@udiophilia

A Beginner's Guide to Cartridge Setup

Andrew Chasin

[The fine print: The cartridge setup procedure described here is to be used solely as a guideline, and may not be applicable to all cartridges and tonearms. If the instructions here conflict with those provided by your cartridge or tonearm manufacturer (assuming you're fortunate enough to get any), follow those from the manufacturer. Furthermore, Audiophilia will not be held responsible for any damage sustained by your cartridge, tonearm, turntable or anyone foolish enough to sneak up on you from behind while following these instructions.]

With the near-complete erosion of support for vinyl playback at the retail level, audiophiles devoted to the analog disc have little recourse but to become adept at the finer points of cartridge setup. And while correctly setting up these delicate devices does require relatively vast amounts of both time and patience, the steps involved are well within the scope of the audio enthusiast with a steady hand and the right tools at his disposal.

The goal of vinyl playback is to extract, as faithfully as possible, the tiny signal carved into the surface of the record by the record cutting lathe. If the stylus replicates exactly (in three dimensions) the cutter's path through the record groove, then the signal extracted should be an exact replica of the one deposited in the groove by the cutter. Of course there are many reasons why correct stylus geometry with respect to the groove is insufficient to guarantee perfect analog signal extraction, the electromagnetic properties of the cartridge's internal wiring and magnet structure, and the shape of the stylus itself being but two. Even exercising the utmost care and patience during setup, the best we can hope for is a good approximation of the original signal, which, in practice, turns out to be more than sufficient for superb musical results.

Tools at a Glance

Here's a quick summary of the tools you'll likely need to install your phono cartridge:

* Pair of tweezers
* Small needlenose pliers
* Toothpicks
* Non-magnetic headshell screws, washers and, possibly, nuts if not provided by the cartridge manufacturer
* Small, non-magnetic, screwdriver set
* Stylus pressure gauge, like the Shure SFG-2
* A lighted magnifying glass of at least 10X power
* An alignment gauge such as the DB Systems DBP-10 (or the one provided by your tonearm manufacturer)
* A test record such as Hi Fi News and Record Review's HFN-1

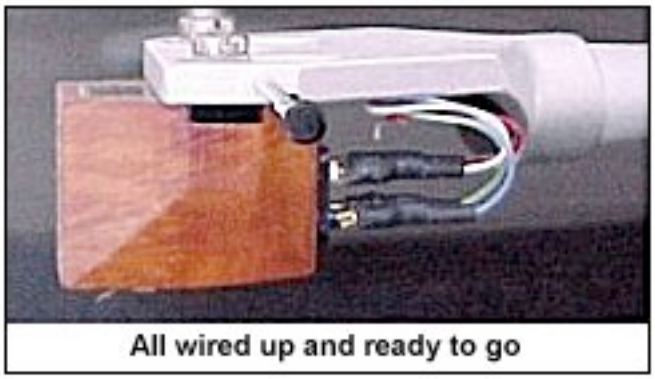
1. Installation
Firstly, if your cartridge was supplied with a cover that clips over the stylus/cantilever assembly, keep it in place throughout this step and the wiring step described below - it might just prevent you from shearing off the cantilever on your $2000 cartridge during an untimely lapse in concentration!

Cartridge installation begins by affixing the cartridge body to the tonearm headshell. Tonearm headshells typically contain either slots or holes through which screws (usually supplied with the cartridge, and should be of the non-magnetic variety) may be passed into the cartridge body. Slotted headshells allow for the position of the cartridge to be adjusted for correct alignment. Headshells containing fixed-position holes (such as those of the venerable Rega RB300 and Naim Aro) assume that the geometry of the partnering cartridge is such that correct alignment will be achieved using the holes supplied. Unfortunately, tonearms whose headshells contain fixed holes will not allow for correct alignment of all cartridges . They do, however, make setup of compatible cartridges relatively simple (tonearm manufacturers who advocate fixed-hole headshells usually have a particular cartridge, or set of cartridges, in mind at the time of design - namely their own or those of a manufacturer whose products are believed to work well with the arm in question).

The holes in a cartridge body, meant to accept the screws which affix the cartridge to the headshell, generally come in two flavors: threaded (or tapped), and non-threaded. Threaded holes are more convenient to use, as they they obviate the need for the small, difficult-to-handle nuts required to secure the cartridge screws to a non-threaded cartridge body. If your cartridge does not have a threaded body, then you'll have to resort to using nuts to secure the cartridge screws. If possible, insert the screws from the bottom of the cartridge, through the slots or holes in the headshell, so that the nuts can be secured from above. Those lucky enough to have a tapped cartridge can simply insert the screws down through the headshell into the tapped holes in the cartridge body (it is a good idea to use a washer between each screw head and the headshell so that the tightened screw will not mar the headshell's finish). In either case, the cartridge screws should be tightened slightly so that the cartridge is somewhat secure but still allowed to move with moderate hand pressure. In the case of a fixed-hole headshell, the cartridge screws can be fully tightened as no further adjustment is possible. Keep in mind that cartridge screws should be quite snug but not over-tightened. Overtightening can distort the cartridge body or, in the worst case, cause it to crack.
Cartridge Wiring Photo

2. Wiring
Once the cartridge is affixed to the headshell, connect the fine color-coded tonearm wires to the corresponding color-coded pins on the back of the cartridge body. While connecting the tonearm wires to the cartridge pins, always handle the wires with great care - they are fragile and can be damaged by surprisingly little force. Grab the small metal cartridge clips which terminate the tonearm wires using a pair of tweezers (never grab the tonearm wires themselves!), and guide the clips onto the cartridge pins. In some cases, the clips may be difficult to fit over the cartridge pins unless they are pried open slightly using a small screwdriver or a toothpick. Don't overdo it or the

clips won't make good contact with the pins. In the event that the clips are spread too wide, they can be squeezed back together using a small pair of needlenose pliers..

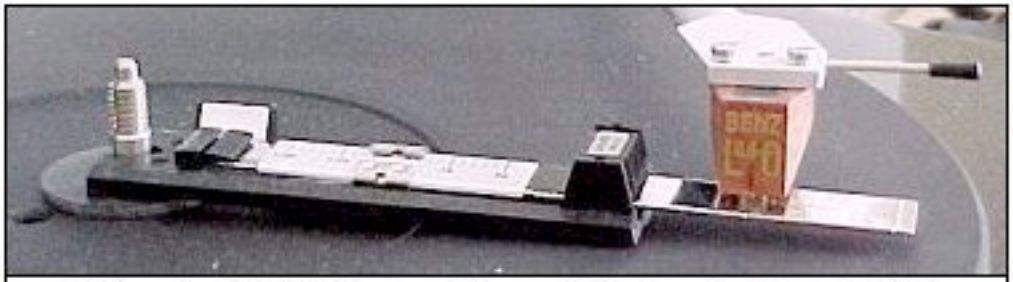


All wired up and ready to go

3. Tracking Weight
(Note that if a stylus guard is still in place at this point, remove it now and leave it off through the remainder of the setup process.)

To play back a vinyl disc, the stylus must make good contact with the walls of the record groove. The question is, how much downward force should be applied so that the stylus will neither lose contact with the groove wall as it traces the path of the groove, nor fail to faithfully follow the path of the groove due to excessive downforce? Cartridge manufacturer's typically specify the downforce, or tracking weight, for a particular cartridge, usually as a range of recommended values in grams. It is best to begin the process of determining the optimal tracking weight within the specified range by setting it to the highest value within that range. To dispel a common myth, a cartridge given insufficient tracking weight is more likely to cause damage to the groove wall than one whose tracking weight is set at the high end of the recommended range. This is because a cartridge that is tracking too lightly will tend to lose contact with the groove wall, or mistrack, on highly modulated passages, causing damage to the groove as it bounces about in an attempt to regain contact.
Setting tracking weight using the Shure SFG-2

There are several devices available currently which can be used to measure tracking weight. The Shure SFG-2 stylus pressure gauge is the most popular due to its low price (about $30 from mail order retailers such as Elusive Disc and Music Direct) and reasonable accuracy. The Shure gauge works essentially like a balance: the stylus is placed in a recessed groove at one end of the balance, and a sliding counterweight, towards the opposite end of the balance, is moved along a calibrated scale in an effort to counteract the weight of the cartridge. When perfect balance is achieved, the weight of the stylus against the balance can be read directly from the calibrated scale. Although the results achieved with the Shure gauge are approximate at best (results are dependent on the accuracy of the calibrated scale, as well as the user's ability to visually judge the degree of balance achieved), they are more than good enough in most cases.



Balancing Act: Setting tracking weight using the Shure SFG-2

Shure states that the SFG-2 is accurate to 1/10 of a gram for tracking weights less than 1.5 grams. For cartridge's that track at heavier weights, it is, in my experience, more realistic to expect measurements taken with the SFG-2 to be accurate to within 2/10 of a gram. Still, given the fact that tracking weight can vary by as much as a few tenths of a gram as a cartridge tracks record warps, the Shure gauge should prove sufficiently accurate for most installations.

Winds Arm Load Meter

For those who desire the ultimate in accuracy and convenience, the Winds ALM-01 Arm Load Meter, accurate to 1/100 of a gram, is a must-have. At about $800, however, this item is only for those vinylphiles with the deepest of pockets (a less expensive alternative is the ALM-1, accurate to within 1/10 of a gram, priced at about $500). A competing device, soon to be released by cartridge manufacturer Clearaudio, is to retail for approximately $375, although its accuracy is unknown at the time of writing.

The Winds gauge is surely the simplest and most accurate gauge I've ever had the pleasure of using. It is completely electronic in nature and is, therefore, not prone to the errors inherent in balance-style devices such as the SFG-2. Use of the gauge is trivial: the user must first zero its LCD display using the built-in calibration wheel. The stylus is then lowered onto a circular sensor located on the top surface of the gauge. After a few seconds, during which time the LCD display gradually converges on a numeric value, the tracking weight can be read from the display.

The only gripe I have with the Winds gauge is that I found it to produce wildly incorrect results, with no warning, if its 9 Volt battery is not fully charged. Considering its price, the omission of a low battery indicator is inexcusable, especially in view of the consequences of setting a cartridge's tracking force terribly

wrong (that is, after all, why one would want to use a gauge like the Winds in the first place!).

Before attempting to set the cartridge's tracking weight using a gauge and/or a test record, it is best to zero-balance, or "float", the arm with the cartridge affixed. This provides a good reference point from which to begin to increase the tracking weight towards the desired value. The arm/cartridge is floated by moving the arm's counterweight either towards or away from the headshell until the arm reaches a point at which it floats with virtual weightlessness. At this point, the tracking weight of the cartridge is approximately 0 grams and can be set accurately using a gauge like one of those described above.

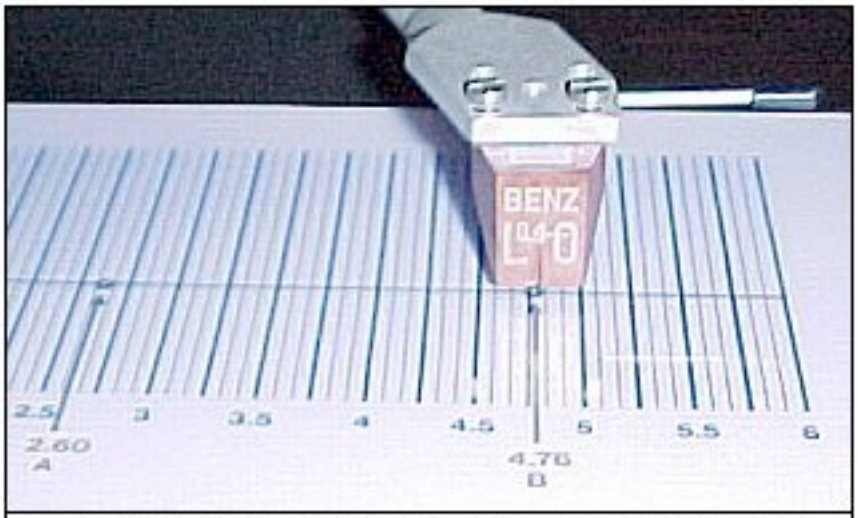
4. Arm Height: Part One
With the stylus pressure set to the high end of the manufacturer's specified range, it's a good time to adjust the height of the tonearm so that the arm tube is roughly parallel to the platter. You'll fine tune the height of the arm later in the setup process, but getting it set parallel now will make later adjustments that much easier. Most arms allow for some form of height adjustment. Inexpensive arms, like the Audioquest PT series, typically provide a set screw which holds the arm pillar in place, which allows for a wide range of adjustment but makes it difficult to repeatedly find previous settings. More expensive arms, like the Graham 2.0 and the VPI JMW, provide more sophisticated height adjustment mechanisms which contain finely calibrated scales and allow previous settings to be repeated with great ease. The Rega RB300 is one of the few arms in its class that provides no height adjustment mechanism. However, small spacers can be placed under the arm to raise it to the desired height.

Don't fuss too much over the height of the arm at this point. You'll have plenty of time to obsess over it with typical anal(og) retentiveness later in the process.

5. Alignment
Records are cut using a cutter head that is positioned at a tangent, or parallel, to the cut groove. With a pivoted tonearm, which forces the stylus to trace an arc across the record surface, only an approximation to the cutter head's tangential path is possible. The seminal work of Baerwald ca. 1941 showed that the tracking error of a pivoted stylus could be minimized if the stylus is aligned such that it is parallel to the groove at two points along its curved path: specifically, at the two points that are a distance of 66 and 120.9 mm (or 2.6 and 4.76 inches) from the center of the spindle (note that these numbers assume that the inner and outer radii of the record's grooves are no smaller than 2.375" and no larger than 5.75" respectively, which is, thankfully, the case for most records). These two points are commonly referred to as "null points" as a tracking error of zero is achieved when the stylus is tangent to the groove at these points. A commercially available cartridge alignment gauge can be used to align the cartridge such that it satisfies the tangency requirements at the null points.
Aligning the cartridge using the DB Systems alignment gauge

Most modern cartridge alignment gauges, such as the popular D B Systems DBP-10, are designed to produce correct Baerwald two-point alignment, although there are some that are designed using a less common one-point method (the alignment jig that is included with the VPI JMW tonearm, for example). When aligning a cartridge for tangency using any alignment protractor, it is essential to remember that you are

attempting to align the cantilever (and, hence, the stylus), not the cartridge body. There is no guarantee that the cantilever is perfectly aligned within the cartridge body, so simply aligning the cartridge body will not necessarily produce the desired result. Furthermore, many cartridge bodies have non-parallel sides, making tangential alignment of the cartridge body with the lines of tangency on the gauge virtually impossible.



Cartridge alignment using the DB Systems two-point alignment gauge

Most alignment gauges are simply cardboard, plastic (or, in some cases, glass) templates onto which are printed or scribed the null point(s) and lines of tangency against which the cartridge should be aligned. The template is placed over the turntable's spindle (made possible via a spindle-sized hole drilled in the template) and placed against the platter. The cartridge's position in the headshell is then manipulated until the stylus is parallel to the gauge's lines of tangency at the null point(s). This process is made somewhat easier by the use of a small, lighted magnifying glass which will allow you to better view the near-microscopic stylus and scrawny cantilever, both usually obscured by the shadow of the cartridge body. This is, by far, the most frustrating and time-consuming part of the cartridge installation process. Making small adjustments to align the stylus with the null point(s) invariably alters its relationship to the lines of tangency - or vice versa. Keep the screws holding the cartridge to the headshell as tight as possible, but just loose enough to allow slight changes in cartridge position. With any luck, the force of the screws against the headshell will hold the cartridge in position while you check your changes against the template (if you're unlucky, the force of the tonearm wires against the back of the cartridge will negate all of your hard work up to that point!). When everything is lined up, tighten the headshell screws with one hand while holding the cartridge steady with the other. Hold the cartridge firmly in place, as the torsional force generated while snugging down the screws will tend to twist the cartridge in the headshell, thus spoiling the cartridge's tangency.

While it might, at some point into this process, seem that aligning what has now become known as "that freaking cartridge" with "those freaking lines and points" of "that freaking gauge" is virtually impossible, take solace in the fact that you're only a dozen or so hours away from playing a freaking record.

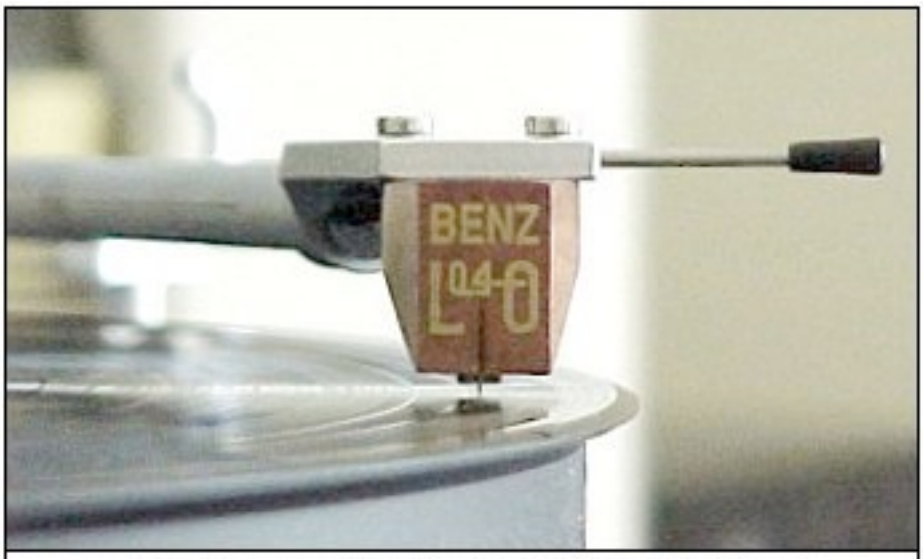
6. Azimuth

With the cartridge aligned (and the sweat squeegeed from your turntable's platter), it's time to set the cantilever's azimuth, or perpendicularity to the groove. Without a correct azimuth setting, the electrical output from the cartridge's two generators will be unequal (when reproducing a signal with equal amplitude in both channels), resulting in a channel imbalance and a shift of the soundstage to either the left or right. Be warned, however, that not all tonearms allow for changes in azimuth, the Rega RB300 being one prominent example. Other tonearms, such as the Audioquest PT family, allow for crude azimuth adjustment via a set screw at the base of the headshell. More costly tonearms, such as the unipivots from Graham and VPI, supply sophisticated azimuth adjustments, via one or more weights, that make setting and maintaining correct azimuth a relative joy.

Visually setting azimuth

Azimuth can be roughed-in visually by inspecting the front of the cartridge while the stylus is in the record groove. Does one side of the cartridge appear to be closer to the record surface than the other? If so, then use whatever means the tonearm manufacturer provided to adjust the azimuth such that the cartridge body is parallel (within the limits of your vision) to the record surface. Once a rough azimuth adjustment is found visually, it can be fine tuned via measurement.

The optimal azimuth setting is the one that produces electrical signals of equal amplitude from the cartridge's generators when signals of equal amplitude are present in both channels of the record. Therefore, if we play a record with the same signal in both channels (a monophonic record, for example), but wire one channel out of phase, then the correct azimuth adjustment is the one that produces zero (or near zero) output when the two out-of-phase channels are summed (remember that summing two signals, one out of phase with respect to the other, results in no signal due to destructive interference.)



Straighten up and fly right: visually roughing-in cartridge azimuth

This out-of-phase, or "null", test, can be performed in several ways. If you've got a test record such as the one produced by Hi Fi News and Record Review (and I recommend it highly), then you can simply make use of the azimuth test track it provides. This test track consists of a mono signal with the left and right channels out of phase. If your preamplifier has a mono blend switch (which sums the left and right channels), you can simply play the test track, engage the mono switch, and adjust the cartridge's azimuth until you hear minimal output through the loudspeakers.

In the absence of a test record with an out-of--phase mono track, you can simulate such a track by playing a mono record through a DIY phase-inverting cable. To build such a cable, buy yourself a cheap female-to-male patch cord from your local Radio Shack, cut one leg of the cable in half, and strip away some of the insulation around the copper conductors. Then, solder the positive conductor from one half of the cut leg of the cable to the negative conductor from the other half of the cut leg. Finally, solder the negative conductor from the first half of the cable to the positive conductor from the second half. Cover the exposed conductors/solder joints with electrical tape. You now have a cable that inverts phase in one channel. Now, connect the male end of your tonearm cable to the female end of the inverting cable you've just created, and connect the other end of the inverting cable to the inputs of your phono stage or the phono inputs of your preamplifier. Play a mono record (I use the DCC reissue of Sonny Rollins' Tenor Madness) and switch your preamplifier into mono mode. The azimuth of your cartridge can now be adjusted until you hear zero (or, at least, minimal) output from your loudspeakers.

If your preamplifier doesn't provide a mono blend switch (this feature is becoming rapidly extinct, and I applaud Audible Illusions for continuing to provide one on its Modulus 3A product), then you can dial-in the azimuth of your cartridge using either an oscilloscope (if you have access to one), cartridge analyzer (if you can find one), or the rough 'n ready visual test described above.

7. Tracking Weight: Revisited

With the tracking force roughed in, alignment spot on, and azimuth nailed down, a test record, such as the terrific one produced by Hi Fi News and Record Review, can be used to really optimize the setup. In particular, the cartridge's ability to track difficult passages can be fine-tuned using several bands on the test disc. The tracking tests consist of a test tone (300 Hz in both channels at +15dB) spaced evenly across the surface of the record in order to gauge the consistency of the arm/cartridge's tracking ability. With the cartridge's tracking weight set to the manufacturer's specified maximum value, the tones produced should be pure, without any audible signs of buzzing or distortion. Be aware that buzzing in one channel only is likely the result of an incorrect anti-skating setting (discussed below), rather than a problem with the cartridge's tracking weight. If the signal is stable in one channel but unstable in another, don't increase the tracking weight in an attempt to compensate. You'll likely be able to eliminate the buzzing in the one channel when you set the anti-skate shortly.

The tracking weight can now be decreased gradually until it reaches the minimum value for which the tracking tests continue to produce good results. The resultant tracking weight should represent a good balance between tracking ability and record wear. Of course, modifying the tracking weight changes the deflection of the

cantilever with respect to the cartridge body. In other words, the Herculean effort you expended to get the stylus to fall squarely on the magic null point(s) of the alignment gauge has just been undone by a simple change in tracking weight (you'll soon come to realize that almost every cartridge setup parameter is affected by every other). Fix the cartridge alignment, and recheck the tracking weight and azimuth while you're at it. If that old CD player in the corner is starting to look awfully good about now, don't despair, you're getting there!

8. Anti-Skate

The last critical setup parameter that can be optimized using a test record, such as the one from Hi Fi News and Record Review, is anti-skate. The so-called skating force is a vector force which tends to draw the tonearm/cartridge towards the center of the record when the cartridge is mounted in an offset headshell i.e. a headshell that is at an angle to the line of the arm tube (most modern tonearms utilize offset headshells in an effort to minimize tracking distortion). Unless countered, this force can produce uneven, and premature, wear of the walls of the record groove and stylus, and compromises the ideal spatial relationship between the cartridge's coils and magnet structure. Unfortunately, the skating force varies continuously across the surface of the record and is, therefore, difficult to combat fully. Most tonearms contain a spring-like device that applies a force in the opposite direction of the skating force with approximately equal magnitude. Some arm designers, most notably VPI's Harry Weisfeld, eschew anti-skating devices, claiming that they are a source of vibration and don't accurately and consistently counteract the skating force over the whole of the record surface. Bob Graham , designer of the Graham 2.0 unipivot tonearm, disagrees. His tonearm incorporates a unique lever/weight system that produces a variable force that does, according to Graham, change in direct proportion to the skating forces involved.

Using the anti-skating mechanism provided on your tonearm, adjust the amount of anti-skate until the Bias Setting tracks on side 1 of the Hi Fi News and Record Review test record produce a clean, undistorted signal in both channels. Buzzing in the right channel indicates that more anti-skating force is required, whereas buzzing in the left channel indicates that less anti-skating force is required.

9. Arm Height: Part Two

Thus far, the cartridge has been aligned in such a way as to minimize the tracking error across the surface of the record, and the cartridge's azimuth has been set such that the stylus is perpendicular to the surface of the record. The last adjustment we can make in an effort to duplicate the cutter's path through the vinyl disc is to set the angle of the cantilever relative to the record surface to closely approximate that of the original cutter head. This angle, referred to as the vertical tracking angle or VTA, is changed by modifying the height of the tonearm relative to its base. As the arm height is increased, the VTA is increased, and as the arm height is decreased, the VTA is decreased. Most records are cut with a VTA of approximately 22 degrees, although it is not uncommon for a record to be cut with a VTA as low as 18 or as high as 24 degrees.

Setting a cartridge's VTA is best begun by setting the arm tube parallel to the record surface (if you followed my previous advice, you will already have done this prior to aligning the cartridge). If the cartridge manufacturer was clever enough to have

angled the cantilever at approximately 22 degrees to the horizontal, then setting the arm tube parallel to the record surface should set the VTA to approximately 22 degrees - just fine for playing back the majority of discs. Unfortunately, cantilevers are not always angled at exactly 22 degrees, so setting the arm tube parallel to the record surface may not result in the correct setting. Since there is no convenient way to measure a cartridge's VTA, the best one can do is experiment with different settings and settle on the one that sounds best to the ear. If you're happy with the sound you're getting with the arm tube parallel to the record surface, then leave it there and spend the rest of your time enjoying your record collection. If you want to experiment with various VTA settings, keep in mind that setting the VTA too high will cause the high frequencies to be accentuated, resulting in a bright, fatiguing presentation. In contrast, setting the VTA too low will cause the low frequencies to be accentuated, resulting in a boomy, sluggish presentation.

One could spend a good portion of their remaining days on earth tweaking their cartridge's VTA. It will, after all, vary depending on the thickness of each record played. While it's worth investing a reasonable amount of time to find a VTA setting that works well for a representative sample of records in your collection, don't obsess over it. Life's too short, and there's too much music to be heard.

10. Final Adjustments

Congratulations! You're not done yet! Go back and verify that the tracking force, alignment, and azimuth settings haven't been fouled while making other adjustments. Pay particular attention to azimuth, as adjusting the arm height will likely have subtly modified this setting (although it is difficult to visualize in three dimensions, raising the height of a tonearm with an offset headshell will affect the stylus' perpendicularity to the groove).

Continue to listen to your setup and make minor adjustments until you're satisfied with the results. Then put away the alignment and stylus pressure gauges, file away the test records, and kick back with a fist full of your favorite records. I think you'll find that it really was worth all the effort.

[Thanks to Brian Hartsell at The Analog Room, surely one of the audio industry's kindest souls, for the generous loan of the Winds ALM-01 Arm Load Meter.]