Audrey Bund, editor
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# the Advent Newsletter

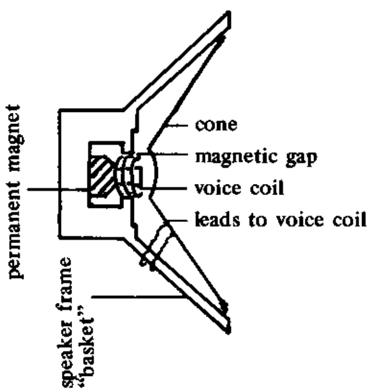
Here as promised, almost on schedule, is the second installment of the Advent Newsletter on Equal Level Speaker Presentations. In the first part we talked about one set of reasons for the need for such presentations; now we would like to tell you about the technical reasons for them.

## How a Speaker Works

Contrary to what many advertisements would have you believe, there is nothing mysterious or magical involved in speaker design. Speakers are physical objects which exist in the real world and as such they are subject to the laws of physics. These laws relate the speaker system's performance characteristics to its physical parameters in a very straightforward way. If you understand how these laws operate you will be able to tell a great deal about a speaker's performance based on its size and the claims made by its manufacturer, even before you have heard it.

## The Parameters Which Affect Efficiency

*Diagram A.*




As you know, speakers belong to the class of devices known as "transducers", which simply means that they change energy from one form to another. A speaker basically consists of a paper cone to which is attached a coil of wire. This wire, which is referred to as the voice coil, is within the magnetic field of the permanent magnet which surrounds it. When a varying electric current is supplied to the voice coil from the amplifier, an electromagnetic field is created, causing a voice coil to move. As the coil moves it causes the paper cone to vibrate, creating sound waves. While this is happening, the movement of the coil simultaneously generates a current that is opposite in direction to the input signal. The additional and opposite current created by the coil's movement is called the "back EMF (electromotive force)". You'll see why this is important a little later.

The efficiency of a speaker system is simply the measure of how effectively it converts electric energy into sound waves. Generally when people talk about the "efficiency" of a speaker they are talking about its midrange efficiency because that is where most fundamental musical information is found. By definition the range of a speaker is that portion of the frequency range over which its efficiency remains constant. In other words, when you say a speaker has a flat response from 50 to 15,000 cycles, you are saying that the speaker's efficiency is the same at 50 cycles as it is at 15,000 cycles and everywhere in between; and that below 50 cycles and above 15,000 cycles its efficiency decreases causing a loss of output. To talk about overall speaker performance we have to talk about efficiency through two important areas of frequency range—the midrange and the bass. Midrange efficiency is a function of:

$$\frac{(\text{the area of the cone})^2 \times (\text{the strength of the magnetic motor*})}{(\text{the mass of the cone})}$$

There is no simple formula we can use to define low bass efficiency; however, it is proportionally affected by the amount of EMF, the stiffness of the speaker system and the mass of the cone. These three factors are determined by the parameters which appear in the above equation. What we are now going to do is see how the variations in the mass and area of the cone, and the strength of the motor affect speaker performance. To do so let's take an imaginary speaker driver in a fixed enclosure and see what happens when each of these parameters is changed while leaving the others constant.

* The strength of the magnetic motor is determined by the magnetic field created by the voice coil and the magnet.

**Motor**

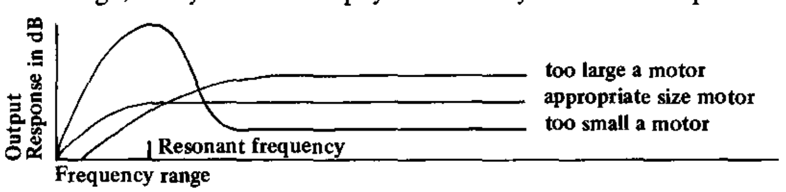
As we said before the strength of the motor is a function of both the voice coil and the magnet. For now we are going to deal only with the magnet size because that is what everybody talks about and consequently there is a great deal of misinformation circulating about the effect of magnet size on overall speaker performance.

A common assumption about magnets has always been the bigger the better. As you can see from the algebraic relationship stated above, the greater the magnet size and hence the motor strength, the greater the midrange efficiency of the system. This is desirable and probably is where the "bigger and better" came from. However, as the magnet size increases, the bass response of the system decreases, more specifically, it rolls off sooner. The reason this happens is that the bigger the magnet, the more back EMF is generated. This is not critical at mid and high frequencies, but at low frequencies where the cone makes long excursions, an overly large magnet causes so much back EMF to be generated that it begins to cancel the main signal current, and the speaker can no longer move as far, thereby decreasing bass efficiency.

If we go in the other direction and make the magnet smaller, we reduce the back EMF and thereby increase the low frequency response of the system. But, by referring to our formula for midrange efficiency, you will see that this also causes a decrease in the output through the midrange. If carried to an extreme, the back EMF will drop so low that there will be inadequate control over the movement of the cone at low frequencies. Output through the midrange will be severely depressed and there will be a large peak in the bass.

Diagram B shows what happens to the frequency response of our theoretical loudspeaker when only the magnet size is changed. As you can see, increasing or decreasing the magnet size buys you extra output through one part of the frequency range, but you have to pay for that by a loss of output elsewhere.

*Diagram B.*




**The Area of the Cone**

Referring once again to our formula you can see that the midrange efficiency increases in proportion to the square of the area of the cone. Let's imagine that as the area of the cone is increased one somehow keeps the mass constant. The changes in overall performance which result from increasing the area of the cone are very similar to what happens when the magnet size is increased: midrange efficiency goes up, but the bass response is rolled off sooner. Why a larger cone means less low bass output, if everything else is unchanged, can best be explained by making an analogy between a speaker cone and a guitar string. You probably know that the tighter you adjust a guitar string (i.e. the greater the stiffness) the higher its pitch. With an acoustic suspension speaker the stiffness of the system is a function of the proportion of the cone area to the amount of air sealed in the enclosure against which the cone is trying to move. Keeping the volume of the enclosure constant, while increasing the area of the cone, results in greater stiffness. As the stiffness increases there is a more rapid roll off of the bass response of the speaker: in a way the "pitch" of the speaker goes up. (This pitch is called the "resonant frequency" of a speaker system, and in a multi-driver system it is the resonant frequency of the woofer.)

What happens if you make the area of the cone smaller, again holding the mass constant? Low bass response becomes more extended, but you lose midrange efficiency. We should also mention at this point that a speaker's power handling capability is also a function of its area. Decreasing the area of the cone has another effect on performance in that it reduces the power handling capability of the system. It's the same old story: you can't get something for nothing. High midrange efficiency and large power handling capability can only be bought with a loss of low frequency response and vice versa.

**The Mass of the Cone**

Let's go back to the analogy between the guitar string and the speaker. The heavier the guitar string the lower its pitch. Similarly, the heavier the cone the lower the bass response of the speaker. But this time when we go back to our formula, we find that midrange efficiency is inversely proportional to mass, so the heavier the cone the less efficient the speaker through this part of the range. If we go too far in increasing the mass, midrange output will fall significantly below the bass output and we will end up with a very boomy speaker. Turning this around and decreasing the mass of the speaker improves midrange efficiency, but inevitably decreases the low bass output.

**The Volume of the Speaker Enclosure**

We'd like to sneak in a fourth parameter now, the enclosure volume. It does not appear in our original formula because it affects only the low frequency efficiency of the speaker. You may remember that the enclosure volume of a speaker came up in our discussion of the stiffness of a system, where we said that if we held volume constant and increased the cone size, stiffness went up. As you may have guessed, changing the volume also changes the stiffness of the system. The larger the enclosure volume, the lower the stiffness, which if all other things remain constant, results in an extension of the low bass response of the system. Similarly, the smaller the enclosure volume the sooner the bass rolls off. In either case the midrange output is unaffected. This is the only way in which you can change one area of the speaker's performance without directly affecting its efficiency elsewhere.

**Summing Up**

There are two *important* conclusions to be drawn from the preceding discussion. One is that knowing any single parameter in isolation tells you nothing about a speaker's overall performance. All the parameters are interrelated. For example, trying to figure out the bass response of a speaker when all you know is the area of the cone is like trying to figure out if you can go from one place to another in a car if you know how many miles you get to the gallon, but don't know how many gallons of gas you have or how far you have to go.

The other conclusion is that for any given enclosure size there is an unavoidable trade off between range, especially low bass response, and midrange efficiency. As you saw, variations in the magnet size, cone area or cone mass of a speaker system always result in an increase of midrange efficiency at the expense of low bass efficiency, or vice versa. Given two speakers, equal in size, if one is designed to optimize midrange efficiency it will not have the wide range, especially the low bass response, of the other.

## The Ideal Speaker

Taking into consideration all the parameters we have discussed let's see how we can manipulate them in designing speakers. Suppose we first of all decide to try to design a very small speaker that many people would find "ideal." This speaker would be approximately 8" x 6" x 4", so it could fit anywhere; it would cover the entire frequency range smoothly; it would be incredibly efficient, 5 watts per channel would produce ear shattering volume levels; and best of all it would cost only $29.95.

Let's assume we make our primary design decisions with low bass response as our first priority. We could keep the stiffness of the system low by using a cone with a very small surface area. To keep back EMF low and costs down we'd use a small magnet and to keep the "pitch" of the speaker low we'd keep its mass high by using a very dense cone material. If all these design choices were made, we would indeed have a speaker with an enclosure volume of less than one-eighth of a cubic foot with a range, including low bass response, that would be unsurpassed by any currently available speaker. Unfortunately this speaker would have two serious drawbacks. First, it would have a very limited power handling capability. Second, it would be *incredibly* inefficient. For our "ideal" speaker to produce the same volume levels as an Advent Loudspeaker driven by 10 watts per channel, it would need more than 100 watts per channel. Such a speaker is totally impractical and it becomes obvious that to maintain full range and achieve reasonable efficiency we have to go in the direction of "bigger."

## How Big is Big

If we were to make our speaker big enough we would not have to sacrifice anything in the way of performance. Our colossal acoustic suspension speaker would have very high power handling capabilities and the same full range as our tiny speaker, with high efficiency at all frequencies. If our colossal speaker were 5' x 4' x 3' with an internal volume of 60 cubic feet, its efficiency would be 40 times greater than that of the Advent Loudspeaker. But going to this extreme has a few drawbacks. To begin with, very few people would have the room to accommodate a pair of these speakers. And even if they were willing to dispose of all their furniture so they would have a place to put them, most people probably couldn't afford them. The cabinet, which contributes more than any other component to the overall cost of manufacture, would make such speakers prohibitively expensive for most people. The price in terms of both size and cost would make such speakers inappropriate for home use. Only in certain specialized cases would such costs be warranted.

## Making Speakers in the Real World

So here we are back in the real world armed with the knowledge that our "ideal" speaker can never exist. Improved speaker cones and crossover networks may come and go, but the laws of physics won't change. What we have to do is design a speaker that is somewhere in between the two extremes. And it is just because there are so many "in betweens" that an incredible number of speakers of different size, cost, efficiency and range exist.

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If you would like to go into the theory of speaker design in more depth and from a more technical perspective, please drop a note to me, and I will be happy to send you a copy of *Hoffman Iron Law* by Henry Kloss.

One such "in between" speaker is the Advent Loudspeaker. In light of our previous discussion we feel that the design goals for the Advent Loudspeaker can be easily understood as representing the most realistic approach we could have taken. The primary goals were:

1

A size that the greatest number of critical music listeners would find acceptable. From our previous experience in retailing and speaker manufacture we had a good idea that the maximum size which would meet this requirement was that of a large bookshelf speaker, with approximately 1.5 cubic feet internal volume.

2

To accurately reproduce the entire musical bandwidth, including the fundamental bass octave, giving the Advent Loudspeaker the same range as the best of the most expensive speakers available.

3

To make the Advent Loudspeaker as efficient as possible, concurrent with the goal of maintaining full bass response.

4

To have the power handling capability to be able to play at really loud volume levels in a large room in a home.

5

To build a speaker which would do everything we have discussed so far at a price approximately one half that of existing speakers fulfilling these same criteria.

Hopefully you can see how all goals but number 5 directly relate to the speaker theory we have discussed; and to the fact that the cost of amplifier power has dropped sharply over the past few years. Super high efficiency no longer has to be an absolute design requirement. We were able to achieve our pricing goal by using knowledge accumulated from our earlier experiences in speaker design and manufacturing, and by fully exploiting the potential of the two-way speaker design.

In designing the Smaller Advent speaker our performance goals were the same, only we wanted to achieve them in a smaller, less expensive speaker. To maintain the same range in a smaller cabinet we had to remanipulate the physical parameters of the system. The first thing we did was to make the woofer slightly smaller, but not small enough to seriously impair power handling. This in turn meant that we needed a stronger magnetic motor, so we used a heavier gauge voice coil wire. The final change we had to make was to increase the mass of the cone. What we ended up with was a speaker with an enclosure volume one-half the size of the Advent Loudspeaker, with an identical range and with slightly lower efficiency and slightly more limited power handling capability. For the consumer who cannot afford either the cost or the space for the Advent Loudspeaker, the Smaller Advent Loudspeaker is the only alternative. It allows him to buy a system, in the $400 range, for use in medium sized or small rooms, which will reproduce the entire musical bandwidth.

Other speaker manufacturers have chosen design goals which are different from ours and of course we can't quarrel with their decisions. If you want to find out what choices they have made, in comparison to what we did, it can be easily done by comparing their speaker to ours at **Equal Volume Levels**. We have now come full circle, and in doing so we hope you now fully understand not only how to do a proper speaker comparison, but, equally important, why it is necessary.