STEREOPHONIC SYSTEM EMPLOYING AUDIO MATRIXING

David H. Brunner, Abington Township, Montgomery County, Pa., assignor, by mesne assignments, to Philadelphia Corporation, Philadelphia, Pa., a corporation of Delaware

Filed Mar. 13, 1961, Ser. No. 95,394

12 Claims. (Cl. 179—1)

The present invention relates to stereophonic signal reproducing systems and more particularly to stereophonic signal reproducing systems employing audio matrixing to develop the two stereophonic acoustic wave signals.

One simple form of stereophonic reproduction system employs two high fidelity channels, each channel comprising an amplifier and its associated speaker unit. The speaker units are spaced six to eight feet apart to provide two distinct sources of acoustic waves. Each channel amplifies one of the two stereophonic program signals. It is customary to refer to the two stereophonic program signals as the "A" signal and the "B" signal and this terminology will be employed herein. The two channel system mentioned above produces excellent stereophonic effect. It has the additional advantage that an existing high fidelity monaural system may be converted to a high fidelity stereophonic system by exactly duplicating all of the parts of the monaural system except the source of program signals. However such a system has several drawbacks. The necessity of having two high-powered stereo amplifiers and two wide range speaker units makes the system expensive. Also the two wide range speaker units are not readily accommodated in small rooms.

Several modified stereophonic reproducing systems have been proposed in an attempt to overcome one or more of the disadvantages of the stereophonic reproducing system employing two identical channels. However none of the systems proposed heretofore have fully met the need for a compact, relatively low cost stereophonic reproduction system which is either self contained or constitutes an addition to existing monaural equipment. The present invention is an object of the present invention to provide a stereophonic reproduction system which provides excellent stereophonic reproduction with a minimum of expensive components.

Another object of the present invention is to provide a stereophonic reproduction system which does not require physically spaced speaker systems.

An additional object of the present invention is to provide a stereophonic reproduction system in which the apparent spacing between speaker systems may be made greater than actual spacing.

A further object of the present invention is to provide a stereophonic reproduction system in which the spacing between the apparent or effective sources of acoustic waves may be varied electronically.

Another object of the invention is to provide an improved stereophonic reproduction system which provides excellent stereophonic reproduction with only one full range amplifier and speaker unit and one or more amplifiers and speaker units of limited frequency range.

Still another object of the present invention is to provide means for converting existing monaural equipment to a stereophonic reproduction system without modification of existing equipment.

In general these and other objects of the present invention are achieved by matrixing the two stereophonic program signals at a low level to produce electrical sum and difference signals. The sum signal is amplified in a wide band amplifier and converted to an acoustic wave in a wide band speaker unit. The difference signal is amplified in a circuit which may have a more restricted bandwidth than the one employed in the sum channel. The acoustic wave representing the difference signal is radiated by an electro-acoustic transducer or speaker unit having a different orientation from the one employed in the sum channel. Again this second speaker unit may be a limited range speaker unit. The present invention relies on acoustic matrixing of the sum and difference acoustic wave signals to produce the desired stereophonic effect.

For a better understanding of the present invention together with other and further objects thereof, reference should now be made to the following detailed description which is to be read in conjunction with the accompanying drawings in which:

FIG. 1 is a block diagram of one preferred embodiment of the invention;

FIG. 1A is a schematic diagram of the matrix circuit of FIG. 1;

FIG. 2 is a vector diagram which explains the operation of the system of FIG. 1;

FIG. 3 is a block diagram of another preferred embodiment of the present invention;

FIG. 3A is an alternative loud speaker arrangement which may be employed in the system of FIG. 3; and

FIG. 4 is a view partially in section of an enclosed speaker assembly which may be employed in certain embodiments of the present invention.

Turning now to FIG. 1, the source of two stereophonically related program signals is represented by block 10. This source may be a phonograph pickup, a stereophonic tape reproducer, a stereophonic radio receiver or the like. For convenience, the program signal at the output connection 12 of source 10 will be referred to as the "A" program signal while the signal at connection 14 will be called the "B" program signal. Both the "A" and "B" program signals are wide range audio frequency signals. For example, in a high-fidelity stereophonic system the "A" and "B" program signals may vary in time to include components having frequencies in the range from 20 cycles to 20,000 cycles. It is to be understood that, in general, the "A" and "B" program signals will have different amplitudes and different amplitude versus time waveforms.

The "A" and "B" program signals are supplied to a matrix circuit 16 which combines the "A" and "B" program signals to produce a sum signal (A+B) and a difference signal (A−B). Matrix circuits for performing this operation are well known in the art, but for the sake of completeness one simple transformer matrix circuit is shown in FIG. 1A. This matrix circuit comprises two audio frequency transformers 18 and 20, each having a primary winding and two independent secondary windings. The "A" program signal is supplied to the primary winding of transformer 18 and the "B" program signal is supplied to the primary winding of transformer 20. One secondary winding of transformer 18 and one secondary winding of transformer 20 are connected in series in the proper polarity to provide on output lead 22 the (A+B) signal. The remaining secondary windings are connected in series to provide on output lead 24 the (A−B) signal. It should be understood that in high fidelity systems it is usually preferable to substitute phase splitter amplifiers and resistor-capacitor coupling for the transformers 18 and 20 because of the well-known bandwidth limitations of audio frequency transformers.

Output lead 22 of matrix circuit 16 is coupled to the input of an amplifier 26. The bandwidth and power handling capabilities of amplifier 26 must meet the standards established for the reproducing system since it handles all
of the "A" program signal components and all of the "B" program signal components. The output of amplifier 26 is connected to a wide range electroacoustic transducer or loud speaker system 28 by way of a pad 29. Pad 29 may be a conventional L-pad or T-pad.

Output connection 24 of matrix circuit 16 is coupled to the input of a second amplifier 30. Amplifier 30 may have a more restricted bandwidth and a lower power handling capacity than amplifier 26 without reducing the over-all quality of the system performance. As a typical example, amplifier 30 may be designed to pass signals of from 300 to 10,000 cycles. Amplifier 30 provides oppositely phased signals at outputs 32 and 34, respectively. These signals may be provided by usual push-pull circuitry in the output of amplifier 30. Output connection 32 is coupled to a speaker unit 36 by way of a pad 27 and output connection 34 is coupled to a speaker unit 38 by way of pad 39. Pads 27, 29, 37 and 39 represent one conventional way of changing the relative amplitudes of the signals supplied to the three speaker units 28, 36 and 38. Other means of signal amplitude control may be substituted for pads 27, 29, 37 and 39. For example, suitable gain control circuits may be included in amplifiers 26 and 30. The speaker units 36 and 38 are so oriented that all three speaker units 28, 36 and 38 project sound into a common volume of space centered at O from different directions. It is desirable but not strictly necessary that the directive axes of all three speakers intersect at the same point in the space. For realism which will appear presently, it is desirable that speaker 28 occupy a position between speakers 36 and 38. It is also desirable but not essential that the spacing \( P_r \) between speakers 28 and 36 be equal to the spacing \( P_l \) between the speakers 28 and 38 and that the angle \( \theta_l \) between the line parallel to the directive axis of speaker 28 and the directive axis of speaker 36 be equal to the angle \( \theta_r \) between the second line parallel to the directive axis of speaker 28. It is also desirable but not essential that the difference in elevation of the three speakers 28, 36 and 38 be small compared to the distance from the centers of the three speakers to the listener location O.

It will now be shown that the acoustic waveforms from the three speaker units 28, 36 and 38 combine at point O to provide a wave which appears to have an "A" component which originates from an apparent source \( T_a \) at a point to the left of speaker unit 28 and a "B" component which originates from an apparent source \( T_b \) at a point to the right of speaker unit 28. It will also be shown that by properly selecting the orientation of speaker units 36 and 38 and the relative gains of amplifiers 26 and 30, the resultant "A" and "B" component signals at point O are the same as would be produced by a stereophonic reproducing having two spaced speaker units which radiate solely the "A" program signal component and the "B" program signal component, respectively. Since the subjective effect experienced by a listener at point O depends only on the net acoustic waves present at point O and not in the manner in which they are generated, a listener at point O receives the impression that he is listening to a two stereophonic system employing two appropriately spaced wide range speaker units. Portions of the following analytical explanation of the operation of the system of FIG. 1 are graphically illustrated in the vector diagram of FIG. 2. In order to qualify the vector diagram of FIG. 2, it will be assumed that the distances \( P_a \) equals the distance \( P_l \) and that the angle \( \theta_a \) equals the angle \( \theta_r \). It will also be assumed that, instantaneously, the "B" program signal supplied by source 10 has an amplitude which is equal to one-half the amplitude of the "A" program signal supplied by source 10.

The acoustic wave signals radiated by the three speaker units 28, 36 and 38 may be expressed as follows:

- Speaker unit 28, Sum Signal = \( A_a + B_a \) \hspace{1cm} (1)
- Speaker unit 36, Left Diff = \( K_1 (A_a - B_a) \) \hspace{1cm} (2)
- Speaker unit 38, Right Diff = \( -K_2 (A_a - B_a) \) \hspace{1cm} (3)

where \( A_a \) and \( B_a \) are relative amplitudes of the "A" program signal components radiated by the center, left and right speaker units, i.e., speaker units 28, 36 and 38, respectively, \( B_a \) and \( B_a \) are corresponding "B" components and \( K_1 \) and \( K_2 \) are constants.

It will now be assumed that \( A_a = A_a = A_a = A_0 \) so that any differences in the gains of amplifiers 26 and 30 will be reflected only in the constants \( K_1 \) and \( K_2 \). In the vector diagram of FIG. 2 (but not in the following analytical explanation) it is assumed that \( K_1 = K_2 = 1 \).

Treating the "A" and "B" components separately for the moment, the component \( A_a \) which is the resultant "A" component for the three speaker units at point O taken parallel to the directive axis of speaker unit 28 may be expressed as follows:

\[ A_a = A_a + K_1 A_a \cos \theta_a - K_2 A_a \cos \theta_2 \]

which may be rewritten as:

\[ A_a = A_a (1 + K_1 \cos \theta_a - K_2 \cos \theta_2) \] \hspace{1cm} (4)

The component \( A_a \) which is the resultant "A" component taken at right angles to the directive axis of speaker unit 28 may be expressed as follows:

\[ A_a = K_2 A_a \sin \theta_a + K_2 A_a \sin \theta_2 \]

which may be rewritten as:

\[ A_a = A_a (K_1 \sin \theta_a + K_2 \sin \theta_2) \]

The vector sum of components \( A_a \) and \( A_a \) is the vector \( A_a \). The magnitude of the components \( A_a \) for the three speaker units may be expressed as:

\[ |A_a| = \sqrt{A_a^2 + A_a^2} \] \hspace{1cm} (5)

Substituting Equations 3 and 7 in Equation 8, it will be seen that

\[ |A_a| = \sqrt{A_a^2 + A_a^2} \]

Treating the "B" components in the same fashion

\[ B_a = B_a (1 - K_1 \cos \theta_a + K_2 \cos \theta_2) \] \hspace{1cm} (9)

\[ B_a = B_a (K_1 \sin \theta_a + K_2 \sin \theta_2) \]

Substituting Equations 3 and 7 in Equation 8, it will be seen that

\[ |B_a| = \sqrt{B_a^2 + B_a^2} \]

If the system is to produce a true stereophonic effect, the amplitude ratio \( |A_a|/|B_a| \) must equal the magnitude of \( A/B \). Since the second term under the radical is the same for \( |A_a| \) as for \( |B_a| \),

\[ \frac{A}{B} = \frac{|A_a|}{|B_a|} \]

Substituting Equations 5 and 7 in Equation 16:

\[ \tan \theta_a = \frac{B_a}{A_a} \]

where \( \theta_a \) is the angle between the apparent line of direction of the acoustic vector \( A_a \) and the directive axis of speaker unit 28.
Now if
\[ \theta_1 = \theta_2 \quad \text{and} \quad K_1 = K_2 \]
\[ \tan \theta_a = 2K_1 \sin \theta_1 \quad \text{(18)} \]
It will be seen also that
\[ \tan \theta_a = \frac{B_x}{B_y} \quad \text{(19)} \]
where \( \theta_0 \) is the angle between the apparent line of direction of the acoustic vector \( B_x \) and the directive axis of the speaker unit \( 28 \). Substituting Equations 10 and 11 in Equation 19,
\[ \tan \theta_a = \frac{-(K_1 \sin \theta_0 + K_2 \sin \theta_0)}{(1 - K_1 \cos \theta_0 + K_2 \cos \theta_0)} \quad \text{(20)} \]
Again if
\[ \theta_1 = \theta_2 \quad \text{and} \quad K_1 = K_2 \]
\[ \tan \theta_a = -2K_1 \sin \theta_1 \quad \text{(21)} \]
or
\[ \theta_2 = \theta_0 \quad \text{(22)} \]
Thus the apparent directions of the vectors \( A_2 \) and \( B_2 \) are the same as that required for normal stereophonic effect.

From Equation 18 or 21 it can be shown that for
\[ \theta_a = \theta_0 \quad \text{and} \quad \theta_0 = \theta_0 \]
\[ K_1 = K_2 \quad \text{(23)} \]
Thus by proper selection of the constants \( K_1 \) and \( K_2 \) the distance between the apparent source \( T_2 \) of vector \( A_2 \) and the apparent source \( T_3 \) of vector \( B_2 \) may be made to coincide with the actual sources \( 36 \) and \( 38 \). Alternatively, speaker units \( 36 \) and \( 38 \) may be spaced any convenient distance apart and the constants \( K_1 \) and \( K_2 \) varied by changing the relative gains of amplifiers \( 26 \) and \( 30 \) or the attenuation provided by pads \( 37 \) and \( 39 \) until the desired apparent separation is achieved between the apparent sources \( T_2 \) and \( T_3 \).

It has been demonstrated experimentally that the acoustic matrixing of the signals from speaker units corresponding to speaker units \( 28, 36 \) and \( 38 \) of FIG. 1 occurs for a considerable area around point \( O \). It can also be shown that the acoustic matrixing of the signals from the three speaker units produces the desired stereophonic effect for asymmetrical as well as symmetrical arrangements of the speaker units. However, asymmetrical placement of the speaker units may require that the constants \( K_1 \) and \( K_2 \) have different values.

It is well known that the low frequency acoustic wave components of typical original source material are relatively nondirectional and that the low frequency components of the "A" and "B" program signals typically have nearly identical amplitudes. As a result the low frequency components of the difference signal \( (A - B) \) will have very small amplitudes. Since the low frequency components contribute little to the over-all stereophonic effect and since there is a very little low frequency energy in the difference signal \( (A - B) \), the amplifier \( 30 \) may have a lower cutoff frequency of the order of 300 cycles without materially affecting the fidelity of reproduction of the over-all system.

Since at frequencies above about 10,000 cycles the wavelength of acoustic energy is comparable to or less than the inter-ear spacing of the average listener the location of a source emitting only high frequency signals becomes ambiguous. For this reason it has been found that in many instances components of the difference signal above approximately 10,000 cycles may be eliminated without adversely affecting the over-all performance of the system or lessening of the subjective stereophonic effect. For these reasons, amplifier \( 30 \) may have a restricted bandwidth, for example a bandwidth of 300 to 10,000 cycles. Since the peak power in most acoustic waves occurs in the very low frequency signals, the elimination of the low frequency signals from amplifier \( 30 \) permits this amplifier to have a lower power rating than that of amplifier \( 26 \). Speaker units \( 36 \) and \( 38 \) are not required to reproduce low frequency signals. Therefore these speaker units may be made quite small.

It will be seen that if amplifier \( 26 \) and speaker unit \( 28 \) comprise the amplifier and speaker unit of a monaural system, no modification of these units is required in order to convert this monaural system to a stereophonic system of the type illustrated in FIG. 1. Furthermore, the addition of adding amplifier \( 30 \), speaker units \( 36 \) and \( 38 \) and matrix unit \( 16 \) will, in general, be far less than the cost of duplicating the wide band amplifier \( 26 \) and the wide range speaker unit \( 28 \).

The system shown in FIG. 3 is similar to the system shown in FIG. 1 except that a single push-pull electrostatic speaker unit \( 52 \) has been substituted for the two speaker units \( 36 \) and \( 38 \) of FIG. 1. Components in FIG. 3 corresponding to like components in FIG. 1 are identified by the same reference numerals. In the embodiments of FIG. 3, only one output \( 32 \) from amplifier \( 30 \) is required. The push-pull electrostatic speaker unit \( 52 \) generates the push-pull acoustic waves \( (A - B) \) and \( -(A - B) \).

In the embodiment of FIG. 3, the directive axis of electrostatic speaker unit \( 52 \) is oriented at right angles to the directive axis of speaker unit \( 28 \). The difference acoustic wave \( (A - B) \) from the left side of speaker unit \( 52 \) is reflected from a suitable reflecting surface \( 62 \) to the listener location \( O \). Similarly the acoustic wave \( -(A - B) \) from the right hand side of speaker unit \( 52 \) is reflected from a second reflecting surface \( 64 \) to the listener location \( O \). The reflecting surfaces \( 62 \) and \( 64 \) of FIG. 3 may be the walls of the room in which the system shown in FIG. 3 is located. This reflection from the surfaces \( 62 \) and \( 64 \) of FIG. 3 produces an apparent source of the \( (A - B) \) signal at point \( 52' \) and an apparent source of the \( -(A - B) \) signal at point \( 52'' \). It will be seen that speaker unit \( 28 \) and apparent sources \( 52' \) and \( 52'' \) correspond to speaker units \( 28, 36 \) and \( 38 \), respectively, of FIG. 1.

It has been demonstrated that the acoustic waves above 300 cycles are sufficiently directive so that appreciable acoustic matrixing of the sum and difference signals radiated by speaker units \( 28 \) and \( 52 \) of FIG. 3 occurs at listener location \( O \). The system shown in FIG. 3 has the advantage over the embodiment of FIG. 1 that all speaker units may be at a single location. For example, the electrostatic speaker unit \( 52 \) may be incorporated in or placed upon the cabinet or enclosure for the wide range speaker unit normally employed in a monaural system. One possible arrangement of the speaker unit in the same enclosure as speaker unit \( 28 \) is shown in FIG. 4.

Enclosure \( 80 \) is provided with ports \( 82 \) and \( 84 \) for the acoustic wave difference signals \( (A - B) \) and \( -(A - B) \). Baffles \( 86 \) and \( 88 \) may be provided adjacent ports \( 82 \) and \( 84 \), respectively, for concentrating the acoustic waves in the desired direction. If enclosure \( 80 \) is placed in the corner of a room, baffles \( 86 \) and \( 88 \) may be augmented by or replaced by the adjacent walls of the room. In setting up the system of FIG. 3, due consideration must be given to the reflective properties of the acoustic wave reflecting surfaces \( 62 \) and \( 64 \).

FIG. 3A shows an alternative speaker arrangement which may be employed in the embodiment of FIG. 3. In FIG. 3A, two electrodynamic speakers \( 70 \) and \( 72 \) are substituted for the electrostatic speaker \( 52 \) of FIG. 3. Speakers \( 70 \) and \( 72 \) are pointed in opposite directions so that they produce approximately the same distribution of acoustic energy as speaker \( 52 \) of FIG. 3. The speakers \( 70 \) and \( 72 \) may be energized from a single output \( 32 \) as shown in FIG. 3A by transposing the connections to one of the speakers \( 72 \). Alternatively, speakers \( 70 \) and \( 72 \) may be energized individually with the push-pull outputs \( 32 \) and \( 34 \) of amplifier \( 30 \) of FIG. 1.

While the invention has been described with reference to the preferred embodiments thereof, it will be apparent that various modifications and other embodiments thereof
will occur to those skilled in the art within the scope of the invention. Accordingly I desire the scope of my invention to be limited only by the appended claims.

I claim:

1. A stereophonic signal reproducing system comprising a system comprising input means for providing at first and second outputs electrical signals representative of the instantaneous sum and the instantaneous difference, respectively, of two stereophonically related program signals, a first amplifier coupled to said first output, a first electroacoustic wave transducer coupled to the output of said first amplifier, said first transducer directing acoustic wave energy representative of said instantaneous sum of said two stereophonically related program signals in a selected path in response to the signal supplied by said first amplifier, additional amplifier means coupled to said second output, additional electroacoustic wave transducer means coupled to the output of said additional amplifier means, said additional transducer means producing two differently directed, oppositely phased acoustic waves representative of said instantaneous difference of said two stereophonically related program signals in response to the signal supplied by said additional amplifier means, said last-mentioned two acoustic waves being directed differently than the acoustic energy wave produced by said first transducer.

2. A stereophonic signal reproducing system in accordance with claim 1 wherein said first transducer and said additional transducer means are so oriented that the paths of the acoustic wave energy from said first transducer and said oppositely phased waves from said additional transducer means are initially directed toward a common location.

3. A stereophonic signal reproducing system in accordance with claim 1 wherein said first transducer and said additional transducer means are so oriented that the acoustic wave energy from said first transducer and said oppositely phased waves from said additional transducer means are initially directed along non-intersecting paths.

4. A stereophonic signal reproducing system in accordance with claim 1 wherein said first transducer and said additional transducer means are located at substantially the same region in space and wherein said first transducer and said additional transducer means are so oriented that acoustic wave energy from said first transducer and said oppositely phased waves from said additional transducer means are initially directed along non-intersecting paths.

5. A stereophonic reproducing system comprising a matrix means adapted to receive first and second stereophonically related program signals, said matrix means including means for providing at first and second outputs electrical signals representative of the instantaneous sum and instantaneous difference, respectively, of said two program signals, first, second and third electroacoustic wave transducer means each adapted to project acoustic wave energy in a path centered about a separate directive axis, said transducer means directing acoustic wave energy so as to arrive at a common location from different directions in response to electrical signals supplied thereto, a first amplifier means coupling said first output of said matrix means to said first transducer, said first transducer producing an acoustic wave representative of said instantaneous sum of said two program signals in response to the signal supplied by said first amplifier means, said additional amplifier means coupling said second output of said matrix means to said second and third transducers, said second and said third transducers producing oppositely phased acoustic waves representative of said instantaneous difference of said two program signals in response to the signal supplied by said additional amplifier means, said last-mentioned acoustic waves being directed differently than the acoustic energy wave produced by said first transducer.

6. A stereophonic signal reproducing system in accordance with claim 5 wherein said first transducer is located intermediate said second and third transducers.

7. A stereophonic signal reproducing system in accordance with claim 5 wherein said three transducers are so oriented that the directive axis of said first transducer makes equal angles with the directive axes of said second and said third transducers.

8. A stereophonic signal reproducing system in accordance with claim 5 wherein the directive axes of the three transducers lie substantially in a common plane and wherein the directive axis of said first transducer bisects the angle formed by the directive axes of said second and said third transducers.

9. A stereophonic signal reproducing system comprising input means for providing at first and second outputs electrical signals representative of the instantaneous sum and the instantaneous difference, respectively, of two stereophonically related program signals, a first electroacoustic wave transducer arranged to direct acoustic wave energy in a selected path, means coupling said first output to said first electro-acoustic wave transducer, said first transducer producing an acoustic wave representative of said instantaneous sum of said two stereophonically related program signals in response to signals supplied at said first output, additional electro-acoustic wave transducer means, additional amplifier means coupling said second output to said additional electro-acoustic wave transducer means, said additional transducer means producing in response to the signals supplied at said second output two differently directed, oppositely phased acoustic waves representative of said instantaneous difference of said two stereophonically related program signals, said last-mentioned two acoustic waves being directed differently than the acoustic energy wave produced by said first transducer.

10. A stereophonic signal reproducing system comprising input means for providing at first and second outputs electrical signals representative of the instantaneous sum and the instantaneous difference, respectively, of two stereophonically related program signals, a first amplifier coupled to said first output, a first full range electroacoustic wave transducer coupled to the output of said first amplifier, said first transducer directing in a selected path, in response to the signal supplied by said first amplifier, an acoustic wave energy representative of said instantaneous sum of said two stereophonically related program signals throughout substantially the full frequency range of said two stereophonically related program signals which is to be reproduced by said system, additional amplifier means coupled to said second output, additional limited range electroacoustic wave transducer means coupled to the output of said additional amplifier means, said additional transducer means producing two differently directed, oppositely phased acoustic waves representative of said instantaneous difference of said two stereophonically related program signals in response to the signal supplied by said additional amplifier means, said differently directed acoustic waves having a frequency range substantially less than the full frequency range of said two program signals which is to be reproduced by said system, said last-mentioned two acoustic waves being directed differently than the acoustic energy wave produced by said first transducer.

11. A stereophonic reproducing system comprising a matrix means adapted to receive first and second stereophonically related program signals, said matrix means including means for providing at first and second outputs electrical signals representative of the instantaneous sum and instantaneous difference, respectively, of said two program signals, first, second and third electroacoustic wave transducer means each adapted to project acoustic wave energy in a path centered about a separate directive axis, said transducer means directing acoustic wave energy so as to arrive at a common location from different directions in response to electrical signals supplied thereto, a first amplifier means coupling said first output of said matrix means to said first transducer, said first transducer producing an acoustic wave representative of said instantaneous sum of said two program signals in response to the signal supplied by said first amplifier means, additional amplifier means coupling said second output of said matrix means to said second and third transducers, said second and said third transducers producing oppositely phased acoustic waves representative of said instantaneous difference of said two program signals in response to the signal supplied by said additional amplifier means.
program signals throughout substantially the full frequency range of said two program signals which is to be reproduced by said system, additional amplifier means coupling said second output of said matrix means to said second and third transducers, said second and said third transducers producing in response to the signals supplied by said additional amplifier means oppositely phased acoustic waves representative of the instantaneous difference of said two program signals in a frequency range substantially less than the full frequency range of the two program signals which is to be reproduced by said system.

12. A stereophonic signal reproducing system comprising input means for providing at first and second outputs electrical signals representative of the instantaneous sum and the instantaneous difference, respectively, of two stereophonically related program signals, a first full range electroacoustic wave transducer arranged to direct acoustic wave energy in a selected path, means coupling said first output to said first electroacoustic wave transducer, said first transducer producing in response to signals supplied by said first output an acoustic wave representative of the instantaneous sum of said two stereophonically related program signals throughout substantially the full range of said two program signals which is to be reproduced by said system, additional limited range electroacoustic wave transducer means, additional means coupling said second output to said additional electroacoustic wave transducer means, said additional transducer means producing in response to the signals supplied at said second output two differently directed, oppositely phased acoustic waves representative of said instantaneous difference of said two program signals in a frequency range substantially less than the full frequency range of the two program signals which is to be reproduced by said system, said last-mentioned two acoustic waves being directed differently than the acoustic energy wave produced by said first transducer.

References Cited in the file of this patent

UNITED STATES PATENTS

3,076,873 Owen et al. ........................ Feb. 5, 1963
3,104,729 Olson ............................ Sept. 24, 1963

OTHER REFERENCES