

Secret Chord Analogue[®]

The Impact of Fine Particles on a Vinyl Record



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Introduction			
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The Modern Stylus, Refurbishing Older Records and Protecting New Ones			
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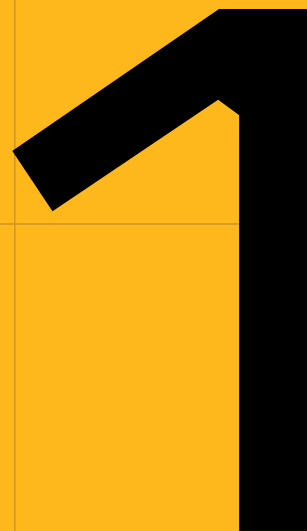
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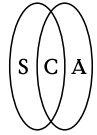
Measured Success of Record Restore™			
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Introduction

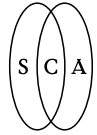
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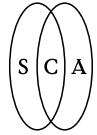


SECTION 1.

<h1>Introduction</h1>		
<p>Most vinyl record aficionados understand the mechanics of the medium. For those new to spinning the ‘fantastic black plastic’, here’s a snapshot:</p> <ul style="list-style-type: none"> – 12 inch records are mostly played at 33$\frac{1}{3}$ RPM or .556 turns per second – Effective stylus velocity at this speed in the outermost turn is .509 m/s and .196 m/s at the innermost turn. The effective wavelength of a given frequency will therefore be different across the record, much shorter at the innermost groove – The length of the groove on one side of a record, if straightened out, is about a kilometer – The effective pressure exerted by the stylus at each tiny touch point is over 20 tons per square inch (which is why styli wear out) – The groove is a V shaped right angle, the width at the top of the groove being 56μm, the depth nominally 28μm (a fine human hair can be as small as 40μm, about the viewing extent of the naked eye) – There is a 6μm clearance between the bottom of the groove and the tip of the stylus (unless the stylus is extremely worn). Small particles can collect there – A stylus tracking a mono recording moves only laterally and at a constant depth half way up the groove wall at a width of 36μm 	<ul style="list-style-type: none"> – As well as laterally, a stylus tracking a stereo recording also moves vertically meaning the engagement width or effective depth on the groove modulations varies – The introduction of stereo recordings necessitated a new stylus shape, elliptical. This avoided the mistracking of conical shaped tips by allowing deeper groove penetration and effective tracing of high frequency details without bottoming the stylus – Shibata style styluses as well as micro-ridge and micro-line with their greater groove contact area are less tolerant of fine particles – So called ‘needle scratch noise’ is most often caused by contaminants in the record groove, not physical damage – The cartridge stylus is vibrated by modulations on the record groove wall thereby producing a small voltage which is amplified to produce audible sound. Stylus acceleration in the groove can be truly staggering – e.g. 26,000 m/s² when tracing a 8kHz signal' 	<p>Given the enormous forces at play and the microscopic scale it is paramount that there is no interruption to the proper relationship between the stylus and the modulations on the groove wall. Where this happens the quality of playback is degraded. Worse still, the minute particles that cause this to happen exacerbate wear of the stylus itself; they can also permanently damage the groove walls.</p>

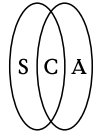


<p>The following examples of minute particles when compared to the dimensions of grooves and styluses provide an indication of the nature of the problem of maintaining pristine grooves.</p> <p>Medium-size particles are considered to lie in the range 1µm - 100µm (the human eye capable of seeing 40µm and greater). These particles include pollen, hair, large bacteria, windblown dust, fly ash, coal dust, silt, fine sand, automotive particles such as brake dust and small dust.</p>			<p style="text-align: center;">↓</p> <p>Further helpful information on stylus and groove geometries may be found at: pspatialaudio.com/max_accel.htm</p>
<p>Particles smaller than 6µm are small enough to pass below the tip of the stylus.</p> <p>Particles smaller than 1µm are probably too small to be audible. They include viruses, small bacteria, metallurgical fumes, soot, oil smoke, tobacco smoke, clay, and fumes. In sufficient volume and when held by sticky binder substances, they will mask the very fine groove modulations. You may not hear these particles during playback but at the same time you won't hear the detail they are masking.</p>			
<p>→ Fig.1</p> <p>The smallest particles, when present in sufficient numbers to form a layer, will fill the very small modulations. For example, tobacco smoke particles as small as 0.01µm, cooking oil smoke from 0.03µm to 0.9µm and even bacteria which start at 0.3µm. Stylus dust particles (abraded pieces of diamond) are amongst the smallest as well as the most dangerous particulate matter in a groove given its abrasive qualities. Binder substances including fats, oils and greases will effectively weld these particles within the groove wall modulations (worse if actually embedded into the vinyl itself) masking fine detail, adding noise and greatly exacerbating stylus wear.</p>			
<p>→ Fig.2</p>			

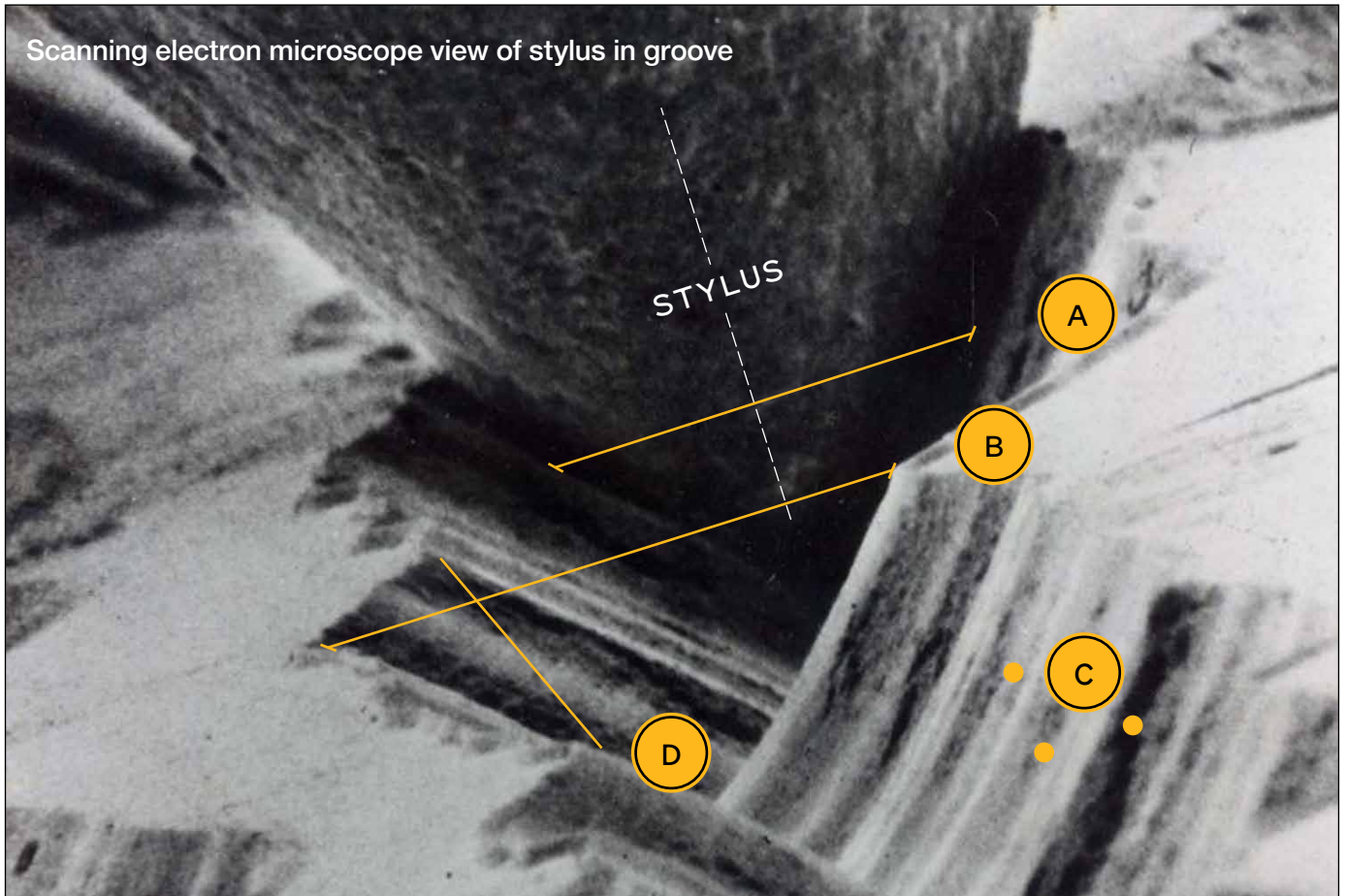


↓ Fig.1

PARTICLE	PARTICLE SIZE IN MICRONS	NOTES
Atmospheric Dust	0.001 - 40	
Viruses	0.005 - 0.3	
Tobacco Smoke	0.01 - 4	Sticky; a binder substance
Oil Smoke	0.03 - 1	Airborne cooking by product
Smoldering or Flaming Cooking Oil	0.03 - 0.9	Sticky; a binder substance
Household dust	0.05 - 100	
Face Powder	0.1 - 30	
Burning Wood	0.2 - 3	
Carbon Black Dust	0.2 - 10	E.g. abraded from records
Bacteria	0.3 - 60	Never blow dust off a record
Insecticide Dusts	0.5 - 10	
Skin flakes	0.5 - 10	
Clay, fine	0.5 - 1	
Clay, medium	1 - 2	
Auto and Car Emission	1 - 150	Metropolitan areas in particular
Iron Dust	1 - 4	E.g. Steel wool; keep away from cartridges
Clay, coarse	2 - 4	
Combustion-related - motor vehicles, wood burning, open burning, industrial processes	Up to 2.5	Generally described as 'soot'; sticky
Mould	3 - 12	Germinated from spores
Spores from plants	3 - 100	
Antiperspirant	6 - 10	Aerosol
Human Sneeze	10 - 100	Aerosol
Mould Spores	10 - 30	
Pollen	10 - 1000	



↓ Fig.2



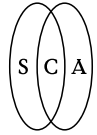
A	B	C	D
<p>Stylus contact points with walls 18µm apart at lowest point</p>	<p>Width of groove 52µm</p>	<p>Therefore these tiny groove wall modulation details are in the order of fractions of a single micron</p>	<p>Sound wavelength Assuming that a 10kHz sound is represented here by the large crests and that this is the outermost groove and the speed is 33⅓ RPM this distance is 51µm. If it was the innermost groove the distance would be 20µm</p>



The Modern Stylus, Refurbishing Older Records and Protecting New Ones

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SECTION 2.

The Modern Stylus, Refurbishing Older Records and Protecting New Ones

Evolution of the stylus

In 1964 Grado patented the first elliptical stylus. It was invented to improve playback of records recorded in stereo where a narrower stylus was required to improve trackability, especially towards the centre of the record where the shortening wavelengths (due to the relative slowing velocity) became too small for the stylus to track. The Grado stylus with its narrower profile was able to sit lower in the groove thereby improving higher frequency playback without risk of bottoming out.

Next came the Shibata stylus, primarily invented for quadrasonic playback. Quadrasonic failed but the new stylus shape proved highly effective and went on to give rise to the line contact, hyper-elliptical, micro-line and micro-ridge shapes, the latter demonstrating minor axes of 4µm or less, the smallest being 2.5µm. It should be noted these are extraordinarily fine tolerances making these styluses quite unforgiving of foreign materials in the groove.

This new generation of styluses feature longer contact profiles with the groove wall as compared to the conical or spherical shapes of the 60s and perhaps still in use in the 70s. Older styluses contacted each groove wall at a single point. This highly focused contact point, when combined with the usual cocktail of abrasive materials common in record grooves at the time, often caused a scoring of the groove walls at the two single points of contact.

With the possibility of actual physical scarring in decades past from the action of older stylus types, a recommended further addition to any refurbishment of older collections is a change of stylus type. By installing a cartridge featuring a micro-ridge, micro-line or even hyper-elliptical with their longer, narrower contact profiles, unwanted noise possibly due to damage from earlier years may be minimized if not eliminated. It is also highly probable that upgrading the stylus in this fashion will protect against undue record wear in concert with the removal of fine, abrasive materials.

Static electricity: The biggest contributor of noise

As demonstrated in the previous pages, the mechanics of vinyl record playback involve extremely small tolerances and quite extraordinary forces. Optimal playback performance demands the complete absence of foreign materials from the record groove. Older records, even those considered to have been maintained, will harbor various types of soiling. Record Restore with its unique composition demonstrates a comprehensive ability to fully expose the finest modulations to the stylus by removing the masking amalgam of extremely fine particulate material and binder substances ensuring full and proper contact by the stylus.

Of the foreign materials which gather in a record's grooves and apart from the diamond dust caused by wear of the stylus, the greatest contributor to unwanted, noise creating particles in a record's grooves is static electricity. Caused by the triboelectric effect¹, a static charge on a record's surface will attract all airborne particles in the record's vicinity and bind them to the record's surface. The charge will periodically discharge via the stylus and cantilever to be heard as 'pops and crackles' during playback. Record Restore's formulation specifically targets statically charged micro-particles. This form of soiling is extremely difficult to remove as without elimination of their static charge the micro-particles will remain tightly bound to the vinyl surface, unable to be lifted into solution. By remaining in the record groove these particles contribute unwanted noise during playback by coming between the stylus and the sound modulations of the groove wall.

The long term benefit of the use of Record Restore on new or older records is a permanent protection against the reintroduction of static electricity.



Scan the QR code to watch a demonstration of Record Restore in action.





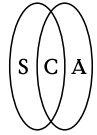
<p>In May 2018, Dave Askew then of MediaDMA, performed analysis of several vinyl record recordings before and after treatment with Record Restore. In summary:</p>			
<p>“I averaged the amount of noise over time, and took percentages of each recording. We ended up with an 11db increase in overall signal to noise ratio, which is around a 75% improvement in how it sounds to the logarithmic way that humans hear sound, and an 8db improvement to the peak noise floor, which is over 50%.”</p>			
<p>Dave Askew</p>			



Measured Success of Record Restore™

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SECTION 3.

Measured Success of Record Restore™

Analysis of Record Restore vinyl record cleaning film by Dave Askew

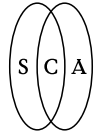
I'm an audio professional who specializes in audio editing, preservation and restoration, audio forensics, and audio sciences. So to make me a believer in an audio product, I need to be extra discriminatory as to what's happening on a microscopic level. I need to cut through the marketing jargon, and get down to brass tacks. My experience with Secret Chord Analogue's Record Restore has left me quite astounded, so I'd like to share some interesting findings with you. Sometimes the best way to see how a product works is to actually see it work. I was given the task by Record Restore's owner and creator, Stephen, to somehow quantify the results of Record Restore's cleaning method. I was given a fantastic product demonstration via Skype, and a few audio files to discriminate. We also had the pleasure of discussing some of the scientific aspects of what is really happening during the manufacturing process, aging process, and cleaning process. My findings were true, absolute, and unquestionable, that Record Restore is undoubtedly one of the best products I've seen.

I've seen, and used, other vinyl cleaning systems ranging from expensive scrubbing contraptions, to the old 'hand me down' methods of cleaning using off the shelf substances. I can safely say that due to the nature of how those products work there is a certain level of degradation or damage to the original media after the cleaning has taken place. This is caused by the type of chemical substances used where residues linger on the surface of the vinyl which may lead to breakdown of the vinyl over time. Or it can happen by the mechanical removal of so-called "crud" using a manual cleaning method.

While "crud" can certainly be removed by these methods, so can vital high frequency information that gives us the true analog listening experience. To understand this, it's important to understand how a record works.

How it works is simple. It's similar to the now discredited 'wood glue' method, by spreading Record Restore on the surface of the vinyl, and lifting off the remnants. However, it does this with the utmost consideration to the physics of a vinyl record, and without leaving any chemical residue behind, or without causing any damage to the original media. In fact, Stephen at Secret Chord Analogue has quantified that not only does it remove decades of particles, tar from cigarette smoke, "diamond dust" left from the breakdown of the record stylus, but with multiple cleanings it can remove even the original moulding residue left from the manufacturing process.

In the spirit of preservation, we need to be absolutely sure that the product that is entrusted to clean and preserve our audio isn't damaging the original media.

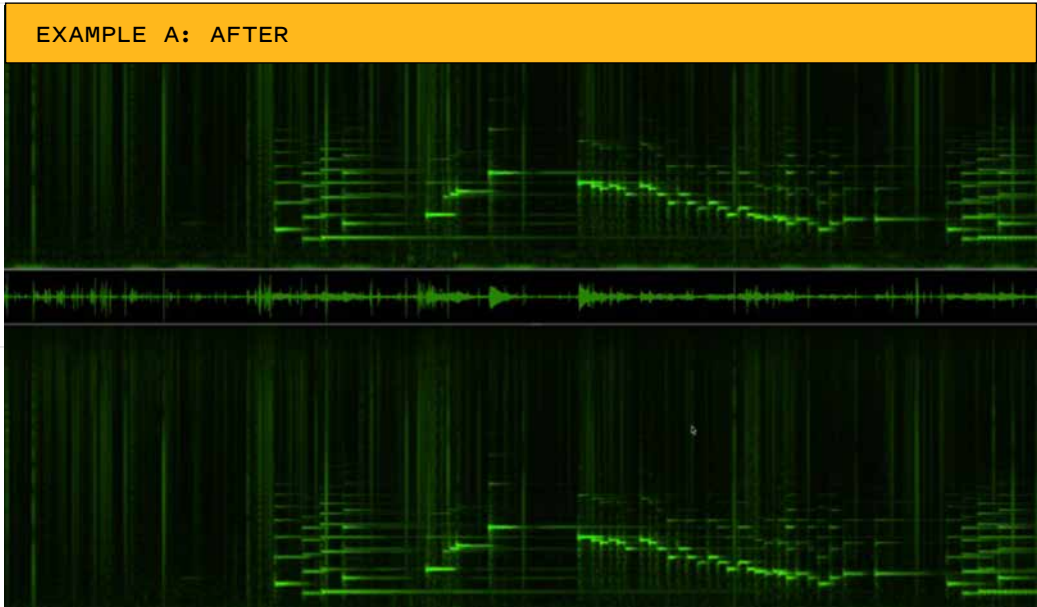


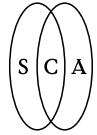
Here are some of the audio files to show the before, and after. But how can we hear ONLY the ‘crud’ that Record Restore so elegantly removes? That’s where I come in, and it was much more challenging than

I originally anticipated. The Record Restore cleaning process was affecting some things that I hadn’t previously thought of which essentially effects how I’m able to extract this information from the recordings.

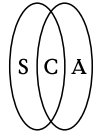
Here we have Example A which is a simple A/B test before and after being cleaned by Record Restore. What you are seeing is a spectral analysis of the audio. The brighter colors reflect the intensity of the sound.

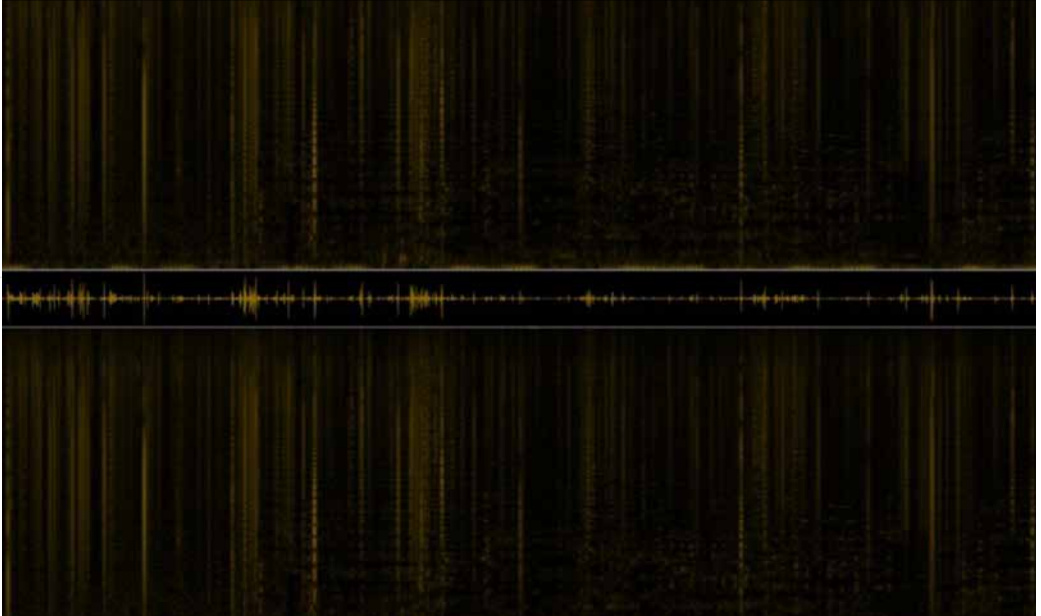
We can see the original piano notes, but also the “crud” that is getting removed.





<p>In this visual example it is fascinating to note a few things that you may not hear on your first listen, but can clearly see. There are no “pits” or holes left over in the audio data where the ‘crud’ was removed. All of the musical information is retained, even in the upper harmonics. This means that there is no destruction of even the most sensitive parts of the vinyl. You can also see that the musical material looks brighter and stronger after cleaning. So the original musical material that you weren’t hearing before has resurfaced. This comes</p>			<p>So you can hear how much ‘crud’ we’re actually lifting off the surface with the Record Restore product, with no musical remnants!</p>
<p>from the stylus being able to sit deeper in the groove and become more reactive to the grooves. You will also see at the beginning of the notes there is much more intensity vertically. This results in the restoration of audio transients and dynamic range. This will give you a deeper sense of accuracy and realism. In the cleaned version, you can clearly hear the hammer of the piano striking the note, which is difficult to hear in the dirty version.</p>		<p>Previously, I touched on a few things that made this result difficult to achieve. In the digital audio world, we rely heavily on material that is exact in the time and frequency domain. When working with analog media like tapes or vinyl, time and frequency are affected by playback speed. Old media is often troubled by what we call ‘wow and flutter’. As the playback speed fluctuates, the speed and pitch of the media change. While this data is certainly quantifiable, it would take thousands of dollars of equipment and software to even come up with a simple percentage of improvement, at least in the digital domain. In the analog domain,</p>	<p>we rely on counters and strobes to do the work for us. So without a vinyl test medium, and the proper hardware and software, it would be virtually impossible to figure out the exact numbers.</p>
<p>Example B is where I came in to do the spectral differencing. This time, we can see ONLY the crud that has been removed. This is not just as simple as removing musical data, because we still needed to get the difference of the noise. To achieve this, I needed to take a spectral difference of the dirty vs cleaned example, which separates the natural noise in the recording from the noise created by the ‘crud’. Once I had that, I needed to extrapolate the noise and remove any musical artifacting left over as the result of an interesting unforeseen phenomenon that I will describe later. What we are left with is just the pure noise that the Record Restore system removes from the recording.</p>			<p>Luckily I was able to visualize the effects of these wow and utter improvements down to the millisecond using my specialized software. Piano notes had certain levels of “vibrato” which were completely removed. What I found was that some of the ‘crud’ on the recording, actually slowed down the playback speed, lowered the pitch, and sometimes caused the stylus to skip. We’re not talking about the obvious skips though, we’re in milliseconds territory. When this happens, your stylus can break down over time, creating “diamond dust” that also sits in the grooves of your beloved vinyl. The turntable motor wears faster, and in our case where a direct drive turntable was used, can cause the stylus to get caught on this crud and allow the vinyl to skid on the platter. This eventually leads to a mechanical breakdown of the vinyl over time, which cannot be restored.</p>
<p>→ Fig.1</p>			



<p>In the end, I averaged the amount of noise over time, and took percentages of each recording. We ended up with an 11db increase in overall signal to noise ratio, which is around a 75% improvement in how it sounds to the logarithmic way that humans hear sound, and an 8db improvement to the peak noise floor, which is over 50%.</p> <p>I stand behind my measurements and say with confidence that Record Restore is a superior product that I would put my stamp of approval on, and entrust my entire vinyl collection to for years to come. While we can't reverse the effects of aging, we can certainly control them, and Secret Chord Analogue's Record Restore is the only way I'd recommend to any audiophile.</p>		<p>“I stand behind my measurements and say with confidence that Record Restore is a superior product that I would put my stamp of approval on...”</p>	
		<p>Dave Askew 15.03.2018</p>	
<p>→ Fig.1</p>	<p>EXAMPLE B: ISOLATED NOISE</p> 		

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music you love.

Secret Chord
Analogue®

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