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STEREOREPRODUCTION SYSTEM WITH COMMON REVERBERATION AND BASS CENTER CHANNEL

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2 Sheets-Sheet 1

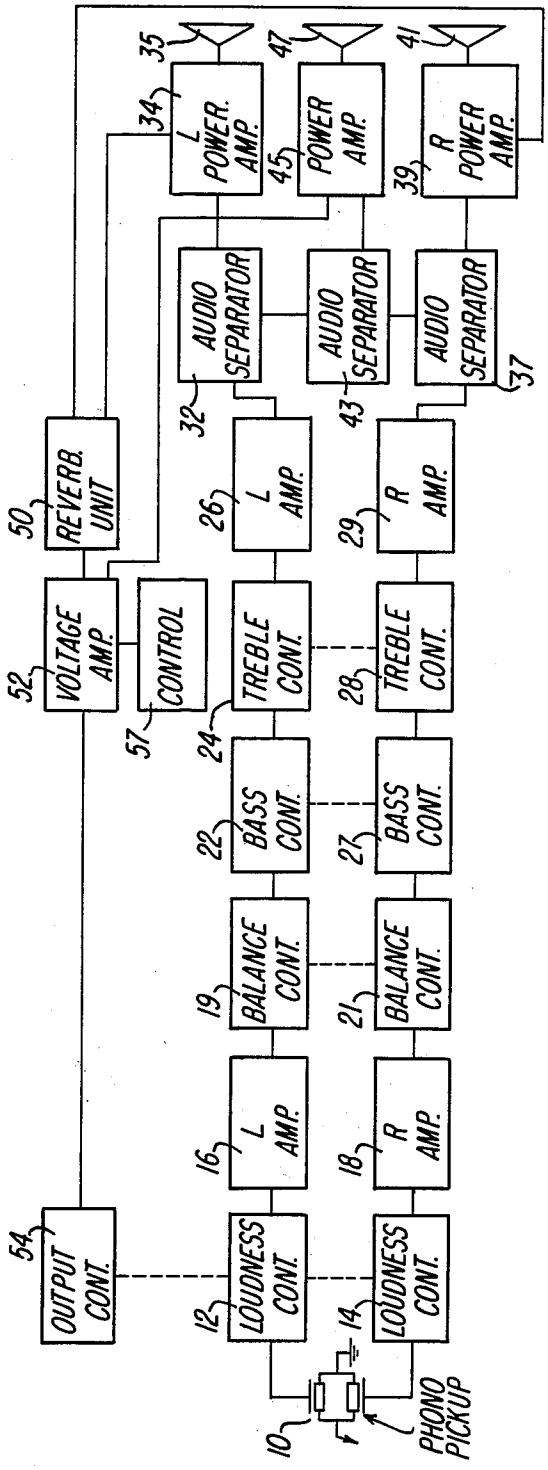


FIG. 1

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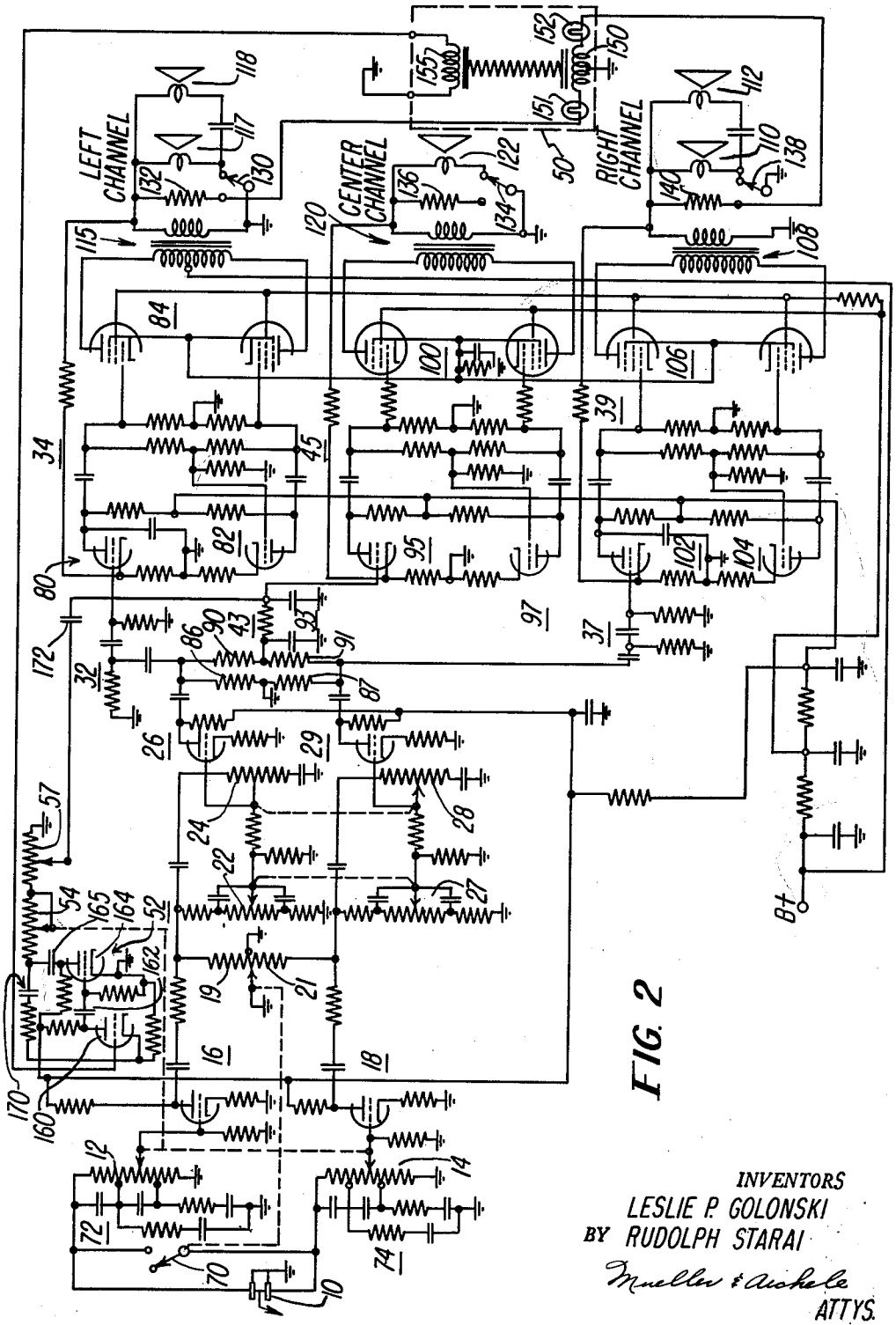


FIG. 2

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STEREO REPRODUCTION SYSTEM WITH COMMON REVERBERATION AND BASS CENTER CHANNEL

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6 Claims. (Cl. 179—100.1)

This invention relates to amplifier systems and more particularly to a stereophonic sound reproducing system such as may be used in playing stereophonic records.

In the present day art of electronic sound reproduction it is possible to obtain a depth or realism in the sound reproduction by using two or more spaced loudspeakers with each speaker simultaneously providing the sound as it existed in the original performance at different spaced locations. These different sounds at such spaced locations generally occur in sound patterns which do not develop from a stationary point source of sound. Thus, differing sounds from the same overall sonic performance can be separately recorded or transmitted and then reproduced individually by spaced sound reproducers in order to provide a more realistic overall pattern for a listener.

Prior stereo sound signal reproducing apparatus often employed two complete amplifier channels, one channel translating signals representing sound to the right of a performance area and one amplifier channel translating singals representing sound to the left of the performance area. As a modification of such two-channel reproducing systems, it has been found possible to utilize three different signal channels with two of the channels translating respectively the higher frequency components of the right and left signal components and the third channel forming a so-called "center" channel translating only the low frequency signal components (for example, below 2 or 3 hundred cycles per second). A system of this form is effective because the low frequency signal components are not subject to any appreciable stereo effect and only the more directive relatively high frequency components need be emitted from spaced sound reproducers to produce the desired sound pattern. Such a system can result in some economy in construction since only one amplifier channel, namely the center channel, need have an extended low frequency range and a relatively high power handling capability for these frequencies.

In a further attempt to achieve "concert hall realism" and for music reproduction especially, it is also possible to introduce a reverberation effect into the sound pattern. This has been accomplished by translating the sound signal components through a device to delay the signal components at a decaying rate for a period of about two seconds and then reproducing such delayed signal components with the necessary additional amplifier and speaker system to add to the main sound pattern an illusion of operation in a large reverberative room such as a concert hall or auditorium.

It is an object of the present invention to reduce the cost of stereophonic-reverberative sound reproducing apparatus by making maximum use of the capabilities of the system amplifiers and components thereof.

Another object is to improve the performance of electronic sound reproducing apparatus for more realistic reproduction of stereophonic signal components, for example, as contained in phonograph recordings.

A feature of the invention is the provision of a three channel stereo-reverberative sound reproducing system in which the so-called center channel is used to translate both low frequency non-stereo sound signal components and delayed signal components for producing a reverberative effect in the overall reproduced sound pattern.

A further feature is the provision of a sound reproducing system in which the relatively high frequency right and left stereo components are translated in different respective amplifier channels and such signal components are also timed delayed at a decaying amplitude to be translated through a center amplifier channel which also translates relatively low frequency signal components associated with both the right and left stereo signal components.

In the drawing:

FIG. 1 is a block diagram illustrating the invention; and

FIG. 2 is a schematic diagram of a particular circuit of the invention.

In a specific embodiment of the reproducing system, right and left stereophonic signal components are derived from a suitable source such as a 45–45 disc phonograph record. These signal components are translated through separate amplifier channels to high pass sections of a separator filter and from there to respective suitable amplifiers and loudspeakers for stereophonic reproduction. The low frequency components from both the right and left stereo signals are derived from a low pass section of the separator filter and applied to a center channel power amplifier and loudspeaker capable of faithful reproduction of such low frequency signal components. A portion of one or both the right and left signal components are derived from the respective channels therefor and applied to a reverberation device for combining these signals and causing the resultant signal to be sustained at a decaying amplitude over a predetermined delay period. The reverberation signal thus formed is applied to the center channel amplifier so that the center channel amplifier translates both the low frequency signal components from the right and left stereo signals as well as reverberative signal components from one or both stereo signals. This system makes maximum use of the capabilities of the center channel amplifier and loudspeaker and also permits less stringent requirements for the separate channels associated with the right and left stereo signal components.

Considering now the invention in greater detail, reference is made to FIG. 1 in which the stereophonic phonograph pickup cartridge **10** is connected to a loudness control **12** and the loudness control **14**. The controls **12** and **14** are ganged in order to simultaneously vary the level of a stereophonic signal which may be derived from a conventional 45–45 disc phonograph record. It will also be understood that other sources of right and left stereophonic signal components may be used with the system.

The left and right signal components are applied respectively to the left preamplifier **16** and the right preamplifier **18**. The outputs of the amplifiers **16** and **18** are coupled respectively to the balance control **19** and the balance control **21**. The controls **19**, **21** may take various forms and are intended to provide the function of varying the gain in one channel with respect to the gain in the other channel in order to compensate for any lack of balance between the two channels and thus produce a total sound pattern in which the left and right signals are in proper relation. The left signal components are then applied respectively through a bass tone control **22**, and a treble tone control **24** to the left channel tone amplifier **26**.

In a corresponding manner the right signal components are applied through the bass tone control **27** (ganged with control **22**) and the treble tone control **28** (ganged with control **24**) to the right channel tone amplifier **29**. The left channel signal components are applied from the tone

amplifier 26 and through a high pass filter section of the audio separator circuit 32 to the left power amplifier 34. Amplifier 34 is connected to a suitable left channel loudspeaker 35. Similarly the right channel tone amplifier 29 is connected through a high pass filter section of the audio separator circuit 37 to the right channel power amplifier 39. The amplifier 39 drives a suitable loudspeaker 41.

The audio separator circuits 32, 37 are both connected to a further audio separator circuit 43 which derives the low frequency signal components from both the right and left channels and combines these to apply a composite low frequency signal to the power amplifier 45. The amplifier 45 may be termed a center channel amplifier and is connected to a suitable loudspeaker 47. It will be understood that the loudspeakers 45, 41 and 47 are all positioned as shown so that the overall sound pattern will be properly established in relation to the pattern which occurred at the original performance. It should be noted that the audio separator circuits 32 and 37 may pass the signal components above approximately 200 cycles per second to the associated amplifiers 34 and 39 since these frequencies are the ones having the maximum affect on the stereophonic reproduction. On the other hand, the lower frequencies below approximately 200 cycles per second are conducted through the audio separator circuit 43 to the power amplifier 45 and these signal components can be reproduced by a single amplifier and speaker system 45, 47 since the relatively low frequency components are substantially non-directive and do not contribute appreciably to the stereophonic effect.

A portion of the left signal components and a portion of the right signal components are derived respectively from the amplifiers 34 and 39 and applied to a reverberation unit 50. The unit 50 may be a transducer device which will combine the right and left signal components to produce a substantially monaural signal and then through suitable electromechanical means will sustain the signal with a decaying amplitude for a reverberation time of approximately one second. The resultant reverberated signal components from the two stereophonic amplifier channels are applied to the voltage amplifier 52 to increase the level thereof and provide some modification of the frequency range of the reverberated signal. An output control 54 is connected to the amplifier 52 and control 54 may be conveniently ganged with the loudness controls 12, 14 in order to reduce the reverberation effect at high volume levels and thereby prevent instability of feedback in the reverberation channel. A gain control 57 is also connected to the amplifier 52 to permit adjustment of the amplitude of the reverberation signal components for varying the amount of reverberation effect to satisfy the desires of a user of the system.

The amplifier 52 is connected to the center channel power amplifier 45 in order to apply the reverberation signal components to this amplifier stage for reproduction by the loudspeaker 47. It will be understood that amplifier 45 is constructed to have relatively high gain at the low frequencies in order to provide sufficient amplification for the signal components representing the principal or non-reverberated signals applied thereto from the left and right amplifier channels. Loudspeaker 47 would preferably be a woofer in order to test reproduce such low frequency signal components. Furthermore, it will be seen that the reverberation signal from the amplifier 52 will contain essentially treble frequencies, but it should be noted that there will be sufficient gain in the amplifiers applying the reverberation signal to the power amplifier 45 that the reverberation signal may be reproduced by the speaker 47 with entirely sufficient power. It should be clear that amplifiers 34 and 39 will translate the lower frequency signal components down to a frequency of the order of 200 cycles per second with some amplitude and that the amplifier 52 may have a frequency range characteristic to provide amplification of signals of this low frequency range. Accordingly, the reproduced reverberation signal may contain frequencies down as low as 200 cycles per second.

It has been determined that frequencies above 5 kc. add little to the reverberation effect and accordingly it is unnecessary to extend the frequency range of the reverberation signal beyond 5,000 cycles per second. Amplifier 52 may thus be constructed so that the frequency response characteristic of the center channel power amplifier 45 and its associated speaker 47 need only extend from a range of about 5,000 cycles per second and downward to the lowest frequency desired in the system. It should be clear from the foregoing that the present system obviates the need for a separate power amplifier and speaker for the reverberation system and at the same time the system retains the advantage of not electrically mixing the original and reverberated signal components which can cause distortion and other undesirable operation of the overall system. The present system utilizes "acoustic" mixing of the main signal and the reverberation signal (in the same frequency range), that is, these signals are mixed in the air after emission from the speakers.

FIG. 2 is a detailed schematic diagram of a particular embodiment of the system shown in FIG. 1. Corresponding portions of the system are given the same reference characters in FIG. 2 as were used in FIG. 1. Considering the salient features of the circuit of FIG. 2, there is a switch 70 which is connected across the output terminals of the pickup cartridge 10 so that by closing the switch these two terminals are connected together and the cartridge will respond to a recording having one track by developing a signal with respect to a reference or ground. With the switch 70 closed the same input signal will be carried by both the right and left amplifier channels and there will be no stereophonic reproduction although the reverberative system will remain operative. Switch 70 may be conveniently operative as part of the balance controls 19, 21.

The loudness controls 12 and 14 are each connected to respective RC networks 72, 74 which provide frequency compensation for different volume levels of operation of the overall reproducing system. The balance controls 19, 21 are a variable potentiometer connected between the output signal points of the left amplifier 16 and the right channel amplifier 18 to regulate the relative gain between these amplifiers. The bass tone controls 22, 27 are ganged together to afford adjustment of the low frequency response of the two channels simultaneously. Similarly, the treble controls 24 and 28 are ganged together and these provide regulation of the high frequency response of both channels. Suitable resistor-capacitor networks are interconnected to each of these controls to permit the described operation in a manner known in the art.

The left tone amplifier 26 is connected to the treble control 24 and the output of the amplifier 26 is coupled through the high pass filter or audio separator 32 to the left driver amplifier 80 in the amplifier 34. A portion of the output from the amplifier 80 is applied to the left phase inverter 82 and the respective outputs of the amplifiers 80, 82 are applied to the push-pull power amplifier stage 84.

The output signal from the left tone amplifier 26 and the right tone amplifier 29 are interconnected through series connected resistors 86, 87 and the junction point of these resistors is coupled to ground. A pair of resistors 90 and 91 are series coupled across the resistors 86, 87 and the junction point of resistors 90, 91 is connected through the low pass filter 93 to the bass driver amplifier 95. A portion of the output of amplifier 95 is applied to the bass phase inverter 97. The output signals from amplifiers 95 and 97 are applied to the center channel push-pull power amplifier 100.

The output signals from the right channel tone ampli-

fier 29 are applied through a high pass filter to the right channel driver amplifier 102. A portion of the output of the amplifier 102 is applied to the phase inverter 104. The output signals from amplifiers 102 and 104 are applied to the push-pull amplifier stage 106. Amplifier stage 106 is coupled through the output transformer 108 to the mid-range loudspeaker 110 and the tweeter loudspeaker 112. Similarly, the output of the push-pull amplifier stage 84 is coupled through the output transformer 115 to the mid-range loudspeaker 117 and the tweeter loudspeaker 118.

The push-pull power amplifier stage 100 is coupled through the output transformer 120 to the woofer loudspeaker 122. It will be understood that left channel loudspeakers 117 and 118 correspond to the loudspeaker 35 shown in FIG. 1, that the loudspeaker 122 of the center channel corresponds to speaker 47 in FIG. 1 and that the speakers 110, 112 correspond to the loudspeaker 41 in FIG. 1.

It should further be noted that each of the power amplifier stages 34, 39 and 45 include feedback from the secondary windings of the respective output transformers to the cathodes of the vacuum tubes in the driver amplifiers of these respective stages. This negative feedback in each of the power amplifiers helps to reduce distortion and provides improved frequency response.

The loudspeakers 117 and 118 are connected to the secondary winding of transformer 115 through a switch 130. In a different position of switch 130 the resistor 132 may be switched across the secondary winding of transformer 115 in place of the loudspeakers in order to provide a substitute load for the left channel power amplifier and to render the loudspeakers 117 and 118 inoperative. Similarly, a switch 134 can be used to connect a resistor 136 across the secondary winding of transformer 120 in place of the loudspeaker 122. Finally a switch 138 can be used to switch a resistor 140 across the secondary winding of transformer 108 in place of the loudspeakers 110 and 112. A user of the system may operate the switches 130, 134 and 138 in order to listen to each of the three different channels one at a time or in any desired combination to check the balance and proper operation of each of the three different amplifier channels of the overall system.

Turning now to the specific reverberation features of the system, it will be observed that the reverberation unit 50 includes an input winding 150 having a center tap grounded and one terminal connected through light bulb 151 and resistor 132 to the secondary winding of transformer 115. Furthermore, the remaining terminal of input coil 150 is connected through light bulb 152 and the resistor 140 to the secondary winding of transformer 108. In this way portions of the output signals from both the left and right channels are intermixed and coupled in a balanced manner to the transducer or reverberation unit 50. Light bulbs 151 and 152 provide signal compression in order to reduce the level of the reverberation signals at high signal intensities. The light bulbs have respective resistances which increase with increase of current therethrough thereby reducing the power drive of the input coil 150 as the signal level to the reverberation unit increases.

The operation of the transducer reverberation unit 50 may best be described in terms of its function. In a form thereof commonly known at the present time, this unit translates the input signal from coil 150 into a mechanical reflection system wherein the input energy is continually reflected over a predetermined delay period and the reflections are permitted to be damped or to decay at an exponential rate over the delay time. The mechanical delay structure of the unit 50 is coupled to an output coil 155 which provides an electrical signal equivalent to the input signal but having the delay and decay characteristics just referred to.

The reverberation signal from the unit 50 is applied to the amplifier 52. This amplifier includes a first amplifier tube 160. The output signal from the anode of tube 160 is coupled through a blocking capacitor 162 to the grid of the second amplifier tube 164. The output signal from tube 164 is coupled through the blocking capacitor 165 to the output control 54 which is in the form of a variable resistor. The output control 54 is coupled through a series connected RC feedback path 170 to the cathode of tube 160 for reducing distortion and improving frequency response of the amplifier 52 by providing some measure of negative feedback in the amplifier. The output control 54 is series connected with the output control 57 to ground. Control 57 is in the form of a variable resistor having an arm which is coupled through a capacitor 172 to the grid electrode of the first amplifier tube in the bass driver amplifier stage 95. Accordingly, it will be seen that a portion of the left channel signal and a portion of the right channel signal are combined in the reverberation unit 50 and formed into a reverberation signal which is amplified in the amplifier 52 and applied to the input circuit of the center channel power amplifier 45.

As has been previously indicated, the reverberation circuit may conduct some of the lower frequency signal components down to about 200 cycles per second and these will be amplified and applied to the center amplifier channel 45. The center amplifier channel translates the unmodified or main signal components from a range of approximately 200 cycles down to the lowest frequency desired in the system. Thus, amplifier 52 is constructed to provide some gain at frequencies of the order of 200 cycles per second. However, signal components at a frequency much lower than this do not contribute significantly to the reverberation portion of the sound pattern. Furthermore, the amplifier 52 need not have appreciable gain at frequencies in excess of 5,000 cycles per second.

It should be noted that the center channel amplifier 45 would preferably be constructed as a push-pull amplifier capable of handling relatively high power in order to properly bring forth the low frequency components of the desired signal. However, it may be found unnecessary to construct the left channel output amplifier 84 and the right channel output amplifier 106 in push-pull form since the power requirements for the higher frequency components are not as great. Push-pull amplifiers do have advantageous operation in the rejection of harmonics and an improvement of the overall distortion specifications of the system. It will further be observed that the center channel power amplifier 45, if constructed to have the necessary low frequency response and power capabilities for fulfilling its proper function, would ordinarily not be utilized for reproducing signals above 200 or 300 cycles per second since signals of higher frequency than this do contribute to the stereophonic effect and should be properly reproduced by the right and left channel speakers. Accordingly, some of the reproducing capabilities of the center channel have not been utilized in previous systems constructed with three channels. However, the present system makes full utilization of the center channel by incorporation the reverberation signal into this channel which thus obviates the need for a separate power amplifier speaker to reproduce this signal. As a modification of this system for further cost reduction, amplifier 52 may be omitted entirely, if there is sufficient gain in the other amplifiers, and reverberation unit 50 could be connected through a control directly to amplifier 45.

While some reverberation system of the past have utilized the same power amplifiers and speakers for the main or non-reverberated signal components as for the reverberation signal components, this may prove to be a disadvantage due to the intermixing of the signals in the electrical circuitry of the system. However, in the present system the possibility of electrically intermixing reverberation signal components with the non-reverberation signal components is minimized since the reverberation signals are reproduced only in the center channel which

otherwise only handles signal components not contributing materially to the reverberation effect.

We claim:

1. Stereophonic record playing apparatus for utilizing right and left stereo signal components, said apparatus including in combination, first, second and third amplifier channels having respective loudspeakers connected thereto, the loudspeaker of said third amplifier channel being adapted to be positioned intermediate the loudspeakers of said first and second channels during use of the apparatus, a stereo phonograph pickup device connected to said first and second amplifier channels for reproduction of the stereo information by said loudspeakers connected thereto, filter means for applying the low frequency portion of the stereo signal components from said first and second amplifier channels to said third amplifier channel and means operative by a signal from said first and second amplifier channels for developing a reverberation signal having decaying amplitude throughout a reverberation time period and for applying the reverberation signal to said third amplifier channel to be amplified thereby, whereby the loudspeaker associated with said third amplifier channel may reproduce both the low frequency portion of the stereo signal components and the reverberation signal associated with the stereo signal components.

2. Stereophonic sound reproducing apparatus for utilizing right and left stereo signal components, said apparatus including in combination, first and second amplifier channels including speakers associated therewith for separately reproducing the stereo information in the form of respective right and left high frequency stereo components, a further amplifier channel including a loudspeaker, filter means for deriving low frequency signal components from at least one of said first and second amplifier channels and for coupling such low frequency signal components to said further amplifier channel, a reverberation device producing a delayed signal of decaying amplitude coupled from said first and second amplifier channels to said further amplifier channel so that the delayed signal is amplified by said further amplifier channel, whereby said further amplifier channel may reproduce both low frequency signal components and stereo signal components subjected to delay and decay for a stereophonic and reverberation effect in the overall sound pattern produced by said loudspeakers of said amplifier channels.

3. Stereophonic sound reproducing apparatus for utilizing right and left stereo signal components, said apparatus including in combination, means for deriving first and second stereophonic signal components, first and second amplifier channels respectively for the first and second signals and including associated loudspeakers for separately reproducing the stereo signal components, a further amplifier channel including a loudspeaker, filter means for deriving low frequency signal components from said first and second amplifier channels and for coupling such low frequency signal components to said further amplifier channel, a reverberation device producing a delayed signal of decaying amplitude coupled from said right and left amplifier channels to said further amplifier channel for amplifying the delayed signal of decaying amplitude, so that said further amplifier channel may reproduce both the low frequency signal components and reverberated signal components for a stereophonic and reverberation effect in the overall sound pattern produced by said loudspeakers.

4. Stereophonic sound reproducing apparatus for utilizing right and left stereophonic signal components, said apparatus including in combination, first and second amplifiers having tone control means therein for regulating the frequency response of such amplifiers, means connected to said first and second amplifiers for applying the right and left stereo signal components respectively thereto, third, fourth and fifth power amplifiers having respective loudspeakers connected thereto, said loudspeaker of said fifth amplifier being adapted to be positioned intermediate said loudspeakers of said third and fourth amplifiers during use of the apparatus, a first high pass filter coupling said first amplifier to said third amplifier, a second high pass filter coupling said second amplifier to said fourth amplifier, a low pass filter coupling said first and second amplifiers to said fifth amplifier, a reverberation device producing a delayed signal of decaying amplitude coupled to said third and fourth amplifiers, and a sixth amplifier coupled between said reverberation device and said fifth amplifier, whereby said loudspeakers of said third and fourth amplifiers reproduce stereophonic sound information and said loudspeaker of said fifth amplifier reproduces both low frequency signal components and reverberation signal components.

5. Apparatus for sound signal reproduction including in combination, amplifier means for translating a signal having high and low frequency portions, first means connected to said amplifier means for reproducing the high frequency portion of the signal, second means connected to said amplifier means for translating only the low frequency portion of the signal, third means connected to said second means for reproducing the low frequency portion of the signal, and a reverberation device for producing a delayed signal of decaying amplitude connected from said first means to said second means so that said second means may further reproduce reverberation components in response to the signal in said first means.

6. Stereophonic sound reproducing apparatus for utilizing right and left stereophonic signal components, said apparatus including in combination, a source of stereophonic signal components, first, second and third amplifiers for translating the stereo signal components, a plurality of loudspeakers for reproducing the stereophonic signal components translated by said amplifiers to provide both high and low frequency reproduction of the entire information contained within said stereo signal components, a further signal translating channel for the high frequency portion of the stereo signal components, said further signal translating channel including a reverberation device for developing a signal having a decaying amplitude throughout a reverberation time period, and means connecting said further signal translating channel from an output circuit of one of said amplifiers to an input circuit of another of said amplifiers so that the loudspeaker connected to said other amplifier carries both reverberation and non-reverberation signal components, whereby a reverberation effect is added to the overall sound pattern produced by said loudspeakers without the addition of a power amplifier and loudspeaker solely for reverberation signal components.

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