21ST CENTURY VINYL

Michael Fremer

Practical Guide to Turntable Set-Up

INTRODUCTION

Disc cutting, vinyl playback, and turntable set-up don't readily translate to the visual medium as well as, say, war, sex, or a good old-fashioned alien invasion.

So I've tried my best to make the video semi-interesting and perhaps occasionally entertaining, by keeping it relatively simple and leaving out the small, head-spinning details, many of which have actually caused "audiophile wars" to break out among the bickering parties.

VTA (Vertical Tracking Angle) is one such contentious subject, as you'll read on another page in this file. I chose to not bog the video down with these controversies, preferring the old '60's adage: "Just do it," to the paralysis inducing, hand-wringing doubt occasioned by differences of opinion regarding even the most basic issues involved in LP playback and turntable set-up.

For instance, a while back, my friend and colleague Harry Pearson, founder of *The Abso!ute Sound*, suggested tracking Dynavector's XV-1s cartridge at 2.6 grams, though the manufacturer's suggested VTF (vertical tracking force) range was 1.8–2.2 grams.

I conceptually disagreed with Pearson's suggested VTF in my review of the XV-1s because to my way of thinking, the designer of the cartridge best understands the mechanical capabilities of the suspension he's designed. He knows the force necessary for proper tracking, and for locating the moving coil within the most linear region of the magnet system's gap.

Increasing tracking force by almost a half gram above the recommended maximum VTF must put some stress on the suspension (which is, after all in most cartridges, merely a taut piece of thin wire), as well as move the coil physically from the center of the magnetic gap, perhaps to a location beyond the linear region of the coil/magnet interface. What's more, adding a half-gram of additional down-force will certainly change the SRA/VTA (Stylus Rake Angle/Vertical Tracking Angle).

In fact, a VTF increase of 1gram will decrease VTA/SRA by approximately 1 degree (the precise amount depends upon cantilever length and compliance). That is equivalent to lowering the back of most arms a not insignificant 4 millimeters!

Specifically to make a 1degree VTA change in a Linn Ittok arm (Effective length, 229mm) requires moving the arm pillar slightly less than 4mm. Rega arms (239mm), a bit less than 4.2mm. Brinkmann (258) a bit less than 4.5mm, and the SME 12 and other 12" arms (305mm), almost 5.4 mm.

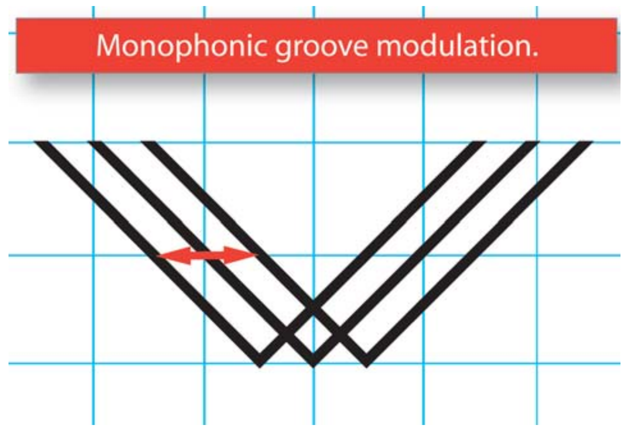
So increasing tracking force by almost ½ gram is equivalent to lowering the back of the arm a not insignificant 2 millimeters—a distance that VTA fetishists insists makes a huge sonic difference!

Perhaps that, and not improved tracking, accounts for the sonic improvement heard by Mr. Pearson. Well, then why not move the arm pillar down 2 millimeters instead of doing it by increasing tracking force beyond the manufacturer's recommended force?

Of course this opens another vinyl can of worms, which is, can you really hear a change of VTA/SRA of 1 degree? And in the long run does it matter? Given the wildly variable angles at which records are cut, and have been cut over the past 50 or so years of stereo (because in mono it doesn't matter since all information is engraved in the grooves laterally), what are you, the listener, supposed to do? Find the correct VTA for every record in your collection and then (if possible) change it for every LP you play? Knock yourself out! I don't do that. I want to play music, not twiddle with my turntable.

At this point in this discussion, perhaps your head is spinning and you want to stop reading and go back to listening. Then by all means do! Be my guest! If you follow my simplified video instructions you cannot go wrong. Your records will sound great. You should hear no audible distortion.

On the other hand, if you want to learn more and explore the controversies, then keep reading! Keep in mind that even this discussion is a simplified version of the math and science, which can go on for days and lead to painful migraines.

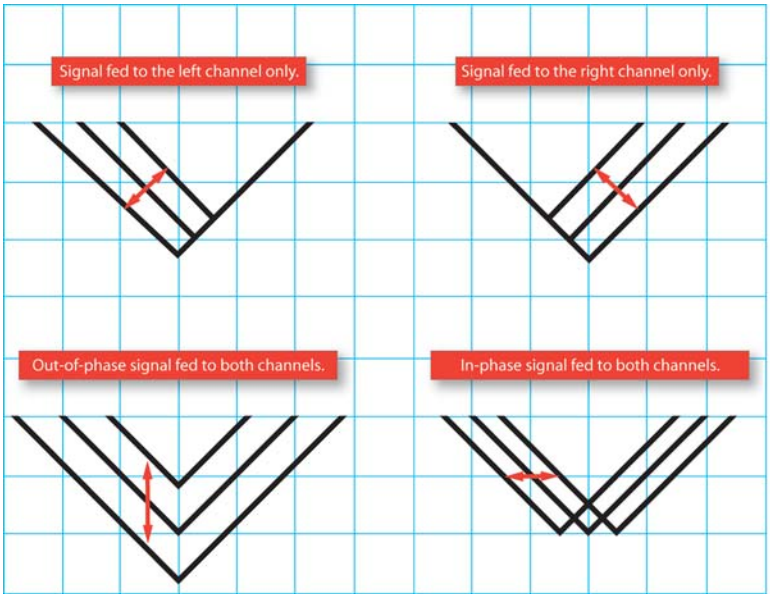


What's In The Groove?

The grooves in a monophonic record are cut with lateral modulations only.

The stylus need only wiggle side-to-side to extract the music, and music is what's in the grooves: wave forms engraved in plastic that are analogs of the waves of air that originally struck the microphone diaphragm, that produced a tiny electrical waveform analogous to the wave of air that made it. The pure analog recording and playback chain maintains the analog of that original wave modulation throughout the processing. While the wave amplitude does get changed, sometimes purposely as in the RIAA equalization curve, and sometimes not, by various kinds of inevitable distortion and loss, the waveform engraved in the groove remains an analog of that original wave hitting the microphone. That's the "magic" of analog.

The conversion of that analog wave to data in the form of a stream of bits, continues to improve, but there remains something inexplicably mesmerizing



about having the "living music" engraved in the grooves of a phonograph record, waiting for the stylus to trace the analog of the waveform to produce a tiny voltage that's an analog of that engraving, that gets re-equalized to produce the full, flat frequency response of the original music, that gets amplified to create a bigger electrical analog of that original wave of air, that excites the coils in the loudspeakers, that causes the diaphragm to pulse and produce a wave of air analogous to that original wave of air, that reached your eardrum that produces the final analog that reaches your brain.

What could be purer than that? Certainly not representing living, breathing music as a stream of "1"s and "0"s! At least not to me.

Perhaps you know all that, but you'd be surprised by how many emails I get from readers asking exactly what is the difference between analog and digital.

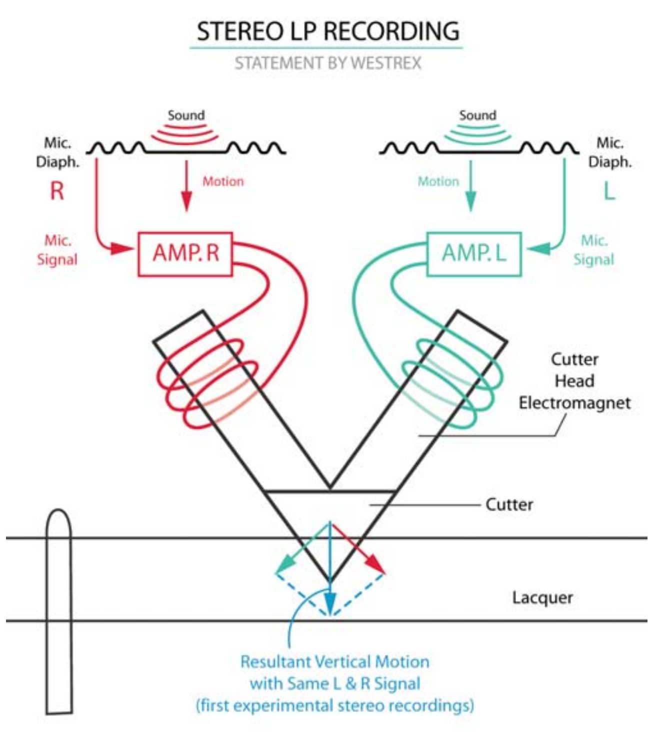
Stereophonic records are cut using the Westrex "45/45" system, which allows for four cutting stylus motions: lateral (as in monophonic cutting), right and left groove wall modulations at a 45 degree angle to a vertical line bisecting the groove, and vertical. However these four motions can lead to an endless combination of playback stylus movements.

In researching information for the production of this PDF file (to make sure my knowledge wasn't faulty), I came upon conflicting information as to what these movements convey.

A lengthy piece about the Westrex system written when it was invented suggested that the vertical modulation recorded in-phase information (*ie*: monophonic), while another reference piece suggested the opposite (L-R or out of phase information), which reflects my longtime understanding of the system.

Needless to say, this caused a great deal of consternation because I want to be factually correct here. *Stereophile* editor John Atkinson confirmed my long held understanding that the vertical modulation represents out-of-phase information. WAM Engineering's Wally Malewicz said both were correct and provided a historical explanation for the discrepancy.

The original Westrex standard did, indeed, have vertical motion created by "in-phase" signals. That is, if both microphone diaphragms in a stereo pair deflected inward, both cutter head coils would be actuated in-phase, resulting in equal cutter head deflection downward. The first non-commercial stereophonic disc recordings were made that way.



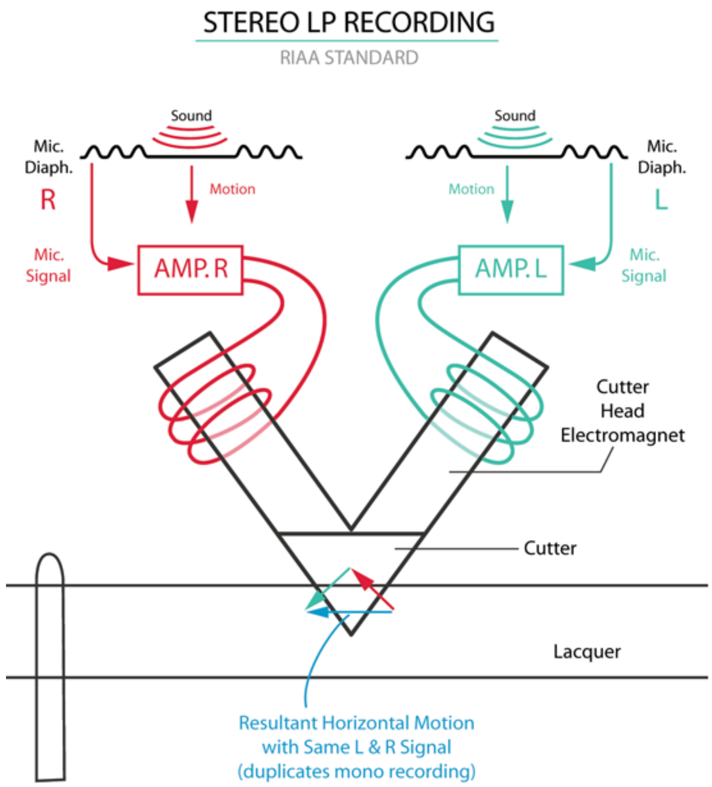
However, when the RIAA (Recording Industry Association of America) got involved, it insisted that the in-phase modulations (essentially the monophonic signal) be engraved in the grooves laterally, thus making the new stereo records "compatible" with older monophonic cartridges that only read lateral signals (though, of course, playing a stereophonic record with a monaural cartridge is not recommended).

In order to accomplish that goal, the phase for one channel of the cutter head is reversed. Doing that causes one coil to "pull" and one to "push" in opposite directions, resulting in lateral movement of "in-phase" information. "Out of phase" information is engraved as vertical modulations.

Stereo cartridges are actually wired with one channel out of phase, so that "in-phase" information arrives in phase (from horizontal modulations) and "out of phase" information arrives out of phase (from vertical modulations).

As John Atkinson pointed out to me, having the vertical modulations represent the out of phase information is one of the reasons it is difficult to cut a recording made with spaced, omni-directional microphones, containing a great deal of bass. The bass on such recordings will mostly be out of phase. "Up to a point," he wrote, "grooves can be cut as wide as you like, but the vertical cut is limited by the depth of the lacquer."

So that's what's cut in the groove: four distinct movements. And four distinct movements are the only ones your stylus should allow. Incorrect deflections generate distortions. This is why bearing tolerances are so important. It's also why some audiophiles are afraid of unipivot arms, which seem to be able to wobble where they shouldn't. Properly designed and set up ones don't, in my experience.



RIAA EQUALIZATION

Were records to be cut with full frequency response intact, bass excursions would have to be so wide, the number of grooves able to be cut on a side, and therefore the amount of material able to fit on a side, would be severely limited. Therefore, during the early days of monophonic LP disc cutting, various equalization curves were devised that cut the bass response, and in a precursor to Dolby™ Noise Reduction, boosted the treble well above cutter head noise. Record labels used proprietary cutting EQ curves during those early days, forcing hi-fi manufacturers to offer a variety of inverse playback curves on their equipment (FFRR, Columbia, etc.).

A curve devised by the aforementioned RIAA became the industry standard by the time of the introduction of stereo records. A close variation, the IEC curve (International Engineering Consortium), was proposed and adopted in Europe in 1976, and while some modern phono preamps include an IEC option (it modifies the curve in the deep bass), most don't. It's nothing to be concerned about, both because of its similarity to the RIAA curve and because of how relatively few records were cut using it. However, if you own a substantial collection of early monophonic LPs, you should consider adding a phono preamp that offers EQ curve options.

When you feed your cartridge's output into a phono preamp, the built-in inverse RIAA curve boosts the bass and cuts the treble in a mirror-image operation that (hopefully!) restores the original recording's flat frequency response. So while audiophiles are down on "equalizers," every time you play a record, you're using one—and a severe one at that!

What follows is a reiteration and in some cases a clarification and amplification of what's on the video…

STEP ONE: LEVEL YOUR TURNTABLE!

Using a spirit bubble level, check the level of the platform upon which you've placed your turntable. If it's significantly off, level it first. Dedicated equipment and turntable stands usually include threaded feet for this purpose, and some even let you level each shelf, but even if you have to use a wooden shim (hardware stores sell them in packs of 10), it's a good idea to begin with a level, or nearly level stand.

Next, place the bubble level on the platter in the area where the stylus will track the record. If that area is not level, level the 'table using its threaded feet. If that's not an option, improvise. Starting with a level 'table is critical. Note: some platters are slightly concave (lower at center) and the bubble level will give a false reading. So place a flat LP (preferably a 200g, such as a Classic Quiex SV-P) on the platter, and without using a clamp, place spirit level on the record, and then level.

INSTALL THE CARTRIDGE

That's covered in detail on the video. Be sure to watch the RM-5's cartridge installation for useful tips that can be applied to any turntable and cartridge installation.

VERTICAL TRACKING FORCE

Begin with the tracking force at the midpoint of the manufacturer's recommended force (if it's 1.8g-2.2g, begin at 2.0g). As you set horizontal tracking, the cartridge will move fore and aft in the headshell, causing your setting to change. When you're finished setting the horizontal tracking, be sure to reset the VTF to the midpoint recommended tracking force. Don't forget: for complete accuracy, VTF should be set as close to the record surface as possible.

HORIZONTAL TRACKING GEOMETRY

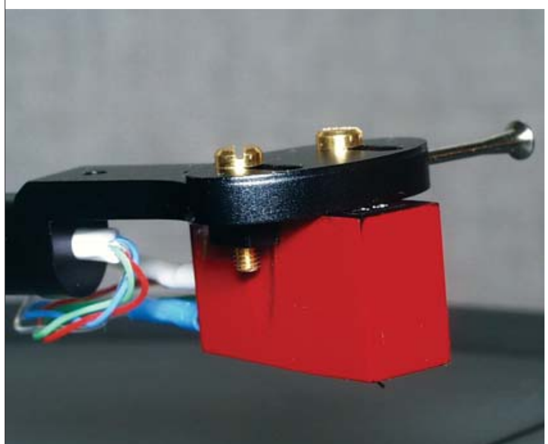
As pointed out in the video, the cutter head "chisel" moves in a straight, radial line to the center of the record. Ideally, the playback stylus should too. That would keep the cantilever tangential to the grooves at all times and the stylus perpendicular to the section of groove wall being tracked.

Unfortunately, many so-called "linear tracking" arms are anything but. While they appear to trace a radius across the record, thus maintaining tangency to the groove, most don't. They either suffer from "yaw" errors, which translate into a series of small, tight, tracking error-producing arcs across the record, or bearing play allows the arm to move fore and aft, which also creates distortion. These tracking angle errors create more and more frequent distortion in my opinion than are produced by a properly designed, properly set-up pivoted arm.

There are many other problems associated with designing a true tangential tracking tonearm, and, admittedly a few designers have solved most of them, but as with all technologies, the solutions involve trade-offs. A large horizontal mass (the entire arm mechanism) must be dragged across the record. Because most LPs are not concentric, the large mass will shift back and forth each half-revolution of the LP. Unless somehow damped, the back and forth movement of this high mass (especially with essentially frictionless air bearing designs), puts a great strain on the cantilever, causing the coils (in a moving coil design) to shift back and forth, in and out of the cartridge magnetic gap's most linear region. That's but one of many problems to be solved and again, designers of the better tangential trackers have, for the most part, solved them, but make no mistake: there are still trade-offs involved in the solutions.

In my experience, a properly designed and set-up pivoted arm offers the most attractive mix of low distortion, high performance, ease of use, and price, though if you are willing to spend a great deal of money and endure the hassle of air pumps and the like, the true linear tracking arms such as the ones from Rockport and Kuzma offer extraordinary transparency, harmonic clarity and spatial performance thanks to zero tracking error. That said, a properly designed and set up pivoted arm offers iron-fisted bass and image solidity that the air bearing arms I've heard don't accomplish quite as well, while being fully competitive in the other areas.

Because a pivoted arm traces an arc across the record surface, even under the best conditions, there can be zero horizontal tracking angle error in but two locations in the arc across the grooves. Those are commonly called the "null" points. They are reachable on this arc traced by the stylus because of the arm's overhang and offset angle. The overhang is a specified distance from the spindle forward to where the stylus would sit, were you to move it in front of the spindle to form an imaginary line from the stylus, through the spindle, directly to the arm pivot. Of course you don't actually do that to set "overhang," but that is to what "overhang" refers. Tonearm designers use either an angled headshell and straight arm tube, or an "S" shaped tube to create the offset angle. Most modern arms use the former approach.



Koetsu Urushi Red

Where those "null" points should occur is subject to debate, and various mathematicians have worked on the problem and come up with differing solutions. The two mathematician's names most familiar to vinyl enthusiasts are Baerwald and Löfgren. Each came up with an alignment designed to minimize tracking distortion, but based on differing criteria.

Tracking distortion varies proportionately with tracking error and inversely with groove radius. In other words for a given amount of tracking error, there will be less distortion at the larger circumference outer grooves. Löfgren, whose analysis came first, in 1938, chose null points of 70.3mm and 116.6mm to minimize distortion in the middle of the arc, between the null points, while allowing slightly higher distortion at the beginning and end of the record. His thinking was that by 'breaking up' the distortion it would be less noticeable.

Baerwald's alignment, with null points at the 66mm and 121mm points across the arc, minimizes average distortion across the entire record surface. Most alignment devices use Baerwald's math, a few, such as Wally's, offer both, and others, such as Rega's, are "custom" alignments. Rega puts the innermost "null" point closer to the lead-out groove area, to minimize tracking angle error where distortion is greatest and where large scale symphonic crescendos tend to occur.

The point of this discussion is simply to make sure you understand that there are many solutions to the tracking angle error issue, that all of them solve the problem in different ways, and that essentially all are compromises in one way or another. In fact, all are based on a "standardized" beginning and end groove area that is not always adhered to.

I happen to prefer the Baerwald solution, which is the most often used. If you order a WallyTracktor, or purchase a Graham arm, you get both Baerwald and Löfgren alignment options. Knock yourself out "experimenting," but I'd rather just listen to music.

How Long is Long Enough?

Most tonearms range in length from between 9 and 12 inches (pivot to stylus distance). Advocates of 12 inch arms cite the lower tracking angle error such arms offer but that advantage only holds true if your horizontal tracking set-up is absolutely perfect because any set-up error gets magnified by the longer length. In addition, the longer the arm, the more difficult it is to match the rigidity of the shorter arms—a critical factor in arm performance. What's more, hanging the weight of the cartridge further from the pivot creates a greater moment of inertia, which means the arm will not be able to react to a warp as quickly as a shorter arm. The point I'm trying to make here is that there are no quick and easy panaceas to solve the many problems associated with LP playback. So don't ever think: "9 inch arm good, 12 inch arm better," or "pivoted arm good, tangential tracker better." That works in the advertising world, but not in the real one.

ISSUES OF MASS AND COMPLIANCE

Way back in the late 1960's and early 1970's, high compliance cartridges and low mass tonearms were idealized. The superiority of such a combination was self-evident. Tracking forces of ¾ to 1 gram were possible, combined with outstanding 'trackability." Shure built its reputation on it, promising low record wear, among the benefits. Yet today, most tonearms are medium to high mass and most cartridges are low to medium compliance. 1.75 grams to well over 2 grams are both commonplace and acceptable. What happened? For one thing, the rise of the moving coil cartridge. With the heavy coils and former (the structure on which the coils are wound) attached to the cantilever, compliance had to be lowered. Yet record wear is still basically a non-issue because proper tracking, more than light tracking prevents record wear (up to a point where too much down force simply crushes the vertical modulations).

The easiest way to conceptualize the relationship between the arm's mass and the cartridge's compliance is to think of a car's suspension, with the springs being the cartridge's cantilever suspension, the tires the stylus, the road the record and the tonearm the car itself (for now we'll leave the role of the shock absorber out of the discussion).

Put really stiff springs (low compliance) on a very light car, and when it goes over bumps the car will rise and fall with the bumps, giving the passengers an unpleasantly bumpy ride. Put really mushy, soft springs on a heavy car and the passengers will get an equally bouncy, uncontrolled ride, though perhaps one that's not quite as bruising to the kidneys.

However, put appropriately soft springs on a light car and the springs will "give" (compress) and absorb the shock when the car goes over the bumps, allowing the car to deliver a level ride to the passengers. Put appropriately stiff springs on a heavy car and the passengers should enjoy an equally pleasant ride.

In addition, any spring (cantilever)/mass (tonearm) system will have a resonant frequency—a frequency that will excite the system, resulting in continued excursions beyond the initial one caused by the road bump or groove motion. In a vinyl playback system it is critical that the resonant frequency fall below music's lowest frequency, yet above "warp/wow" frequency. Generally, acoustic music's lowest note is around 16Hz. (the lowest "stop" on a pipe organ).

A record warp causes an unwanted vertical arm/cartridge deflection. Wow is caused by groove eccentricity, causing the arm/cantilever to deflect horizontally. Clearly you don't want any musical frequency to "excite" the system, nor do you want it excited by the predictable frequencies of "warp/wow," which is determined by the platter speed. The platter rotates at 33⅓ revolutions per minute, or approximately 0.55 revolutions per seconds. Therefore the ideal resonant frequency, both horizontally and vertically should be above "warp/wow" (4-6Hz), and below music (16Hz.).

The generally accepted range where the resonance should fall is between 8Hz. and 12Hz., though upwards of 15Hz. is acceptable unless you play a lot of organ music. If the resonance occurs at a low musical frequency, bass will be muddy, but if it occurs higher up, bass will roll off at 6dB per octave below the peak, and bass could actually sound wimpy.

Now apply that scenario to the arm/cartridge/record groove scenario. It's essential that the tonearm not bounce up and down as the stylus "hits the bumps" (vertical groove modulations). Records are purposely "bumpy" roads, which makes the mass/compliance match that much more critical. The arm should behave as a neutral carrier so the cantilever can follow the groove undulations horizontally and vertically unimpeded by reactive arm movements.

Combine a low mass arm with a stiff, low-compliance cartridge, and you have the light, stiffly sprung automobile scenario: go over bumps and the car will move "in-phase" with springs, bouncing the car up and down. What's more, the system will have a relatively high resonant frequency, so small, numerous and commonplace pavement deviations that should be easy to absorb, might keep the car jittery at cruising speed throughout your trip.

Looking at the behavior of the low mass arm and low compliance cartridge, depending upon the mismatch, groove deflections could cause the stiff cantilever to deflect the arm sympathetically with the groove undulations—something you don't want. Warps might push the stylus out of the grooves entirely. Even were the combination able to negotiate the grooves, the high resonant frequency would be in the music. Depending upon where it fell it could muddy and bloat the bass, or actually roll it off, causing anemic low frequency performance.

Combine a high mass arm with a highly compliant cartridge and you have the heavy, loosely sprung automobile scenario: go over big bumps and the car will undulate slowly up and down, and pitch to and fro, perhaps continuing to do so well after the initial impact. The next bump would do likewise, and if it follows closely behind the first, it could combine with the first bump's remnants and wreak total havoc with the passengers' ride. If the system's resonant frequency was low enough, the problem could be more pronounced at low city street speeds, rather than at highway speeds, and lead to constant bouncing and lurching.

Looking at the performance of a high compliance, high mass cartridge/arm combination, depending on the specifics of the mismatch, there would be a slow uncontrolled low frequency bouncing and wobbling. The tail might actually wag the dog, with the arm, rather than the groove modulations, causing the cantilever deflections. Warps might cause the cantilever to collapse as the arm's mass exerts downforce. So just when you want the arm to rise with the warp, it would do the opposite, putting the whole system out of phase! If the resonant frequency fell in the "warp/wow" area, unwanted low frequency excursions would be amplified, causing amplifier power sucking rumble, as well as mistracking.

These are extreme scenarios, but they do demonstrate the mismatch consequences with great clarity and even a measure of drama.

Clearly, it's important to carefully match a cartridge's compliance to an arm's mass. Roughly speaking, a low compliance (stiff suspension) cartridge is one rated at up to 10 CU (compliance units-dynamic). Medium compliance is 11 to 20 CU, and high compliance is 21 and up.

Now for some math (ugh): CU, using the older measurement system equals 10 to the -6 power x cm/dyna (the displacement of the stylus per unit force). The newer methodology is CU = µm/mN, which equals micrometer/miliNewton. 1mN equals about 0.1gram. If a cartridge's compliance is 10 CU and the cantilever length is, say, 6mm from stylus to internal suspension point, changing VTF (tracking force) by 1 gram will change VTA/SRA 1 degree. If you hear a difference by moving the arm pillar 1mm, you'd hear the same difference, changing tracking force by 0.25 grams.

As for arm mass ratings, low (effective) mass arms are 10 grams and below, medium is 11-20 grams and high is 21 and up.

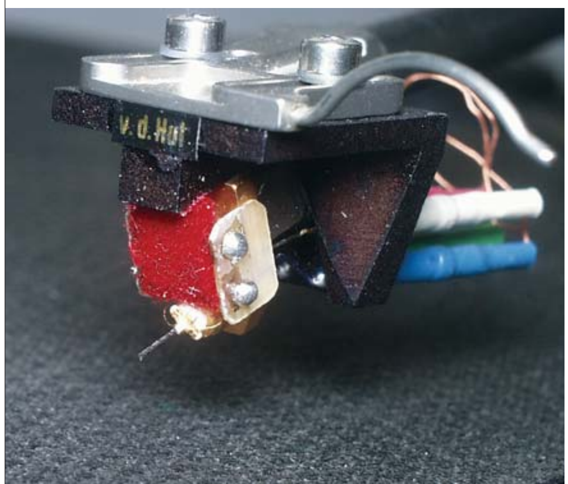
The formula for determining the natural resonance of the arm/cartridge system includes the effective mass of the arm, the effective mass of the cartridge and the dynamic compliance of the cantilever suspension.

Fortunately, you needn't worry about most of this since most cartridge and tonearm manufacturers specify the compliances of their cartridges and the effective masses of their tonearms. Most modern tonearm manufacturers suggest the kind of cartridges best used with their products, and retailers specializing in analog usually (well, at least often) can give you good advice.

A properly designed test record can actually show you both the horizontal and vertical resonant frequencies of your tonearm/cartridge combination, without the use of test gear. The "tonearm resonance" tracks (one for vertical, one for horizontal) consist of low frequency tones identified by an announcer. Most also include an audible high frequency tone. As the tones descend in frequency, you will begin to notice the pitch of the high frequency tone becoming wobbly. At the resonant frequency, the arm should begin to noticeably twitch, sometimes rather violently, shaking side to side for the horizontal resonant frequency and up and down for the vertical one. Hopefully both will be located within the ideal range.

If you don't see or hear one or both of the resonances, you've got a big problem: it means the resonance or resonances are located beyond the frequency range of the test tones. More likely than not, the resonance is higher in frequency than the tones and well into the frequency of music. The result will be mistracking and potential record wear at some audible frequency, and less than satisfactory bass response.

If your arm is pivoted, both resonances will almost certainly fall at the same or very similar frequencies because the horizontal and vertical masses will be the same. Why? Because both horizontal and vertical movements share a common pivot point so the effective masses will be identical. (The only pivoted arm I know of that will have differing horizontal and vertical masses and so probably different resonant frequencies is Dynavector's, which features a unique 'vestigal' vertical arm pivoted well in front of the horizontal pivot).



van den Hul Grasshopper Condor Gold

Tangential tracking arms will almost certainly have different resonant frequencies for a reason that should be obvious to you: the vertical and horizontal effective masses are radically different. The effective vertical mass system is similar to a pivoted arm's, consisting of the arm's mass and the weight of the cartridge hanging at one end of the arm, far from the pivot point, and the counterweight's mass hanging out, but much closer to the pivot point. The horizontal mass, though, consists of the entire arm structure, including the counterweight, which must be dragged across the record. In the case of some air bearing arms, where the rail and not the bearing moves, the mismatch is compounded.

This vertical/horizontal mass disparity creates problems, which various designers have attempted to solve in a number of interesting and not always successful (but sometimes successful!) ways. For instance, in order to minimize the horizontal mass of his air bearing tangential tracker, one designer, John Bicht, minimized the length of his arm tube to little more than a stub. While this worked as intended, it put the pivot point very close to the stylus. When the arm encountered a warped record, it rose and fell at a more extreme rate than a normal length arm, causing the stylus to describe a rather extreme arc as it rose and fell. The result was audible "wow" as the stylus literally moved forward and back in time as it tracked the record.

On one early version of the Rockport air bearing arm, designer Andy Payor went with light counterweights, hung well back from the pivot which increased effective vertical mass sufficient to properly set VTF, while lowering the horizontal mass of the entire moving structure. However, with certain relatively light cartridges, the vertical mass was too low to bring the vertical resonant frequency below musical frequencies. The result was roll off below the resonance and rather weak bass.

Eminent Technologies's Bruce Thigpen's ET2 arm features a fixed air bearing and a sliding rail (the opposite of the Rockport, Kuzma, and some others). His horizontal mass reducing solution was to use a light, low mass thin-walled rail. To minimize the amplitude of the horizontal resonance, he spring-decoupled the counterweight.

The point I'm trying to make here is that when it comes to analog playback, execution counts as much as concept, and perhaps even more so when it comes to "tangential trackers."

One related pivoted arm tip: when given a choice between a light counterweight hung well back from the pivot point, and a heavier one hung close to the pivot, opt for the later: it reduces the moment of inertia, resulting in more responsive and accurate tracking, especially on warped records.

SILICONE DAMPING

"As long as you're analogizing tonearms and cartridges to automobiles and springs, what happened to the shock absorbers?" I hear car buffs asking.

Well, that's where damping and damping fluid comes in. The most effective and sensible place to provide damping in a car is where the springs are and that's where you'll find the shock absorbers. The most effective and sensible place to provide cartridge damping is at the headshell. The only tonearms I know that accomplishes this is/was the pivoted one made by Max Townsend of Townsend Audio, who put a pivoted damping trough in front of the headshell to which was affixed a small, adjustable paddle that sat in a bath of silicone fluid, and the original linear tracking Mapleknoll.

The swing-away trough was located above the vinyl and had to be moved out of the way to change records. Having a load of goo directly above precious vinyl didn't sit well with many audiophiles, and the arm (based on a Rega) never became popular. Nevertheless it worked effectively, as did Shure's mechanical damper located at the front of its late and much lamented V15VxMR.

Today, arms from VPI, Graham, Immedia, SME and perhaps a few others, offer damping. The SME uses a trough similar to the Townshend but it's located closer to the pivot as are Graham's and VPI's damping fluid wells. Graham's allows the inverted bearing to be immersed in fluid. VPI's is somewhat less effective in that the fluid sits in a cup below the actual bearing point. In any case, given the popularity today of medium to low compliance cartridges, damping is less critical than it once was (it's essential for high effective horizontal mass, ultra-low friction air bearing tangential trackers in my opinion), though once you've "fine tuned" an arm/cartridge with an arm that offers damping, you may think otherwise.

If your arm includes a damping option, by all means try it. SME's damping paddle is easy to adjust up and down in the trough. With Graham and VPI you add fluid with a syringe-like device and remove it with cotton swabs. Adding a touch of damping can tighten "woolly" bass, but if you add too much you can overdamp the system and make it unresponsive to where it sounds "sloggy" and slow. So experiment, but be careful not to drip any fluid on your precious LPs. Once a glop of it gets in the grooves it's difficult to remove.

SKATING AND ANTI-SKATING

As I demonstrated on the video, "skating," the tendency of a pivoted arm to want to move toward the center of the record, thereby causing the stylus to be biased toward the inner groove, is a real problem, that most tonearm designers feel should be addressed, even if it can't be with complete accuracy. It's the result of a "vector force" caused by the drag force between the stylus and the groove and the tonearm's offset angle, but beyond that, not being a physicist, I won't attempt a scientific explanation. However, I will say it's not the result of "centrifugal" force as the arm's travel accelerates across the surface due to the tighter groove spirals.

As I reiterated on the video, the amount of skating that occurs varies across the surface of the record, varies with groove modulations, varies with VTF, and varies with the vinyl formula. That makes solving the problem a "moving target," but that doesn't mean it shouldn't be addressed. Better to get it approximately right across the surface of the record than ignore it!

Because skating is a dynamic force, do not attempt to set anti-skating using the flat, non-grooved "plateaus" found on some test records. That is wrong. As we showed on the video, I got surprisingly accurate results following the manufacturer's instructions included with the Pro-Ject and Rega turntables and tonearms. Following the manufacturer's instructions is a great place to start when it comes to setting anti-skating, though as I found out "live" on camera, VPI's new anti-skating device (highly recommended), provides too much anti-skating force, even with the provided weight at the minimum setting. Fortunately, removing the weight and allowing the pivot arm alone to provide the force, proved to be ideal for a 1.75 gram tracking force. That should prove to be ideal upwards of 2 grams as well. Perhaps by the time you read this, VPI will offer a lighter pivot and weight system.

I have found WAM Engineering's anti-skating device to be very accurate, but not everyone will want to invest in it. Do not use "maximum trackability" test tones on some test records to set anti-skating or you'll be setting it way too high.

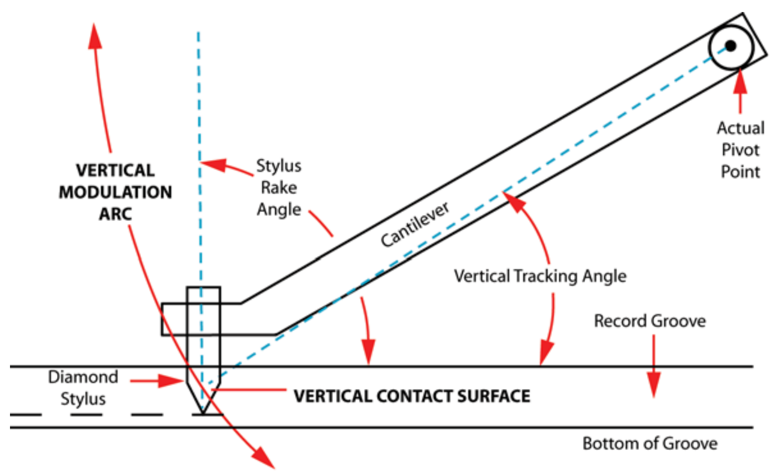
VERTICAL TRACKING ANGLE/ STYLUS RAKE ANGLE (VTA/SRA)

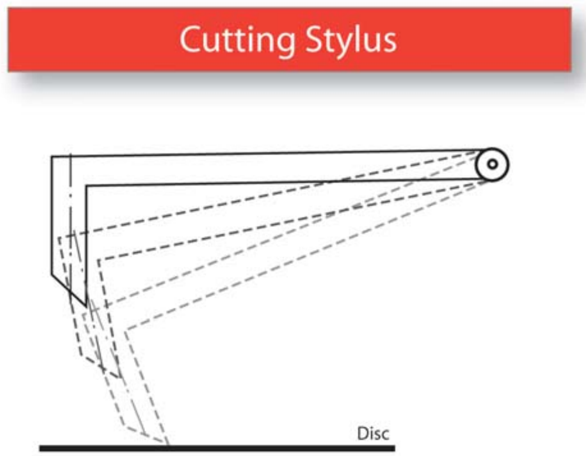
Here we go! When records were cut laterally (monophonically) Vertical Tracking Angle (VTA) was a non-issue. The motion was side-to-side, the styli were round, and it didn't matter at what vertical angle the stylus "saw" the grooves. Once vertical modulations were introduced into the picture, the vertical angle at which the stylus "raked" the grooves became important.

Why? While the cutter head describes a radius across the lacquer surface, and it appears to be directly over the cutting surface, in fact, the cutting stylus is pivoted, and offset slightly from vertical. What's more, it is (sort of) sickle-shaped.

Now imagine a pivoted sickle inscribing both horizontal and vertical modulations into soft lacquer. The horizontal (lateral) inscriptions won't be affected, but the vertical modulations will be angled or "raked."

In playback, not tracking that raked angle precisely will lead to intermodu-





The cutting stylus describes an arc in the vertical mode. This is the angle VTA/SRA adjustment tries to duplicate in playback.

lation distortion—that is, distinct frequencies will "co-mingle" to produce new, unwanted frequencies that are not part of the music.

Ideally, you'd want to match the stylus rake angle to the cutter head's rake angle. Theoretically, you can do this by changing the vertical tracking angle by raising or lowering the arm pillar, or by increasing or decreasing the VTF (tracking force). As I pointed out at the beginning of this long, involved discussion, because the pivot point within the cartridge is much closer to the action than the pivot point at the rear of arm, small changes to VTF will produce greater changes to SRA than small changes in VTA.

So, it stands to reason and geometry, "locking in" VTA and/or SRA is a good idea, and that when you do so, the sound should suddenly "lock in" and become focused and precise. And that is, indeed the case!

Unfortunately, the reality is, unless you plan on diddling with every record you own to get it "locked in," it can't be done. Ironically, it is the VTA "fetishists" who insist that they can hear tiny, less than 1 degree shifts in VTA/SRA, that damage their argument most!

Why? Almost every record you own (unless, say, you are talking about everything cut at Bernie Grundman's and pressed on 200 gram vinyl at RTI by Classic Records, or everything cut by Willem Makee at the Berliner mastering facility in Hamburg, Germany and pressed on 180g vinyl at Pallas, etc.) will have different "locked in" VTA/SRAs!

Why is that? Were you to take the time to research the history of this subject from the earliest days of stereo LPs, you'd find wildly varying VTA standards worldwide, ranging from 0 degrees to 15 degrees to well over 20 degrees. Attempts by the RIAA to standardize both the cutting and playback angles were woefully inadequate and unsuccessful, the result of the usual bickering, infighting and disagreements. It's a wonder it didn't turn violent! Given the relatively limited range of VTA adjustment provided by even the most VTA adjustment friendly tonearm, it is impossible to set correct VTA for every record you're likely to own-especially if you've collected vintage albums.

What's more, even if it was standardized throughout the history of stereophonic LP playback, the nature of the soft lacquer material, and variables in cutting styli and their installation in the cutter head, all conspire to muck things up.

Because of lacquer "spring back," or the tendency of soft lacquer to want to return to it's uncut state (much as a piece of raw meat "springs back" after you press it in with your finger), by the time the lacquer gets plated, it has already begun to "spring back" to some degree, and the amount will vary across the surface of the lacquer, which means during playback, the VTA will actually change across the surface of the record!

In addition, the cutting styli vary in shape and how they are installed in the cutter head can vary each time they are replaced. And of course, variable thicknesses mean that each time you cue up a different weight LP, you're changing VTA/SRA.

And remember: different cartridge manufacturers "rake" their styli and cantilevers at different angles

Add it all up, and what do I conclude? Yes, play a record, and you can change VTA or VTF (to change SRA) and "lock in" the sound noticeably when you manage to duplicate the angle at which the cutter heard inscribed the groove. However, because of all the variables, locking it in for one record does not mean it will be locked in for every record, or even the next one you put on the platter.

If your tonearm's VTA is easily adjustable, you could probably "lock in" and note new records mastered at known facilities such as Classic's (cut at Bernie Grundman's), Analogue Productions' (cut at their own AcousTech facility), and Speakers Corner (mostly cut at either UMG's Berliner facility or at AcousTech). But as soon as you stray from those known entities, you're on your own! Favorite records could be "locked in" and noted (for me it would be my Parlophone Beatles, Decca Stones, original "Living Stereo"s, "pink label" UK Islands, and I guess a few others), but to tell you the truth, I don't do it. I'm more interested in playing music and having it sound great, but not necessarily "perfect."

So what's the best strategy for setting VTA initially? Most contemporary cartridge manufacturers suggest beginning with the tonearm parallel to the record surface, and they specify a range of tracking forces, with some also giving you their "ideal" if your arm can track at that force. You can bet that following the manufacturer's instructions is a good place to start your exploration of VTA. Choose the LP thickness most important to you. If you've made a big investment in Classic 200g Quiex SV-P LPs, start with one of those, or a 180g or whatever. I use a 180g LP because then a 200g Classic and a standard 120g LP will fall on either side of the divide.

From that starting position, you can experiment to find the "lock in" position (see section coming up on what to listen for) for any particular LP or label. If you want to note the correct VTA/SRA for every record in your collection or by label, or whatever, knock yourself out! I don't do that. You could find the precise "locked in" position for your favorite demo record, for instance, so you can go there when you want to show off your system. I don't bother.

If your tonearm allows for VTA adjustability, but not the convenient kind, find a satisfactory position and, in the words of Ron Popeil "set it and forget it!"

Remember: if need be, you can decrease SRA by increasing tracking force and vice versa.

While preparing this file, I read a very interesting, detailed and useful musing on this subject by Geoff Husband, published on the website TNT-Audio.com. With his kind permission I have reproduced portions of it, toward the end of this file.

AZIMUTH

If your tonearm allows you to adjust azimuth, it's well worth investigating. If you're using a unipivot, it's mandatory if you hope to extract the most performance from your cartridge. WAM Engineering has been kind enough to provide me with a voltage to decibel chart (attached to this PDF) as well as a form designed to make electronic azimuth adjusting relatively easy.

As I demonstrated on the video, at the very least, use a mirror on the platter and with the stylus resting on it, you should see the stylus and its reflection creating a straight line. If it's crooked, adjust the arm according to the manufacturer's instructions, until the line is straight.

However, using the electronic method is far more accurate. While I thought I explained it pretty well on the video, I'll go over it again here. You will need an accurate digital voltmeter and a good test record that has separate left and right channel 1kHz tones, preferably running two or three minutes in length each.

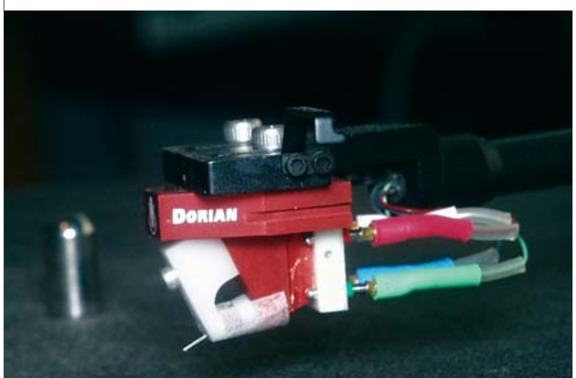
Here's how to do it, without using WAM Engineering's azimuth adjustment device:

Begin by setting the voltmeter to low AC volts (5V or less), and insert the probes into your amplifier's left channel speaker terminals. Play the left channel tone, turning the volume up until the meter reads two volts or so. If you can go a few higher without it hurting your ears, four volts is fine too. Because of rumble and other record irregularities, the voltage will vary. Try to determine an average value and write it down, labeling it "big volts, left channel."

Now play the same left channel tone again, but this time with the voltmeter probes in the right channel amplifier's speaker terminals. This is the crosstalk voltage (unwanted left channel voltage appearing in the right channel) and it will be far smaller, probably around .14 volts or so. Write it down, labeling it "right channel small voltage."

Now, without changing your preamp's volume control, reverse and repeat the process, playing the test record's right channel 1kHz tone, labeling the 4 volts or so "right channel big voltage," and the crosstalk left channel voltage "left channel small voltage."

Now, convert all of the voltages to dB volts (dBV) using the chart you'll find elsewhere in this file. Then subtract the smaller right channel dBV from the larger left channel dBV. That is your left channel separation. Repeat for the other channel. Acceptable crosstalk is 25dBV left to right and right to left. Good is 30dBV and above that is very good!



Lyra Dorian

If the two dBV numbers differ by more than 3dBV, you need to adjust your azimuth.

Begin by changing it slightly in one direction (however that's accomplished on your arm) and repeat the procedure. If the results differ by a greater amount, you've gone in the wrong direction. Adjust in the other direction and try again.

If the first azimuth change narrowed the difference, you're going in the right direction. If you're within 10 percent, you can leave it, or move it a bit more in that direction and measure again.

If you're even closer, good! If not, you've gone too far and will need to head back in the other direction until the two dB values are within 10% of each other. Then you're done. You've minimized and equalized the crosstalk, thereby maximizing channel separation.

Wally's azimuth adjuster does make the job easier. It includes a high pass filter above 500 cycles and low pass filter below 2kHz that remove voltage-spiking rumble, which will give you more stable voltage readings. It also lets you connect both amplifier channels as well as your voltmeter to it. A front panel mounted switch lets you toggle between channels, which is a real time saver. The device also includes load resistors, allowing you to disconnect your speakers so your ears don't take a beating from the tones.

Do not try to set azimuth by putting one channel out-of-phase, summing the two channels and playing a so-called "azimuth setting test tone" found on some test records, and then adjusting for minimum sound. Each coil in your cartridge, and each channel of your phono preamp (especially if it's tubed) ,will have slightly different sensitivity, as will your speakers. If you try to set "azimuth" that way, all you'll be doing is using your cartridge as a balance control to equalize the output of your system. The goal is to minimize and equalize crosstalk, not balance the output of your stereo's electronics!

SPEED ACCURACY

If your 'table allows you to adjust speed, use a strobe disc and make sure that you're running precisely at 33⅓ and 45rpm. That goes without saying, but I said it anyway!

"DIALING IN THE SOUND" BY EAR

Once you've gotten your turntable set up "by the numbers," it's time to listen. If you've followed the instructions carefully and done everything correctly, your turntable should be sounding great.

You should be able to play a record through from beginning to end without hearing distortion of any kind. Playing a well-recorded reference album, preferably one that was minimally miked, the soundstage should be wide, deep and appropriately tall. Images should be well-focused and stable. There should be no "image-wandering," or "pulling" to one side or the other. The picture should remain consistent from the beginning of the record to the end.

If the soundstage balance is not satisfactory, check the balance setting on your preamp (if it has one) and the azimuth of your cartridge.

Even if it all sounds fine, it's worth trying to "dial in the sound" by ear. Begin by backing off the tracking force to the cartridge manufacturer's minimum recommendation. Remember that doing so changes SRA! Play a recording of a female vocalist and listen to the sibilants as well as the overall smoothness and integrity of the voice. Now listen again at the maximum recommended VTF. Play a few familiar records experimenting with VTF until you find a setting that sounds best to you. Usually, the lower the VTF, the more open, airy and "fast" the sound, the higher the VTF, the smoother, and "cleaner" the sound. If you go too light, you'll hear "break-up" or a smearing. If you go too heavy, the sound will get slow and overly smooth.

I usually find the best VTF setting to be slightly above the midpoint of the recommended range, but it's arm and cartridge dependent.

If your arm allows for easy VTA/SRA adjustability, play a well-recorded trumpet or female vocal recording, preferably one with an acoustic bass accompaniment (I find Joni Mitchell's *Blue* to be extremely revealing). Again, you could set it perfectly for one record but there's no guarantee it will be the correct setting for others. In general, if you set VTA/SRA too low, bass gets muddy, indistinct and sluggish. Too high and the sound gets bright and edgy.

If you play with VTF and/or VTA/SRA and you don't hear any significant differences, don't worry about it! Just play your vinyl and enjoy yourself!

"LOADING" MC CARTRIDGES

When it comes to resistive "loading," used to smooth out the frequency response of moving coil cartridges, despite the manufacturer's suggested resistive load, I find that it's often a matter of taste and/or interaction with the particular phono preamplifier you are using. In any case, many manufacturers suggest such a wide range that it's almost meaningless (*ie*: 100 ohms to 47k ohms). However, don't be fooled into thinking "brighter is better," because the point of loading is to tamp down peaks in the frequency response in an attempt to get it flat, so listen carefully before choosing, because like a moth to a flame, the ear tends to be attracted to "bright."

If your phono preamplifier uses a step-up transformer, try to choose a cartridge whose internal impedance closely matches that of the transformer's input impedance. Otherwise the transformer will act like a filter, and alter the cartridge's frequency response. The match doesn't have to be exact, just "in the ballpark."

CAPACITIVE LOADING FOR MM CARTRIDGES

Because MM cartridges are now the "bottom dwellers" in the cartridge market, few users pay much attention to loading, assuming that the "standard" 47k resistive loading is appropriate in all cases, and all but ignoring capacitive loading. In fact, many MM cartridges should be loaded at a much lower resistance.

In fact, there is a critical frequency (Fc), above which the highs will roll off at 12dB per octave, and below which, there will be an unwanted response peak determined by the resistive loading. Clearly if you can optimize both the resistive loading and the capacitance, you can help assure extended, smooth high frequencies. If your phono preamp doesn't allow any of this to be adjusted, be happy with the performance obtained by 47k ohm resistive loading and whatever the specified capacitive loading of your preamp. However, you can calculate the optimum resistive and capacitive loading for your cartridge and determine how well your phono preamp will do combined with your cartridge.

The way to determine capacitive and resistive loading, is to check the inductance of the cartridge specified by the manufacturer (in milli-henries). Calculate the total capacitance by adding your preamp's pre-set capacitive (pF or pico-farads) loading (unless it's adjustable), plus the tonearm and interconnect cable (not necessarily easy to obtain!) and then do the math:

1 over 2Pi (3.14) times the square root of the inductance times the capacitance. So, for example, if you can determine your phono preamp's capacitive loading (200pF for instance), add 50pF for the tonearm wires from the cartridge clips to the RCA plugs (or whatever yours is spec'd at, if you can get it), and then plug in the numbers. If your cartridge's inductance is spec'd at 380mH and your total capacitance is 250pF, you'd have 1 over 380x 10 to the -3 power times 250 times 10 to the -12 power, which equals 16, 329Hz. That means the highs will roll off at 12dB per octave above around 16K.

There's another calculation for the optimum resistance (as opposed to the "standard" 47K), which is referred to as "Ropt." To calculate that, it's .707 times the square root of the inductance divided by the capacitance or in this case, .707 times 380 x10 to the -3 power over 250x 10 to the 12 power, which comes out to 27.5k ohms, which is far off from 47k ohms!

However, if you had a phono preamp with adjustable capacitance, were you to lower it to 150 pF and re-calculate, you'd find the critical frequency (Fc) would now extend out to 21, 080k, which is excellent and the Ropt. would calculate out to 35.5k ohm, which is much closer to 47k.

So if you can adjust capacitance on your phono preamp and you know the induc-

London/Decca Reference

tance of your MM cartridge, you can use the above formulae to know both the optimal resistance and capacitance, and hopefully be in a position to optimize your MM cartridge's performance.

Get a math wiz to help you if you can't do it yourself. Or? Just enjoy your cartridge at 47k ohms and whatever capacitance your phono preamp is preset to. However, if you do the math you might find you have a serious mismatch and that you're not getting maximum performance from your system.

THE TYPICAL MOVING COIL CARTRIDGE EXPOSED!*

Cartridge body – the structure that everything else is mounted to. Nearly always made of plastic or metal.

This drawing shows a "nude" or "open-air" cartridge that has the operating bits and pieces all exposed. Other cartridges may have a body that fits over the operating bits and pieces and conceals them from view, and this enclosed body can be made from metal, plastic, wood, or stone.

Some nude cartridges don't have a protective stylus guard, which can make them a bit easier to damage than a fully enclosed cartridge. Other nude cartridges have a stylus guard which offers full protection, and in practice these are no more prone to damage than a fully enclosed cartridge.

Mounting screwholes (one on each side)– Some cartridges use plain holes, others use threaded holes (which are a LOT easier to use). Usually these are for screws that are 1⁄10 inch in diameter, or in metric 2.5mm or 2.6mm diameter. Made from diverse materials like aluminum, brass, and stainless steel. The stainless steel hex-head (allen bolt) are the easiest to use.

Output pins – usually from copper or similar conductive metal, plated with gold or rhodium on better cartridge models. The normal color-coding is red (right hot) green (right neutral), white (left hot), blue (left neutral). Usually, the cartridge will be designed so that the right output pins come on the right side of the cartridge when installed in the tonearm, with the left output pins on the left side of the cartridge when installed in the tonearm.

Output pin block – usually made of plastic, and used to secure the output pins in place.

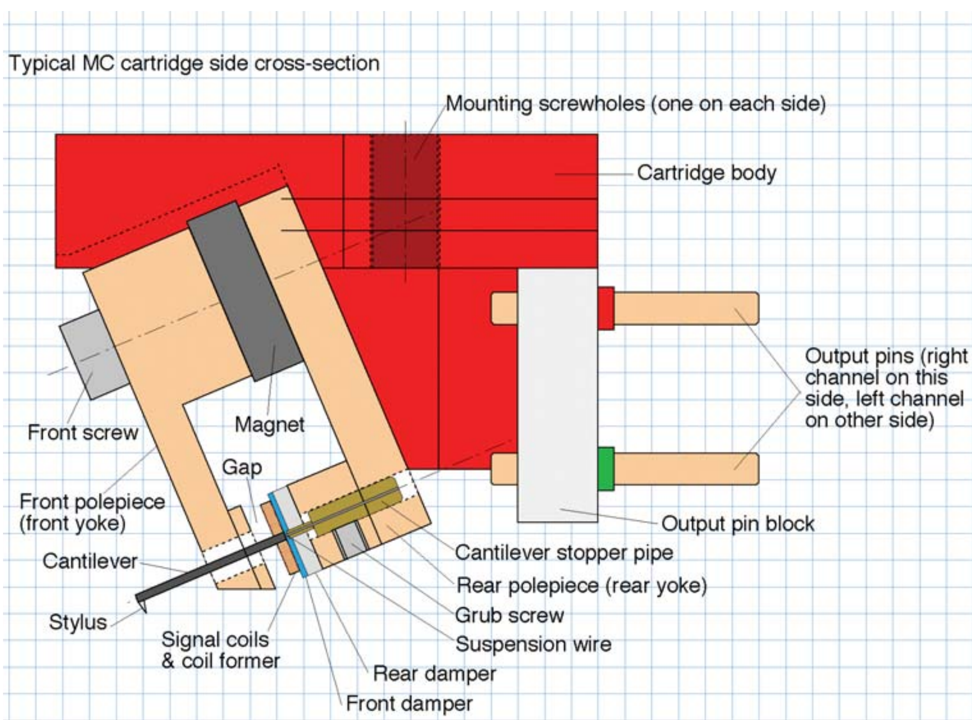
Front screw – the part that holds the magnetic circuit to the cartridge body. Do not try to tamper with this screw! Chances are almost 100% certain that the magnetic circuit will become misaligned and you won't be able to get the performance of the cartridge back to where it should be.

Magnet – made from materials like Alnico, samarium-colbalt, neodymium, and in some cases platinum alloys. The part that provide the magnetic flux required to create a magnetic field inside the gap, so that when the signal coils move, they can generate an electrical signal.

Front polepiece – usually made of iron (of various grades depending on the quality of the cartridge), but it can also be made of materials like permendur. The shape can be simple on cheaper cartridges, or it can be complex on more expensive models. The part that helps transport the magnetic flux from the magnet down to where it is needed –the gap (where the signal coils are). The front polepiece usually has a hole in it to allow the cantilever and stylus to pass through and move unimpeded, but some cartridges has a front polepiece with a slit cut into it rather than a hole.

Rear polepiece – usually made of iron (of various grades depending on the quality of the cartridge), but it can also be made of materials like permendur. The shape can be simple on cheaper cartridges, or complex on more expensive models. The part that helps transport the magnetic flux from the magnet down to where it is needed–the gap (where the signal coils are). Usually the rear polepiece is equipped with a hole to allow the cantilever assembly to be mounted. Because the rear polepiece also serves as the mounting system for the cantilever assembly, it should be quite stiff and free of resonances.

Gap – an open space between the front and rear polepiece that contains a powerful magnetic



*Thanks to Lyra cartridge designer Jonathan Carr, who also provided the description.

field (created by focusing the magnetic flux from the magnet, using the front and rear polepieces). The signal coils move within the gap, and generate electrical signal by virtue of the magnetic field in the gap.

Together the magnet, front polepiece, and rear polepiece are the components that form the magnetic circuit. Some advanced cartridges don't even use polepieces. They use magnets to directly create the magnetic field inside the gap.

Stylus – nearly always made from diamond. A "nude stylus" is a stylus that is made completely of diamond, and is the type found on nearly all high-grade cartridges. A "bonded diamond" is a part-diamond part something else stylus consisting of a diamond tip bonded to another material. It is cheaper than a nude stylus, and is therefore usually found on lower-grade cartridges. The stylus is the part that contacts the LP groove and transmits its undulations into mechanical movements (or vibrations) of the cantilever.

Stylii come in many different profiles (shapes) and sizes, and usually simple profiles like conicals and ellipticals are cheaper and offer less performance than hyperelliptical and line-contact profiles. The various kinds of line-contact stylii, including Fritz Gygers, van den Huls, Weinz, Namiki microridge, Ogura PA and some custom designs offer better ability to reproduce fine detail, longer life, and less record wear, but are usually more difficult to set up than conicals or ellipticals. In addition to the stylus profiles, stylii can come in the form of various-sized blocks. Physically smaller (and lower-mass) stylii again offer better ability to reproduce fine detail (particularly at high frequencies), but are harder to make and more expensive.

Cantilever – can be made from any number of materials like aluminum, boron, carbon-fiber, ruby or sapphire, even diamond. Generally light and strong materials will result in better performance and are therefore preferred. Various shapes and constructions are also in use, such as solid rod, straight pipe, and tapered pipe. The cantilever transmits the vibrations from the stylus (originating from the LP groove) to the signal coils, which will convert those vibrations into electrical signal.

Signal coils and coil former – Signal coils are made from conductive wire like copper, silver, or gold. The wire is invariably very thin–50 micrometers is a very thick coil wire, and some cartridges use wire as thin as 15 micrometers. By comparison, a human hair is about 100 micrometers thick. The signal coils are wound around a former or core, which can be made from permeable materials such as permalloy or iron, or non-permeable materials such as plastic, carbon-fiber, or ruby. The signal coils are attached to the end of the cantilever, and move together with the LP groove. The movement of the signal coils inside the magnetic field of the gap is what produces an electrical output signal.

Shelter 301

When the signal coils of an MC cartridge are wound around a permeable core, the cartridge is called an "iron-core" (or sometimes permeable-core) design. When the core is made of a non-permeable material, the cartridge is usually called an "air-core" design. Iron-core cartridges usually have greater signal output voltage, and at lower generator impedances (which means less wire in the coils).

Conversely, air-core cartridges usually have lower signal output voltages. While some air-core cartridges have signal output voltages comparable to iron-core designs, the impedance is nearly always substantially higher. In many cases, the loading of the cartridge at the phono stage is related to the impedance of the cartridge, so even for similar signal voltages, the optimal loading may be different depending on whether the cartridge is an iron-core or air-core design.

Suspension wire – made of diverse materials like piano wire, stainless steel, nylon and so on. It is a flexible, springy part and is what allows the cantilever, stylus and signal coils to move. It can also be made in different thicknesses and stiffnesses, and together with the dampers, is what determines the "compliance" of the cartridge (*ie*, flexibility of the cantilever system). This is an important factor that can affect the compatibility of the cartridge with the tonearm–some cartridges work best with tonearms of a given effective mass, while other cartridges may work better in other tonearms of greater (or lesser) effective mass.

Front damper – made of elastic materials like various rubber compounds or synthetic elastomers. Because the suspension wire is a spring, it (as well as the cantilever) has resonances which need to be damped, which is what the dampers accomplish. The cartridge can use a single damper or multiple dampers, of various sizes, thicknesses and shapes. A single damper is simpler and likely to be found on lower-grade cartridges, while multiple dampers are more complex but can do a more effective job of controlling the resonances of the suspension and cantilever. The dampers have a major impact on the sound of the cartridge, and need to be adjusted precisely. Ideally the dampers should be matched to the suspension, cantilever and coils (actually the magnetic circuit as well).

Rear damper – made of elastic materials like various rubber compounds or synthetic elastomers. Because the suspension wire is a spring, it (as well as the cantilever) has resonances which need to be damped, which is what the dampers accomplish. The cartridge can use a single damper or multiple dampers, of various sizes, thicknesses and shapes. A single damper is simpler and likely to be found on lower-grade cartridges, while multiple dampers are more complex but can do a more effective job and controlling the resonances of the suspension and cantilever. The dampers have a major impact on the sound of the cartridge, and need to be adjusted precisely. Ideally the dampers should be matched to the suspension, cantilever and coils (actually the magnetic circuit as well).

Cantilever stopper pipe – usually made from brass. This is the rear part of the cantilever assembly, and is the mounting structure for the suspension wire. It therefore also plays a role in the sound of the cartridge. The stopper pipe is usually in turn mounted into a hole in the rear polepiece.

Grub screw – usually made of a strong material like steel. This is what secures the cantilever stopper pipe in place.

RECORD CLEANING MADE DIFFICULT!

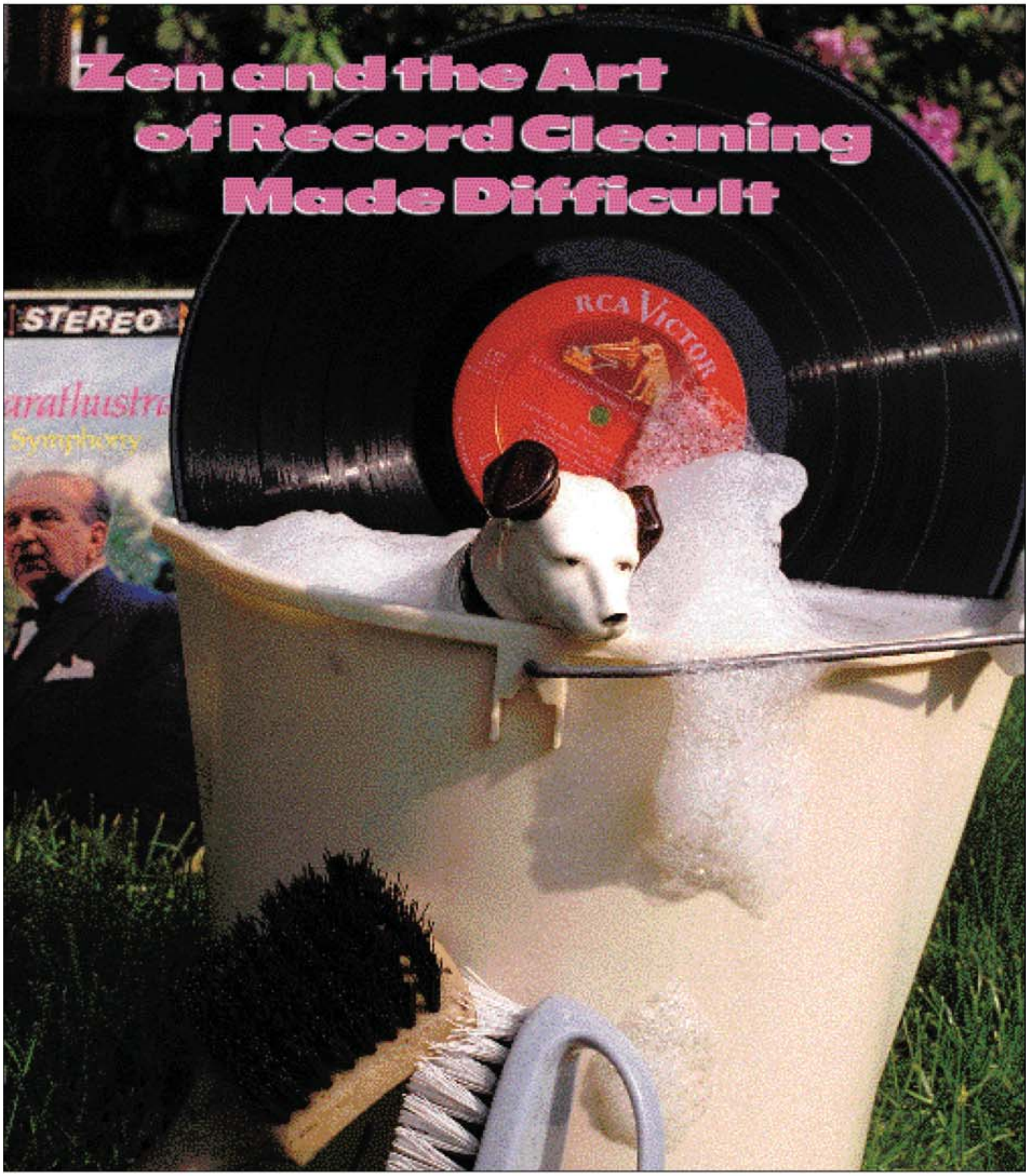
(reprinted from www.musicangle.com)

Dozens of LP and CD Reviews!

the tracking angle

Volume 1, Issue 3
Late Summer 1995

US $5



Zen and the Art of Record Cleaning Made Difficult

By Michael Wayne

You've finally secured a copy of that elusive Golden Era record you've sought for so long. It cost you more than a set of tires for a Porsche 959. Now you are ready to reap the rewards of your unrelenting efforts; but first, since you consider yourself a well informed audiophile record collector, you decide to vacuum wash your treasured disc, both to make certain you hear nothing but its unvitiated analog beauty, and because you vaguely recall reading something somewhere about the potential record damaging dangers of playing uncleaned records.

Dutifully, you apply your favorite fluid to the disc – perhaps using a brush to scrub and spread the fluid about. You set the machine to vacuum, and in a mere few revolutions, you are at last ready to revel in the sonic ecstasy of your new vinyl treasure.

By the end of side one, a slight but persistent vinyl noise and a subtly cloudy musical presentation fill you with doubt and nascent frustration. Vinyl angst has set in. Wasn't this LP supposed to be "Super-mint", or "AAA-Ultra-Plus" – or some such hyperbole? It was certainly expensive enough. Burned again? Perhaps another cleaning cycle might do the trick.

Doggedly, you repeat the ritual, and this time you are reassured. Why yes, more of that whooshy background is gone, and darn if the entire sound stage hasn't increased in scope and definition. The instruments sound richer and timbrally more accurate. Ah! Your troubled soul begins to relax. Another few cleanings and perhaps even that thin hiss which has now replaced the initial whoosh will disappear; the soundstage and hall reverb will become ever more evident and pure. This disc may yet sound the way your dealer "Sid the Groovemeister" promised it would.

Keep dreaming, Alice. Wonderland ever beckons the desperate. Your fastidious but flawed, and woefully incomplete cleaning attempts may have insured that you never experience the full potential of your cherished record. You may as well go digital.

Indeed, the very first alarm signaling a potentially serious record cleaning problem sounds simultaneously with improvements heard after the first cleaning cycle. It indicates that the cleansing attempt was only partially successful.

In place of the large, original groove contaminants, there now are smaller, possibly stickier ones, to which cleaning fluid has bonded chemically and, if the record is played after this single cleaning cycle, probably thermodynamically as well, due to the intense heat and pressure generated by the stylus travelling through the groove.

Play a record with foreign matter sticking to its grooves, and you run the risk of welding it in permanently. The solution, of course, is to start with a completely and perfectly cleaned disc.

Let's examine a few widely held misconceptions about record cleaning. The first is that vacuum cleaning is sufficient and complete. In fact, it may be, but only in those few special cases where the contaminants are primarily dust and nothing more. When a disc has been subjected to an environment of tobacco smoke, fingerprint oils (which over time tend to harden and solidify on a vinyl surface), silicone record cleaning cloths (true groove polluting monsters), God knows what cleaning fluids and brushes, and a variety of other sticky, gummy substances, a simple vacuum cleaning cycle is unlikely to do the trick.

Using the techniques described in this article, I have regularly taken vacuumed discs and removed globs of yellow-brownish gooey subtances from the supposedly "clean" record grooves.

The safe and highly effective cleaning techniques described here, do require some time and effort, but since when has that stopped analogue devotees? The cleaning approach I recommend is based upon the following principles and strategies:

(1) Use of a chemically wide spectrum of cleaning fluids.

No single fluid is completely effective in removing all possible types of disc contaminants. To insure effective cleaning, several fluids, must be used. Whatever one fluid cannot clean well, another fluid must be used which can.

As Myles Astor* has demonstrated, groove wall interactions occur on a molecular level, and like it or not, any and every cleaning fluid will leave some amount of itself behind. In order to keep residues to a minimum, the cleaning solution used in each step must dissolve the one used previously. This minimizes or prevents audible cleaning fluid residue signatures such as low level "whoosh" and high pitched hiss.

(2) Minimal contamination of final brushes.

The surface of the vacuum cleaning

**Myles Astor:"Record Cleaning Fluids", Sounds Like #8, May 1990. This is the finest article to date on the subject of record cleaning fluid chemistry and its sonic consequences.*

brush should only come into contact with a purely clean disc surface, otherwise it will transfer contaminants from record to record, absorbing and smearing more and more goo as it goes

To accomplish this, prior to disc vacuuming we must use a fluid application/ absorption/groove scrubbing device, with replaceable and disposable pads. In this regimen, vacuum cleaning is the last step, the purpose of which is to remove fluids rather than gross contaminants and debris from the record surface. This insures that the vacuum suction pads will not spread dirt from disc to disc.

Tools, Supplies and Preparation

You will need several inexpensive items, the first of which is a used turntable. It need not be operational, but it will ease your task greatly if it is – a high torque model being preferable. Your only concern is a platform which rotates, or may be easily rotated. I found an old Pioneer PL-35 belt drive for ten bucks. Its moderate torque drive works very well in this application. Do not use your primary turntable for these procedures, due to the stress and wear which will be exerted on the main bearing and suspension.

You'll also need two record mats. Wash one with dishwashing liquid, rinse, then rinse again with any alcohol based record cleaning solution (or use a diluted alcohol solution). You want to remove all residues from this mat. Then dry it carefully. This will be your clean mat; it must come into contact with only the cleaned side of a record. Keep your fingers off of the record supporting surface. The second mat will be used only under the uncleaned side of a record.

Step 1 in this cleaning procedure requires sterile cotton pads. I use quilted cotton squares sold for use with infants and for cosmetics application. You can use plain cotton wadding sold in drug stores but it is trickier to handle and more expensive.

Buy a number of small nylon bristle brushes which will be used to clean the various record brushes used throughout the procedure. I use fingernail brushes, but any small brush with a handle which keeps your fingers from touching the bristles will do. You'll also need a small, clean bowl in which to soak the brushes. First wash the bristle brushes, as you washed the clean record mat, but be sure not to scrub them with your hands; instead, use another brush and rub them together.

Pour some undiluted isopropyl alcohol into the bowl and soak the brushes for about 15 minutes. Since you'll be making frequent use of these bristle-brushes to wipe your record brushes clean, you want to make sure they carry no lubricants and/or contaminants which could be transferred from brush to brush and onto the record surface.

You'll be using several record cleaning hand brushes. The first can be any sort of dust grabbing felt or carbon fiber brush, such as an old Discwasher, Parastat, etc. It will be used only for top layer dust removal of an uncleaned disc surface. Never use it on a cleaned disc. The other brushes you'll need are two Allsop Orbitracs**. This is the most effective record groove scrubbing device I have tested to date, and it is crucial to successfully accomplishing the procedures described here.

The key to the Orbitrac's superb effectiveness is its pads which change from pure white to sickly yellow as they absorb groove contaminants. The Orbitrac's pads are replaceable. Other hand brushes are nothing more than highly effective grease applicators, spreading unwanted substances from one disc to the next.

Obtain several handsized spray bottles- preferably chemistry lab grade glass bottles – if you can find them. Glass is basically inert and will not react with the various solutions we'll be using. I have also used plastic bottles with no problems. Be sure to rinse the interior of each spray bottle – including the intake stem– several times with isopropyl alchohol, finishing with Nitty-Gritty First solution.

A newly designed Allsop Orbitrac replaces the one referenced in this article. A far greater variety of cleaning fluids and other record care products are available today compared to 1995. However, the principles outlined in this story continue to be valid. Don't feel obliged to follow this regimen precisely. Use it as a guide. –MF 2006

Once these atomizer bottles are clean and dry, fill one with Nitty Gritty First fluid, then quickly cap the original supply bottle and apply tape around the cap seam to help prevent evaporation. This is the solution to be used in step 1. For step 2 you may use any record cleaning solution you wish as long as it is not the same as the solution you apply when vacuuming your discs (principle 1).

I prefer alchohol bearing fluids since they are the most effective in cleaning raw, dirty records. The solution I use for step 2 consists of 80% VPI Record Cleaning fluid and 20% of the purest alcohol I can obtain. I advise against using drug store grade 91% isopropyl alchohol as I have found that it leaves a substantial residue.

If you can't obtain chemically pure alcohol (99% or better), you may safely use a grain alcohol such as Everclear (94%) which is sold in liquor stores to those harty (or foolish) enough to use it for other than practical applications. Do not use vodka.

The Process

Step 1

The first step is of key importance. If carried out effectively, the entire process will be more successful. Begin by removing the loose dust on the record surface with your felt brush (Discwasher etc.). You simply want to wipe off some surface dust. Be sure to place your 'dirty' record mat – not the clean mat – on your cleaning turntable.

Next, spray some First fluid on some cotton wadding. If using quilted cotton squares (prefered), make a three layer pad, being careful not to touch the surface which will come into contact with the disc.

As the record rotates, spray First directly on the lead in groove area of the record's surface, while holding the pad against the same section. Since this maneuver requires some experience to perfect, you might want to practice on a few reject LPs.

Never touch the part of the cotton pad or wadding which comes into contact with the record surface. The aim here is to remove contaminants. not to reapply them. Also, never use the part of the cotton wad you grip as a cleaning surface.

The appropriately named Nitty-Gritty First solution is the most effective solvent I have tested for initial loosening of oily, gummy, contaminants such as tobacco tar, silicone cloth goop, hand oils, and the like. It also effectively removes used record store price stickers from album jackets, and the glue sometimes left behind if you do manage to peel them off.

After several revolutions you'll have a good idea how clean or dirty the disc really is. Dirty discs of the tobacco/hand oil/silicone/unknown-substance-from-Mars variety will leave a yellow-brownish (or sometimes grey-blackish) band smeared across your cotton pad.

If your previously vacuumed disc reveals this kind of filth, you will instantly know the error of your ways. Clean the outer section again, using either a clean, untouched portion of your cotton pad, or a fresh one. Continue until further passes no longer deposit any filth on the pad.

Once you have satisfactorily cleaned the outer edge, repeat the process in sections, moving inward to the center of the disc. Be careful not to touch the contact surface of the cotton pad, and use a fresh one whenever it begins to show even a faint yellow stain. Don't cheap out here.

You will find that the the record's filthiest portions – often by a wide margin- are the outer and inner area. Avoid getting any cleaning fluid on the record label, which is liable to bleach and turn white.

Having finished applying and wiping an entire record side with moderate to large amounts of First you may notice some wet spots. Allow them to evaporate dry. This is the only fluid with which you may do this. NEVER ALLOW ANY OTHER FLUIDS TO EVAPORATE DRY ON A DISC SURFACE. All fluids must either be absorbed, vacuumed, or diluted by other fluids lest they leave a groove fouling residue. Letting First evaporate actually increases its effectiveness since the remaining residue continues to loosen foreign contaminants from the groove walls.

Step 2

Here we'll wash away First residue, microscopic particulate matter, and any remaining substances not loosened by step one. We'll also effectively but gently scrub the vinyl, cleaning down to the groove bottom – something plain vacuuming does not accomplish.

We'll do this using the Orbitrac. But first you must brush the surface of a virgin Orbitrac pad with one of the previously mentioned hand brushes, in order to remove lint and any other large particles possibly trapped in the pad filaments. Brush carefully: a hard particle trapped in an Orbitrac pad can scratch a disc surface.

We will be using two Orbitracs: one for cleaning, the other for mopping and drying. After you've brushed the

Orbitrac pad, spray it with some of the alcohol based fluid you've previously prepared. Use enough to make it wet, but not saturated to the point where it drips.

Turn off the turntable. Take a small portion of cotton wadding (or wear a loose, clean plastic glove) and use it to apply enough pressure against the record edge to hold it stationary. Don't let your bare finger touch the record itself.

Following the simple directions which come with the Orbitrac, rotate it over the record using your free hand. After several revolutions, stop and examine the Orbitrac's pad. If only the faintest signs of yellow show, quickly take a second bristle brush and vigorously brush the pad surface.

Reapply the alcohol based fluid to the Orbitrac and repeat the above.

If, on the other hand, your initial pad examination turns up clearly yellow or yellow-brownish (or worse) stains, that is an indication that you have not successfully carried out step one: Your disc is still filthy and will foul every brush surface with which it comes into contact – including your vacuum suction brush. Repeat Step one-or switch to CDs. When you return to step 2 Be sure to start with a fresh Orbitrac pad.

When your Orbitrac-ing leaves no yellow on the pad, use the second Orbitrac to dry the disc. Start with a dry pad and don't worry if the disc is not bone dry when you're done. Wipe the wet-cleaning Orbitrac pad with one of the bristle brushes, spray some fluid on the Orbitrac pad and repeat the wet cleaning followed by the dry one.

Next, we'll vacuum (at last!). The purpose of the drying Orbitrac is to remove any gross contaminants from the record. The vacuum's only purpose is to remove minute levels of fluid residue, which is all that should remain once you've completed step one's top-of-the-groove wall pre-cleaning and step two's deep-groove-wall Orbitrac cleaning.

Step 3

Simply apply your fluid of choice and vacuum. I prefer to evenly spread a large quantity of VPI record cleaning fluid across the disc using a non-abrasive felt applicator like the one Audio Advisor supplies with the Nitty Gritty vacuum machines. Stiffer brushes – the one VPI packs with its machines are also effective.

A large quantity of fluid insures both complete groove penetration and the removal of anything remaining in the grooves. Extra fluid also requires longer vacuuming time, which also increases the chances of getting everything sucked out of the grooves.

Observe the disc being vacuumed under good lighting: you'll find that thorough fluid removal requires more revolutions than you probably thought necessary. What appear to be groove modulations may actually be residual fluid wedged into tiny crevices. Remember, any fluid not sucked from the grooves may obscure low level resolution and inner detail or result in audible noise. Once the record is dry, re-apply fluid and vacuum a second time.

When you repeat step 1 to clean the opposite side of the disc, be sure to use the clean record mat under the just-cleaned side of the record. If you own a VPI cleaning machine, be sure to place the clean mat under the just cleaned side when you vacuum. Use the clean mat for all subsequent vacuum cleanings of records you have washed using this regimen.

FINAL TIPS

There is one additional step you can take to make this cleaning regimen even more effective. Obtain a supply of triple distilled water* and use it between each step described above, to purge or effectively dilute all chemical residues remaining in the grooves. So, after performing step 1, repeat with triple distilled water using cotton wadding or pads. After performing step 2, follow up with triple distilled water. After your first vacuuming do likewise.

Now that you have a really clean record, it makes no sense to return it to its original smelly, oily, decades old vinyl-leaching inner sleeve. Use a fresh, new sleeve **. You can also clean disc covers quite effectively using 409 and plain old paper towels. Avoid using Fantastic, which contains a powerful pine perfume that seems to stick to album covers forever. 409 will remove the aged, mildew-moss appearing wear, as well as a good deal of ring wear. Try it. Be sure to allow the cover to dry thoroughly before replacing it on your shelf or the residual moisture may grow mildew.

When your cleaning session is over, take yet another bristle brush and wipe your final fluid applicator so it dries quickly. Run the vacuum to allow the suction nozzle and its pads to dry. If you own a manual machine such as a Record Doctor, gently brush the suction pads to and fro as you run the vacuum.

While the entire process described herein may seem hopelessly complex, in practice it is logical and straightforward, albeit time consuming. Do not take short cuts: they will lessen the effectiveness of the procedure and may lead to the contamination of record cleaning pads and the soiling of all subsequent discs which come into contact with them. Unless the record is very clean to begin with, follow the entire procedure or don't bother at all. Follow these instructions carefully and you're sure to be pleased with the results.

**Triple distilled water, available at some pharmacies, is not easy to come by: when I tried to obtain some in NYC the pharmacist accused me of being either an abortionist or an intraveneous drug user. In fact, it requires a doctor's prescription in New York. Perhaps it is easier to obtain where you live, either at a pharmacy, or a chemical supply house. You could use plain distilled water, but be careful: if it hasn't been properly manufactured, you could leave a residue of noise creating minerals in the grooves, thus defeating the entire purpose of this complex, time consuming procedure. – MF*

***I prefer the rice paper sleeves MoFi and RTI use. They are available from a variety of sources including MoFi, SoundSource in Los Angeles, Audio Advisor, etc. – MF*

THAT'S ABOUT IT!

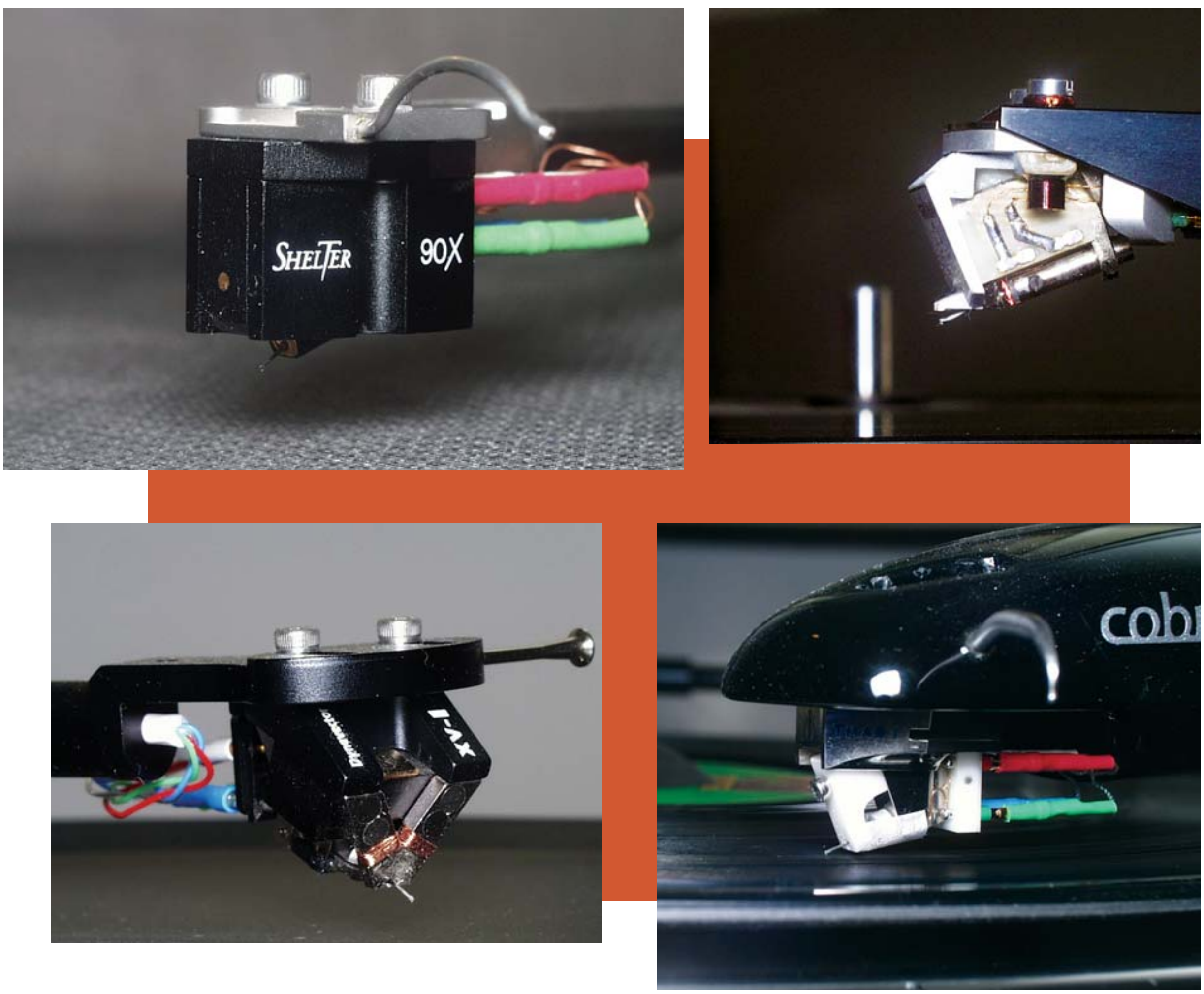
Keep your stylus clean, keep your records clean, keep you platter and/or mat clean, and your records should last a lifetime and never "wear out."

I have almost every record I've ever bought, going back to the late 1950's and I don't hear where record wear is a problem. I have played my British Beatle, Who, Kinks, Traffic (etc.) albums hundreds of times for almost 40 years and they still sound better than the CD versions, including the high frequencies that supposedly get "shaved off" after a few plays. The key is record and stylus cleanliness and good tracking!

I wish you a lifetime of enjoyment from your record collection!

Michael Fremer

clockwise from top left: Shelter 90X, Brinkmann EMT, Lyra Titan *i*, Dynavector XV-1s.



WallyAzimuth Volt to Decibel Conversion Chart

Volts	dB	Volts	dB	Volts	dB
10,000	60,0	0,794	38,0	0,063	16,0
9,441	59,5	0,750	37,5	0,060	15,5
8,913	59,0	0,708	37,0	0,056	15,0
8,414	58,5	0,668	36,5	0,053	14,5
7,943	58,0	0,631	36,0	0,050	14,0
7,499	57,5	0,596	35,5	0,047	13,5
7,079	57,0	0,562	35,0	0,045	13,0
6,683	56,5	0,531	34,5	0,042	12,5
6,310	56,0	0,501	34,0	0,040	12,0
5,957	55,5	0,473	33,5	0,038	11,5
5,623	55,0	0,447	33,0	0,036	11,0
5,309	54,5	0,422	32,5	0,034	10,5
5,012	54,0	0,398	32,0	0,032	10,0
4,732	53,5	0,376	31,5	0,030	9,5
4,467	53,0	0,355	31,0	0,028	9,0
4,217	52,5	0,335	30,5	0,027	8,5
3,981	52,0	0,316	30,0	0,025	8,0
3,758	51,5	0,299	29,5	0,024	7,5
3,548	51,0	0,282	29,0	0,022	7,0
3,350	50,5	0,266	28,5	0,021	6,5
3,162	50,0	0,251	28,0	0,020	6,0
2,985	49,5	0,237	27,5	0,019	5,5
2,818	49,0	0,224	27,0	0,018	5,0
2,661	48,5	0,211	26,5	0,017	4,5
2,512	48,0	0,200	26,0	0,016	4,0
2,371	47,5	0,188	25,5	0,015	3,5
2,239	47,0	0,178	25,0	0,014	3,0
2,113	46,5	0,168	24,5	0,013	2,5
1,995	46,0	0,158	24,0	0,013	2,0
1,884	45,5	0,150	23,5	0,012	1,5
1,778	45,0	0,144	23,0	0,011	1,0
1,679	44,5	0,133	22,5	0,011	0,5
1,585	44,0	0,126	22,0	0,010	-
1,496	43,5	0,119	21,5		
1,413	43,0	0,112	21,0		
1,334	42,5	0,106	20,5		
1,259	42,0	0,100	20,0		
1,189	41,5	0,094	19,5		
1,122	41,0	0,089	19,0		
1,059	40,5	0,084	18,5		
1,000	40,0	0,079	18,0		
0,944	39,5	0,075	17,5		
0,891	39,0	0,071	17,0		
0,841	38,5	0,067	16,5		

WALLYAZIMUTH MEASUREMENT CHART

To be used with voltage to decibel conversion table

SIGNAL FROM LEFT CHANNEL ONLY				SIGNAL FROM RIGHT CHANNEL ONLY			
TEST ONE		**VOLTS**	**DECIBELS**	**DECIBELS**	**VOLTS**		NOTES
METER READING	**IN LEFT**					**IN RIGHT**	
METER READING	**IN RIGHT**					**IN LEFT**	
CALCULATE	**CROSSTALK**	LdB minus RdB =			= RdB minus LdB	**CROSSTALK**	
TEST TWO		**VOLTS**	**DECIBELS**	**DECIBELS**	**VOLTS**		NOTES
METER READING	**IN LEFT**					**IN RIGHT**	
METER READING	**IN RIGHT**					**IN LEFT**	
CALCULATE	**CROSSTALK**	LdB minus RdB =			= RdB minus LdB	**CROSSTALK**	
TEST THREE		**VOLTS**	**DECIBELS**	**DECIBELS**	**VOLTS**		NOTES
METER READING	**IN LEFT**					**IN RIGHT**	
METER READING	**IN RIGHT**					**IN LEFT**	
CALCULATE	**CROSSTALK**	LdB minus RdB =			= RdB minus LdB	**CROSSTALK**	
TEST FOUR		**VOLTS**	**DECIBELS**	**DECIBELS**	**VOLTS**		NOTES
METER READING	**IN LEFT**					**IN RIGHT**	
METER READING	**IN RIGHT**					**IN LEFT**	
CALCULATE	**CROSSTALK**	LdB minus RdB =			= RdB minus LdB	**CROSSTALK**	
TEST FIVE		**VOLTS**	**DECIBELS**	**DECIBELS**	**VOLTS**		NOTES
METER READING	**IN LEFT**					**IN RIGHT**	
METER READING	**IN RIGHT**					**IN LEFT**	
CALCULATE	**CROSSTALK**	LdB minus RdB =			= RdB minus LdB	**CROSSTALK**	

* Adjust cartridge azimuth so that crosstalk in both channels is within 5 - 10% of each other.