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Real High Fidelity.

Turntable “Brinkmann Oasis” — a white paper

History

Sometime in 2005 we decided to complement the “Brinkmann Balance“ and “LaGrange“ turntables with a third model. The new turntable was to be a less expensive, while still living up to the Brinkmann reputation in terms of sound quality. In order to create a true alternative, the new model was to differentiate itself from our existing line-up by means of a plinth and thus look more like a traditional turntable.

We were well aware of the consequences our decision would have when we decided to design a turntable with plinth which was to be sold at a lower price point. We knew that although we would be able to benefit from our vast experience in building state of the art mass loaded turntables, very little (if any) of the actual parts used in the “Balance” and “LaGrange” would actually transfer over to the new family member.

This gave us the benefit of being able to start the design with a clean sheet of paper so to speak.

Purpose

The fundamental principal behind a turntable is to spin a record at a specified speed so that the groove’s modulation may be traced mechanically. Two major sources of sound degradation can be deduced from the facts that the modulations are microscopically small and that the stylus cannot differentiate good from bad modulations:

a) Vibrations and resonances of any kind

b) Any deviation from a specified rotational speed

The design requisites for a turntable are thus:

- As precise and constant as possible rotational speed of the platter
- Minimal bearing friction for the highest possible running smoothness
- High degree of immunity against any external disturbances such as vibrations, sound waves or hum
- Quick absorption and dissipation of unwanted resonances resulting from mechanical tracing

Let us examine the various components of a turntable (drive mechanism, bearing, platter and chassis) more closely and in concrete terms.

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1. Drive mechanism

The drive mechanism is probably a turntable's single most important component. This significance results from the fact that music consists of sounds organized in time. A turntable therefore has to play back a record at precisely the same speed at which it was cut, normally 33 1/3 or 45 rpm. Any deviation, no matter how small, from the correct speed will ultimately change pitch and tempo and result in music reproduction that is not true to the recording.

Our hearing is much more sensitive to short term speed variations, as opposed to long term ones. The onomatopoetic term wow & flutter correctly identifies the underlying issues— wow describes continued, longer lasting deviations, caused for example by eccentric records, whilst flutter denotes short-term irregularities best demonstrated by piano tones that fade away with a slightly howling quality.

Let us consider the following example: a 1 kHz tone (1000 cycles per second) is cut into a lacquer at precisely 33 1/3 revolutions per minute. If the pitch is to be accurate, the turntable has to play back this tone at exactly the same 33 1/3 revolutions per minute. A seemingly insignificant variation of 1% would result in a playback speed of either 33 or 33@d revolutions per minute with pitch being off by ±10 cycles. Even people with perfect pitch would have a hard time correctly identifying a 990, 1000 or 1010 Hz tone without a reference—yet even "brass ears" would easily hear the differences in a direct comparison.

Speed precision is perhaps even more important for the music's tempo. For our perception of music to be real, the tempo—timing and pace—is more crucial than the pitch. This is where the 1% difference would make itself heard far more easily. Considering that a typical record has a playing time of around 20 minutes per side, a ±1% difference would amount to no less than 24 seconds. This seemingly irrelevant deviation would result in either a slightly restrained and darker sound, or a livelier, brighter reproduction of the original event.

In order to meet the claims of High Fidelity—no more, no less than music reproduction true to the original—the cutting and playback speed have to be absolutely identical. Due to reasons being outlined in the following pages, this theoretical ideal is practically not feasible—turntables are hence (and in the best case) the closest possible approximation to the theoretical optimum.

1.1 Drive mechanisms

The turntable's platter can be driven by various means: hydro-dynamically, pneumatically, by spring power or through electric motors of various kinds, just to name a few. As a rule, manufacturers mostly rely on electric motors; further, most manufacturers (sadly) content themselves with cheap and inexpensive cookie-cutter motors, none of which were created with vinyl playback in mind.

Electric motors have become the de facto norm for vinyl playback as they offer plenty of positive attributes and only a few negative ones, among these cogging and their high speed level.

1.1.1 Cogging

The basic operating principle of all electric motors is the same, no matter weather they are driven by single or multi-phase AC or DC: current flows through concentric stationary coils of wire (stator) and creates a magnetic field which again acts upon magnets attached concentrically to the motor's axis. Since equal magnetic poles repel each other and opposite poles attract one another, the rotor begins to revolve inside the stator's magnetic field. Herein lays the fundamental downfall of the electric motor: cogging.

The cause of cogging is the fact that the fields of a permanent magnet are not uniform, but strongest on the two ends and weakest in the centre. This causes the motor's torque to fluctuate; hence the actual speed of the rotation oscillates around the motor's nominal speed. Upon closer inspection, very short phases of acceleration alternate with equally short phases of braking. The frequencies and intensities of these irregularities increase with the number of poles.

Cogging is intrinsic to all electric motors. Design features such as diagonally opposed poles or overlapping poles can reduce, but not completely eliminate, the effect of cogging.

1.1.2 Rotation speed

Two elements determine the rotational speed of an AC based electric motor: the power line frequency and the number of magnetic poles. The formula used to describe this is as follows: rotational speed = line frequency x 120/number of magnetic poles. In countries with a 60 Hz power grid, a two-pole electric motor therefore runs at 3600 rpm (60 x 120/2 = 3600). Each doubling of magnetic poles cuts the rotational speed in half: 4 poles equal 1800 rpm; 8 equal 900 rpm; 16 equal 450 rpm. Theoretically this could be continued even further, however, practically, there are only so many poles one can fit inside a motor case. Further, each additional pole also increases the motor's torque, which in turn increases the cogging effect. DC electric motors don't fare any better either and most are offered in standard 1500 rpm configurations.

This showcases the ensuing problem quite easily: on one hand we have an electric motor spinning at 1500 rpm, on the other we have a platter which has to spin at 33 1/3 rpm. The ratio of motor to platter speed is therefore 45:1. Logic dictates that the drive pulley has to be 45 times smaller than the platter. If we take a platter diameter of 30 cm as an example, this would equate to a pulley of only 6.6 mm in diameter. The contact area for a belt is therefore very small, which in turn increases slippage; which in turn influences speed stability negatively. The problem is further exacerbated by the fact that the cogging is transformed into a frequency range in which human hearing is very sensitive (more about this later).

The power line frequency (and thus the motor's rotational speed) can be reduced with frequency converters; however, the cogging problem still persists.

1.2 Power transmission to the platter

The platter of a turntable can either be driven directly or indirectly. In case of an indirect drive mechanism, platter and motor are two separate components whereby the power from the motor is transferred to the platter through intermediary means. In case of a direct drive turntable, platter and motor are assembled into one and the same unit.

1.2.1 Non-direct drive

Motor and platter are two separate entities; some sort of medium is necessary to couple the motor to the platter. Typical applications include the following:

> Belt (round or flat; geared or v-belt type; various threads made of synthetic or natural fibers)

> Idler wheel

> Gear wheel drive

The choice of transfer medium is critical since it not only transmits the motor's torque to the platter but also all motor-based interferences, among them the motor's cogging, which compromises speed stability since the platter is not driven continuously but somewhat jerkily instead. The more direct the connection between platter and drive, the more directly these interferences will be transferred. An idler wheel for example couples the motor very directly to the platter. As a result, the cogging effects are more pronounced; in the best case they manifest themselves as a slight flurryness of the sound; in the worst case through clearly audible distortions.

Because of the reasons stated above, most turntable designers therefore prefer a softer coupling between the motor and platter by means of (more or less elastic) drive belts. Unfortunately, no rose is without it's thorns: belts made from rubber, sorbothane or other similar soft materials are in fact elastic enough to dampen some of these interferences with long intervals. But the shorter the intervals of the mentioned jerks (i.e. cogging), the less they will be absorbed by the belt. Cogging from motors with a minimum of 375 rpm turns to high-frequency pulse spikes, which are small in amplitude but high in frequency; these irregularities will not—or only marginally—be filtered by the belt.

Another problem inherent with the functional principle of belt driven turntables is the awkward ratio between the diameters of the motor pulley and the platter. Even tiny discrepancies in the belt's uniformity will have a serious impact on the platter's speed stability. Consider the following example: say a DC motor running at 1500 rpm drives a 20 cm sub-platter via a 1 mm thick flat belt. A discrepancy in tolerance of only 1/100 mm will have a net effect of 0.9% wow & flutter on the platter!

Countering these effects demands substantial efforts in the design of a belt driven turntable. Heavy platters (12 kg or more) and low rpm motors tend to mitigate these side effects to the point of not being significantly audible.

1.2.2 Direct Drive

Studios (radio stations in particular) demand quick start-up times – turntables typically have to reach their correct speed within half a revolution. For LPs this means 0-33 1/3 rpm within 0.9 seconds. Such acceleration figures can only be achieved through use of high-torque motors and correspondingly tight coupling between the drive and platter. It isn't a surprise then that for decades idler wheel drive designs were the de facto standard in studio applications.

But idler wheel turntables also had seriously high maintenance costs in order to be up and running 24/7 and to avoid rumble and other sound degrading issues caused by worn out idler wheels to affect the sound negatively. Thus out of necessity, in the late 1960s manufacturers of studio turntables began to look for low(er) cost maintenance alternatives. They came up with direct drive, whereby the platter was placed directly on the motor's shaft, ie the stator was mounted around the bushing and the shaft was used as the rotor and voila, the goal was achieved; at least in theory.

But start-up times of less than 1 second necessitated high torque motors, which designers achieved by using motors with 32 and more poles. The penalty they paid were heavy cogging effects accompanied by high wow & flutter numbers. The cure was found in quartz locked motors and phase locked regulators; which corrected for any deviations from their preset with an iron fist.

On paper at least, these "corrected" direct drive turntables boasted hitherto unimaginable low wow & flutter numbers down to 0,001%. But the rigorous iron fist regulation prevented the platter from spinning smoothly; instead, the regulation caused the platter to oscillate continuously between speeding up and slowing down. These start/stop motions translated into an unpleasantly rough and hard sound; odd as wow & flutter numbers in the 0,001% range are deemed inaudible.

Once the direct drive technology had gained a foothold in pro audio applications, the benefits of mass production (ie. trickle down effect) made sure that very soon even $100 turntables were equipped with direct drive and advertised as having less than 0.01% wow & flutter. This is precisely where direct drive got its bad rap sheet.

Under closer scrutiny however, this assumption were based on some misunderstandings. For one, in home audio application use, turntables are not really required to reach 33 1/3 rpm in less than a second, thus 32 pole motors and phase locked regulators are not really necessary either.

Finally, one more relatively unknown factoid: while it is common knowledge that direct drive turntables became popular in the late 1960's, their actual invention dates back to a small Swiss manufacturer in 1929. The name? Thorens, who enjoyed and even today is looked upon with great respect for their idler wheel and belt driven classics.

2. Bearing

To be perfectly correct, the term bearing should actually be used in plural terms: bearings; after all, each indirectly driven turntable has at least two bearings: one for the motor's shaft, and one for the platter. Both bearings are the potential source of a number of interferences and noise, which can compromise the sound quality (the same of course also goes for the tonearm bearings, but that's a discussion for another day).

Dealing with bearings, the designer is faced with a paradox dilemma: the ideal bearing would have zero play *and* zero friction. In reality however one can not have the cake and it eat, because friction increases as play is reduced—and vice versa, play increases when friction is reduced. In other words: it is impossible to build a bearing completely void of play and friction.

Further, the platter's and the motor's shafts need to run perfectly true – therein lies another problem: the heavier the platter, the more imperative is the quest for a bearing design free of wobble, thus the more difficult it is to fulfill this crucial design element.

Additionally, the coupling medium itself (belt-drive or idler wheel) exerts a unilateral load on pulley and platter. In order to run the shaft of motor and platter true despite this one-sided load, the bearing play needs to be kept at a minimum, which again translates into high precision manufacturing (run perfectly true, minimal imbalance, optimal surface treatment) and correspondingly high manufacturing costs.

As previously discussed, decreasing the bearing's play results in an increased amount of friction. This bears the risk of rupturing the thin oil film which ideally builds up between the shaft and bushing and thus avoids mechanical contact between the two metals. Losing this oil film results in metal to metal contact, thus increased friction and the advent of a phenomenon called "Stick-Slip Effect" whereby the otherwise smooth spinning bearing is suddenly subject to braking effects, resulting in overall rougher sound.

Conversely, a direct drive turntable eliminates this unilateral load on the platter's bearing since the concentric configuration of the rotor and stator is self-aligning. In other words, the designer of a direct drive turntable is setup for far less headaches overall.

3. <u>The platter</u>

The record platter carries two main functions in a turntable: first, the weight of the platter influences wow & flutter – the heavier the platter, the bigger the flywheel-effect, and the better it is apt at resolving minute speed fluctuations of the motor and bearing; although here too, you quickly run into other issues, ie. a heavy platter brings higher demands on the bearing quality, etc. Second, the material and surface choice for the platter should be such that it quickly absorbs and deflects any resonances occurring from the transfer of acoustic energy from the record's groove to the cantilever. In terms of manufacturing, the platter should run as true as possible; additionally a precisely balanced platter (statically and dynamically) yields far superior speed stability overall.

4. <u>The chassis</u>

Unlike the bearing or motor, the chassis has no effect on the overall speed stability of the turntable. It does however impact the overall sound quality since the chassis acts as the main connector and bridge between the tonearm and platter. Resonance control and vibration absorption are therefore key elements in chassis design. On one hand the chassis has to render innocuous the resonances, which result from the mechanical tracing and travel through vinyl, and the cartridge/tonearm assembly; on the other hand, the chassis has to prevent any (airborne or mechanical) vibrations from reaching the platter and tonearm, which would compromise playback quality.

To answer these problems, two principal designs have evolved over the years: mass loaded turntables are built around the idea that a more massive overall design yields superior resonance control; whereas spring-loaded sub-chassis designs are supposed to absorb and deflect resonances through carefully setup and optimized spring suspension systems.

Here again, we find that there are pros and cons to each design choice. Typically, a mass-loaded design is costlier to manufacture, whereas a suspended sub-chassis design asks for stringent resonance control of its own spring system: you don't want the chassis' own resonances to affect the rest of the system!

Conclusion

Integrating the motor into the platter bearing eliminates several sources of interference. For example, the bearing of a separate motor; also, since the coupling medium has been eliminated, no noise or other interferences are being transferred to the platter. Further, as the single-sided pull on the bearing has also been eliminated, the oil film is more uniform therefore increasing speed stability.

Cogging is further reduced since a smaller motor drives a substantially larger platter without the need for any sort of gear reduction in place. Also, since the motor's rotational speed is slower, the cogging frequency is further reduced, moving it into the inaudible band of human hearing.

In short, direct drive turntables aren't as bad as their reputation precedes them. If the design emphasis is on overall drive smoothness instead of short run-up times, the benefits actually outweigh their negatives.

We therefore decided to utilize a direct drive concept for our new turntable.

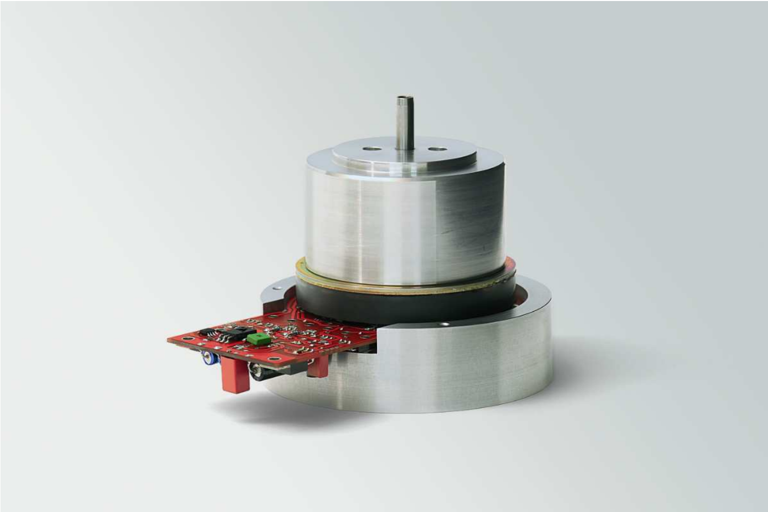
The realization

The following paragraphs will demonstrate how we utilized the various discussed techniques in designing our new "Oasis" turntable.

1. <u>The drive mechanism</u>

Having decided to utilize a direct-drive mechanism for our new turntable, we began searching for the appropriate motor. Sadly (or luckily, as it should later prove) and despite much effort we were unable to find a motor that was up to our stringent quality requirements. We therefore decided to design and build the motor in-house—which had the nice side effect that we did not have to cut any corners and instead were in the fortunate position of defining all relevant parameters ourselves.

The motor's stator consists of four specially designed field coils, which are mounted concentrically with high precision around the platter bearing. Based on listening and tuning sessions, we decided to forgo the typical 90-degree mounting angle in favour of a non-standard 22.5-degree raster, which, due to the magnetic fields overlapping, further reduced cogging. The motor's rotor also acts as the sub-platter and carries a magnetic ring with 8 poles on its underside.



The drive mechanism, based around Hall sensors and an encoder disk, is designed in such a way that there is just enough power to bring the 10 kg heavy platter up to 33 ! e rpm in about 12 seconds. Conversely, only a minimal amount of energy is actually necessary to keep the rotational speed at a constant. While the drive mechanism is indeed direct, power is actually transferred without any contact. This soft coupling via a low power magnetic field translates into a silent drive, which reduces cogging further. One of the main attributes behind the sound quality of the "Oasis" has to do with our proprietary motor control. It works proportionally, i.e. it transfers just enough energy to the motor for it to remain at constant speed. Conversely, due to our ultra low-friction bearing, only a small amount of energy is actually necessary to keep the motor at constant speed. Previously available regulators typically work disproportional and rather abruptly: they speed up *and* slow down the motor very rapidly when necessary.

During the development phase of the "Oasis" turntable, we spent many long hours auditioning several different regulator designs; it became quite evident that utilizing our concept of proportional regulation always resulted in better sound: typical "harder" motor control concepts produced a sound significantly lower in quality, with less color and drive.

2. <u>The bearing</u>

The design of the "Oasis" bearing proved far simpler: after all, we were able to utilize our long-term knowledge gained from designing our "LaGrange" and "Balance" bearings. "Oasis" uses our silent and maintenance free hydrodynamic bearing; the shaft (with carefully controlled play) rotates in an oil bath on a synthetic thrust plate, which is the only mechanical contact point between the platter and chassis. Our long-term experience shows us that this bearing is undisputed in precision and longevity.

3. <u>The platter</u>

The "Oasis" platter utilizes the same tried and true resonance optimized aluminum alloy material with an embedded crystal glass top layer, just like our "LaGrange" and "Balance" non-direct drive turntables.

The platter's height has been carefully chosen as being optimized for resonance control through extensive listening auditions and mathematical calculations.

In order to transfer the energy inherent in tracing a record's grooves through the platter more efficiently, the record itself is tightly coupled to the crystal glass platter top. This is done via a washer, which raises the record by about 1 mm (1/25") over the platter. A screw-down clamp securely fastens the record onto the platter, which also eliminates any potential for slippage.

4. The chassis

The “Oasis” chassis consists of a metal plate in which both the tonearm base as well as the drive/platter assembly is integrated. It is not necessary (and makes no sense) to decouple either, since the motor doesn’t transfer any vibrations to the chassis and the coupling to the platter is magnetic. Fundamentally, this integration allows for zero movement between the platter and cantilever, further refining the overall sonic qualities. In order to further minimize any tracing resonances, the chassis is CNC machined from a solid block of 12 mm (1/2") thick hard aluminum with rounded corners (which typically store the highest resonance energy) in varying radii.

To further minimize airborne and other occurring resonances, the chassis and wood frame are not coupled to one another. The result is that resonances are damped even more before coming into contact with the chassis.

Three height adjustable spikes mounted in the bottom of the chassis transfer the remaining resonant energy quickly and efficiently to the platform of your choice. You can choose to mount the “Oasis” turntable with all three spikes countersunk flat on your surface, or fully extended. Regardless of your choice, the turntable will always be properly coupled to the appropriate surface.

With a properly matched tonearm / cartridge combination, the “Brinkmann Oasis” turntable will reproduce LPs true to their wide band nature. Music playback will be neutral in the strictest sense – just as the music was recorded.

Attributes and technical specifications

Drive: Platter driven directly by rotating magnetic field; soft proportional control

Power supply: External power supply in solid state technology

Bearing: Lubricated hydrodynamic precision bearing, quiet and maintenance-free

Platter: Resonance-optimized special aluminum alloy; surface-ground crystal glass inset; threaded record clamp

Chassis: 12 mm hard aluminum with resonance-optimized geometry; controlled shunting of resonances with 3 threaded spikes

Armbase: Movable (rotating) without play for simple and precise tonearm adjustment, with quick release. Accepts all tonearms between 9 and 10.5" as well as several linear tracking tonearms

Connectors: RCA, XLR or feed-through for tonearms with 5-pin DIN connectors; DIN connector (3 pin) for umbilical cord of external power supply; 2 mm connector for ground wire

RPM: 33 1/3 and 45, selectable by push-buttons; LED indicator for chosen speed (33 1/3 = green, 45 = red)

Deviation from nominal speed: 0,0% (adjustable)

Fine adjustment of speed: ± 10% with trimpot

Wow & flutter: 0,07% linear, 0,035% weighted DIN 45507

Run-up time: 12 / 16 seconds (33 1/3 / 45 rpm)

Rumble (noise): -64 dB (test record DIN 45544); -68 dB (measuring adapter)

Dimensions: 520 x 398 x 100 mm ***(w x d x h):***

Weight: Total 27,3 kg (Chassis 17,5 kg, Platter 9,8 kg); Power Supply 2 kg

Plinth: Maple or cherry (others on request)

Accessories: Tube power supply “RöNt” (available in 2009), additional armbases, acrylic dust cover (Europe only)