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Title:

Size Is Not Everything-

AKG C 2000B uses New Diaphragm Technology

by Richard Barnert

Theme:

When talking about condenser microphones, sound engineers often mention large-diaphragm and small-diaphragm types. These terms refer to specific properties that make engineers choose one type for a specific kind of application and the other type for other tasks. But why, one wonders, should it not be possible to combine the benefits of both designs in a single microphone?
This is exactly what AKG did in designing the C 2000 B.

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Selected discography (producer and/or composer):

- ***"New Aspects of Cutting Wood"***
- ***"Electric Groove featuring Patricia Ferrara"***
- ***"Peter Natterer Quartet feat. Wolfgang Puschnig"***

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Size Is Not Everything

AKG C 2000 B uses new diaphragm technology

When talking about condenser microphones, sound engineers often mention large-diaphragm and small-diaphragm types. These terms refer to specific properties that make engineers choose one type for a specific kind of application and the other type for other tasks. But why, one wonders, should it not be possible to combine the benefits of both designs in a single microphone? This is exactly what AKG did in designing the C 2000 B.

The meaning of the term "small-diaphragm"

To understand why condenser microphones differ in size and why different designs are used for different applications, we should take a look at the history of technology in the 20th century. The first condenser microphones were known around 1928 but it was not before a few years later that they were used commercially as sound transducers. The effective diameter of the vibrating diaphragm of the first condenser capsules was 1 inch or more because the large area provided maximum sensitivity.

The breakthrough of condenser microphones did not come until the 1940s when they displaced the ribbon microphones that had been predominantly used before. In addition, TV stations demanded smaller and more convenient models more and more urgently, so manufacturers began to develop microphones with a diaphragm diameter much smaller than 1 inch. To make a distinction between the conventional and the new designs, the term "small-diaphragm condenser microphone" was coined.

The capsules previously used automatically became known as "large-diaphragm capsules". To this day, the industry calls capsules with a diaphragm less than 1 inch in diameter "small-diaphragm capsules" although some new companies may be less strict about their terminology and call a microphone with a 3/4" diaphragm a "large-diaphragm" design.

Things have changed, however, since the first small capsules arrived. A wide variety of designs down to almost invisible miniature capsules are feasible and available on the market. And it is a fact that the capsule diameter largely defines the sound of a microphone and thus its application area. The smaller the capsule diameter, the higher the frequencies the microphone can reproduce.

In fact, the typical upper frequency limit of large-diaphragm transducers is approximately 12 kHz whereas small-diaphragm designs can easily capture frequencies up to 20 kHz. On the down side, small capsules have smaller capacitor surfaces, which reduce sensitivity and degrade the signal/noise ratio. Another fact is that the sound will be the more neutral and accurate the smaller the capsule is.

Conversely, one inherent property of large-diaphragm microphones is that they present a large mechanical obstacle to a sound field and actually distort the sound field. The sheer size of these microphones results in a characteristic timbre on one hand and a polar pattern that varies widely with frequency and is not very well defined on the other. Typical off-axis rejection values are 20 dB for a large-diaphragm cardioid and up to 35 dB for small-diaphragm microphones.

The latter are also much less expensive to make than their larger counterparts that require much closer production tolerances across large surfaces. This is one of the reasons why the number of manufacturers of large-diaphragm microphones worldwide is still very limited.

AKG C 2000 B: A small-diaphragm microphone with great features

In designing the C 2000 B, AKG aimed at combining the best of both worlds by transferring the beneficial properties of a large-diaphragm microphone to a 1/2" small-diaphragm model, both in terms of engineering and pricing, for true large-diaphragm microphones are still much more expensive than their smaller counterparts.

Fig. 1: Inside view of the AKG C 2000 B.

To find a way to eliminate the inherent disadvantages of a small capsule, one should first take a look at the usual design of a condenser capsule (fig. 2).

A metal coated plastic diaphragm is stretched at a uniform spacing of typically 40 to 60 microns from a fixed electrode usually called a backplate. The diaphragm is only a few microns thick and together with the backplate forms a plate capacitor to which a DC voltage (U_0) is fed. Acoustic resistors behind the backplate in conjunction with the forced sound path from the rear sound entry define the polar pattern of the microphone.

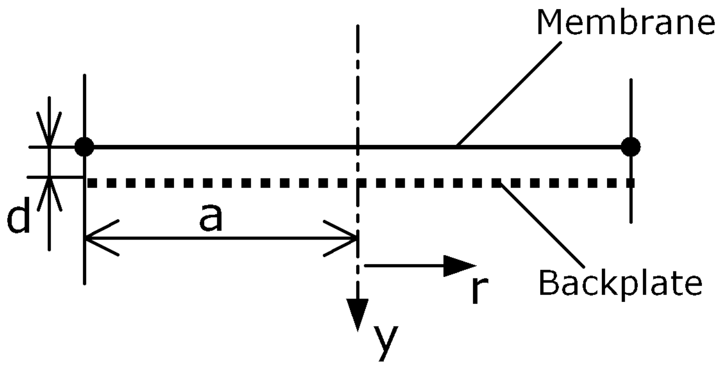

Fig. 2: Sectional view of a typical condenser capsule.

Omnidirectional capsules are the only ones with no rear sound entry; their backplate sits above a closed cavity. Fig. 3 shows another popular design with a screw that anchors the diaphragm in its center.

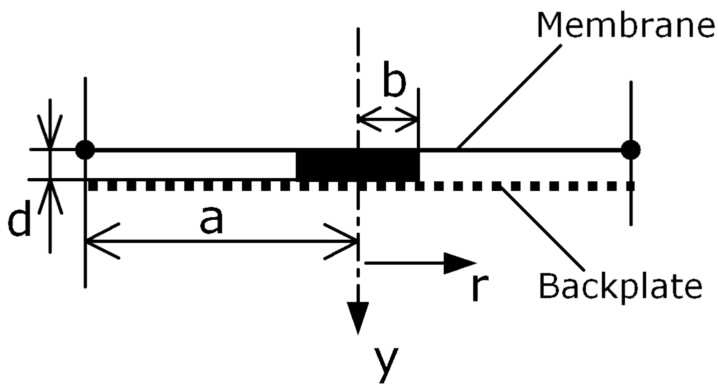

Fig. 3: Condenser capsule with diaphragm anchored in the center.

Anchoring the diaphragm in its center has enormous effects on the vibration behavior of the diaphragm so the frequency response of the microphone is changed, too. One basic property of condenser diaphragms is that the diaphragm will vibrate in preferred modes, the so-called eigenmodes, at specific frequencies. These modes are easy to calculate on a computer and can be verified with laser measurement equipment. Fig. 4 shows typical eigenmodes of a floating diaphragm and fig. 5 shows the corresponding modes of an anchored diaphragm.

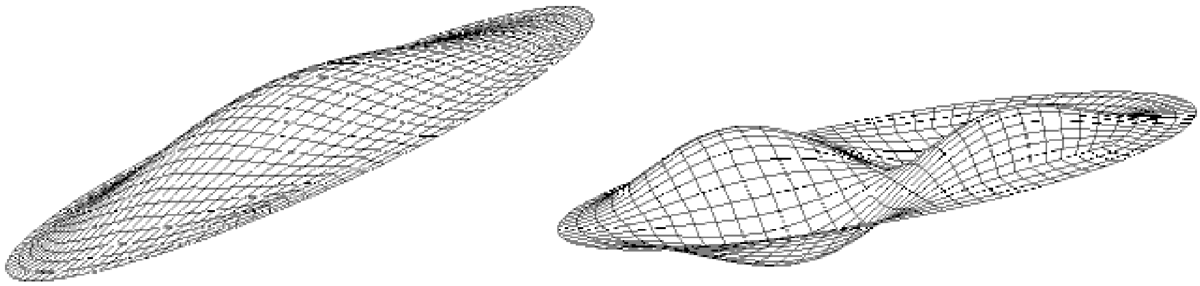

Fig. 4: Eigenmodes of a floating condenser diaphragm.

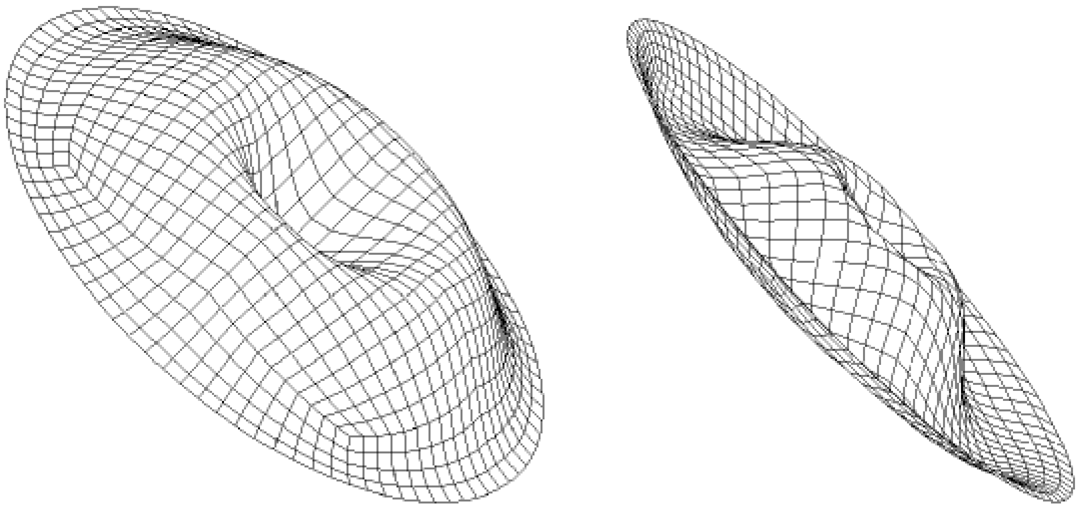

Fig. 5: Eigenmodes of a centrally anchored diaphragm.

These eigenmodes are described by indices *m* and *n*. Index *m* gives the number of radial node lines and index *n* defines the number of azimuthal node circles. Eigenmodes occur at specific frequencies and produce specific output voltages U_{mn} at these frequencies. The frequency response of a system can be computed by summing all eigenmodes. The mathematical expression for the mode-dependent output voltage is

$$U_{mn} = \frac{1}{r^2 \pi} \int_{r=b}^{a} \int_{\varphi=0}^{2\pi} U_0 \frac{\mathrm{Re}\{y_{mn}\}}{d} r\, dr\, d\varphi$$

where Re $\{Y_{mn}\}$ are the Bessel solutions of the mechanical wave equation. An in-depth study was presented at the 111th AES Convention [1]
Once the eigenmodes and their effects are known, the capsule parameters can be changed with high accuracy.

The AKG C 2000 B diaphragm technology

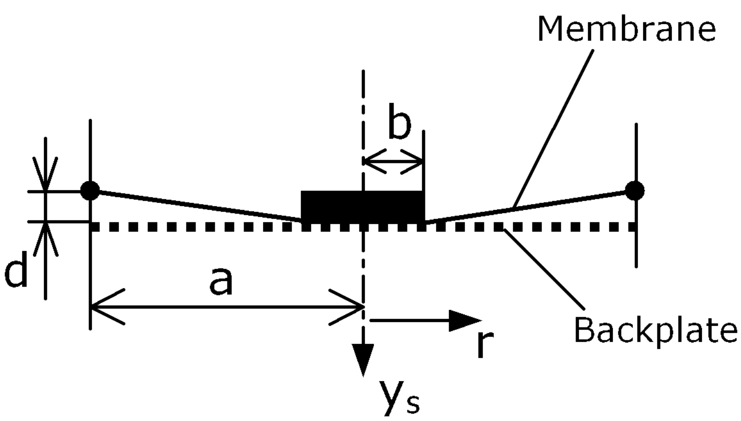

Fig. 6: Condenser capsule of the AKG C 2000 B.

[1] *Richard Barnert: Modal Improved Condenser Microphone, Proc. 111th AES Convention, 2001 November 30 to December 03, New York, NY.*

The diaphragm in the transducer capsule of the AKG C 2000 B is stretched and pressed against the backplate as shown in fig. 6. As a result, the spacing between the diaphragm and backplate is not uniform. A patent application has been filed for this development [EP1120996.A] that gives the designer much better control over parameters than the two previous designs.

The basic idea is quite simple: the smaller the spacing between the diaphragm and the backplate, the higher the sensitivity of the capsule. The diaphragm on the AKG C 2000 B is stretched so the spacing between the diaphragm and the backplate is not uniform but very small in the center and wider toward the perimeter. Along the perimeter the spacing is in the usual range from 40 to 60 microns. Therefore, vibrations near the center will contribute more to the overall frequency response than vibrations along the perimeter of the capsule.

This type of diaphragm allows the designer to shape the frequency response with great accuracy. In the case of the AKG C 2000 B, this innovative technique was used to extend the bass range about one octave below that of comparable microphones.

The diaphragm material plays an important role, too. Like on most AKG microphones, high quality polycarbonate is used for the C 2000 B diaphragm instead of the usual Mylar polyester mixture. This provides much higher mechanical strength and dramatically reduced susceptibility to temperature variations and humidity.

The new design provides another important benefit. One of the parameters limiting the sensitivity of a condenser capsule is the maximum excursion of the diaphragm. High sound pressure levels cause wide diaphragm excursions so the diaphragm may be pushed against the backplate as shown in fig. 7.

At best, this causes an unwanted noise, but at worst, the diaphragm may stick to the backplate, making the microphone unusable. Of course, a capsule must be designed so as to make sure this will never happen but in a conventional design this usually reduces the transducer's sensitivity.

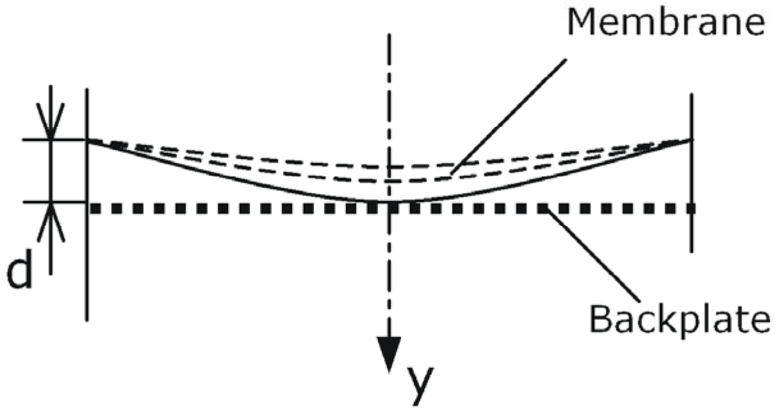

Fig. 7: Excursion of a condenser diaphragm at high sound pressure.

The diaphragm of the AKG C 2000 B is much less prone to sticking than other designs, which is partly due to the modified forms of its eigenmodes. The stretching of the diaphragm increased the sensitivity by 3 dB and therefore, the signal/noise ratio is also 3 dB higher than in conventional transducers.

The capsule shock mount is another masterpiece. After all, poor handling noise rejection would ruin the best frequency response. Therefore, the new capsule is suspended in a computer optimized rubber shock mount that imparts ultimate perfection to the sound of the microphone. Careful matching of the mechanical admittances of the capsule and shock mount resulted in a significant handling noise rejection.

In addition, holes in the shock mount provide an acoustic short circuit that ensures the same excellent polar pattern as that of a small-diaphragm capsule. 180° off-axis rejection is 20 dB, the same as for a typical large-diaphragm cardioid. Off-axis rejection at 155°, however, is an excellent 35 dB. This means that live engineers can use the C 2000 B to get a large-diaphragm sound in applications where large-diaphragm microphones usually fail because of their typical polar response.

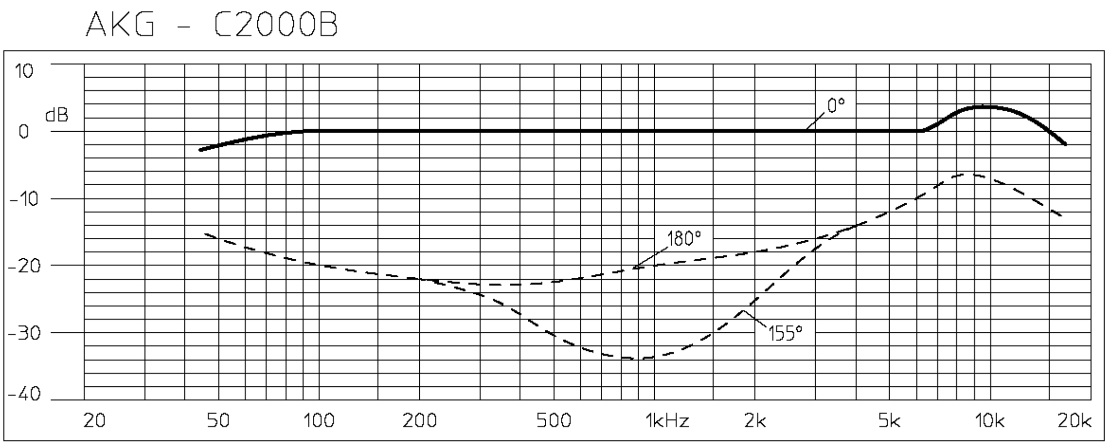

Fig. 8: AKG C 2000 B frequency response.

To summarize, the innovative design of the AKG C 2000 B combines the benefits of large and small-diaphragm transducers in the same microphone. Using a new type of capsule and computer optimized acoustic circuitry, the C 2000 B from AKG with its cost efficient 1/2-inch diaphragm provides typical features that were previously limited to much more expensive large-diaphragm microphones.

Richard Barnert