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Stabilising stereo images

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A disadvantage of multimicrophone recording technique is that it usually gives stereo images that are only heard correctly by people sitting in the 'stereo seat'. This means that a producer can be assured with a high degree of confidence that most consumers having good stereo equipment will not hear the mixdown with the intended stereo effect. In many circumstances, a recording can be made or modified to have a stable stereo image that may be heard even by a very off-centre listener.

Many readers will recall the brief battle in the pages of *Studio Sound* in early 1971 between multitrack technique (defended by Bob Auger) and coincident microphone technique (defended by the present writer). That controversy was entirely concerned with classical music, and clearly a high proportion of musical effects desired in pop cannot conceivably be obtained with any sort of purist technique. Nonetheless, the creative flexibility of multitrack is bought at the expense of sacrificing certain desirable qualities of sound; as always in technical matters, one never gets something for nothing. It is worthwhile reviewing some of these losses, as they are not always understood by engineers. This analysis of defects of multimic is not in the nature of a dirge to the effect that all who dabble therein are damned, but to offer constructive comments and suggestions as to how some of these technical defects can be cured. For too long, recording has been considered as purely an art, and its science, its systematic principles, need to be presented.

Consider a Blumlein pair, a crossed coincident pair of figure-of-eight microphones angled 90° apart (see Fig 1a). Suppose that a relatively distant sound is picked up from 22½° left of front as illustrated. Then, even presuming that the microphones are *precisely* coincident and that their polar diagrams are accurate, the direct sound is picked up in the stereo image in a fashion identical to a mono sound fed to a panpot set to half-left (Fig 1b). This illustrates that coincident microphone recordings and panpot recordings differ technically in only one way, namely that coincident microphones also panpot the reverberation and reflected sounds in a precisely defined fashion. As far as direct sounds are concerned, and assuming a 'perfect' multimic balance, the two techniques are identical.

Yet when one performs a comparison between a Blumlein and a multimic recording, one is struck by their essentially different behaviour in the listening room. We may enumerate several points of difference. Musical lines balanced very quietly relative to others playing at the same time are almost inaudible and impossible to follow in multimic (a fact that all good balance engineers learn to cope with with great skill), whereas such a line remains clearly audible through the others in a Blumlein recording. The quiet passages of a multimic recording tend to be obliterated by high noise levels in the listening room, whereas corresponding quiet Blumlein passages can still be followed by the listener. The differing spatial positions of closely spaced artists are clearly separated in a Blumlein recording, whereas sounds panpotted so closely together are often indistinguishable in position. One can judge the relative distances of different sounds in Blumlein recordings with almost the same accuracy as one can live, whereas this information can rarely be simulated convincingly in multimic. Lastly, and very importantly, stereo images stay stable and well-centred with Blumlein recordings for most listening positions, whereas multimic recordings tend to hug the nearest speaker away from the stereo seat.

This list of properties of Blumlein recordings is certainly impressive, but we must warn the reader of certain provisos. We require that the recording be made with a crossed pair of figure-of-eights angled between 85° and 90° apart, and suppose that microphones with reasonably accurate figure-of-eight polar diagrams are used. As we shall see, the benefits listed cannot be obtained with arbitrary coincident techniques – coincidence is not of itself a magic prescription of goodness as some of its more dogmatic proponents would suggest. We also suppose that reproduction is via speakers with a particularly good phase response at mid frequencies (such as Quads or Tannoys), as poor phase response tends to mangle the effect of reverberation. (We note in passing that many cheap single unit speakers are good in mid frequency phase behaviour, leading to the apparent paradox that the cheapest equipment can sometimes give superior stereo effect over some of the most expensive equipment.)

The fact that the 'magic' properties of Blumlein recordings are solely due to their handling of reverberation is easy to demonstrate. I have heard Blumlein recordings made in the open air in the middle of fields (with windshields!) and these non-reverberant recordings are as unstable in their stereo effect I as any panpot recording.

Having established that certain types of stereo reverberation can lock and stabilise stereo images, the next thing is to enquire what properties of the reverberation are being used by the ears to produce this effect. Once we have this knowledge, we can try and recreate the same advantages artificially on multimic recordings. We are handicapped first of all by the fact that we really have no understanding whatsoever of how the ear uses the directional qualities of reverberation, even though this was the whole *raison d'être* for stereo in the early days (1930-1958) when much research on directional hearing was done. This ignorance becomes somewhat less surprising when one asks oneself how on earth one would conduct experiments to isolate the effect on the ears of reverberation with various controlled directional characteristics. We simply cannot provide a listener with such controlled reverberations for two good reasons. We cannot set up a simulation of very complex multidirectional reverberation outside of the most sophisticated computers at great expense or reproduce it without literally millions of amplifiers and speakers. Neither can we take a very complex spatial pattern of reverberation and characterise it by a few parameters. It is clearly necessary to be able to give a *simple* description of reverberation's essential properties if we are to study the effect of varying these in a small number of experiments!

Having pleaded profound ignorance, there is a way in which the effect of the directional properties of reverberation can be studied. This is to take recordings of a known reverberant room using various stereo microphone techniques, and to use mathematical analysis to compute the theoretical directional distribution of reverberation energy within the stereo recording. One can then attempt to correlate this distribution of reverberation with the subjective reactions of the listener.

A problem arises in computing the theoretical distribution of reverberation energy for stereo recordings. The computations themselves are somewhat lengthy but quite feasible, but in order to know how much of the reverberation energy lies between two given reproduced directions, one also has to know the precise apparent reproduced direction of a sound recorded in each panpot location in a stereo image. Strange to relate, given the billion dollar nature of the stereo industry's turnover, there is no agreement as to what the reproduced direction is of a sound recorded so many dB up on one channel relative to the other channel. Different experimenters get wildly differing answers (see ref 1).

For this reason, we shall not describe the apparent distribution of reverberation energy versus direction for various types of stereo recording. Instead we shall describe the distribution of reverberation energy versus the direction of stylus motion. Each position within a stereo recording corresponds to a direction of motion of a stylus tracing a gramophone record of that recording. A front centre sound (see Fig 2) corresponds to a stylus motion that is horizontal, a sound on the left channel causes a stylus motion 45° above horizontal, an out-of-phase sound causes a stylus motion 90° above horizontal (or –90°), and a right-channel sound corresponds to a motion –45° from horizontal.

The computed distributions of reverberation versus direction of stylus motion for various coincident microphone techniques are shown in Figs 3, 4 and 5. These results were first reported in ref 2. Fig 3 shows the distribution of reverberation energy for crossed pairs of figures-of-eights, angled apart by 120°, 90° and 60°. Fig 4 shows the distribution of reverberation energy in a stereo recording made with MS technique using a cardioid for the M signal. The three curves given correspond to different S gains, corresponding to an acceptance angle (*ie* the angle around the microphone between a sound picked up only on the left mic and a sound picked up only on the right mic) of 90°, 141° and 180°. Fig 5 shows the reverberation energy distribution of angled cardioid microphones for intermicrophone angles of 180°, 120° and 90°. Note that, as is to be expected, cardioids pick up no reverberation that is out-of-phase. All these curves show the reverb energy in arbitrary units, and assume that the microphones are coincident (by which we do *not* mean spaced 20cm apart!).

Now the interesting thing about these curves is this: the best stereo image stability and sense of distance behind the loudspeakers is always obtained if the reverberation distribution curve of the microphone technique is as flat as possible. Thus the pure Blumlein technique (90° angled figure-of-eights) as in the centre curve of Fig 3 is particularly good in this regard. The MS technique using cardioid M and an acceptance angle of 140° (central curve of Fig 4) is also pretty fiat for in-phase positions, and gives the best image stability and depth for MS techniques, although the stability is not as good as pure Blumlein technique. 120° angled cardioids have the flattest reverb distribution curve available for cardioids (see Fig 5) and so is the best behaved cardioid technique (which agrees with some BBC findings).

On the other hand, if reverberation distributions occur which are somewhat emphasised at the edges and the out-of-phase positions (top curves in Figs 3, 4 and 5), then the reverb tends to be concentrated at two 'pools' near the two loudspeakers, leaving a nasty hole in the middle with poor image stability. Conversely, if a somewhat centre-biased reverb distribution occurs (lower curves in Figs 3, 4 and 5), then the sound tends to be somewhat 'close' and mono-ish. In practice, it is found that the optimal reverb distribution is fairly critical; an error in the difference gain of about ±1dB being the maximum before the advantages of optimal reverb start disappearing. Thus it is hardly surprising that there is so much disagreement about the merits of coincident microphone technique, and it must be considered the hand of a smiling providence that the 'standard' Blumlein technique, recommended by Blumlein in 1931 (see ref 3) happens to be optimal in stereo stability and accuracy of stereo positioning in depth as well as width (see Fig 6). Indeed, the surviving first-ever experimental disc of Blumlein using this technique from the early thirties is distinguished by a quality of stereo imaging that most modern recordings cannot rival.

Presumably other factors besides reverb distribution come into play, but at present we have only the most rudimentary idea of the role of such factors as the delay and direction of arrival of the first few initial reflections. We know that they are of some importance, but not much else.

We can clearly get the advantages of Blumlein technique in multitrack work by using Blumlein technique for laying down individual stereo 'tracks', and where this is practical (*eg* for a folk singer with guitar only, or for a backing chorus that would in any case be mixed down to one or two tracks) it is in fact a good idea. Blumlein technique, however, does not take kindly to subsequent processing (artificial reverb, compression) or to mixing with spot mics trained on the *same* group of musicians at the same time. Also, Blumlein technique requires at least a tolerable quality of acoustic. Naturally, to take advantage of reflected sounds, the Blumlein mics should not be placed *very* close. Those who have tried Blumlein technique in multimic work under these conditions report that indeed most of the claimed advantages are realised, namely the ability to hear 'inner lines' very well to obtain a wide internal dynamics, and improved stereo imaging and stability.

Using Blumlein technique is often impractical in multitrack work because of the need for processing, good separation, poor studio acoustics or the lack of a 48 track recorder. So we now describe a technique for adding artificially many of the advantages of Blumlein technique to a panpot recording. Essentially this technique is to add to the stereo mixdown a stereo reverb signal derived via a Blumlein microphone pair.

In most cases we do not want to add a bathroom or concert hall acoustic to a pop recording, so that we must choose a room to provide a reverberation that has acoustics typical of a good domestic room, with a reverb time of around, say, 0.4s. The room must also be quiet and have an uncoloured acoustic. A well designed control room might well fulfil these requirements; alternatively one might have to provide a suitable room for this specific purpose. The reflections should not be from excessively smooth or regular surfaces, and a certain amount of reflecting 'junk' scattered around the room is acoustically helpful.

The basic set-up is shown in Fig 7, and consists of a loudspeaker fed by a mono mixdown picked up by a Blumlein pair, this to be mixed with the usual stereo mixdown. The speaker and microphone signals may be equalised, as may the direct stereo signal. These equalisations, when used, serve several functions. Firstly, smallish rooms tend to have a somewhat coloured reverb in the bass, and this coloration tends to be worse when the reverb and direct signals are mixed. Thus it is helpful to attenuate the bass in the reverb path, and possibly to boost it in the direct path enough to re-flatten the bass response. The situation is somewhat different in the treble, as there is now considerable evidence that the subjective frequency response of sounds in the treble is determined mainly by the direct sound. Thus the direct path should have a flat frequency response in the treble, and the reverb response should be shaped for best effect (normally a gentle treble cut). The equalisation of the mics and speaker should be chosen to ensure best signal-to-noise ratio for the power handling capacity of the speaker at moderate distortion levels. Thus if the speaker can handle a lot of bass cleanly, all bass cut used should be in the mic output paths, whereas if they can handle little bass, the bass cut should be in the speaker feed.

The arrangement just described is inadequate in so far as it not only picks up reverberation, but also delayed direct sound travelling between the speaker and the mics. As we commented earlier, the first few reflections or delayed sounds are important for good stereo imaging, and it is clearly undesirable to provide gratuitously such a strong 'first reflection' that is so patently artificial. Also, the interference between the direct feed and first delayed sound will cause bad coloration.

For this reason, we eliminate the direct sound between speaker and mics by using a figure-of-eight *loudspeaker*! There is one excellent such speaker on the market: the Quad electrostatic. If (see Fig 8) we place the Blumlein microphone array in the null-plane of the speaker (*ie* in the plane of its diaphragm), then at least in theory no direct sound can reach the mics. We can reduce the direct pick-up even further by arranging that the common null direction of the two microphones (*ie* the axis perpendicular to the plane in which the microphones are pointing) points at the loudspeaker's centre. This way it should be easy to get an attenuation of 30dB for the direct sound path. This good attenuation makes it possible for the microphones to be placed quite close to the speaker, say within 1½ metres of the speaker's centre. This has the advantage that there is not a delay of 10ms or so before the first reverb sounds arrive after the direct feed. Such a delay would provide definitely erroneous 'first reflection' information, whereas placement close to the speaker provides a more natural effect.

With this arrangement (which should also be suitable for use in ordinary reverb chambers) we may provide quite a reasonable stabilising Blumlein reverberation to panpot recordings. We note the commonsense point that the direction in which the Blumlein pair points should be chosen to avoid channel asymmetries due to the positions of floors, ceilings and walls. It is useful when setting up to monitor the Blumlein mic output on an XY oscilloscope display, to make sure it has the correct more-or-less circular ball-of-wool appearance, and to adjust the relationship of the speaker and mics to the room till best results are achieved.

The amount of derived Blumlein reverb required to stabilize the image is quite large, and will have larger energy than the direct feed. The exact reverb level is a compromise between inadequate image stability (too little reverb) and an unpleasantly over-reverberant sound. To monitor image stability, a listener sitting in the stereo seat should sway from side to side over a distance of a metre or so, and note whether 'centre' images stay centred. One advantage of adding Blumlein reverb is that a definite sense of wide stereoism is obtained even if the direct sound image is narrow, which gives the producer an option not normally available. 'Blumleinised' recordings are also particularly suitable for regular matrix quadraphonic reproduction.

There are many evident variants of this technique. For example, we could use more than one loudspeaker, placing the various figure-of-eight loudspeakers in different locations around the microphones, taking care to ensure that all the speaker nulls point at the microphones (Fig 9). This arrangement requires that each loudspeaker be fed with different tracks contributing to the mixdown, the diversity of speaker positions contributing a diversity of reverberant field. Two points should be borne in mind: firstly the overall levels of the balance will be determined mainly by the levels fed to the speakers. This is because the reverb contributes most of the energy, and because the level picked up by the microphones does not depend on the speaker distance, there being no direct sound path. Secondly, the most convincing effect will be obtained if each loudspeaker is placed in that direction around the Blumlein pair (which may now be horizontally-pointing) that corresponds to the same stereo position as the panpotted position of the same sounds in the direct-feed mix. This way, some illusion of spread in space will be obtained, although whether the effect is worth the trouble may be doubted by many. Ideally, the speakers should be 'phased' (Fig 9) so that some sounds do not have reverb of one polarity, some of the other.

The same technique may evidently be used for quadraphonic recording using a properly designed quadraphonic microphone (such as the sound field microphone the author is now developing with the NRDC and Calrec Audio), but here the choice of 'good' microphone technique is even more critically dependent on the correct technical parameters of the microphone system. Although I doubt if it would work, one might also try adding 'dummy head' reverb for headphone listeners in a similar manner.

While the author has conducted some tests with the technique of Figs 7 and 8, he does not have a sufficient range of experience with a wide range of conditions to guarantee the results in all cases. To some extent, the technique of image stabilisation for off-centre listeners must be still regarded as somewhat experimental. It is in order to encourage others to try it and its variants out that this article has been written. Undoubtedly some 'debugging' is still required for practical use. However, one must regard the fact that the effect heard by the public is almost never that intended by the producer as being one of the industry's most serious artistic problems, and anything that may help to overcome this problem deserves an airing.

References

1) H D Harwood, ‘Stereophonic Image Sharpness’, *Wireless World,* pp207-211, July 1968
2) M A Gerzon, ‘Recording Techniques for Multichannel Stereo’, *British Kinematography, Sound and Television,* vol 53, pp274-9, July 1971
3) A D Blumlein, UK Patent 394,325 (14 Dec 1931).

Further Reading

B Bauer, 'Some Techniques Towards Better Stereophonic Perspective', *IRE Transactions on Audio,* vol 11, pp88-92, 1963

M A Gerzon, 'Synthetic Stereo Reverberation', *Studio Sound*, December 1971 and January 1972

M A Gerzon, 'Why Coincident Microphones', *Studio Sound,* March 1971

FIG. 1A BLUMLEIN TECHNIQUE ON DIRECT SOUNDS

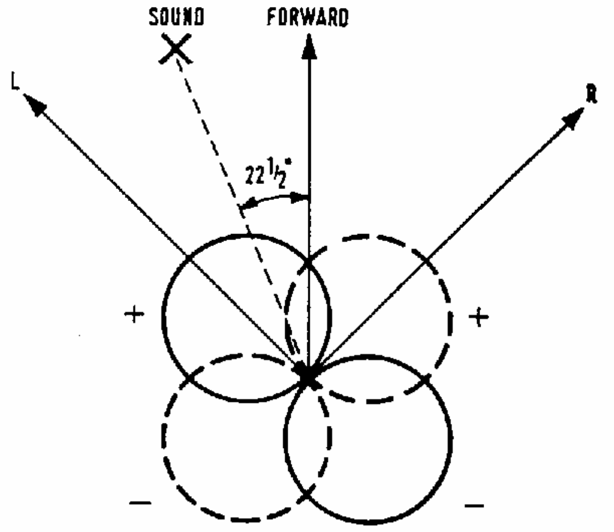

FIG. 1B BLUMLEIN TECHNIQUE ACTS AS A PANPOT ON DIRECT SOUNDS

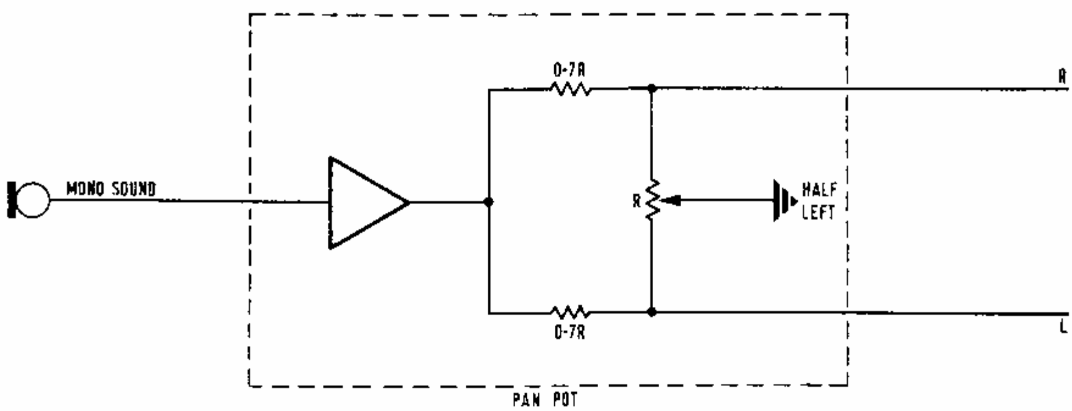

FIG. 2 STYLUS MOTIONS FOR VARIOUS STEREO POSITIONS

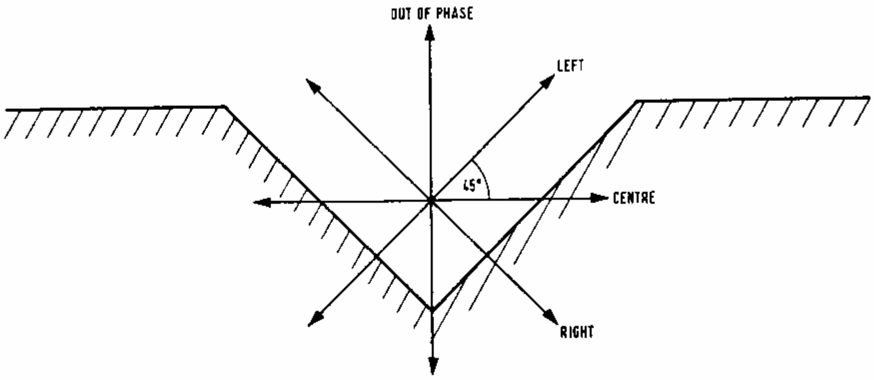

FIG. 3 FIGURE-OF-EIGHT REVERBERATION DISTRIBUTION

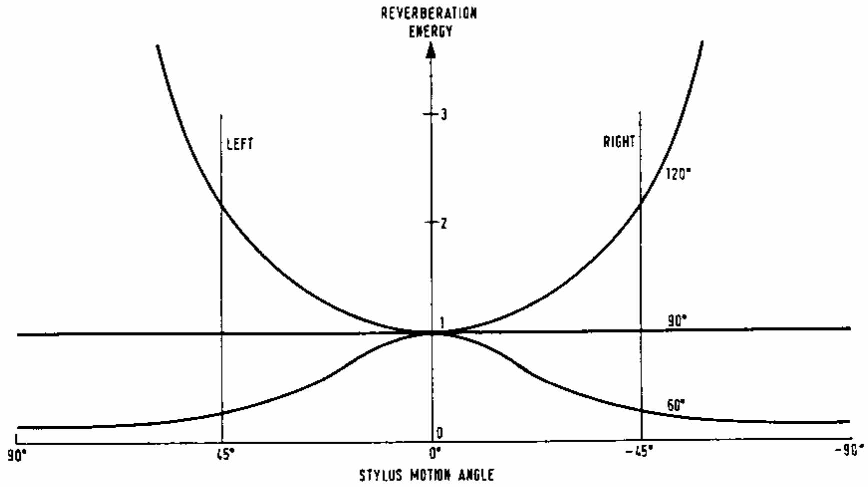

FIG. 4 MS TECHNIQUE REVERBERATION DISTRIBUTION

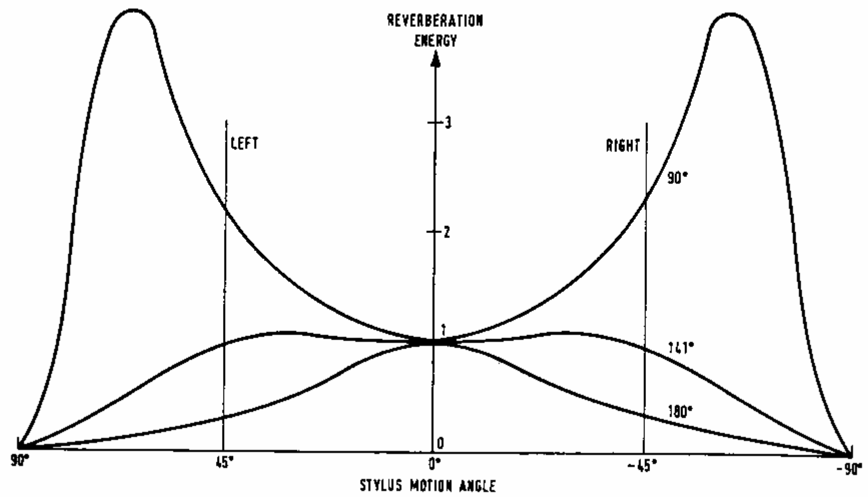

FIG. 5 CARDIOID REVERBERATION DISTRIBUTION

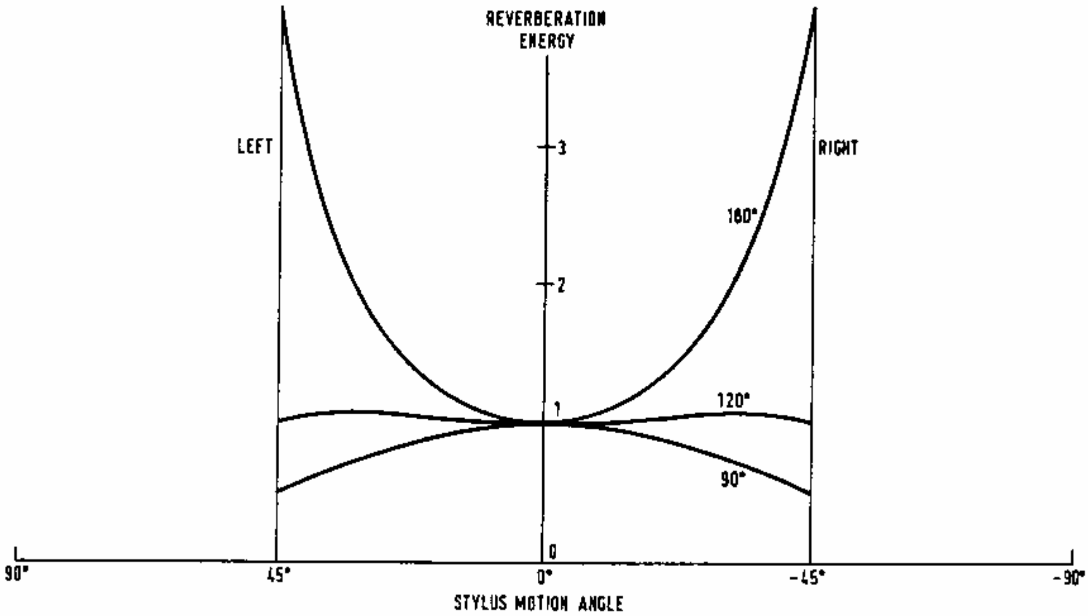

FIG. 6 STEREO SOUND STAGE INCLUDING BOTH DIRECTION Θ AND DISTANCE D. D-INFORMATION IS MISSING IN CONVENTIONAL PANPOT SIGNAL.

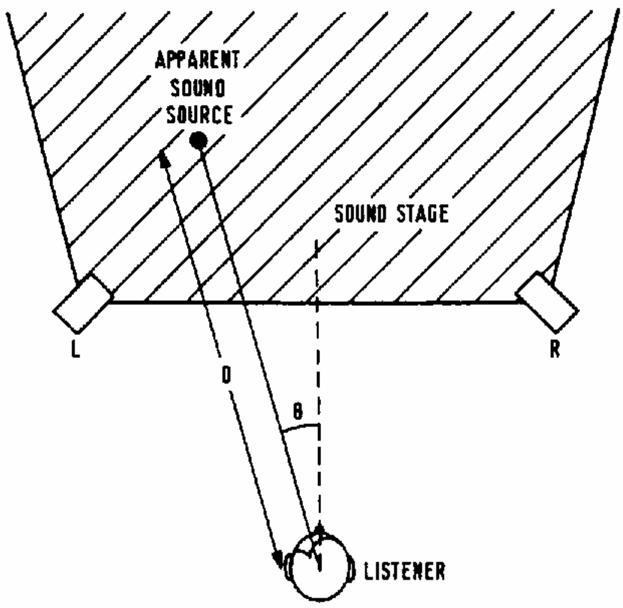

FIG. 7 ADDING BLUMLEIN REVERB TO A MIXDOWN

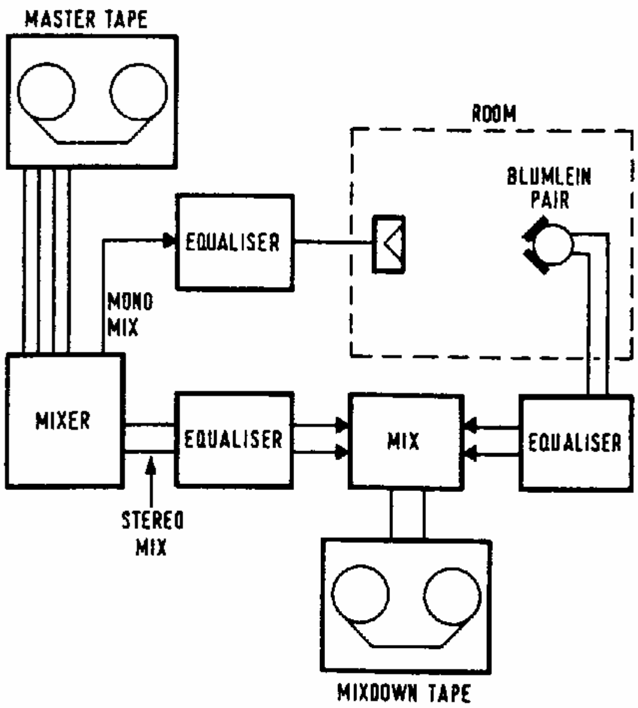

FIG. 8 ACOUSTIC ARRANGEMENT FOR BLUMLEIN REVERB

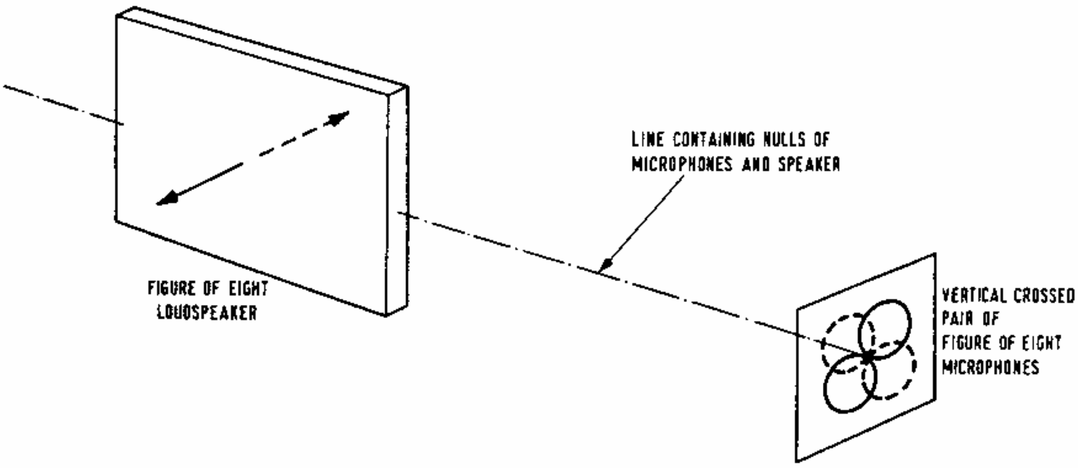

FIG. 9 MULTISPEAKER BLUMLEIN REVERB ARRANGEMENT (SEEN FROM ABOVE)