

TRIFIELD: A MISSED

Originating in the work of the late Michael Gerzon, the Trifield system deserves wider recognition

by KEITH HOWARD

For many in the audio industry the late Michael Gerzon enjoys the status of a latter-day Alan Blumlein. Although different in many respects — for instance, Gerzon was a talented mathematician whereas Blumlein generally shunned the use of equations — the two shared an intense interest in and rare insight into the reproduction of natural, three-dimensional sound fields. Sadly, both also met untimely deaths: Blumlein in the hushed-up

crash of Halifax V9977 on 7 June 1942, while developing H2S radar; Gerzon as the result of an asthma attack on 6 May 1996.

When such talented people die prematurely the temptation is to speculate about what they might have achieved had they survived. But another characteristic shared by Blumlein and Gerzon is that they left legacies of important work which had yet to be fully commercialised. In Blumlein's case, his seminal research into stereo didn't bear fruit for 25

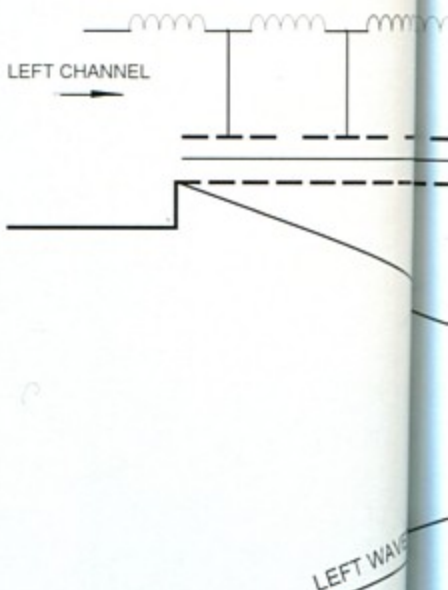
years; in Gerzon's, the audio industry appears to be busy forgetting one aspect of his work just when it should be looking to exploit it.

Readers who know of Michael Gerzon's important contributions to surround sound theory in general and Ambisonics in particular may think I'm about to launch into a diatribe on the subject of multichannel recording and reproduction, and how the arrival of DVD-A will reveal that record companies still haven't a clue how to do it properly. While I won't be greatly surprised should that prove the case in many instances, it's not the subject I had in mind. Rather I'm thinking of an offshoot of Gerzon's multichannel work, published in the early '90s, which was prompted by the



Trifield, a sophisticated process using an additional channel to create better stereo, originates with the work of the late Michael Gerzon (seen below). Despite the proven, benefits Meridian (whose products are seen here and on page 73) remains the only Trifield licensee in the domestic audio field

Before Trifield: the concept of using multiple speakers to reproduce a two-channel stereo signal was given this novel twist (right) by Peter Walker and D T N Williamson in the 1950s. A multi-section electrostatic panel and delay line are used to generate angled wavefronts which subtend the same angle wherever the listener is located in front of the panel



Michael Gerzon (1969):
photo courtesy Stephen Thornton

D OPPORTUNITY?

increasing popularity of home cinema surround systems and a realisation that herein lay a golden opportunity to enhance the reproduction of two-channel 'legacy' recordings.

If you know of this work at all it will probably be through Trifield, the signal processing algorithm which allows enhanced reproduction of two-channel stereo signals over the three frontal loudspeakers (left, centre, right) of a 5.1-channel or similar surround system. Picking up on an idea briefly pursued by Paul Klipsch in the late 1950s and early 1960s, Gerzon realised that multiple loudspeakers could be used to improve (not artificially enhance or otherwise 'frig') two-channel reproduction, and developed

psychoacoustically rigorous schemes for doing this involving three or more loudspeakers.

Trifield — the three-speaker variant — is the only one ever to have been exploited commercially, and then only by Meridian in its 568 Surround Processor, 561 Digital Sound Controller and 861 Reference Surround Processor. Every review I have read of these products has enthused about the improvements in image focus wrought by Trifield, yet the concept continues to stimulate apparently zero interest elsewhere. With high quality multichannel sound reproduction about to enter an important new phase with DVD-A and SACD, you might have imagined that industry minds would be bent to the matter of minimising

system redundancy: of ensuring that multi-channel systems offer the best possible value to their users even when reproducing two-channel source material. But there is little evidence that the importance of Gerzon's conception has been at all widely appreciated.

PHANTOM MICROPHONES AND SIGNAL MUTUALITY

Alan Blumlein was not the only stereo pioneer; there were others, working around the same time (early 1930s), based at Bell Telephone Laboratories in the US. With film stereophony foremost in mind, the Bell team developed a three-channel, three-loudspeaker stereo system, use of a centre channel being favoured because it better locked the sonic

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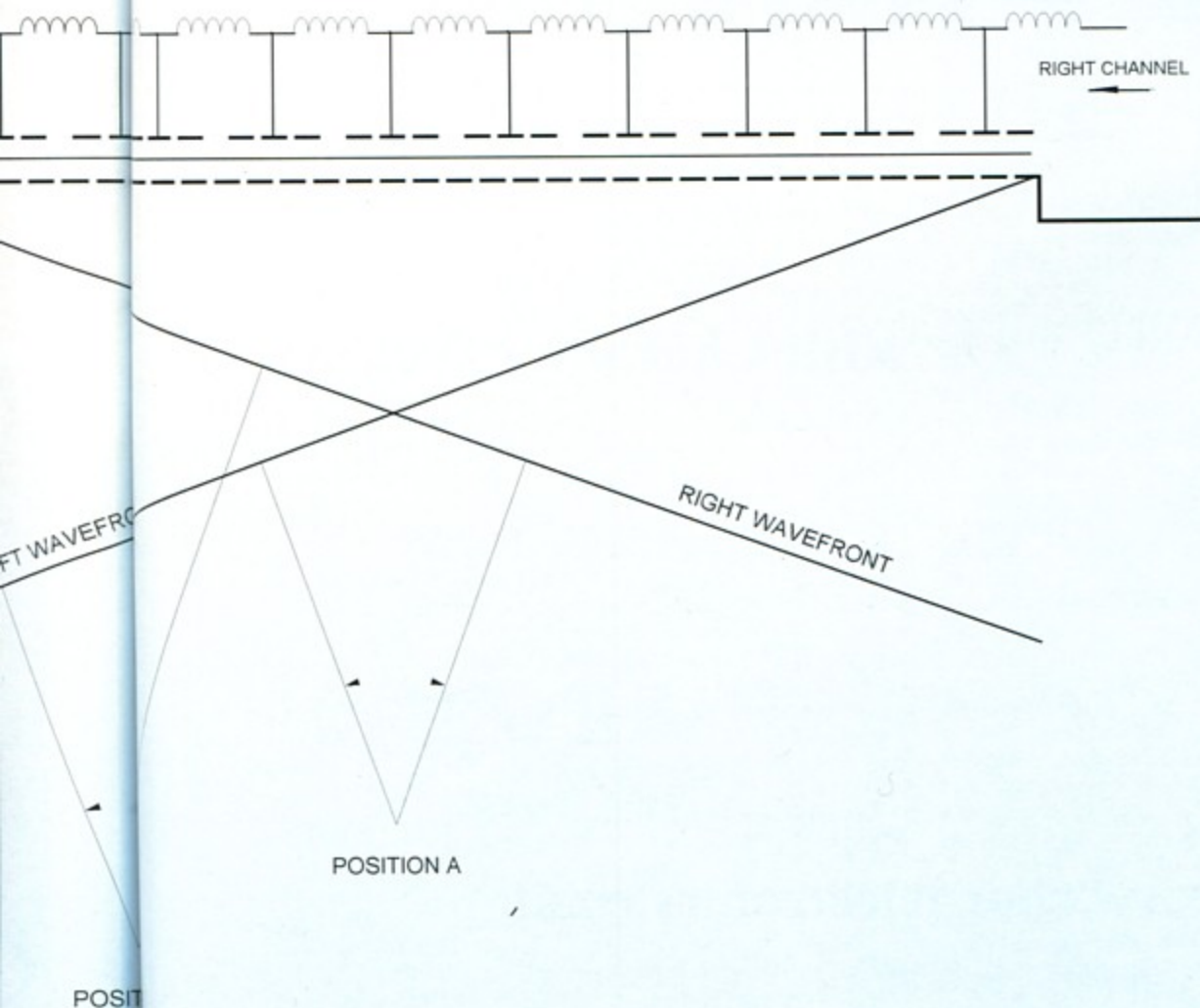


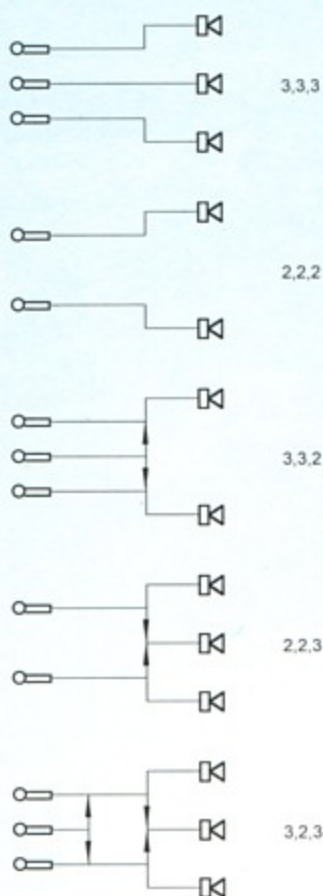
image to the screen image for viewers offset to one or other side of the auditorium, and better tracked movement of sources across the screen. In 1933 Bell's engineers gave an ambitious demonstration of the system to a distinguished audience in Constitution Hall, Washington DC which involved transmitting a live three-channel signal from the Academy of Music in Philadelphia, where the Philadelphia Symphony Orchestra played a programme of music for the purpose.

So far as the domestic application of stereo was concerned, none of the advances in understanding and technology made in that golden period, either by Blumlein at EMI or the researchers at Bell Labs, were to become of significance for a further 25 years. When the first single-groove stereo LPs were released in mid-1958 they were inevitably two-channel discs based on the Blumlein 45°/45° cutting system (although at the time it was generally credited to Westrex). There was no practicable method whereby a modulated groove could carry more than two channels, although twin pickups playing twin grooves were suggested and a further 15 years on JVC would conceive the multiplexed CD-4 system for providing discrete quadrophony from LP, as well as the Shibata line-contact stylus required to play it.

Two-channel stereo had won out because it was more practicable, but that did not mean the end of the three-channel concept. Drawing on part of the Bell Telephone Laboratories work in which its full three-channel stereo system was compared with various alternatives including two-channel recording reproduced using a derived centre channel¹ (see figure), Paul Klipsch began a series of experiments from which he concluded that using three loudspeakers with two-channel stereo offered superior results^{2,3,4,5}.

This is how Klipsch himself described the underlying principle⁴: 'The concept of 3-channel stereo derived from 2 sound tracks is predicated on the principle that if 2 microphones are properly placed relative to each other and the sound source, their combined output would be that of a microphone between them, and that this microphone that wasn't there can be recovered by recombination.'

Klipsch termed the high level of commonality present in the two channels of a stereo system 'signal mutuality'; today we would more likely express the same idea by saying that there is a high degree of correlation between them. Signals of equal amplitude and phase in either channel represent a central image: by summing the two channels and



presenting the summed signal via a third, centrally placed loudspeaker, Klipsch made real what was otherwise virtual — a central sound source.

Although largely forgotten these days, a broadly similar idea had been mooted by Peter Walker and D T N Williamson in the 1950s, as part of developing what would become the original Quad Electrostatic. Within the patent describing their developments⁷ and the series of *Wireless World* articles Peter Walker subsequently wrote about them⁸, a multi-panel electrostatic loudspeaker was described which utilised a delay line to generate a spreading displacement across the diaphragm. One channel was fed in at one side, the second channel at the other, the delay line and vertically disposed radiating strips thereby causing two angled wavefronts to be produced that subtended the same angle across a wide listening area (see pages 68-69). Although the concept was never exploited, the potential for using a delay line to control an electrostatic's radiation pattern was of course to re-emerge, with rather different motivations, within the later Quad ESL-63 loudspeaker.

While Klipsch, a man of considerable reputation in the American audio community, was bullish about the benefits of the 2,2,3

approach (two recording channels, two transmission channels, three loudspeakers) — 'All the stereo recording systems are amenable to using a derived central channel and the expense is small for a large gain in stereo geometry'⁴ — the idea of using a third loudspeaker simply did not catch on.

Probably there were various reasons for this, not least among them being (despite Klipsch's assertion 'the expense is small') that audio consumers were sufficiently intimidated by the prospect of having to buy and house two loudspeakers and power amplifiers for stereo, let alone three. It could also be argued that better loudspeakers and better recording techniques were to demonstrate that two loudspeakers were adequate for music reproduction — an outcome that was presaged by the Bell Labs pioneers who in 1934 wrote: '...two-channel reproduction of orchestral music gives good satisfaction, and the difference between it and three-channel reproduction for music probably is less than for speech reproduction or the reproduction of sounds from moving sources'¹.

Whatever, it was soon fixed in most people's minds that stereo meant two channels, two loudspeakers. In fact it became a high fidelity credo. But in 1991/2, Michael Gerzon tried once again to challenge that assumption.

TRIFIELD

If Klipsch had failed because a third loudspeaker and amplifier were financially and domestically unacceptable in the early 1960s, then the arrival of home cinema systems — equipped with a centre-channel speaker as standard — should represent an opportunity to resurrect the concept. That was Gerzon's thinking when he presented a paper on the subject to the 91st Convention of the Audio Engineering Society in October 1991, which was subsequently published in the *AES Journal*⁶.

Although the idea was inspired by home cinema and the need identified all those years previously by Bell Labs to provide better locking of the audio and visual images over a wider listening area than can be achieved with two loudspeakers, Gerzon didn't only have this application in mind. Although the principal benefit of his reworked 2,2,3 concept was that it stabilised the stereo image over a wider listening area — on the basis that home cinema is more commonly a group activity than is listening to music — that was not the only justification for it. On the contrary, Gerzon also claimed advantages for

Left: although Bell Telephone Laboratories chose a 3,3,3 system as a result of its pioneering stereo research in the early 1930s, it experimented with four alternatives including a 2,2,3 derived centre channel arrangement

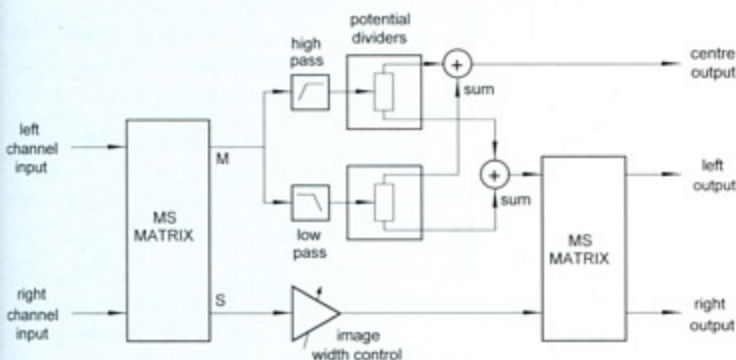
the listener comfortably ensconced in the stereo 'hot seat', in the form of improved image focus and, intriguingly, reduced listener fatigue. What Gerzon was suggesting was that a central loudspeaker, by reducing the amount of unconscious work our brains have to do to reconstruct a credible three-dimensional soundfield from just two fixed sources of sound, could not only improve the quality of the stereo image but also reduce the mental workload involved in sustaining it.

Implicit in these claims, of course, is an understanding that conventional two-channel, two-speaker stereo is not the paragon some stubbornly claim it to be. Although, particularly as expressed by Blumlein, it has undeniable elegance, 2,2,2 stereo is in reality merely the minimum necessary to provide some sense of the acoustic space in which a recording was made. It is not by any means a nonpareil. Far from it: the audio

the express intention of refining the stereo image rather than synthesising something ersatz.

The Bell/Klipsch approach to generating the signal for a third, centrally placed loudspeaker from a two-channel input signal had been almost childishly simple: the two channels were just summed and subject to appropriate, perhaps variable, attenuation. The Gerzon Trifield scheme is significantly more complex, in recognition of the fact that the psychoacoustic imperatives are not so easily satisfied.

A block diagram of the Trifield 'optimum reproduction matrix' (ORM) is shown in the figure below. First the left and right channels are passed through an MS matrix to convert them into sum (M) and difference (S) signals. In the Bell/Klipsch scheme the M component would be fed directly to the centre speaker, but not here. First it is divided into two overlapping frequency ranges by



literature teems with descriptions of its inadequacies, beginning with the original Bell Labs work, and Gerzon, an admirer of Blumlein, probably understood the sources and consequences of these limitations better than anyone.

Given his established interest and expertise in the psychoacoustics of sound reproduction, much of it forged during the development of Ambisonics, it should come as no surprise to learn that Gerzon's variation on the three-speaker stereo concept was significantly different to the simple Klipsch idea. In fact it represented only one, albeit the most important, of a hierarchy of MxN reproduction systems, utilising M channels and N loudspeakers (where N is greater than M). No source encoding was involved — the elaboration was entirely at the replay end — nor was there any suggestion of creating a pseudo-surround signal in the manner of the Hafler ambience extraction concept. In Gerzon's scheme the extra loudspeaker(s) were disposed between the normal stereo pair, with

complementary low-pass and high-pass filters, with their corner frequencies set at 5kHz or above. Gerzon's listening tests showed that the exact frequency, and the filters' rate of roll-off, were uncritical although the transition should not be too rapid. Each filtered signal then passes to a potential divider, which is set differently for either frequency band.

Only with this arrangement, Gerzon found, could a wide stereo image and sharpened central focus be traded off effectively across the entire audible spectrum. The outputs of the potential dividers are then summed as shown, one sum being fed to the centre speaker and the other being passed to a second MS matrix where, in combination with the difference (S) signal from the input matrix, feeds for the left and right speakers are reconstructed. A variable attenuator in the S line provides a stereo width control; otherwise the difference signal is unaltered in its passage through the ORM provided that the crossover filters in the M path introduce no

References

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- 3) P W Klipsch (1959), 'Wide-Stage Stereo', *IRE Transactions on Audio*, vol AU-7, July-August 1959
- 4) P W Klipsch (1960), 'Signal Mutuality in Stereo Systems', *IRE Transactions on Audio*, vol AU-8, September-October 1960
- 5) P W Klipsch (1962), 'Stereo Geometry Tests', *IRE Transactions on Audio*, vol AU-10, November-December 1962
- 6) M A Gerzon (1992), 'Optimum Reproduction Matrices for Multispeaker Stereo', *J. Audio Engineering Society*, vol 40, July/August 1992
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Above: Gerzon's 2x3 optimum reproduction matrix, as used in Trifield processing. The DSP power required to implement it is almost trivial

phase distortion (something which is easily achieved with digital filters). If the filters are phase distorting, then an all-pass network has to be added to the S path in order to mimic their phase error.

NEW HORIZONS?

To implement Trifield processing in a DSP (digital signal processing) environment is almost trivially simple, yet to date Meridian remains the only audio manufacturer to have done so. Trifield Productions Ltd of north London, which owns the



rights to Trifield, has confirmed to me that no other licenses have been granted in the domestic arena, although there are a couple within the pro audio field. So far as Philips/Sony and the DVD Forum are concerned, it seems that Trifield processing might as well not exist — despite the fact they both acknowledge that the forthcoming SACD and DVD-A discs will often carry two-channel signals and be listened to over surround sound systems with a (redundant) centre front loudspeaker. This astounds me. Although I'm relishing the prospect of high resolution multi-channel sound as avidly as anyone, I'm also looking forward to buying back-catalogue recordings in their original two-channel form, but now with the benefit of 24/96 or even 24/192 encoding. The widespread adoption of (switchable) Trifield processing would only heighten that anticipation, and provide the audio industry with another lever for prising people away from CD.

So why isn't this happening? Simple ignorance of Trifield's benefits, despite the fact they have been attested in so many reviews? 'Not invented here' syndrome — difficult to believe considering DVD-A's adoption of Meridian Lossless Packing, which Michael Gerzon co-developed? Unwillingness to pay the royalty? Or is it just one of those apparently inexplicable oversights?

Whatever the reason, it represents a major disappointment for anyone concerned to maximise the pleasure of listening to older recordings over multi-channel hardware. For Trifield to wither on the vine in the way of Ambisonics would be a crying shame; more importantly, it would be a fumbled opportunity. +