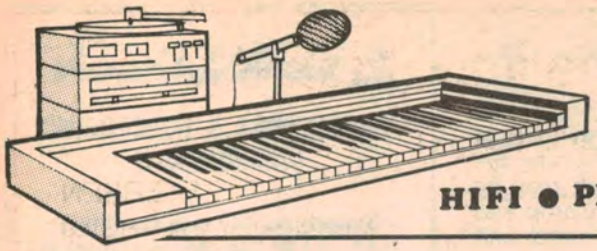

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PHONO CARTRIDGES AND STYLI — SOME BASIC PRINCIPLES REVISITED

These days, the vast majority of hifi enthusiasts use magnetic phono cartridges with diamond styli. This article, sourced from Ortofon of Denmark, may assist newcomers who have not yet sorted out some of the relevant terms which occur in hifi literature.

In broad terms, a magnetic cartridge is one in which movement of the stylus mechanism in a magnetic field causes a signal current to be generated in associated coils. This produces a signal voltage which is fed to the amplifier system.

As distinct from "magnetic" cartridges, types using the so-called "piezoelectric" principle have been very popular, but mainly in lower priced record playing equipment. The two best known variants are "crystal" cartridges, now largely superseded in popularity, and "ceramic" cartridges, as fitted to many budget priced players.

The manufactures of magnetic cartridges have coined a variety of terms to describe their product but most fall into one of the three groups to be described: moving magnet, induced magnet, or variable magnetic shunt (VMS). In all of these, the magnetic circuit is manipulated, the coils remaining stationary.

In another type of magnetic system, the magnetic circuit remains stationary but the coils move, thereby generating the signal current and voltage.

MOVING MAGNET: The most common magnetic cartridge is the moving magnet. Here, the magnetic field emanates from a tiny, fixed magnet that is fastened to the remote end of the cantilever.

When the magnet is set into motion, which occurs when the stylus follows the modulations of the record groove, the magnetic field through the coils changes, and electrical voltages are generated in the coils. Although a moving magnet cartridge uses a tiny, powerful magnet on the cantilever, the weight of the magnet can still constitute something of a restraint on the cantilever, increasing its mass and reducing its ability to react precisely to transients in the music. (See Fig. 1)

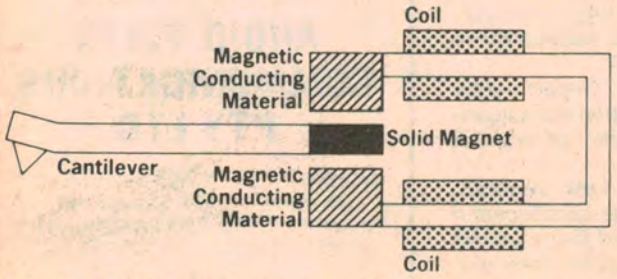


Fig. 1: The moving magnet system, the one most commonly used. Movements of the magnet produce currents in the coils. For simplicity, only one pair of coils, for one channel, is shown.

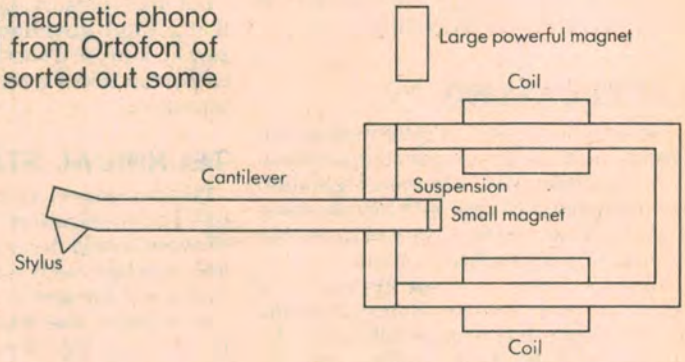


Fig. 2: By using a very small moving magnet and a large fixed magnet, the induced magnet cartridge achieves lower tip mass at the expense of extra weight in the cartridge itself.

INDUCED MAGNET: This type of cartridge must be considered a further development of the moving magnet type. With the induced magnet cartridge, it is possible to use a smaller and lighter armature on the cantilever because a larger, powerful, fixed magnet increases the moving element's magnetic strength.

Compared to a moving magnet cartridge, the total mass of the cantilever can be reduced, thus improving transient reproduction. On the other hand, the cartridge's weight is increased by the fixed magnet, which may render this type of cartridge unsuitable for use with tonearms which already have a high mass. (Fig. 2).

VARIABLE MAGNETIC SHUNT (VMS): This represents the latest development of the magnetic cartridge principle.

The cantilever in a VMS cartridge can be made extremely

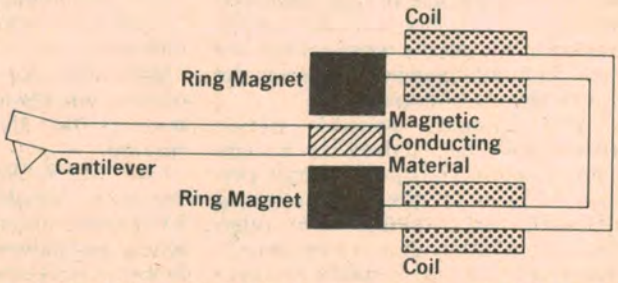


Fig. 3: The VMS or Variable Magnetic Shunt principle used in Ortofon's Low Mass cartridges. A tiny armature modulates the field beween a ring magnet and the tips of four coils.

light because it is not weighed down by a magnet.

Here, the magnetic field emanates from a fixed ring magnet that encircles the cantilever, the rearmost part of which consists of a thin-walled armature of magnetic conducting material. When the cantilever is set in motion, the armature short-circuits part of the magnetic field, and a voltage is generated in the coils.

The VMS principle not only makes it possible to reduce the mass of the cantilever to an absolute minimum, but the construction is such that the weight of the entire cartridge can be reduced, making the VMS cartridge suitable for use with a large number of tonearms.

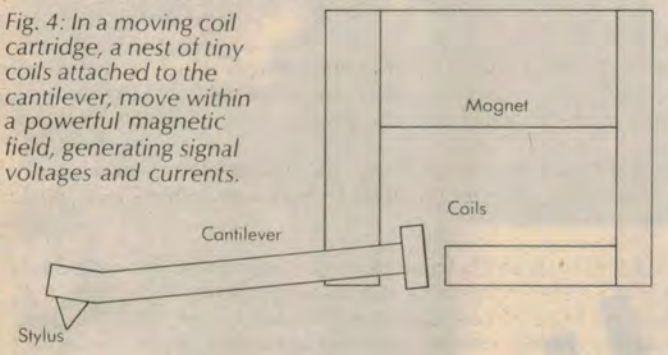
The special construction of the VMS principle means that the magnetic operating point in the cartridge may be placed at the origin of the induction curve, where there is no risk of non-linearity that can lead to distortion. The VMS principle has made it possible to produce low mass cartridges with a weight of only 1.5 grams. (Fig. 3).

MOVING COIL CARTRIDGES: The first cartridges with true hifi specifications were developed in the mid-forties and were of the moving coil design.

In general, moving coil cartridges are more expensive than magnetic cartridges and they do not, therefore, enjoy the same popularity. However, the most demanding hifi enthusiasts remain loyal to the moving coil design, because of its greater linearity and lower distortion.

Compared with a moving magnet cartridge, the reverse principle is applied in the moving coil cartridge. Here, a powerful fixed magnet is used and the coils are mounted on the cantilever itself. When the coils move in the field of the magnet, they cut the flux lines of the magnet and voltages are generated in the coils. (Fig. 4).

Fig. 4: In a moving coil cartridge, a nest of tiny coils attached to the cantilever, move within a powerful magnetic field, generating signal voltages and currents.



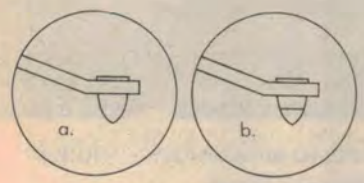


Fig. 5: (a) shows a whole or "nude" diamond stylus. (b) shows a diamond chip on a metal shank.

Once again, with a moving coil cartridge, it is important that the moving parts be as light as possible. Therefore, there are normally only relatively few turns of wire in the coils, and the output voltage from a moving coil is generally so low that it cannot feed a conventional amplifier without special steps being taken.

Nowadays, it is becoming more common to equip amplifiers in the higher price range with a special input stage for moving coil cartridges, but otherwise it will be necessary to purchase a transformer or pre-preamplifier before a moving coil cartridge can be connected to the phono inputs of a normal amplifier or receiver.

OTHER CARTRIDGE TYPES: The cartridge types mentioned in the preceding paragraphs are the most common and by far the majority of cartridges on the market today belong to one of these groups.

Many attempts have been made to use other electrical transformation principles, and some of the prototypes have –

The importance of cartridge mass

by Ib PETERSEN

Technical Director, Ortofon Mfg A/S

How significant is the total mass of a cartridge in relation to ultimate playback quality?

It is very significant because, if the mass of the playback system is high, the moving mass will also be high. This remains true, even if the tonearm is properly counterbalanced and the tracking force is set, say, to a low one gram.

For example, if the moving mass is of the order of 20 grams, and the cartridge has a high stylus compliance,

A high-mass cartridge/tonearm tracking a warp.

acceleration caused by warps in the record will not produce corresponding movement of the arm and cartridge. What tends to happen is illustrated above. Most of the upwards (or sideways) thrust is absorbed by the stylus and not — as it should be — by movement of the cartridge as a whole.

Because of unnatural pressures on the stylus mechanism, a high mass combination can produce or accentuate problems such as wow, sound colouration and acoustic feedback.

A low-mass cartridge/tonearm tracking a warp.

So if you want to use a truly high compliance cartridge — and this is important for accurate tracking ability at low frequencies — it is essential to ensure that the effective mass of the moving system be as small as possible. In practice it should be around 10 grams or less. But there is more to it.

All normal tonearms exhibit some natural low frequency resonance, of which the moving mass forms a vital parameter. Most modern quality tonearms have a moving mass of around 20 grams and, combined with a modern high compliance cartridge (15μm/mN to 35μm/mN) exhibit a natural reasonance in the region 9.2Hz to 6.0Hz. This is too low, being in the range excited by record warps and acoustic feedback.

At the other extreme, a resonance at too high a frequency can be excited by bass notes on the record and result in a highly coloured bass end reproduction. Ideally, the resonance of the moving system should be guided into the 10-15Hz region and this underscores the desirability of selecting a cartridge which will combine the required high compliance with reduced mass.

A typical Ortofon low-mass cartridge intended for use with a standard arm.

These were the kind of factors which were taken into account by Ortofon during our LM — Low Mass — development program.

albeit to a limited extent – found their way into the hifi specialist shops. These are electret, condenser, and strain gauge cartridges, which require a special preamplifier section. They have so far not enjoyed much popularity on that account.

THE STYLUS: It goes, almost without saying, that the stylus is an extremely important component in a hifi cartridge. (Fig. 5).

It is usually made of diamond – the hardest material known – to give it maximum durability. However, the fact that it is of diamond is not sufficient in itself, for its construction and shape are also crucial factors in sound quality.

Many less expensive hifi cartridges use a so-called "tipped" diamond, where the diamond tip is mounted on a metal shank. However, such a shank may increase the stylus tip mass and thus impair the cartridge's transient reproduction, in comparison with a cartridge that uses a nude, untipped diamond.

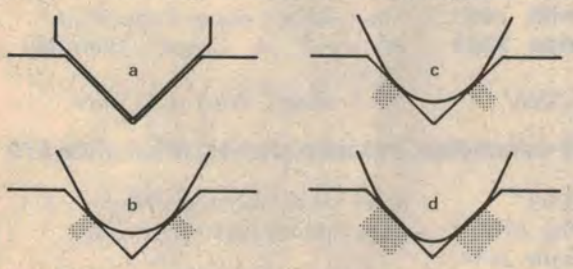


Fig. 6: A triangular stylus cutting a groove (a) and the contact area, shown shaded, for three popular types of stylus: (b) standard spherical; (c) elliptical and (d) Shibata or similar.

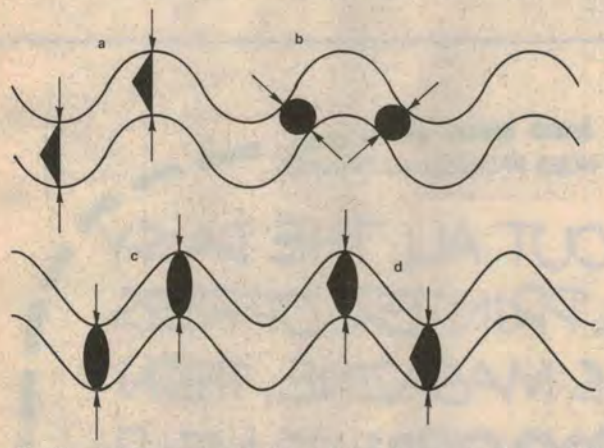


Fig. 7: Viewed from above, this is how the respective styli fit a typical groove. A spherical stylus (b) tends to be "pinched" where the groove is sharply angled, causing distortion.

There are several different diamond shapes to be found and the most important are described in the following paragraphs. (Fig. 6).

THE SPHERICAL STYLUS (b in Figs. 6 and 7) is the simplest and cheapest to produce and it is, therefore, the most common. Spherical styli can be recommended in all cases where robustness and economy are to be taken into consideration in the purchase of a cartridge.

THE ELLIPTICAL STYLUS (c in Figs. 6 and 7) comes just a little closer in contour to the triangular shaped cutting stylus that is used when cutting master records.

The elliptical stylus is able to follow the groove oscillations more accurately than the spherical type, and its distortion and phase error will, therefore, be less.

In the outer turns of the record groove where the diameter is greatest, it may be difficult to hear the difference between a spherical and an elliptical diamond, as there is relatively good space in the groove for the highest frequencies.

However, in the innermost turns of the record groove, the wider radius of the spherical diamond makes it difficult for this shape to track the finer groove undulations. This can muffle the treble, and lead to audible distortion in difficult passages.

There was a time when the experts disagreed about the choice between spherical and elliptical cartridge styli. However, this debate can now be considered resolved and today, very few, if any, elite cartridges are supplied with spherical styli.

OTHER STYLUS TYPES: The introduction, in 1971 of quadraphonic music reproduction from disc records, based on the CD-4 system, triggered a completely new development in the hifi cartridge field.

Cartridges for CD-4 records must be capable of reproducing frequencies as high as 45,000Hz.

This was more than the models in existence at that time could manage, as even the contact surface of the elliptical diamond is too wide for a 45,000Hz oscillation to be tracked accurately.

A solution to the problem might have been a sharper grinding of the elliptical diamond to obtain a reduced horizontal contact surface. This would, however, increase wear on the record groove considerably. The Japanese scientist – Shibata – went in an entirely new direction and invented the special stylus shape that now bears his name.

The Shibata shape distinguishes itself by having the necessary small contact surface at the horizontal level for playback of the ultra-high frequencies found on CD-4 records. At the vertical level, the special shape of the stylus gives a wider contact surface than is the case with either spherical or elliptical styli.

This means that a Shibata shaped stylus, in spite of its high frequency capabilities, gives less record wear than traditional stylus shapes.

Various cartridge manufacturers have been inspired by the Shibata shape and now produce cartridges with stylus shapes that give the same advantages as the Shibata. These have names such as bi-elliptical, pramanic, quadrahedral, hyperbolic, pathemax, and Fine Line.

Although CD-4 and other quadraphonic systems never really caught on with consumers, they have helped to speed up development of stylus types that improve playback of stereo records in the form of a more precise treble reproduction, lower distortion, and less record wear.

PORTABLE STEREO PLAYER FROM SANYO

Sanyo's new M 5550 "go-anywhere" stereo cassette player can bring high quality stereo sound to people on the move. It measures 80 × 132 × 25mm, weighs 340g and offers a response 63Hz to 10kHz. It is powered by two AA cells and can drive two sets of phones. RRP is $229.