Proceedings of the Institute of Acoustics

STEREOPHONIC SOUND IN THE HOME - HEARING IS BELIEVING

J White

1. INTRODUCTION

The well worn arguments associated with the problems in designing small control rooms (1) will no doubt continue alongside such subjects as stereophonic microphone techniques and the choice of loudspeakers, and it comes as no surprise to find that new ideas are beginning to flow for widening the listening area for stereophonic reproduction. Having secured the situation in the television studios and control rooms it was now time to enter the living room and listen to the results of the work.

Reading the literature one gets the general feeling that the perfect loudspeaker is an illusion like stereophonic sound and that the number of technical, psychoacoustic, commercial, artistic and in particular the number of domestic constraints on getting rid of the anti-social "stereo seat" is considerable.

Whether or not surround systems will be fully accepted into the living room along with HDTV remains to be seen, but one thing is certain, the problems will be compounded by the fact that it is impossible to make six loudspeakers invisible in a living room, and the male population usually has no control over the position and degree of furnishings and to a large extent the listening level.

Whilst aural and visual directional cues can be made to match for a single viewer/listener, it is much more difficult to achieve such a result for two people sitting side by side. The vast majority of television programmes are assembled by directors/producers/and sound balancers sitting behind large mixing consoles in post production suites that have nothing in common with the living room apart from the fact that the dimensions are similar, and what is more, it is guaranteed

that the sound will be monitored on different types of loudspeakers, (2) One thing is for certain, they will all have to wrestle with the psycho-acoustic phenomenon known as the Precedence Effect.

2. BACKGROUND

The first thing that one does when arriving at an airport is to seek the conveyor belt that spins the luggage round and round and everybody makes a grab for what they hope is their rightful belongings. This system works because every bag looks different.

The loudspeaker industry has flourished since the late 40's and developed the idea of having two conveyor belts running simultaneously. All sizes of rectangular boxes are thrown by loudspeaker manufacturers onto the larger belt which supplies the general public: the fact that each and every one of these boxes looks alike and produces a unique sound when fed with the same signal is of no consequence - the system works well and manufacturers are well pleased.

The other conveyor belt is very much smaller: this is the one that supplies the so called professionals, who are not always pleased with what they take off the first time round. The fact that they throw this one away and take another, and then another is also a satisfactory situation for the manufacturer: but what about the science.

There is a conveyor belt for the science of audio - and this is oiled by words in technical journals and the popular press for example:

> Tannoy have abandoned rectangular boxes for a polygonal shape to minimise wave problems.
>
> KEF are moving forward with a new Reference loudspeaker: there are four loudspeakers in the cabinet but it looks like one loudspeaker with a hole in the cabinet.

HEARING IS BELIEVING

Canon's first venture into audio is a novel loudspeaker that gives stereo all around the room - can they succeed where others have failed.

Nothing is new, especially omni-directional loudspeakers, in fact Gilbert Briggs way back in the 50's placed a narrow wooden column with upward facing drive unit onto the conveyor belt and this was soon taken off and lost.

In the meantime KEF are celebrating thirty years in the loudspeaker business and they are still exploring new ideas and technology for the future. It is well known that KEF are part of a distinguished psycho-acoustics research team being funded by the European Eureka scheme (3) with the primary objective to quantify the subjective influence of listening room acoustics and loudspeakers' directivity on reproduced sound in the hope that the results can be used to develop improved systems for sound reproduction.

Maybe when loudspeaker directivity is fully understood we can look forward to some more ideas on how to get rid of the 'stereo bug'. In the meantime this project is not an invention or a review but it is a serious attempt to improve the listening experience in the living room by introducing a unique method of controlling the directionality of the system.

3. THE OBJECTIVE

The aim of this work is twofold:

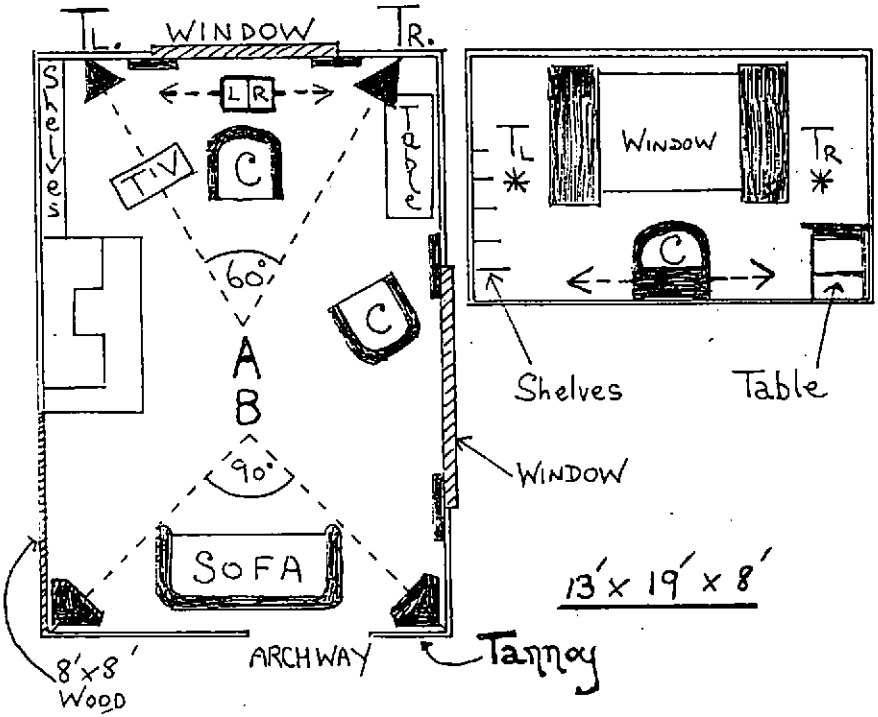
to widen the listening area for stereophonic reproduction.

to explore the reproduction of 'spaciousness' (timbre, richness, depth and height).

The precedence effect has been known about for a long time and the fact that the effect describes a psycho-acoustic phenomena whereby a listener localises on the source direction of the first arriving sound, seems to indicate that the least one can hope for is to modify the effect and accept any compromises so

produced: it is not surprising to learn that the effect is not well documented for stereophonic programme material. This matter will be rectified immediately by a listening test in the living room.

The living room comprises a large stone fireplace, 80 sq ft of windows and is furnished with a three piece suite, carpet, and heavy velvet curtains.



HEARING IS BELIEVING

4. THE 'NEW SYSTEM' versus 'THE REST'

Two independent Stereo loudspeaker systems are shown.

a) The so called 'New System' is auditioned from position A which subtends an angle of 60 degrees towards two tweeters (T) spaced 10' apart; these are considered to be the main L & R stereophonic loudspeakers.

The other loudspeaker enclosure is positioned on the floor behind the easy chair and central between the tweeters. This enclosure comprises two separate 5" loudspeaker units that are mounted sideways on, and each has a cross-over frequency at 5 KHz. In other words 'the system' is such that the listener will perceive direct sound above 5 KHz and indirect sound below this frequency and furthermore, it should be noted that the precedence effect has been put to good use, in that composite signals appear to originate from the position of the tweeters in spite of the fact that the sound heard from the central units is physically delayed by 3 - 5 ms. It is noted that the balance/pan pot functions normally.

b) 'The Rest' is represented by a long established stereo system with optimum listening point at position B, and this consists of a pair of Tannoy (Lancaster) corner loudspeakers with 15" Dual Concentric units: incidentally this unit was used by Granada Television in their standard monitoring loudspeaker for a considerable number of years.

5. THE LISTENING EXPERIENCE

LISTENING TEST 1

This project is unique in more ways than one - a conclusion was drawn at this point after listening to a live concert from the Albert Hall of the LSO performing Bernsteins' symphonic Dances (West Side Story) and a BBC recording made in the Free Trade Hall by the Halle performing Enesco Romanian Rhapsody No 1 in A.

HEARING IS BELIEVING

DISCUSSION: The impression formed was that I was listening to the most natural and exciting sound that I have ever heard in this living room.

The flicking fingers and vocalising from members of the orchestra during West Side Story had clarity and was spread right across the soundfield and the position of all the soloists could be clearly identified.

It is the first time that I have perceived individual position for each member of the woodwind section, and what's more they had depth.

The overall effect was that the orchestras had richness, depth and height, which the literature often refers to as having ambience or 'spaciousness', and the effect so created gave the feeling that the orchestra was in the living room: in particular the string section during Enesco.

Bearing in mind that the only direct sound perceived in all listening positions originates from the tweeters means that the ears were forced to work as they have never been made to work before: it was remarkable to hear good solid bass drum notes emanating from the right hand tweeter: it was immediately obvious that the precedence effect was no longer of concern. Unbelievable, but hearing is believing.

LISTENING TEST 2

The described 'new system' was then switched off and the listener turns through 180 degrees; a repeat performance was reproduced via the Lancasters.

DISCUSSION: It is with regret that I have to say that the sound was just not acceptable - it was coloured and lacked definition.

This was particularly noticeable on the conductor's voice when he addressed the audience prior to the performance of West Side Story. On this occasion it was very obvious that the sound engineer had only the one microphone faded up in the Albert Hall centre stage, because the audience was monophonic - good test material.

HEARING IS BELIEVING

LISTENING TEST 3

Reproducing the Kenny Ball and Big Band programmes via the 'New System' produced excellent results.

DISCUSSION: Where one listener may be barely conscious of the subtleties of stereo imagery, this listener will take particular pleasure in pin-pointing musicians within a recorded acoustic, and expects to hear a good stereo performance from an audience, for example, when listening to the Kenny Ball programme one expects the piano to be on the extreme left and from left to right the Trombone, Trumpet (centre), Clarinet, Banjo, Guitar: the Perc is positioned to the rear and provides a sense of depth.

The audience response to the jokes had clarity and imagery as did the banter between the musicians - it was a joy to hear and could not have been better in the control room. The Big Band 'was big', spread, and flat, and positions of the individual players could be pinpointed.

LISTENING TEST 4

At this point the tweeters were taken down off the wall and placed on the central unit above their respective channels, and angled in the same direction, in other words there was 100% reflections into the listing point.

DISCUSSION: The result of removing the direct sound on both the above programmes caused the stereo to revert to being monophonic, and it is assumed that the operational method used to produce these programmes was the pan pot or intensity method and this information is not carried in the reflections.

LISTENING TEST 5

A similar type of sound to the Big Band is that of the Syd Lawrence Orchestra playing the music of Glenn Miller in Super Stereo (Philips) and under the same conditions as those in Listening Test 3 (no direct sound)

HEARING IS BELIEVING

DISCUSSION: The result produced was different - the imaging was discernible and spread across the soundfield. This indicates that in addition to pan potting maybe some form of time difference processing was used by the recording studio and the ear now detects these time differences in the reflections.

LISTENING TEST 6

Switching to a live programme from the concert hall at Broadcasting House (piano/violin) it was observed that the performance was stereophonic, which indicates once more that the ear is capable of detecting time differences in the reflections, in this case the reflections reproduced from a stereophonic microphone and not a processor.

LISTENING TEST 7

Switching now to the BBC Maida Vale Pop output, it is now possible to say how the recording was made - intensity, 'time processing'.

LISTENING TEST 8

The original LSO/Halle performances were reproduced with absolutely no direct sound and once again I must say that it is with regret that I preferred the 'New System' with no direct sound to the direct sound from the Lancasters in spite of the 'lack of shine' with the high frequencies subdued.

Restoring the tweeters to their rightly places on the wall, the timbre, clarity, imagery and spread of sound brought the orchestras into the living room once more, peaking 100 dB-c whenever necessary - something the purists have been saying is impossible.

At all times a real time analyser was used to observe that the full broadcast bandwidth was being fully utilised, and to achieve the results outlined with 5" units is remarkable.

LISTENING TEST 9

To place the icing on the cake the demoted pair of rear Lancasters were switched out of phase and were now highly suited to provide reflections to the rear of the pinnae.

HEARING IS BELIEVING

DISCUSSION: With both systems now switched on and the respective volume levels adjusted such that the ambient noise of the audience prior to the entrance of the leader pervaded the room and thereby created the feeling of being amongst the audience.

LISTENING TEST 10

The television receiver took over from the easy chair.

DISCUSSION: When the whole audience sang Land of Hope and Glory at the last night of the Proms, the Albert Hall was moved by sound and this provided a rare experience of surround sound in the home.

Furthermore, it is surprising how often music tends to be reproduced at well above realistic levels; from experience it is known that this distorts the spectral balance of a recording. There is usually a preferred replay volume setting at which the reproduced perspective sounds natural, and this is often quieter than expected, and usually acceptable to the housewife.

LISTENING TEST 11

Finally a reproduction of Sir Michael Tippett's acclaimed latest opera New Year was set up as per that of the last night at the Proms.

DISCUSSION: This was very disappointing, so much so that the system was checked out and a number of A/B tests carried out with the Lancasters once more. In addition the normal monophonic loudspeaker on the television receiver was auditioned alone and this gave confirmation that indeed the words were very difficult to comprehend all the time and the timbre of voices often gave the game away that it was being mimed.

Every now and again the quality of the spoken word was acceptable which restored faith in the reference points: in particular I liked the words of Merlin - "there's a gremlin in the works, intolerable, try again." The whole production lacked definition and it certainly lacked 'spaciousness' and everything that goes with this word.

HEARING IS BELIEVING

Immediately the playback terminated it was a real joy to switch over to Radio 3 and hear a performance given by the BBC PO of Mahler's Symphony No 6, and as a result, I standby everything that I have previously said, and listening tests over and out.

The obvious question now is how can this so called 'New System' with its 10/20 watt amplifiers driving a cheap loudspeaker system that is arranged to eliminate all the direct sound with frequencies below 5 KHz, make a respectable direct radiator system redundant and completely nullify the precedence effect.

There are many indications that phase distortion plays a prominent part and this is emphasised by the fact that the University of Southampton Institute of Sound and Vibration Research strongly recommends that the step function fingerprints and their Fast Fourier Transform derived phase and frequency/amplitude graphs should become the accepted reference standard for all loudspeaker and loudspeaker/room combinations which are intended for accurate studio monitoring (4).

6. PHASE DISTORTION

One aspect of the conventional loudspeaker which has been largely neglected is the phase response. From previous work done (1) it became clear that while measured frequency responses appeared acceptable the transient response was definitely not, with clear time delays between the three outputs; it is yet to be proven whether these time delays are affecting the subjective acceptance of source material such as speech and transient sounds.

However, it does seem reasonable to suggest that there will be some effect otherwise why would KEF have produced a new Reference loudspeaker that gives the appearance of being a single unit, when in actual fact it comprises four units designed in such a way that high and middle frequencies are radiated from the same point on the front baffle, which promotes the claim, "in the mid-band the KEF's are outstanding resolving the slightest differences in tonal colours between instruments with finesse and ease."

Furthermore why would Tannoy have produced new 6.5/7.9 ins. drive units that resort to using a 'tulip wave guide' which sits in front of the tweeter and is said to create a spherical wave front for optimum integration with the output of the mid/bass driver that surrounds it. One cannot get away from the fact that if there is a dip at the cross-over frequency and a peak from the tweeter at 5 KHz one is going to hear it at sometime or other.

Canon avoid phasing problems in that they use a single unit to cover the whole audio bandwidth. The 'New System' has a crossover at 5kHz and forces the auditory system to use the pinna and not to rely too much on the two basic mechanisms which we have at our disposal to synthesize image localization in the front quadrant.

7. THE PINNA

Many studies have shown that the pinna transform incoming signals in that they superimpose upon the original a comb filter like spectrum, and this spectral shaping has been shown to add an additional cue to the now classic hierarchy of localisation cues, interaural intensity, phase and time of arrival differences.

Believing that we hear a different timbre from every angle, it seems reasonable to say that when listening to the 'New System' the ear uses the direct high frequency sounds for reference and sums the various timbres of each reflection into a composite signal, and of course the precedence effect phenonema nullifies the effect of phase distortions.

We know that with experience it is possible for the auditory system to spontaneously identify the locations and to recognise the different type of instruments, and voices for that matter, by the characteristic timbre of the sounds. Furthermore the perception of depth again is strongly influenced by acquired listening experience, for example, differing distances from a sound source lead to a change in intensity and the brain can deduce a different distance in the case of familiar sound sources from the relationship between intensity and the timbre of the sound.

HEARING IS BELIEVING

It shouldn't come as any surprise to learn that when a group of people listen to the same piece of music that not everybody listens to the same instrument or perceives the same timbre at any one instant of time; in fact the more times one hears a piece of music the more information one perceives.

8. CONCLUSION

So far the experience has been a critical assessment of programme material with a view to comparing the studio with those at home, however the introduction of the 'New System' has opened up a whole new area of controversy; since the results have been outstanding. It is hoped that an explanation of the performance of the 'New System' will have been developed by the time that this paper is presented. Music gives experience and the means for careful experiment in sound.

First impressions when listening to a sound source are very important; a conclusion was drawn earlier after listening to a live concert from the Albert Hall, and this remains so even after many hours of extensive listening to BBC Radio Programmes.

During all stages of microphone placement, mixing, and editing the sound engineer performs to secure the desired sound quality (timbre) that is the sound quality he or she would like to create. In other words judgements are made very quickly and when one is no longer a practising sound engineer, it is simply a case of, would I have liked to have produced an end product like that one.

Should the sound quality become unsatisfactory the sound engineer must understand how to change the technical parameters to create a sound that is acceptable. The 'New System' forces the auditory system to use the pinnae and the experiments have shown that besides the direct sound significant components for localizing a source of sound are the time and frequency dependence of the early reflections.

Furthermore it has been observed that differences in timbre sensation are commonly associated with differences in the power spectrum and in the phase relationships between sound components, and the question of phase with loudspeakers has been stressed.

However, the differences in the spectral distribution of sound energy are considered to be more important than are the phase differences although both contribute to changes in timbre. When one takes a look at the spectral content of speech emitted from Television - sound radio - film - and commercials it is easy to understand why they all sound different.

The fact that the precedence effect allows the 'New System' to latch all the early reflections onto the direct wave originating in the tweeters and this results in a richness of sound that is natural to one pair of ears at least, is a bonus, and so is the fact that 'the stereo bug' doesn't exist in this living room.

9. REFERENCES

(1) R J G Ellis/J White 'Problems in Designing Small Control Rooms for Monitoring Television Stereo Sound' Proc. Inst. Ac. 1989

(2) J White 'The Control and Monitoring of Stereophonic Sound with Television Pictures' IBC 1988

(3) KEF Electronics Ltd 'Free Field Simulation of Loudspeaker/Room Proc. Inst. Ac. 1990

(4) P R Newell/K R Holland 'Impulse Testing of Monitor Systems' Proc. Inst. Ac. 1989