The Making of Beck's Edison Bottle

Having seen footage of hard drive actuator arm play music when connected to amplifier convinced us we could invert the process and use the actuator as the cutter head once we mounted an appropriate cutting tip.
Effectively reverse engineering from the digital realm to create an analogue result.

Other factors in that influenced our approach having spoken with other cutters and scouring the web included:
Cutting a mono recording, this allows for higher output levels with less chance of the stylus skipping in the deeper frequencies.
Coating the bottle and all our test platters and cylinders with nitro-cellulose paint as has been the industry standard since the 1940's, rather than cutting directly into a solid substrate.

Utilising a small engineering lathe we retro fitted a speed controller that precisely locked the the rotational and tracking speeds of the cutting arm
Cutting head and arm:
We stripped 8 hard drives down the ascertain the most appropriate actuator for our application.

The arm from 4"drive as opposed to 2.5" drive allows more current resulting in greater amplitude this equals higher volume.

We built three versions of cutting head gaining improvements at every step.

A Google search revealed a patent listing that confirmed the problem of an audio dropout at around 8khz due to harmonic resonance introduced by the mechanical clamping of the tiny bearing between the arm and drive housing.
We eliminated the bearing all together, replacing it with a machined piece of flat aluminium clamped to the head between thin rubber shims.

The Cutting tool
Initially following advice we used a standard stylus as used on 78rpm recordings, being three times bigger than the later microgroove keeping the engineering out of the truly microscopic realm.
But were not getting a good retrieval of the upper frequencies, so we opted to use a microgroove cut. This also gave us a little over 3 mins of audio onto the bottle rather than less under 2 minutes a standard groove.
Also the downforce is much less resulting in less heat input to the cutting tip and less current required, the coils on the head were smoking in some tests!

We ground a high-speed steel cutting tool which we polished to mirror finish resulting in a very quiet cut, all this taking place under a microscope!
We also have a couple of sapphire tips which we used for some test cuts but we found the steel one are quieter but with a much shorter life, in fact any contaminants in the coating would take a microscopic chunk out of the tip effectively destroying it!

Heating the tip by winding hair-thin NiChrome wire and passing a current through it resulted in a smoother cut, requiring less downforce and reduced surface noise as it helps it glide through the surface without tearing the substrate.

Every time the downforce, cutting speed or heat adjustments were made recalibration and equalization of the audio was required, many days were spent resolving this.

Surface Substrates and Coatings

Initially we cut onto polycarbonate and acrylic to test the feasibility of using a hard drive actuator this proved the principle but a lot of surface noise was present.
We spent the first few weeks of test cuts onto acrylic platters coated in Nitro-cellulose mounted on a high torque custom built turntable.

Clear nitrocellulose was successful once a the correct amount of castor oil was established, again through trial and error. We continued with this formula though out the remainder of the project.

Sound Engineering

Using Garageband we applied the RIAA equalisation curve, a filter that reduces the low frequencies and increases high frequencies this is reversed by the phono input in playback through the amplifier.
Further equalisation was needed to cancel out resonances and harmonics introduced by the cutting head and arm.
Tone Sweeps of 50hz>5000khz used for the test cuts allowing us to adjust the equalization throughout the frequency range.

We cut scores of tracks in the quest for the greatest dynamic range and least amount of surface noise, monitoring through 15" Tannoy Moniter Gold speakers.

Cutting the Groove

Many of the above developments gave us incremental improvements to upper frequency ranges, but we achieved a big improvement by recording at a quarter speed, and subsequently 1/8 speed. This way the cutter head didn't need to achieve these high frequencies in real time in order to cut them onto the record.
Consequently the cutting time for the track was a very tense 26 minutes.

Using small tube mounted close to the cutter vacuumed away the swarf as it peeled off the surface, should it come in contact with the hot cutting tip it would instantly bake on.

To control the actuator's movements, damping was attempted with various materials, a more powerful spring was able to temper the actuator's large movements without reducing fast ones. This introduced resonances and harmonics which were removed prior to recording by software equalization.
We experimented with damping he cutting head initially with blue tack (as Gum was used in the middle of the last century), we then mounted a silicone oil filled trough to the arm with a paddle attached to the head and later to the arm itself, this being easily tuneable by adjusting the size of the paddle and viscosity of the silicone.
Adding up to a kilo of ballast to the cutting arm made further improvements.

We also mounted a cartridge to the end of the cutting tip to moniter the audio as was cut real time, also allowing us to compare the difference quality between the cutter and the resulting groove when played back.

Each cut was scrutinised under a microscope to inspect the smoothness and profile of the groove, and to check the cutting tip for damage.

The Player

Once we had the final bottle with it's audio track cut into the surface coating we designed and constructed a player from black acrylic sheet laser cut from a file drawn up in the 3D.

Much of what we learned through the build of the cutter we applied to the player. Special attention was made to eliminate any unwanted noise being introduced by motor noise, bearings and resonances from the tone arm and casing of the player itself.

The Edison Bottle made its public debut at SemiPermanent in Auckland in May to a standing ovation from the assembled media and design community.

Great cutting resource: The Secret Society of Lathe Trolls http://www.lathetrolls.net

Links:
http://shinelimited.co.nz/work/the-becks-edison-bottle
https://vimeo.com/68007497
世界初、音楽が再生できるビール瓶「Edison Bottle（エジソンボトル）」ーエジソンの蓄音機の原理を応用 ー えん食べ

Credits to:
Andrew Turney, Rob Askew & Tom Beeston - Gyro Constructivists
John Baker - Real Groovy
Peter King - Lathe Cut Records
Fred Koke - Retrotronics Auckland
Brian Harris and Chris Davison
Robert Stebbing - Stebbings Recording Centre