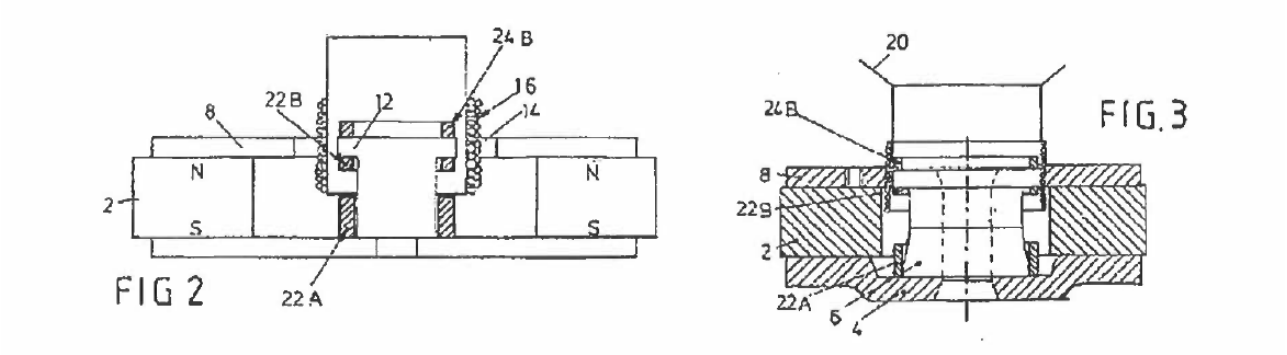
# "Symmetric Drive" SD-System explained

In 1993, Scan-Speak A/S filed a patent application for a magnet system with three Faraday rings. See the following image from the patent application, showing one possible positioning of the rings:




The original SD concept is based on an electrically conductive extended cap (typically copper), as described and patented by Ragnar Lian, 1972, then working at Scan-Speak, and presented in AES papers in 1974 and 1988. Prior to this a copper cap had been used by others, e.g. Philips.
The tenet behind SD (Symmetric Drive) is that it became evident that the voice coil inductance should not just be lowered, but also made - if not constant - then at least symmetric around the rest position of the voice coil. When the behavior is symmetric, second harmonic distortion is minimized.

Qualities achieved when conductive material is placed in the area of the voice coil and air gap:

1. Lower inductance - more output at high frequencies (faster ''rise time" for the voice coil).
2. Less inductance modulation (Le(x) and Le(i)), reducing amplitude modulation distortion and intermodulation distortion (from asymmetry).
3. Better protection of the magnet from the magnetic field generated by the voice coil, stabilizing the working point of the magnet, reducing modulation of the static magnetic field and hence harmonic distortion.
4. Better protection (shielding) of the steel parts (when covered by the copper cap) from the magnetic field generated by the voice coil (iron distortion), reducing hysteresis losses and eddy current losses, reducing phase distortion.

Ragnar Lian realized that a flux-stabilizing ring (a faraday ring) has good effect at stabilizing the magnetic field at lower frequencies. If the ring is located away from the magnetic gap, its effect at higher frequencies is limited. The magnet working point is stabilized by this solution. Iron distortion can be reduced by reducing the amount of iron around the voice coil - and by running the iron well saturated. Ragnar Lian comments that this is the expensive way. (Iron distortion is a term that embraces hysteresis and eddy-currents).
It is desirable to make the voice coil inductance independent of the current in the voice coil as well as the voice coil position (Le(i) and Le(x)).

Additional qualities when the conductive material is positioned for symmetric inductance can be:

1. Even less inductance modulation (Le(x) and Le(i)).
2. Minimized second harmonic distortion at the voice coil.
3. Less DC offset of the voice coil is generated, reducing harmonic distortion further.

Additional qualities when applying rings that do not take up space in the air gap:

1. Smaller air gap, with higher flux intensity and lower magnetic reluctance in the circuit, providing a more efficient magnet system.
2. More conductive material in the short circuit ring gives better effect at lower frequencies and at higher power.

The copper cap solution (or other materials which are also electrically conductive) has a certain resistance, which means it has to be very long and/or very thick, to reduce the DC resistance of the copper cap and thereby prevent saturation. When the copper cap reaches its limits, it will saturate and distortion effects show up. It is necessary to proportion the copper cap so that saturation appears at the highest possible power level, or at least sufficiently high that the distortion is not significant compared to other causes of distortion.

The second generation SD-System patent, sometimes named ***SD-1***, describes a solution with 3 copper rings. This solution is both economic and very efficient in terms of obtaining the goals mentioned above.

The SD-1 patent is implemented in some of our later Classic woofer/midwoofer designs and in all our Revelator woofers and midwoofers.

## *The SD-System versions:*

| | |
|---|---|
| SD | The original solution with a cap on the pole piece |
| SD-1 | The solution with three rings on a woofer magnet system |
| SD-2 | The solution with caps (SD) in a tweeter magnet system |
| SD-3 | The Illuminator underhung magnet system |

References:

Ragnar Lian: Linear and Non-linear Time Delay Distortion in Loudspeakers. AES paper A-4, presented at 47. AES convention 1974

Ragnar Lian: Distortion Mechanisms in the Electrodynamic Motor System. AES paper 2572, presented at 84. AES convention 1988.

*Denmark: PRI 76300*
*Germany: DE 44 93 008 B4*
*GB patent: 2.292.651*
*US patent: 5,815,587*