

The Statement

Genesis:

10 years ago I met Mark Thoke at the Studio Café, and when he asked me what I did I told him that I was a speaker designer, who designed speakers for the Hi-Fi market. He proceeded to tell me that most of those speakers could not play loud enough to really reproduce live music, but recently he had heard a speaker at the AES show that truly impressed him. As he began to describe this speaker to me I realized that it was my very own creation, and we became fast friends from that day forward.

I have been very fortunate to have had some excellent mentors in my time, and two of them had mentioned to me how they had been impressed with a large coaxial loudspeaker. For Laurie Fincham it was the Tannoy 15-inch coax, and for Ed Long it was the Altec 604. I remember that both of them said the same thing, "That impressed me." Well....., that impressed me and it also impressed Mark since his father passed him down a pair built in the 50s.

After working as an OEM for the Tannoy Company producing amplifier modules for their AMS line of powered speakers, I too became impressed with the dynamic capabilities of these speakers and their excellent imaging.

There was one area where the speakers seemed to lack, and that was the very top end. I had been exposed to the beautiful top end of the TAD (technical audio devices) line of compression drivers, and so it seemed natural to marry the best high frequency reproducer to the best woofer.

So, in short, this is what we have created, a loudspeaker made from the finest drivers in the world, assembled into a very quiet cabinet, and built with state of the art electronics. It is capable of reproducing subtle detail and stunning dynamics with "you are there" imaging. In this paper I will outline some of the technical reasons we chose these drivers, and describe the philosophy of the design. The philosophy is based on what has been proven to work, with no regard at all to what is currently trendy or fashionable.

General Design:

The speaker is a three way powered loudspeaker with internal amplifiers and an electronic crossover. In this section I will endeavor to explain why the powered loudspeaker is superior. Let's start with the bass. All speakers have an acoustic frequency response that is a high pass filter. For the passive speaker designer there is little he can do to change that response after choosing the woofer, the box, and perhaps the tuning frequency. The powered loudspeaker designer has an additional degree of freedom. He can boost the bass as it begins to roll off and extend the flat portion of the audio response by an impressive amount. This is simply not practical with conventional speakers. On the top end as well, if the response of a tweeter is falling in the top octave the only thing a passive speaker designer can do is attenuate the lower nine octaves, in order to let the response come back up in the top octave. This is a high price to pay for a more accurate top end. So the powered speaker designer has the ability to push up and down on the

response of the speaker in ways that make the passive loudspeaker designer envious. When it comes to the crossover point, the active designer has advantages again. First let me state that there is no magic or best crossover. It is the combined Electro-acoustic response of the speaker and the crossover filters that determine the success of the crossover. The active crossover offers the designer the following advantages:

- Steeper filters are practical and repeatable
- More EQ can be incorporated
- All pass filters are practical (“all pass filters are analog delay”)
- Adjustments to suit the acoustic environment are more practical
- The speakers changing impedance has no effect on the response

I have worked extensively on both types of filters, and I can say that there is just no comparison. The Active filter is far and away the superior solution. For the latter point a little clarification is in order. A passive filter is designed for a particular impedance. If a speaker is played at a high level, the copper in the voice coil will heat up, its resistance will go up, and the filter driving it will have a less damped response. This is not a problem for the active filter.

Power amplifiers:

In my opinion a good power amplifier is strictly a multiplier. While many people are in love with the sound of their particular amplifier, I think that this misses the point of recreation of the original event. Any sound added by the amplifier was not present at the recording, and so the amplifiers used in the Statement were designed to have as little coloration as possible. That is to say that they have outstanding numbers with regard to noise distortion and frequency response. They are robust, with exceptional current capacity, adequate heat sinking and large power supplies. With low junction temperatures, the amplifiers should last a lifetime. The amplifiers consist of several small amplifiers operating in parallel. Because the noise of each amplifier is random, it tends to cancel the noise from the other amplifiers giving an impressive signal to noise ratio of 120 dB.

Since there is no opportunity to short the output of the amplifiers, there is no need to incorporate complex protection circuitry into the amplifiers. Each amplifier has its own safe area protection, and the amplifiers will never go into protection with the loads they drive.

This is a fundamental advantage of the powered loudspeaker. The designer knows exactly what load the amplifier will be driving. In contrast to this the designer of a typical audiophile amplifier is faced with loads dipping down to ½ of an ohm at high frequencies, and must therefore over design his output stage.

Speaker Wires:

They are as short as this discussion of their sound.

The Drivers:

Sub Woofer:

The 18 inch woofer that is the foundation of the Statement is a beast of a woofer with an four inch under-hung voice coil and a huge radial neodymium magnet structure. The suspension is very linear with a dual spider and a corrugated cloth surround. This allows for a linear excursion of almost two inches PTP. In fact this single woofer will move as much air as two typical 18-inch woofers.

The force factor (BL) is 24 Newton / Ampere with a DC resistance of 5.2 ohms. This gives a magnetic efficiency figure of merit (BL Squared / RDC) of 110. This is an efficient driver, and it can move a long way.

Since the structure is under-hung, the voice coil is surrounded by the same amount of metal at all times. This minimizes the changes in inductance that happen with over- hung designs and keeps the distortion low.

The cone is an ultra rigid honeycomb core designed for very high pressure and low distortion. In short this woofer is a true state of the art design.

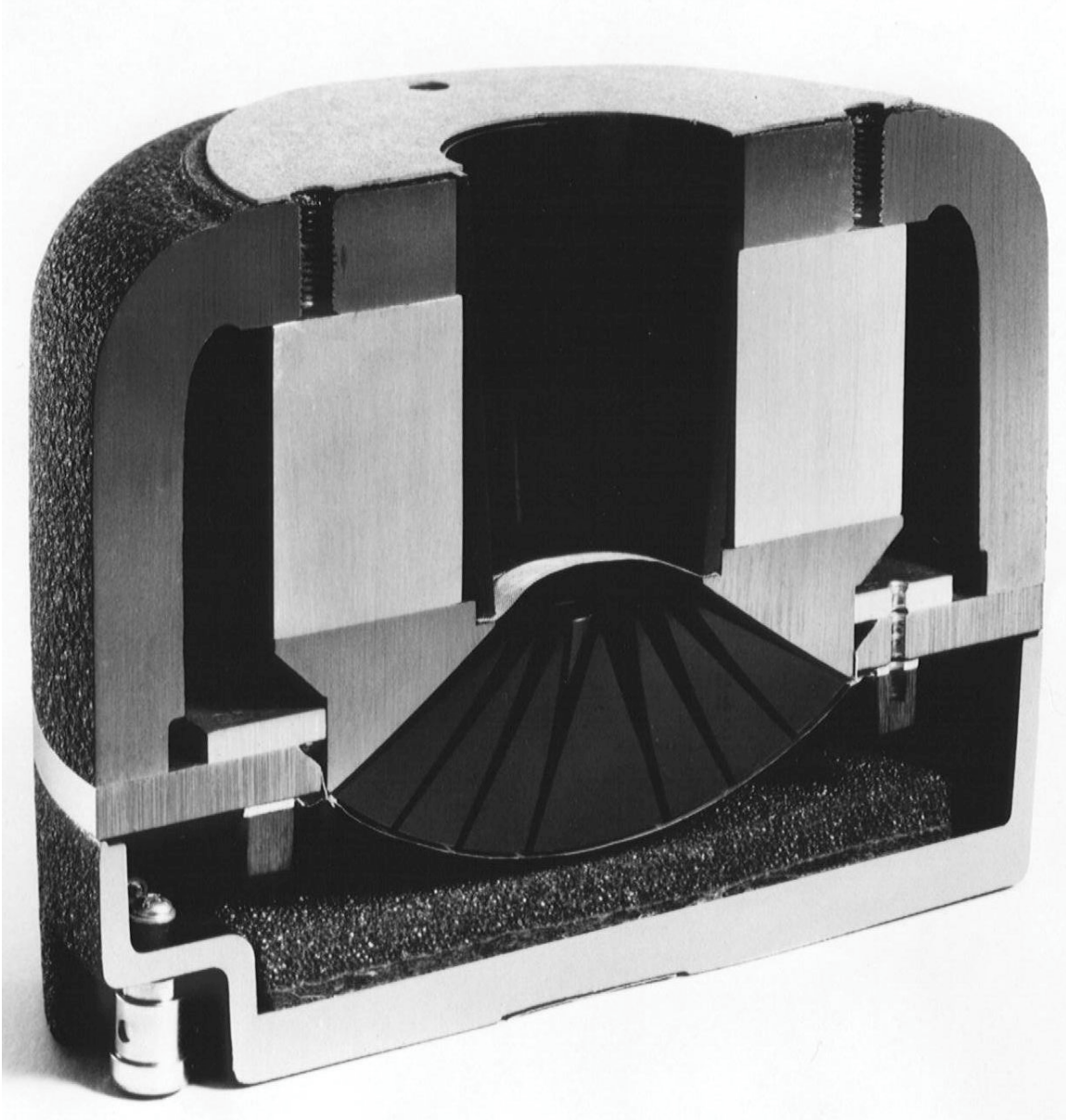
Woofer:

Over 50 years ago the Tannoy corporation started making 15 inch concentric speakers. Since then they have continually refined their 15-inch models. This is a true art in which the shape the thickness and the composition of the cone is delicately balanced to create a woofer that flawlessly covers the midrange without any major inflections. The shape of the cone is a beautiful arc that de-couples the center of the cone from the periphery at high frequencies. This allows the entire woofer to move air at low frequencies while the midrange is radiated only from the center of the cone, preserving wide dispersion of the critical midrange. This woofer is astonishingly flat from the lowest frequencies to the crossover point. I have been designing and measuring speakers for over 20 years and this 15 is without peer through this range. As with all the drivers in this design, the woofer is efficient and low distortion.

Compression Driver:

The TAD-2001 compression driver handles the top five octaves. For those who know what this is, that is enough, but for those who don't know a little story is in order. The compression driver is an amazing device that produces sound with an exceptionally high efficiency. For example the TAD 2001 produces 107 dB SPL with 2.83V (1W) @ one meter. Let's compare that to a typical dome tweeter of say 90 dB SPL. How many watts would it take for the tweeter to equal the output of the TAD? Well if we solve for a 17 dB increase we find that it would take 50Ws. This is an amount of power that the tweeter can only handle for very, very short periods of time. The TAD compression drivers were designed by the late physicists Bart Locanthi, and represent the absolute state of the art for this type of transducer. The Diaphragm is made from pure vapor deposited Beryllium. Beryllium is a very light yet stiff metal. In fact, of all the elements if you divide Young's Modulus / Density you will find that Beryllium is at the top of the list.

This means that sound waves travel faster in this material than any other. For the purpose of this discussion it also means that the first resonance of the diaphragm will be at a higher frequency, in fact the diaphragm in the 2001 behaves like a rigid piston to beyond 20kHz.



This is a cutaway of a typical compression driver. One can see the large Alnico magnet and the wedge shaped phase plug, with the diaphragm underneath. Insight into why the compression driver is so efficient can be gained by considering the mechanical mismatch between air and any mechanical diaphragm. Energy can only be transferred to the few air molecules in the vicinity of the diaphragm, but in a compression driver this number is greatly increased by compression. As the diaphragm moves in the tiny space between it and the phase plug high pressure is created. Typically a compression driver operates at a 10 to 1 compression ratio, and this accounts for its high efficiency. The huge magnet and light diaphragm also help. The purpose of the phase plug is to have an equal path length

from the every point on the diaphragm to the top of the driver. By using a huge magnet and a tight magnetic gap, the pole tips can be very well saturated, further reducing distortion. The center pole of the 2001 is capped by a ring of pure silver to prevent any increase in impedance (and resultant distortion) at high frequencies. In fact, it is low intermodulation distortion, that distinguishes the TAD compression drivers from their competition. Inter-modulation distortion in TAD drivers is typically 20 dB lower than in other compression drivers, and so much lower than typical dome tweeters that comparison is silly.

What this translates to in terms of sound is just incredibly lifelike dynamic sound that never suffers from compression, and never sounds strained even with a loud cymbal crash. In my experience there are no dome tweeters that even approach this type of reproduction.

Electronics:

The electronics in the Statement rely heavily on operational amplifiers (op-amps). These are the basic building blocks of active filters, and the quality of the op-amps has a direct bearing on the quality of the sound. The statement uses the new state of the art audio op amp from National Semiconductor the LME49860. The 49860 is able to drive 600 ohm loads with .00003% THD, it works with +/- 22 Volt rails, and is incredibly quiet. These performance specifications have allowed me to build a crossover that has a superior dynamic range to that obtainable with DSP.

The electronics are pure state of the art analog. There are no switching amplifiers or regulators. The PCBs are four layer with heavy 2 ounce copper foils. Selecting capacitors to a tolerance of less than 1% creates filters of very high accuracy. This is very important in that it ensures that the phase response of the speakers is very well matched. This matching contributes to the precise imaging of the speakers. In fact even with the very complex filters in the Statement, the crossovers match each other to within .1dB.

Many of the components in the filters are composed of multiple resistors to insure a low sensitivity. This means that the filters will not be sensitive to the slight variance in the components. The capability of the op-amps to drive low impedance loads allows lower values for the resistors, and this translates into very low thermal noise. This is a truly state of the art crossover system.

Cabinetry

The cabinet in a high-end speaker is an extremely important piece of the puzzle. Any output from the cabinet walls smears the imaging and degrades reality of the sound illusion. We have chosen a sealed alignment for the Statement after experimenting with vented alignments. Any speaker this large will suffer from standing waves inside the box

unless it is filled with damping material as it is in a sealed speaker. The sound of the sealed speaker has much less group delay, and is notably tighter in the bass.

The Statement is constructed with thick panels damped with bituminous material. The cabinet is extensively braced and the drivers themselves are de-coupled from the main cabinet. Every effort has been made to reduce the output from the cabinet walls to an insignificant level. The result of this effort is a speaker that images like a mini monitor, but whose output capability is enormous.

The Statement weighs in at 430 pounds, providing an excellent mechanical ground for the drivers and producing vanishing amounts of cabinet vibration.

The System

The Statement is an amazing loudspeaker. It has the phenomenal extension in the bass and high frequency response beyond the limits of human hearing. It is very flat and accurate through the critical midrange, and the time coherence of the woofer and tweeter are excellent. Since it is a co-axial design, the time accuracy of the speaker is maintained off axis.

The ability to reproduce dynamic events in music without a sense of strain is a characteristic of this loudspeaker that is awe-inspiring. A live drum kit can be reproduced at live levels with impact and realism that must be heard to be believed. We set out to build a loudspeaker that sounds accurate and can recreate the sound of live events, (from intimate quartets to dynamic orchestras.) I hope you will take the time to listen to the Statement, I think that you will agree that we have succeeded fabulously.

Jim Rush