Designing speakers

Part 1 – The Baffle

At first sight speakers look simple, but there is hidden complexity behind all that woodwork. In this series Peter Comeau uncovers the facts and explodes the myths and shows you how to create your own home-grown loudspeaker from basic theory and practice.

Gilbert Brigg's Wharfedale SFB-3

Most DIY speaker designers start off with the assumption that all you have to do is put some drivers in a box, fiddle about with a crossover and the job is done. Perhaps that is why we see so many new speaker manufacturers hit the hi-fi market every year?

Unlike an amplifier, turntable or CD player, speakers are easy to construct. But that doesn't make them easy to design. What I want to do in this series of articles is to dispel a few myths, point out the pitfalls, and shed light on how to get started and what to look out for.

Almost everyone starts a speaker design by choosing a type of enclosure that suits the look and sound of the system they are after. As with almost everything in loudspeaker design, there are no absolutes. If you are looking for an instant answer, don't expect one here. And don't think you can look at commercial speakers or pick something out of a book to get you on your way either! It is time to make some hard and fast decisions before you start choosing your drive units.

OK, let's start with the basics (and apologies to those who already know them). There are really only four types of enclosures that you can put speakers in, though each can have subclassifications that might seem, in themselves, to be unique (but they aren't, as we shall see).

The simplest enclosure is not an enclosure at all, but it is a very useful one to consider first because of its simplicity and second because it can teach us a lot about how drivers behave when they are put on a baffle.

I am talking about Open Baffle, or OB, speakers here. You don't see them very often but an Electrostatic or Planar speaker is exactly that, an Open Baffle. Very, very few commercial manufacturers put moving coil drive units on an Open Baffle, and it is not hard to see why. The baffle is there to stop the output from the front of the cone (or panel) meeting the back and canceling it out. As the cone moves forwards it increases the air pressure in front and decreases the air pressure behind. So the sound from behind the cone is 180 degrees Out Of Phase with the sound in front and the two will cancel out where they meet so you won't hear anything at all!

Baffle - a board on which the driver sits which helps separate (baffle) the sound from the front and back of the cone. In the early days of the moving coil speaker this was all that was used. Later the board was fitted with sides and a top and bottom to extend the baffle, as you can see in early radio sets.

To stop this happening we mount the driver on a baffle board. Now the dimensions of this board are critical as it will only stop the sound from the front meeting that from the back where the board is bigger than half the sound's wavelength. If the half wavelength is bigger than the baffle then the sound stretches round the baffle to meet the sound from the back and the front and back radiation cancels out. So the baffle has to be

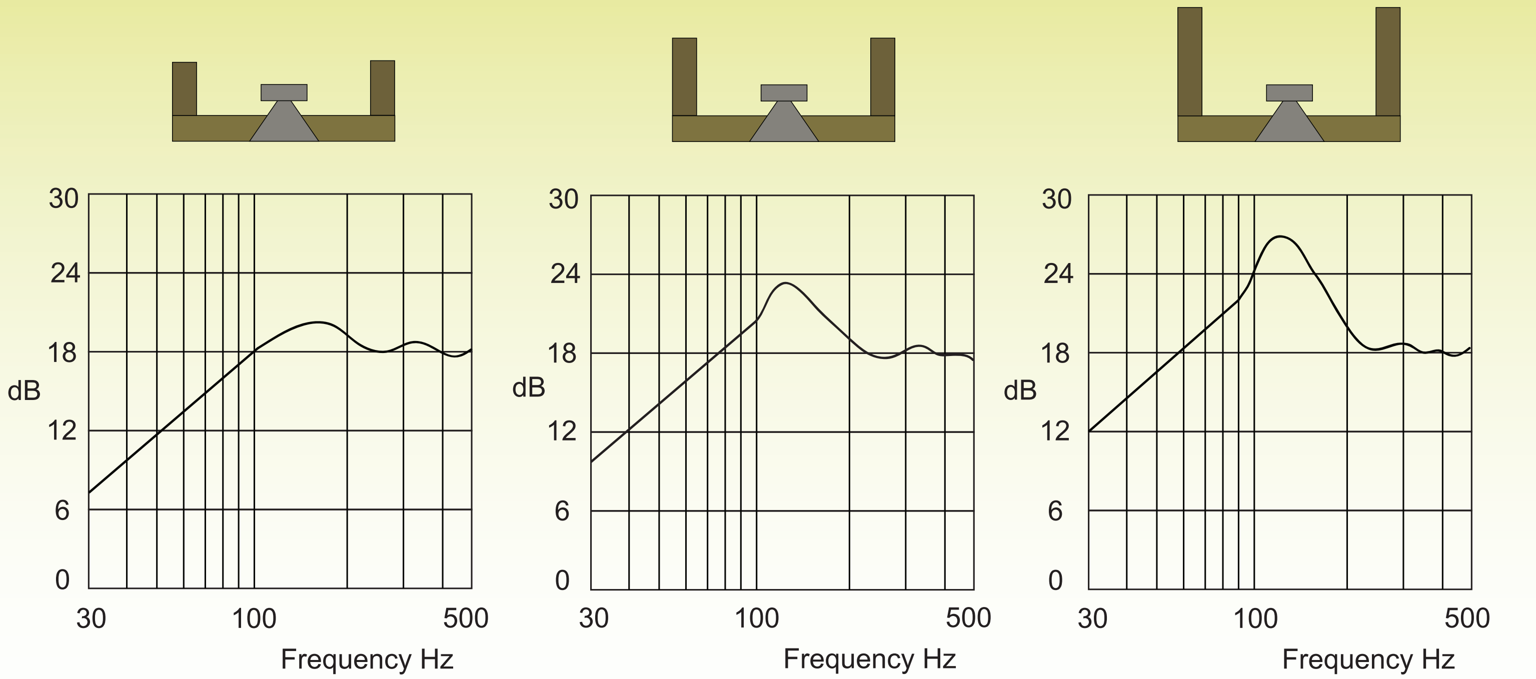

Figure1. Response of 60cm wide baffle with edges folded back showing how bass output peaks as the folds become longer.

big otherwise the bass frequencies, which have the longest wavelengths, can't be heard.

If you are worried at this stage that your electrostatic or planar speaker doesn't have a baffle board, don't be. If you think about it the speaker panel is its own baffle, and its dimensions help decide the lowest frequency that the panel works down to. And things aren't quite as bad as they seem below that frequency either, as we shall see.

If you consider that the wavelength of sound at 43Hz is 8 metres or 26.27 feet then we will need a baffle size of 4 metres across in order to maintain the output of our speaker down to that frequency. Not many people would like a couple of baffles of that sort of size in their room. What is worse the panel resonance from a large baffle can be high enough in resonance to add significant coloration to the speaker output. In a box we can control the panel resonances by bracing. An OB is a free edge panel and has much stronger resonances. We must therefore be careful to construct an OB carefully to reduce panel resonance, as in Gilbert Brigg's Sand Filled Baffle shown in the photo above.

Thankfully we don't have to go this big to make a pair of OB speakers work well in a room. That is because the baffle doesn't suddenly stop the output of the speakers dead at the half wavelength frequency. Instead, as the sound starts to diffract round the edge of the baffle, the cancellation occurs gradually, decreasing in Sound Pressure Level (SPL) at 6dB per octave.

Why did I choose 43Hz when 20Hz is normally taken as the lower limit of audibility? Well 43Hz is close to the bottom note of a bass guitar and below the frequency range of most instruments except for Grand Piano, Pipe Organ and Welsh harp which have fundamentals a little lower. Very few speakers deliver much acoustic power below 43Hz despite what they might claim.

Now, at some point below 100Hz in a real room, our speaker will start benefiting from room gain. The baffle board the speaker is attached to has some edges which are attached to the floor and, possibly, the side wall of the room. So the wall and floor extend the baffle. Taking these into account we can make the baffle much smaller than is theoretically necessary. We can also bend the sides of the baffle backwards which makes the speaker far more room (and wife) friendly.

You have to be careful about creating sides like this, however, as the baffle now starts to become a type of open back enclosure, rather like the old radio and TV sets. This can cause a peak in the bass response before it starts to roll-off, a point not missed by the radio designers who use this peak to reinforce bass output (see fig 1). The peak occurs because the enclosure is beginning to act as a pipe, with an acoustic resonance where the depth of the cabinet is a quarter wavelength long. For example a baffle with edges folded back 60cm will have a peak in output at around 120Hz. And it gets worse. There are associated peaks at odd multiples of this frequency, for example the third harmonic at 360Hz – and emphasis of frequencies this high up in the midrange is not we want to hear at all.

To get round this it is usual to taper the sides to avoid any single, audibly obvious, resonance. But remember the quarter wavelength bass resonance principle; as the old radio set designers found out, it can be quite useful. Remember too all this stuff about diffraction round the edge of the baffle because you'll be needing it when we come on to the other types of enclosures next month.