SAFIRE 9: Some technical explanation about higher tonearm mass

A basic explanation about what is effective tonearm mass, cartridge compliance and its effects on tonearm resonance and reproduction, can be found in our paper KAA 2016 (Kuzma Analog Academy 2016- pages 17-20). More can be found on various web sites.

To transform musical groove modulation into electrical signal we need to fulfil one of Newton's laws about action- reaction, where force moves two opposite objects.
Diamond tip movements in the grooves, via the cantilever generates electrical signals in the cartridge body.

Since we do not have zero mass on the diamond tip & cantilever and the cartridge body does not have infinite mass, there will be always also some small unwanted movements of the cartridge body. These are invisible to the naked eye, but still there. Since the cartridge body moves that means that the diamond tip reading the groove modulation has no zero reference point. In short this will smear, mask, colour music, affect musical peaks and affect general music reproduction……

In practice we need to construct an arm which will carry the cartridge body across the record to follow the spiral groove on eccentric and warped records, in such a way that the cartridge body will be still i.e. zero reference, in relationship to the diamond tip, allowing as accurate as possible transference of groove modulation into electrical signal.

There is a problem keeping the cartridge body as zero reference. The movement of the diamond tip creates forces reacting on the cartridge body with all musical spectrum feedback. The tonearm tube with headshell and the whole tonearm construction has its own multiple resonances (as does any solid body) which are excited by musical feedback over a wide frequency spectrum. Tonearm bearings also have slack and vibrations. This is not counting vibrations coming from the turntable via the armboard, motor noise or vibrations created by loudspeakers playing music,…So keeping the cartridge body in a headshell at the zero reference point over wide frequency range is not an easy task.

One of the main problems is that we need to keep the tonearm light to allow it to carry the cartridge across the record, following the spiral groove, but a high mass to give the cartridge body rigid support as a zero reference point. It is best to chose rigid and light as possible materials for the tonearm´s construction especially for the tonearm tube which carries the cartridge via the headshell.
Tonearm designers use various materials (e.g.: aluminium, steel, carbon, wood, …….etc) which unfortunately always resonate in some parts of the frequency range.

To simplify, imagine a rubber tube, it will not resonate at medium or high frequencies but it will flex at bass frequencies. That might make for a nice midrange but poor bass and midbass. If you use a well constructed aluminium tube it will resonate in the range 1.200-1.800 Hz. Therefore good bass and midbass but upper midrange and high frequencies could be colouring the sound. To minimise rubber flexing or minimise aluminium resonances we make the tube thicker, to minimise vibrations but then it will have more mass.

So we want to push tube resonances as high as possible. We manage with a sapphire tube to go above 5.000 Hz.

Thus we get to the tonearms with higher mass (effective mass). There are two type of tonearms which always have very high effective mass: pivoted broadcasting professional tonearms- like EMT (above 35 g) or most tangential arms where, due to its construction, horizontal mass is not on a pivot but effective mass is actual linear moving mass and would be in the range of 40-100 g.

For example the Kuzma Air Line tangential arm has a total moving mass in the horizontal direction of around 80 g. If we add a 20 g heavy cartridge with low compliance (stiff suspension) of 10 CU it will have a tonearm resonance in the horizontal plane of around 5 Hz. If we choose the cartridge with 25 CU then resonance will drop to 3Hz. But vertical resonance will be similar to that in pivoted arms i.e.: around 10 Hz.

That brings tonearm resonances well below accepted audiophile wisdom, mainly created in the seventies, that tonearm resonance should be in the range of 8-12 Hz due to avoid amplifying rumble below 8 Hz and being clear away from bass range below 20 Hz.
Some tonearms have a damping option like our 4Point tonearm. Such damping is more useful if tonearm resonances are in the upper range like 10-14 Hz. But at the lower range damping is less effective.

In reality, better turntables now have less bearing and motor noise as well as better support stands and various isolation platforms which eliminate noise in range between 3-8 Hz.
Signals created by eccentric grooves on the record and warps are well below 2 Hz.

Most best cartridges have lower compliance and therefore are suitable for medium to high efective mass tonearms and if we can keep tonearm resonance above 3 Hz it will do no harm.

A well engineered tonearm tube will be made from the right material which will have a rigid self damped construction also automatically increasing effective mass.
Such an arm will have more chance of keeping the cartridge body closer to the zero reference point and will extract more music from the records.

We chose a sapphire tube which has the highest hardness and damping vibration characteristics, making it the best compromise, having the stiffest tube with the minimal mass possible.

But a sapphire tube choice comes with a price.

Franc Kuzma, 2022