

# DIAMONDS AREN'T FOREVER

**Play vinyl records with no stylus,  
no wear, and the convenience of  
CD: the Finial Laser Turntable.**

**Part One of a two-stage review . . .**

*by Ken Kessler*

Not vinyl 'whoosh', not rumble. That low-level noise in the background is my sigh of relief. Aside from waiting for my insurance policies to mature and my mortgage payments to cease, the pursuit of the Finial Laser Turntable has been one of the longest projects in which I've been involved. Half a decade chasing a review sample . . . but it's been worth it.

One of the vinyl record collector's dreams has come true. The Finial addresses almost every past and current concern, even allowing the venerable LP to emulate all but one of the practical, non-sonic virtues of the very format which looks set to kill it.

Finial's was not the first attempt at creating a no-contact method for reading information designed for mechanical replay. A player which used light beams or jets of air instead of a stylus was mooted over a century ago by Alexander Graham Bell. The Japanese made more than one attempt and Finial's own AES paper (Stoddard & Stark 4 November 1988) cited one Japanese and seven US patents dating from as far back as 1929.

That none of these worked well enough to survive commercially explains the scepticism which greeted the Finial.

In January 1989, at the Las Vegas CES, it was announced to the press that the Finial

was dead. The excuses were legion, primarily the escalating costs which would have priced the Finial in the stratospheric regions occupied by high-end products like the Wilson WAMM, the Infinity IRS V or the Goldmund Reference turntable. I felt cheated, disappointed and disgusted.

Then, to everyone's surprise, the Finial was at the Tokyo Audio Fair in October 1989. The involvement of Japanese backers and their eagerness to get it working meant revised computer software within the player, the promise of an actual production schedule and a sense that, at last, it might actually happen. And to Finial's surprise, over 300 firm orders were placed at the show. . . .

Looking very much like a CD-V player, the Finial has styling which already appears dated, 'mid-'80s' so to speak. Measuring 475x479x159mm (wdh), it's biggish, but it only seems to dwarf conventional players in the fore-and-aft. But it is sleek, and there's no lid to create a need for shelf height, although you mustn't stack anything on it because it generates a lot of heat. Aesthetically, then, the Finial is understated and its appearance doesn't really imply that within lurks the most complex LP-spinner ever devised. Neither does it look like £21,000 plus VAT, if there is a way of looking like a price tag.

Whoever designed the control panel could have done with a course in lateral thinking. Smart though the sloped acrylic fascia may be, it also happens to surround the undersized – too undersized – controls and it collects fingerprints with the rapidity of the FBI.

Left to right, the tiny press-buttons offer power-on (from stand-by), drawer open/close, pause and play. A second cluster, with logos familiar to CD users, provide track skip in either direction, audible cueing in either direction, and a control which differs from the silent pause (next to the play button) because it locks the laser to a single 'groove', or more accurately, a single turn. Further buttons allow the user to select time-read-out for either the whole side of the LP or the track being played (at any point, you can call up total time, elapsed time or remaining time) and to choose between 33½ and 45rpm (the machine defaults to 33½), or to vary the speed from 30 to 50rpm. The last trio of buttons accepts a variety of commands, including track programming, A-B block repeat, noise reduction cancellation and other custom features.

Above the buttons are two LCD display windows. On the left is the graphic display to show the position of the laser on the disc. A bar, representing the length of the record side, lights up full-length at the beginning of play, extinguishing itself in small blocks as the record is played. A series of 'bumps' indicates track spaces, while a cursor above the line shows the laser position within a block. The display also gives visual confirmation of track

selection if the user has programmed the Finial to skip certain tracks.

At the back are the phono-sockets for connection to a line-level amplifier input: the Finial has onboard RIAA equalization and gives a 1V output. The main on/off switch at the rear cuts all power to the player, whereas the front panel button only powers-up from standby mode. The Finial comes with a calibration LP which takes about 20 minutes to play: this only has to be used when the Finial is switched on from cold.

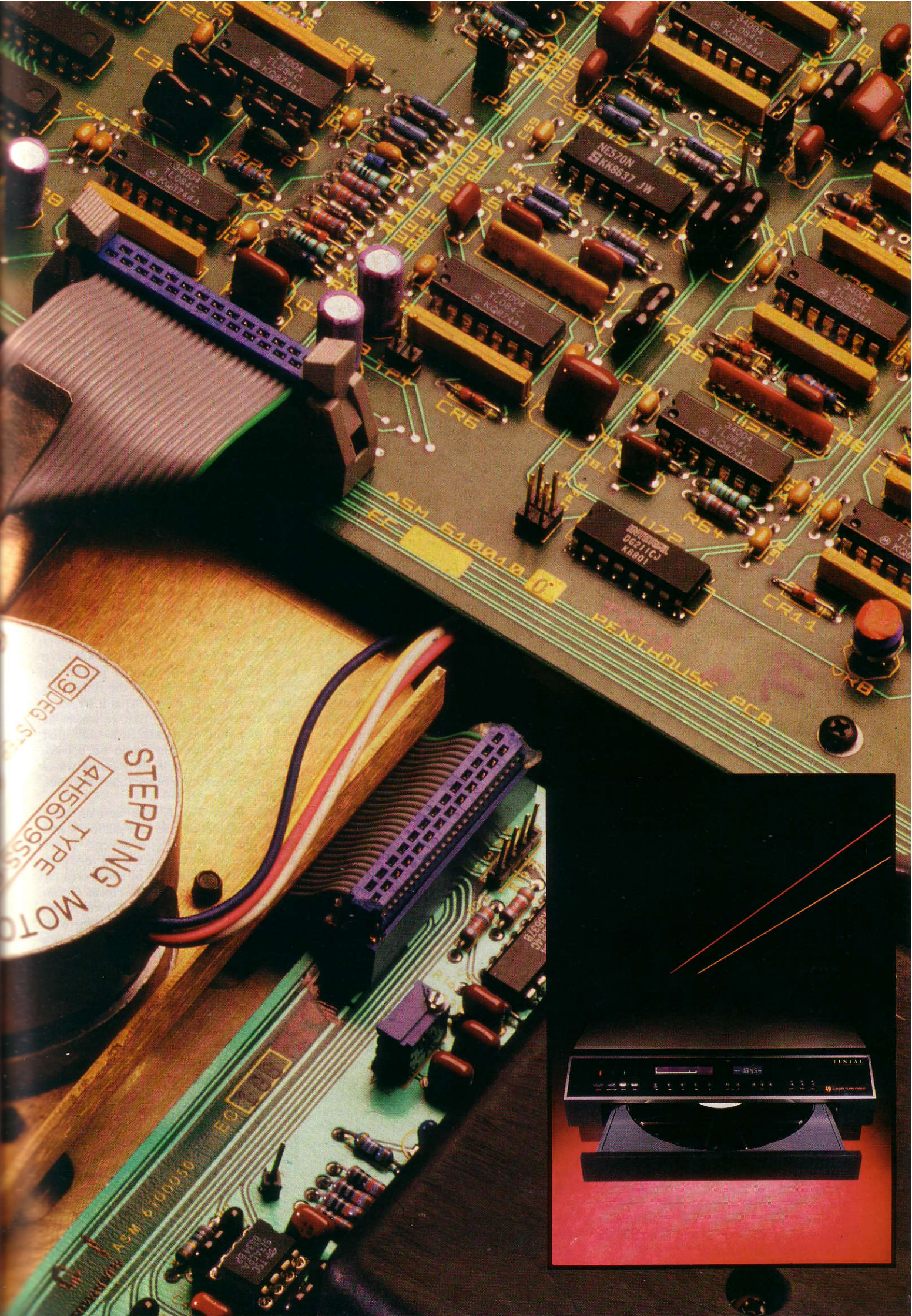
Installation procedure is as for a CD player, including the removal of the transit screw which locks the delicate innards in place. The Finial must be placed on a solid, level surface, but it's far less critical of the 'tuning' of its supporting furniture than a conventional record player. The 18.4kg player rests on springy feet, but even these aren't really necessary, if you're worried about heavy-footed friends. The kind of physical shock needed to make this player skip would involve a fist, not a finger tap.

Press the 'open' button and out slides a tray like that on a CD-V player with 12in disc capability. Here's where the only assembly occurs. You place the lightweight aluminium platter into the 12in opening, a circular groove on the underside locating it over four rubber pegs. The platter is fitted with a mat said to be conductive, protective and vibration-absorptive. This is the first indication that you're dealing with a player which breaks the rules, because it shows that the turntable portion of the Finial only has to do one thing: rotate at the correct speed. Mechanical earthing, silent bearings and the like do not enter the equation.

The Finial's complexity lies in the laser section, or what is equivalent to the arm and cartridge. The technical aspects are covered by MC in the report which follows this, but a full description fills the aforementioned 14-page AES paper reprint called 'The Optical Turntable, Finally a Reality'. The UK distributor will supply copies to anyone sending an A4-size, self-addressed envelope bearing a 30p stamp, to the address given at the end of this review. (This also means that Barry Fox and I will no longer have to scratch our heads every time Finial is mentioned!)

An important feature of the Finial is a bypassable 'Noise Blanker', which minimizes the sound of pops and ticks. This dynamic system is said to differentiate between music and noise by recognizing that musical signals have reverberations, while pops and clicks do not. In use, its effect seemed quite subtle but many will prefer to leave it off except for discs with very high surface noise.

If the calibration disc has been used, the player will issue sounds within about one minute of the drawer closing. It rejected a number of discs on first try but invariably played every one by the second try. The Finial will only play 12in black vinyl discs. It cannot read clear or coloured or picture discs, which I don't find too surprising, but the failure to play 7in or



10in discs was a disappointment. Finial argues that most singles were pressed from recycled vinyl which is too noisy. On the other hand, I have over 100 10in LPs and some 7in 'audiophile' singles which I'd love to have tried.

The saddest irony of all is that the Finial cannot yet cater for 78s, the records with the greatest need for no-contact playback. The difficulty, though, in programming the player to accept discs for which neither the speed nor the groove width/spacing were standardized means that at this stage it's just not possible. I have been told that they're working on it.

But back to the calibration for a moment. If you don't use the calibration LP – likely if you're in a hurry one day and you find out that someone switched of the Finial at the back or at the mains – the player will still work. It will simply require a couple of 'tries' before going into playback mode. But whether or not the Finial is in a good mood, it will never initiate play as quickly as a CD player or a manually-cued, mechanically played LP. (I don't find this a drawback, because I don't think you should try to listen to music in some kind of a hurry!)

## The sound of light

Before you can play anything, you have to take at face value the warning that your discs must be clean. We are not talking Decca-brush clean, nor even the sweep of Finial's own rotary cleaner as supplied with each machine. No, we're talking VPI or Keith Monks or Nitty Gritty clean, which I don't suppose is a problem for anyone who can afford a record playing device which sells for sixty times that of a VPI cleaner.

The reason for the hygiene is straightforward, and it's something Finial can do nothing about, unless they change the laws of physics. In essence, the lasers read microdust which a mechanical stylus would either push out of the way or which lurk above or below the stylus contact point. The benefits of reading a full groove wall, especially making well-worn (not scratched) records much more listenable, are slightly diminished by this. And it is the Finial's Achilles' Heel.

Let me be blunt: only one out of five LPs sounded as quiet as it did on a conventional player as regards surface noise. I tried unplayed records, records which had been played once with a stylus (to 'de-burr' them), unplayed-plus-VPI-cleaned and other combinations, but rarely could I find a disc without some slight crackle, especially at the beginning of each side. It was driving me nuts and affecting my judgment until it had been put into perspective by Xavier of Roksan, who happened to drop by while the Finial was in my custody. 'Does it really matter?' he said, pointing out that noise was only intrusive during silences (between tracks), and that it was a small sacrifice if it meant hearing unplayable records. Because that's where the Finial really shines: it will track discs which no mechanical stylus can manage.

I buy a lot of second-hand LPs which have suffered what looks like a fun session with a litter of kittens. I buy them because they're LPs of which I might never find another copy. Occasionally, they have scratches too deep to traverse. With the Finial, all you hear is a click, but the music carries on playing. Only very rarely (once in the 90 or so LPs I tried) did a disc challenge another spec of the Finial, which says that a skip (or, as the company prefers, 'a stuck') will not cause the player to go into frantic repeat of a locked groove. The Finial will sense and correct automatically any 'stuck' within 20msec. And the disc which did trigger this wasn't scratched; it had a lump of paper pressed into the vinyl.

Other worries which may have kept you from enjoying your LPs, mint or otherwise, are rendered insignificant by the Finial. It is virtually immune to warps (though if the warp is over 10mm, it probably won't even fit in the player anyway) and disc eccentricity and is free of rumble, wow, static, acoustic feedback, stylus tracing 'whoosh' and other ills. This means that, clicks aside, you have to approach the sound of the Finial not as if you were hearing another record player but as if it were a new format.

That's because it will be the first time in your life you've heard an analogue LP without 'insignificant' traces of rumble, wow, *et al* [Goldmund ...? Ed]. The first track I played sounded light, as if the bass had rolled off, until I realised that what I was hearing was an absence of low end grunge with mechanical origins. I played a disc notorious for visible excitement of the woofer ribbons in the Apogees because of warps, rumble and other sub-sonic nasties; played through the Finial and the Stages were as visibly immobile as if it had been a CD.

Full acceptance of this absence of vinyl nasties took me quite a while. Finial had another distinct advantage over normal turntables: it didn't have to drive what is usually the weakest part of any pre-amp – the phono section. Admittedly, it had its own RIAA circuitry on board, so it's not as if Finial has produced a shorter path between groove and loudspeaker; if anything, its complex circuitry makes the signal's route far more circuitous. But how did the Finial really compare with the best mechanical player?

Inescapable clicks aside, with many LPs it sounded leaner, cleaner and quieter than any conventional LP system I can recall. But the mechanical brigade fought back with the more effective, sweep-it-away handling of those microdust-induced clicks, and greater warmth – which I hear someone at the back branding a 'euphonic coloration'. (I don't listen to music to be irritated, so a little humanizing warmth is most welcome.) Then the Finial parried with superb transparency – approaching the Audioquest 7000, Ortofon MC3000 MkII and Koetsu Urushi cartridges – and detail up in Deccaland. The Berliner brigade replied with hotter transients than the Finial's, a

more extended top end and far better stage depth. The Finial came back again with stage width reminiscent of the classic Denon moving-coils and, subjectively, tracking ability to shame even a Shure. And the Finial earned a bonus point at the end of the side with no end-of-side tracing error. But then I wasn't using a radial tracking tonearm....

If I were scoring the Finial *vs* the world, I'd have to call it a draw because the two are simply not comparable. The Finial is too much like hard work even compared with a mechanical system because of the operational lags, the fanatical cleaning, the slow play initiation and the disc restrictions. But it does what no other players can do, by eliminating wear if it's a concern (and we all have irreplaceable LPs which we're almost afraid to take out of their sleeves). Most LPs which can't be played because of damage or pressing faults are rendered listenable at the very least, as I learned from my latest batch of Oxfam Non-Audiophile Scratch-Insistent acquisitions.

Whether you own a Dual 505 or a Goldmund Reference, the Finial does not make obsolete the conventional turntable. Cost? A Goldmund sells for the same money if it's true high end karma which you require. Sound? Considering the price-to-performance ratio, I'd have to say it's only on a par with a good £1000 front end. Universality? Only if all of your records are black vinyl 12-inchers. But if you are a collector – and you'll still have to hang on to your normal player for certain discs – the Finial is the only truly safe player on the market. That it works at all is near-miraculous. That it works so well is simply remarkable. If only that surface noise problem could be solved, because it really is a distraction when listening to anything other than loud rock music.

How many Finials will actually find homes outside of the pro sector I just don't know. What I do accept, if it's justification you want, is that it's very easy to assemble a collection of LPs worth far more than the cost of the Finial. (I can name three Beatles LPs with a total worth of over five grand.) But just dealing with the hands-off aspects of laser playback isn't enough to balance out the good-but-not-phenomenal sound quality. It's far more appropriate to look at the Finial as an intellectual exercise which worked. If the company ever decides to make an affordable version which addresses the limitations of this first model, then I'll be writing a review of a viable Finial product rather than what can only amount to a thought piece. That's because simply talking or writing about the Finial is still largely academic at this point, however truly fascinating it may be and whatever freedom it does offer from wear and tear. Unless you have a spare £21,000 plus VAT. In which case, can I marry you?~

### Supplier:

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# DIAMONDS AREN'T FOREVER

by Martin Colloms

## Technology

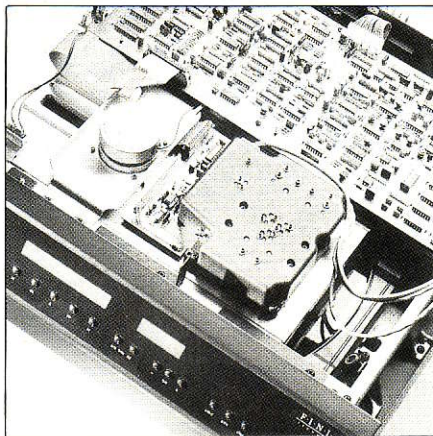
Removal of the light aluminium cover reveals a laterally mounted ball-bearing slide of very high quality, where the traverse sled carrying the optical head is moved via a low-noise rack-and-pinion drive by a high-resolution stepping motor. The electronics are at the rear – both servo and audio circuitry mounted on one huge full-width board with 99% of the circuitry achieved using ICs, including the ubiquitous Ne5532.

An interesting aspect is the platter drive. Once loaded, the disc is aligned on a sub-platter drum, machined in a heavy bronze alloy. This is belt-driven from another high-resolution stepping motor, with the compliant belt tuned to provide a filter effective for motor vibrations above 1Hz. The motor is the same as that used for the optical sled and has 400 poles to give 0.9° stepping resolution. Positional accuracy is augmented by micro-stopping each pole into subdivisions of a 256th, giving a final resolution of 0.0035°. The result is a virtually noiseless, high-torque drive for both platter and head.

Low noise is essential for both, since the optical system is an ultra-high-sensitivity velocity/angle sensor capable of responding to any spurious movement or vibration between the head and the record. However, one useful byproduct of the optical sensing is that its primary response is to changes of modulation *angle*, which makes it relatively immune to the amplitude deflections representing vertical rumble: thus a ball-race platter bearing has been chosen.

Finial ended up with a spot of light approximately  $6 \times 20 \mu\text{m}$ , which, making some allowance for Gaussian distribution at the edges, has a geometry quite similar to that of the groove-wall contact-area generated by a line-contact type of stylus. A frequency of 20kHz has a recorded wavelength of about  $11 \mu\text{m}$  at the inner LP disc radius, and the corresponding tracing loss at normal modulation levels is theoretically about 1dB – less than the 2dB or so inner loss usually encountered with pickup cartridges.

Left and right optical sensors are entirely independent, but are claimed to be time-aligned to within less than 20° of phase error at 20kHz. In addition to the anti-rumble feature, angle-sensing confers some immunity to vibrations normally affecting vinyl disc replay in other respects, including acoustic feedback and the wow and flutter components induced by warps. Also, complex noise modulations resulting from the subsonic resonance effects in conventional arm/



cartridge systems are avoided entirely. There is *no* mechanical subsonic resonance in the Finial: the problems associated with manifold mechanical and geometrical variations on the stylus/groove contact are sidestepped by the contactless optical tracking system.

The main compromise concerns the sensitivity, and thus the fundamental signal-to-noise ratio of the angle measuring system, whose linear range is finite. If the angle sensitivity is set low, a wide range of modulations may be read without peak limiting, including those which are well outside industry specifications. But the S/N performance suffers, since the additional gain required raises the noise-floor. Conversely, a high sensitivity gives a satisfactory signal-to-noise ratio but runs the risk that the sensing beams may be deflected off scale – *ie* 'clipped' by some high-level HF modulation with very steep waveforms. Loud rock programme with excessive treble content, or wide-range orchestral climaxes at the ends of sides may be limited by the Finial, but with an effect rather less severe subjectively than the mechanical mistracking and/or poor tracing which can occur with a pickup cartridge when used on tracks cut beyond normal modulation levels.

The technical detail is so extensive that only a small part of the fascinating material can be covered here. Fig 1 shows the basic geometry of the optical sensing

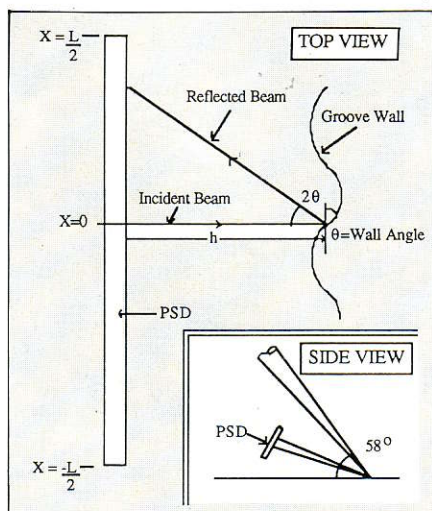


Fig 1. Finial laser turntable: basic geometry of data extraction system

system, where the 'position-sensitive detector' (PSD) is 12mm long and is positioned 3.5mm (h) from the groove, with 'X' representing a magnitude signifying the reflected beam's arrival point. As noted, the linear range is finite, and Fig 2 shows the non-linear response for a range of groove radii, plus the output after linearity correction in an electrical network. A recorded velocity of 20cm/sec gives a level of 3V rms, but an attenuator is used to the final output. The same beams are used for audio sensing and for tracking across the disc, with the two informations separated by multiplexing at 100kHz. Thus the bandwidth is theoretically limited to half the sampling rate, *ie* 50kHz; but Finial halves this with a filter at 25kHz (together with a sample-and-hold circuit) to remove the sampling harmonics from the output.

In an effort to reduce audible clicks, Finial has incorporated a noise-blanking circuit which is permanently engaged unless otherwise deliberately cancelled. Here, the sampled audio is fed into a traditional 'bucket brigade' delay-line, while another part of the circuit assesses transients and determines whether they have reverberation or overhang. If they do, they are genuine, but if not, they are true clicks and the circuit blanks them out of the delayed audio emerging from the line. Clusters of clicks confuse the circuitry, so only isolated noises are dealt with in this manner.

The optical servos are claimed to track the groove wall at up to 2kHz with a  $2.5 \mu\text{m}$  precision to ensure accurate lateral positioning, and are fed advance predictive information to improve tracking reliability. Any positional error, random or periodic, would appear as significant audio distortion. A byproduct of the high-speed servos is a degree of 'chatter' – optical 'needle talk' if you like, coming from the laser head. If the volume level is low and the player sited close to the listener, rock vocalists can be heard directly from the optics! It is also crucial to maintain the sensors at a constant height above the record, irrespective of warps, and again a  $2.5 \mu\text{m}$  accuracy was chosen. A smaller bandwidth of up to 5Hz is required here (a single warp-frequency is 0.55Hz), and the vertical servo is actuated by a pair of powerful 'voice-coils' driving a ball-bearing carriage on polished rods. This carries the height cylinder lens, height beam-directing monitor, height imaging lenses, and associated position detector, over a maximum warp amplitude of 9mm. In addition, it carries the modulation sensors, two data focusing lenses, and two data beam mirrors. It is no wonder that this turntable is so expensive to make and set up.

A simplified(!) diagram of the tracking system (Fig 3) gives an idea of the overall complexity, and shows how the system microprocessor fits in, while Fig 4 portrays the system of lenses and mirrors. Any engineer can only marvel at the quality of this research and the practical solutions embodied in the working player,

and I would only add that a helpful feature would be addition of a remote control, which could easily interface with the microprocessor.

## Sound quality

This is not and never was intended to be an audiophile turntable, yet the replay fidelity is undoubtedly good – and has that quality of growing on you. Sure, it is a bother to have to clean every record properly almost every time you use it, but would you take a photo with a fine lens that had a massive fingerprint on the front element? The Finial has a good claim to sound nearer the original mastertape in respect of its almost total lack of added harshness. That inevitable trace of a 'scrapey', 'grainy', roughened sound apparent with vinyl (admittedly only of mild degree with top-class mechanical players) is absent here.

One is not aware of wow except with severely eccentric discs, while the system's intrinsic noise is held at just below inherent tape and disc levels. There was no question about the low coloration with this player; it did not *sound* like a turntable/arm combination. One can clearly sense the absence of vinyl 'roar', the resonances and reflections resulting from stylus tip reaction energy. Also absent were the bass coloration resulting from arm/cartridge subsonic resonance, the mechanical/structural resonances of a cartridge, and its relationship with the tone-arm, the arm itself, and that of the arm to the chassis. The disc lies there inertly, on its firm but absorptive mat, providing an audibly near-distortionless drive to the mass-less optical reading beams. The sound was seamless, consistently even and articulate throughout the frequency range, and feeling highly secure and as sweet and unfussed as the original recording quality will allow. Generally, distortion was low, and when the system did meet excessive recorded velocities, the sound in optical overload was gentle and not particularly disturbing.

Good levels of detail were reproduced, while stereo focus was sharp and particu-

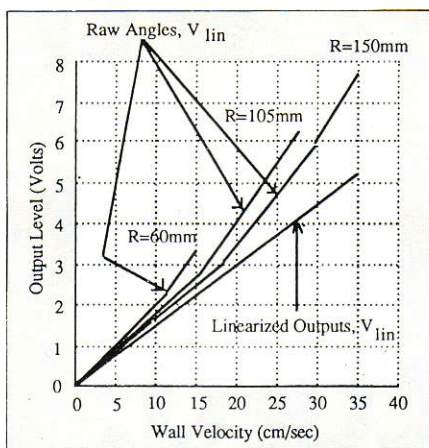


Fig 2. Finial laser turntable: output level *v* wall velocity

larly stable. Stage width was the best yet for vinyl, while depth was pretty good and transparency was comparable with that of a second-rank good quality moving-coil cartridge. In tonal balance the sound was slightly dulled in the treble, especially on transients and louder passages (more noticeable with noise-blanking), while the bass was slightly soft and tended to dryness. But neither aspect was very significant in terms of the overall result at normal modulation levels, and the 'tape' sound was a major plus feature.

It did however suffer from a variable degree of surface clicks and pops, accord-



ing to record condition. Even new discs were virtually unplayable straight out of the wrapper and needed at least the wet vacuum clean. This is recommended every ten plays, while between cleans the Finial hand rotary cleaner will keep noises more or less at bay. In Finial's defence, the noise-blanker helps a bit on 'ticky' records, while the sound of surface flaws (including odd scratches) was much less annoying due to the softened HF transient response and the averaging ability of the system in respect of microdust and groove imperfections. One also has to forgive the Finial for occasionally starting a groove or two late, very occasionally skipping a groove, and sometimes needing two 'play' commands to operate.

## Lab report

Many lab measurements proved to be difficult with the Finial, since it is susceptible to noise on older test records and will only play 30cm discs, which rules out the use of my master lacquer pressings for assessing precise levels of rumble and wow and flutter.

The smooth sound from this player is partly the consequence of its frequency response, which at the outer disc radius is 3dB down at 20kHz, which rules out the use of my master lacquer pressings for assessing precise levels of rumble and wow and flutter. The smooth sound from this player is partly the consequence of its frequency response, which at the outer disc radius is 3dB down at 20kHz, which rules out the use of my master lacquer pressings for assessing precise levels of rumble and wow and flutter. The smooth sound from this player is partly the consequence of its frequency response, which at the outer disc radius is 3dB down at 20kHz, which rules out the use of my master lacquer pressings for assessing precise levels of rumble and wow and flutter.

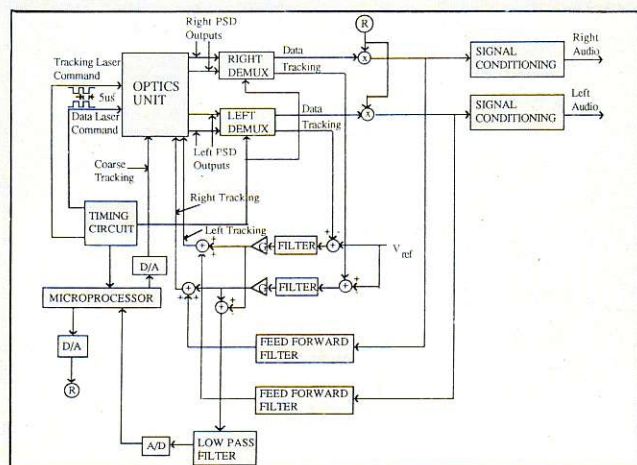


Fig 3. Finial laser turntable: block diagram of tracking system

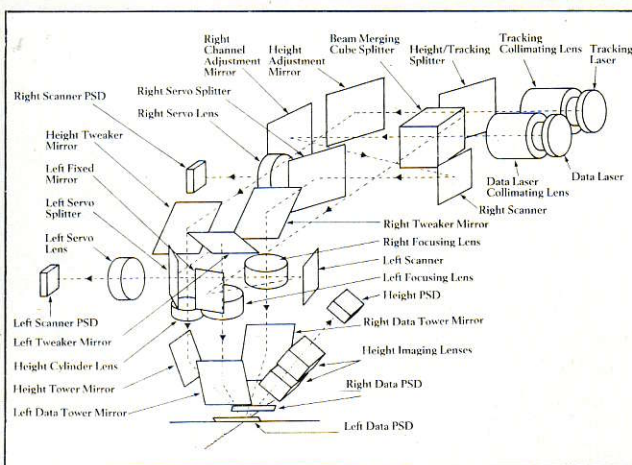


Fig 4. Finial laser turntable: the optical system

ter simulation (also Fig 5) is less severe, but this must surely have been calculated for lower 'average' recorded velocities.

Channel balance held within 0.5dB, and the phase difference between channels at 10kHz was less than 15°, close to specification. But while Finial indicates a theoretical (low-level) channel separation of 80dB, I could not better 25dB at 3.45cm/sec (45°) with test records which have previously given close to 40dB from mechanical cartridges of the highest precision and alignment. Channel separation was nevertheless found to be consistent over the full frequency range except at high modulation levels, this discrepancy due to the response fall-off in the driven channel. The crosstalk signal was measured for distortion and gave around 3%, of low and hence fairly innocuous harmonic order.

Using the supplied test record, a range of recorded velocities was tried as a combined test for linearity and trackability. At 50Hz, velocities of 1.4, 2, 2.8 and 4cm/sec were tracked, with distortion levels of 1, 1.3, 1.6 and 2.2% respectively. At 300Hz, the classic test frequency, the recorded velocities were considerable: 8.5, 12, 17 and a maximum of 24cm/sec. All were negotiated, with distortion levels of 1.4, 1.7, 2.5 and 3% respectively, which were good results for the range concerned. The final sequence was at 3kHz, with the same velocity run as at 300Hz, again resulting in secure tracking, with satisfactory distortion readings of 1.5, 1.8, 2.4 and 4.5%.

At normal modulation levels (well below those 8.5cm/sec 300Hz/3kHz minima) low distortion might be anticipated from this optical system, but this was not the case. At 3.45cm/sec, 1kHz/45°, the spectrum analysis showed 2nd-harmonic at -34dB, 3rd at -53dB, and both 4th and 5th at -44dB. Predominantly 2nd-harmonic, this totals to 2.4%, rather higher than for a good analogue cartridge. The old Audio Technica AT33E moving-coil achieved 0.2% even at 10cm/sec lateral, 300Hz, with 3% recorded for mid-band intermodulation at a high 24cm/sec using 1kHz and 1.5kHz tones. For the Finial, the IM test was made at half that velocity (12cm/sec) with a tone mix of 300Hz and 3kHz at a 10:1 amplitude ratio (20dB), and the resulting distortion spectrum is shown in Fig 6. Here, the harmonic spectrum of the 300Hz tone is seen towards the left (2nd-harmonic -28dB=4%), while the IM products comprise 300Hz sidebands centred on the 3kHz tone. The sidebands are some 30dB below the 300Hz fundamental, giving an IM distortion of typically 3%.

Clearly some sort of compromise has been reached with regard to dynamic range. Given that a clean vinyl pressing was used, the average signal-to-noise ratio was 53dB (CCIR/ARM, using a 1kHz referenced frequency). A-weighted, the noise might scrape a just satisfactory -60dB relative to an output level of 144mV, the sensitivity rating for 3.45cm/sec modulation at 1kHz. A spectral analysis of the

noise background was undertaken, averaged to suppress clicks and pops. On the bench, some mild hum was present (gone by 200Hz) but the absence of motor vibration harmonics or irregular mechanical rumble was evident. Possibly due to servo-action and RIAA equalization, the noise spectrum reached a maximum of approximately -40dB at 17Hz, shown in Fig 7, where the 50/100/150Hz hum components are also visible. An analysis extended to 100kHz showed the aliasing filter working at 25kHz, with some interference lines at -74dB, while above 30kHz the noise-floor was respectably low.

A narrow-band analysis of 1kHz tone (Fig 8) shows a spreading of  $\pm 15$ Hz from the central line, with side-bands approximately 40dB down at  $\pm 30$ Hz. Platter or disc eccentricity would place wow components at around 0.55Hz, so these flutter artefacts are probably a function of the

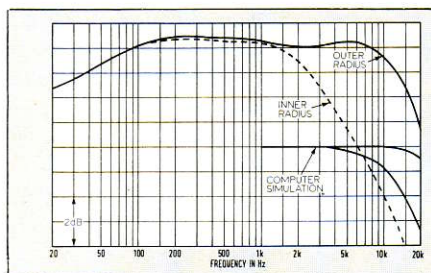


Fig 5. Finial laser turntable: measured frequency response (L+R) at inner and outer disc radii (5.0cm/sec lateral modulation), with Finial computer plots for same radii given beneath

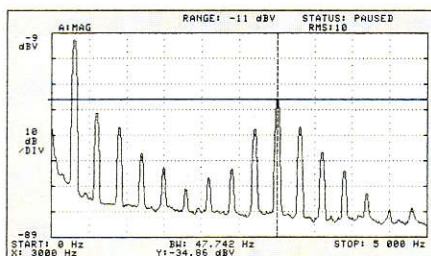


Fig 6. Finial laser turntable: harmonic and intermodulation spurs up to 5kHz generated by 300Hz tone at 12cm/sec and 3kHz tone at 12cm/sec

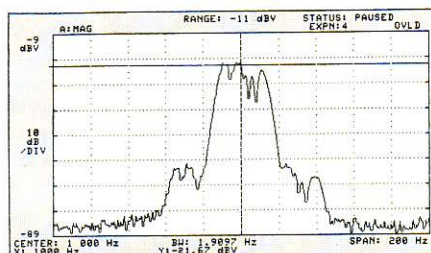
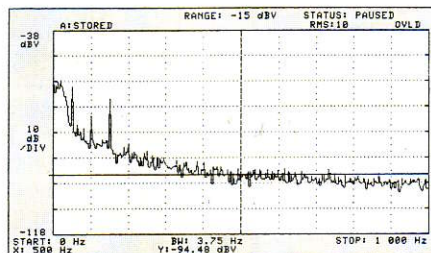


Fig 8. Finial laser turntable: narrow-band display of 1kHz recorded tone, with 20Hz lateral scale divisions

optical tracking servos; but they are coincidentally rather close in frequency to the region of LF rise in the measured noise spectrum. Overall pitch stability was very good, with no loading effects to disturb the disc, and absolute speed accuracy was fine at typically  $\pm 0.04\%$ .

Looking back at the results, I should point out that the frequency response test record (lab standard version of JVC TRS 1007) is cut according to convention with only the LF section of the RIAA response in place. The normal treble boost to +19dB at 20kHz is omitted to reduce record wear, so the reproduced frequency responses were taken with the appropriate RIAA treble boost added to the Finial output afterwards, to restore the overall replay characteristic. Consequently, the player was actually subjected to a very modest recorded characteristic, effectively one with falling treble modulation in comparison with music recordings. Treble sounds of low and moderate level will be unaffected by this, but as the recorded modulation rises into the top 10-15dB of available dynamic range the Finial system will progressively roll-off the treble according to a complex envelope determined by groove radius, frequency, and recorded velocity. In this respect it is analogous to HF squashing on cassettes, and I suspect that aside from other matters this is why the Finial sounds rather smooth and sweet, and why dynamic transient sounds are softened and lack their full subjective impact.

## Conclusions

The Finial laser turntable is a remarkable achievement as a working product. It is clear that many engineers have fought long and hard to make its optical system play microgroove records with considerable reliability; moreover, some LPs which are unplayable by mechanical means may be tracked by this non-invasive device. By definition it cannot injure a disc, although achieving a respectably quiet background does require scrupulous care in handling discs, plus fairly frequent wet/vacuum cleaning.

Given the high level of investment in development, and not least the very high price of the player itself, one is surely entitled to expect a commensurately high standard of performance. This was confirmed in some areas – for example, its response to vibration, shock and acoustic feedback was so good that no ill-effects could be obtained. Rumble, wow and speed accuracy were all fine. High-level tracking was also very good, and was free from wave-form breakup.

The dynamic range in the treble and the susceptibility to micro contamination are serious problems, and only a very dedicated enthusiast would find it worthwhile. In the case of archive applications, the current machine is limited by its present inability to handle 10in. and 7in. microgroove, and 78rpm coarse-groove discs. It was a wonderful dream, but the present long-evolved realization is as yet far from perfect.  $\nabla$