final

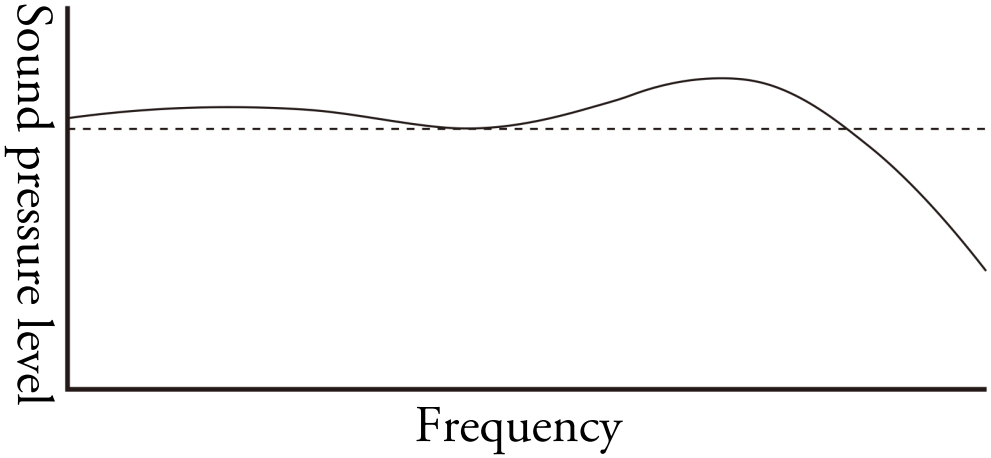
Why Planar Magnetic Headphones with Air Film Damping System (AFDS)

01

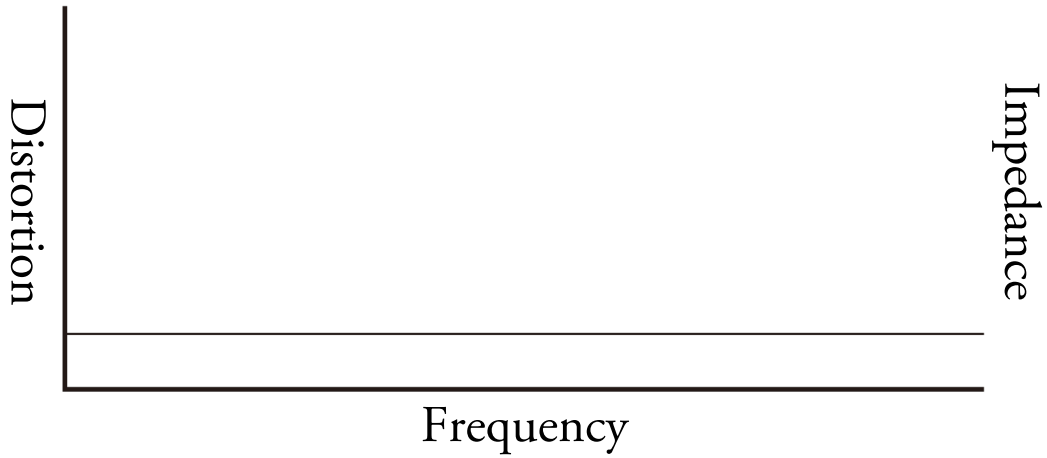
Toward the ideal headphones

01 Toward the ideal headphones
What is ideal characteristics of headphones

Frequency response
human hearing perceives as flat



Distortion / Impedance response



- Measurement result does not show a flat response like a speaker due to the morphological influences by a pinna and an ear tube.

- Distortion : Smaller the better
- Impedance : Should be constant over the entire frequency range

01 Toward the ideal headphones
Comparison of different types of headphones

	Planer Magnetic Drivers	Electrostatic Drivers	Dynamic Drivers
Ideal frequency response	★★☆	★★☆	★★☆
Ideal frequency response	★★★	—	★☆☆
Low distortion	★★★	★★★	★★☆
Delicate sound at high frequencies	★★★	★★★	★★☆
Natural bass sound with richness and openness	★☆☆	★★☆	★★★
Remarks	Issues the products in the markets have can be solved, which are the volume and quality of low frequencies sound.	Principally, the richness of low frequencies sound is missing. Need an exclusive unit to provide high voltage to the plates.	Principally, it is difficult to make the diaphragm lightweight to produce the delicate sound at high frequencies.

Which driver unit is suitable for the ideal headphones?

01 Toward the ideal headphones final's decision

Electrostatic and dynamic driver units principally have the insoluble issues.

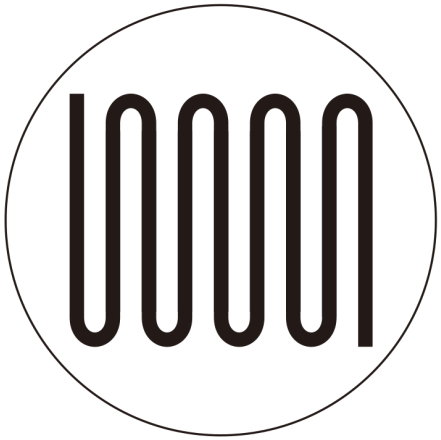
We use the Planer Magnetic divers. Aim for producing the natural bass sound with richness and openness.

02

Conventional Planer Magnetic driver units

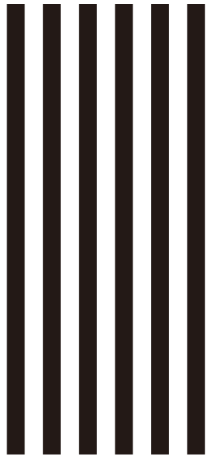
02 Conventional Planer Magnetic driver units System

Planar 1.0



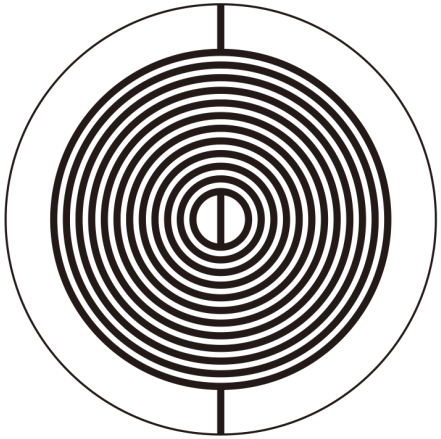
Diaphragm with a zigzag coil

+



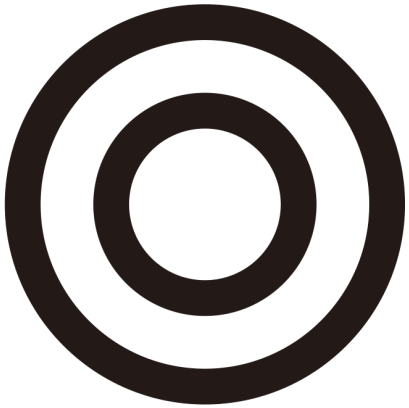
Columnar-shape magnets

Planar 2.0



Diaphragm with a spiral coil + corrugation

+

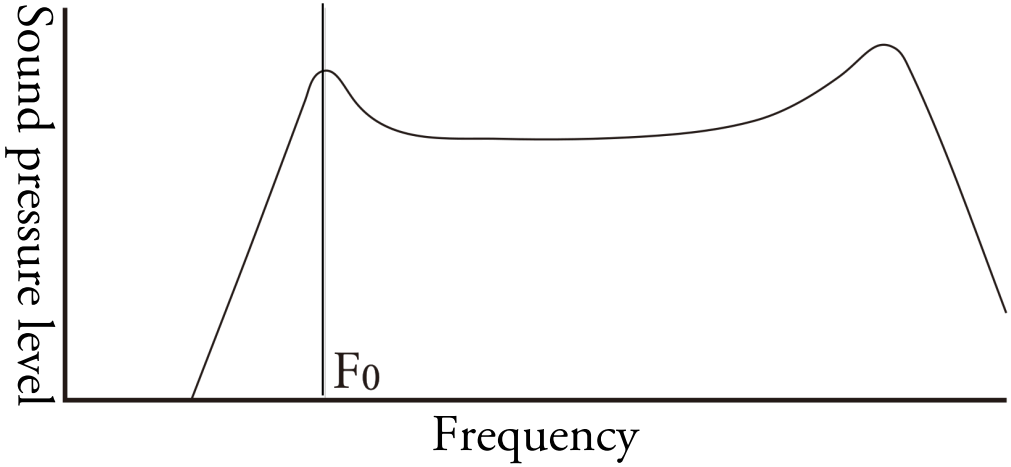


Doughnut-shaped magnets

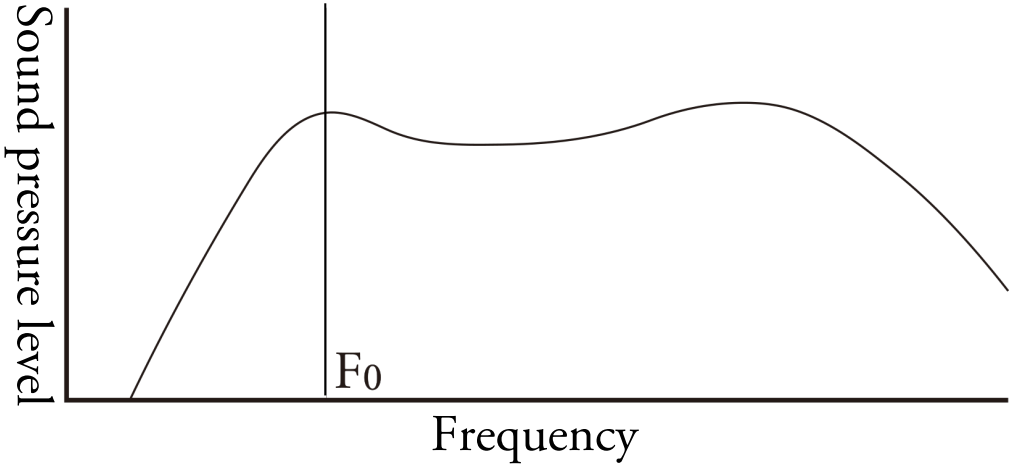
Both systems has a same motion principal.

02 Conventional Planer Magnetic driver units
Characteristics

Characteristics of a driver without a housing

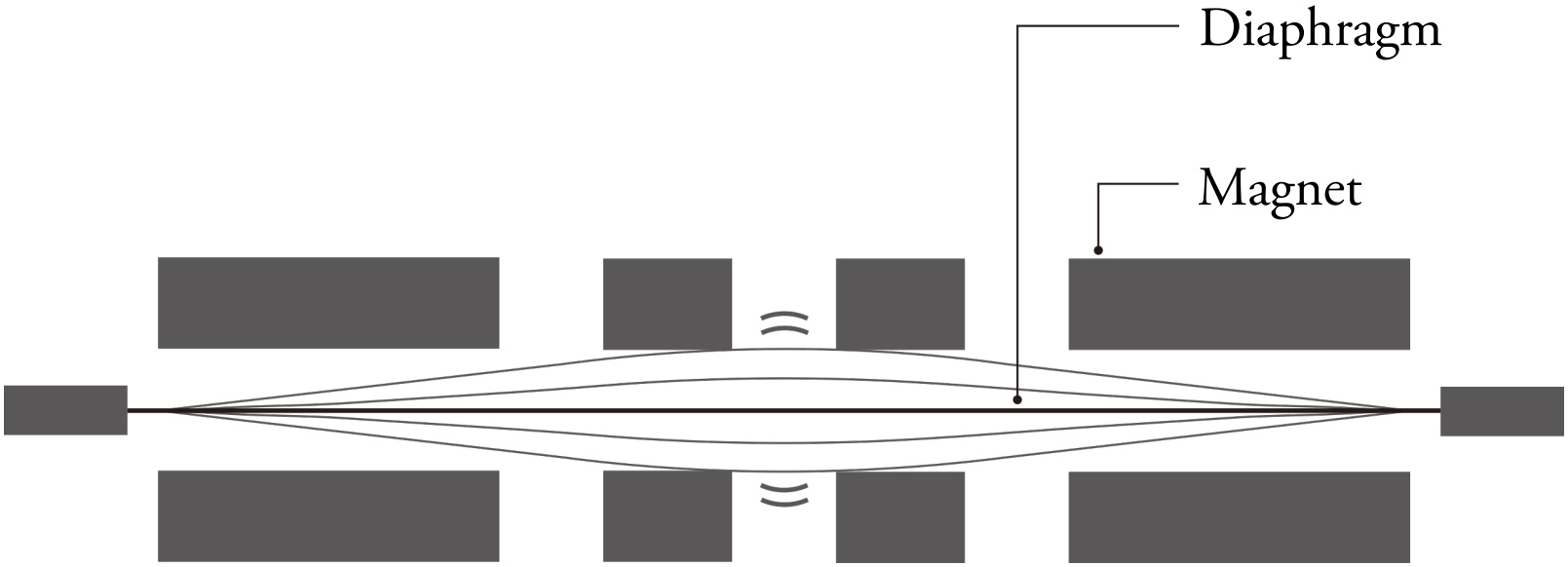


Characteristics of a driver with a housing



02 Conventional Planer Magnetic driver units Issues

Cross-section view

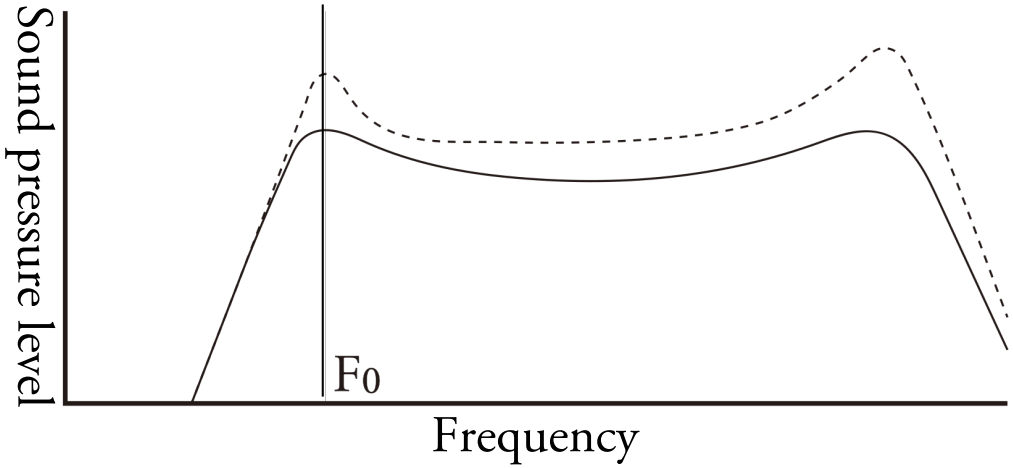


A diaphragm touches the magnet at the F0 where the amplitude is maximum.

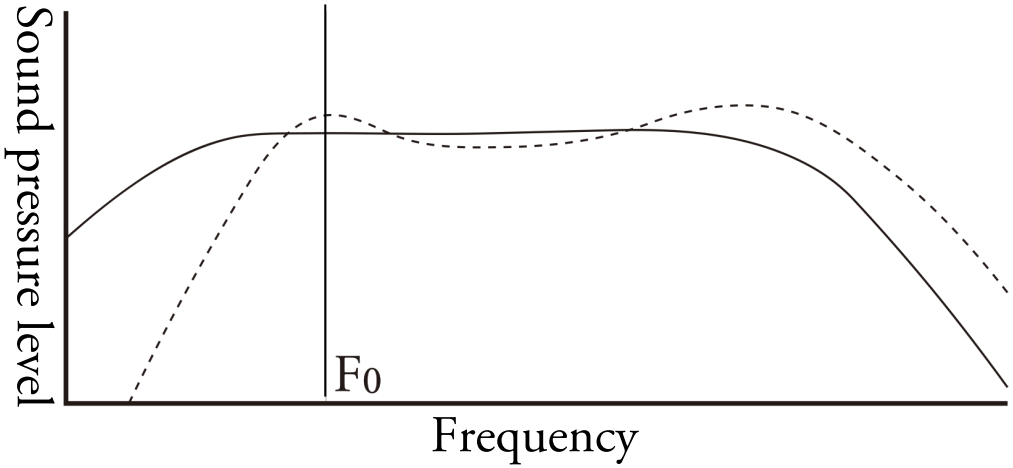
02 Conventional Planer Magnetic driver units
Solution #1 of the issues

Suppress the peak at F0 by coating the diaphragm with damping materials

Characteristics of a driver without a housing



Characteristics of a driver with a housing



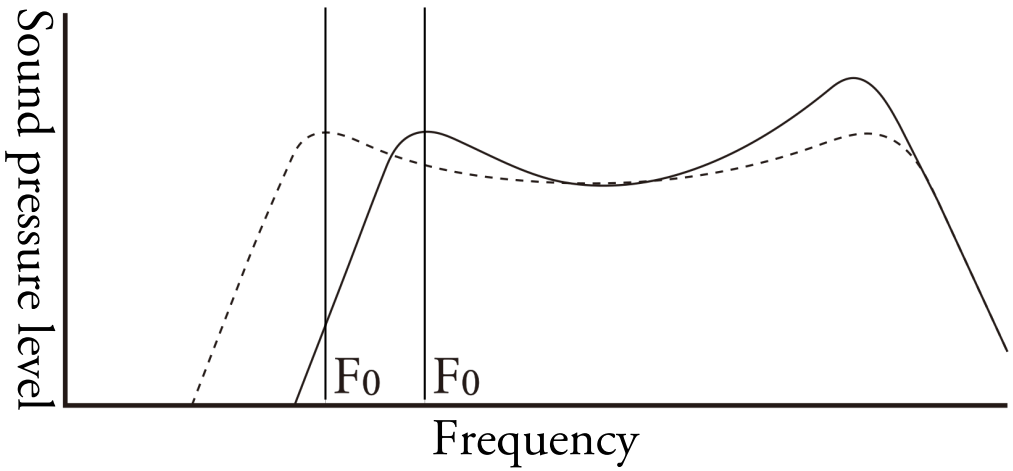
--- before — after

Although a diaphragm never touch the magnet, the response at high frequencies are deteriorated because a diaphragm becomes heavier.

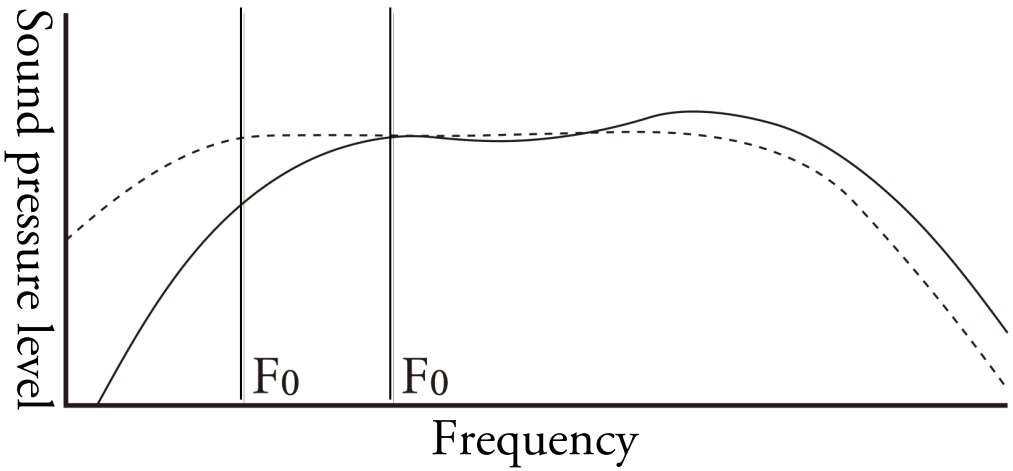
02 Conventional Planer Magnetic driver units
Solution #2 of the issues

Improve the responses of high frequencies by shifting F0 higher with a bigger tension of diaphragm.

Characteristics of a driver without a housing



Characteristics of a driver with a housing

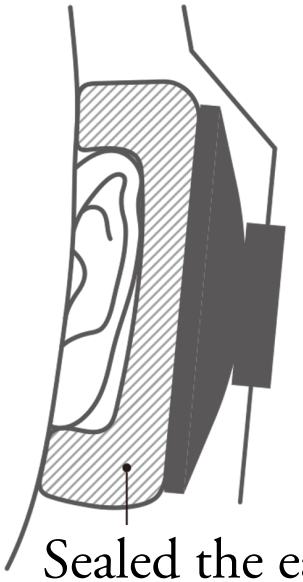


--- before — after

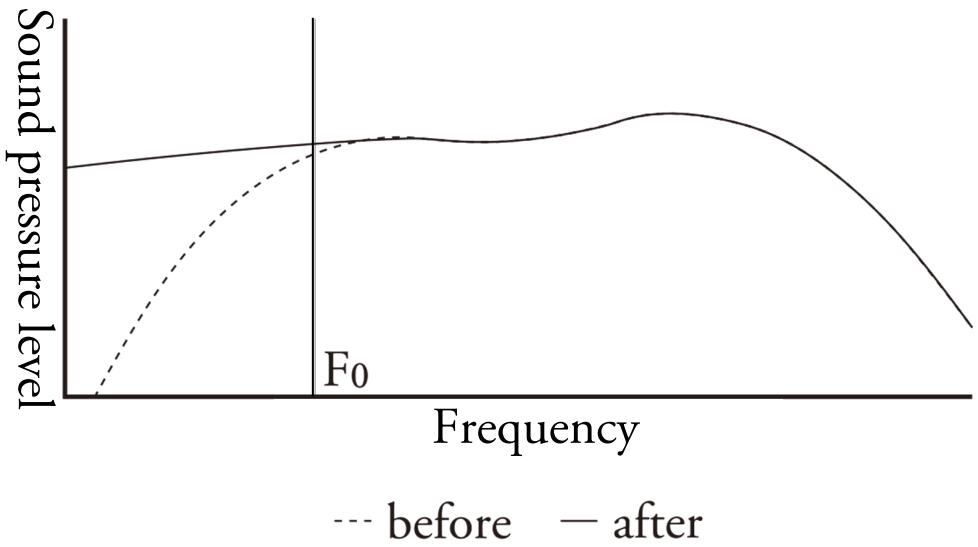
Although the responses of high frequencies are improved, the sound pressure levels of low frequencies are insufficient due to the higher F0.

03 Conventional Planer Magnetic driver units
Solution #3 of the issues

Stiffness control with a sealed ear pad.



Non-sealed (before) / Sealed (after) characteristics



Although loss of low frequencies are compensated, richness of low frequencies sound are still less. Openness is lost and the low frequencies sound are similar to that with earphones.

02 Conventional Planer Magnetic driver units
Present state

Dynamic driver units dominate in the natural low frequencies sound with openness and richness. This is a reason why dynamic driver units are the main stream.

— final's solution —

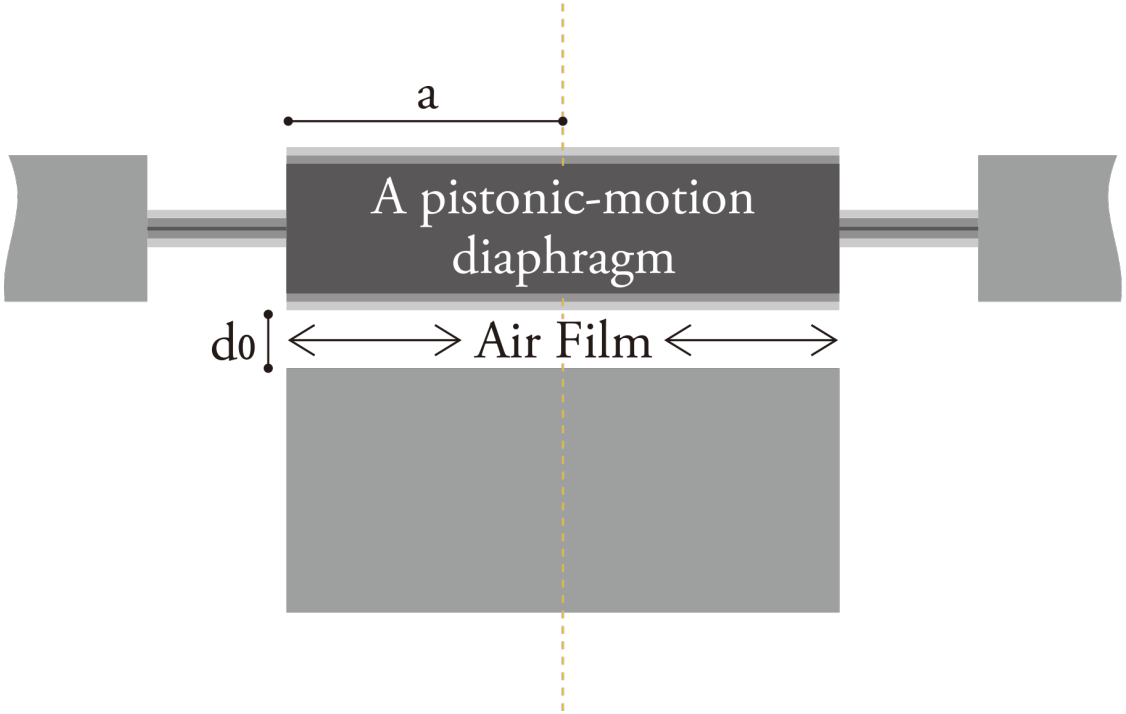
Planar Magnetic Headphones with Air Film Damping System(AFDS)

03

AFDS Planar Magnetic Headphones

03 AFDS Planar Magnetic Headphones
Principle of AFDS

One-side back plate without holes.



$$R_1 = \frac{3\pi}{2} \frac{a^4}{d_0^3} \mu$$

$$M_1 = \frac{3\pi}{20} \frac{a^4}{d_0} \rho$$

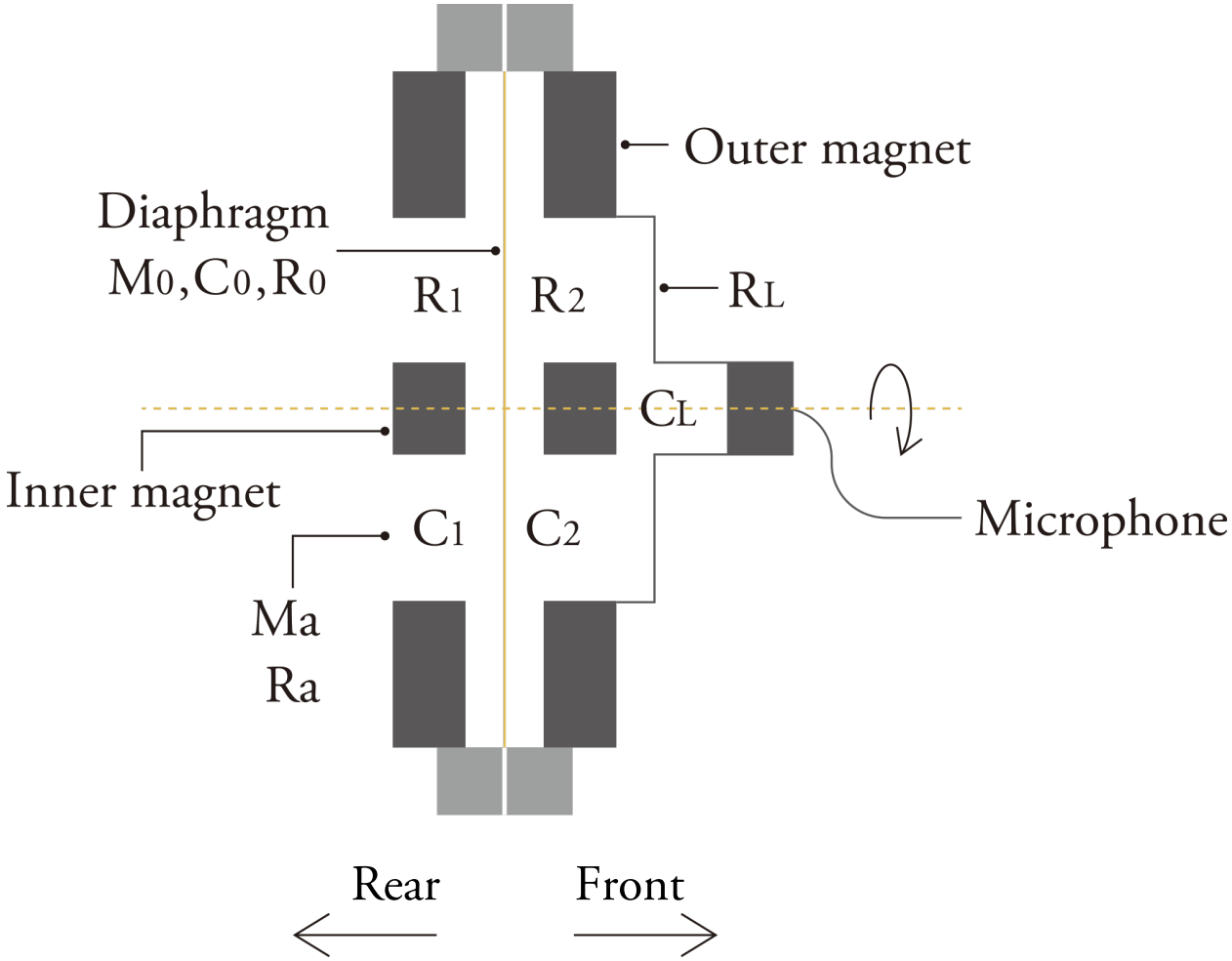
Smaller the gap d_0 is larger the resistance.

Where R is resistance, M is inductance, ρ is pure inductance and μ is viscosity coefficient.

Damping the diaphragm by the resistance of Air Film.

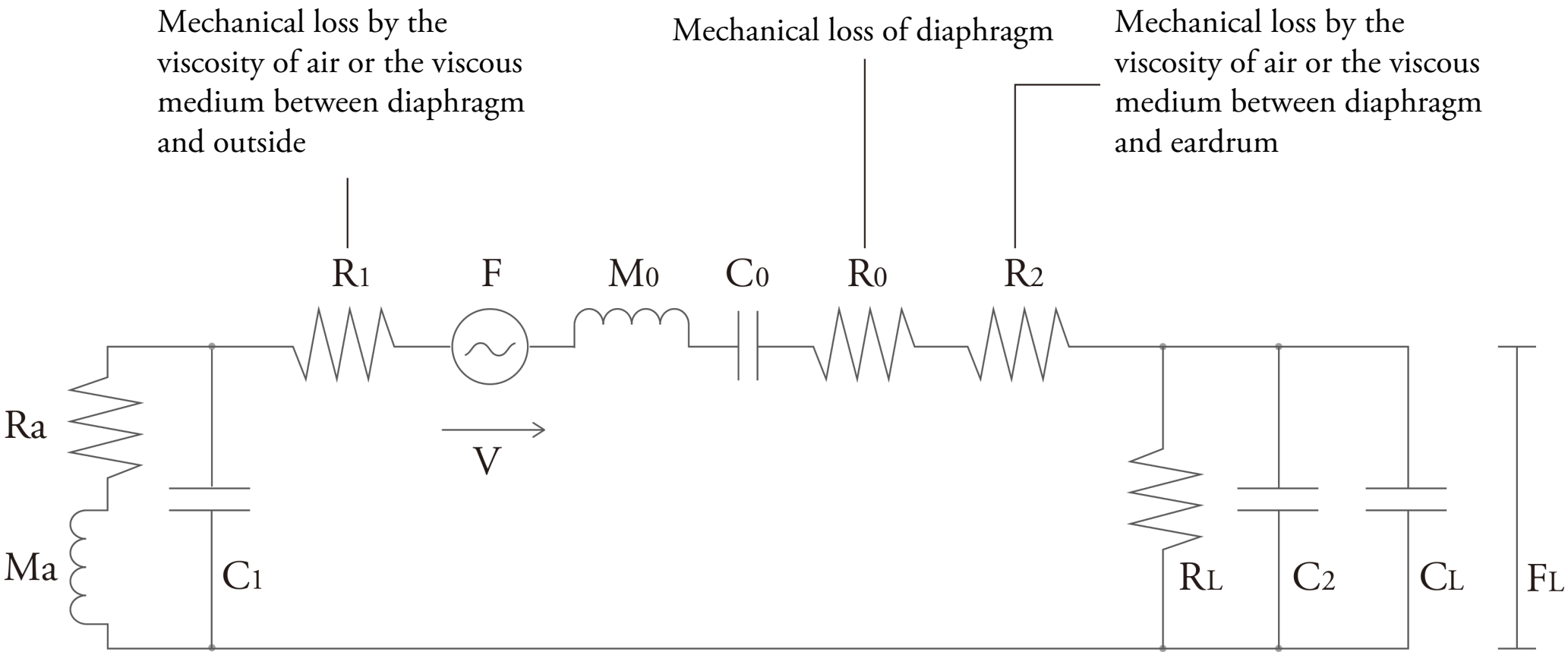
03 AFDS Planar Magnetic Headphones Principle of AFDS

Cross-section view of the driver and coupler



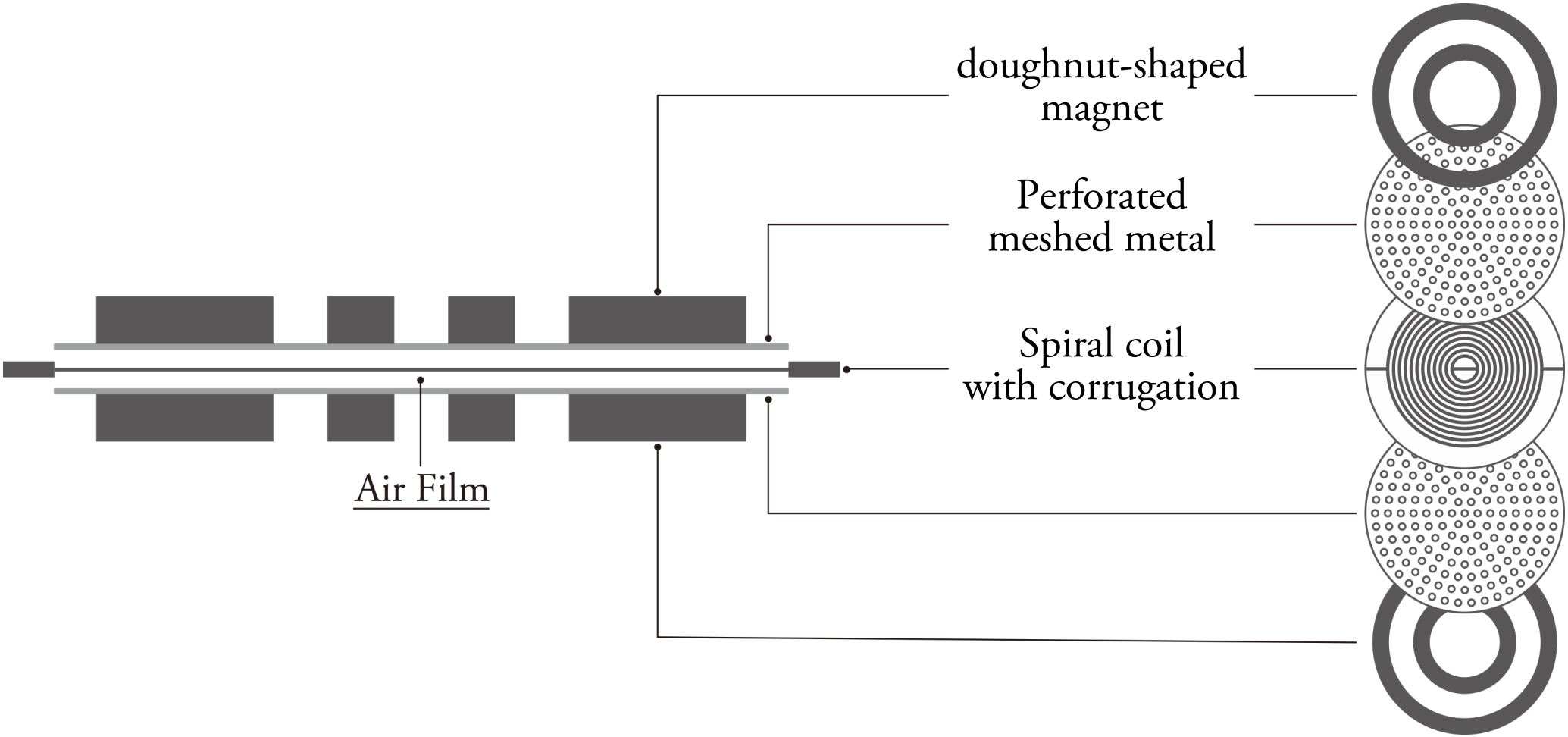
03 AFDS Planar Magnetic Headphones Principle of AFDS

Review the equivalent circuit



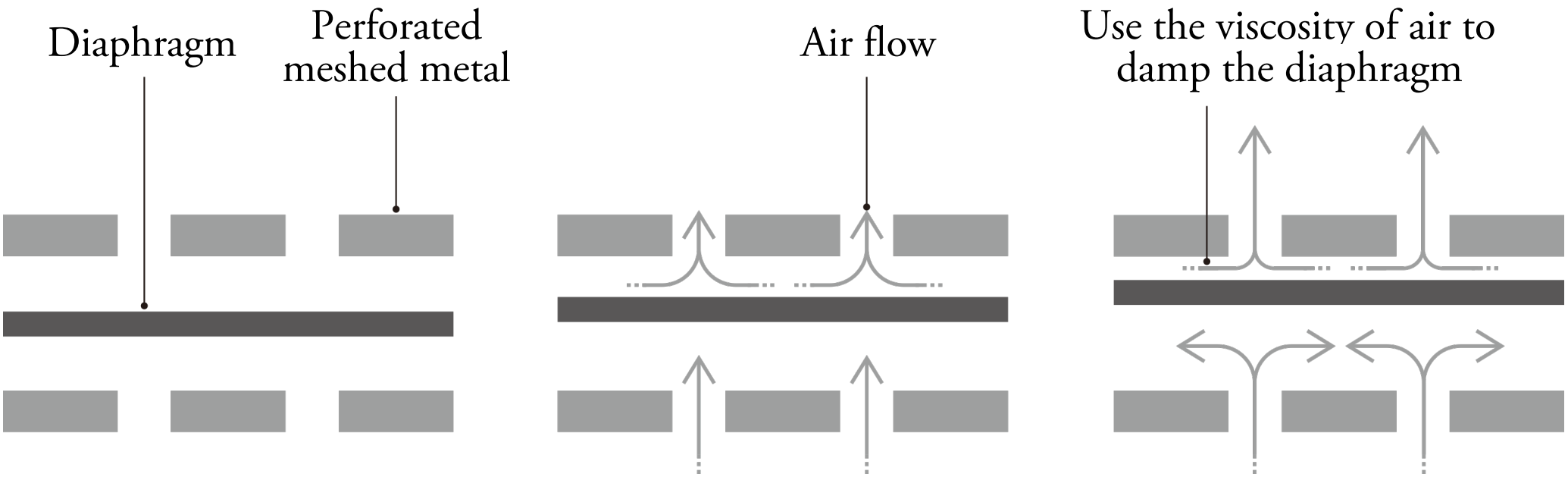
03 AFDS Planar Magnetic Headphones
Principle of AFDS

Cross-section view



03 AFDS Planar Magnetic Headphones Principle of AFDS

Air Film is the viscosity of air

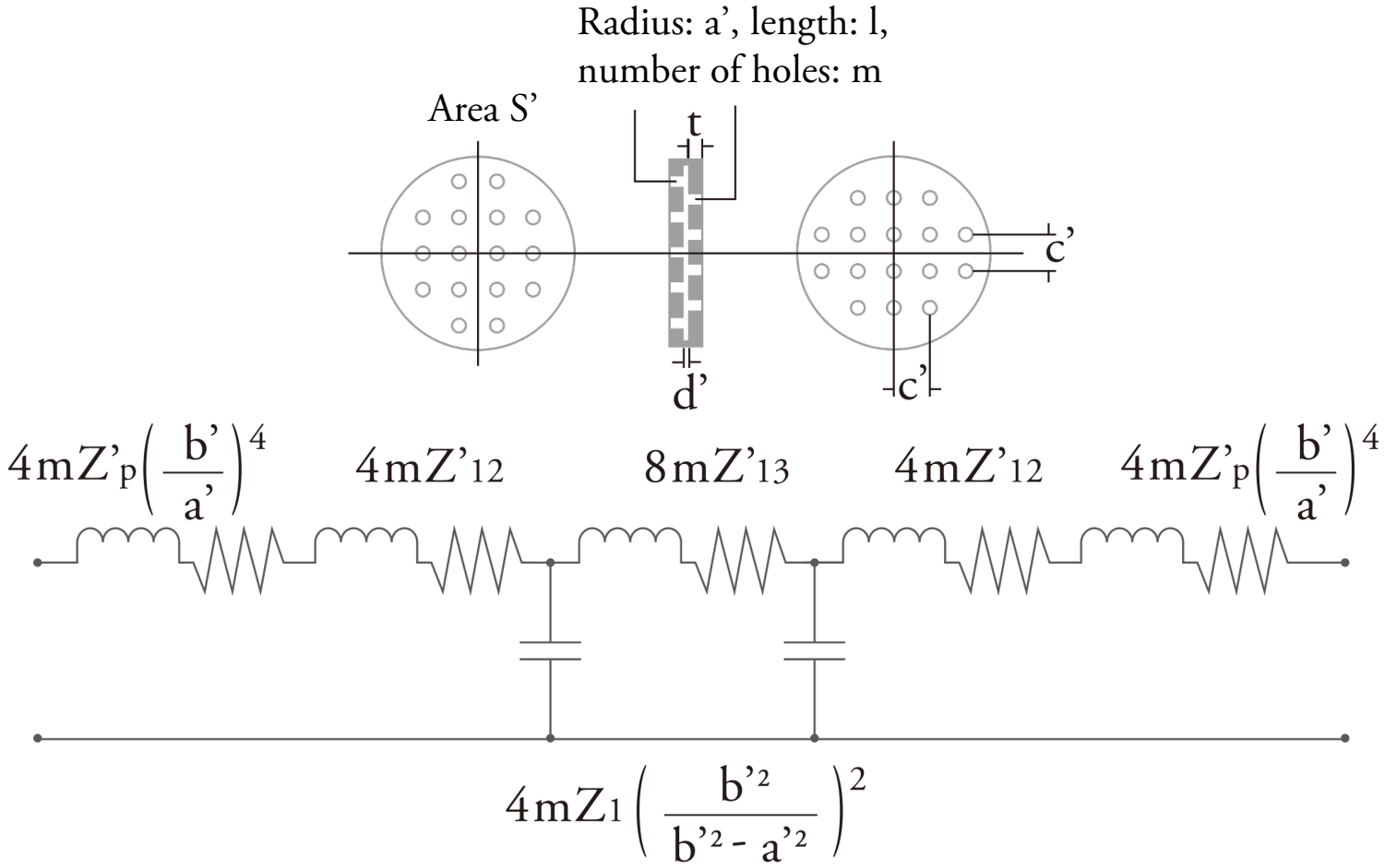


Damp the diaphragm by the proper use of Air Film between the perforated meshed metal and the diaphragm.

03 AFDS Planar Headphones
Principle of AFDS

Resistance component applied to pistonic-motion diaphragm located between perforated meshed metals

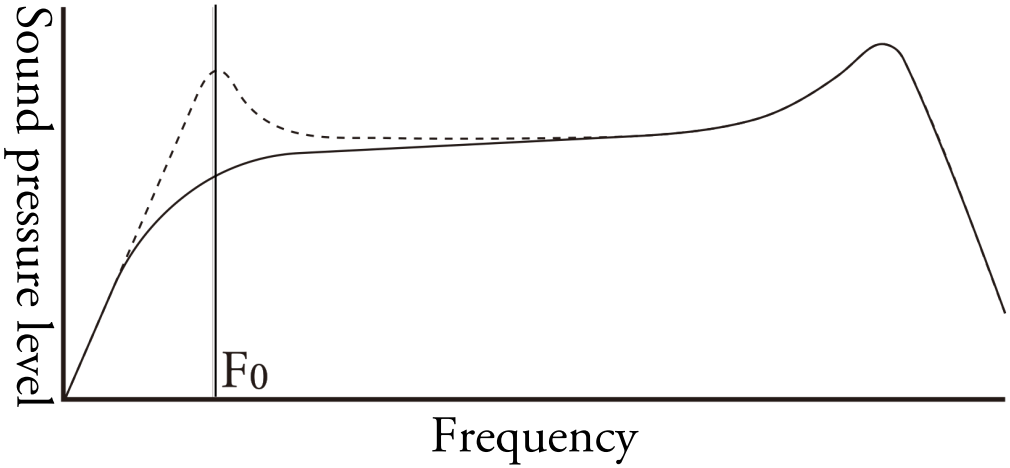
Equivalent circuit of the actual unit



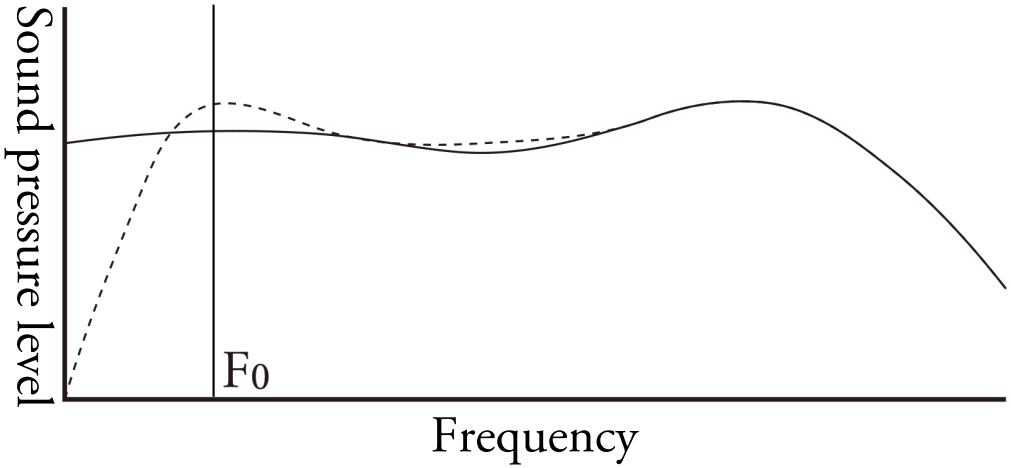
Where a' is a radius of a hole, and b' is a radius of an equivalent air film at the elemental part.

03 AFDS Planar Headphones
Difference of characteristics with or without AFDS

Characteristics of a driver without a housing



Characteristics of a driver with a housing



--- Without AFDS — With AFDS

Damping is observed only at around F0, so no impact can be found on the characteristics at high frequencies.

04

Conclusion

04 Conclusion
Comparison between different types of headphones and AFDS Planar Headphones

	AFDS Planer Magnetic Drivers	Planer Magnetic Drivers	Electrostatic Drivers	Dynamic Drivers
Ideal frequency response	★★★	★★☆	★★☆	★★☆
Ideal frequency response	★★★	★★★	—	★☆☆
Low distortion	★★★	★★★	★★★	★★☆
Delicate sound at high frequencies	★★★	★★★	★★★	★★☆
Natural bass sound with richness and openness	★★★	★☆☆	★★☆	★★★

04 Conclusion
AFDS has been realized in the headphones – D8000

D8000 is the headphones having both the delicate sound at high frequencies, a typical feature of planar magnetic type, and the open-feeling rich sound at low frequencies, a typical feature of the dynamic type.