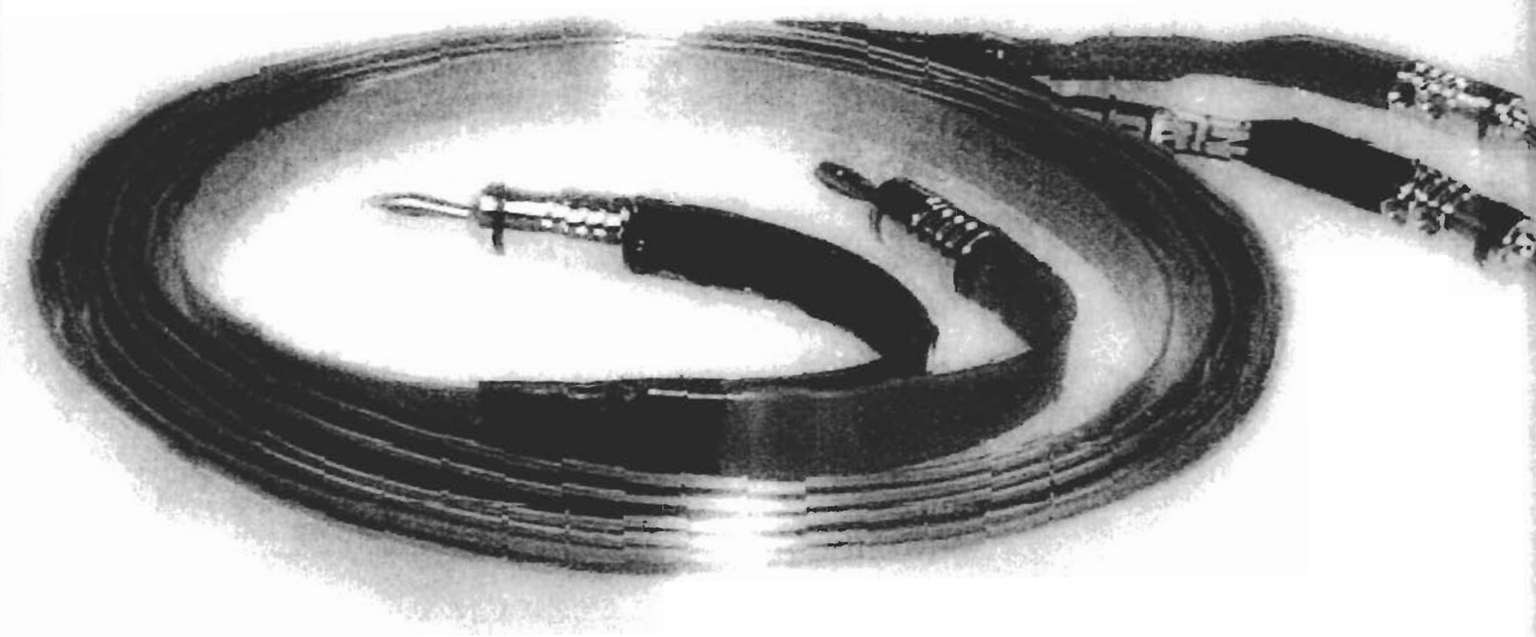
The freezing issue...



Relating cable sound quality to differences in crystal structure of the conductor material remains controversial. The cryogenic 'deep freeze' treatment used in other fields provides a way of assessing such claims. But listening to cryogenically-treated speaker cables and interconnects proved to be an astonishing experience

WORDS KEITH HOWARD

'The following article has aroused considerable controversy among the editorial staff, eliciting such comments as "balderdash" and "sensational"...' Thus began the understandably cautious editorial introduction to a feature article published in the August 1977 issue of *Hi-Fi News & Record Review*, which readers of a certain age are bound to recall. It was entitled 'Can we hear connecting wires?' and for many of us it marked the beginning of a controversy that has continued unabated across the quarter century since: Do interconnect and speaker cables sound different, and if so why?

I still recall the impact of that Jean Hiraga piece, translated from a French original published in *La Nouvelle Revue du Son*. So-called subjectivism was still a relatively young hi-fi movement at the time, albeit one which had already shaken the foundations of audio orthodoxy with its exposition of 'turntable sound' and 'amplifier sound'. But these were mere pre-shocks ahead of the eight-on-the-Richter-scale upheaval triggered by the Hiraga article. If even connecting cables sounded different, I remember thinking, then nothing of the old view could be taken for granted any longer. Intellectually, the earth had moved.

Hiraga's piece was concerned mostly with the effects of different cable constructions, with a particular emphasis on Litz cable (in which each strand of a multi-strand conductor is individually insulated), a type which, ironically, has rather fallen out of favour in the interim. Within a few years, though, cable protagonists became at least as concerned with the materials from which cables were made. Insulators (dielectrics) such as PTFE (Teflon) and polyethylene found favour over the more usual PVC, and the purity of the conducting copper became an issue also. OFC (oxygen-free copper) and LC-OFC (long crystal oxygen-free copper) soon became a badge of quality, while more extreme cable manufacturers went on to use silver and, eventually, carbon fibre in preference.

Of all the many controversial issues that still bedevil cable sound, this one of conductor type and purity is arguably the most bitterly contested. In seeking to explain why conductor quality should affect sound quality, numerous writers have evoked the notion of crystal boundaries within the material acting like miniature diodes and causing distortion. Meanwhile those who dispute that there is any cable effect beyond that predicted by lumped parameter circuit theory have ridiculed this claim, and with some reason since nobody, to my knowledge, had ever produced a convincing measurement to prove these notional diodes exist.

For the open-minded outsider — me in this context — one of the principal obstacles to assessing the practical significance or otherwise of the conductor's crystal structure is that it has rarely if ever been assessable with even semi-scientific rigour. You don't have to subscribe to double-blind ABX testing — the assessment method the sceptics would demand — to appreciate that determining the importance of any single design factor is difficult to the point of impossible when other variables are not held constant. In other words, when differences in conductor quality are not the sole disparity between one cable and the next.

If you were rich enough then you could, if so inclined, pay for otherwise identical cables to be manufactured using different grades of copper or other conductors. But for most of us — even cable manufacturers — such profligacy is not an option. So how can the importance of a cable's crystal structure be isolated and assessed?

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The answer came serendipitously for me, while I was researching an article on Deep Cryogenic Treatment (DCT) for *HFN*'s sister magazine *Racecar Engineering*. DCT involves the cooling of metals and other materials to very low temperatures, typically around -190°C. Liquid nitrogen (boiling point -196°C) is usually used to achieve this, although other liquefied gasses can be used to reach even lower temperatures (for example, neon, boiling point -246°C).

Early experiments with cryogenic treatment — America's Los Alamos nuclear weapons laboratory built a cryogenic facility as early as 1952 — plunged the component to be treated straight into the liquid coolant, with the result that many were damaged because of thermal shock. Today's DCT equipment is computer controlled so that components are cooled and warmed slowly either side of the 'soak' period over which the minimum temperature is retained. Typically each phase of the process takes many hours, and although liquid nitrogen is still used it never comes into direct contact with whatever is being treated. Instead it is usually dripped into the cryogenic chamber where it evaporates and cools the contents indirectly.

DCT's effects have been most widely studied in the context of engineering steels, where it is used to complete the heat treatment process. The properties of many steels can be enhanced by first heating them to about 900°C and then rapidly quenching (cooling) them in water or oil. The metallurgy of this process is well understood. Heating has the effect of transforming the steel into a soft solid phase called austenite; on rapid quenching most — typically 85% — of this is converted into a much harder form called martensite, which is responsible for the quenched steel's enhanced hardness. Increased brittleness is an undesirable side-effect but subsequent tempering — raising the steel's temperature to between 200 and 600°C and then cooling it in air — can offset this, and restore both ductility and toughness (the ability of the material to resist cracking).

The problem with this process is that the conversion from austenite to martensite is incomplete, which results in internal stresses that can weaken the metal and compromise its dimensional stability. What DCT does, in effect, is complete the quenching process so that most of the retained austenite — the source of the internal stresses — is converted to martensite. The benefits can be dramatic. When DCT is used to treat tool steels, for instance, tool life is typically improved by 200-400%, sometimes 600%.

Although DCT's effect on steel is the most completely understood, the technique is also quite widely applied to other

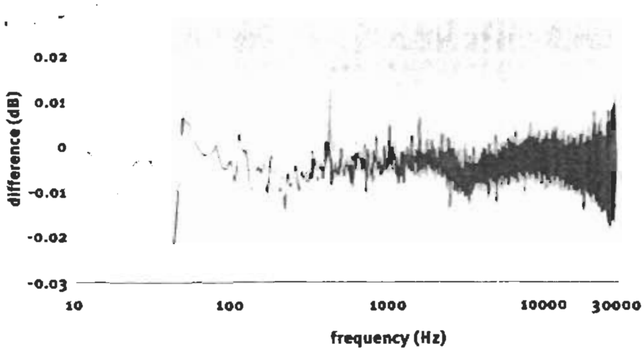


Fig 1: spectrum analysis showed a negligible difference in frequency response between treated and untreated cables!

metals such as cast iron, titanium, aluminium and brass, and to non-metallic materials such as plastics. In this case the improvement in physical properties apparently results from the elimination of dislocations in the material's microstructure. Trumpets and other brass instruments have been found to produce a better tone after DCT, and it is also used to treat guitar and piano strings.

For our purposes, the most important finding is that DCT also beneficially affects the crystal structure of copper. Cryogenic treatment of welding electrodes, for example, has been shown to improve their current capability and extend their working life. As soon as I first read this, it struck me. Here is an ideal means of establishing whether the crystal structure of an audio cable's copper really does have an effect on its sound.

The interconnect cables, when they arrived a little later, proved even greater a revelation than the speaker cables

But I'd need two willing collaborators in the experiment, who I found in Max Townshend of Townshend Audio [*www.ds.dial.pipex.com/townshend.audio*] and Greg Bartlett of Frozen Solid, a DCT facility based in Stowmarket [*www.frozensolid.co.uk*]. Max's Isolda cables have a deservedly fine reputation and — critically — he assembles them himself, starting with bare copper strip. So it is possible to 'get at' the conductor and treat it prior to assembly, thereby allowing the comparison of two otherwise identical cables. Max was keen to try it and Greg Bartlett kindly agreed to process a small quantity of copper strip FOC, so away we went. In a matter of a few weeks I had two sets of Max's speaker cables, each 4m in length, and three sets of his interconnects, all 1m long, only one pair of which in each case had been cryogenically treated. With the speaker cables I knew which was which, with the interconnects I didn't: they were identified only by letters.

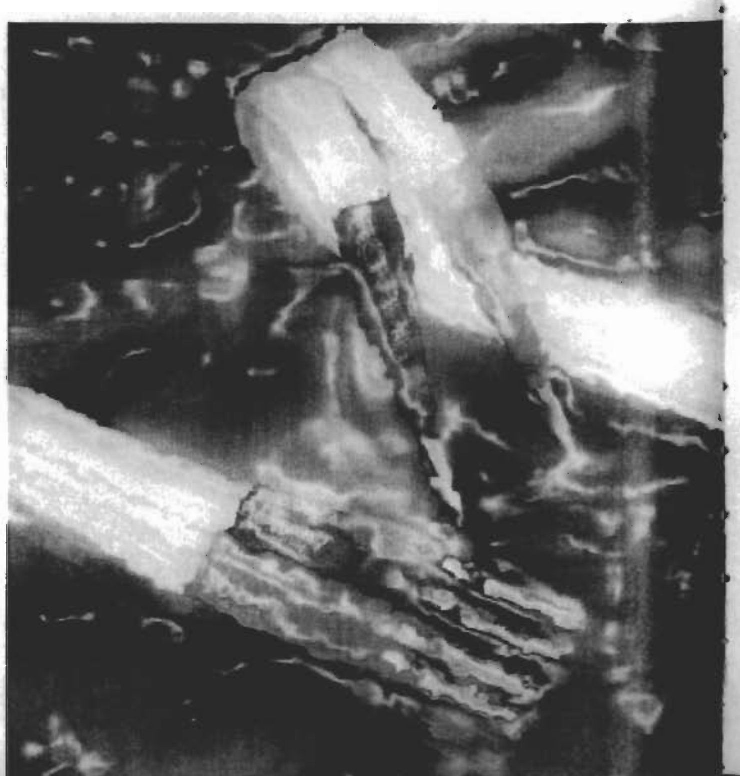
The speaker cables arrived first. Max delivered them in person (together with a car-full of Seismic Sink products, of which more on another occasion) so that we could listen to the differences together. Townshend cables already use annealed copper because Max had found that it sounds better; DCT is, in effect, a super annealing process, and it was quickly apparent that the cable with the cryo copper sounded better still. I've now done the comparison many times, and the difference continues to astound me. The DCT cable has greater resolution and a notably airier, more natural sound — to such an extent that, having heard it for himself, Max returned home and immediately arranged for a first batch of copper to go to Frozen Solid for treatment. Cryo versions of his cables will be available by the time you read this.

Because DCT has the effect of reducing copper's resistivity somewhat, it was important to check that the audible differences could not be explained away by small changes in frequency response at the loudspeaker terminals. To test for this I used MLSSA to measure the difference when using the two cables. You can see the outcome in Fig 1. MLSSA gives a rather noisy plot at this resolution (I could have used smoothing to disguise it) but even so it is clear that the disparity in frequency response is comfortably within +/-0.01dB across the entire audible frequency range — much too small a difference to account for the significant change in sound quality.

If anything the interconnect cables, when they arrived a little later, proved even greater a revelation than the speaker cables. Max had identified them as A, B and C, and only when I told him that I vastly preferred pair C over the other two did he confirm that this was indeed the cryogenically treated set. Once again, the sound of the treated cables was characterised by manifestly superior transparency. Music was dynamic in a way that simply eluded the other two cables (one annealed, the other not) — more finely etched and yet more weighty and punchy too.

Delighted as I am with the outcome of this experiment (although I don't imagine for one moment it will change the minds of those who regard cables sonics as a figment of others' imaginations) I have now to concede, rather like Scott trudging forlornly up to the South Pole, that someone got here before me. While the copper was with Frozen Solid being treated, I stumbled across a Pearl advert in a 1993 issue of *Glass Audio* that mentioned cryogenic treatment of vacuum tubes.

Some web searching soon revealed that Ed Meitner was the man behind this: that he had performed similar experiments to



mine with cables, and a great deal else besides, a decade and more ago: and that he'd actually sold cryogenically treated cables for a while under the Museatex brand. For some obscure reason this all passed me by at the time, despite a fair few column inches being devoted to the subject in magazines like *Stereophile*.

I tracked Ed down to his company EMM Labs in Calgary, Canada, and spoke to him on the telephone about his many experiments with DCT and why his pioneering work has slowly slipped from view. You can read what he told me in the accompanying panel. I must say, even after that conversation, I remain puzzled. Having heard for myself the astonishing effect of cryogenically treating the copper in speaker and interconnect cables, I can't imagine how this process and its benefits could fade into obscurity. As Ed Meitner himself says, it can't be due to cost because — in the context of high-end gear, at any rate — it is swamped by all those digits in the price tag. Although Meitner still uses cryogenic treatment himself, for everyone else in the audio industry it appears to have been a case of NIH (not invented here) or maybe IDU (I don't understand). Perhaps things will be different this second time around. And before you ask, yes — I will be striving to find some way of quantifying the sonic difference DCT so obviously makes.

INTERVIEW

Here Ed Meitner of EMM Labs talks about his pioneering work with cryogenic treatment.

'We know what copper looks like under heavy magnification - it has a very erratic lattice structure, and we know that this comes from the way it is made. Most materials come from a liquid and are shocked, more or less, into a solid. So the lattice structure of the material isn't in its natural state. What this does is produce stress, residual stress.

'If you treat the material at low temperatures, where the strength of the atomic bonds starts to diminish, it reverts to the natural crystal structure. So this process relieves the residual stress. It is a function of temperature and time. The absolute temperature doesn't matter very much, but if you only go down to, say, –100°F it may take several weeks. If we take it down to liquid nitrogen temperatures then it happens much faster. Our treatment time for copper was 12 hours on the way down, 12 hours soak, and 12 hours back. You don't want to go too fast: then you put thermal stresses into the material and break it.

'As a sanity check on this, I also took permanent magnets and treated them — and of course they deplete.

'We're still using this technique but we haven't concentrated as much on it because this is not my real livelihood. Even though I like to tweak with hi-fi stuff, we're building commercial products here — recording studio consoles and test equipment. I have a friend in town who uses it for vacuum tubes because what it does is cut resonance. Residual stress increases the Q of resonances. A vacuum tube is riddled with resonances, so it's very beneficial.

'We also used it with CDs. That was most interesting because it proved a point so well. If you put a CD player into an anechoic chamber, in front of a loudspeaker, and sweep frequency you will find a really vicious peak in the focus servo current around 800Hz, very high Q. The disc resonates and the focus wants to follow it. This current demand modulates the power supply and generates jitter, which is influenced by the acoustic energy going to the CD player from the speakers.

'Since it's around 800Hz, we have this problem with female voices. If you know somebody who can sing in that frequency range, very loud, they can shut CD players down. Cryogenic treatment doesn't change the frequency of that resonance, it just changes its Q [damping]. Once you are talking high velocity vibrations, as they are at 800Hz, clamping doesn't change things much. We tried damping mats and all sorts of stuff: they improved things a little but never as much as the cryogenics did.

'*Stereophile* had a whole bunch of their test discs treated. Some were treated and some not. Almost everyone they sent them to agreed that the treated discs sounded better. Another thing that happened which was probably even more interesting was that Analogue Devices came to us and we treated some 20-bit DAC chips. They sent out untreated and treated chips for people to try and again the same thing happened: the treated ones sounded better. Again, you have mechanical resonances and they are attenuated by reducing the residual stress.

'There was never a failure. We treated tons of solid-state stuff, whole circuit boards, and the only bad thing that happened was that the electrolytic capacitors would lose their shrink-wrap. That was it. We even treated speaker voice coils.

'What I've found over the last 15 years of being in high-end audio is that most of the minds are pretty closed. And this is strange: it's the opposite of what you would expect. So now I'm back in the pro audio business. What's even more puzzling is that you have all this megabucks equipment out there where the cost of the treatment would be of no concern. It would be a tiny fraction of the overall cost.

'Cryogenic treatment is not nuts. The windows on the space shuttle are treated with liquid neon. We have a company here in North America which sells fishing line that's treated. Apparently it holds the load better. A friend of mine in Boston has a big cryogenic facility and one female customer sends in cheap pantyhose for treatment because they run less!'