KUZMA

ANALOG ACADEMY

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CONTENT:

Consisting of a theoretical description of important and less important parameters for setting up a cartridge on a turntable and a practical description of how this should be simply and precisely done.

THEORETICAL GEOMETRY OF A PIVOTED TONEARM

A/ Tangential geometry

Record making: The first step is to cut grooves in the master laquer. This is done by special lathe machines which cut grooves by a linear movement of the cutter head across the laquer surface.

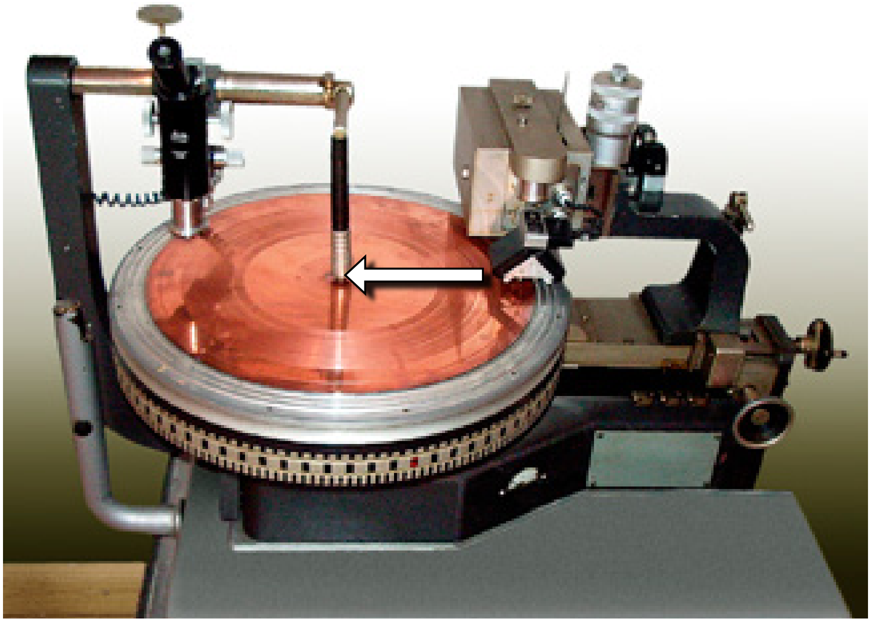


Fig. 1. Record cutting: straight line

Imagine that the cartridge in a pivoted tonearm travels in an arc. It is therefore impossible for the diamond tip (stylus) to be tangential to the grooves, like the cutter head's diamond knife.

Tangential arm remains parallel to the groove at all instances

Pivoted arm changes tangential angle

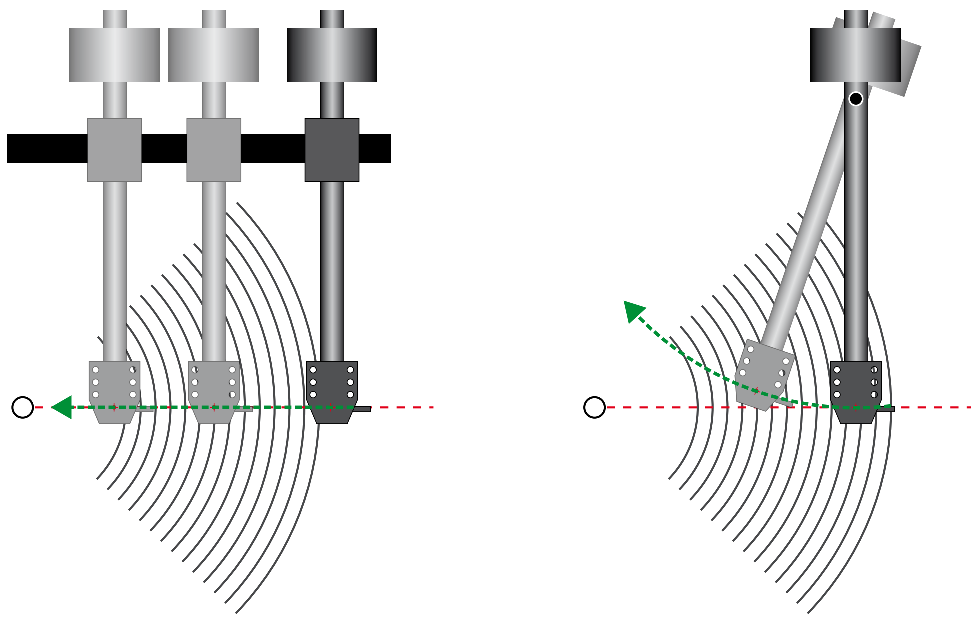


Fig. 2. Tangential tonearm, pivoted tonearm

If a pivoted tonearm was just a straight tube then the tangential error would be in excess of 15–20 deg in some parts of the record. A longer tube has, of course, a smaller error.

But luckily it was found that if the cartridge is fixed at an offset angle, the tangential error is much smaller. With a standard 9 inch tonearm this error is below 2 deg and in some parts of the record zero. Calculations by various mathematicians show us what are the optimal parameters for minimal tangential error and also minimal tracking distortion, thus approaching how the record was cut. It was found that two null points (zero error) appear on the arc and these together with pivot, (tonearm's horizontal bearing) create a triangle which determines the optimal position. (Fig. 3–8).

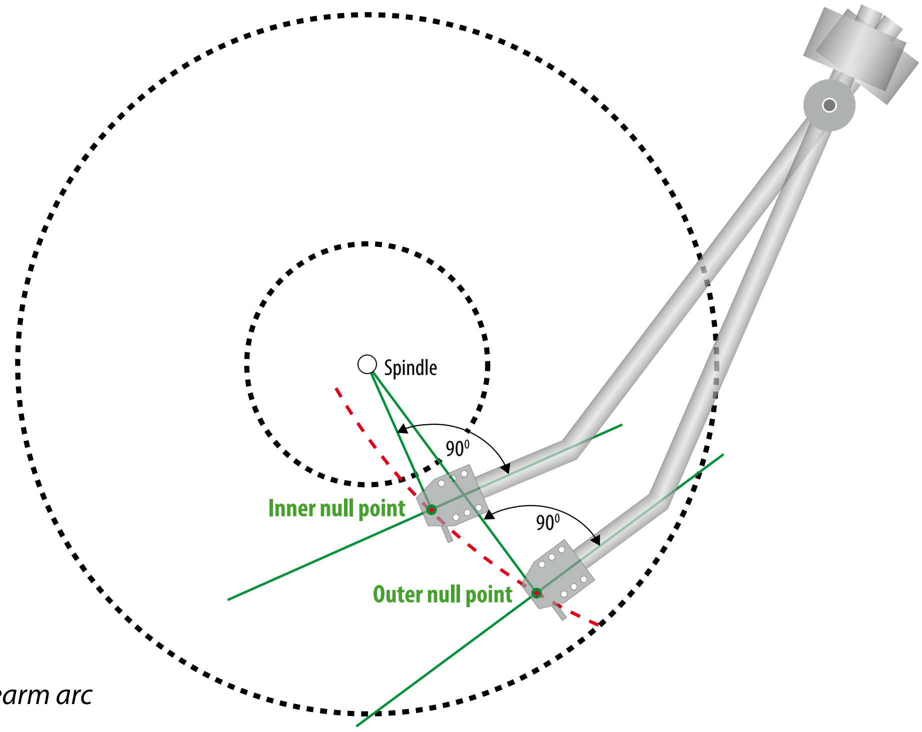


Fig. 3. Pivoted tonearm arc

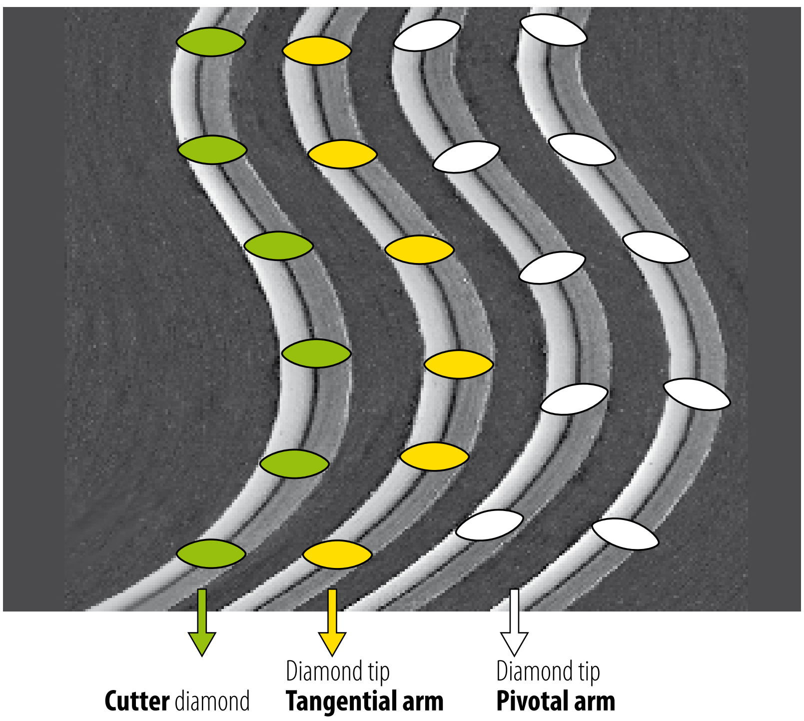


Fig. 4. Diamond tip traveling in grooves

If you look into the grooves (Fig. 4) you can see that the tangential error means that the diamond profile is not symetrical to the groove walls and thus introduces distortion.

First we should check the basic parameters which describe where we should fit the tonearm on the turntable and how we should position the cartridge on the pivoted tonearm to achieve optimal tangential geometry.

Pivoted tonearm – basic

Typical figures depending on tonearm length and applied theory:

Mounting distance: Pivot (tonearm's horizontal bearing) to spindle or in some cases armbase mount to spindle.
Effective length: Pivot (tonearm's horizontal bearing) to diamond tip.
Overhang: Effective length – pivot to spindle.
Offset angle: Angle between effective length line and line of cartridge cantilever with diamond tip (25–15 deg).
Inner null point: 60–80 mm
Outer null point: 110–130 mm
Inner groove: Aprox. 55 mm
Outer groove: Aprox. 145 mm

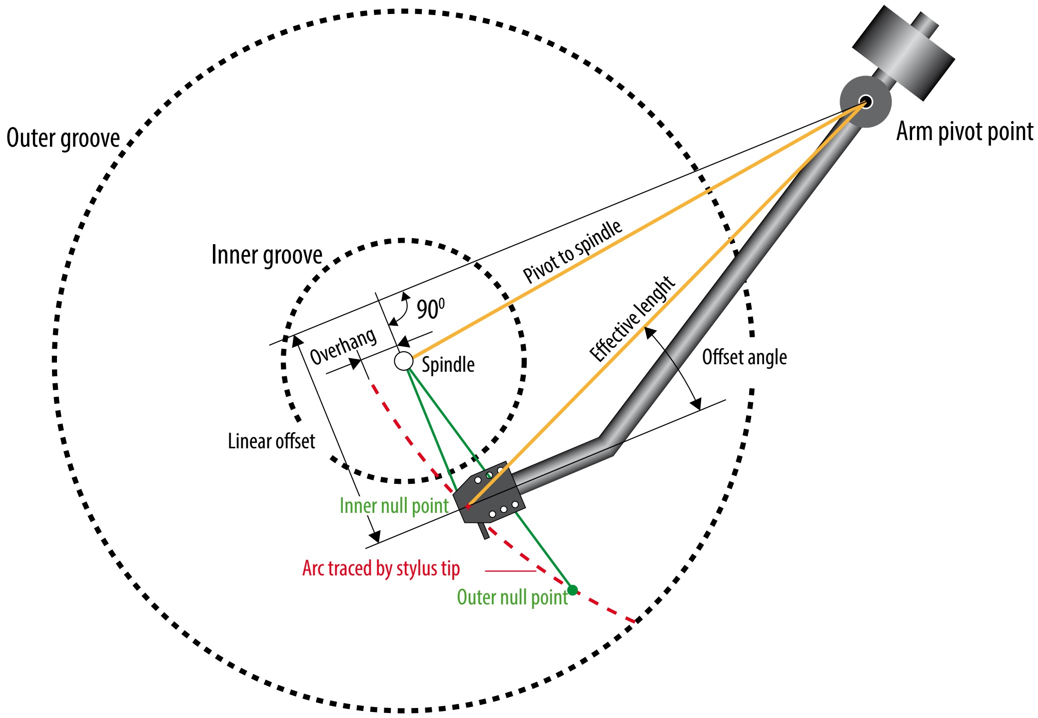


Fig. 5. Basic tonearm parameters: effective length, offset angle, mounting distance, overhang...

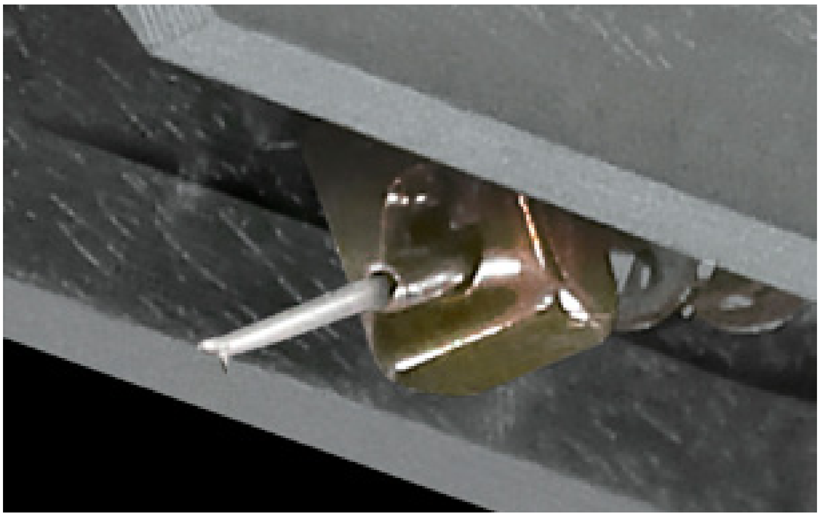


Fig. 6. Diamond tip (stylus) on cantilever

Theory of tangential optimal geometry for a pivoted tonearm:

The cartridge travels in an arc. As we said before there are tangential errors across the record but there are also two null (zero) points.

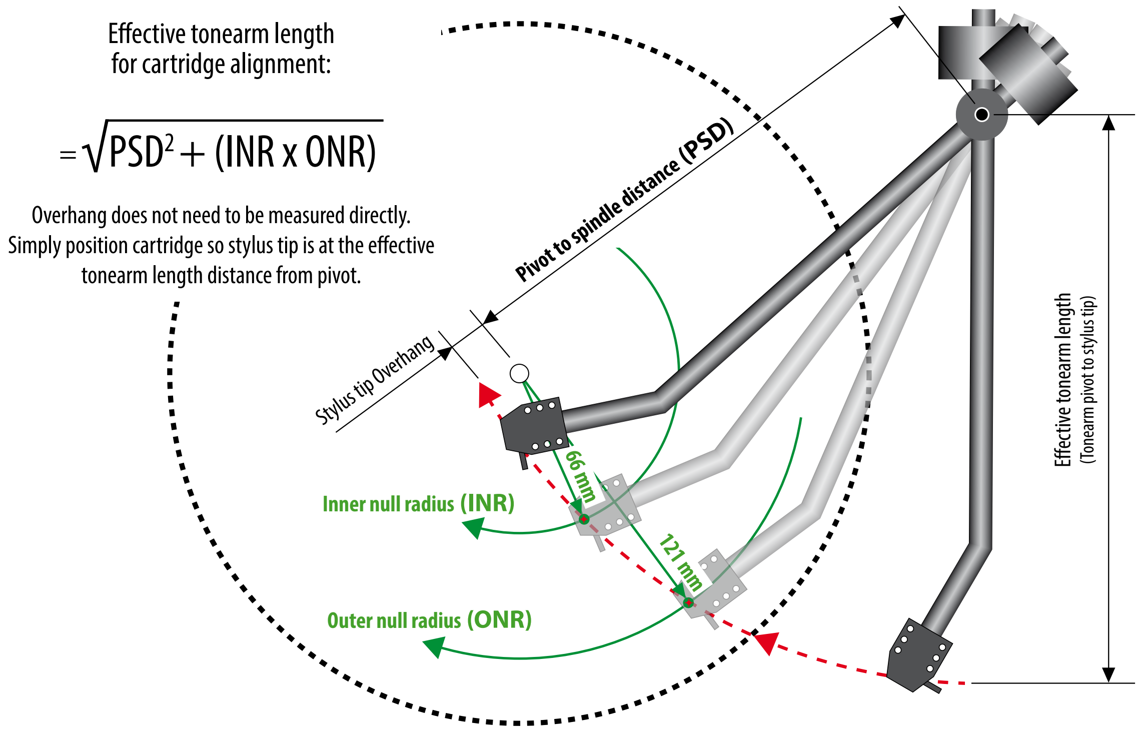


Fig. 7. Tangential error across the record

We have mentioned that the pivot with the two null points creates a triangle. (Fig. 8.). There is a mathematical relationship between these points. If we change one or two, it affects the other parameters, thus affecting mounting distance, moving null point or tangential error (distortion) outside null points. We will skip these formulas.

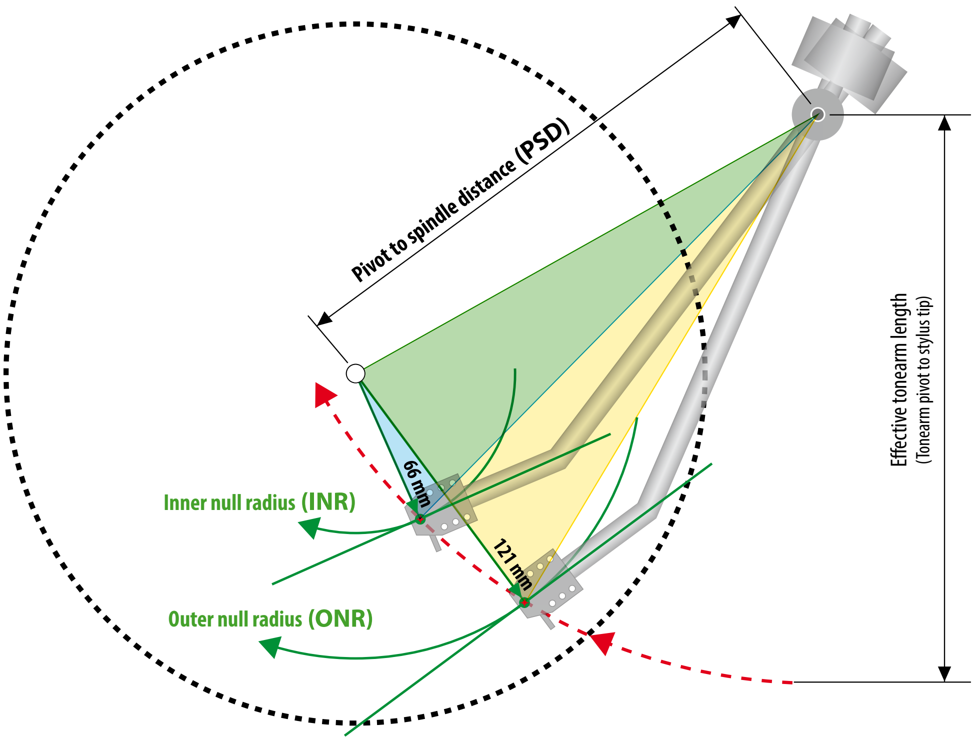


Fig. 8. Triangular: two null points, pivot

Let us see a typical graph: Fig. 9. The horizontal line is the distance from the spindle to the outer groove of the record. On the vertical line we have tangential error shown in blue. As you can see it can be plus or minus but there is the same amount of distortion in practise. The red line shows distortion in %. If you observe the blue line on the outer groove you can read a distortion of just under 2 deg, while the percentage distortion is 0.6 %. At the inner groove the error is 0.8 deg with a similar distortion of 0.6 %. We can observe that at the outer groove a bigger error creates the same distortion as a smaller error at the inner groove.
The reason for this is that at the inner groove the same signal is shorter by about 2.5 x than at the outer grooves and is thus more sensitive to distortion with the same error. Therefore, if we want to have minimal distortion across the playing area we can allow a bigger tangential error at the outer grooves for a similar level of distortion.
Similarly we can observe that between two null points we have error and corresponding distortion.

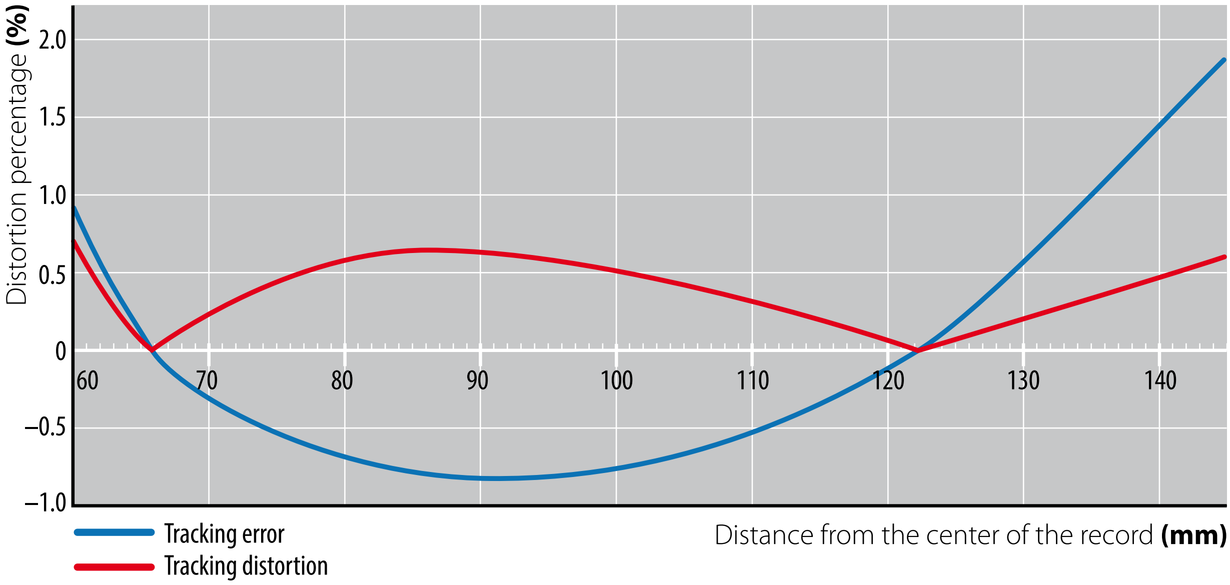


Fig. 9. Tracking angle–error, tracking distortion, standard 9 inch tonearm

If we make the tonearm longer there will be less error and less distortion. Looking at the middle portion between the two null points, distortion with the 9 inch tonearm is 0.7 % while with the 12 inch tonearm it is below 0.4 %.

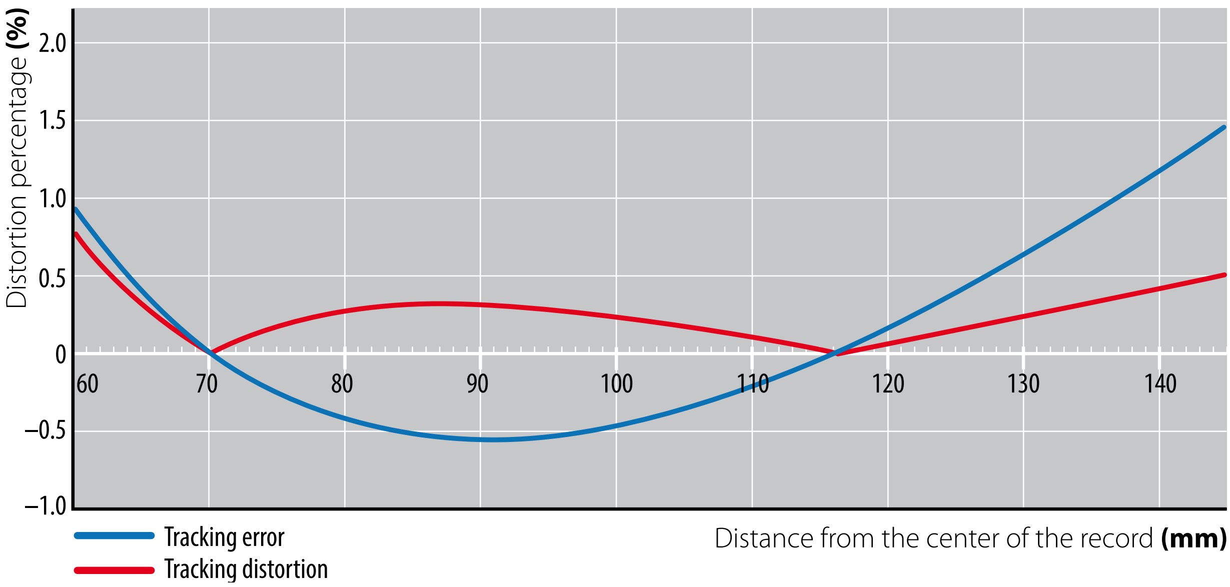


Fig. 10. Tracking angle–error, tracking distortion, longer 12 inch tonearm

Optimal tangential geometry:

There are numerous optimal geometries: Stevenson, Barewald, Lofgren, etc. They all share the same goal – to minimise error and thus distortion across the playing area.
The difficulty is that to optimise parameters we need to choose where the outer playing and inner playing grooves are. Then we can choose how much distortion to allow in all three sectors: between null points and at both extremes of the playing area: i. e. the inner and outer groove.

For example if we look at the graph, (Fig. 11) we can see that while all theories allow for similar distortion at the outer groove, they differ a lot at the inner groove. Also some records have the last modulated groove nearer to the spindle than others and classical records usually have peak modulation at the inner groove, when the music ends... We can observe different levels of acceptable distortion between both null points.

Which theory should we choose? To have the lowest distortion at the inner grooves and a higher distortion at the outer grooves, or to choose to have the lowest distortion in the middle grooves. Any choice will be a compromise and there is no single answer.

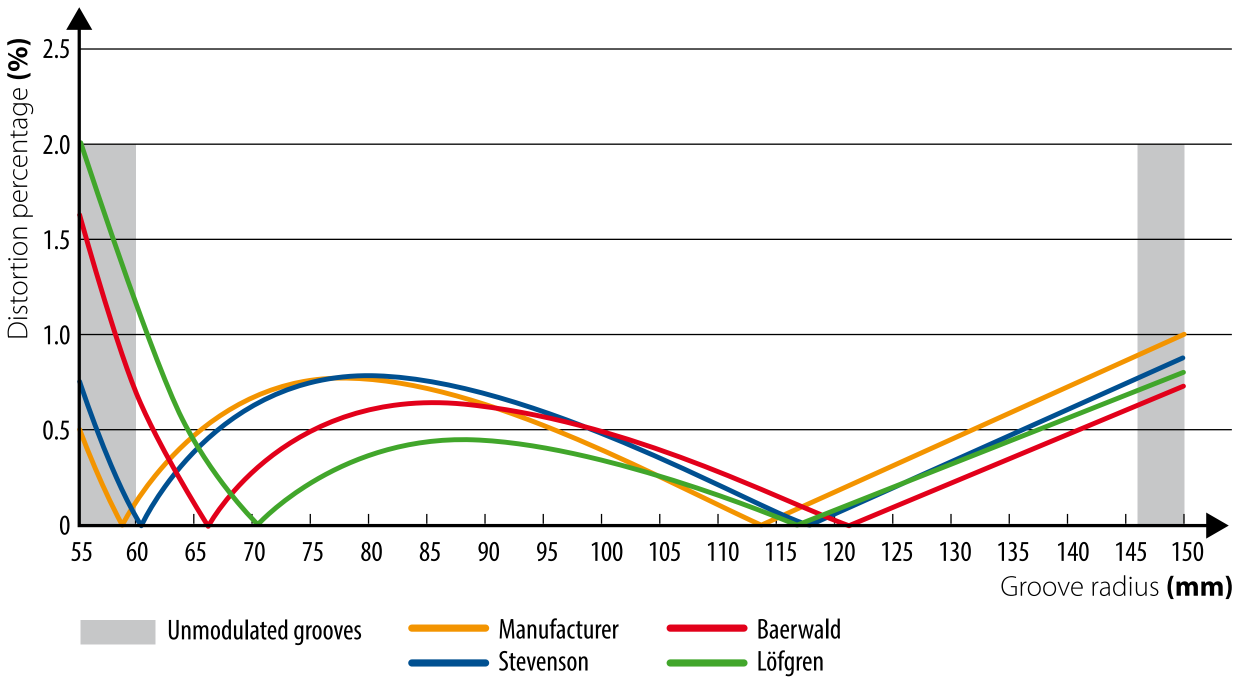


Fig. 11. Various tangential geometries

The simplest decision is to align at two null points as per Fig. 7. The cartridge travels in an arc so we need to have two null points on the same arc. That means for each effective length we should have a different arc. (Fig. 13). There are protractors which have multiple arcs. If a protractor is designed with an arc for each pivot to spindle distance, then one null position is enough.

Then there are special protractors (like Dennesen in the past, or modern copies) which take into account the pivot to spindle distance, so the cartridge can be set up using one null point.

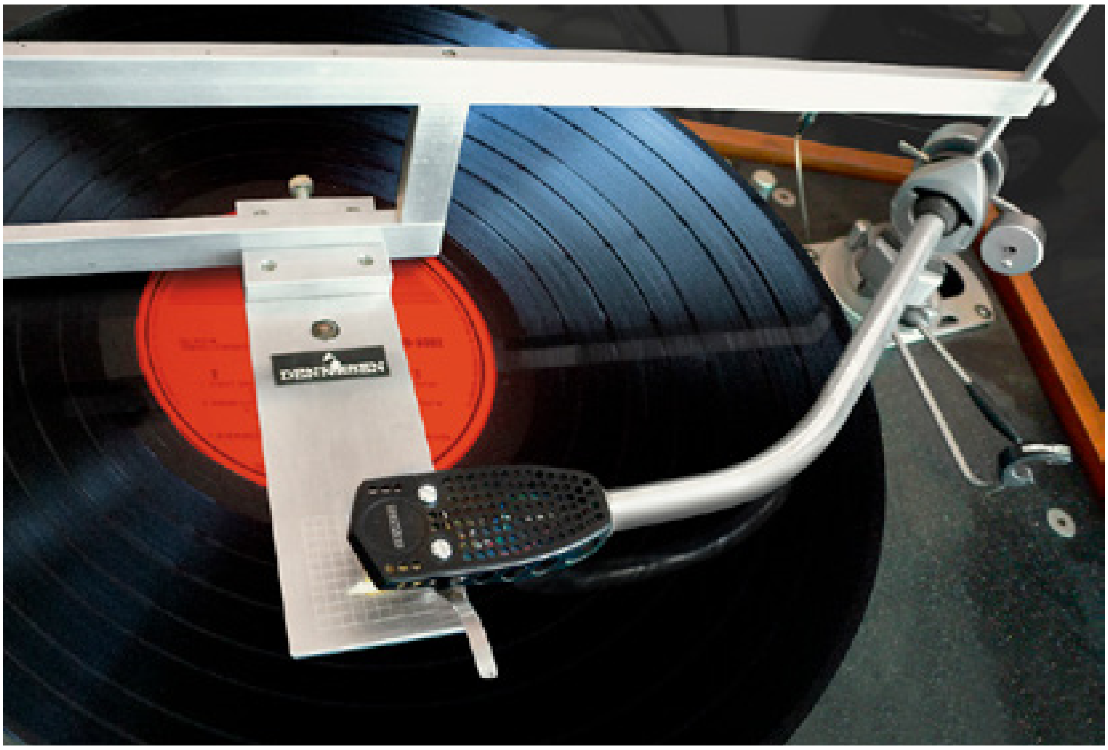


Fig. 12. Dennesen one point protracor

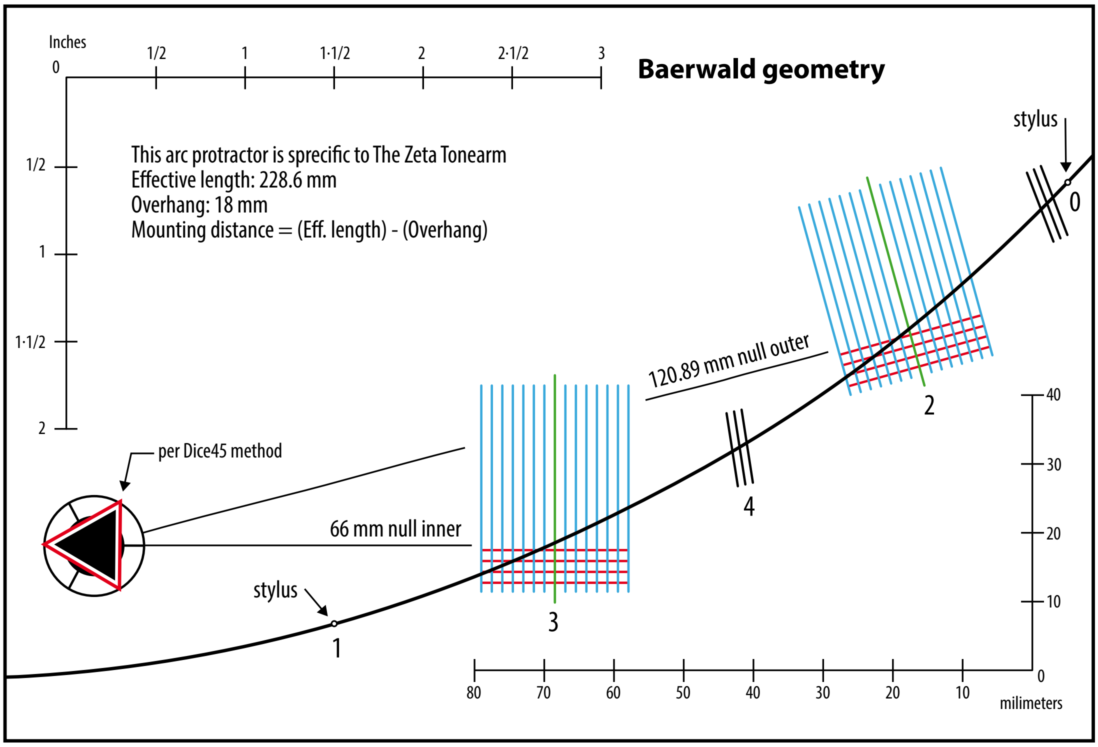


Fig. 13. Single arc protractor

Making a small mistake using these protractors can produce a big error which would not be obvious. We cannot be sure if the pivot to spindle distance or effective length were correct.

If we use a two null point protractor then, with careful set up, even a small mistake will cause only a small error. Fig. 14. If the protractor has distortion lines we can check the distortion level at the extremes and in the middle section and if it is below a certain figure (below 1 %) we can be sure that the set up is optimal.

On the protractor we can observe two null points at 66 mm and 121 mm (A, B) and there is also a line from the spindle outwards showing 0 % distortion and curves showing the amount of distortion in % . We position the diamond tip at the intersection of null points and zero distortion line and check that the cantilver is parallel to the coresponding lines.
We will see later how to use this in practise.

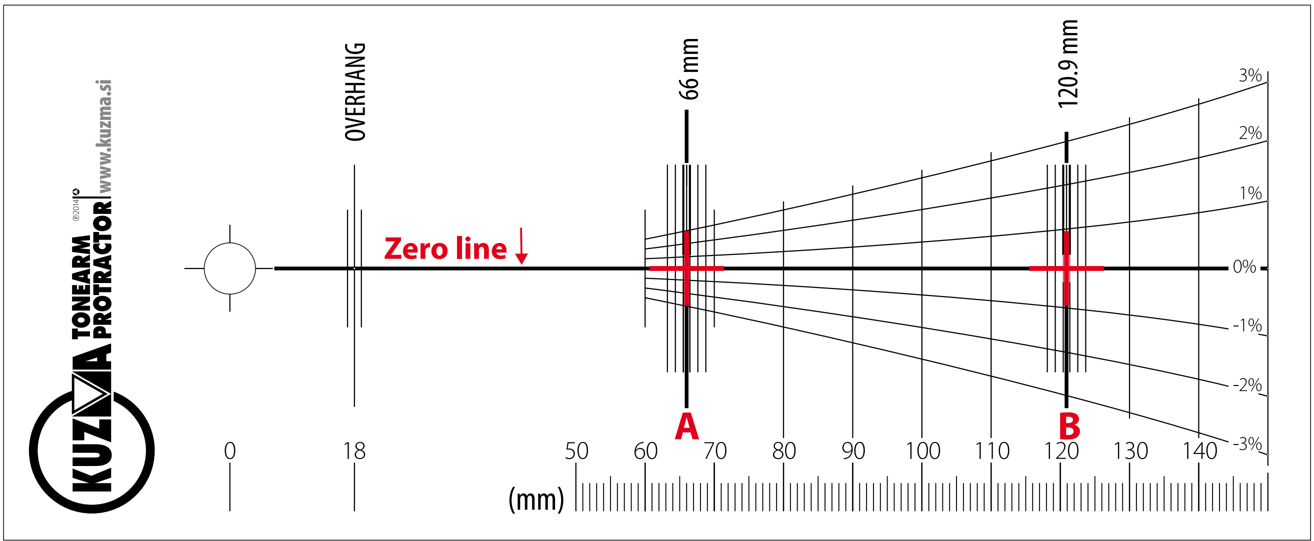


Fig. 14. Two null point (zero) protractor (Baerwald: A: 66 mm, B: 120.9 mm)

B/ Vertical tracking angle (VTA and SRA) – *Fig. 15*

The goal is to bring the diamond tip, in relation to the grooves of record surface, to the same position as the original cutter head's diamond tip. To optimise this we need to set up the cartridge's diamond tip in the grooves at a specific angle.

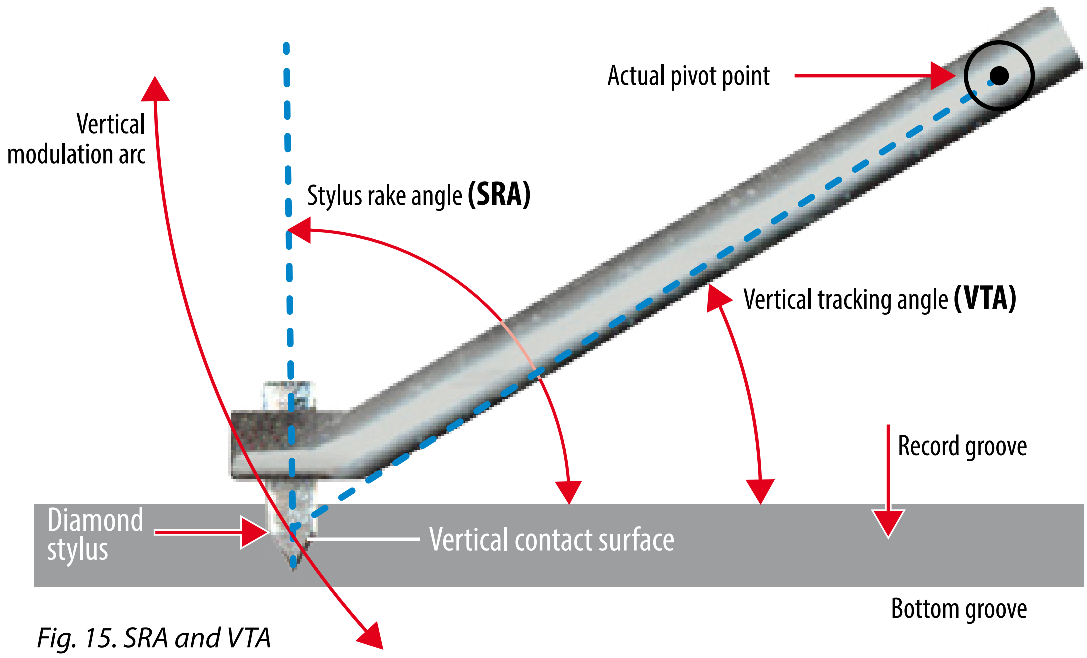


Fig. 15. SRA and VTA

As you can see there are two different angles serving the same purpose. VTA and SRA. These angles are affected by the height of the tonearm and tracking force. The height of the tonearm raises the actual pivot point of the cantilever (SRA). The higher the tonearm on the armboard, the bigger the SRA and VTA (Fig. 16). Changing the tracking force changes VTA due to cantilever suspension. With a lighter tracking force, the cantilever is pushed up less and VTA and SRA are bigger.
In reality different cartridges have variations in design and SRA can be around 85–95 deg while VTA is 18–25 deg.

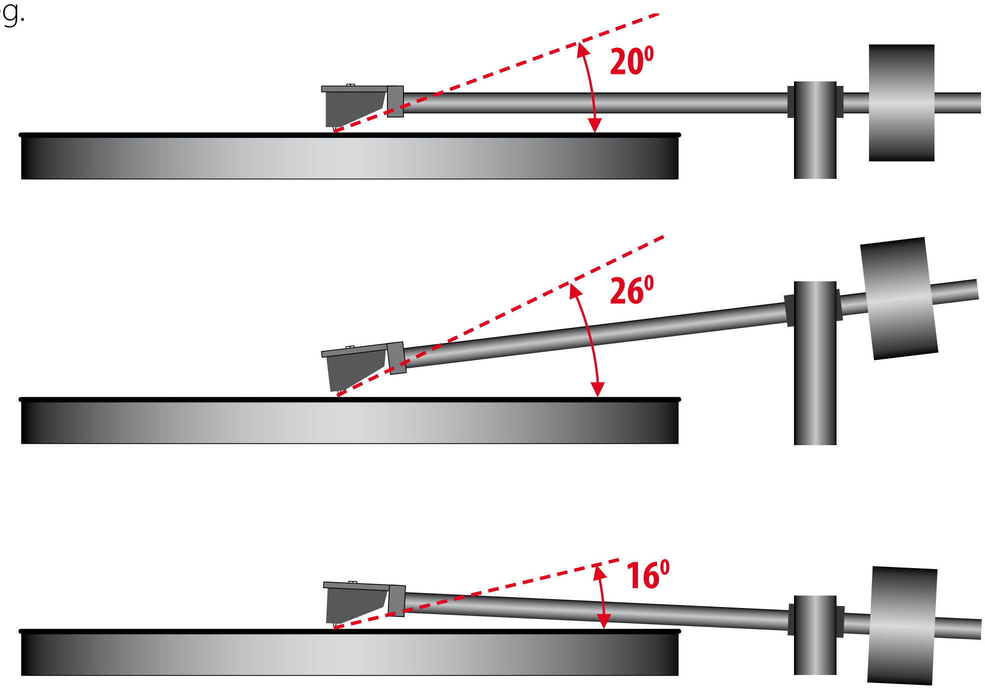
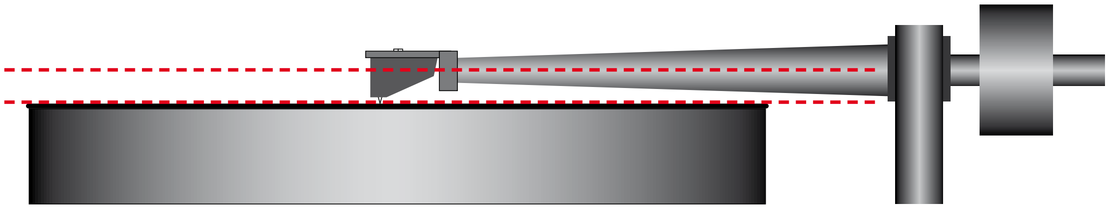


Fig. 16. Tonearm height change affecting VTA



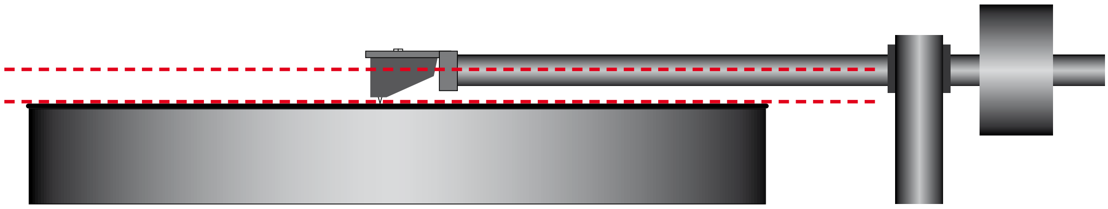


Fig. 17. Central axis parallel

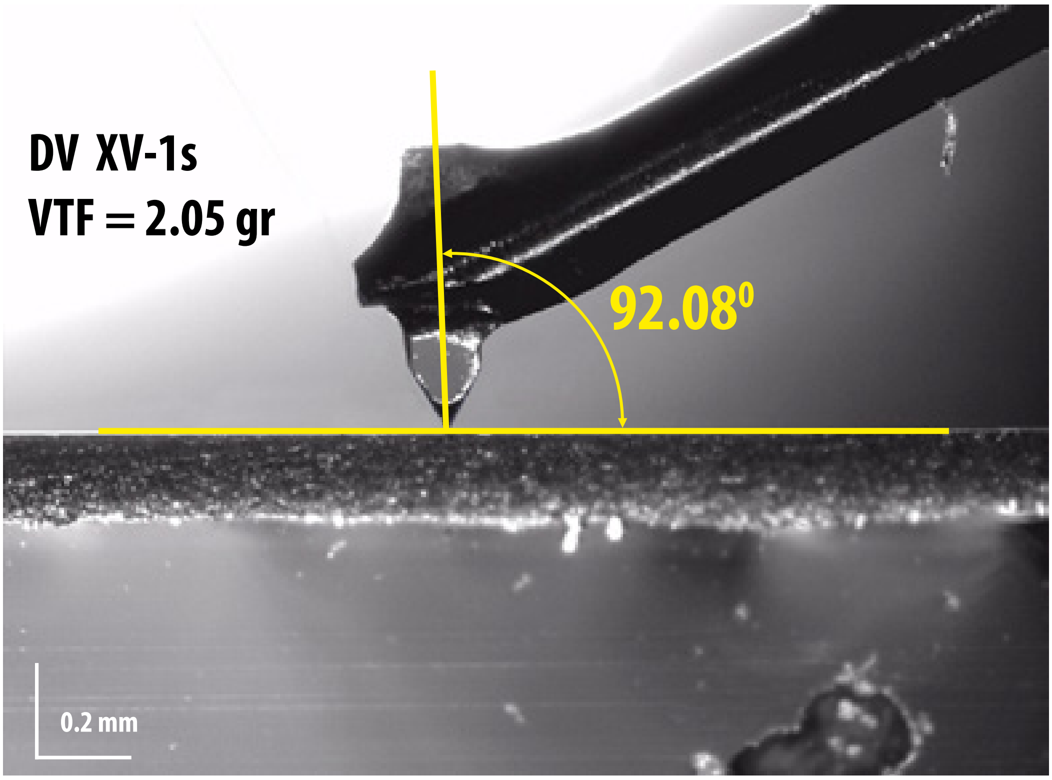


Fig. 18. Optimal VTA seen via microscope

C/ Tracking force

Tracking force is the force which pushes the diamond tip into the grooves. As you can see the tip has a rough ride to play music. Set up tracking force as suggested by cartridge manufactures. Typical figures are between 1.5 g to 2.5 g (grams). Use the higher figure. It is better that the needle is in constant touch with the wall grooves than losing contact for a moment and bouncing against the wall.

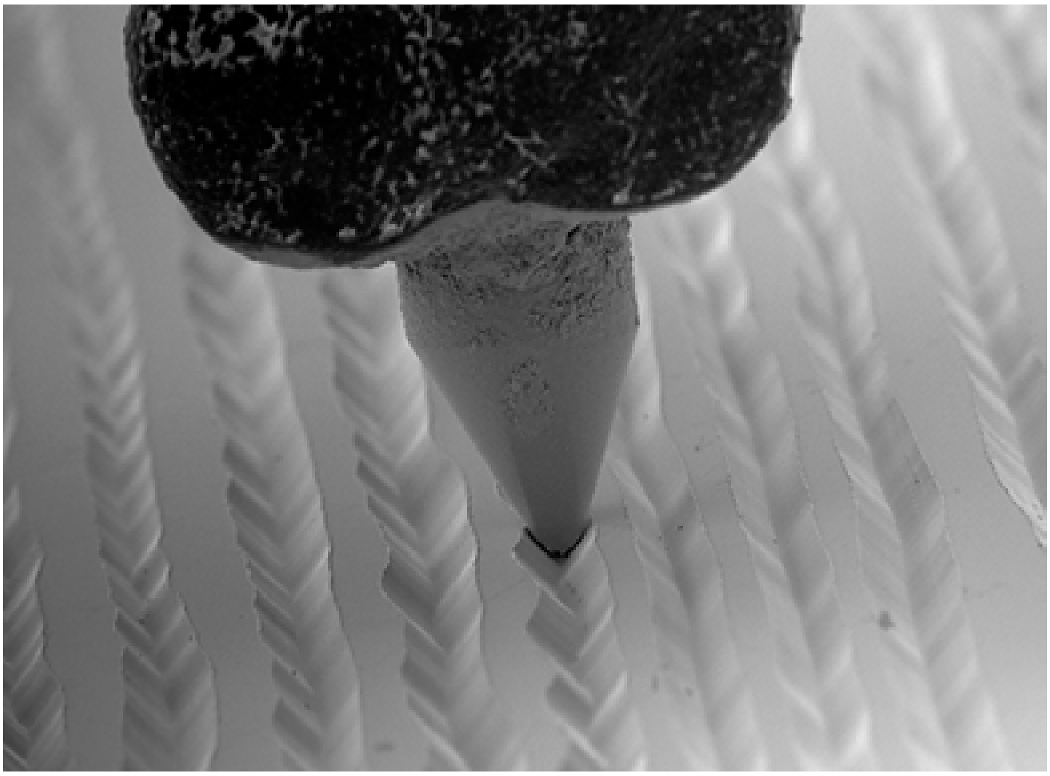


Fig. 19. Diamond tip in the groove

You can check how well specific combinations of tonearm and cartridge can trace high modulated tracks on test records.

In reality heavy modulated tracks on test record and heavy modulated peaks of music are different. On test records they are steady heavy modulation tones while in music they are just shorter loud peaks.

The diamond tip can track short duration peaks of music more easily than long steady tones on test records.

If the cartridge is excellent on test tones it does not necessarily follow that the same cartridge will play musical peaks with minimal distortion and resolution.

D/ Bias force – antiskating

Record rotation pulls the diamond tip along, creating a certain force on the diamond tip. In pivoted tonearms, due to optimal tangential geometry (Fig. 20), a side force is created and this force acting on the diamond tip pulls the tonearm towards the spindle. So we apply bias force or so called antiskating to compensate the inner pull of the tonearm. Longer tonearms have a slightly smaller bias forces.

Bias force is affected by many factors: tracking force, diamond shape, modulation of grooves, arc of grooves at inner grooves vs. outer grooves, eccentricity of record, record warps..
In the past they measured actual tracking force of 2 g in the lab. In reality this varies from 0.3 g to over 3 g due to small warps.

The diamond tip travels all the time in or out due to record eccentricity. This creates side in or out forces on the diamond tip. So bias can at some point even be negative. Bias force is only, therefore, an aproximate figure and not exact like some other parameters and you can not set up accurate bias force. Using a test record with a blank surface is useless because the diamond tip is not in the modulated grooves.

On test records with heavy modulation tracks, you can set up optimal bias force to get best tracking. Unfortunately such bias force is too strong because it is set up for steady tones.
In practise, when there are strong musical peaks, we need the strongest bias force but by the time this happens it is too late for bias force to react. For a short time tonearm inertia helps.

Bias should be about 20 % less than would be set up by use of a test record. Of course the test record must have these modulated grooves at the inner and at the outer end of the record.

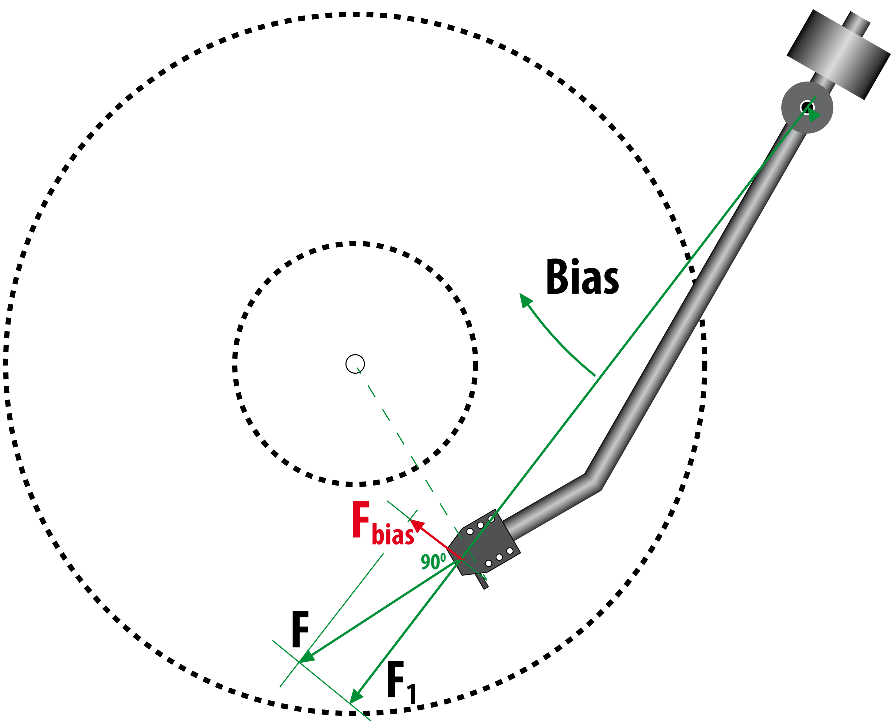


Fig. 20. Forces on diamond tip pulling tonearm inwards

E/ Azimuth

When grooves are cut the cutter head is perpendicular to the record surface. To obtain the best playback we need to recreate the same situation. So our cartridge should be as in Fig. 21. Otherwise the groove walls will not be read accurately.

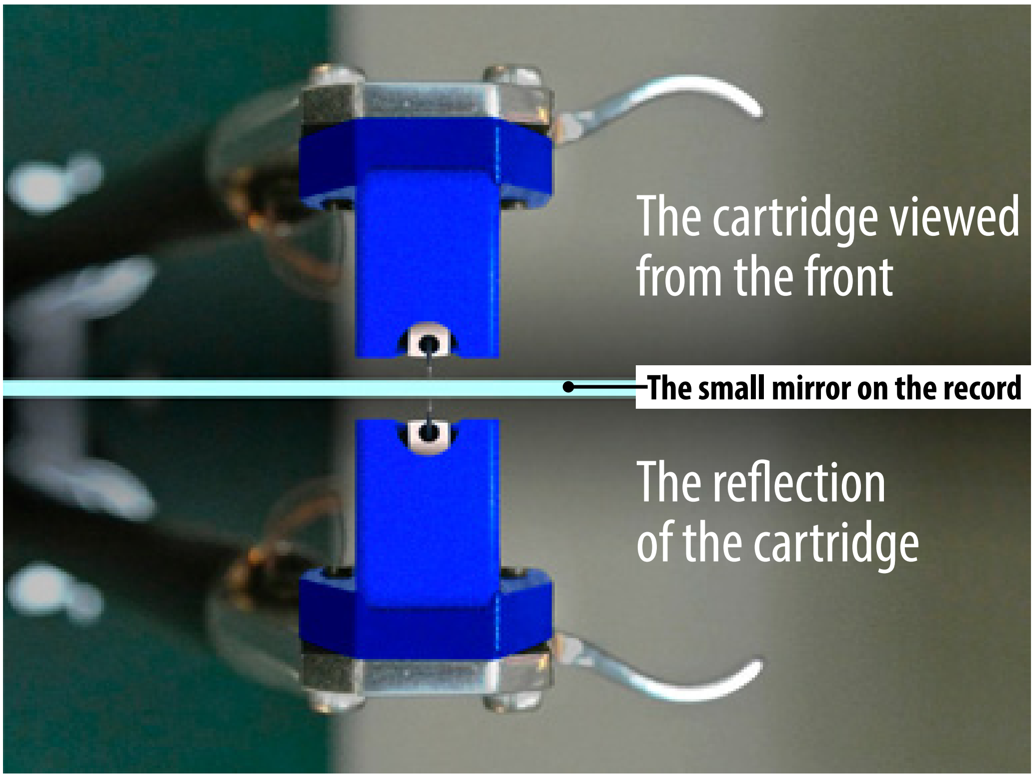


Fig. 21. Azimuth front view

In reality it is not so simple. Even if the cartridge body is square to its mirror image an the record surface that does not mean that the diamond tip and coils are.
A cartridge is constructed of various parts: cantilever with diamond tip, coils, magnets, suspension, etc, all of which must be precisely assembled into the cartridge body. As in any production there is always a level of tolerance. In sum we can not be sure that if the cartridge housing is square to its mirror image, the azimuth is then the best. We need to set up optimal azimuth taking into the account the whole cartridge with its mechanical and electrical parts.

F/ Tonearm cartridge resonance

The tonearm and cartridge are as one body supported by a diamond tip over a rotating point. The cantilever with diamond tip is a small rod, elastically fixed in the cartridge body. It acts as a spring. The tonearm with the cartridge slowly follows the diamond tip across the record. Groove modulation quickly moves the diamond tip and the cantilever moves coils (or magnets), thus creating an electrical signal.
Now imagine that the tonearm with the cartridge has a very low mass. In this situation the diamond tip will, via the cantilever, move the whole tonearm and cartridge and there will be no movement of coils in the magnetic field and thus no signal.

Now imagine a real tonearm with a cartridge. If we move the diamond tip very slowly the tonearm also moves along, as when the diamond tip follows eccentrical records. This will be in the range of 0.5 Hz and the cartridge output would be nil. If we start moving the diamond tip very fast, the tonearm with the cartridge will not move but the coils will and we will have an electrical output. Between these two situations when we do not have ouput (0 Hz) and we have 100 % linear output (above 20 Hz) is an area where we get mixed output. Somewhere between these situations is the resonance frequency of the tonearm & cartridge combo.
Typically this can be between 2–20 Hz.

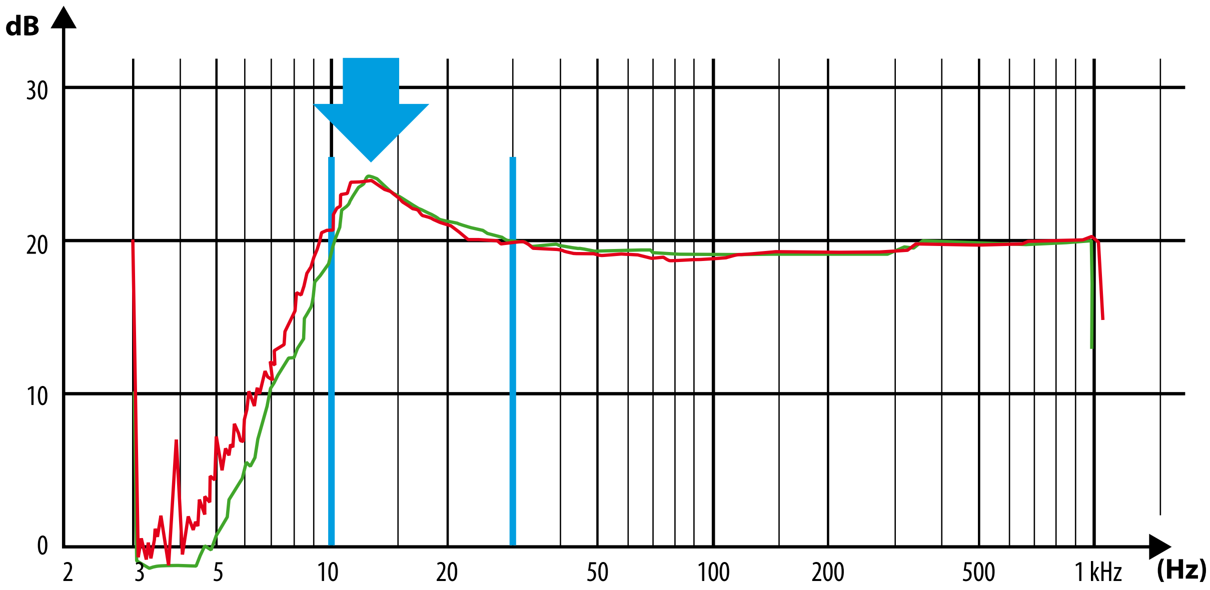


Fig. 22. Frequency response with peak resonance at around 12–13 Hz

We need to observe a situation when the diamond tip slowly moves the cartridge body with the tonearm but not the coils (no output) and when the diamond tip quickly moves the coils but not the cartridge (full output).

This can be shown on a simple spring mass system. Fig. 23.
On a spring hang a weight and hold it in your hand. The spring will stretch due to mass for a certain distance X.

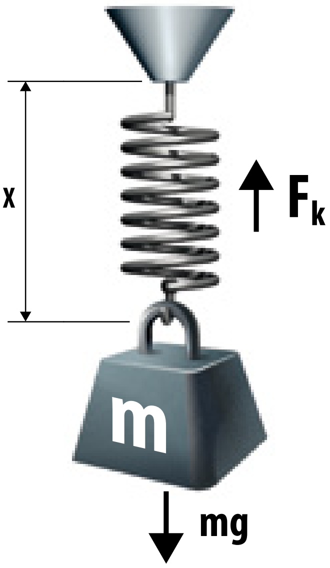


Fig. 23. Weight on spring– X distance

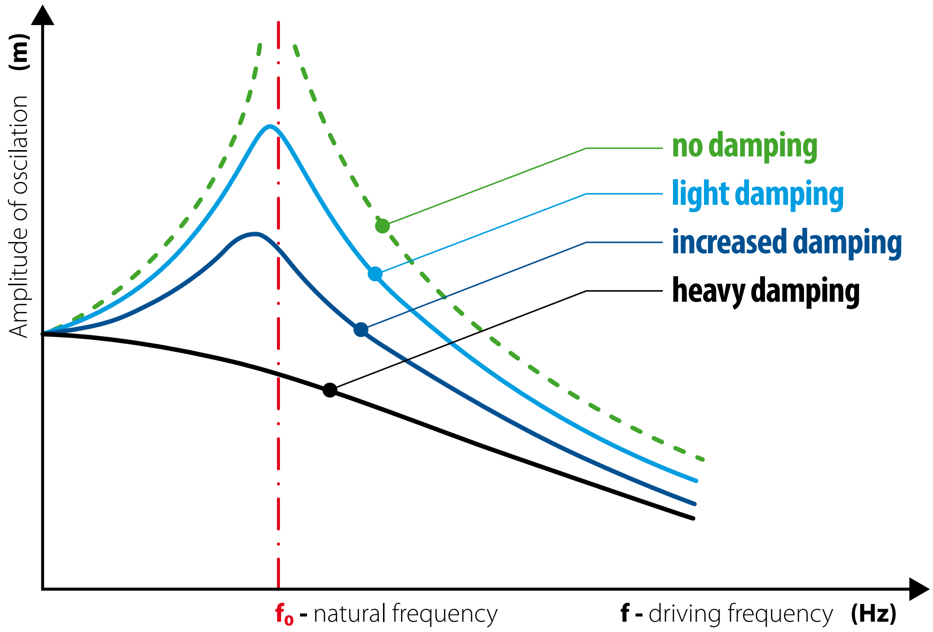


Fig. 24. Effect of damping on resonance's amplitude

Now start very slowly going up and down with your hand and observe distance X. If you move it very slowly (very low frequency) X will stay the same.

But if you start moving down a bit faster then, due to inertia of mass, the spring will stretch a bit more than X and when you start moving the hand up, the mass is still traveling down and eventually, with a bit of a delay, the mass will also start traveling up. Due to inertia the mass will now travel up higher and thus distance X will be smaller.

If you move faster (higher frequency), there will be more delay and X distance will change more. At a certain speed your hand will go up while the mass travels down. When this happen the variation will be the biggest.

If you then move your hand up and down even faster, inertia will keep the mass in the same position so even though your hand is moving up and down, the spring is absorbing all the changes. When X has the biggest variation we say that the system has a resonance and the biggest X (biggest output in the cartridge combo). See Fig. 22.

Response is divided into three areas: below resonant frequency, resonant frequency and above resonant frequency. In reality resonance is not just one frequency but looks like a peak.
This means that very little energy at the resonant rate is needed to create high amplitude.

Lets look at the graph Fig. 24.
You can see that amplitude, in theory, goes at the resonance frequency to infinity. But all systems have some damping built in or added external damping. Imagine if, in our spring system, the mass was submerged in water, that would slow down movement. This is the effect of heavy damping. On the graph you can see that heavier damping decreases the amplitude peak but broadens output above resonance frequency.

A tonearm with a cartridge and elastically suspended cantilever, is a spring mass systems. With known parameters we can calculate where the resonant frequency will occur.

Above resonance there will be linear output, below resonance no output and at resonance there will be too big output. The tonearm cartridge combo will, at the resonant frequency, create high amplitude, meaning the tonearm will shake with the resonant frequency.

So we cannot choose resonance in the music spectrum between 20–20.000 Hz. We need to go below 20 Hz where there is no music.

Below 20 Hz there are still some disturbing frequencies–low frequency noise caused by eccentricity, warps, bearing and belt noise. It is generally accepted that minimal noise is between 8–12 Hz, so we must choose the tonearm resonance in this area where there is the least chance that noise will act on the resonant frequency and start vibrating the tonearm itself.

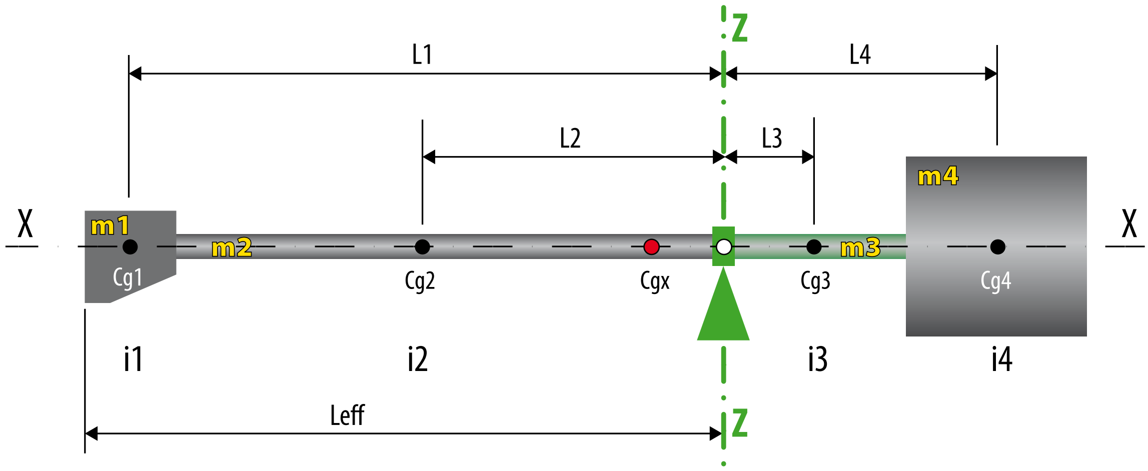
We need to know what mass the tonearm and cartridge have and how elastic the spring is (cantilever suspension). Mass is in grams while the spring parameter relates to how much the spring stretches for a given mass (g/mm).

Because we need to know what is happening at the diamond tip we cannot simply use tonearm mass because the tube and counterweight are at some distance from the tonearm bearings (vertical and horizontal).

The effective mass of a tonearm is a figure in grams. It represents the 'force' needed on the diamond tip to move the tube at the bearings.

In principle it is like this:
If the tube has a mass (m2) of 20 g (grams) the centre of mass is in the middle of the tube (Cg2 at distance L2). Fig. 25.

Lets us say the tube is 200 mm long (L1) and therefore the centre of mass is only 100 mm from the bearing. The diamond tip is at the end of the tube at 200 mm. Because the tube mass is nearer to the bearing the diamond tip 'sees' it as less mass. The effective mass of the 20 g tube is, therefore, only 5 g. Mathematics is about the moment of inertia but we will not discuss that here.
There is the same calulation for the counteweight. The mass (m4) is 100 g and at a distance (L4) of 50 mm from the bearing but the diamond tip will 'see' it as an effective mass of 6.25 g. (calculation is simple). Tonearms have an effective mass between 6–30 g.
Because the cartridge mass (m1) is 200 mm from the bearings (L1), its mass is the same as effective mass. So to get total effective mass we add together cartridge mass and effective tonearm mass and calculate the resonance frequency.



m1, m2, m3, m4 = masses
i1, i2, i3, i4 = moments of inertia
Cg1, Cg2, Cg3, Cg4 = centroids
L1, L2, L3, L4 = distances to centroids
Leff = effective length
Z - Z = pivot / axis of rotation

$i_{tot} = i1 + i2 + i3 + i4$

Balance:
$m1 \times L1 + m2 \times L2 = m3 \times L3 + m4 \times L4$

Centroid of total mass:

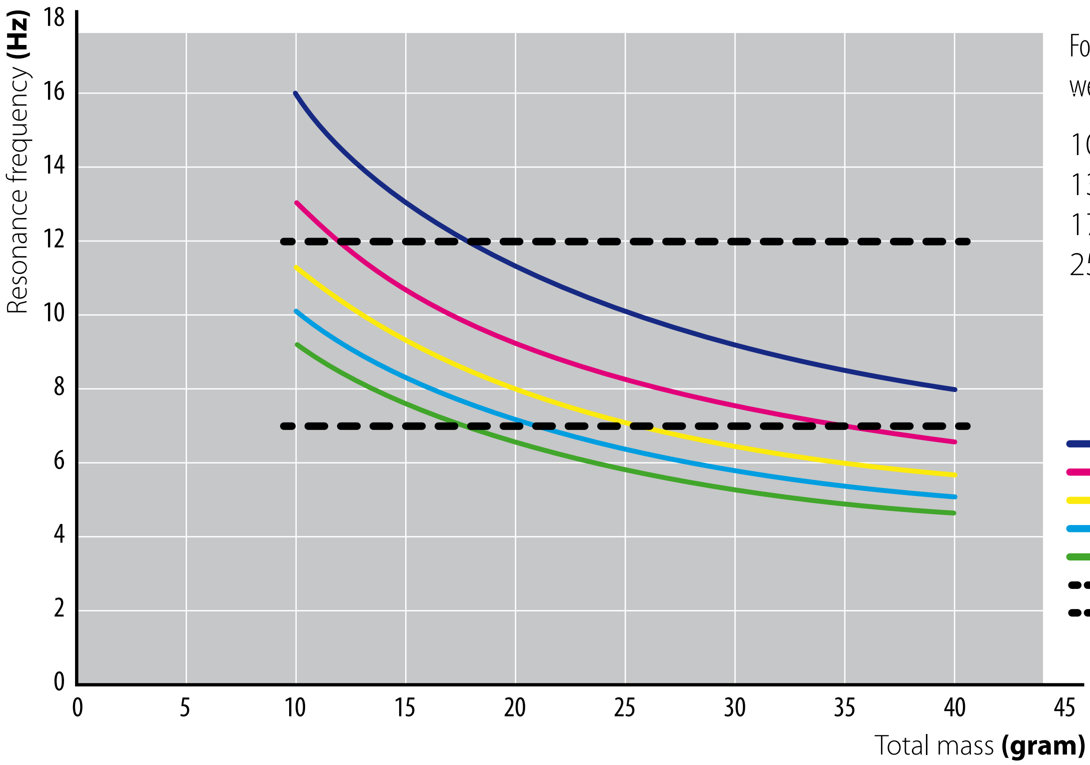
$$Cgx = \frac{(-m1 \times L1 - m2 \times L2 + m3 \times L3 + m4 \times L4)}{(m1 + m2 + m3 + m4)}$$

Fig. 25. Tonearm mass and effective tonearm mass- inertia

Cantilever suspension – dynanic compliance often refered to as CU (compliance unit) is expressed in micronmeter deflection of mN force. I will not go into details here but a useful number is 10–50, the lower numbers being low compliance cartridges and 50 very high.

Usually MC cartridges have a lower compliance and MM cartridges have higher. In the past there was an idea that the higher the CU the better tracking. But in reality more than one factor is important for good sound.

In the graph below you will see that low CU requires a higher effective mass of cartridge. Fig. 26.



For optimal 10 Hz resonance we could choose:

10 g with 25 cu
13 g with 20 cu
17 g with 15 cu
25 g with 10 cu

Fig. 26. Optimal effective mass tonearm & cartridge choice

Low compliance cartridges require a higher tonearm mass. There is more feedback into the tonearm but the higher mass allows the construction of a more robust tonearm.
Resonance can go lower then 6 Hz (tangential tonearms in horizontal direction, added damping...)
Tonearm choice: it is obvious – Kuzma.

When chosing a tonearm the first consideration should be whether the tonearm will fit on the chosen turntable and vice versa. Tonearm size, mass and cartridge choice should be considered. Can the turntable suspension accommodate a heavy mass tonearm? Is there enough space for an appropriate cut–out to be made on the armboards, to fit tonearm height, depth and counterweight space when the tonearm is in the rest position or at the inner grooves?

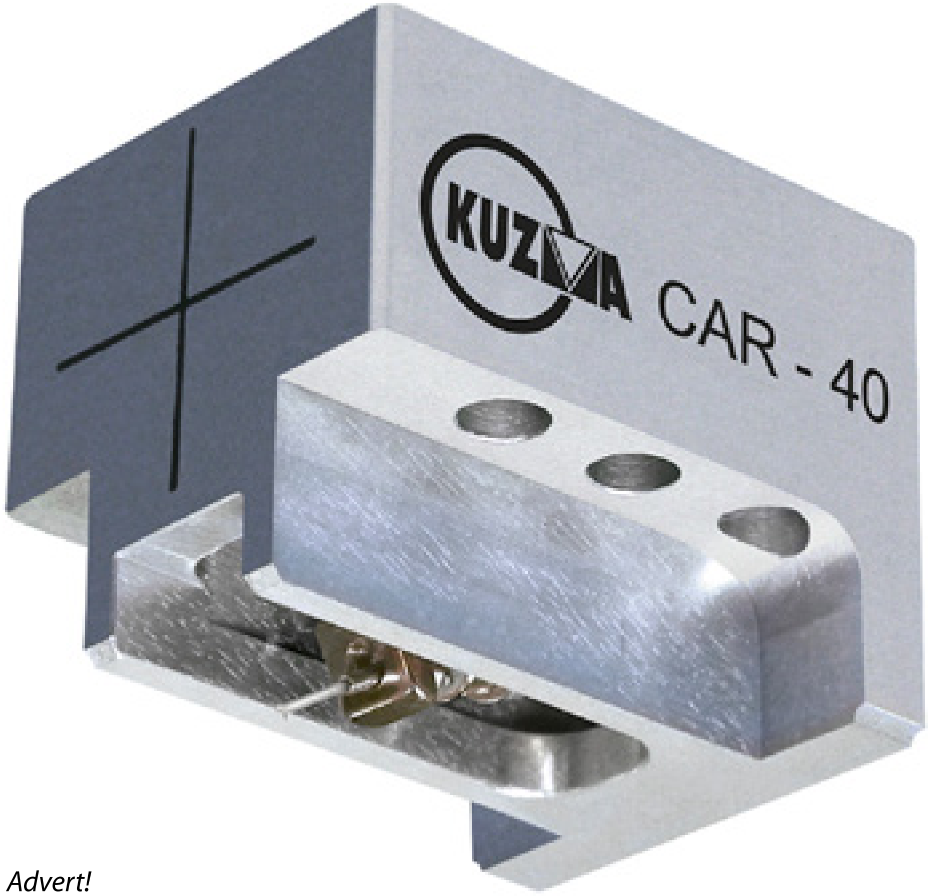
Advert!

PRACTICAL CARTRIDGE SET UP

Refer also to paragraphs A–F

G/ Tonearm and cartridge choice and mounting

Obviously the cartridge choice will depend on the tonearm, taking into account tonearm resonance but it is more important that a top quality tonearm is used. There is no sense using a high quality cartridge on an inferior tonearm. Check that you have the correct armboard cutout for the tonearm and check that there is enough space on the turntable. Please also first read the tonearm, turntable and cartridge manuals.



Advert!

1. Armboard and armbase mount

Mount armbase on turntable armboard. Remember that the armboard is part of a turntable and the manufacturer should provide an armboard with the specific cutout. Do not ask the tonearm maker to provide part of a turntable, unless it is a Kuzma tonearm for a Kuzma turntable. We also provide various cutouts for most other tonearms for all our turntables. Check how you will route cable from the tonearm behind the turntable.

2. Height of the tonearm

Raise or lower tonearm so the top of the headshell is at least 15–25 mm above the record surface.

3. Mounting cartridge

You need screws M 2.5 mm, with or without nuts, which need to be an appropriate length.
Use screwdriver or allen key. Use tweezers and not pliers to fit cartridge clips onto cartridge pins.
It is easier to break the wires under the clip insulation by use of pliers than with good tweezers, buy them in a tool supply shop.

● Red: **+ R**
● Green: **– RG**
○ White: **+ L**
● Blue: **– LG**

4. Tracking force

Balance the cartridge by adjusting the counterweight. When moving the cartridge above the platter be sure that the cueing device is the right height.
Use cartridge manufacturer's tracking force suggestion for the upper half of the recommended range. Use gauge or dots on counterweight. Less damage is done if the tracking force is higher than a lower force, when the diamond loses contact with groove walls.

5. Tonearm height– rough VTA – Fig. 17 (page 11)

Adjust the tonearm height so that the tube is parallel to the record surface when the diamond tip is on the record.

6. Bias force

Set it up as recommended in tonearm manual.

7. Azimuth – Fig. 21 (page 14)

If there is an adjustment just be sure that it is, for now, in the neutral position or that it is perpendicular to the record surface.
You can observe its square mirror image on the inner, blank portion of the record.

H/ Tangential geometry set up & adjustment

Once the cartridge has been mounted, it is necessary to ensure that the cartridge is tangential to the record grooves in order to minimize tracking distortion during playing. As the cartridge moves in an arc across the record, tracking distortion occurs and is minimized by the tonearm geometry and the angle of the cartridge in the headshell.

With optimum tonearm geometry, very low distortion levels (below 1 %) can be obtained across the entire playing surface. Cartridges have zero distortion at two null (zero points) on the record and these points are used when aligning the cartridge. In practice these points lie at 66 mm and 121 mm from the record centre (see protractor). Other protractors make use of different null points due to the use of different parameters in calculation. In this case 60 mm has been chosen as the inner groove and 146 mm as the outer groove which still has optimum tracking distortion. Fig. 14.

Note: Ensure bias is on minimum or switch off.
Note: Place protractor over spindle on platter.
Note: To rotate and move cartridge, slightly loosen the screws which attach the cartridge to the headshell.
Holding headshell in one hand slightly rotate the body of the cartridge.

If you have difficulty seeing the cantilever it may help to raise the arm a few mm, taking care that the protractor does not rotate. This also prevents tilting of the cantilever due to the effect of bias force. It may also be helpful to fix the platter by inserting a wedge between platter and plinth and by inserting a sheet of white paper to give a clear background while observing the cartridge. Use a strong light and tighten cartridge screws gently for now.

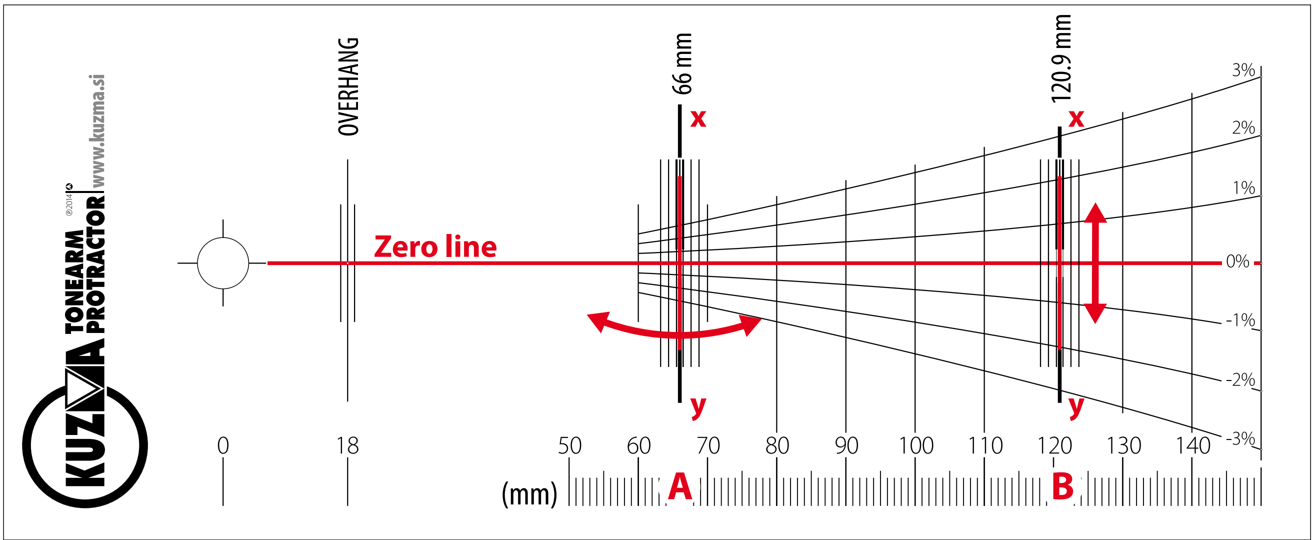


Fig. 26A. Two null protractor

A: This is when the diamond tip is positioned at the intersection of the inner null line 66 mm (Y–X line) and zero line (0 % distortion).
B: This is when the diamond tip is positioned at the intersection of the outer null line 120 mm (Y–X line) and zero line (0 % distortion).

1. Alignment at intersection A *Fig. 27 & 30*

Place the tip (stylus) precisely at intersection A. Observe cartridge from front and side.
If the cantilever is not parallel with Y–X line, then the body of the cartridge will have to be rotated slightly and then checked again. Do not adjust the cartridge just by observing the body of the cartridge, check the cantilever itself from the front.

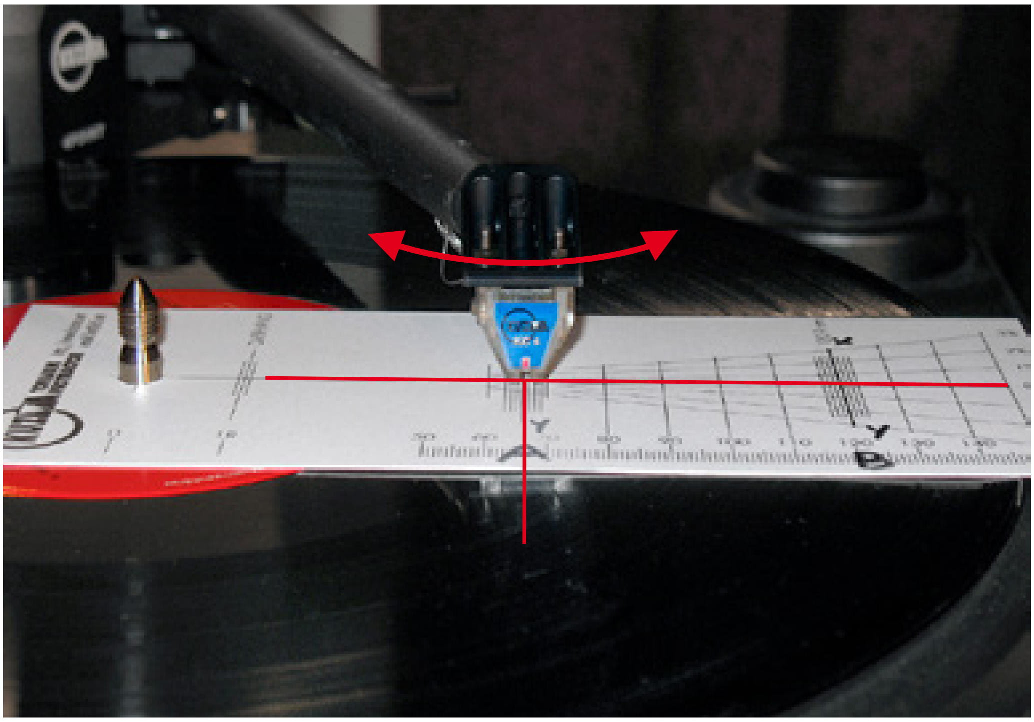


Fig. 27. Alignment at intersection A (inner null line: 'Y–X' and zero line)– cartridge rotation

2. Alignment at intersection B *Fig. 28 & 29*

Place tip (stylus) at intersection B. Observe cartridge from front and side.

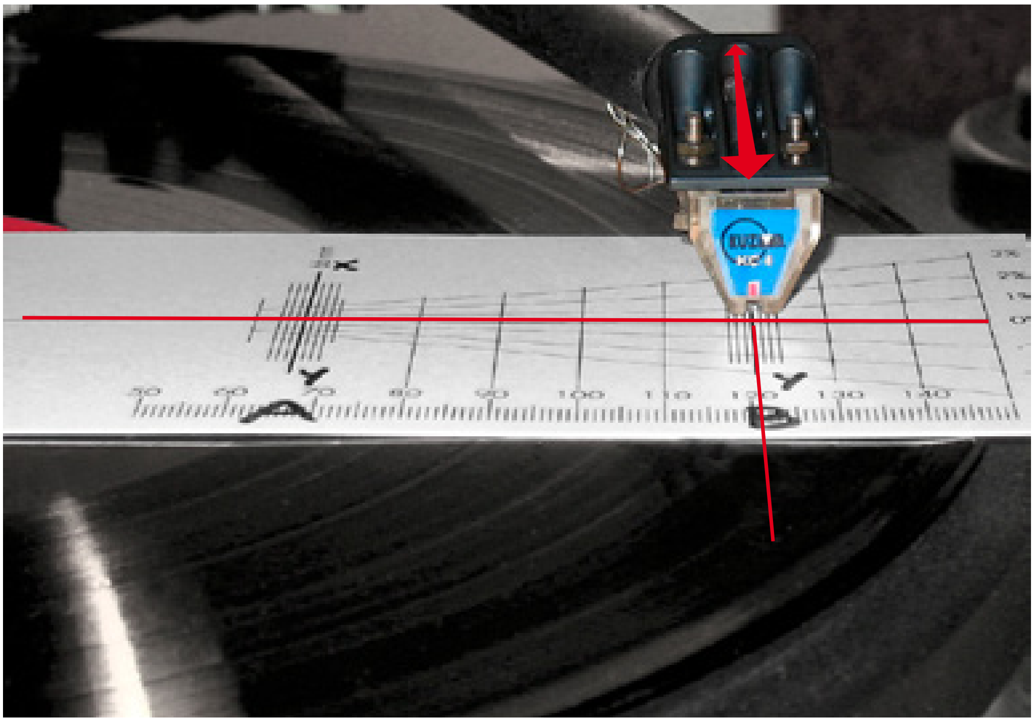


Fig. 28. Alignment at intersection B (outer null line: 'Y–X' and zero line)– cartridge move along headshell

Observe the cantilever from the front and rotate protractor until the cantilever is in alignment (parallel) along Y–X line, though the stylus tip will probably be somewhere along this line but not yet at intersection B. Raise the cueing device a little to see better. (Fig. 28 & 29)

If the stylus tip is in front of the zero line, pull the cartridge forward (away from the zero line) in the slots of the headshell, for approximately the same distance 'S' as the stylus tip is 'overhanging' the zero line.

If it is behind the zero line, push the cartridge backwards towards the tonearm armbase for the observed distance 'S'. (Fig. 29)

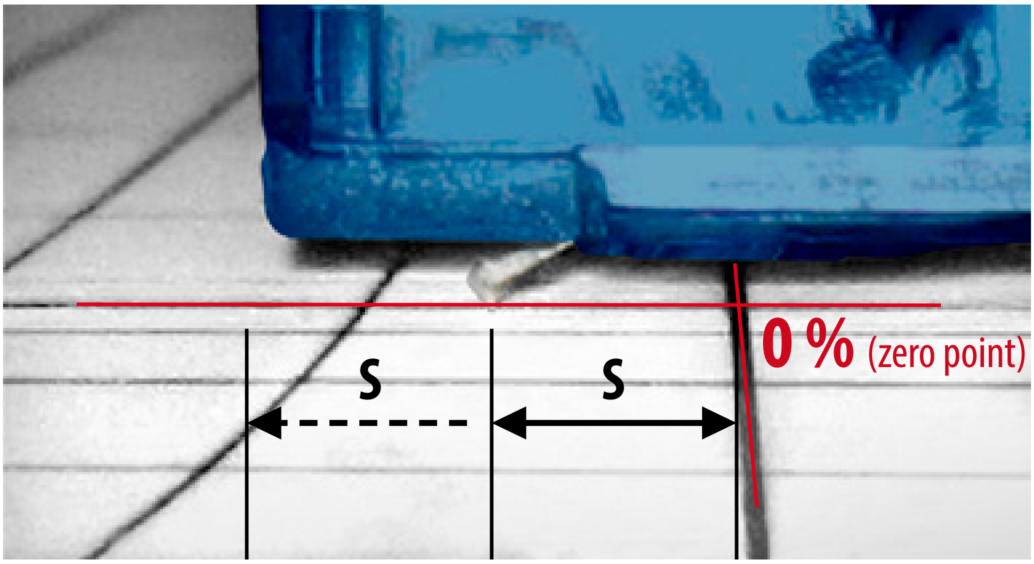


Fig. 29. Stylus tip is in front of zero line for distance 'S'

3. Repeat alignment at intersection A *Fig. 27*

Again place the tip (stylus) precisely at intersection A. If the cantilever is not parallel with the 'Y–X' line, then the body of the cartridge will have to be again rotated slightly and then checked again at B. Fig. 27.

4. Repeat alignment at intersection B *Fig. 29*

Observe the cantilever from the front and again rotate protractor until the cantilever is in alignment (parallel) along the 'Y–X' line, though the stylus tip will still be somewhere along this line but not yet at intersection B. If by any chance the tip is at intersection B, gently tighten screws and go for final check 6.

It is more likely that the stylus tip will be either in front or at the back of zero line for the new distance 'S'. Move cartridge (away from the zero line) in the slots of the headshell, for approximately the new distance 'S' as the stylus tip is 'overhanging or underhanging' the zero line.

5. Repeat alignement at intersection A *Fig. 27*

Again place the tip (stylus) precisely at intersection A. If the cantilever is not parallel with the Y–X line, then the body of the cartridge will have to be again rotated slightly and then checked again. If by any chance the tip is at intersection A, gently tighten screws and go for final check 6.

But more likely the cantilever is still not parallel with Y–X line, then the body of the cartridge will have to be again rotated slightly. and go to B (4).

6. Continue set up 3–5 until the stylus tip and cantilever are in alignment at A and B intersections.

7. Final check up

Tighten screws each a little at a time ensuring that the cartridge body will not move or rotate in the headshell and repeat 1 & 2 for final check up. Take into account that small errors will always occur.

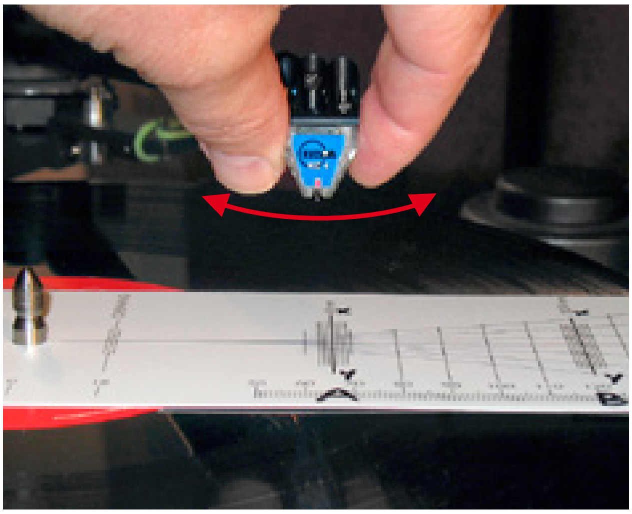


Fig. 30. Rotate cartridge at A position

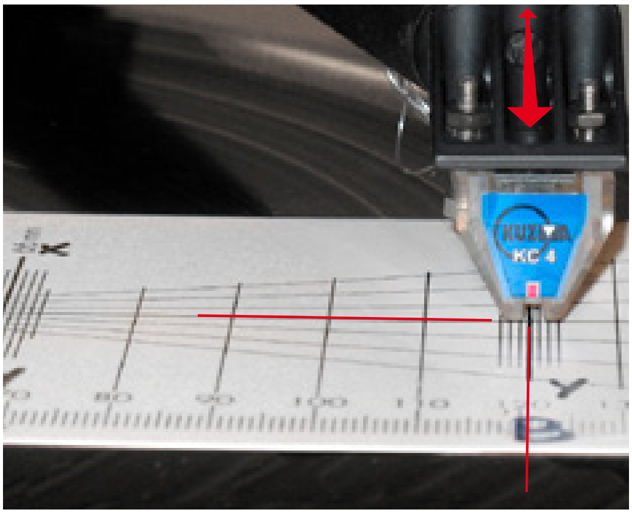


Fig. 31. Move cartridge along Y–X line at B position

REMEMBER STEPS:

a) **A:** Put the stylus tip at the intersection A of zero line and 'Y–X' line and, by cartridge body rotatio,n align the cantilever along the 'Y–X' line. Fig. 27 & 30

b) **B:** Align the cantilever along 'Y–X' line by rotating the protractor and see where the stylus tip is on the line 'Y–X'. Observe the distance 'S' and whether it is in front or behind the zero line. Fig. 28 & 29. Move the cartridge body along the headshell (not rotating cartridge body) for the observed distance 'S' away from the zero line. Fig. 29.

c) **A:** Put the stylus tip back at the interesection A of zero line and the 'Y–X' line and observe the cantilever along 'Y– X' line. If the cantilever is aligned with the 'Y–X' line and the stylus tip is still at the intersection A then repeat 'b'.

If the stylus tip is also in the intersection B (distance 'S' is null) cartridge geometry is adjusted, so gently tighten screws.

Repeating these steps (a, b, c, a, b, c…) until the stylus tip and cantilever are in alignment at both intersection points A & B.

Note: Ensure that cantilever is not twisted due to bias force.

I/ Fine VTA (SRA) adjustment

In the old days to set up VTA you needed a good pair of ears or maybe a special test record and an oscilloscope.

Rough guidance was, too high VTA, a lot of high frequencies and thin bass, too low VTA dull high and strong bass. This was not like using an equaliser to compensate for the lack of a specific spectrum. A lot of people misunderstand what optimal VTA is. Some believe that the tube being parallel to the record surface is optimal VTA (Fig. 16–17) . To get more highs, raise the tonearm a little. Not exactly.

First you do not know where optimal VTA is. It might be when the tonearm in the armbase is higher than 10 mm and the tube is slanted down. When you change the tracking force the cantilever is pushed up and VTA (SRA) is changed again.

Today a USB microscope can be used with an accepted angle of 92 deg. Unfortunately this angle does not apply to all cartridges, so you still need to use ears and common sense.

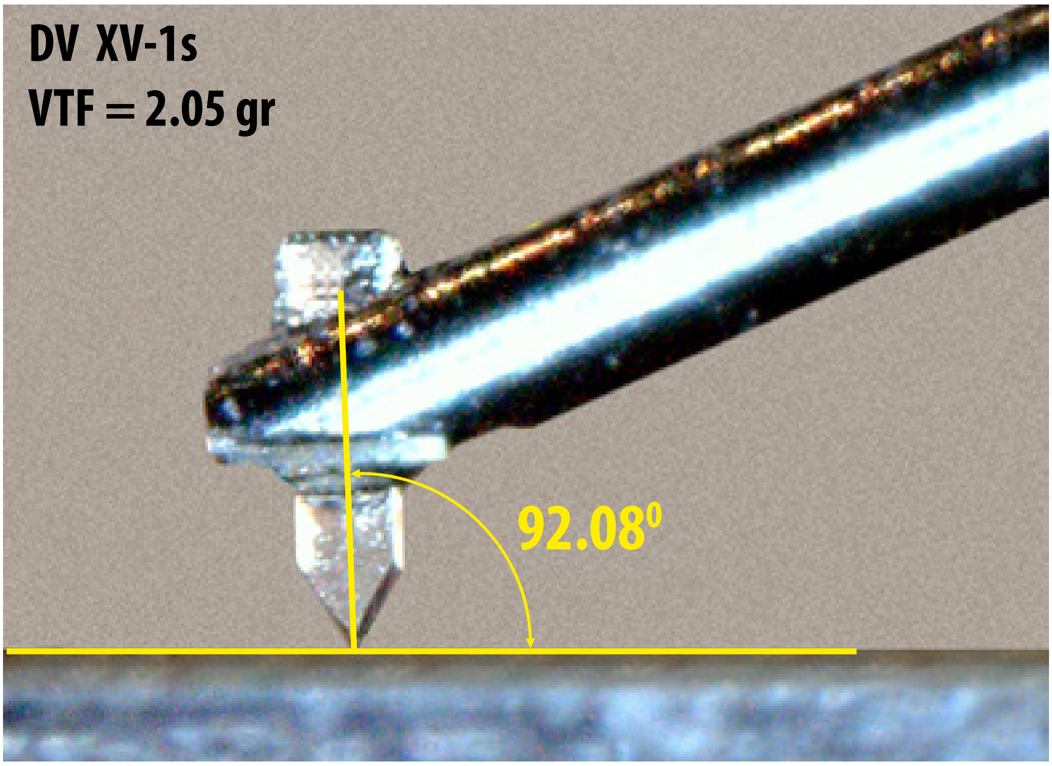


Fig. 32. Optimal VTA (SRA) angle

J/ Fine bias adjustment

1. Set bias and tracking force as previously described and listen to mistracking on highly modulated tracking bands on a test record. On higher modulated bands mistracking can be heard as impure tones and there will be more overtones. (See instructions on test record)

2. If mistracking is apparent, increase or decrease bias until minimum mistracking is found. If mistracking is heard on the right channel only, then the bias is too low, if on both channels, the bias is too high or the trackability limit of the cartridge has been reached.

3. Finally further decrease mistracking by increasing tracking force to the maximum recommended for the cartridge.

4. It is best to have the highest possible tracking force and low bias force but remember to lower bias for 20 %.

5. Do not change bias after you set up precise azimuth.

K/ Azimuth adjustment

This is another important parameter that needs to be set up properly.

We measure the differences in crosstalk between both channels. The idea is that this should be equally small on both channels. For that we need a test record with tracks recorded for left and right channels separately. Then we compare crosstalk from the left channel on the right channel, which is a very small signal, to the same type of signal from the other channel. By adjusting azimuth, crosstalk on both channels should be made equal.

Today there are various gadgets such as Dr. Feicker program, Fosgate meter, osciloscope... etc which can help but the final decision should be made by listening.

Cartridges with fine profiles (VDH, Microline etc.) are more sensitive to this adjustment. On the other hand cheaper cartridges are not made so well and making fine adjustment still improves the sound.

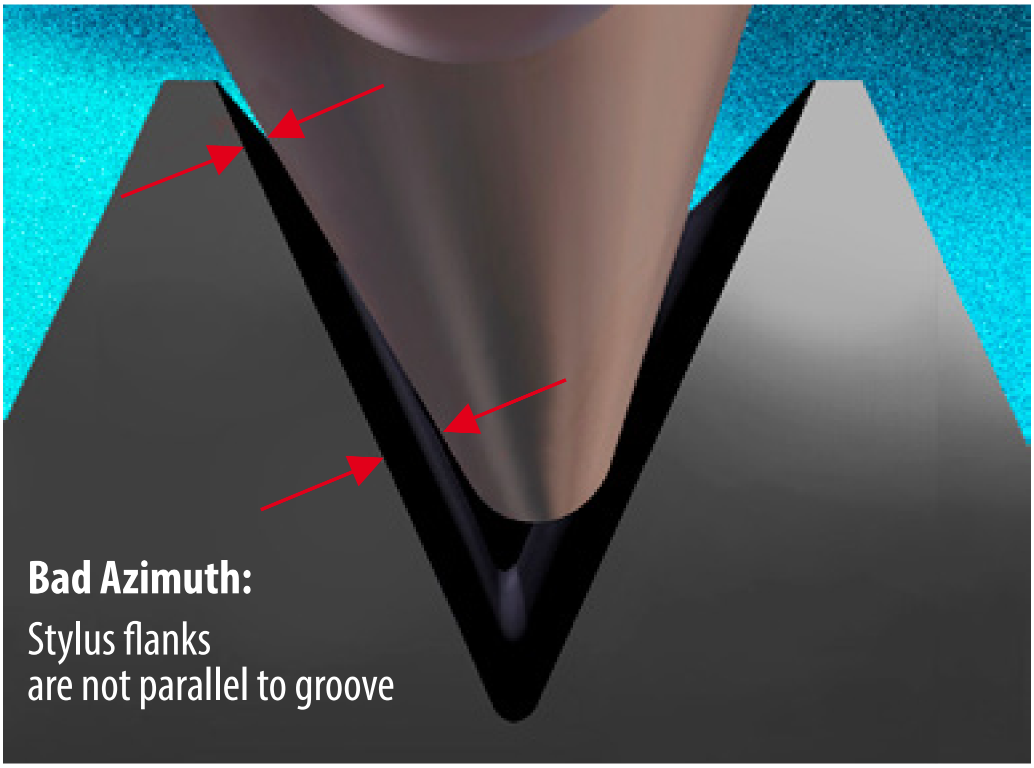


Fig. 33. Stylus in the groove

Listening from LP

On top Kuzma tonearms, start listening with the tube in the zero position, with the marking lines aligned. Listen to the sound–stage, the focus and the stability of the instruments. Release the two locking screws and rotate the Allen key so that the tube rotates for approximately the width of the mark. Listen and then rotate the tube for a similar amount in the opposite direction and again listen. Adjust the arm to the position in which the best sound was obtained. In this position make further adjustments by turning the Allen key for a quarter turn in one direction, listening and then turning a quarter turn in the other direction and listening.

Continue this process making ever decreasing adjustments, 1/8 of a turn, then 1/16 and so on. When optimum results are obtained fix the locking screws. To remember the position of the azimuth, imagine that the inserted Allen key acts as a dial on the clock.

Dr. Feickert azimuth program

This is the simplest way to set up azimuth. Using a test record and software in the lap top makes it easy though you will still need some practice to get the right result. Top cartridges will have even channel crosstalk in the range of over –33 dB.

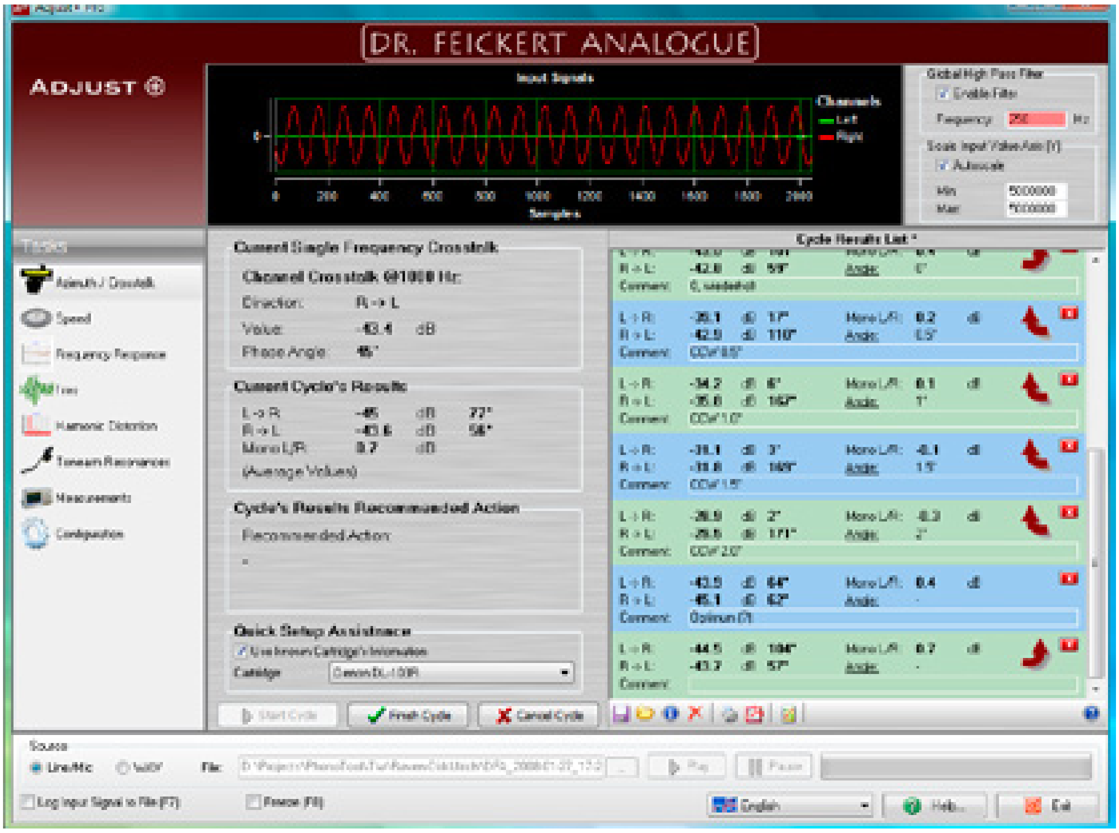


Fig. 34. Dr. Feickert azimuth program

Fozgometer

Fig. 35. Simple to use but not so accurate

Design, illustrations & layout: adam

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