Why Stereo?
The Philosophy of Multichannel Recording of Music*

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Two effects which contribute greatly to our enjoyment of live music are the ability to locate the source of the sound (stereophony) and the feeling of being in a good concert hall (ambiophony). These effects and their relationship to music are discussed. Microphone placement in multichannel recording is seen to depend on which effect is to be recreated in the home, and to what degree.

STEREO is all the rage these days—there's no doubt about it. There are many articles in the literature on the techniques of stereophonic recording and reproduction, but few which discuss "why stereo?" If we want to reproduce a ping-pong game or a passing railroad train or airplane the need for stereo is obvious. But how about reproducing music, where the music itself has some meaning other than just as sound—is the need for stereo so obvious?

In order to see "why stereo," let us look at the factors which enhance our enjoyment of a live musical performance. With this background, let us see how we can duplicate these effects in the home in order to enhance the enjoyment of a reproduction of a musical performance.

In listening to a musical performance in real life we can tell where various instruments are located, and this is part of the enjoyment of a live musical performance. In fact, music has been written which was specifically designed to utilize the directional properties of sound. In 1597, Giovanni Gabrieli wrote canzonas for two and three brass choirs to be performed in a church which was cross-shaped with each choir at the end of a different arm. The music was written so that the choirs would answer each other back and forth across the church above the heads of the listeners.

J. S. Bach wrote the *Passion According to St. Matthew* in 1729, with the chorus divided into two entirely separate groups, each with its associated orchestra. They were arranged to the right and to the left in the choir loft of the church, and the music was so written that the choruses would answer back and forth. So we see that this is an old and legitimate musical device. (Since this paper was originally written, *five* stereophonic recordings of the Bach *St. Matthew Passion* have been announced, and several stereophonic recordings of the Gabrieli canzonas have been released.)

When present-day musical arrangers write for stereophonic recording, they usually take advantage of the directional characteristics of sound.

The other important characteristic of listening in real life is the sense of being in a room, which is produced by reverberation. Several investigators have found that the *directional* characteristics of the reverberation are more important to the sound quality of the room than the reverberation *time*. Meyer[1] has defined "directional diffusivity" in terms of the amplitude and direction of the direct and reflected sound reaching a listener; high directional diffusivity indicates that the sound reaching the listener comes approximately equally from all directions. Vermeulen[2] observes that "I do not think that it is possible to build a hall of conventional design which will have a well diffused sound field, i.e., produce a great many strong reflections, without at the same time having a long reverberation-time. So we have become accustomed to associate one with the other, and to take the easily measurable property for the essential one."

The effect that we desire is for the listener to hear the sound coming primarily from the source (say, instruments on stage), then equally reflected (reverberated) from all directions (as opposed, for instance, to a dead room with no reverberation at all, or a room having a few audible echoes coming from particular walls). Somerville and Gilford,[3] in

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[1] Erwin Meyer, J. Acoust. Soc. Am. **26**, 630-636 (1954).
[2] R. Vermeulen, J. Audio Eng. Soc. **6**, 124-130 (1958).
[3] T. Somerville and C. L. S. Gilford, J. Audio Eng. Soc. **7**, 160-172 (1959).

a discussion of auditoriums for music performance, speak of diffusion as a most important property of a hall. (Diffusion describes the uniformity in distribution of sound energy in an enclosure.) They have found that an auditorium which uses acoustical reflectors to increase the *direct* sound decreases the diffusion and causes the sound to have a rather harsh quality. (This is a similar situation to a home reproduction system wherein all of the sound comes directly at the listener from a speaker, with no diffusion of the sound around the room.)

Directional diffusivity may be obtained in an auditorium by the original design of the room acoustics, or it may be added electronically to the room by means of delayed sound fed to speakers distributed about the room. This electronic directional diffusivity has been installed in the La Scala Theater in Milan and several other European auditoriums with a great deal of success in improving the sound of the auditorium for live musical performance.[4]

This principle of electronic directional diffusivity has also been employed in the stereophonic sound reinforcing system at the Stardust Hotel in Las Vegas.[5] In this auditorium, the walls have purposely been made very sound absorbent and all reverberation is supplied electronically via speakers around the room. In this way, it is possible to change the apparent size and acoustical characteristics of the room at will, depending on the effect desired.

This aspect of listening to sound in real life has been studied and reported on by R. Vermeulen of Philips' Research Laboratories of the Netherlands.[2,4] His name for "the sound around you" is *ambiophonic*.[6]

We see that the listener uses his *binaural hearing* to determine both the direction from which the direct sound is coming (to locate the instruments) and to determine the direction from which the reflected (reverberated) sound is coming (giving the sense of "being in a room").

THE GOALS OF REPRODUCED MUSIC

Having discussed the two most important aspects of listening to sound in real life, let us now review the goals of electronically reproduced music. The limits would be, on the one hand, to make a literal duplication of the sounds heard in life and, on the other hand, to create new sounds which are not achievable except by electronic means.

On first thought we might assume that the ideal would be a literal duplication of the live performance. There is one problem, however: real life is three-dimensional, wide-screen, in color, with ambiophonic stereophonic sound. But most of life does not have a *startling* stereophonic effect, so that unless the recordings are made in such a manner as to remind us occasionally that they *are* stereophonic, one would likely forget that it is stereophonic sound.

The other extreme is to create entirely new sounds, such as the French *musique concrète,* the German *electronic music* and such productions as *Vortex* at the Morrison Planetarium in San Francisco. These are often designed specifically to call attention to multidirectional effects and to startle one, sometimes at the expense of musical content.

Two important intermediate cases also exist: First, in a live performance one is able to *see* where the performers are located; but in a reproduced performance, the performers cannot be seen, and this loss of visual perception may be partially replaced by an enhanced aural perception, i.e., an exaggerated stereophonic effect.[7] Second, contemporary, nonelectronic music (both "popular" and "serious") is often intended from its conception for electronic reproduction. In this case, we must evaluate the artistic effect of the reproduced music as a whole—"music," "performance," and "recording technique" become almost inseparable.[8]

Therefore, for *reproducing* music, we will see that one will probably desire some sort of a mid-ground technique where the directional effects are enhanced but the reproduction will still be essentially a recreation of a live musical concert. In creating contemporary music intended from conception for electronic reproduction, "anything goes."

In summary, then, the two primary *effects* in enhancing the enjoyment of music are the ability to locate the source of the sound, which "brings the orchestra into the room"; and the quality of the sound's "filling the room" produced by high directional diffusivity, which "brings the concert hall into the room." Our *goals* range from that of duplicating a real concert, through an enhanced duplication of a real concert (the "better than being there" effect), to sounds peculiar to electronic systems. Let us now see how these effects relate to "stereophonic" sound recording.

THE TECHNIQUES OF STEREOPHONIC MUSIC RECORDING

The original stereophonic music experiments were conducted in 1933 by the Bell Telephone Laboratories.[9] They had a symphony orchestra in one auditorium and wished to make a literal reproduction of this orchestra in another auditorium. Under these conditions they were concerned only with the problems of reproducing the location of the source, since the directional diffusivity would be supplied by the auditorium into which the program was reproduced. This philosophy (reproducing the location of the source) is used by everyone in the stereophonic sound recording industry, but reproduction in the home of the ambiophonic

[4] R. Vermeulen, IRE Trans. on Audio AU-4, 98-105 (1956).

[5] G. R. Hayes and H. L. Bryant, "Stardust Hotel Stereophonic Recording and Sound Reinforcing System," presented before the Audio Engineering Society, February 19, 1959.

[6] R. Vermeulen, "Now: *Ambiophonic* Music, Just as in the Concert Hall," *New York Herald Tribune,* Engineers' News Suppl., March 22, 1959.

[7] This concept of stereophonic enhancement as a replacement for the lost visual sense was brought to the author's attention in conversation with Benjamin B. Bauer.

[8] This concept was pointed out in the symposium "Techniques in Production of Stereo Tape and Disks" (Chairman, Irving Joel), October 9, 1959 at the Eleventh Annual Convention of the Audio Engineering Society in New York.

[9] Fletcher *et al.,* Bell System Tech. J. 13, 239 (1934).

effect is ignored. (Two stereo speakers do give a rudimentary ambiophonic effect since the sound comes from two points and is more "around you" than if it came from just one point.) The "location of source" stereo requires only simple equipment for reproduction since it takes only two speakers in front of you, whereas an ambiophonic system requires many speakers around the room. Although an ambiophonic system might be more enjoyable than a location of the source system,[6] it is not nearly so simple or neat to install, and no commercial work has been done as yet with ambiophonic sound reproduction in the home. Therefore, the microphone techniques described below will be directed primarily toward the location of the source aspect.

For literal reproduction of location of a source, we simply need to place one microphone in front of each side of an orchestra or band, then the instruments on the left will be picked up by the left microphone and the instruments on the right will be picked up by the right microphone. There is, however, a flaw in this sort of pickup. It frequently happens that a player sitting on one side of the orchestra and close to that microphone may have an instrument whose directional characteristics are such that the loudest sound is picked up by the other microphone. This sort of "cross fire" pickup arrangement results in considerable confusion to the listener and reduction of the stereophonic effect.

This problem may be eliminated by either of two schemes. The first involves the use of multiple microphones so that several microphones, for instance, on the left side are mixed together to form a left channel. These microphones are so placed as to be both near to and on the axis of the instruments which they are picking up. A second way of eliminating the "cross fire" problem is to use the intensity (also called MS) system.[10] In this case, two directional-type microphones are placed at the same position in front of the orchestra at the middle. Then each musical instrument is the same distance from both microphones, and each microphone picks up those instruments toward which it is directed.

For an enhanced stereo effect in music, one must experiment with the arrangement of the orchestra so that the stereophonic effects in the music will be more prominent. Often the instruments which are to be on left channel will be grouped together and separated by considerable distance from the instruments for the right channel. If this is done in a dead studio, it is possible to get almost complete separation of the sounds, right and left (one may introduce artificial reverberation to improve the over-all quality of this sound without degrading channel separation). In this case very startling effects may be obtained, though it is sometimes questionable how musical the effect is, since in much music the ensemble is very important. One must decide in advance whether a given recording is intended to convey musical thought or to entertain primarily by the unusual arrangement of the sound.

[10] G. Bore and S. Temmer, Audio 42, 19 (April, 1958).

A soloist with an orchestra presents another problem. With a literal reproduction using two microphones in front of the orchestra, when the soloist turns from side to side he appears to be racing back and forth across stage. In this case, the intensity (MS) system may have some advantages. The usual method of enhancing solo placement is to use a single microphone for the soloist and have the output of this microphone fed into each of the two other channels (usually slightly more into one side, so the soloist is toward one side). By this means the soloist will appear to be just off center, and if he turns he will not appear to move from one side of the stage to the other.

In order to reproduce the ambiophonic effect, we must either have in the home a device which will create smooth, time-delayed, reverberant sound; or else we must record it on another channel of the original tape. At the present time, no satisfactory practical device exists for recreating the reverberant sound in the home. Therefore, if we want the ambiophonic effect it must be carried as a third channel or instead of the second "location" channel.

To record an ambiophonic channel we could have our original performance in an auditorium with acoustics appropriate to the sort of music we are recording. Then a microphone placed at a *distance* from the orchestra will pick up the desired delayed, reverberant sound.

The author has done a limited amount of recording ambiophonically, as described here, using a two channel recorder. The loudspeaker setup for reproduction used a "main" speaker connected to the channel with the close microphone pickup, and "surround" speakers connected to the channel with the distant microphone pickup. (At least three to five "surround" speakers must be used, so that the sound is "around" the listeners and the source of the surrounding sound cannot be localized to particular points.) The listening group consisted variously of performing musicians, development engineers, recording engineers, and others. All were very favorably impressed with the ambio-

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phonic reproduction, and several felt that they would prefer this to the more usual stereophonic reproduction.

SUMMARY

To recreate in the home the effect of a live concert of music, it is necessary to recreate the spatial effects of both the orchestra, through stereophony; and the spatial effects of the auditorium, through ambiophony. Thus far, no economical system exists for producing recordings for the home with both stereophonic and ambiophonic effects; present practice is to favor the stereophonic (location of the source) since the equipment required in the home is relatively simple. But there is a possibility that the ambiophonic effect contributes more than stereophony to the enjoyment of music.

It is both necessary and desirable to exaggerate the stereophonic effect in recordings if the effect is to be perceived by the listeners as stereophony, and not just half-hearted ambiophony. ("Stereophonic" recordings in which the sources are not clearly located, but which have the effect of "opening up" or "filling" the room are just this—simple ambiophony, with the sound coming from a wide front position instead of from all around you.) For true stereophony careful orchestra arrangement is necessary, frequently with multiple microphones. But all is lost if musical ensemble is lost through a misguided attempt for dramatic stereo effect.