, connected by balanced sets of piston rods. Multiple acoustic vents pump the surrounding air to provide sound radiation, and the push-pull operation of the diaphragms cancel both distortion and mechanical vibration.

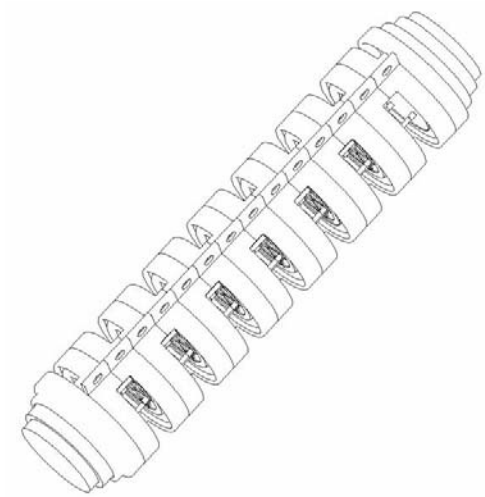
With a "space to bass" improvement potential of greater than 300% over existing drivers, our new Linear Array Transducer technology can turn a Flat Panel Television into a high impact home theater. It can turn a small bookshelf speaker into a truly full-range monitor. It can turn a slender speaker stand into a 20 Hz subwoofer, with virtually no mechanical shaking. At the other end of the size spectrum, the Tymphany LAT can scale up, to fill a venue with visceral bass from a single box.



The Linear Alternative

Moving air is what sound is all about. The more air a speaker can move, the greater its SPL and bass potential will be, and the more impact and involvement the listener can experience. The difficulty this presents is that moving enough air to realize a truly high fidelity listening experience requires speaker drivers with large radiating areas and long excursions. It is widely recognized that, as a general rule, a 12” woofer will play louder and provide much more bass than a 4” woofer. Unfortunately, many consumer applications that would benefit from the accuracy and impact of deep bass just don’t have the space available for large, conventional woofers. By re-thinking the shape and mechanics of a woofer, dividing one large cone into many smaller ones, Tymphany can squeeze serious air movement into new places, while providing other important benefits.

The maximum air movement capacity of any speaker is called Volume Displacement, abbreviated V_d. Since V_d is the mathematical product of the radiating area (S_d) times the maximum displacement of the diaphragm (X_{max}), it is obvious that moving more air means moving more radiating surface over longer distances. Now imagine taking a 12” woofer and transforming it into 10 smaller disks that together add up to the same total area. A commercial 12” woofer has a cone that is typically about 11” across, yielding an area of 5.5^2*π= 95 in^3. Dividing this over 10 smaller cones, we get 9.5 in^3 per cone. And each of these smaller cones must have a diameter of 2*sqrt(9.5/π)= 3.47”. From this exercise, we can see that ten 3.5” diaphragms actually achieve a slightly greater radiating area than one 11” cone.



Ten complete 3.5” woofers would not be a very logical alternative to a single 12” woofer, in terms of either cost or space. However, if those ten bare cones, minus the extra frames, magnets, etc., could be lined up inside a tube and driven by a common motor and lightweight piston rods, they can deliver real space savings—and deep bass from a totally new form factor. The underlying operating principle is similar to a regular dynamic woofer, but the surface utilization is much more space efficient.

Up until now, engineering challenges have prevented designers from considering this kind of speaker driver. Tymphany tackled the mechanical complexity of this new driver with advanced acoustical and mechanical modeling and design tools to achieve the required performance level. Fully scalable, the Tymphany LAT applies not only to a 12” woofer, but to a wide range of transducer sizes.

Push/Pull Benefits

In addition to the obvious benefits related to size and form factor, there are some subtle aspects to the construction of the Tymphany Linear Array Transducer that not only improve its overall audio performance, but offer important side benefits as well. These benefits include lower harmonic distortion, reduced mechanical vibration and reduced cone breakup.

A key feature of the Tymphany LAT is that it operates as a push/pull device, as evidenced by the two motors. These motors move in opposite directions, and each is responsible for actuating alternating sets of radiating diaphragms. In other words, any two adjacent small diaphragms are always moving towards or away from each other, pumping air into or out of the vent between them. This push/pull operation results in the cancellation of certain types of even-order distortion, which can arise from electrodynamic motor nonlinearities. In contrast to a conventional subwoofer, this balanced operation allows the LAT to produce very high SPLs in the listening environment without transmitting mechanical vibrations to its enclosure.

As mentioned, the radiators are connected to the diaphragms using piston rods. In total, there are six of these, made from low mass, high strength carbon fiber to keep the moving parts in near-perfect balance. So, no matter how loud and how deep the Tymphany LAT is playing, the driver housing exhibits very little mechanical vibration. Even if a 110 dB bass line is played, vibration is negligible. This means that the Tymphany LAT won’t disturb critical circuitry in a Flat Panel TV (FPTV), even at very loud acoustic outputs. The Tymphany LAT can be assembled into speaker stands as a subwoofer without bouncing the speakers off; when used as an in-wall sub, it will shake the air without pounding the wall.

The reduction in cone breakup comes from the fact that multiple smaller diaphragms exhibit greater rigidity than one large diaphragm. To assure stability, each of these small radiators is driven by three piston rods, distributed over its surface for a more uniform application of driving force. The gain in stiffness and rigidity allows these small diaphragms to be very light, more than compensating for the added mass of the connecting rods. In fact, the total moving mass of a Tymphany LAT is usually somewhat lower than an acoustically equivalent conventional woofer.

Technical Details

A Tymphany LAT contains two motors that may be wired in series or in parallel, or powered independently with a mono signal. Each of the two motors directly actuates a special coupling diaphragm connected to the voice coil. This coupling diaphragm in-turn connects to three piston rods, which together form the central structure of each of two moving “trees”. Alternate radiating diaphragms connect to each tree. This means that each of the diaphragms has six rods passing through it. Three of these rods are connected to the diaphragm, while the other three rods pass through contact-free, tight tolerance holes, and connect to the next unit. So, as the motor coils move in opposite directions, so does each pair of diaphragms, squeezing the air in and out through the side vents in a highly efficient manner.

Because the Tymphany LAT is a type of high efficiency air pump, it works best in the bass and midrange regions. Just like a normal speaker, it forms a front and a rear pressure wave. These waves must be dealt with using traditional enclosure means: sealed, vented, transmission line, etc. All the vents on one side of the device will be in-phase, and so the mounting flange attaches naturally to a baffle separating the front and rear waves of the driver.

Conventional small-signal design tools will model the Tymphany LAT accurately at low frequencies, and the electrical load presented to a driving amplifier or passive crossover network is not unusual or demanding. Tymphany LAT systems are modular and scalable in size, and may be designed with flexible combinations of small signal parameters in order to adapt to specific customer applications.

Applications

The Tymphany Linear Array Transducer can bring subwoofer-grade bass capability to product sizes and shapes never before possible, revolutionizing space-sensitive products such as FPTVs, automotive audio systems, home theater systems, portable pro audio speakers, external personal computer speakers, and in-wall sound systems. Small versions may be considered for

applications that would normally require a single 6.5” woofer, while single larger versions can exceed the combined output of many 12” woofers.

Summary

Tymphany believes the transducer described in this paper represents a real and practical step forward in the “more bass, less space” race, with real benefits such as:

- Tubular form factor for efficient new product design possibilities
- Up to 300% bass density benefit over existing technology
- Low distortion and high output capability
- Readily scalable from smaller than 2”x6” to over 12”x36”, representing equivalent woofer sizes ranging from 6.5” to multiple arrays of 12” (and beyond)
- Low mechanical vibration, even when driven hard
- Electrically similar to normal electrodynamic drivers
- Highly flexible size and operating parameters that can adapt to most applications

