

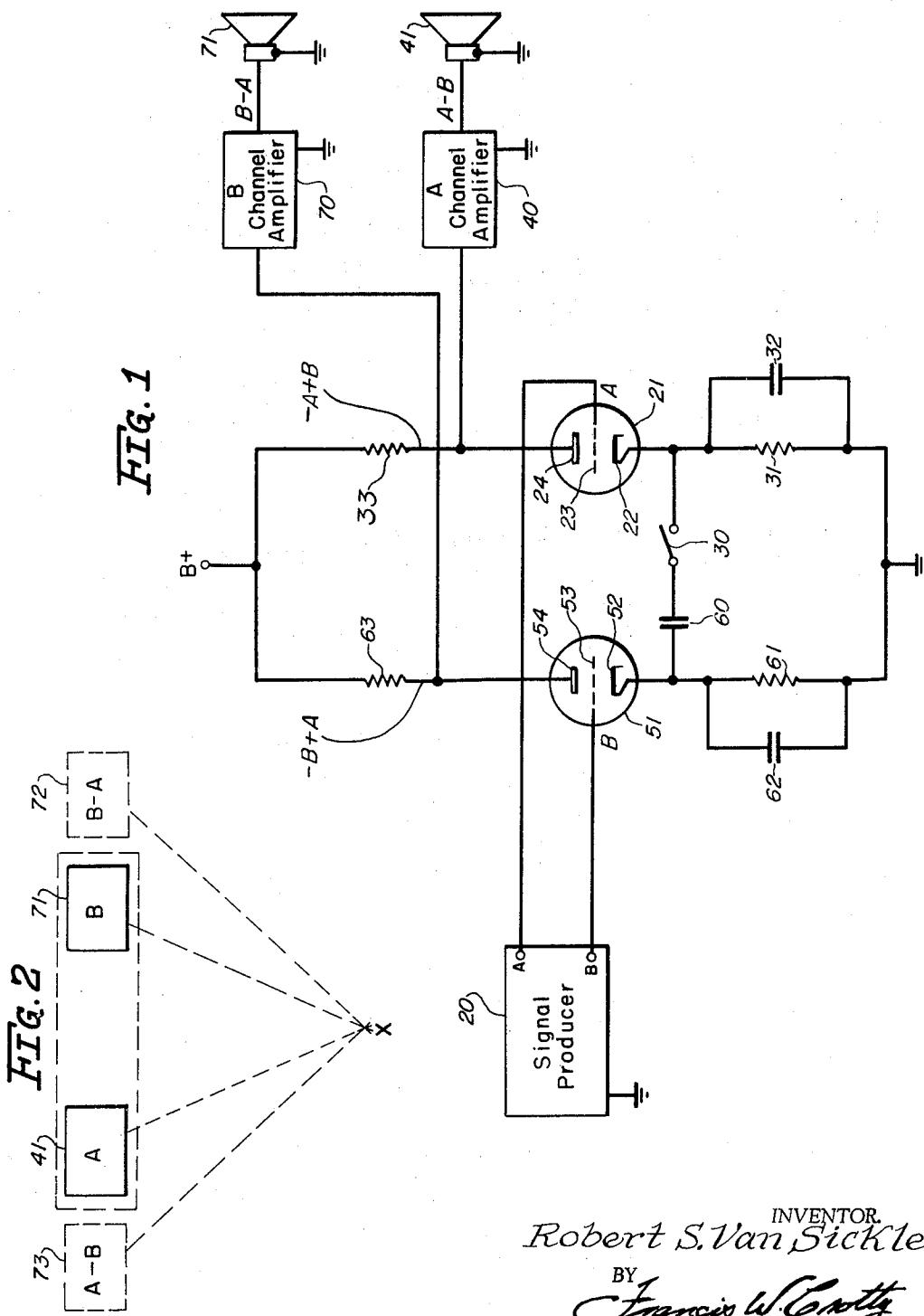
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SIMPLIFIED EXTENDED STEREO

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SIMPLIFIED EXTENDED STEREO

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The present invention relates to stereophonic sound systems. More particularly, it is directed to apparatus for increasing the apparent separation of sound emitted from two sound reproducers employed in such systems.

In general, a conventional stereophonic sound system reproduces program material, either broadcast or recorded, in a manner designed to simulate what would be heard by one attending the performance as originally produced. A spacial relationship between sound waves emitted from the stereo system is required to duplicate the program as heard by a member of the audience. In translating both stereophonic radio broadcasts and phonograph records, two program signals representative of the original performance are developed. One signal, designated the left or A signal, is representative of sound waves reaching a sound transducer, such as a microphone, located to the left of a predetermined point of the original performance. The right or B signal is similarly representative of program material reaching a transducer to the right of the predetermined point. In either stereo radio or phonograph systems two separate signal translating and amplifying channels are required to reproduce the A and B program signals with this spacial effect. One of these channels amplifies the A signal and the other channel amplifies the B signal. The outputs of these channels are respectively coupled to two loudspeakers.

If the two loudspeakers were physically located adjacent to each other, no physical separation of the sound sources of the reproduced A and B program signals would be noticed by a listener and a monaural sound representation of the program signals would result. As the loudspeakers are moved apart a spacial effect becomes more apparent to the listener. The optimum spacing for these speakers is a function of the room conditions, listening characteristics of the listener, the speaker radiating characteristics, etc., but it is sufficient to say that normally a spacing of 8 to 10 feet between loudspeakers will produce a generally acceptable spacial sound effect to a listener who is sitting approximately between and somewhat outwardly from the loudspeakers.

Because the design trend of stereo systems has been directed toward incorporating both speakers into a single cabinet housing, the physical separation between loudspeakers has been reduced resulting in rather poor sound separation between A and B program signals as observed by a listener. To increase the apparent separation of the program signals originating from the two reproducers, a somewhat complex electrical arrangement has been previously employed. It has been found that if the A and B electrical program signals are properly matrixed in the amplifiers of the stereo system, an A plus B (A+B) and an A minus B (A-B) program signal can be obtained. By employing conventional signal adding and phase inverting techniques, the A program signal and a fraction of the B program signal in phase opposition to the B signal normally applied to the B signal reproducer may be applied to the A signal reproducer. Similarly a signal containing the B program signal and a fraction of the A signal in opposition to its normal phase may be applied to the B signal reproducer. In effect, the A loudspeaker reproduces the A signal minus a small portion of the B signal while the B loudspeaker reproduces the B signal minus a small portion of the A signal. Referring to the A signal only, the A channel reproducer appears to move outward at the same time the B channel

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speaker appears to move inward a slight amount due to the negative A signal applied thereto. This results in an A signal sound front which appears to emanate from a point displaced from the A loudspeaker. A similar explanation may be applied to the B program signal channel. A listener positioned midway between the speakers observes a spacial sound effect as though the A and B signals emanated to the left and right of the stereo cabinet which houses the loudspeakers.

The described system has proved quite satisfactory but when it is desired to reproduce normal stereo, i.e., the A loudspeaker reproducing only the A signal and the B loudspeaker reproducing only the B signal, the magnitudes of some of the signals to be added must be varied. It has been found that the magnitude and phase of the varied signal becomes quite critical when trying to reproduce normal stereo and the resultant A and B program signals are not entirely free from one another. This can result in poorer separation than can be obtained from pure A and B program signals.

It is a primary object of this invention, therefore, to provide new and improved stereophonic sound reproducing circuitry.

It is another object of this invention to provide new and improved circuitry which increases the apparent separation between two sound reproducers in a stereophonic sound system.

It is still another object of this invention to provide new and improved circuitry which increases the apparent separation of the sound reproducers in a stereophonic sound system and employs a minimum number of components.

In accordance with the invention, a network for increasing the apparent separation between the left and right stereo sound signals generated by two sound reproducers includes means, such as a stereophonic phonograph pickup or a stereophonic broadcast tuner, for generating different left and right electrical signals representative of different left and right sound signals. The network further comprises first and second separate signal translating channels respectively coupled to the sound reproducers, means for applying only one of the left and right electrical signals to the first channel in a particular phase and means for applying the other of the left and right electrical signals to the second channel in a particular phase. In addition, the network comprises means for selectively applying a portion of the aforesaid one signal into the second channel to develop therein a signal containing the said other signal and a portion of the aforesaid one signal in phase opposition to that of the said one signal in the first channel, and for selectively applying a portion of the aforesaid other signal into the first channel to develop therein a signal containing the aforesaid one signal and a portion of the aforesaid other signal in phase opposition to that of the aforesaid other signal in the second channel, thereby to increase the apparent separation of the left and right sound signals generated by the reproducers in response to the signals.

The features of this invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in conjunction with the accompanying drawing, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 is a schematic representation of a preferred embodiment of the invention; and

FIGURE 2 is a schematic diagram demonstrating the extended stereo effect achieved with the circuitry of FIGURE 1.

The apparatus of FIGURE 1 comprises a sound signal

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producer 20, such as a stereophonic phonograph pick-up or a stereophonic broadcast tuner, which at its output produces left and right electrical signals respectively representative of left and right sound signals. As previously mentioned, the left signal will be referred to as the A signal and the right signal will be referred to as the B signal. The A electrical signal is coupled from producer 20 to an A channel amplifying or signal translating circuit which comprises a triode vacuum tube 21 having a cathode 22, a control electrode or grid 23 and a plate electrode or anode 24. More specifically, the A program signal is coupled to the grid 23 of tube 21. The cathode of tube 21 is coupled to one contact of a switch 30 and to a cathode circuit comprising the parallel combination of a bias resistor 31 and a frequency compensating capacitor 32. This parallel combination 31, 32 is connected at its opposite end to a plane of reference potential such as ground. Anode 24 of tube 21 is coupled to both a load resistor 33 which has its opposite end coupled to a source of battery potential B+ and to an A channel amplifier 40 of one or more stages. The output of this amplifier is fed to an A sound signal reproducer or loudspeaker 41.

The B electrical signal, representative of the right sound signal, is coupled to a B channel amplifying or signal translating circuit which comprises a triode vacuum tube 51 having a cathode 52, a grid or control electrode 53 and a plate or anode electrode 54. The cathode of tube 51 is coupled to both a signal coupling capacitor 60 which has its remaining end coupled to the blade of switch 30 and a cathode network comprising the parallel combination of a bias resistor 61 and a frequency compensating capacitor 62. The opposite end of the parallel combination 61, 62 is coupled to ground. The anode of tube 51 is coupled to a load resistor 63 which has its opposite end coupled to a potential source B+. In addition, anode 54 is coupled to a B channel amplifier 70 of one or more stages preferably corresponding in its electrical characteristics to that of the A channel amplifier 40. Amplifier 70 is in turn coupled to a sound reproducer 71 which produces the B program signal.

Assuming switch 30 to be open, the A electrical signal developed by signal producer 20 and coupled to grid 23 of tube 21 produces an amplified minus A signal, opposite in phase to that of the A signal present at the grid, at load resistor 33. In addition, the A signal presented at grid 23 is produced in cathode circuit 31, 32. The A signal appearing in the cathode load is in phase with the signal presented at control electrode 23 but of reduced amplitude. The operation of the B channel is similar, resulting in a B electrical signal, opposite in phase to that applied to control electrode 53, at resistor 63 and the presence of a B signal in the cathode circuit of reduced amplitude but in phase with the signal presented at grid 53.

The A channel amplifier 40 receives the minus A signal and, assuming it is of an odd number of stages, inverts the phase of the minus A signal and transfers it to speaker 41 for reproduction. Similarly, the B channel amplifier receives the minus B signal, inverts its phase, and translates it to speaker 71 for reproduction. The reproduction of these signals with switch 30 open is normal stereophonic reproduction.

When switch 30 is closed, the tubes 21 and 51 operate in essentially the same manner except that a fraction of the B signal, appearing in the cathode circuit of amplifying tube 51, is injected into the cathode circuit of amplifying tube 21. Similarly, a fraction of the A channel signal is injected into the cathode circuit of amplifying tube 51. The amount of the signal transferred from one channel to the other is determined by the voltage divider arrangement formed by capacitor 60 and the parallel combination of elements 31 and 32 in one circuit and the combination of capacitor 60 and elements 62 and 61 in the other circuit. As is well known, any signal injected in the cathode circuit of an amplifier tube appears in the output circuit in phase with the injected signal. Thus, the portion of the

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B signal fed to the cathode circuit of tube 21 appears across load resistor 33. Similarly, the portion of the A signal injected into the cathode circuit of tube 51 appears across load resistor 63 in the same phase as it was injected. Taking into consideration the signals applied concurrently to the grid and cathode elements of tubes 21 and 51, the minus B plus A (-B+A) signal and the minus A plus B (-A+B) signal are respectively fed to amplifiers 70 and 40 which produce amplified B minus A (B-A) and A minus B (A-B) signals for reproduction by loudspeakers 71 and 41 respectively.

The apparent sources of sound for this condition are designated 72, 73 in FIGURE 2 and are to be contrasted with normal stereophonic reproduction obtained with switch 30 open in which case the sound sources, in relation to a listener X, are designated 41 and 71. The separation of the sound sources appears to have increased when switch 30 is closed. The apparent separation of the sound sources may be increased by adjusting the values of the voltage divider networks comprising capacitor 60 and the cathode circuits of tubes 21, 51 to increase the signal component introduced from one channel into the opposite channel. Thus, while the sound reproducers may be conveniently located in a single cabinet, the sound sources may appear to originate from points outside of the cabinet.

Because sound having a long wavelength is less directional, it is unnecessary to cross couple the low frequency portions of the A and B signals. Cross-coupling of low frequency signals is prevented by appropriate choices of the values of capacitors 32, 60 and 62 in view of the values of bias resistors 31 and 61.

Merely by way of illustration and in no sense by way of limitation the following circuit component values and voltages may be employed in the preferred embodiment of FIGURE 1:

Tubes 21, 51	.....	½ 12AX7A each.
Resistors 33, 63	.....	100,000 ohms each.
Resistors 31, 61	.....	2,200 ohms each.
Capacitors 32, 62	.....	.0068 microfarad each.
Capacitor 60	.....	.22 microfarad.
B+ supply voltage	.....	250 volts direct current.

Thus the invention provides new and novel circuitry for achieving extended stereophonic sound reproduction. The new structure requires a minimum number of components and produces accented stereo separation without deleterious effects when the unit is used as a conventional stereophonic sound system.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made therein without departing from the invention in its broader aspects. The aim of the appended claims, therefore, is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. A network for increasing the apparent separation between left and right stereo sound signals generated by two sound reproducers comprising: means for generating different left and right electrical signals representative of different left and right sound signals; first and second separate signal translating channels respectively coupled to said sound reproducers; means for applying only one of said electrical signals to said first channel in a particular phase; means for applying the other of said electrical signals to said second channel in a particular phase; and means for selectively applying a portion of said one signal into said second channel to develop therein a signal containing said other signal, at a predetermined average amplitude and a portion of said one signal, at an average amplitude which is less than that of said other signal and in phase opposition to that of said one signal in said first channel, and for selectively applying a portion of said other signal into said first channel to develop therein a

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signal containing said one signal, at a predetermined average amplitude, and a portion of said other signal, at an average amplitude which is less than that of said one signal and in phase opposition to that of said other signal in said second channel, to increase the apparent separation between the left and right sound signals generated by said reproducers in response to said signals.

2. A network for increasing the apparent separation between left and right stereo sound signals generated by two sound reproducers, said network comprising: means for generating left and right electrical signals representative of left and right sound signals; first and second separate signal translating channels respectively coupled to said sound reproducers; means for applying only one of said electrical signals to said first channel in a particular phase; means for applying the other of said electrical signals to said second channel in a particular phase; and means for selectively and instantaneously applying at least a portion of said one signal into said second channel to develop therein a signal containing, with no significant delay therebetween, said other signal and a portion of said one signal in phase opposition to that of said one signal in said first channel and for selectively and instantaneously applying at least a portion of said other signal into said first channel to develop therein a signal containing, with no significant delay therebetween, said one signal and a portion of said other signal in phase opposition to that of said other signal in said second channel to increase the apparent separation between the left and right sound signals generated by said reproducers in response to said signals.

3. A network for increasing the apparent separation between left and right stereo sound signals generated by two sound reproducers, said network comprising: means for generating left and right electrical signals representative of left and right sound signals; first and second separate signal translating channels respectively coupled to said sound reproducers; means for applying only one of said electrical signals to said first channel in a particular phase; means for applying the other of said electrical signals to said second channel in a particular phase; and capacitor means for selectively and instantaneously applying at least a portion of said one signal into said second channel to develop therein a signal containing, with no significant delay therebetween, said other signal and a portion of said one signal in phase opposition to that of said one signal in said first channel and for selectively and instantaneously applying at least a portion of said other signal into said first channel to develop therein a signal containing, with no significant delay therebetween, said one signal and a portion of said other signal in phase opposition to that of said other signal in said second channel to increase the apparent separation between the left and right sound signals generated by said reproducers in response to said signals.

4. A network for increasing the apparent separation between left and right stereo sound signals generated by two sound reproducers, said network comprising: means for generating left and right electrical signals representative of left and right sound signals; first and second signal-translating channels individually including an electron device having an anode electrode, control electrode and a cathode electrode; means for applying only one of said signals to one of said electrodes of said device of said first channel for translation therethrough in one phase and for applying the other of said signals to one of said electrodes of said device of said second channel for translation therethrough in said one phase; and means for coupling predetermined electrodes of said electron devices together to instantaneously inject at least a portion of said one signal, with no significant delay relative to said other signal, into said second channel for translation therethrough in opposite phase and to instantaneously inject at least a portion of said other signal, with no significant delay relative to said one signal, into said

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first channel for translation therethrough in said opposite phase to increase the apparent separation between the left and right signals generated by said reproducers in response to said signals.

5. A network for increasing the apparent separation between left and right stereo sound signals generated by two sound reproducers, said network comprising: means for generating left and right electrical signals representative of left and right sound signals; first and second signal-translating channels individually including an electron device having an anode electrode, control electrode and a cathode electrode; means for applying only one of said signals to said control electrode of said device of said first channel for translation therethrough in one phase and for applying the other of said signals to said control electrode of said device of said second channel for translation therethrough in said one phase; and means for coupling said cathode electrodes of said electron devices together to inject at least a portion of said one signal into said second channel of translation therethrough in opposite phase and to inject at least a portion of said other signal into said first channel for translation therethrough in said opposite phase to increase the apparent separation between the left and right signals generated by said reproducers in response to said signals.

6. The apparatus of claim 5 wherein said means coupling said cathode electrodes of said electron devices are frequency selective to inject audio signals of the mid-audio band and higher.

7. The apparatus of claim 5 wherein said means coupling said cathode electrodes of said electron devices together include a switch for selectively disabling the cross coupling of said channels.

8. A network for increasing the apparent separation between left and right stereo sound signals generated by two sound reproducers comprising:

means for generating different left and right electrical signals representative of different left and right sound signals;
first and second separate signal translating channels respectively coupled to said sound reproducers;
means for applying only one of said electrical signals to said first channel in a particular phase;
means for applying the other of said electrical signals to said second channel in a particular phase;
and means cross-coupling said first and second channels for selectively applying a portion of said one signal into said second channel to develop therein a signal containing said other signal and a portion of said one signal in phase opposition to that of said one signal in said first channel, and for selectively applying a portion of said other signal into said first channel to develop therein a signal containing said one signal and a portion of said other signal in phase opposition to that of said other signal in said second channel, to increase the apparent separation between the left and right sound signals generated by said reproducers.

9. A network for increasing the apparent separation between left and right stereo sound signals generated by two sound reproducers comprising:

means for generating different left and right electrical signals representative of different left and right sound signals;
first and second separate signal translating channels respectively coupled to said sound reproducers;
means for applying only one of said electrical signals to said first channel in a particular phase;
means for applying the other of said electrical signals to said second channel in a particular phase;
and common bilateral passive circuit means cross-coupling said first and second channels for selectively applying a portion of said one signal into said second channel to develop therein a signal containing said other signal and a portion of said one signal

in phase opposition to that of said one signal in said first channel, and for selectively applying a portion of said other signal into said first channel to develop therein a signal containing said one signal and a portion of said other signal in phase opposition to that of said other signal in said second channel, to increase the apparent separation between the left and right sound signals generated by said reproducers.

10. A network for increasing the apparent separation between left and right stereo sound signals generated by two sound reproducers comprising:
 means for generating different left and right electrical signals representative of different left and right sound signals;
 first and second separate signal translating channels respectively ocupled to said sound reproducers;
 means for applying only one of said electrical signals to said first channel in a particular phase;
 means for applying the other of said electrical signals to said second channel in a particular phase;
 and an impedance cross-coupling said first and second channels for selectively applying a portion of said one signal into said second channel to develop therein a signal containing said other signal and a portion of said one signal in phase opposition to that

of said one signal in said first channel, and for selectively applying a portion of said other signal into said first channel to develop therein a signal containing said one signal and a portion of said other signal in phase opposition to that of said other signal in said second channel, to increase the apparent separation between the left and right sound signals generated by said reproducers.

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