THE WIDE IMAGING STEREO

By

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1. Introduction - The Abandoned Land

Since A. D. Blumlein invented sterephony in 1931, a lot of theoretical/technical achievements have led stereophony to be a standard method for music reproduction. However, it is also true that stereophony has many shortcomings. One of the shortcomings is the limitation of listener positions. While well-known 'hot spot' deserves all the virtues of stereophony, side positions are not tendered appropriately, as if they are left abandoned. The origin of the shortcomings seem to be in the loudspeaker design/theoretical background.

There is a possibility that these shortcomings may compel listeners away from the delectation of joint listening.

It is important to cultivate this abandoned land so that a group of listeners can experience together the same stereophony, as in the theatre. It also provides a sound foundation for the coming multi-channel sound field reproduction where stereophony plays a principal role.

2. The Wide Imaging Stereo - One of the Possible Solutions

Wide Imaging Stereo (hereafter WIS) allows a range of listener positions for stereophony reproduction. This contrasts with the conventional situation, a single central position, the so called high-focus 'hot spot', with abandoned side positions suffering severe distortion of sound stage presentation.

The ultimate purpose of WIS is to provide side positions with an 'intensity stereo-like' sound image without sacrificing any of the high-focus 'hot spot' quality.

3. The WIS Hypothesis

Since the area of concern for WIS remains an almost blank notebook, the following points are introduced to form WIS Hypothesis.

The WIS Hypothesis contains 4 parts.

The WIS H-P1 : Haas Effect in Stereophony

The WIS H-P2 : Optical Theory in Audio

The WIS H-P3 : Viva Human Sonar!

The WIS H-P4 : Hologram-like Sound Image

3.1 The WIS Hypothesis Part 1 : Haas Effect in Stereophony

"Initial time delay between left and right source could be compensated by initial sound pressure difference. Conversion factor between 'milli-second' and 'dB' is to be determined by further psycho-acoustical study".

This is a quite natural extension of the well-known Haas Effect cited by Dr. Haas,Goettingen in 1951. In his extensive study of psycho-acoustical problems, the relation between arrival time and sound pressure had been revealed for sound localisation. But his argument is based on monaural source and left/right situation, considerably different from stereophonic reproduction.

The WIS H-P1 is based on the common sense expectation that the nearer loudspeakers dominace is compensated by much louder sound by the other speaker so that sound image is not distorted. Actually, this is the case for car stereo where the listeners are normally off-centred, therefore, balancing volume is the only way to get reasonable stereo image although still only for the one listener.

3.2 The WIS Hypothesis Part 2 : Optical Theory in Audio

"The required intensity compensation for time delay differences at off-centre listening positions could be obtained by geometrical reflection based on optical theory".

WIS

Since light and sound are both waves, a lot of similarities are observed. The WIS H-P2 relies on the assumption that sound waves will behave like light waves in reflection. One of the biggest differences between sound and light is wave length, namely 17 mm to 17m for audible sound 400nm to 700 nm for visible light.

It is well known that the longer the wave length, the more susceptible it is to diffraction. But it is also known that only middle to high frequencies have influence over sound image localisation, and they are less susceptible to diffraction.

Second part of the WIS H-P2 is off-centred audio mirror. The idea of the Audio Mirror itself is more than sixty years old, but most of them are either omni-directional or randomly diffusing/reflecting. No similar arrangement like WIS is encountered yet. It is assumed that conventional conical driver is suitable for concentric audio mirror, but it is inconvenient for off-centre mirror from the point of view of sound quality as well as negative psychological impression.

3.3 The WIS Hypothesis Part 3 : Viva Human Sonar!

"Human perception for stereo image in stereophony relies on initially arriving sound waves from both speakers for their arrival times and pressures.

Any delayed arrival via longer path, even within loudspeakers, appears to be meaningless for sound location, but important for it's timbre".

Basically, it is quite in line with well received theory, except the time span between initial and successive sound waves.

Recent psycho-acoustic studies argue that the dividing line between 3ms - 30ms, or 1m - 10m length in sound path. It normally implies the effect from room acoustics. The WIS H-P3 brings the demarcation level much lower. For instance, C. A. Poldy has argued for 0.6ms or 0.21m already. Since diffraction is inevitable, a lot of delayed sounds within the loudspeaker, which is caused by diffraction/reflection among external surface and audio mirror, arrive successively. It smears the sound pressure measurement, but the WIS H-P3 believes that Human Sonar is capable of distinguishing between them.

3.4 The WIS Hypothesis Part 4 : Hologram-like Sound Image

"Like image of three dimensional hologram, stereo image varies from different angles. Human Sonar can reproduce stereo image from an angle, provided consistent sound signals arrive from WIS two loudspeakers. The WIS supplies much better sound signal to non 'hot spot' area".

It is another extension of commonsense. Three dimensional object provides different image from different angle and same can be said of real sound image. Holography is a method to reproduce three dimensional image and stereophony for sound image. They provide different images from different angles. There is another similarity because of their theoretical limitations, best image qualities are obtained at the centre of the front.

Those 4 parts are essential to the WIS Hypothesis, since they represent different steps of stereophony reproduction/ perception.

4. Experiments

4.1 Functional Models

A pair of 30 cm diameter concrete audio-mirrors with 90° apex angle were prepared. Two pairs of single cone full-range loudspeakers were employed for audition.

4.1.1 Loudspeaker with 8 cm planer driver : OPUS-1

i) Reference 1. conventional stereo mode on 50 cm high rigid frames

The usual results were obtained, with a well defined symmetric sound stage distribution and good central focus, but only for a 'hot spot' listener. At side listening positions, the image 'pulled' towards that respective side with a loss of sound stage and the localisation attributable to the furthest speaker.

ii) Reference 2. crossed axes stereo mode (Hugh Brittain)

An improvement in localisation was observed, together with a slightly better tonal quality. On Axes the simple drive unit has a rising mid-treble, which is non too pleasant. Off-centre subject positions showed slightly better localisation.

iii) WIS Stereo Mode

Unlike previous two references, loudspeakers were mounted onto rigid frames facing upward, with off-centred audio mirrors on the top. The WIS Opus-1 system clearly demonstrated the principle with barely any loss of central focus, but with a marked improvement in image spread and positions. Quite good stereo was possible with the listener close to the side wall : this is not possible with normal direct radiator designs.

(iv) Reference 3. Concentric omni-directional stereo mode

As a control test, the reflecting cone was placed concentrically to provide omni-directional radiation in the horizontal plane. The results showed a loss in focus, a serious dilution of the WIS effect and excess rear and side wall reflection.

4.1.2 Loudspeaker with 10 cm cone shape driver

Though the loudspeaker itself is regarded as a reasonable performer, WIS arrangement did smear sound quality. At high level of reproduction audible distortion was observed. Concentric audio-mirror position was checked as a control test and sound quality was acceptable.

It is assumed that off-centre audio-mirror reflection from cone shape driver produces multi/intermodulate-reflections resulting in audible distortion.

4·2 Three way prototype Demonstration Model

Two sets of pairs were prepared and demonstrated at Canon Expo Europe '88 which was held at Queen Elizabeth Conference Centre in London on 27th-30th April 1988. One set was for Super-Vision digital stereo sound and the other for WIS Theatre. At WIS Theatre 20 off-centred seats were occupied by more than 1200 visitors in a period of 4 days, and 1077 listener questionnaires were obtained. During preparation, several obstacles were encountered.

i) Speaker Interface Designing

It is quite conceivable that reflection/diffraction are frequency dependent in multiway configuration resulting in dip and peak on main axis. It is also known that tonal balance or perceived frequency response is a function of environment and local boundaries too.

To overcome above problems, it was necessary to try succession of crossover and equalisation networks to get reasonably flat tonal balance.

ii) Demonstration Site

The venue had unknown variable part of a large exhibition hall, with an extremely high ceiling (4.3m). Since the interface, designed for ordinary listening environment, did not fit the venue, modification was made leading to a musically effective tonal balance for Expo demonstrations.

iii) Result

84.6% of the 1077 listeners enjoyed stereophony from their off-centred seats, 10.7% were not sure, 1.9% said "no" and remaining 2.8% kept silent.

5. Conclusion

Though it is still in the very early stages of development, WIS seems to be promising to cultivate abandoned land without sacrificing 'hot spot' quality. Further effort should be made to prove/testify the WIS Hypothesis, so that the delectation of the group of listeners is fulfilled.

6. Acknowledgement

Three years have passed since the author realised the existance of the abandoned land problem, crystalisation of the WIS concept owes much to many people.

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FIG. 2A

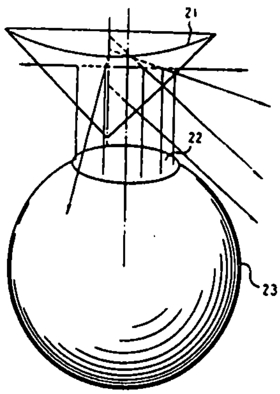

FIG. 2B

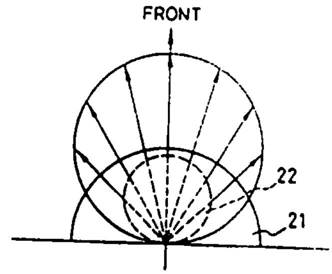

FIG. 3A

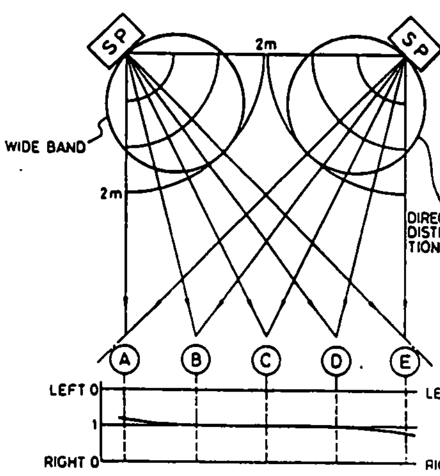

FIG. 3B
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