

VECTOR EFFECTIVE MASS FINE TUNING WEIGHTS

THE PHYSICS OF EFFECTIVE MASS

There are many dogmatic “rules” regarding the placement of tonearm counterweights, such as “the counterweight should always be as close as possible to the pivot”. Some of these rules were born when tonearm “designers” published articles, white papers, or were interviewed as “experts” by audio magazines. Unfortunately, like most dogma as it relates to complex mechanical systems whose behavior is attempted to be analyzed by “seat of the pants experts”, the “rules” are almost always wrong, or are only “situationally” correct. Because an experiment worked in one system, the wrong conclusion that the theory was correct across a wide range of systems was assumed. This is one of many examples in the record player industry of the designer having a fundamental misunderstanding of the basic laws of *physics* and the studies of *Statics*, *Dynamics*, *Strength of Materials*, and *Vibrational System Theory*, all of which are derived from the laws and principles of physics. (Strength of Materials is not to be confused with a discussion on the strength and properties of various materials. Rather, it is the study of stresses, strains, and all behavior of mechanical members of different shapes.) The Vector tonearm is certainly the only commercially available tonearm which is based upon a scientifically reasonable and plausible “engineering model” and the correct analysis of that model to yield a pick-up system of truly linear response. Based on the engineering model and subsequent analysis, it is therefore not entirely surprising that the Vector is the first tonearm to be free of mistracking during the play of musical signal, and is the first essentially silent tonearm when the cartridge is tracing the record grooves. (However, when being compared to other tonearms, yes, this behavior is totally surprising.)

One small subset of the analysis of a tonearm system is the counterweight system. Counterweights are probably the most popular subject of “elevator theorizing” on tonearm design. Commonly heard dogmatic but unfounded rules include “It should always be close.” “It should hang low.” “It should always be decoupled.” Without qualifying each of these statements with the particulars of the exact problem posed by the cartridge and tonearm characteristics the generalized statements can be shown to be false. This is typical of the rampant “phony physics” and “pseudo science” put forth by many experimenters (calling themselves “product designers”) in high-end audio. This subject is of such complexity that a multi-page engineering paper suitable for a term project discussing the physics of tonearm counterweight systems could be written. That discussion, although modeled, tested and documented by Basis, is beyond the scope of this text.

The one basic tenet that the reader should grasp is that the counterbalance effect, or torque of the counterweight, for a given desired amount, can be achieved by an infinite number of combinations of counterweight masses and distances from the pivot. Although the torque of each combination would be the same (resulting in the same tracking force), the moment of inertia (contribution to the effective mass of the tonearm) is different. The rule of thumb to remember is:

Any single counterweight that is *lighter, and pushed further out* on the shaft results in a higher contribution to the moment of inertia of the arm. Any counterweight that is *heavier and pushed further in* on the shaft will result in a lower contribution to the moment of inertia of the arm.

The fine tuning weights, when used *closer to the pivot* than the main counterweight, will lower the effective mass of the arm. When used *beyond the main counterweight* they will have a smaller effect, and will sometimes raise, but other times lower, the effective mass of the tonearm.

The reason dogmatic statements can not be made about which situation is better is that sometimes, with certain cartridges, lower effective mass is beneficial. In other cases the opposite is true. A specification on the compliance of the cartridge is not a reliable indicator of which configuration would be better, as the compliance of a cartridge is not linear, and is itself the result of multiple miniature “mass-spring systems”. The analysis of this incredibly complex system would be non-linear and involve complex high-order differential equations. The best indicator of the optimal counterweight configuration is sound. The erroneous conclusion that states that the ideal situation is the heavier counterweight closer to the pivot was certainly spread by individuals not

understanding the most basic science behind tonearms. Most likely they were seeing better results that were due to the tonearms being too heavy for the prevalent cartridges of the era (no longer the case), or that suffered from inadequate counterweight shaft stiffness or damping. You should resist forming any conclusion before your testing so that you can objectively determine the configuration that sounds best to you.

USE OF THE TUNING WEIGHTS

In using the 2 Vector tuning weights, it would first be advisable to become accustomed to the sound of the system with only 1 main counterweight. Then, at some point, one could install a fine tuning weight in front of (closer to the pivot) the main counterweight. Reset the tracking force, and listen to your favorite records. This configuration will result in a slightly lower effective mass. Listen particularly to the lower frequencies for detail, dynamics, and depth to determine which effective mass you prefer.

One can also use 2 of the weights together, and the fine tuning weights can be placed behind (toward the end of the shaft) the main counterweight. It must be pointed out that the effect of using the fine tuning weights in this position will be more unpredictable than using them in front of the main weight. As stated earlier, in front of the main weight they will cause the effective mass of the arm to be lower. When placed behind the main weight the fine tuning weights will sometimes raise but other times lower the effective mass of the arm. This will depend upon the original position of the main weight and the position chosen for the fine tuning weight(s). Placing the fine tuning weights in front of the main weight, closer the pivot, will make a larger overall change in the effective mass than placing the tuning weights behind the main counterweight. (The opinion of some readers may be that placing the counterweights behind the main weight cannot have 2 different effects on the effective mass depending on the situation. For those readers we can furnish more detail and the mathematical analysis which proves the Basis stance.)

Determining the optimum position of the weights will be a matter of trial and error, comparable to setting VTA. The results may not make any sense to you, and the system is complex enough that the sonic results probably should not make sense! Should you find the process too frustrating simply go back to the single main counterweight and enjoy the music. Without any fine-tuning of counterweights the Vector represents a step forward in tonearm performance. Lengthy discussions over the telephone or e-mail are not something in which we at Basis Audio can engage as the results are too unpredictable and system dependent. We spent several thousand dollars to make the weights available as our experience has shown us that certain individuals will spend hours tuning and adjusting to achieve the best sound, and will welcome the opportunity to fine tune their record player system.

We at Basis would like the reader to contemplate the hours spent on the above research and the effort in making the parts available. These parts obviously can never be justified as a commercial product. Instead, the research and the weights themselves are done as a purely academic exercise to better understand tonearm behavior and then to offer to the audiophile a chance to experiment himself and possibly improve his system. Projects such as this make Basis stand alone in the understanding of all of the factors affecting record playback. Basis therefore also stands alone in offering superior analog products based on science as well as the art of listening.