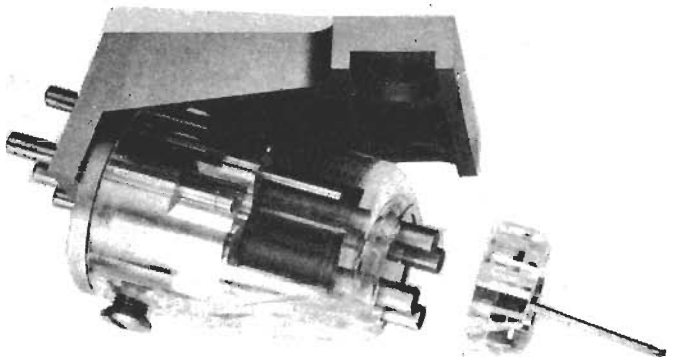
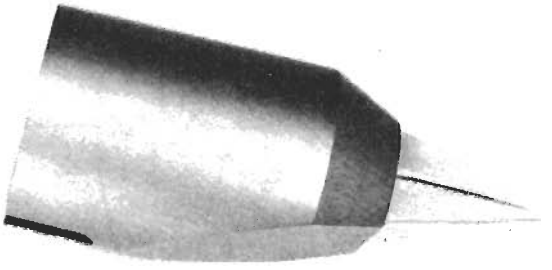


PICKUP PRINCIPLES



Ron Harris explains the workings of Hi-Fi's smallest black box

FOR ALL THE continuing sophisti-cation within the electronics of the hi-fi chain, no viable method has been offered up to extract the mechanical information from the good old L.P. other than the trusty electro-mechanical cartridge.

This in itself generates an order of magnitude more distortion than any hi-fi component, but for some as yet unexplained reason, people seem more ready to accept some quite quirky behaviour from cartridges than from anything else.

After all if a particular brand of amplifier needed its wires cleaning before every usage, its sales would remain nicely static at zero.

The term electro-mechanical can be seen to excuse a multitude of sins.

INDUCTION

Most pickups owe thier existance to Mr Faraday and his laws of induction. If you move a wire relative to a magnet within its field, you will generate an emf across that wire. It matters little whether you move the magnet or the coil of wire.

Various methods and variations have of course been evolved to utilise this principle to obtain an amplifiable voltage from the ups and downs of the vinyl.

Not all cartridges operate on this principle, just 90% of them!Ceramic devices are the main exception but these have completely faded from hi-fi usage, as the quality is no longer of comparitively high enough standard for the enthusiast.

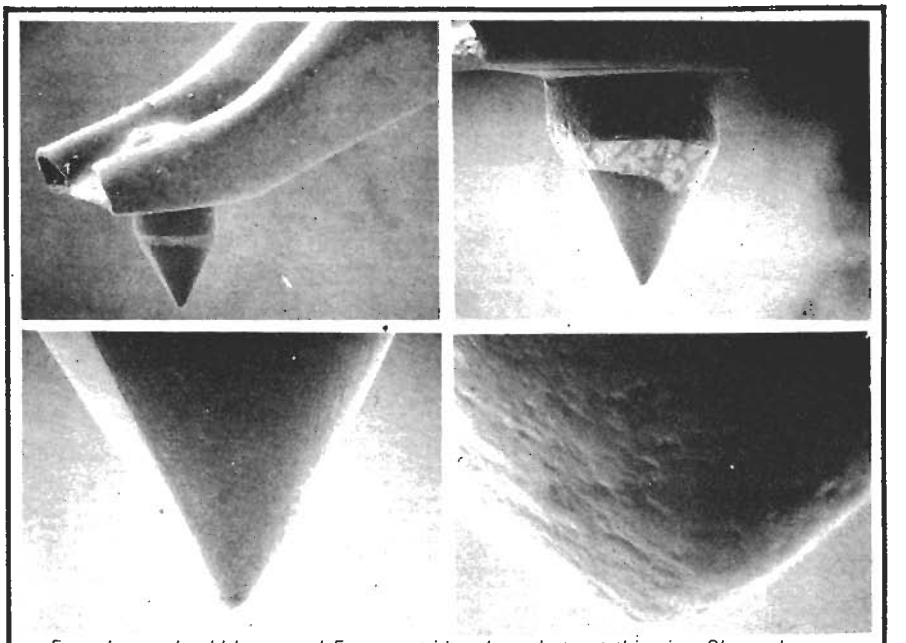
The most common types are;
(i) Moving magnet
(ii) Moving coil
(iii) Moving iron Induced magnet
(iv) Electret

We shall be considering each type in turn.

No reference is made in this article to such universal parameters as tip mass compliance of cantilever, arm resonance, output level etc etc

Such things are of paramount importance, but have little to do with the operating principles behind the cartridges themselves.

We mention them lest you think we had forgotten, or worse still were ignorant of them!



Every home should have one! Every cartridge does, but not this size. Shown here are four extreme magnification shots of a Stanton stylus. From top, left to right, 50X, 100X, and on the bottom 400X and 2000X.
And you thought that diamond was smooth eh?

MOVING MAGNET

By far the most common method. Fig I shows the basic operation of a Phillips 412 super M pickup, which can be considered typical of the bar magnet variety.

The pole pieces PL and PR are composed of mu-metal. When the stylus moves following the groove wall at say the left channel signal, the magnet will follow a similar path such that movement takes place parallel to PR, varying the distance relative to PL. This causes an emf to be set up across the left channel coils. Since that movement takes place parallel to the right channel coil, no emf is generated across that coil.

Since the coils are detecting minute changes in flux, sheilding from external influences must be good so that these are not registered as signals. Transformers must be kept well away from all pickup cartridges, which is why your deck will invariably work better on one side of your amplifier than on another!

A variation on this theme has been penned by Audio Technica, who use one magnet for each channel, set at 45o to the record surface which makes them perpendicular to the groove walls. This does imitate the return of the cutting head pretty closely. The magnets are much smaller than usual, being around 25% of the mass normally utilised.

Since each channel was a totally separate motor assembly, stereo separation cannot help but be enhansed. Perhaps the most famous sons of the moving magnet are Shure, led by the VI5 111. This flagship design uses a laminated core structure, increasing the efficiency.

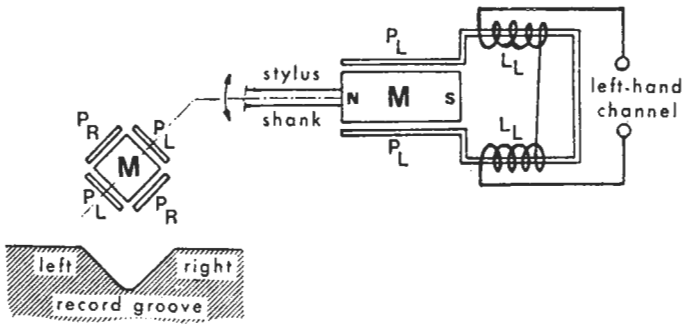
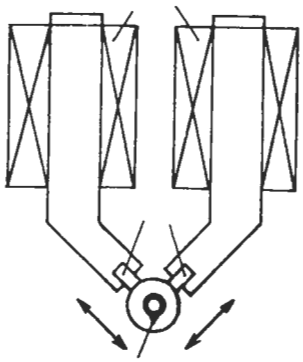
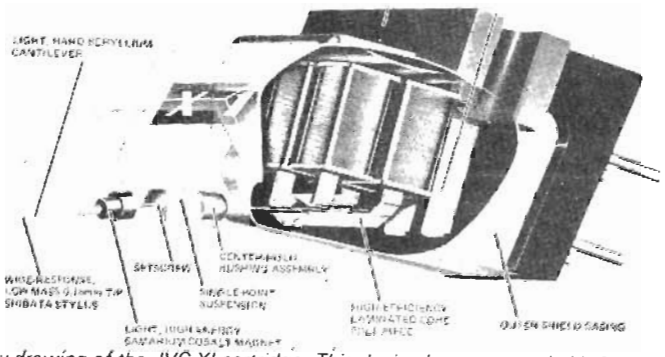


Figure 1. The workings of a moving magnet cartridge, which in this case is a Philips 412. The bar magnet is marked 'M', and PL and PR are the pole pieces for each channel.



Audio Technica's dual magnet system. On the left an actual stylus assembly, and on the right how that bit in the circle operates, copying the cutting head movements.



A cutaway drawing of the JVC XI cartridge. This device has an extended h.f. response to allow it to produce CD4 records, a task for which it has become the standard machine!

Surely this needs no introduction? The Shure V15 Mk3, probably the most famous moving magnet cartridge and arguably the most transparent in reproduction.

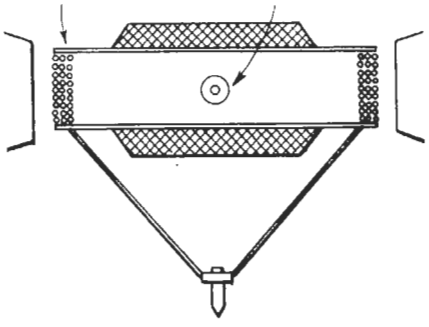
A Philips 422 Super M. Very under-rated device this, people tend to only use them in Philips decks! The diagram in Fig 1 refers to this cartridge.

MOVING COIL

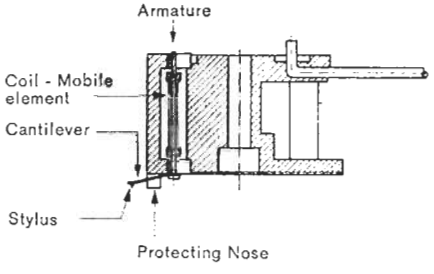
The oldest form of pickup cartridge. Originally developed by Ortofon, and now carried on by such adherents as Satin, Fidelity Research (and even Sony!).

The principle is extremely simple. The magnets are held in a fixed position within the cartridge body, and the coils for each channel are attached to the stylus assembly. The basic design is shown below. As the stylus follows the groove, the coils are forced to move next to the relevant magnets, thus inducing an emf in each.

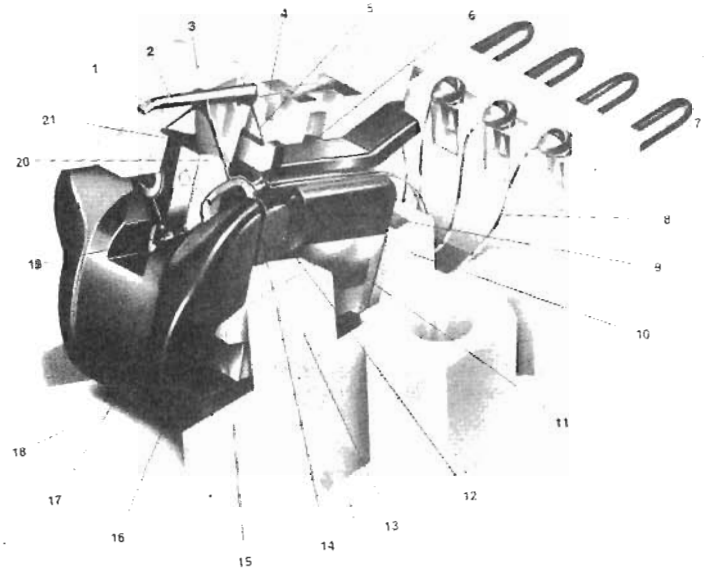
The main drawback is the low output, roughly 0.5 mV, as compared to 2 - 5 mV for the moving magnet designs. There are exceptions, notably Satin and Ultimo which produce outputs around 2mV. In order to raise this low level to one which can be fed to a normal input, a transformer or booster amp is required between cartridge and amplifier. However a tiny, but increasing number of amplifiers are now incorporating moving coil input to negate this requirement.



A highly simplified model of how a moving coil cartridge works. The blocks to either side represent the magnets, and the little flocks of circles are the coils.



Cutaway drawing of an early Ortofon moving coil device. An interesting feature is the vertical armature mounting. Note the protective nose mounted to safeguard the stylus!

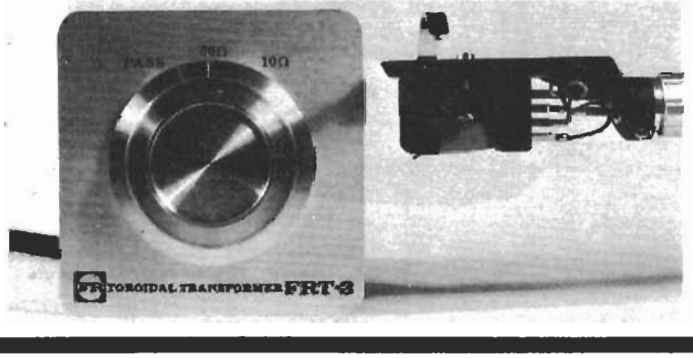


1. Stylus tip
2. Cantilever
3. Stylus housing
4. Tension wire
5. Plate spring
6. Stylus mounting magnet
7. Output terminals
8. Connecting wire
9. Oscillating block resonance damper
10. Oscillating block restriction wall
11. Magnet
12. Pole piece
13. Oscillating block restriction wall
14. Magnetic gap
15. Gap spacer
16. Yoke
17. Moving coil
18. Cartridge main housing
19. Armature positioning pin
20. Armature support
21. Pantograph-type armature

Above is an internal peek at a Satin moving coil pickup. This is one of the high-output cartridges which does not need a transformer or booster amp to be used with normal amplifiers.

If you're setting up a hi-fi system based on a moving coil cartridge, check out the Yamaha 1010 amplifier, it already possesses a high quality moving coil pre amp!

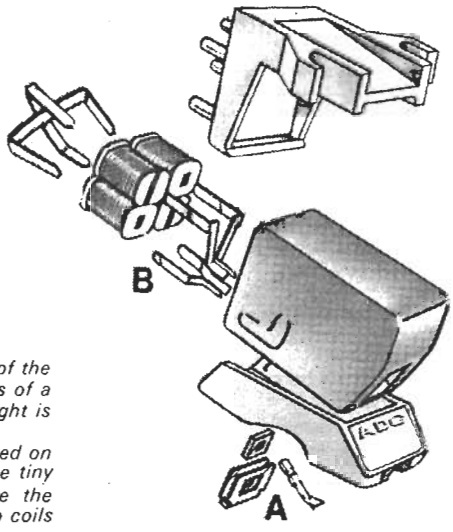
And in the right corner . . . a Fidelity Research device with its booster transformer. This Japanese device has picked up quite a few followers in its short but glorious career in Britain.



INDUCED MAGNET OR MOVING IRON

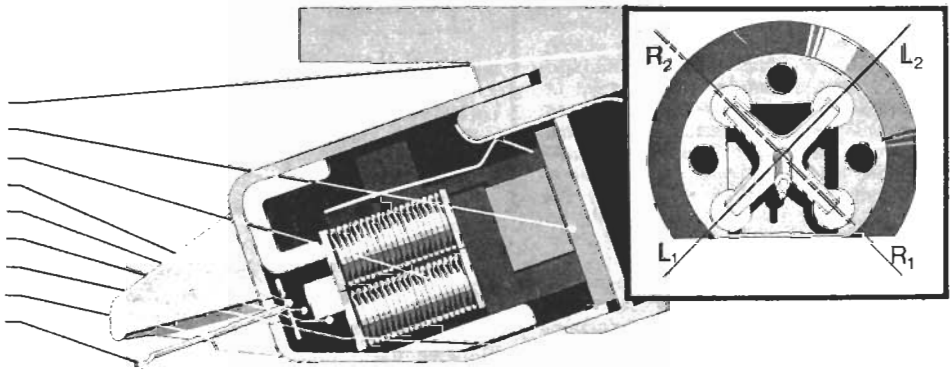
Replacing the moving magnets is a single high permeability armature which itself moves with the stylus within the field of the (fixed) magnets. As there is no mechanical linkage the mass of the stylus is reduced. ADC are the prophets of this system.

Bang and Olufsen have an innovation on the market in the form of the MMC range. Here a small 'cross' is attached to the armature and this influences the 4 induction coils, to obtain that emf.



Right: ADC are the main exponents of the art of the induced magnet. The drawing shows the vitals of a Q36 pickup following this doctrine. Further right is how it looks when in use and in one piece.
Below: Bang and Olufsen MMC is heavily based on the moving iron principle, but incorporates the tiny little cross (shown as an insert) to improve the transfer from armature to coils. Note that two coils per channel are used.

½" mounting bracket
Hycomax magnet
Induction coil (4 in total)
Moving micro-cross (MMC patent)
Block suspension
Pole piece (4 in total)
Mu metal screen
Ultra light cantilever
Stylus

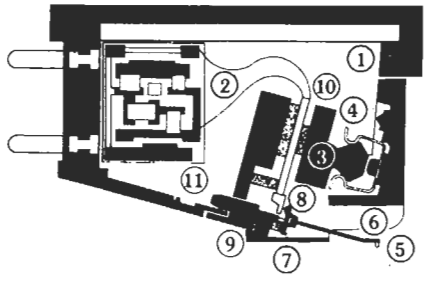


ELECTRET

Just as a quartz crystal is capable of producing an output under stress so are some semiconductor substances. An 'electret' is a permanently polarized block of material which, when stressed, produces an output voltage directly proportional to the force causing the stress.

In the Micro-Acoustics QDC 1E cartridge, a conventional stylus assembly joins with a pyramid shaped chunk of material which is pivoted in the centre of the base, and supported by two elastomer blocks, at each corner, where the actual electret contacts the pyramid.

Output impedence is around 8K, which shunts the usual 47K of amplifier inputs down. Micro claim this engenders their cartridges with lower noise figures. Phase shift characteristics should certainly be good, since the output impedence will be almost pure resistance, with very little capacitance present, and no inductance. The signs are that this system will be used increasingly as time goes on.



The drawing shows the insides of a Micro Acoustics 2002 electret cartridge. This is the cheaper version of the QDC 1E referred to in the text. To explain the numbers: 1, Total device possesses a mass of 4.0 grams; 2, Internal connecting wires to the matching circuit; 3, Dampers (mechanical); 4, Retainer spring for the stylus assembly; 5, Stylus assembly; 6, Beryllium cantilever; 7, Bearings and resolver; 8, Stylus to electret coupling; 9, User replaceable stylus assembly; 10, The actual electret transducer; 11, Passive matching circuit (matching to phono inputs).