WHAT ARE THE CHARACTERISTICS OF THE MOST TECHNOLOGICALY ADVANCED HIGH-ENERGY TRANSDUCER EVER CREATED?

WHAT FOLLOWS IS A COMPREHENSIVE SET OF OBJECTIVE CRITERIA THAT ALL HIGH-END LOUDSPEAKER MANUFACTURERS SHOULD BE ADDRESSING IN THEIR DESIGNS. IN THIS PROJECT IT IS OUR GOAL TO IDENTIFY AND SATISFACTORILY RESOLVE EACH OF THESE ISSUES.

FURTHERMORE WE HAVE TASKED OURSELVES WITH ACHIEVING EACH OF THESE GOALS THROUGH OBJECTIVELY VERIFIABLE METHODS.

THE CONTEXTUAL MINDSET WE HAVE FOLLOWED IN ARRIVING AT A SOLUTION TO EACH INDIVIDUAL PROBLEM IS THAT PHYSICAL WAVE PHENOMENA, WHETHER OPTICAL, MAGNETIC, OR GRAVITATIONAL, ALL FOLLOW THE SAME LAWS. FOR EXAMPLE, MAXWELL'S PARTIAL DIFFERENTIAL EQUATIONS ARE NOT ONLY THE FOUNDATION OF ELECTRODYNAMICS, BUT ALSO OF FLUID DYNAMICS, AND IN TERMS OF TENSOR FIELDS ALSO GOVERN GRAVITATION AND SPECIAL RELATIVITY. IN OTHER WORDS, IT IS POSSIBLE TO FIND A SOLUTION TO EACH OF OUR TECHNICAL CHALLENGES THROUGH RESEARCH INTO IMMUTABLE PHYSICAL PRINCIPLES.

WIDEST POSSIBLE BANDWIDTH WITHOUT DISTORTION

Flat response between 16Hz and 50 Khz. (-3db points 12Hz and 72 Khz)

NO PHASE ERRORS

A new family of filter topologies developed exclusively for this project based on classical all-pass phase networks. These proprietary networks are more phase coherent in the cross band between drivers (minimum ripple) with lower output in the stop-band. Transducer phase coherence is vastly more complex than the elementary alignment of drivers in space according to their acoustic centers. Generating smooth lobing patterns in 3-dimensional space requires blending of 2π to 4π radiation patterns with the intrinsic lobe output of the electrical network. Our proprietary networks maximize phase coherence by taking into account the variable radiation area of the piston, inter-driver distance, and frequency at which the drivers cross. These new formulas dictate that driver filters will be idiotypically different within the array.

Phase in this regard includes all distortive effects that compromise the presentation of time in a recording. Digital audio engineers are acutely aware of the bandwidth and transient response compromises inherent in brick-wall filters vs. more sophisticated methods. The passage of time is an absolute constant; loudspeakers distort or destroy this invariant quantity more than any other component in the audio chain. Most loudspeakers do this poorly while some ignore the existence of time entirely.

NO GROUP DELAY DISTORTION

No phase errors are acceptable in the last octave between 32Hz and 16 Hz.

The goal of no low frequency phase errors and bandwidth below 16 Hz is not achievable with a vented box (phase deviation below cutoff frequency of the port) or a sealed box (impossible to generate low extension at full power without excessive rear cavity size). The only viable solution given the previous design constraints is a transmission line, bringing its own set of problems to be solved. Ripples in the pass-band that obscure midrange harmonic structure must be eliminated. Aperiodic tapering and internal standing wave control are critical. The best musical blending of the TL with mid-bass frequencies was achieved through our implementation of tempered scale tuning. The **twelfth root of two** or $\sqrt[12]{2}$ is an algebraic irrational number which circumscribes the frequency ratio of a semitone in equal temperament in the Western musical scale. This principle was essential in separating standing nodes within the transmission line.

In order to reach the low Q levels of the mid-bass and midrange a high Bl product system had to be created. This was achieved by designing a custom driver with specific characteristics and utilizing it in an isobaric configuration. System Q is 0.5 with

electronic manipulation of the lowest octave to give flat frequency and phase response. Electronic low pass filtering extinguishes any ripple in the pass-band before it interferes with the output of the mid-bass section. A combination of passive elements in parallel with the sub-woofer section is employed to generate a ruler-flat impedance of 5 ohms. A 2.5 Kw amplifier is directly connected to the TL of each channel within the loudspeaker.

MINIMAL INTERMODULATION DISTORTIONS

This refers to the distortion between adjacent drivers in the array. Any vibrating surface adjacent to another vibrating surface will induce distortions in the output pattern of that waveform. The solution is to use only the output of each plane in phase, extract any low level vibration from a driver not engaged in the full power output of the system and add specific physical planes to redirect uncorrelated energy. Inert physical cabinet structures are essential in achieving this goal; however no material or combination of materials is immune from vibrating. Excessive reverberations must be eliminated, while tertiary low level vibrations are harmonically integrated into the signal.

SHARP IMAGE EDGE DEFINITION WITHOUT FREQUENCY RESPONSE EXAGGERATION

Analog domain anti-aliasing filtration eliminates excessive bandwidth from related overlapping wave generators. Noise outside the stop-band must be specifically limited in order to eliminate the Moiré blurring effect at the edges of images. Proprietary analog filter technologies are applied to eliminate this effect.

MAXIMUM AMBIENCE RETRIEVAL

Most hall ambience is -20 db from the fundamental tonal structure and often as low as -60 db. Any phase noise or intermodulation at high frequencies will obliterate this information. No break-up modes are permitted in any driver, especially the tweeter; the antithesis of a soft diaphragm solution.

LOW NOISE FLOOR

Lost information within the filter network is common in all loudspeakers, hence the misguided idea that simpler networks are better. Poor components will exacerbate these losses in complex circuits. Our solution has been to create proprietary precision elements. These are low-loss components with specific time constants (known number of micro seconds of storage time), precision resistance (no temperature dependent changes in resistance), and low hysteresis (minimized self-inductance and low DC resistance through a wide bandwidth). With these component elements it is possible to design complexity into the circuit, conferring significant electrical control over driver output; this would be impossible in a simplistic crossover.

MAXIMIZED DYNAMIC HEADROOM BY ELIMINATION OF CURRENT SATURATION EFFECTS

Pioneering technology in inductor and core design makes possible 10x the current spike within the device before saturation effects are present.

MAXIMIZED TRANSIENT SPEED THROUGH CONSTANT Q AND VANISHINGLY LOW HYSTERESIS

Electrical signal contouring is combined through the previously enumerated techniques with careful matching of driver Vas, Bl product, and specifically shaped and damped driver cavities to produce a constant Q design. In this instance constant Q refers to minimal transient ringing at all frequencies within the array as well as keeping the Q consistent from driver to driver. This requires a sealed enclosure in some cases and a vented or transmission line enclosure in others.

A new ceramic/honeycomb mid-bass driver was custom designed for this purpose with an extremely high Bl magnetic structure in an underhung gap for the continuation of the 0.5 Q into the warmth zone of the transducer. New radial magnetic structures are employed in the midrange and tweeter with a combination of sealed transmission lines to continue the minimal ripple transient response concept.

- *POINT SOURCE FOCUS FOR REALISTIC IMAGE SIZING WITHOUT FREQUENCY DEPENDENT BLOAT OR SHRINKAGE*
- *SMOOTH AND EVEN POLAR RESPONSE*
- *CONSTANT FIRST DERIVATIVE OF CROSS SECTIONAL RADIATION AREA*

These three criteria are intertwined. In a multi-driver array only a line source or point source driver arrangement are viable options in maintaining faithfulness to the original recorded information. The same is true for polar response. Without an open omni-directional or open-cardioid response, phase errors will enter the presentation post driver/cabinet interface. This is not solvable through room treatment. The most common solution in elementary loudspeaker design is to use first order filters without any equalization in a large complex array. This non point source approach will inevitably produce huge overblown midrange images at the front of the stage and tiny anemic images at the back of the stage. THIS IS THE MOST IGNORED LOUDSPEAKER DISTORTION and one of the most obvious.

A Smooth polar response brings evenness of image presentation across the soundstage, while careful

attention to radiation area is an added component in the previous discussion of image size. If an array is incorrectly balancing its surface area output, instruments or voices that should be small will appear large and vice versa.

PURELY PISTONIC MOTION THROUGHOUT THE PASS BAND

No driver break-up modes in the passband. No soft diaphragms that intrinsically distort phase information while coloring harmonic structures with a specific artifact. This is a holdover from incorrectly equating high-end transduction with instrument amplification and sound reinforcement. In the "players world" we are always searching for a specific sound we have in mind for our instruments and amps. The best playback transducers should be faithfully reproducing the sound (from an amplified instrument, e.g. guitar) that the musician has determined through his choices, not by adding a specific sound of our own. The colorations of various instrument amps (Marshall vs. Fender vs. Hiwatt for example) are significantly due to the exitation of specific cone modes. This is unacceptable in high-end reproduction.

We will allow no phase error or break-up within -60 db of the signal.

- *FLAT IMPEDANCE CURVE FOR EACH DRIVER TO ELIMINATE AMP-SPEAKER INTERFACE DISTORTION*
- *DAMPING NETWORKS FOR NO BACK EMF AT ANY FREQUENCY*
- *ENTIRELY NON-REACTIVE LOAD SEEN BY THE AMPLIFIER*

These three criteria are addressed through a combination of physical driver damping and passive electrical elements which cancel voice coil inductance as well as back EMF. All drivers are considered equal in this, not just the woofers. These issues are essential to the loudspeaker/amplifier interface. By providing a benign load to the amplifier the best (and worst) qualities of the amplifier will be easily heard. We are all aware of loudspeakers that sound quite the same regardless of the amplifier or front-end driving them. This blunt instrument approach is antithetical to our goal.

TOTAL ENERGY RADIATION IS CALCULATED OVER THE ENTIRE SURFACE OF THE LOBE NOT AT ONE MICROPHONE POSITION

Loudspeaker radiation patterns have intrinsic effects on distortion of the waveform being generated as well as in-room distortion effects from the loudspeaker interacting with the room itself. Judgment of waveform spread should be conducted as though measured from an infinite number of points around the transducer and integrated over the entire radiational area. Measuring from any single point (including the listening position) will not give an accurate representation of the actual signals that impinge upon the listener.

Physically large loudspeaker arrays add another problem which is rarely considered by designers; how do we make such an imposing structure sonically disappear? Regardless of how well the initial signal from the transducer integrates with the listening environment, when energy returns from the room boundaries to the loudspeaker cabinet, it will be "seen." If a refrigerator shaped box is added to a room, even without making a sound of its own, it will be heard. Only by carefully designing a "stealth cabinet structure" through reversal of the radiation concepts discussed above will a large array sonically disappear in a listening environment.

More than 20 years of dedicated research into the specific physical and electrical phenomena of transduction has provided the foundation for our incomparable line of loudspeakers. Never before have all of the previously discussed qualities been incorporated into a high-energy audio transducer. We have named this culmination of research, design, and aesthetic balance **TESSERACT** - a four dimensional hypercube or more metaphorically, an extra-dimensional object that has been projected into our 3D world.