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DEVELOPMENTS IN HIGH FIDELITY SYSTEMS

HEADPHONES IN HIGH FIDELITY SOUND SYSTEMS

4 PAGE SUMMARY

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Leonardo da Vinci said that pictures were the result of giving corporeal shape to the 3 dimensions on a flat surface. Leonardo the artist used Leonardo the scientist to fix his design, to project his true perspectives, to mix his colors and to imprison light like Ariel in his web.

One of the aims of motion picture presentation is to achieve the visual illusion of reality. In the reproduction of high fidelity sound, the ostensible objective of the engineer is to duplicate, in the most minute detail, the aural experience of reality.

Paradoxically, the requirements of perfection should not be too strongly emphasized. In viewing motion pictures there is an easy adjustment to the seeming gigantism of the screen. In transporting a large orchestra into our living room through high quality sound reproduction, there are comfortable accommodations by the individual which may diminish his listening pleasure only in small degree. By carefully readjusting the psychacoustical factors governing real life perception, it is possible, perhaps, actually to enhance the musical performance.

To assist in this consideration we may observe that there are, principally, 14 ways in which the brain achieves stereoscopic effects, of which binocular vision is only one, albeit an important one. In the digression to follow, we will draw comparisons between the aids to visual stereo perception and the many assisting factors involved in aural perception in 3 dimensions.

In visual 3 dimensional perception in real life the eyes converge on the image of the point; in humans the ears lack this ability to converge but compensate by comparing intensities, quality and arrival times of the disparate "aural pictures" of the sound source reaching the 2 ears. By focussing the eyes upon the image of the point, the brain evaluates muscular stress to determine distance and direction. Aurally, human ears lack this ability to focus, although many animals can rotate the ears over wide angles to perceive acutely the angular position of the source.

Stereophonic listening has a peculiar advantage denied to stereoscopic processes. This is the ability of the brain, through the ears, to evaluate the arrival times of sounds reaching the 2 ears from a single source. These times for 1 or 2 degree accuracy are quite small, varying from 10 or 20 microseconds on the median plane, to .7 of a millisecond well off the axis with less accuracy. Above 1000 HZ the phase angles are small and multiple, causing ambiguity; intensity differences due to head diffraction effects take over to give localization.

In home stereo speaker systems there is observed frequently an effect called "the hole in the middle", especially when the listener is too close to the plane of the speakers, or when the speakers are too far apart. Another related effect is the so called "orchestral shift" when the listener moves to one side or the other of the median line between the two speakers. These effects are related to arrival times from the multiple speaker sources, when reality discloses only one true source. As previously suggested, compensations with other stereophone perception aids can help to diminish the deleterious effects, if not completely overcome them.

It is to be interpreted from our discussion that the microphones must duplicate the ears and their position in space (and the true arrival times) during the recording process to duplicate reality. This, in fact, is achieved in binaural reproduction where the microphones are separated by a dummy head in the audience position and the listener uses wide range headphones. The time delays are faithfully transmitted to each ear and the illusion is complete except for one thing: the listener cannot turn the dummy's head. On the other hand, a stereophonic system produces an abnormal sound pattern through microphone placements within the orchestral field, and by the loudspeaker placement in the living room. Arrival times are distorted both in pickup and playback.

These distortions can be offset somewhat by control of loudspeaker directivity and level. By proper recording and reproducing techniques sensations can be evoked which give ambience, direction and depth, all combining to achieve a high degree of auditory pleasure. In many cases this pleasure exceeds that derived from the original performance, but identity with reality is remote.

It is the vogue among some hifi enthusiasts to seek "surround" sound, or an effect of intimate immersion in the sound field. This is achieved through speakers by reflecting the direct sound to the walls and ceiling of the living room. With headphones, while the arrival times have the inherent distortion of the pickup process, the transients are preserved as recorded, for there are no further reflections added by the listening environment.

Here lies an exciting contrast with "surround" loudspeakers! While it is true that fusion of the multiple direct sound pulses from 2 or more sources will cause the pulse to appear singularly if the pulses are under 2 milliseconds apart, speakers, with the added listening room reflections, and especially those from "direct/reflecting" loudspeakers will dilute the transient by the number and amplitude of the reflections. For reception of all the transient information in the recording we must resort to headphones. Conversely, the same reasoning says that a live concert in the concert hall will by the liveness of the hall decrease the transient information. It follows that close microphone positions of the concert orchestra in the recording studio will increase the transient information. Headphones, therefore, will deliver best reproduction of the transients as recorded; loudspeakers will deliver less transient signal as diminished by room reflections, and carried to the extreme, direct/reflecting loudspeakers are transient distortion generators!

The best efforts of the most famous maestro are vastly improved upon by the recording engineer when the phonograph record is produced. The recordist, using individual microphones placed in each orchestral section, augments and monitors the dim harp. He moderates the over-intensity of the clamorous brass. He increases the normally deficient bass section, thus accomplishing a musically balanced performance almost impossible to achieve in real life.

Through stereophones we gain the finest listening position, that of the conductor himself, and through disc recordings bypass his problem of interpreting proper balance of the instruments over near and far distances.

Perhaps we have suggested in the foregoing a limitation in real life listening. If this is not sufficient, consider how real life concert hall listening can be improved upon.

Currently there is extreme interest, not to mention controversy, in four-channel sound, where left, right, left rear, and right rear signals are recorded and played back from the four corners of the room. Peculiarly, if the listener faces the center front and holds his head very still, there is no certainty that sound comes from the rear, although the ambience effect has been enhanced, perhaps because the two extra speakers have assisted high frequency dispersion. Movement of the head, of course, permits rear directional effects. The illustration may disclose why increased "surround sound" effects are achieved with speakers, and suggest that maybe headphone stereo listening has had the "surround" effect right along.

This phenomenon transpires because interaural distances and time differences are symmetrical for sounds from front and rear. The more confused the directionality is by reflections, the greater is the inability to interpret direction, and the source can be believed to be anywhere in the listening room.

It may be interpreted that in real life a visual clue is required to determine front and rear sounds unless the head is rotated. It has also been shown that visual clues are required for determining "up" and "down" sounds. While the two ears do a creditable job of establishing left, center, and right, and the brain evaluates intensity and reverberation to determine near and far distances, to hear rear sounds (without head movement), and to hear sound from "up" or "down", we may need a total of six ears situated on each plane of the head!

Because the headphones turn with the head, movement does not assist in determing "rear" sounds. However, the superior ambience effects, which lend so much to pleasing listening, have always been present in headphones with two channel recordings and now show possibilities of enhancement with the ambience added by four channel techniques.

Headphones offer certain advantages which promote good listening. Consider, first, that there are 2 classes of headphones: the velocity types which function reciprocally in the same manner as a velocity microphone, and those that operate in the pressure mode. The velocity units exhibit good regularity of phase with varying frequency response, whereas the pressure types innately deliver linear bass response below the resonance of the system. The response of the velocity units is fixed by the design, whereas the pressure units are adaptable to individual adjustment to flatten the response. On balance, the pressure units are superior.

The design features needed to present ultimate sound still are lacking, even in dynamic pressure type stereophones. The diaphragm assembly is not the infinitely stiff and infinitely light perfect piston, nor does it possess a form which permits push-pull, distortion-cancelling motion.

The discerning listener will perceive, therefore, the virtues of electrostatic designs. The diaphragm is only .5 mil thick, sandwiched between 2 acoustically transparent conductive plates. Weighing less than a three-eighths inch layer of air on either side, the diaphragm approaches ideal lightness. When a bias is placed on the membrane it is electrically stiffened, to work nearly like the perfect piston in a push-pull mode.

Methods of applying the bias include connection to the AC mains, self energizing by rectifying the first transient of the signal voltage, and the third method invokes electretification. Experimentally, the equivalent of very high static charges have been obtained in the laboratory through electret charge injection techniques. Future electrostatics will give very high sensitivity through these means. Reliability has also been greatly improved, resulting in a rugged assembly of the first order of quality.

At the beginning of this discourse we said that the objective of the acoustical engineer was to duplicate reality, but we included the qualifying word "ostensible" before "objective". The secret and true aim of the electro-acoustic engineer is to flatter the auditory sense with an <u>illusion</u> of reality. The manipulation of sound beams to promote <u>fusion</u> to achieve sound geometry; the controlled dispersion of high frequencies to accomplish ambience are only two. There is the spectral control of amplitude to compensate for ear insensitivity at the lower levels of playback, the introduction of "presence" through the sharper transmission of the higher harmonics, all unified through the art and science, the initiative and bold imagination of the acoustics engineer and today's advanced recording and reproducing media.

While it may seem that in this treatment we have been intricately and trivially concerned with processes, perhaps we will concede that reproduced music at home, especially through headphones, is a miracle of modern technology ---- and even miracles have processes of some kind, however instantaneous they may be.