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[54] SOUND REPRODUCING SYSTEM FOR A FOUR SPEAKER STEREO UTILIZING SIGNAL EXPANSION AND SIGNAL DELAY

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[52] **U.S. Cl.** .....**179/1 G, 179/1 J**

[51] **Int. Cl.** **H04r 5/00**

[58] **Field of Search** .....179/15 BT, 1 G, 1 GP, 1 JP

[56] **References Cited**

UNITED STATES PATENTS

3,229,038	1/1966	Richter	179/1 G
2,343,471	3/1944	Nixon	179/1 G

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[57] **ABSTRACT**

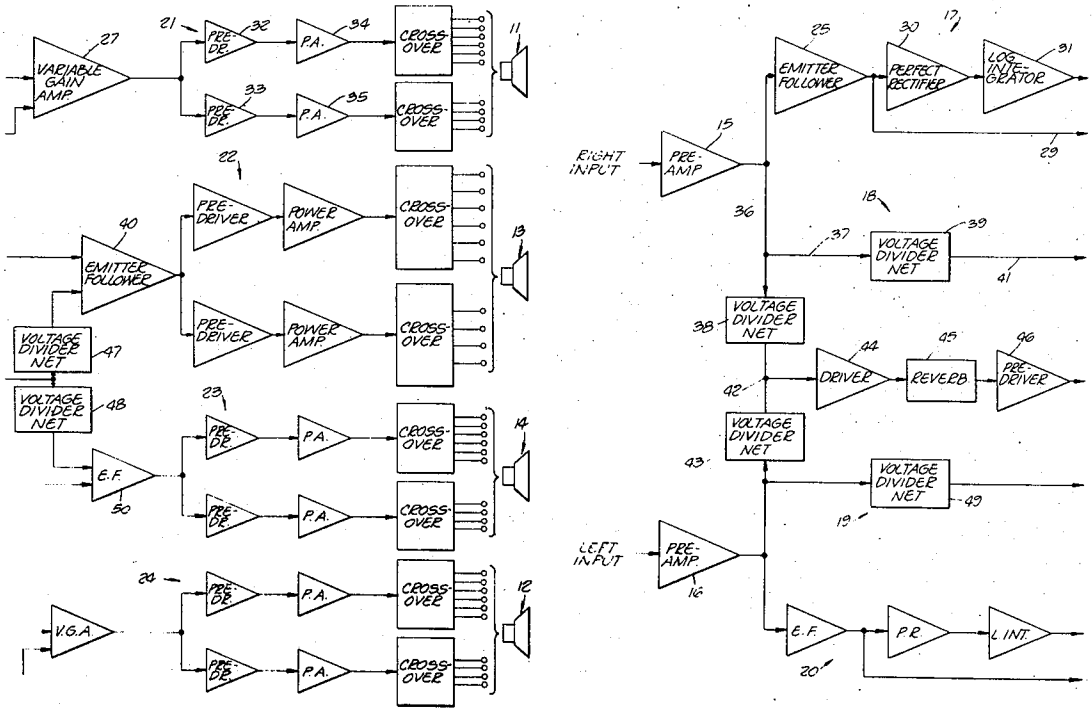
Four speaker systems are arranged at the corners of a rectangle encompassing the listener; two at the front of the listening area and two at the rear. The input sound information is converted into four separate and individual channels which are connected to the respective four speaker systems.

The sound information is, first of all, directed along a first branch to a variable gain amplifier, after which it enters a conventional preamplifier and power amplifier for energizing one of the front speaker systems. The sound is also supplied to a second branch for rectification and integration, after which it is connected to the input of the variable gain amplifier of the first branch. The original sound signal is similarly treated in a further channel and applied to the other front speaker systems.

Each of the rear speaker systems is provided with energization input from the sound signals and admixed with active delay.

The present invention pertains generally to a sound reproducing system, and, more particularly, to a sound reproducing system in which a plurality of speaker systems arranged in surrounding relationship to the listener are provided with separate energization that is selectively controlled to recreate true recording ambience or produce a unique listening environment.

10 Claims, 3 Drawing Figures



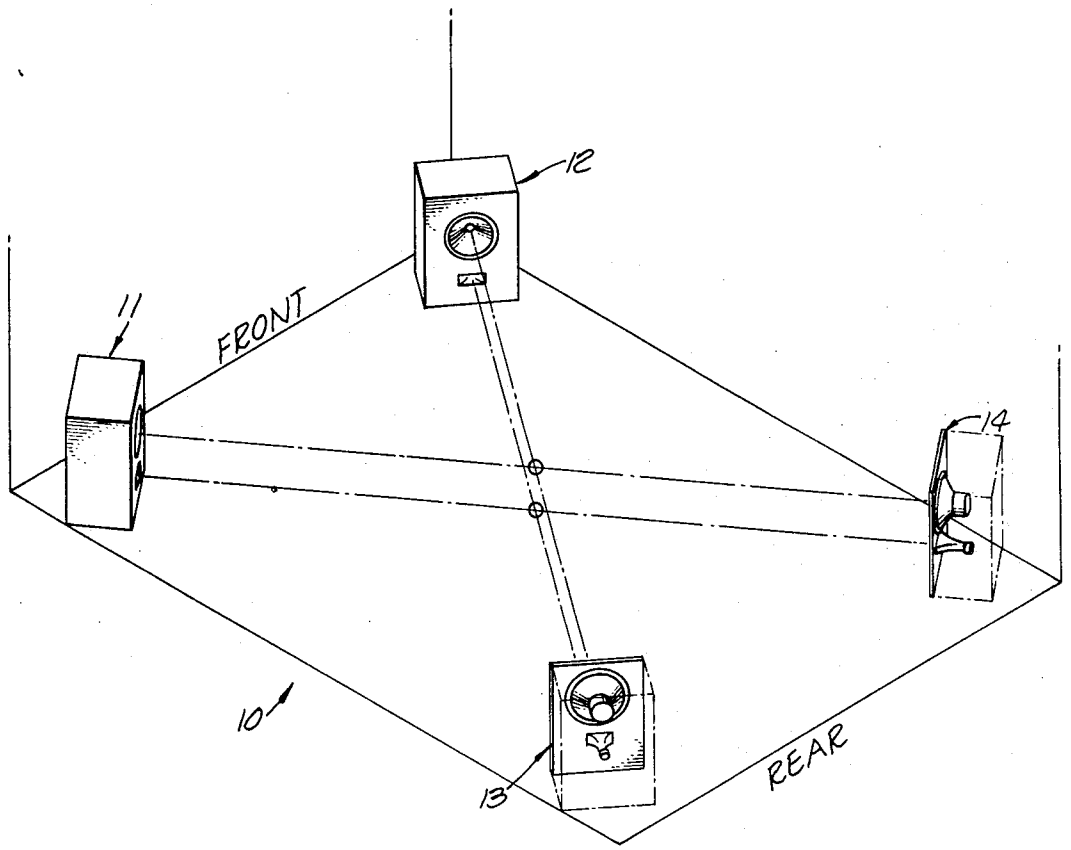


FIG. 1.

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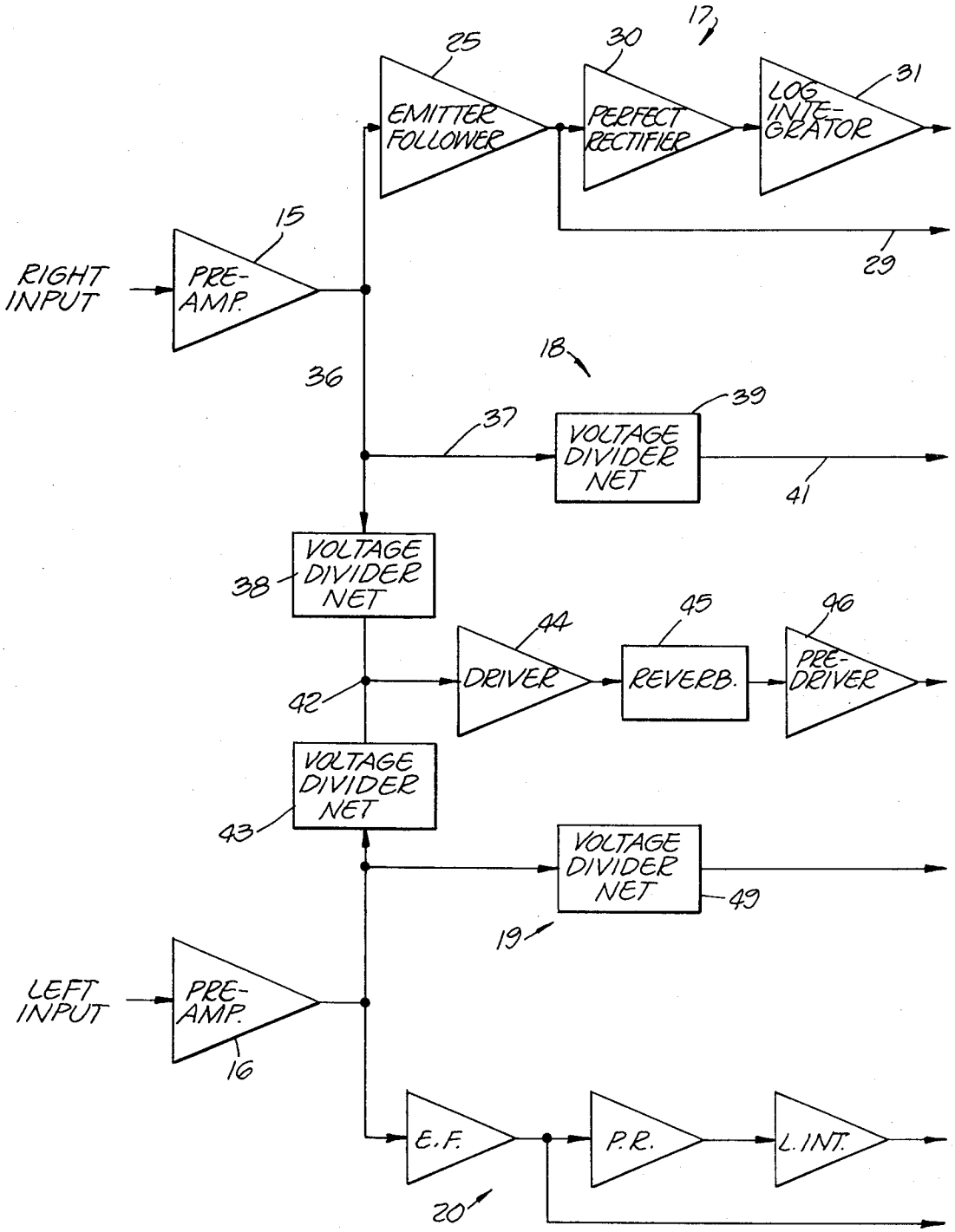


FIG. 2a.

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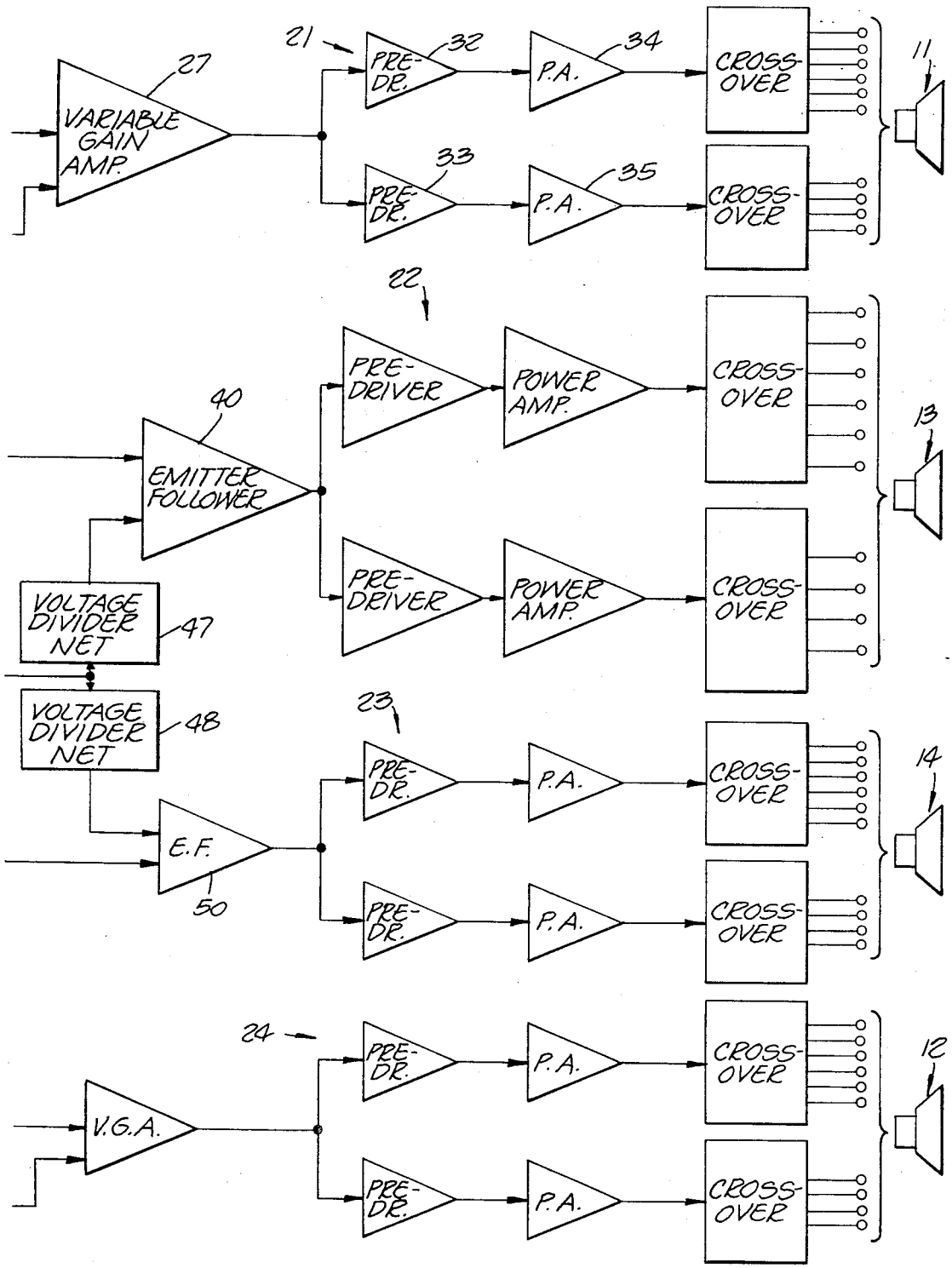


FIG. 2b.

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SOUND REPRODUCING SYSTEM FOR A FOUR SPEAKER STEREO UTILIZING SIGNAL EXPANSION AND SIGNAL DELAY

BACKGROUND OF THE INVENTION

In the recording of sound and the reproduction of recorded sound, it is the primary aim to provide for the listener sound which as closely approximates the sound originally recorded as possible. In recording studios elaborate precautions are taken to insure that the sound recorded is free from unnecessary and undesirable noise and effects which would impair the fidelity of recording. Even so, the best of reproducing equipment known to date still does not provide for the listener the complete recording environment, but leaves out one or more dimensions depending upon the type of reproducing equipment used.

The essential difficulty is that in a recording studio sound recording is effected in a three-dimensional environment, whereas all known reproduction systems are unable to reproduce the full dimensionality of the original recording environment. That is, all known past reproducing equipment has merely included audio signal generating apparatus, preamplifiers, amplifiers and speaker systems and have not been able to provide true environmental reproduction flexibility. The best monaural system can only produce sound emanating from a single, relatively restricted source, and therefore provides sound traveling along a single direction. Although stereo is generally accorded to be a vast improvement over monaural, it still can only offer sound coming from two sources, and is therefore only a two-dimensional approximation of the recording environment. Other past attempts to increase the dimensionality of reproduction have included multiple or four-channel stereo systems in which a number of speaker arrangements encompass the listener striving to achieve natural studio listening. However, none of the multiple channel approaches do more than provide an improved stereo effect, and do not fully increase the dimension capability of reproduction. That is, in all known prior sound reproduction systems there has been no true capability to reproduce for the listener the true recording environment of instrumental sounds, for example, and reflections in the studio, both from side to side and from front to back, as well as emphasizing harmonics which may be lost in the recording.

The need for this three-dimensional quality is even more readily appreciated in sound recordings for motion pictures, or in any theatrical performance where sound is provided taken from an original full or three-dimension environment. For example, the sound of thunder or cannon firing to be genuinely realistic should appear to roll across the audience and not merely originate from a fixed source or from several such sources.

It is also highly desirable to be able to modify a recording by adding dimension and effects to the reproduction. This applies to musical recordings as well as dramatic sound recordings. Monaural recordings reproduced in further dimensions has its esthetic enjoyment considerably enhanced. Of course, for dramatic effect it may be desirable to modify a recording to something other than true studio ambience, and the ability to do this through movement of the sound along

different directions in an auditorium according to a prescribed program was totally lacking in prior known systems.

OBJECTS AND SUMMARY OF THE INVENTION

It is, therefore, a primary aim and object of the present invention to provide a sound reproducing system in which four speaker systems are in surrounding relationship to the listener and each energized individually with sound information at selectively modifiable times and of variable quality and expansion.

Another object is the provision of a sound reproducing system having a four-channel output with a distinct degree of separation available to the channels, or pairs of channels, irrespective of whether the sound recording is monaural, stereo or multiple track stereo.

A still further object is the provision of a sound reproducing system as in the above objects in which the speaker systems are arranged at the four corners of a room and separation of signals for each channel causes the sound to appear to move across the room.

Yet another object is the provision of a sound reproducing system that creates movement of the reproduced sound in a three-dimensional pattern closely approximating that existing during its recording.

Another object is the provision of a sound reproducing system that can create a unique listening environment of improved character for recordings of monaural, stereo or multiple track stereo variety.

A further object is emphasizing harmonics in the reproduced sound which are removed during recording.

In accordance with the practice of this invention, four speaker systems are utilized, arranged at the corners of a rectangle encompassing the listener. For purposes of orientation assume two of the speaker sets are at the front of the listening area and two are at the rear. With a stereo recording, the input sound information is converted into four separate and individual channels which are connected to the respective four speaker sets.

One of the stereo signals is fed along two branches. The first branch interconnects with a variable gain amplifier after which it enters a conventional preamplifier and power amplifier prior to energizing one of the front speaker sets. The second branch after being rectified and integrated is applied to the input of the variable gain amplifier of the first branch. The signal processing accomplished in the first channel is one of high-speed expansion for incoming signals exceeding a predetermined threshold. The other stereo signal is similarly treated and applied to the remaining front speaker set.

Each of the rear speaker sets is provided with energization comprising input from one of the respective stereo signals and an admixed signal from the other stereo signal with active delay.

To the listener, there is the side to side effect from the stereo and, in addition, there is distinctive front to back motion which is proportionally sensed in relation to the instantaneous amplitude, and to a smaller extent the frequency, of the stereo signal. Specifically, sound is heard from the front first with a varying degree of expansion and to a lesser amount from the rear speaker sets without expansion. Finally, the rear speaker sets provide the sound with active delay. This combination

effect is heard by the listener as a full dimension sound with the side to side stereo effect enhanced by an enveloping feeling of the sound irrespective of the location of the listener within the speaker system quadrangle and a decided front to back motion.

For a monaural input, the connections and processing are the same as with a two-track stereo. That is, although the stereo effect is not obtained, the front to back motion and enveloping or surrounding aspect are provided which considerably enhances listening pleasure. With four-track stereo, two of the tracks are applied to the front speaker sets as in two-track operation, and the other two tracks are mixes as described and fed into the rear speaker systems.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic illustration of a room in which four speaker sets or systems are arranged to define the listening space.

FIGS. **2***a* and **2***b* are a block diagram of the system of this invention for driving the speaker set arrangement shown in FIG. **1**.

DESCRIPTION OF A PREFERRED EMBODIMENT

With reference now to the drawings and particularly FIG. **1**, a room **10** generally defining the listening area, or more properly the hearing volume, includes a FRONT and REAR which are arbitrary designations for purposes of illustrating operation of the invention. Each of the corners of the room is provided with a separate speaker system, namely, speaker systems **11** and **12** in the front corners of the room and speaker systems **13** and **14** in the rear corners. Each of the speaker systems are oriented such that sound produced is directed toward the diagonally opposite corner.

It is important to note that although the speaker systems are depicted located in a room having side walls and a ceiling, this is not necessary for operation of the invention. The speaker systems may be arranged in open air, for example, and the various effects described herein are still obtained. Also, as shown in FIG. **1**, the speaker systems are shown at floor level as would be the usual case for a home installation. However, equally good results are obtained with the speaker systems arranged in the upper corners of a room, for example, the only adjustment required being that the speakers should be angled downwardly toward the listener. This latter speaker system arrangement would be most typical in a theater or auditorium.

Reference is now made to FIGS. **2***a* and **2***b* and the circuital aspects of the invention. For the ensuing description it will be assumed that the audio signal information source is a conventional two-track stereo recording identified in the drawings as RIGHT INPUT and LEFT INPUT.

After the stereo signals are individually amplified in the preamplifiers **15** and **16**, they are formed into four separate channels **17–20** for driving the respective power amplifying means **21–24** of the speaker systems **11**, **13**, **14** and **12**.

The channels **17** and **20** are identically constructed and therefore the circuit details and operation for only the channel **17** will be given. The output of preamplifier **15** is fed into a conventional emitter follower **25** via lead **26**. The emitter follower output signal is split into two branches, both of which are applied to the input of a variable gain amplifier **27**. The first branch consists of a lead **29** interconnecting the emitter follower output with the input of the variable gain amplifier. The second branch includes, in serial relation, a rectifying means **30** also termed a perfect rectifier and a logarithmic integrator **31**.

The term perfect rectifier has been selected to emphasize the fact that the rectifying means **30** must not only be able to pass signals of one polarity while blocking signals of the opposite polarity, but also must not distort either the amplitude or phase of the signals passed. A suitable rectifying means for this purpose has been a closed-loop gain operational amplifier with a rectifier in its feedback loop and having intermodulation distortion not exceeding about 0.1 percent.

The integrated output of **31** is thus an expanded rectified expression of the stereo signal (RIGHT INPUT) which is additively applied to the variable gain amplifier **27** with the full stereo signal made available via **29**. The amount of expansion provided will depend upon, and in fact is substantially proportional to the instantaneous amplitude of the stereo signal. That is, whereas the lower amplitude signals experience little expansion, the higher ones (such as a cymbal crash) are expanded proportionately greater. Moreover, since the rectifying means in substantially distortion-free in transmitting characteristics, there is full fidelity in sine wave reproduction during expansion.

Although other power amplifying arrangements may be used, in the illustrated embodiment each speaker system includes a pair of speaker units requiring two predrivers **32** and **33**, two power amplifiers **34** and **35** (P. A.), and two cross-over networks **36** and **37** which feed into the speaker units.

Since channel **20** which powers speaker system **12** is identical to channel **17** described above except energized by other stereo signal, LEFT INPUT, the two speaker systems at the front of the room or other listening area provide the respective stereo signals with expansion. That is, the listener hears the sound from the front speakers first and it is provided with random expansion in the manner already described.

The signal from the preamplifier **15** is also directed at the same time via leads **36** and **37** to voltage divider networks **38** and **39** where the signal is ratioed off to approximately 30 percent and 70 percent, respectively. The larger signal from the network **39** is directly presented to an emitter follower **40**, the output of which is used to energize the amplifying means **22** for the speaker system **13**.

The smaller signal at the output of network **38** is applied to circuit point **42** along with an approximately 30 percent signal from the LEFT INPUT stereo preamplifier **16** via a further voltage divider network **43**. The mixed signal at **42** is presented to driver **44** which drives a reverberator **45**. The reverberated mixed stereo signals are fed to a pre-driver **46** which through a pair of voltage divider networks **47** and **48** applies a 50 percent attenuated signal to the emitter follower **40**. Accordingly, speaker system **13** is driven by a combination signal consisting of approximately 70 percent of the RIGHT INPUT stereo information and a reverberated component of mixed 30 percent signals from both the RIGHT INPUT and LEFT INPUT stereo intel-

ligence. This prescribed mixture provides ambience to the listener.

In a manner similar to that for the speaker system **13**, the LEFT INPUT stereo is applied in approximately 70 percent strength via the voltage divider networks **43** and **49** to an emitter follower **50** (E. F.), another signal applied thereto in additive relation being a 30 percent reverberation signal through the voltage divider network **48**. As in the case of channel **18**, the emitter follower **50** powers the amplifying means **23** for the speaker system **14**.

All persons situated in the listening area accordingly first hear sound from the front speaker systems **11** and **12**. Next, the same audio information is heard substantially unchanged and substantially at the same time from the rear speaker systems **13** and **14**, only at a slightly reduced degree (70 percent). Finally, the 30 percent mixed signal is heard at the rear speaker systems at a slightly later time dependent upon the reverberation parameters.

As an example of operation of the invention, assume a stereo recording of a trumpet and kettle drum where the trumpet was located toward the right of the microphone in the recording studio and the kettle drum toward the left. On reproduction by the described system, since the trumpet is relatively high in frequency range, the trumpet audio signals will experience a correspondingly high expansion in channels **17** and **20** and as long as they are reasonably constant the trumpet sound will be prominent at the front of the hearing region. That is, although there will be a 70 percent signal provided at the rear, the expansion will produce a decided emphasis at the front.

The kettle drum audio signals on the other hand, have a much lower frequency and experience considerably less expansion than the trumpet. This results first of all in the kettle drum being heard with relatively equal prominence at the front and at the rear. In addition, at the conclusion of a kettle drum beat or passage, the active delay provides a slightly delayed repetition at the rear, giving the effect of front to rear motion for the kettle drum part. The total effect experienced by the listener is one of being surrounded by the music with the trumpet music emphasized at the front and the kettle drum appearing to move across the listener in a front to back direction.

An illustration of an unusual effect which can be produced by the described system is that of having the sound appear to be moving in a circle about the listening area. For example, a stereo recording of a speeding automobile passing by from, say, left to right, will sound very much as if the auto were driving in a circle about the listener. That is, first the auto is heard at the left front speaker and moves to the right front speaker system. However, on the left front speaker system dropping out quickly, the active delay produces further delayed reproduction at the left rear system and, similarly, after the right front system drops out, the right rear units are delay activated. This sequence of events in its totality provides the listener with the impression that the auto is circling him.

There is provided in accordance with the practice of this invention a true quadraphonic sound reproduction system which creates in full dimension the studio sound recording ambience including front to back sound motion as well as side to side stereo effects. Although as described herein expansion and active delay are produced in a generally random manner depending on the instantaneous amplitude and frequency of recorded information, it is within the contemplation of this invention to effect a predetermined amount of expansion and delay to produce for the listener a unique sound environment. More particularly, a program control may be associated with the log integrators **31** for the channels **17** and **20** and also the reverberation means **45** for controlling the amount of expansion and delay to any degree and any number of desired times throughout a given sound reproduction. All in all, such program control provides substantially infinite possibilities for artistic expression in the reproduction of recorded sound information.

What is claimed is:

1. A sound reproducing system for a listening region defined by four mutually spaced speaker arrangements, two at the front part of the region and two at a rear part, energization therefor being provided from a source of audio information signals, comprising:

separate power amplifying means connected to each speaker arrangement;

first and second expander circuits interconnecting the audio information signal source and the respective amplifying means for the two front speaker arrangements;

first and second circuit means respectively interconnecting the audio signal source and the amplifying means for the rear speaker arrangements providing an attenuated audio signal thereto;

signal delay means connected to the amplifying means of both said rear speaker arrangements; and

third circuit means interconnecting said audio source and signal delay means for energizing said delay means with attenuated audio information signals.

2. A sound reproducing system as in claim **1**, in which said expander circuits each include a variable gain amplifier having its output connected to the respective front amplifying means; a first branch circuit connecting the audio source to the variable amplifier input; and a second branch circuit including, in series, rectifying means, and an integrating means, said second branch circuit interconnecting the variable gain amplifier with said audio source.

3. A sound reproducing system as in claim **1**, in which said first and second circuit means each include a voltage divider network that attenuates the audio signals to the associated amplifying means not more than approximately one-half.

4. A sound reproducing system as in claim **1**, in which said first and second circuit means produce signals to said amplifying means attenuated to approximately 70 percent of the audio information signals applied from the source to said first and second expander circuits.

5. A sound reproducing system as in claim **1**, in which said third circuit means provides an energizing signal to said delay means which are attenuated to approximately 30 percent of the audio information signals applied from the source to said first and second expander circuits.

6. A sound reproducing system as in claim **1**, in which the source of audio information signals includes

a pair of stereo signals, one of which stereo signals is connected to said first expander circuit, said first circuit means and said third circuit means, and the other stereo signal is connected to said second and third circuit means.

7. A sound reproducing system as in claim 1, in which the source of audio information signals comprises four separate sets of audio signals which are individually connected to said first and second expander circuits and said first and second circuit means, said third circuit means being interconnected with both sets of audio signals that are connected to said first and second circuit means.

8. A sound reproducing system for a rectangular area generally bounded by four speaker arrangements located at the corners thereof, energizing therefor being provided by a pair of stereo audio signals, comprising:

four separate power amplifying means, each having an output connected to an individual speaker arrangement and each having an input;

first and second expansion circuits separately interconnecting the stereo audio signals with two of the power amplifying means corresponding to two adjacent speaker arrangements each expansion circuit including

an amplifier with its output connected to the input of the respective amplifying means,

a first branch circuit connecting the respective stereo audio signals to the amplifier input, and

a second branch circuit having, in series relation and in the order given, rectifying means and a logarithmic integrating means, said second branch circuit interconnecting the amplifier input with said respective stereo audio signals;

first and second circuit means separately interconnecting the stereo audio signals and each of the other two amplifying means, each of said circuit means including a voltage divider network that attenuates the audio signals to a first degree;

reverberation means connected to said other two amplifying means; and

third circuit means interconnecting both said stereo signals and said reverberation means energizing said reverberation means with said audio signals attentuated greater than said first degree of attenuation.

9. A sound reproducing system as in claim 8, in which said first and second circuit means produce signals to said amplifying means attenuated to approximately 70 percent of the audio information signals applied to said first and second expansion circuits.

10. A sound reproducing system as in claim 8, in which said logarithmic integrating means is selectively variable to produce controlled predetermined expansion.

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