Magnets and Field Coils

THE TECHNOLOGY BEHIND MAGNETS AND EXPERIENCES OF THE FIELD COIL APPROACH

"the field coil can sound better, more delicate, and 'sweeter' to the ears, though it is indisputably married to the drive unit in which it is used."

There was a time when permanent magnets were very weak and expensive. So much so that when the now ubiquitous 'mass controlled' flat response moving-coil cone loudspeaker was invented in the early 1920s, the fixed magnetic field (against which the varying magnetic field generated by audio signal currents in the coil can react to shove the cone about), was generated by direct current flowing in a large stationary copper coil, integral with the iron parts of the driver.

This is wire-wound-on-a-nail stuff, connected to a battery; in essence it's a Victorian solenoid or electromagnet. In loudspeaker parlance it's called a field coil, and when connected to a suitable direct current (DC) supply, it generates the powerful fixed magnetic field. This magnetism is conducted by iron parts, poles and armature to the precision clearance radial gap in which the moving-coil resides and moves axially.

Electromagnetism defines the force directed to the moving coil as a product of the length of wire in the gap '*l*' (calculated from the coil circumference and the number of turns of wire in the gap), the current flowing '*I*', and the magnetic field '*B*' in Teslas. Simply *BlI*.

Those resultant forces on the moving-coil translate into cone displacements, hence vibrations that couple to the air resulting in sound. We assume that the coil current is a linear audio signal supplied by a good amplifier. We can also be assured that this current supply may be low distortion and linear assuming good amplifier quality. However, that is not enough to ensure a linear acoustical or sound output. At low frequencies, where the coil is undergoing substantial movement, some distortion will result from the inexact relationship between the moving coil and the magnetic force distribution in the magnet gap. In addition the cone suspension will also be working harder with less linear travel at lower frequencies.

But aside from these matters, another mechanism which can affect the overall reproduced sound is the intrinsic quality and the dynamic characteristics of the magnetic field itself. The immutability of a magnetic field is not a given. Now if a field coil winding was used alone, this would be largely true, but such an approach suffers from so much magnetic flux leakage that the speaker would be too quiet and would also run very hot. Iron parts are needed to concentrate and focus the available magnetic flux into the coil gap more efficiently, and it is those parts, chosen for their high magnetic permeability (*ie* their ability to be strongly magnetised) which can also affect the sound. The quality of the iron or iron alloys used – and whether they are operated saturated with magnetic flux (in the plateau section of their B-H curve, which maps induced *vs* applied magnetic flux), or are lower down the slope of the 'magnet curve' – will affect the amount and kind of distortion which results.

Permanent Magnets

A variety of permanent magnets of different 'strengths' are available today, ranging from natural ferrite lodestones to traditional magnetised iron, ceramic or ferrites, Alnico, Ticonal, samarium-cobalt etc. However, in recent years samarium-cobalt has faded due to its high cost and has been supplanted by a more powerful, less costly and more versatile sister rare-earth material, neodymium-iron-boron (NdFeB), invented in 1983. This has resulted in energy products climbing from 28 MGOe to 45 MGOe, equivalent to a ten-fold increase in available magnetic energy. New applications have consequently emerged, and the resulting assemblies may also be very compact.

All these types may be used in a variety of complementary magnet geometries, all aspects of which can subtly affect distortion and therefore sound quality in loudspeakers. Different geometries affect the flow of leakage flux, alter induced eddy currents flowing in the metal parts of the operating driver, and may have subtle characteristic sonic effects, such as a thinning or brightening of timbre, together with less expressive dynamics, and perhaps a more 'mechanical' sound.

The way the 'iron' parts are shaped, and whether copper rings or similar eddy current reducing devices are fitted, will affect the distortion and output at different frequencies. Skilled designers carefully blend all these variables to provide what they feel is the most musical and natural sound, taking into account other factors such as diaphragm characteristics.

Field Coils

Nevertheless the field coil type is inherently simpler and 'cleaner' than permanent magnet loudspeakers with their differing but characteristic B-H curve 'signatures'. So, the field coil can sound better, more delicate, and 'sweeter' to the ears, though it is indisputably married to the drive unit in which it is used.