What is it about sealed boxes?

The Metamaterial Absorption Technology story

KEF HAS CO-OPERATED WITH ACOUSTIC METAMATERIALS GROUP TO PERFECT A PLATE TYPE BACKWAVE SOUND ABSORBER. IS THIS A SPEAKER REVOLUTION?

Moderately sized sound sources, from loudspeakers to musical instruments to humans, typically emit sound in all directions. We are so familiar with the acoustics of speech that a head-sized loudspeaker of significant quality may sound particularly lifelike because size is part of the recognisable signature of a sound source. The BBC LS3/5A is a notable example of this behaviour.

Loudspeakers employ drivers or motor units – typically with a vibrating, sound radiating cone or dome – and essentially these move to and fro like a piston. The sound pressure 'pushed forward' at the front is complemented by an equal reaction from the back, in the opposite direction. Looking at the maths, for what is technically termed a 'monopole', positive air pressure at the front gives rise to an equal negative pressure at the back. If the two pressure contributions are not separated they cancel almost to zero sound output.

Typically we put a barrier between the two contributions, which – if large and essentially flat – is a baffle, and – if moderately sized and folded round – is a box, or enclosure: this contains that reverse negative pressure component. The generally unwanted sound energy component inside the box needs to ebb away smoothly and rapidly if it is not to interfere with the overall loudspeaker performance. Otherwise it can reflect on the back of the driver cone or dome disturbing the purity of its output.

To work well in the bass a simple baffle needs to be large at perhaps 20 square foot or about 1.8 square metres. Unsurprisingly much more compact enclosed boxes are widely used, but there is a particular problem since the box constitutes a small room or enclosure. It has its own internal acoustic, a reverberation signature.

If not controlled, this acoustic will be audible in the overall output of the driver-box system as some of its signature will be heard via the loudspeaker cone as these are inevitably partially transparent to sound energy. Fibre wadding and/or acoustic foam in the box is useful to absorb these reflected, standing wave resonances but is effective only to a degree: there still remain consequences for the sound quality and also the overall efficiency.

That question of rear energy control also affects midrange and tweeter units which typically have reasonably effective compact absorptive enclosures located behind these cone or dome sound radiators.

Acoustic engineers would like the equivalent of an acoustic 'black hole', a mythical abstraction where sound is almost completely absorbed, much how light almost disappears when incident on matt black paint, or really does disappear when incident on Anish Kapoor's Vantablack pigmented artworks.

Some transmission line loudspeaker systems use a 'labyrinth' structure inside the enclosure, more or less filled with absorbent material, to suck up the major proportion of the unwanted out of phase sound energy from the back of the drive unit. If that absorption is not uniform with frequency, perhaps due to the geometry of the line, with residual reflections and standing waves, this unevenness over frequency of the now imperfect absorption will become audible as an un even frequency response, altering timbre and obstructing clarity.

In the USA, Terman published in 1940 a design for an effective if rather bulky back wave absorber,, while KEF founder Raymond Cooke also devised a line absorber for the dome mid unit of his flagship three-way Carlton of 1967.

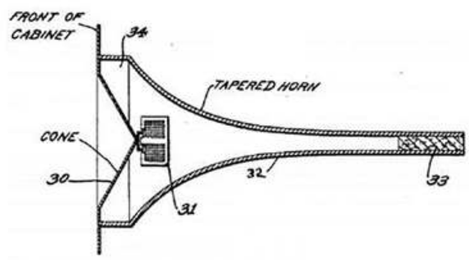

Figure 1. Terman , (1940) An example cone driver (seen on the left) with termination for the back wave, achieved with an exponentially tapered horn ending in absorptive fibrous termination. Airflow in the fibrous tangle results in resistive i.e. frequency independent damping, so back reflections are largely absorbed avoiding back box resonance colouration.

However, some new maths and physics are behind a recent development in backwave absorption. At first it was applied to radio waves, for example to build a a more compact anechoic