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(71) Applicant: SIEMENS AKTIENGESELLSCHAFT 80333 München (DE)	
(72) Inventors: • Aubauer, Roland 46395 Bocholt (DE)	

(54)

Method for reproducing a plurality of mutually unrelated sound signals, especially in a motor vehicle

(57)

In a method for reproducing a plurality of mutually unrelated sound signals (26, 28) by means of a plurality of loudspeakers (12, 14), first, the sound signals (26, 28) are received from one or more sound sources. Next, the received sound signals (26, 28) are filtered in a crosstalk cancellation filter (16) in order to cancel out crosstalk between the individual sound signals (26, 28). Finally, the filtered sound signals are supplied to the

loudspeakers (12, 14). In an embodiment of the method according to the invention, the sound signals (26, 28) comprise multichannel sound signals and the multichannel sound signals are filtered in the crosstalk cancellation filter (16) in order to cancel out cross talk between the individual channels of the multichannel sound signals. The filtered multichannel sound signals are supplied to the loudspeakers (12, 14).

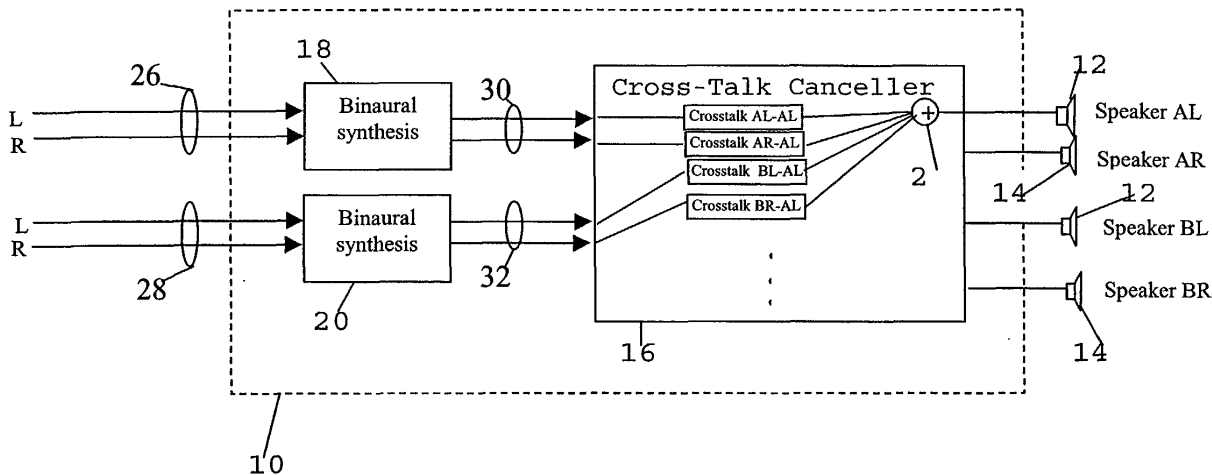


Fig.

Description

[0001] The invention relates to a method for reproducing a plurality of mutually unrelated sound signals by means of a plurality of loudspeakers and to a sound reproducing system for applying this method.

[0002] When two or more people want to listen to different audio signals inside the same space, for example in case of a dual window television or inside a car, at least one of them typically needs to wear headphones. However, JP08289389 discloses a acoustic system for use in a vehicle in which each seat is provided with one or more loudspeakers. Each person in the car can select a sound signal from a plurality of sound sources independent from the selection made by the other persons. By means of a signal matrix switch the selected sound signal is supplied to the loudspeaker(s) closest to the person making the selection. In such a situation it may easily occur that a person in one seat is bothered by the sound signal reproduced by the loudspeakers associated with another seat.

[0003] In order to reduce this effect the on-vehicle acoustic device of JP09171387 provides a masking means which outputs noise from a speaker to mask the sound signals reproduced by the loudspeakers of other seats.

[0004] In a situation where different people have selected different sound signals it might easily occur that these different sound signals interfere with each other so that the perceived sound quality of the sound signals is relatively low. Therefore, in order to cancel the contribution of the unwanted sound signals, in accordance with the invention, there is provided a method for reproducing a plurality of mutually unrelated sound signals by means of a plurality of loudspeakers, the method comprising:

- receiving the sound signals from one or more sound sources;
- filtering the received sound signals in a crosstalk cancellation filter in order to cancel out crosstalk between the individual sound signals;
- supplying the filtered sound signals to the loudspeakers.

[0005] So, shortly said, according to the invention, unwanted crosstalk between the individual sound signals is eliminated by means of a crosstalk cancellation filter.

[0006] Crosstalk cancellation filters are known per se, for example from M.I.T. Media Laboratory Perceptual Computing Section Technical Report No. 342, July 6, 1995, Transaural 3-D audio, by William G. Gardner. In this report a 3-D audio system is disclosed in which a stereo sound signal is first processed by a binaural spatializer. The output of the spatializer is thereafter fed to a transaural audio system which delivers binaural signals to the ears of a person using a pair of stereo loudspeakers. The transaural audio system includes a

crosstalk cancellation filter for canceling the crosstalk leakage from each loudspeaker to the opposite ear. This report does not address the problem of crosstalk between mutually unrelated sound signals which are reproduced for different people.

[0007] In an embodiment of the method according to the invention the sound signals comprise multichannel sound signals and the method comprises the additional step of filtering the multichannel sound signals in the crosstalk cancellation filter in order to cancel out cross talk between the individual channels of the multichannel sound signals, the filtered multichannel sound signals being supplied to the loudspeakers. The operation of the crosstalk cancellation filter is in this respect similar to the operation of the crosstalk cancellation filter as used in the 3-D audio system of Gardner. The crosstalk leakage from each channel to the other channel(s) is thereby effectively eliminated.

[0008] In a preferred embodiment of the method according to the invention the multichannel sound signals are stereo sound signals for reproduction by a pair of stereo loudspeakers.

[0009] In another embodiment of the method according to the invention the method comprises the further steps of processing the stereo sound signals in a binaural spatializer and of filtering the binaurally spatialized stereo sound signals in the crosstalk cancellation filter.

[0010] In a further embodiment of the method according to the invention the loudspeakers are provided on or above a plurality of seats or chairs.

[0011] In another embodiment of the method according to the invention the loudspeakers are provided on the top of the backs of the seats or chairs.

[0012] In yet another embodiment of the method according to the invention the loudspeakers are provided on headrests of the seats or chairs. Alternatively, the loudspeakers may be provided above the seats or chairs, e.g. on the ceiling above the seats or chairs.

[0013] In a preferred embodiment of the method according to the invention the seats or chairs are comprised in a car or in a space for presenting multi-media shows such as motion pictures.

[0014] The invention also relates to a sound reproducing system, for applying the method of anyone of the preceding claims, comprising sound processing means and coupled thereto loudspeakers, the sound processing means being arranged for receiving a plurality of sound signals from one or more sound sources, the sound processing means comprising a crosstalk cancellation filter for filtering the received sound signals in order to cancel out crosstalk between the individual sound signals, the sound processing means being further arranged for supplying the filtered sound signals to the loudspeakers.

[0015] Preferably, the sound signals comprise multichannel sound signals and the crosstalk cancellation filter is arranged for filtering the multichannel sound signals in order to cancel out cross talk between the indi-

vidual channels of the multichannel sound signals, the sound processing means being further arranged for supplying the filtered multichannel sound signals to the loudspeakers. The multichannel sound signals may be stereo sound signals for reproduction by a pair of stereo loudspeakers.

[0016] The sound processing means may comprise a binaural spatializer for processing the stereo sound signals and for supplying the binaurally spatialized sound signals to the crosstalk cancellation filter.

[0017] Preferably, the loudspeakers are provided on or above a plurality of seats or chairs, e.g. on the top of the backs of the seats or chairs or on headrests of the seats or chairs. Alternatively, the loudspeakers may be provided above the seats or chairs, e.g. on the ceiling above the seats or chairs. The seats or chairs may be comprised in a car or in a space for presenting multi-media shows such as motion pictures.

[0018] The invention will be apparent from and elucidated with reference to the example as described in the following and to the accompanying drawing, which shows in the sole Figure schematically the sound reproducing system according to the invention.

[0019] The sole Figure shows schematically an embodiment of a sound reproducing system according to the invention. The sound reproducing system comprises sound processing means 10 and coupled thereto loudspeakers 12, 14. The sound processing means 10 are arranged for receiving a plurality of sound signals 26, 28 from one or more sound sources (not shown). In this example, the sound signals 26, 28 are stereo sound signals and the loudspeakers 12, 14 are stereo loudspeakers for reproducing the stereo sound signals. However, the sound reproducing system may equally well be used with other multichannel or single channel sound signals with corresponding loudspeaker arrangements.

[0020] The sound processing means 10 comprises two binaural spatializers 18, 20 and a crosstalk cancellation filter 16. The binaural spatializers 18, 20 are arranged for processing the stereo sound signals 26, 28 and for supplying the resulting binaurally spatialized sound signals 30, 32 to the crosstalk cancellation filter 16. The crosstalk cancellation filter 16 is arranged for filtering the binaurally spatialized sound signals 30, 32 in order to cancel out crosstalk between the individual sound signals 30, 32 and between the individual channels of the multichannel sound signals. In the Figure this filtering is shown in detail for the left channel of the stereo sound signal 26 and the therewith corresponding left channel of the binaurally spatialized stereo sound signal 30. The crosstalk between this channel and each of the four channels of the stereo sound signals 30 and 32 is canceled by means of a specific crosstalk cancellation unit: for instance the crosstalk between the left channel of sound signal 30 (AL) and the right channel of sound signal 32 (BR) is cancelled by means of a specific crosstalk cancellation unit BR-AL. The output signals of the four specific crosstalk cancellation units are combined

in an adder 22 and the combined signal, from which the crosstalk is substantially removed, is finally supplied to the speaker 12 (Speaker AL). The crosstalk cancellation for the other channels AR, BL and BR is not shown in detail in the Figure but is similar in operation to the crosstalk cancellation for the AL channel. For each of these other channels AR, BL and BR four specific crosstalk cancellation units and an adder 22 are provided. The filtered stereo sound signals are supplied to the loudspeakers 12 and 14. In this example, the loudspeakers 12 are the left loudspeakers reproducing the left channel of the stereo sound signals and the loudspeakers 14 are the right loudspeakers reproducing the right channel of the stereo sound signals.

[0021] Crosstalk cancellation filters and binaural spatializers are known per se, for example from M.I.T. Media Laboratory Perceptual Computing Section Technical Report No. 342, July 6, 1995, Transaural 3-D audio, by William G. Gardner.

[0022] In one alternative embodiment (not shown), the sound processing means 10 does not comprise the binaural spatializers 18 and 20 in which case the sound signals 26, 28 are directly supplied to the crosstalk cancellation filter 16.

[0023] The loudspeakers 12, 14 may be provided on or above a plurality of seats or chairs (not shown). For example, the loudspeakers 12, 14 may be provided on the top of the backs of the seats or chairs or on headrests of the seats or chairs. Alternatively, the loudspeakers 12, 14 may be mounted on a ceiling above the seats or chairs. The seats or chairs are preferably comprised in a car, in which situation application of the invention allows the passengers of the car to listen to different sound signals without having to wear headphones and without substantial interference of the different sound signals. The seats or chairs may also be comprised in a space for presenting multi-media shows, such as a cinema in which motion pictures are shown, in which situation application of the invention may allow members of the audience to listen to different language versions of the sound signals without having to wear headphones and without substantial interference of the different sound signals.

[0024] Now, the invention has been disclosed with reference to the Figures in connection with the disclosure of preferred embodiments. However, persons skilled in the art will readily recognize various amendments, modifications, and combinations. Therefore, the above disclosure should not be considered as limitative, but rather illustrative, and the due scope of the present invention should be determined from the scope of the Claims appended hereto, the invention being embodied in each new characteristic and each combination of characteristics. Any reference signs do not limit the scope of the claims. The word "comprising" does not exclude the presence of other elements or steps than those listed in a claim. Use of the word "a" or "an" preceding an element does not exclude the presence of a plurality of

such elements.

Claims

1. Method for reproducing a plurality of mutually unrelated sound signals by means of a plurality of loudspeakers, **characterized by**:

- receiving the sound signals from one or more sound sources;
- filtering the received sound signals in a crosstalk cancellation filter in order to cancel out crosstalk between the individual sound signals;
- supplying the filtered sound signals to the loudspeakers.

2. Method for reproducing a plurality of mutually unrelated sound signals, according to claim 1, **characterized in that** the sound signals comprise multichannel sound signals and wherein the method comprises the additional step of filtering the multichannel sound signals in the crosstalk cancellation filter in order to cancel out cross talk between the individual channels of the multichannel sound signals.

3. Method for reproducing a plurality of mutually unrelated sound signals, according to claim 2, **characterized in that** the multichannel sound signals are stereo sound signals for reproduction by a pair of stereo loudspeakers.

4. Method for reproducing a plurality of mutually unrelated sound signals, according to claim 3, **characterized in that** the method comprises the further steps of processing the stereo sound signals in a binaural spatializer and of filtering the binaurally spatialized stereo sound signals in the crosstalk cancellation filter.

5. Method for reproducing a plurality of mutually unrelated sound signals, according to anyone of the preceding claims, **characterized in that** the loudspeakers are provided on or above a plurality of seats or chairs.

6. Method for reproducing a plurality of mutually unrelated sound signals, according to claim 5, **characterized in that** the loudspeakers are provided on the top of the backs of the seats or chairs.

7. Method for reproducing a plurality of mutually unrelated sound signals, according to claim 5, **characterized in that** the loudspeakers are provided on headrests of the seats or chairs.

8. Method for reproducing a plurality of mutually unre-

lated sound signals, according to anyone of the claims 5-7, **characterized in that** the seats or chairs are comprised in a car.

9. Sound reproducing system, for applying the method of anyone of the preceding claims, comprising sound processing means and coupled thereto loudspeakers, **characterized by** the sound processing means being arranged for receiving a plurality of sound signals from one or more sound sources, the sound processing means comprising a crosstalk cancellation filter for filtering the received sound signals in order to cancel out crosstalk between the individual sound signals, the sound processing means being further arranged for supplying the filtered sound signals to the loudspeakers.

10. Sound reproducing system according to claim 9, **characterized in that** the sound signals comprise multichannel sound signals and wherein the crosstalk cancellation filter is arranged for filtering the multichannel sound signals in order to cancel out cross talk between the individual channels of the multichannel sound signals.

11. Sound reproducing system according to claim 10, **characterized in that** the multichannel sound signals are stereo sound signals for reproduction by a pair of stereo loudspeakers.

12. Sound reproducing system according to claim 11, **characterized in that** the sound processing means comprises a binaural spatializer for processing the stereo sound signals and for supplying the binaurally spatialized sound signals to the crosstalk cancellation filter.

13. Sound reproducing system, according to anyone of the claims 9-12, **characterized in that** the loudspeakers are provided on or above a plurality of seats or chairs.

14. Sound reproducing system, according to claim 13, **characterized in that** the loudspeakers are provided on the top of the backs of the seats or chairs.

15. Sound reproducing system, according to claim 13, **characterized in that** the loudspeakers are provided on headrests of the seats or chairs.

16. Sound reproducing system, according to anyone of claims 13-15, **characterized in that** the seats or chairs are comprised in a car.

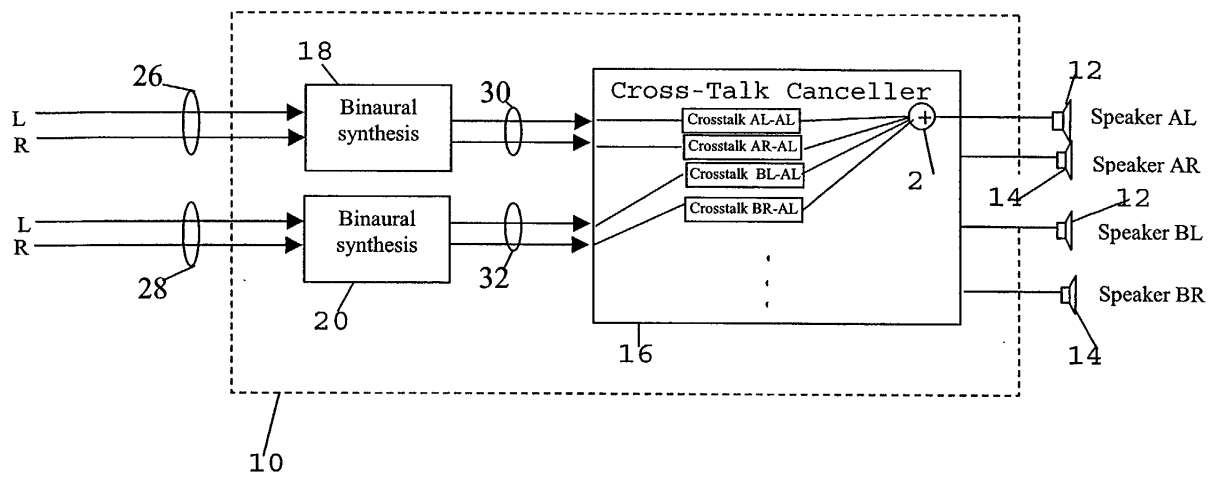


Fig.



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 02 01 3455

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 6 243 476 B1 (GARDNER WILLIAM G) 5 June 2001 (2001-06-05) * column 2, line 28 - line 47 * * figure 4 *	1	H04S1/00
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 April 2003	Examiner Dionisi, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 02 01 3455

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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09-04-2003

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