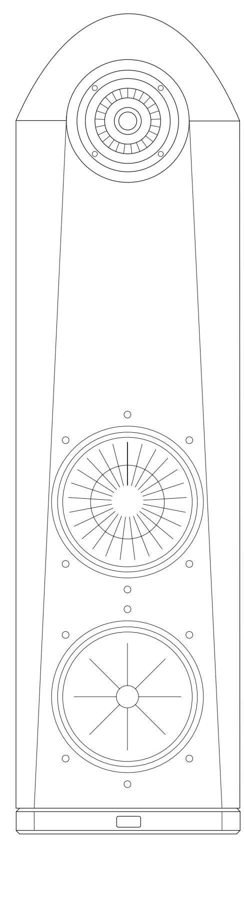
Supplemental Technical Information for model

THIEL CS3.7

Coherent Source® Loudspeaker

This paper contains only information specific to the CS3.7 speaker system. It is intended to supplement the general technical information paper which explains our engineering philosophy, goals and techniques.

This advance copy contains only technical information about the unique midrange driver used in the CS3.7.



NEW MIDRANGE DRIVER

The most important reason for the improved sonic performance of the CS3.7 is its new midrange driver. This driver was developed to solve two problems that otherwise exist in midrange performance – diaphragm resonances and tweeter interference. Before explaining the new solutions I will review the problems that have been addressed by the new design.

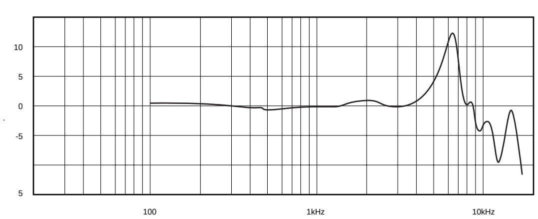
Review of the Basic Problem

Drivers produce sound by moving their diaphragms in and out following the waveform of the input signal. Ideally, the diaphragm moves as a whole, every point moving the same as every other point. This is called “piston” movement. All diaphragms achieve piston operation at low frequencies but as the frequency increases a point is reached where the movement of the diaphragm “breaks-up”, with different parts of the diaphragm moving independently of other parts. At these higher frequencies the diaphragm is internally resonating, meaning that it is oscillating of its own accord. These resonances cause the sonic output of the driver to “ring” at these frequencies, producing sonic output when it’s not supposed to. The resonances also cause some frequencies to be exaggerated and others to be diminished, changing the tonal character of the sounds being reproduced.

Previous state-of-the-art

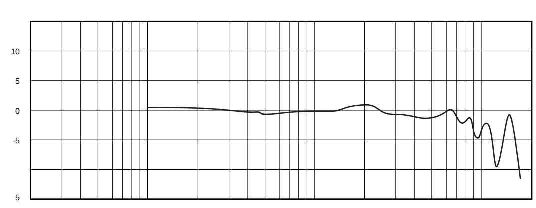
The approach that THIEL has pursued to minimize the effects of diaphragm breakup is to develop diaphragms that are stiff enough to maintain piston operation throughout their primary operating range. This is achieved by using aluminum as the material, careful engineering of the diaphragm’s shape, laminating the aluminum with styrene foam to stiffen and damp the diaphragm and the use of larger diameter voice coils. These techniques can result in diaphragms that have a much greater range of frequencies reproduced under piston operation. An example of such a driver is the THIEL CS6 midrange whose response is shown here.

Response of CS6 midrange driver



This driver exhibits exceptionally good response, with piston operation being maintained to beyond 5 kHz, almost an octave above its primary operating range of 3 kHz. In addition, the resonant behavior that is exhibited at high frequencies is much simpler than usual, basically consisting of only one resonance below 10 kHz. This simplicity of resonant behavior provides the advantage of making it feasible to electrically correct and compensate for the dominant resonance. The response exhibited after such electrical correction is graphed here. This is exceptionally wide band and resonant-free operation.

Response of CS6 midrange driver with electrical correction



The Remainder

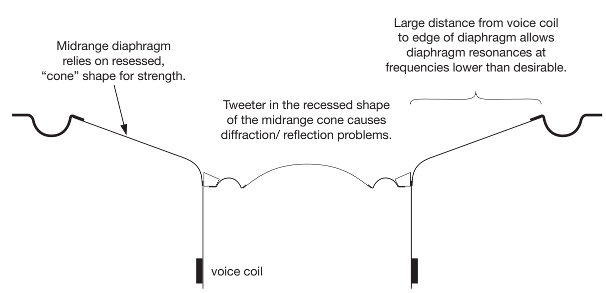
However, it is still true that what imperfections remain in the midrange performance are primarily due to the residual effects of the diaphragm resonances that do exist. And, therefore, to achieve even better performance requires further improvement in diaphragm behavior.

An Additional Problem

There is an additional problem concerning the midrange driver that we wish to address. This second problem exists only as a by-product of solving another problem (this type of situation is not uncommon in loudspeaker design). The “other” problem in this case is that of time coherence. Time coherence describes that all component harmonics of every sound reach the listener’s ears at the same time and is achieved by positioning the drivers so that each is the same distance from the listener’s ears. THIEL uses two techniques, singly or in combination, to achieve time coherence in all our products. One technique is to mount the drivers on a sloping baffle and adjust the angle of the slope and the driver spacing to achieve coherence. This can work well for floor standing speakers, especially at lower frequencies. But it cannot work for non floor standing speakers where the location of the speaker is unknown, and in any case the accuracy of the results at high frequencies becomes somewhat dependant on the listener’s position. For this reason, a better technique for time coherence at higher frequencies is to mount the tweeter coincidently (both coaxially and coplanarly) with the midrange driver. Such mounting ensures that the sound from both drivers always reach the listener at exactly the same time, regardless of where the speaker is placed or where the listener is. Such mounting also completely eliminates any “lobing” in the speaker’s radiation pattern.

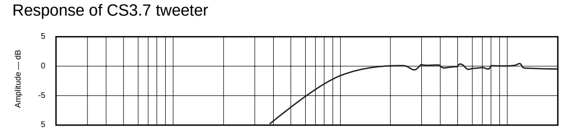
Our “additional problem” is that such coincident mounting of

Tweeter coaxially mounted in conventional midrange

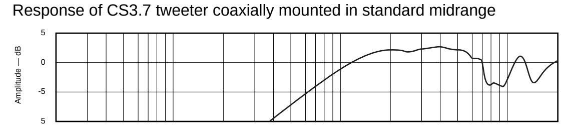


the tweeter in the center of the midrange driver alters the tweeter’s output due to reflections and diffractions from the midrange diaphragm. This effect is illustrated by the two graphs below. The first shows the tweeter response as being extremely uniform and free of resonances to beyond audibility. The second shows the response when mounted in a normal midrange driver. The detrimental alterations are clear. Even after electrical correction the response leaves room for improvement.

Response of CS3.7 tweeter



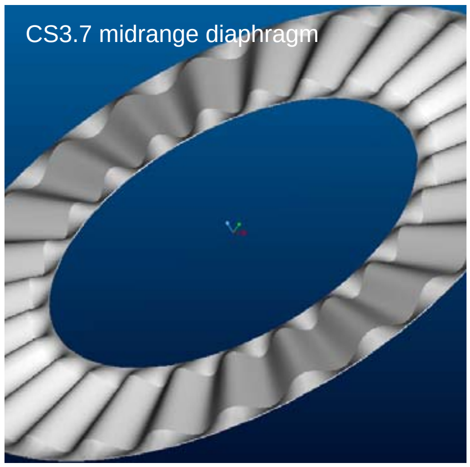
Response of CS3.7 tweeter coaxially mounted in standard midrange



A Solution

What is needed to solve both these problems simultaneously is a midrange diaphragm that is ten times as stiff per weight as the previous extremely stiff composite diaphragm while also being flat rather than cone shaped. But these requirements work against each other. The flatter the diaphragm's shape the weaker it becomes. And even with a normal shape, how can we increase the stiffness this dramatically? Even exotic materials like beryllium are not nearly that stiff, even in the traditional cone shape.

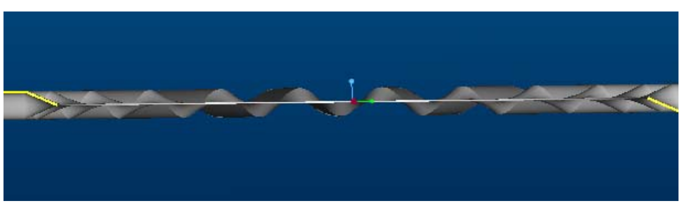
The solution we developed relies on geometry rather than a more exotic material to achieve both goals. There are several elements to the design:



• A large voice coil is used so that its force is applied at a point equally spaced between the diaphragm's inner and outer edges, rather than at the inner edge. This reduces the distance from the driving point to the diaphragm's edge and therefore greatly increases stiffness.

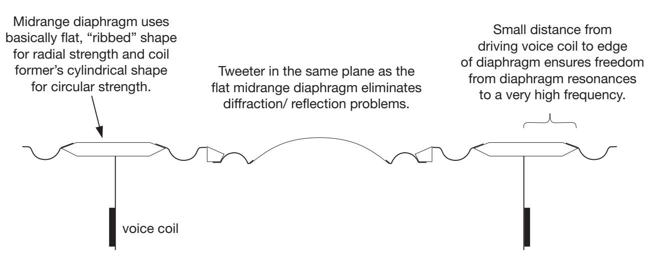
• Reliance on the great stiffness in the circular direction of the voice coil former's cylindrical shape so that the diaphragm itself is only required to provide stiffness in the radial direction. This allows the diaphragm to be formed with shapes that greatly increase strength in the direction from the center to the edge, even if decreasing strength around the circumference.

• An undulating, radially ribbed contour is used for the diaphragm which provides light weight and great stiffness in the radial direction while still maintaining a basically flat shape.



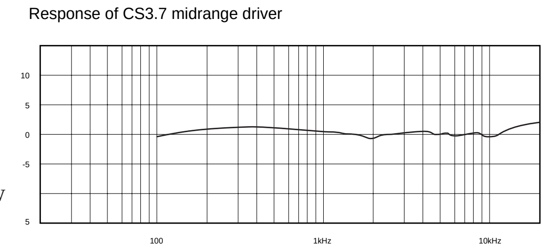
CS3.7 midrange diaphragm viewed edge-on from the center

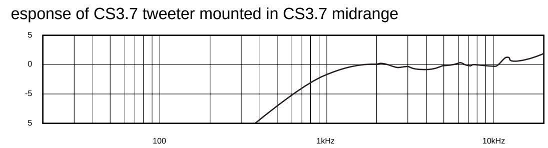
Tweeter coaxially mounted in CS3.7 midrange



Right: CS3.7 midrange parts, cw from left: Die-cast chassis, neodymium magnet, large diameter voice coil, ribbed diaphragm, copper pole sleeve

Results





The top graph above shows the response of the new midrange driver. As you can see the response is very uniform, without resonant peaks, to beyond the range of audibility. This is unprecedented high frequency performance, and in fact is better and more resonant-free response than is exhibited by many tweeters!

The next graph shows the response of the tweeter when mounted in the center of the midrange. Here you can see that the tweeter's performance is extremely uniform. This would be great performance even if not mounted in a midrange driver. When comparing this response to that of the tweeter alone (a previous graph) there is very little difference. Compared to the graph of the response in a normal midrange, the large improvement is obvious.

Other Details

There are of course many other elements to a driver than its diaphragm. Even with the two problems we have discussed solved, there are other design elements that are required to provide clean, dynamic and clear reproduction.

In order to provide very clear (low distortion) output all THIEL drivers employ copper-stabilized, short coil motor systems that produce only one-tenth the distortion of conventional motor systems. The penalty of this approach is that a much larger magnet is required to power the much longer magnetic gap. This creates a greater difficulty with this driver because the voice coil diameter is so large that the required magnet, which must be outside the coil, would be larger than the whole driver! In addition, such a large magnet would make it impossible to provide a good rear venting path for the diaphragm. For these reasons the CS3.7 midrange is powered by a neodymium rare earth magnet that is 10 times as strong per size as a normal magnet. Although this is expensive, it provides high efficiency with a large magnetic gap while allowing excellent venting.

The driver also utilizes a custom, die-cast, eight-ribbed chassis that mounts the motor system from the outside and also provides a rigid mount for the tweeter.

Other details of the driver include a copper pole sleeve to reduce coil inductance modulation, a dual surround suspension, and an aluminum voice coil.

Please see next page for photo of the complete driver

THIEL CS3.7 midrange driver with coincidently mounted tweeter
(actual size)