

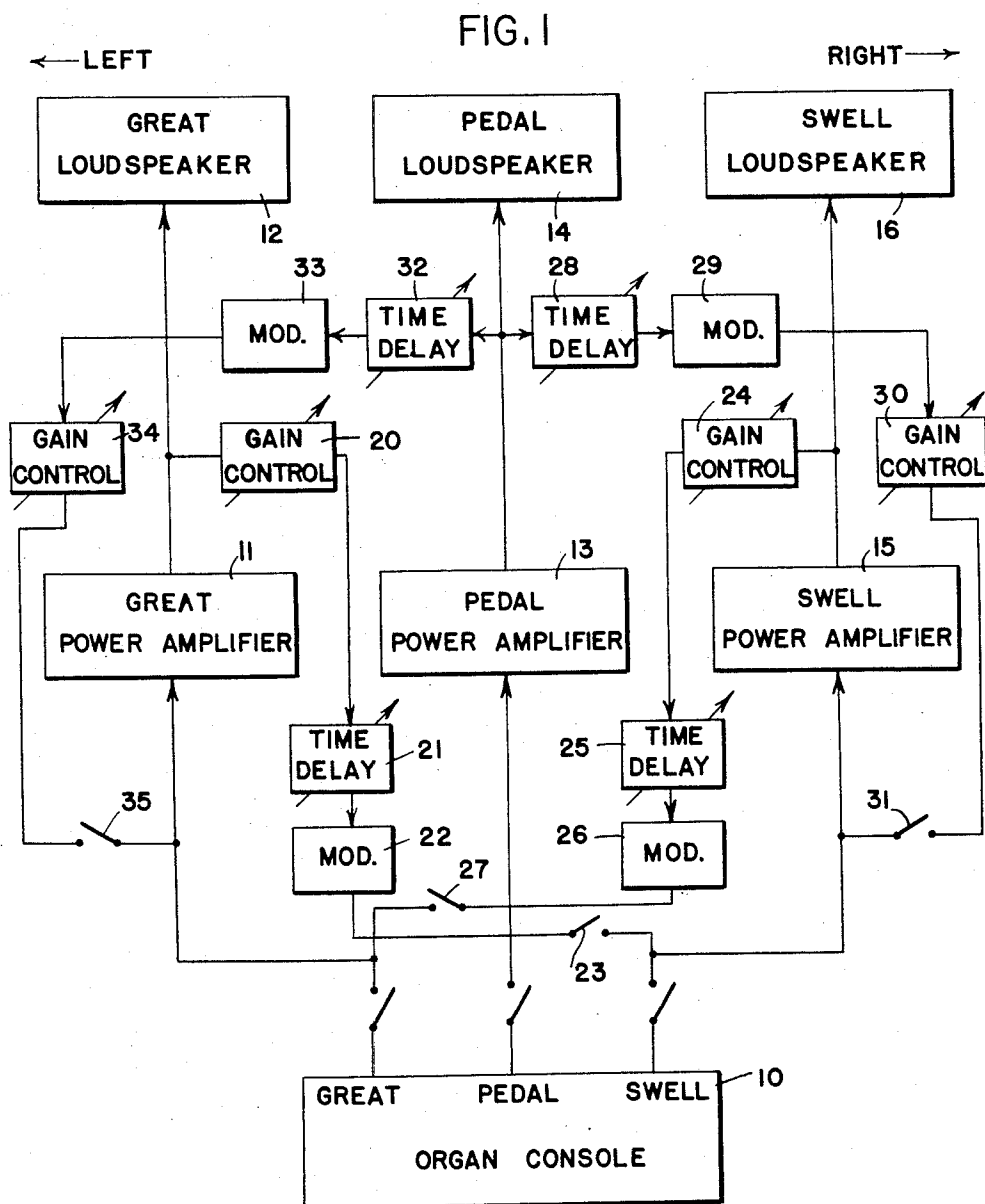
March 31, 1959

D. W. MARTIN
MONAURAL-BINAURAL TRANSMISSION OF SOUND
FOR PRODUCING A HAAS EFFECT

2,879,683

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2 Sheets-Sheet 1



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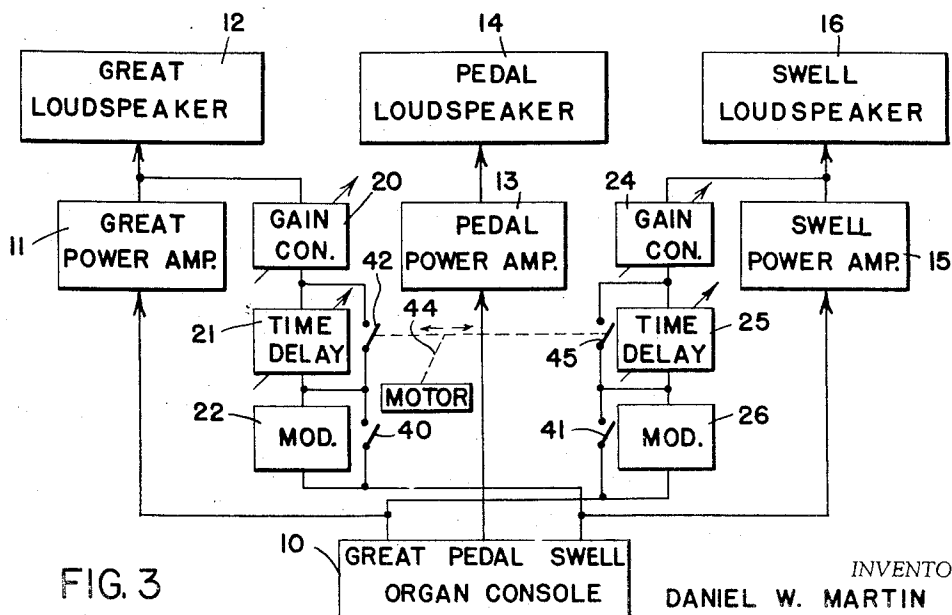
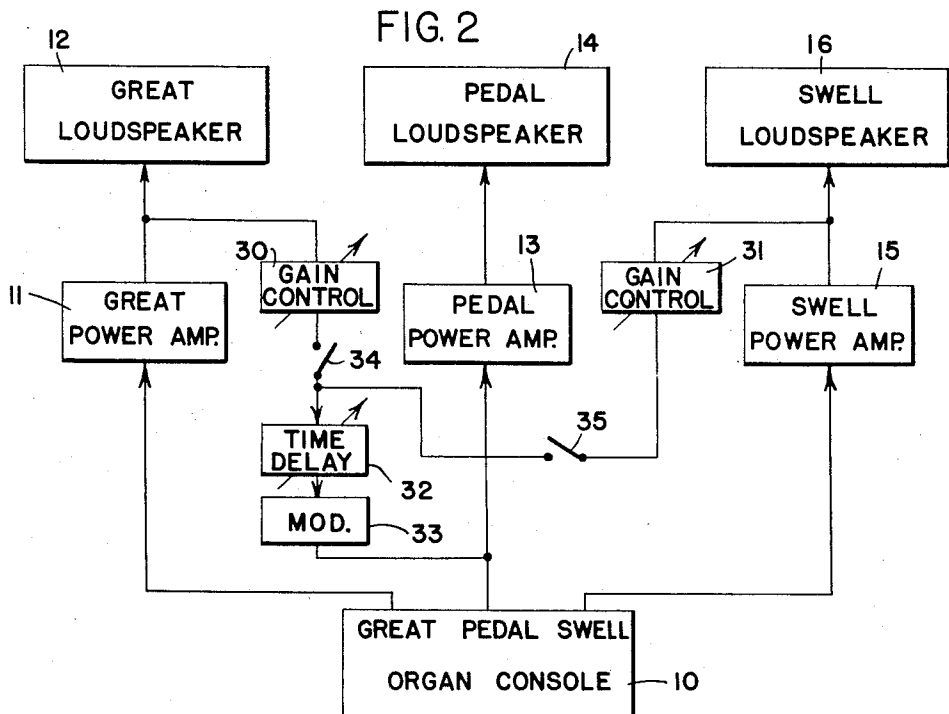
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MONAURAL-BINAURAL TRANSMISSION OF SOUND FOR PRODUCING A HAAS EFFECT

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12 Claims. (Cl. 84-1.24)

The present invention relates generally to electronic organs, and more particularly to systems for efficiently modulating and radiating the tonal output of an electronic organ to achieve interesting choral effects.

The traditional pipe organ consists of many ranks of pipes, which are invariably somewhat out of tune. Certain ranks of pipes, referred to as "celestes" are purposely detuned to produce a rich ensemble effect in the composite tone, which is especially desirable for use in ecclesiastical music. Electronic organ music may be processed in such fashion as to impart enhanced ensemble effects, analogous to those obtainable from pipe organs, and organ tones or the frequency spectrum of organ output may be described as "enhanced," when so processed, to distinguish them from the more conventional unprocessed tones or spectra which are not so enhanced. Various devices for enhancing electronic organ tones exist.

Achieving of enhanced tones according to the present invention involves generally the prior production of unmodulated tones, by an electronic organ, which may be radiated as such. The unmodulated tones may be produced by different divisions of the organ, and each division may be provided with a separate amplification channel and radiating system. The latter are spatially separated, for example across the front of the auditorium. In this respect unmodulated tones may be understood as including tones which may be, or not be, subjected to vibrato or tremolo effects. In accordance with the invention, the organ tones are modulated, in accordance with the teaching of any of the above applications for United States patent, and the modulated tones originating in the different organ divisions may be radiated from separated locations, together with the unmodulated tones.

Generally, the provision of facilities for radiating modulated tones together with unmodulated tone involves the addition of amplification channels and loud speaker systems, to those in any event available, since it is found that radiation of unmodulated and modulated tones deriving from the same organ division, from separated points in space, provides a much closer approximation than is otherwise possible to the multi-source chorus effect of organ pipes separated in space and operating in a non-synchronous manner, or serves to provide novel and desirable tonal effects which are not possible for the pipe organ.

The provision of separate amplification channels for unmodulated and modulated tones, and of separate loud speaker systems for these, is obviously undesirable economically, and also from the point of view of space requirements.

It is a primary object of the present invention to provide a system for radiating modulated and unmodulated tones from common radiating systems, driven from the amplification channels in any event available for the unmodulated tones, while providing the subjective effects of separate radiating systems and separate amplification channels.

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It is generally the practice in providing tone amplifying and radiating systems for electronic organs to provide separate amplification channels and radiation systems for the separate divisions of the organ, i.e. for the great, pedal and swell divisions, and the separate radiation systems are usually separated physically as far as possible across the front of an auditorium, in order to have the sound from each division originate from an audibly separate location. It is feasible and highly desirable to reduce the cost of such systems, and their space requirements, by employing a single highly efficient low frequency tone radiating system for all the organ divisions, and to provide spatial separation of tone radiating systems for the medium and high frequency sounds only. The spatial separation of sound radiators for the separate organ divisions is thus achieved for all tones, including the low frequency tones, on a subjective basis, despite the fact that the origin of all the low tones is the same, and in such systems the principles of the present invention may apply only to the amplification and radiation systems employed for the medium and high frequencies.

In accordance with the present invention, tone deriving from any one organ division is modulated and delayed, and the modulated delayed tone is supplied to the amplification channel serving another and different organ division. The same amplifier channel and radiation system may thus serve for both normal unmodulated signal from one organ manual, and for modulated or enhanced signal from another manual, without loss of identity with regard to auditory localization. The effect involved is subjective, and is known as the Haas effect, being described by the statement that sound subjectively appears to be localized where the initial portion of it originates.

To provide a specific example, unmodulated signals from the great, pedal and swell divisions of the organ may be radiated from the left, center and right of an auditorium, respectively. Connection of a modulator and time-delay device for great signals between the output of the great amplifier and the input of the swell amplifier separates the sources of modulated and unmodulated great tones, and hence provide the full modulated effect of space separated sources of modulated and unmodulated tones, respectively. However, the listener subjectively localizes the entire tone as originating from the left, because the initial part of the tone initiated on the left, i.e., from the great loud speaker. Analogous expedients may be applied to the several divisions of the organ, to the end that all three divisions, or any of these, or any combination of these, may provide both unmodulated and enhanced sound.

Modifications of the invention involve (1) selective utilization of a single modulator by either of two divisions of an electric organ and radiation of the modulated tone by the radiator assigned to the third division, and (2) the periodic or random elimination or variation of delay time, in a modulation channel or in alternate channels, to achieve special tonal effects.

It is, accordingly, an object of the present invention to provide a system for introducing modulated tone into an audio system of an electronic organ, without requiring amplifiers or sound radiators additional to those in any event available for amplifying and radiating unmodulated tone.

It is a further object of the present invention to provide a system for transmitting tones from one radiation system and causing the tones subjectively to appear as deriving from a different radiation system, remote from the one radiation system.

It is still another object of the present invention to provide a system in which an unmodulated and a modulated tone of similar but not identical tonal content are

radiated acoustically from two spaced radiators, and is applied to one of the radiators with a relative time delay, so that the tone will appear subjectively to derive from the other radiator.

It is another object of the invention to provide a system for radiating unmodulated tones deriving from the three divisions of an electronic organ via three separate amplifying and radiating channels, each individual to one of the divisions, to radiate modulated tones deriving from two of the divisions each via the amplification and radiating channel of the other, and to introduce a time delay into the modulated tones, so that the initial times of radiation are later than the initial times of radiation of the corresponding unmodulated tone. A subsidiary feature involves reduction of the time delays of the modulated tones in alternation and periodically, or at random.

It is still a further object of the invention to provide a system for radiating an unmodulated tone from one location and a modulated version of that tone from another location with time delay, and to reduce the time delay periodically or at random.

A broader object of the invention is to radiate an unmodulated tone from one location, and a modulated version of the tone from another location, but with a time delay of the order of 0.05 second.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of various specific embodiments thereof, especially when taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a block diagram of a system according to the invention as applied to an electronic organ; and

Figures 2 and 3 are block diagrams of modifications of the system of Figure 1.

Proceeding now more particularly by reference to the accompanying drawings, the reference numeral 10 denotes an electronic organ having great, pedal and swell divisions. The amplification channel for the great division includes great power amplifier 11 and radiator 12; the amplification channel for the pedal division includes pedal power amplifier 13 and radiator 14, and the amplification channel for the swell division includes swell power amplifier 15 and radiator 16. If desired (in the several modifications of the present invention) the several radiation systems, or loud speaker systems, may be limited to radiating medium and high frequencies, and the low frequencies from all the divisions may be commonly radiated from a single speaker, following the teaching of an application for United States patent filed in the name of the present invention, Serial No. 584,609, entitled Sound Distribution System. However, the present invention does not require the arrangement of the specified patent application, which is permissive only, although generally preferred.

The output of the great division of organ 10 may be derived at the output side of power amplifier 11, passed through a controllable gain control device 20, a controllable time delay device 21, a modulator 22, and via a switch 23 to the input of swell power amplifier 15. The output of swell power amplifier 15 may be applied via controllable gain control device 24, controllable time delay device 25, modulator 26 and switch 27 to the input of great power amplifier 11. The output of the pedal power amplifier 13 may be applied via controllable time delay device 28, modulator 29, controllable gain control device 30 and switch 31 to the input of swell power amplifier 15, and similarly via time delay device 32, modulator 33, gain control device 34 and switch 35 to the input of great amplifier 11.

The several gain control devices may be attenuators, and are arranged to attenuate the level of signal applied to each amplifier so that modulated and unmodulated tone may be radiated at approximately the same level, or so that one may be radiated at relatively reduced level,

as desired. The time delays provided are just sufficient to enable a subjective impression of the relative times of initial radiation of tones, and may be made adjustable to vary the effect, but are required to be of the order of 0.05 seconds. The modulators may be of diverse character, and particularly may be of the types disclosed in any one of the applications of Jones or Wayne, above referred to.

In the system of Figure 1 the great output of organ 10 may be radiated directly, in unmodulated form, by great radiator 12, and also in delayed and modulated form from swell radiator 16. The output of the swell division of organ 10 may be radiated directly by swell radiator 16, but after delay and in modulated form by great radiator 12. By reason of the delays, the swell output will appear subjectively to derive entirely from the swell radiator 16, and the great output from the great radiator 12, but the tonal character of the system is enhanced by the utilization of two spaced radiators, one for modulated tone and the other for unmodulated tone, each of which radiates one unmodulated tone and one modulated tone, deriving from different organ divisions.

The pedal division may have its output delayed and modulated, and the modulated tone radiated selectively by the great speaker or by the swell speaker, or by both. Since the great loud speaker may be located on the left side of the front of an auditorium, the swell loud speaker on the right, and the pedal loud speaker in the center, tonal output of each division may be radiated in modulated and unmodulated form from spatially separated radiators, but due to the delays introduced in the modulated signals they appear subjectively to originate in the loud speaker having the same nomenclature as the associated organ division.

The time delays introduced in the several modulated channels possess greatest usefulness where it is desired to have the modulated signal comparable in strength to the unmodulated signal. Where only a very small amount of modulated signal is required, relative to the unmodulated signal, the amplitude disparity between the modulated and unmodulated signal may be sufficient to provide the auditory localization desired, without the necessity for time delay. The system of Figure 1, may in such case, therefore, be modified to exclude time delays, or these may be adjusted to have zero value.

In a system in which modulation is desired for either the swell or great divisions, or the combination of the two simultaneously, but in which separate and independent modulation for the swell and great divisions is not a requirement, output signals from both the great and the swell divisions could be passed, selectively and at will, through a single delayed modulation channel, amplified by the pedal amplifier and radiated by the pedal loud speaker. Reference is made to Figure 2 of the accompanying drawings for illustration of such a system.

In the system of Figure 2 is illustrated an organ console 10 having great, pedal and swell divisions, the great, pedal and swell power amplifiers 11, 13 and 15, respectively, and the great pedal and swell loud speakers 12, 14 and 16, respectively, following Figure 1. The outputs of great and swell power amplifiers are applied via separate, and independent adjustable gain control or attenuator devices 30, 31, commonly to the input of a time delay device 32, and a modulator 33. The great and swell inputs may be separately connected or disconnected, by means of switches 34, 35, and the output of modulator 33 is connected to the input of pedal amplifier 13.

It follows that a modulated form of either the great or the swell divisions may be radiated by the pedal loud speaker system, but that only one modulating channel is employed, which minimizes the extra equipment required to achieve enhanced tones.

In the system of Figure 3, the output of the great amplifier is delayed, modulated and applied to the input of the swell amplifier, while the output of the swell ampli-

fier is time delayed and modulated and applied to the input of the great amplifier, following the general teachings of the present invention, as described particularly in connection with Figure 1, and accordingly the same numerals of reference are applied to corresponding parts, in Figures 1 and 3.

In the system of Figure 3, however, a switch 40 is provided for by-passing the modulator 22, and a switch 41 for by-passing the modulator 26, at will. Moreover, switches 42 and 43 are provided for by-passing the time delay devices 21 and 25, respectively. The latter switches may be opened and closed in alternation, and cyclically or at random, as by a motor driven device 44, so that time delays are introduced into the great and swell channels in alternation. The apparent sources of the modulated tones is thus changed from left to right, and back, in alternation and periodically, while the unmodulated tones do not shift their apparent origins. A novel effect is thus obtained, which is of considerable interest musically, and simulates a cyclic or random shift of tonal origin, having regard for the subjective effect of the time delay in effecting interchange of origins for the modulated tones deriving from the great and swell divisions, while the unmodulated tones remain relatively fixed as to origin.

The switches 40, 41 which permit by-passing of the modulators, provide a further tonal effect, in that each of the great and swell divisions of the organ are radiated from both the swell and great radiators, but the presence of time delays introduces a subjective effect localizing the apparent sources of the tones. By retaining the time delays, but by-passing the modulators, the output of each division may be radiated from two separated radiators, but subjectively appear to be localized in one of these.

The order of magnitude of the time delays required, in the practice of the present invention, has been specified as 0.05 second. Much greater times give the impression of an echo, and confuses the organist and the listener. Much lesser times would correspond to differences in distance of the same order as might exist between a listener and two widely separated loud speakers, and are insufficient for that reason, i.e., because the desired subjective effect would not be accomplished.

In a broad sense, accordingly, the modulator employed in the practice of the present invention may be any device for processing a band of signals corresponding with music, so as to derive a modified band of signals, in which the modified band includes the musical content of the unprocessed band but is audibly distinguishable therefrom by reason of frequency content. Preferably, different portions of the audio spectrum are distinguishably processed, to introduce a random effect.

The present invention may be practiced by transferring tonal signal from the input of one amplifier to the input of another rather than from output to input, provided that means be provided for compensating for attenuations inherent in delay devices, modulation systems and the like.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the general arrangement and of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. In an audio system for electrical musical production, wherein signals of different tonal character are applied in different audio channels having a separate amplification system for each of said audio channels, each of said amplification systems having an input circuit and an output circuit, a separate acoustic radiation system for each of said amplification systems coupled to the output circuit thereof, said radiation systems being spaced apart by a sufficient distance distinctly to localize the sounds

originating from the separate radiation systems, the combination of at least one cross feed channel connected between said audio channels for deriving tone signals from at least one of said audio channels and for applying the tone signal so derived to the input circuit of at least another of said amplification systems, a time delaying means for delaying tone signal by a time interval selected to localize sound origin by virtue of Haas effect at that one of the radiation systems at which the initial portion of the sound originates, said time delaying means being connected in cascade in said cross feed channel and means for pitch modulating the tone signal, said last means being included in cascade with said delaying means in said cross feed channel.

2. The combination according to claim 1 wherein is provided an electronic organ having swell, great and pedal divisions, each of said divisions being operatively associated with a different one of said audio channels for producing said signals of different tonal character.

3. The combination according to claim 1 wherein said means for pitch modulating is a means for enhancing the tone signal to include chorus effect.

4. The combination according to claim 1 wherein said at least one cross feed channel includes two cross feed channels, and means for at will connecting each cross feed channel between one of said audio channels and another one of said input circuits.

5. In an audio system for electrical musical production, wherein signals of different tonal character are applied in at least two different audio channels each having a separate amplification system, each of said amplification systems including an input circuit and an output circuit, a separate acoustic radiation system for each of said amplification systems coupled to the output circuit thereof, said radiation systems being spaced apart by a sufficient distance distinctly to localize the sounds originating from the separate radiation systems, the combination of at least two cross feed channels, each of said cross feed channels being connected between said different audio channels for deriving tone signal from at least one of said audio channels and for applying the tone signal so derived to the input circuit of another of the audio amplification systems, each of said cross channels including a time delaying means for delaying tone signal by a time interval selected to localize sound origin by virtue of Haas effect at that one of the radiation systems at which the critical portion of the sound originates, said time delaying means being connected in cascade in said cross feed channel, and means for at will pitch modulating tone signal connected in cascade with each of said means for delaying.

6. The combination according to claim 5 wherein said audio system for electrical musical production is an electronic organ having at least two divisions for generating said signals of different tonal character.

7. The combination according to claim 6 wherein said means for pitch modulating is a means for enhancing tone by introducing chorus effect.

8. In an electrical organ system including great, pedal and swell divisions, and wherein each of said divisions generates signals of different tonal character, said signals of different tonal character being each applied in a different audio channel, each audio channel having a separate amplification system having an input circuit and an output circuit, a separate acoustic radiation system operatively associated with each of said amplification systems and coupled to the output circuit thereof, said radiation systems being spaced apart by a sufficient distance distinctly to localize the sounds originating from the separate radiation systems, the combination of cross feed channels extending between said audio channels for deriving tone signals from certain of said audio channels and for applying the tone signals so derived to the input circuit of an amplification system in at least one other of said amplification systems, each of said cross feed

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channels including in cascade a time delaying means for delaying tone signal by a time interval selected to localize sound origin, by virtue of Haas effect, at that one of the radiation systems at which the initial portion of the sound originates, each of said cross feed channels further including in cascade means for pitch modulating the tone signal in said cross feed channels.

9. The combination according to claim 8 wherein each of said audio channels is connected to the remaining audio channels by one of said cross feed channels.

10. The combination according to claim 8 wherein is provided means for at will disconnecting any of said cross feed channels from said system.

11. The combination according to claim 8 wherein is provided means for automatically alternately discon-

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necting certain of said cross feed channels from said system.

12. The combination according to claim 8 wherein is provided means for including a single time delaying means at will into any one of a plurality of said cross feed channels.

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