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(54) **Hearing device providing smooth transition between operational modes of a hearing aid**

(57) This invention relates to a hearing device (100,300) for processing sound and comprising a plurality of filterbanks (104,108) for splitting electric sound signals into a series of frequency channel signals (fc_1 to fc_N), a series of decision units (116_1 to 116_N) each comprising a summing module (118,120) for summing frequency channel signals of said specific frequency channels (fc_1 to fc_N) thereby generating an omni-directional (O_1 to O_N) and directional signal (D_1 to D_N), and a mixing module (126,128,130) for mixing said omni-directional (O_1 to O_N) and directional signals (D_1 to D_N) according to content thereof and to generate a channel-specific signal, a merging unit (132) connected to said series of decision units (116_1 to 116_N) and adapted to receive said channel-specific signals and to merge said channel-specific signals into an output signal.

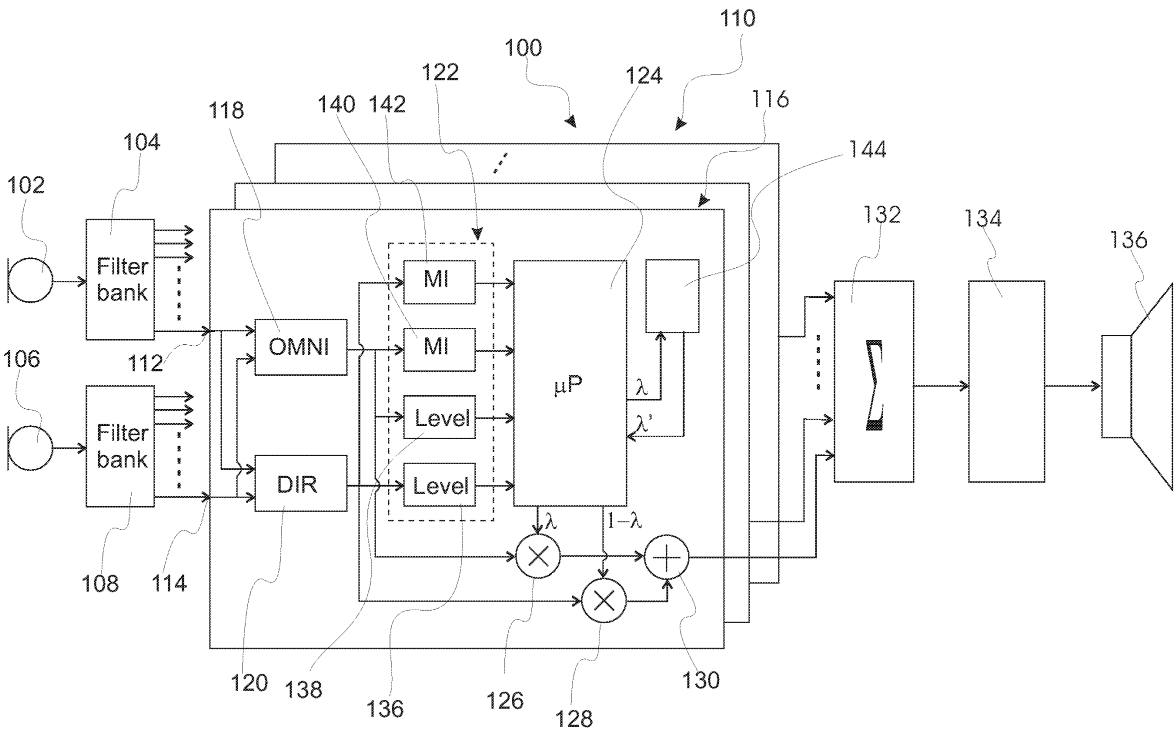

Fig.1

EP 1 827 058 A1

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Description

Field of invention

[0001] This invention relates to a hearing device and method for providing smooth transition between modes in a hearing aid. In particular, this invention relates to a hearing device and a method incorporated therein for providing a smooth transition between an omni-directional and a directional mode. In this context a hearing device may be hearing aids, such as an in-the-ear (ITE), completely-in-canal (CIC) or behind-the-ear (BTE) hearing aids, headphones, headsets, hearing protective gear, intelligent earplugs etc.

Background of invention

[0002] Generally, state of the art hearing aids comprise a directional microphone system operated so as to continuously optimize the hearing situation for the user of a hearing aid in various sound environments. The directional microphone system is switch-able between an omni-directional mode, wherein the signals of the microphones have an invariant spatial sensitivity, and a directional mode, wherein signals of the microphones are weighted so as to focus spatial sensitivity in a direction in front of the user of the hearing aid.

[0003] European patent application no. EP 1 192 838 discloses a hearing aid comprising a plurality of microphones generating input signals to an inverting and summing means establishing signals of 0^{th} to n^{th} order. That is, 0^{th} order is omni-directional or non-differential, 1^{st} order is a directional signal established from the difference between two microphone signals from two spaced apart microphones, and 2^{nd} order is a directional signal established from the difference between two 1^{st} order directional signals. The hearing aid device further comprises a filterbank receiving the omni-directional and directional signals and dampens said signals in accordance with frequency and order. Thus each of said signals is processed in accordance with an independent transfer function before being summed in a speaker driving unit. Hence the hearing aid device achieves a greater directionality in the high frequency spectrum by adding 2^{nd} order directional signals to 1^{st} order directional signals when the sound environment recorded by the microphones comprises high frequency components.

[0004] The above described hearing aid although improving directionality introduces problems which require further thought and development. In particular, when switching between sound environments including either low or great background noises, the directional mode change experienced by the user of the hearing aid is confusing, because sounds originating from behind the user are significantly and suddenly dampened.

Summary of the invention

[0005] An object of the present invention is to provide a system and method providing a smooth transition between operational modes of a hearing aid.

[0006] It is a further object of the present invention to provide a hearing aid comprising a system providing a smooth transition between operational modes.

[0007] A particular advantage of the present invention is the provision of a frequency independent omni-directional to directional mode switch.

[0008] A particular feature of the present invention is the provision of a linear transformation between the omni-directional and directional modes.

[0009] The above objects, advantage and feature together with numerous other objects, advantages and features, which will become evident from below detailed description, are obtained according to a first aspect of the present invention by a hearing device for processing sound and comprising a plurality of microphones each adapted to convert a sound to an electric sound signal, a filterbank connected to each of said plurality of microphones and adapted to split said electric sound signals into a series of frequency channel signals, a series of decision units each comprising a summing module connected to a specific frequency channel of each of said filterbanks and adapted to sum frequency channel signals of said specific frequency channels thereby generating a first and second directional signal and a mixing module connected to said summing module and adapted to mix said first and second directional signal according to content thereof and to generate a channel-specific signal, a merging unit connected to said series of decision units and adapted to receive said channel-specific signals and to merge said channel-specific signals into an output signal, and a speaker unit connected to said merging unit and adapted to generate a processed sound from said output signal.

[0010] The hearing device according to the first aspect of the present invention thus, advantageously, may perform a channel-specific determination of whether an omni-directional, directional or a mixture of both (operational modes) should be generated for a particular frequency channel. Allowing each of the decision units to determine which operational mode is to used for a specific channel enables the hearing device to provide a transition between modes which is perceived smooth, i.e. not abrupt.

[0011] The plurality of microphones according to the first aspect of the present invention may comprise a first and second microphone spaced apart so that the first microphone is affected by a first spatial sound pressure and the second microphone is affected by a second spatial sound pressure. Hence the electric sound signals from the first and second microphones may be used for generating an omni-directional signal and a directional signal.

[0012] Each of the plurality of microphones may be connected to a dedicated filterbank, which splits the electric sound signals into a number of frequency channels, such as in the range between 2 to 64, e.g. 16 or 32. The filterbanks connected to each microphone may comprise predefined frequency boundaries such as 250Hz, 500Hz, 750Hz, and so on. The individual bands of the filterbank may have the same bandwidth (uniform filterbank) or non-uniformly spaced bands (e.g. logarithmic spacing) or critical bands, which have bandwidths determined in accordance with an ears frequency sensitivity, i.e. the ear is more sensitive in some frequency areas compared with other frequency areas and therefore the individual bands of the filterbank may be divided in accordance with this sensitivity. Hence the frequency channel signals from a specific frequency channel of one filterbank corresponds to associated frequency channel signals from the same specific frequency channel of another filterbank.

[0013] The decision unit according to the first aspect of the present invention may be defined for a specific frequency channel of the filterbanks. Thus the number of frequency channels determines the number of decision units. Further, the series decision units may each comprise a communication unit connected to the mixing modules and adapted to communicate control parameters with one another and/or with a processor unit. Thus the decision units, advantageously, may in the process of selecting an appropriate mode for a frequency channel consider the modes of the neighbouring decision units.

[0014] The summing module according to the first aspect of the present invention may comprise a first and second summing element connected to a specific frequency channel of each filterbank and performing a real and complex summation, respectively. Thus the first summing element generates an omni-directional signal constituting the first directional signal and the second summing element generates a directional signal constituting the second directional signal.

[0015] The mixing module according to the first aspect of the present invention may comprise a detector element connected to the first and second summing element and adapted to determine whether the first and second directional signal has a level and/or modulation index above or below a predetermined threshold and to generate a detector signal based thereon. The mixing module may further comprise a processor element connected to the detector element and adapted to generate a control parameter based on said detector signal. The processor element thereby is configured to establish a control parameter, which is a measure for how to mix the first directional signal (generally omni-directional) and the second directional signal (generally directional). The control parameter may provide a linear transition between an omni-directional mode and directional mode thereby ensuring a user of the hearing device is provided a smooth and substantially non-perceivable change in operational modes.

[0016] The control parameter according to the first aspect of the present invention may be in the range between 0 and 1, where "0" provides a fully directional signal and "1" provides a fully omni-directional signal. Where the control parameter has values between 0 and 1 the mixing module factorizes the first directional signal by the control parameter and the second directional signal by one minus the control parameter, which factorized first and second directional signals subsequently are mixed with one another.

[0017] The above objects, advantages and features together with numerous other objects, advantages and features, which will become evident from below detailed description, are obtained according to a second aspect of the present invention by a method for processing sound and comprising converting a first and second spatial sound to a first and second electric sound signal, splitting said first and second electric sound signals individually into a first and second series of frequency channel signals, summing said first and second frequency channel signals of specific frequency channels thereby generating a first and second directional signal for each specific frequency channel, mixing said first and second directional signal according to content thereof, generating a channel-specific signal based on said mixing, merging said channel-specific signals into an output signal, and generating a processed sound from said output signal.

[0018] The features of the hearing device according to the first aspect of the present invention may be incorporated in the method according to the second aspect of the present invention.

[0019] The above objects, advantages and features together with numerous other objects, advantages and features, which will become evident from below detailed description, are obtained according to a third aspect of the present invention by a decision unit comprising a summing module connected to specific frequency channels of filterbanks and adapted to sum frequency channel signals of said specific frequency channels thereby generating a omni-directional and directional signal and a mixing module connected to said summing module and adapted to mix said omni-directional signal and directional signal according to content thereof and to generate a channel-specific output signal based thereon.

[0020] The features of the hearing device according to the first aspect of the present invention may be incorporated in the method according to the second aspect of the present invention.

Brief description of the drawings

[0021] The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of preferred embodiments of the present invention, with reference to the appended drawing, wherein:

figure 1, shows a block diagram of a hearing device according to a first embodiment of the present invention;

figure 2, shows a graph of transition between omni-directional mode and directional mode of the hearing device according to the first embodiment of the present invention; and

figure 3, shows a block diagram of a hearing device according to a second embodiment of the present invention.

Detailed description of preferred embodiments

[0022] In the following description of the various embodiments, reference is made to the accompanying figures, which show by way of illustration how the invention may be practiced. It is to be understood that other embodiments may be utilized and structural and functional modifications may be made without departing from the scope of the present invention.

[0023] Figure 1, shows a hearing device 100 according to a first embodiment of the present invention. The hearing device 100 may be implemented in a wide variety of ear level devices such as ear assistive devices, namely hearing aids, headphones, or headsets, or ear protective devices, namely hearing protectors, ear protectors, or intelligent earplugs. The term "intelligent" is in this context to be construed as comprising sound processing capability.

[0024] The hearing device 100 comprises a first microphone 102 measuring a sound pressure of a first spatial point and converting this sound pressure to a first electric sound signal. The first microphone 102 is coupled to a first filterbank 104 for dividing first electric sound signal in one or more frequency channels, such as 2, 3, 4, 8, 16 or 32 frequency channels. Hence the first sound signal is separated into a number of individual channel-specific first electric sound signals, such as a first channel covering the frequency band between 60 to 300 Hz, a second channel covering the frequency band between 301 to 1 KHz and so on until the frequency bandwidth of the first electric sound signal is covered.

[0025] The hearing device 100 further comprises a second microphone 106 spaced apart from the first microphone 102 and therefore measuring a sound pressure of a second spatial point. The second microphone 106 converts this sound pressure to a second electric sound signal. The second microphone 106 is coupled to a second filterbank 108 for dividing the second electric sound signal in one or more frequency channels corresponding to the frequency channels of the first filterbank 104. Hence as described with respect to the first sound signal the second sound signal is separated into a number of individual channel-specific second sound signals matching the channels defined for the first filterbank 104.

[0026] Hence the first and second filterbank 104 and 108 comprise the same number of frequency channels having identical frequency boundaries. Thus plurality of outputs of the first and second filterbank 104 and 108 comprise the same number of individual channel-specific first and second signals, respectively. The outputs of the frequency channels of the first filterbank 104 and the frequency channels of the second filterbank 108 are forwarded in pairs to a plurality of decision units 110 so that the output of the first frequency channel of the first filterbank 104 and the output of the first frequency channel of the second filterbank 108 are forwarded to a first 112 and second 114 input of a first decision unit 116 of the plurality of decision units 110. Similarly, each output of the frequency channels of the first and second filterbanks 104 and 108 are forwarded to the plurality of decision units 110. The plurality of decision units 110 consists of identical decision units for each frequency channel defined by the filterbanks 104 and 108.

[0027] Since the plurality of decision units 110 consist of identical decision units, the below description of the decision unit 116 may be extended to any decision unit of the plurality of decision units 110.

[0028] The first input 112 of the decision unit 116 is coupled to a first summing element 118, which is adapted to perform a real (i.e. non-complex) summing operation, and is further coupled to a second summing element 120, which is adapted to perform a complex summing operation. Similarly, the second input 114 is both coupled to the first summing element 118 and to the second summing element 120. Hence the first summing element 118 performs a summation of the frequency channel-specific signal established by the first filterbank 104 and forwarded to the first input 112 and the corresponding frequency channel-specific signal established by the second filterbank 108 and forwarded to the second input 114 thereby generating an omni-directional signal. Further, the second summing element 120 performs a summation of the frequency channel-specific signal established by the first filterbank 104 and forwarded to the first input 112 and the corresponding frequency channel-specific signal established by the second filterbank 108 and forwarded to the second input 114 thereby generating a directional signal.

[0029] The terms "real summing" and "complex summing" is in this context to be construed as ordinary addition of two electric signals and a pre-conditioned addition of two electric signals followed by post-conditioning, respectively. The article "Directional patterns obtained from two or three microphones" by Stephen C. Thompson in Knowles Electronics communiqué dated 29 September 2000 gives detailed information regarding how complex summing may be performed. Further, the article "A simple adaptive first-order differential microphone" by Gary Elko et al, Proc. 1995 IEEE ASSP Workshop on Applications of Signal Proc. to Audio & Acoustics, Oct. 1995, shows how the directional signal may be generated.

[0030] The decision unit 116 further comprises a detector element designated in entirety by reference numeral 122 and receiving the omni-directional signal from the first summing element 118 and the directional signal from the second summing element 120. The detector element 122 generates a detector signal based on the omni-directional and directional signals, which is forwarded to a processor element 124. The processor element 124 is configured to calculate a control parameter "λ" having a value between zero and one and determining a mixture of the omni-directional signal and the directional signal.

[0031] The omni-directional signal is, in addition, forwarded to a first multiplication element 126 multiplying the omni-directional signal with the control parameter "λ". Similarly, the directional signal is, in addition, forwarded to a second multiplication element 128 multiplying the directional signal with a factor determined by one minus "λ" (1-λ). Hence the omni-directional and directional signals are factorized by the control parameter "λ".

[0032] The factorized omni-directional and directional signals are forwarded to a third summing element 130, which sums the factorized omni-directional and directional signals and provides an output signal for the decision unit 116.

[0033] The output signals from the plurality of decision units 110 are summed in an output summing unit 132 providing an output electric signal to a sound processor and speaker driving unit 134 converting the output electric signal to a processed electric signal, which is output as processed sound by a speaker unit 136.

[0034] The detector element 122 according to a first embodiment of the present invention comprises a pair of level detectors 136 and 138 for receiving the omni-directional and directional signals and which are activated in accordance with level of the omni-directional and directional signal, respectively. For example, if the level of the omni-directional signal is above a predetermined omni-directional mode threshold and the level of the directional signal is below a predetermined directional mode threshold, then the processor element 124 uses the level of the omni-directional and directional signals to determine a value of the control signal "λ" so that a substantially linear transition between a full omni-directional mode (when the omni-directional signal is below the predetermined omni-directional mode threshold) and a full directional mode (when the directional signal is above the predetermined directional mode threshold) .

[0035] Figure 2, shows a graph 200 of the value of the control parameter "λ" versus the level of the omni-directional and directional signals expressed in sound pressure level (SPL). When the level of the omni-directional signal is below the omni-directional mode threshold 202 the processor element 124 generates a control parameter "λ" having a value equal to one so that the output signal of the third summing element 130 entirely comprises the omni-directional signal. On the other hand when the level of the directional signal is above the directional mode threshold 204 the processor element 124 generates a control parameter "λ" having a value equal to zero so that the output of the third summing element 130 entirely comprises the directional signal.

[0036] The detector element 122 according to a further embodiment of the present invention comprises a pair of modulation index detectors 140 and 142 for receiving the omni-directional and directional signals and which are activated in accordance with modulation index of the omni-directional and directional signal, respectively. The term "modulation index" is in this context to be construed as a ratio between speech signal and noise background. For example, if the modulation index of the omni-directional signal is above a predetermined omni-directional mode threshold and the modulation index of the directional signal is below a predetermined directional mode threshold, then the processor element 124 uses the modulation index of the omni-directional and directional signals to determine a value of the control signal "λ" so that a substantially linear transition between a full omni-directional mode (when the omni-directional signal is below the predetermined omni-directional mode threshold) and a full directional mode (when the directional signal is above the predetermined directional mode threshold).

[0037] The detector element 122 according to a further embodiment of the present invention comprises a pair of level detectors described with reference to the first embodiment of the detector unit and a pair of modulation index detectors described with reference to the second embodiment of the detector unit. The processor element 124 thus uses the level as well as the modulation index of the omni-directional and directional signals to determine a value of the control signal "λ" so that a substantially linear transition between a full omni-directional mode.

[0038] Further, the hearing device 100 in a further embodiment of the present invention may comprise a communicator 144 connecting to the processor element 124 for receiving the control signal "λ" generated for the particular decision unit 116. The communicator 144 communicates this control signal "λ" to neighbouring communicators of decision units handling the neighbouring frequency channels. The communicator 144, similarly, receives control signals "λ'" from the neighbouring decision units and forwards these control signals "λ'" to the processor element 124, which may utilise these control signals "λ'" for further smoothing the value of "λ" between the frequency channels.

[0039] Figure 3 shows a hearing device 300 according to a second embodiment of the present invention. Where the hearing device 300 comprises similar elements as described with reference to figure 1 the same reference numerals are used.

[0040] The hearing device 300 comprises a plurality of decision units 110 each receiving a frequency channel "fc_1" to "fc_N", the decision units 110 each perform a summation by means of the first summing element 118 so as to generate an omni-directional signal "O_1" to "O_N" and a summation by means of the second summing element 120 so as to generate a directional signal "D_1" to "D_N" from the associated frequency channel signals. Each of the decision units 116_1 to 116_N forwards the omni-directional and directional signals "O_1" and "D_1" to "O_N" and "D_N" to a processor unit 302 calculating a control signal "λ" for each of the decision units from 116_1 to 116_N. The processor unit 302 comprises a detector element 122 as described with reference to figure 1, which receives the omni-directional and directional signals from all of the decision units 116_1 to 116_N, and a processor element 124 generating control signals "λ_1" to "λ_N" based on the level and/or modulation index of the omni-directional and directional signals "O_1" to "O_N" and "D_1" to "D_N".

[0041] The control signals "λ_1" to "λ_N" are communicated from the processor unit 302 to respective decision units 116_1 to 116_N. Each decision unit 116_1 to 116_N comprises a calculation unit 302 for generating a signal having a value equal to one minus the control signal "λ" ("λ" being between zero and one). The mixing of the omni-directional and directional signals are subsequently performed as described with reference to figure 1.

Claims

1. A hearing device for processing sound and comprising a plurality of microphones each adapted to convert a sound to an electric sound signal, a filterbank connected to each of said plurality of microphones and adapted to split said electric sound signals into a series of frequency channel signals, a series of decision units each comprising a summing module connected to a specific frequency channel of each of said filterbanks and adapted to sum frequency channel signals of said specific frequency channels thereby generating a first and second directional signal and a mixing module connected to said summing module and adapted to mix said first and second directional signal according to content thereof and to generate a channel-specific signal, a merging unit connected to said series of decision units and adapted to receive said channel-specific signals and to merge said channel-specific signals into an output signal, and a speaker unit connected to said merging unit and adapted to generate a processed sound from said output signal.

2. A hearing device according to claim 1, wherein each of said series decision units comprise a communication unit connected to said mixing modules and adapted to communicate control parameters with one another and/or with a processor unit.

3. A hearing device according to any of claims 1 to 2, wherein said summing module comprises a first and second summing element connected to a specific frequency channel of each filterbank and performing a real and complex summation, respectively, and generating said first directional signal as an omni-directional signal and said second directional signal as a directional signal thereby.

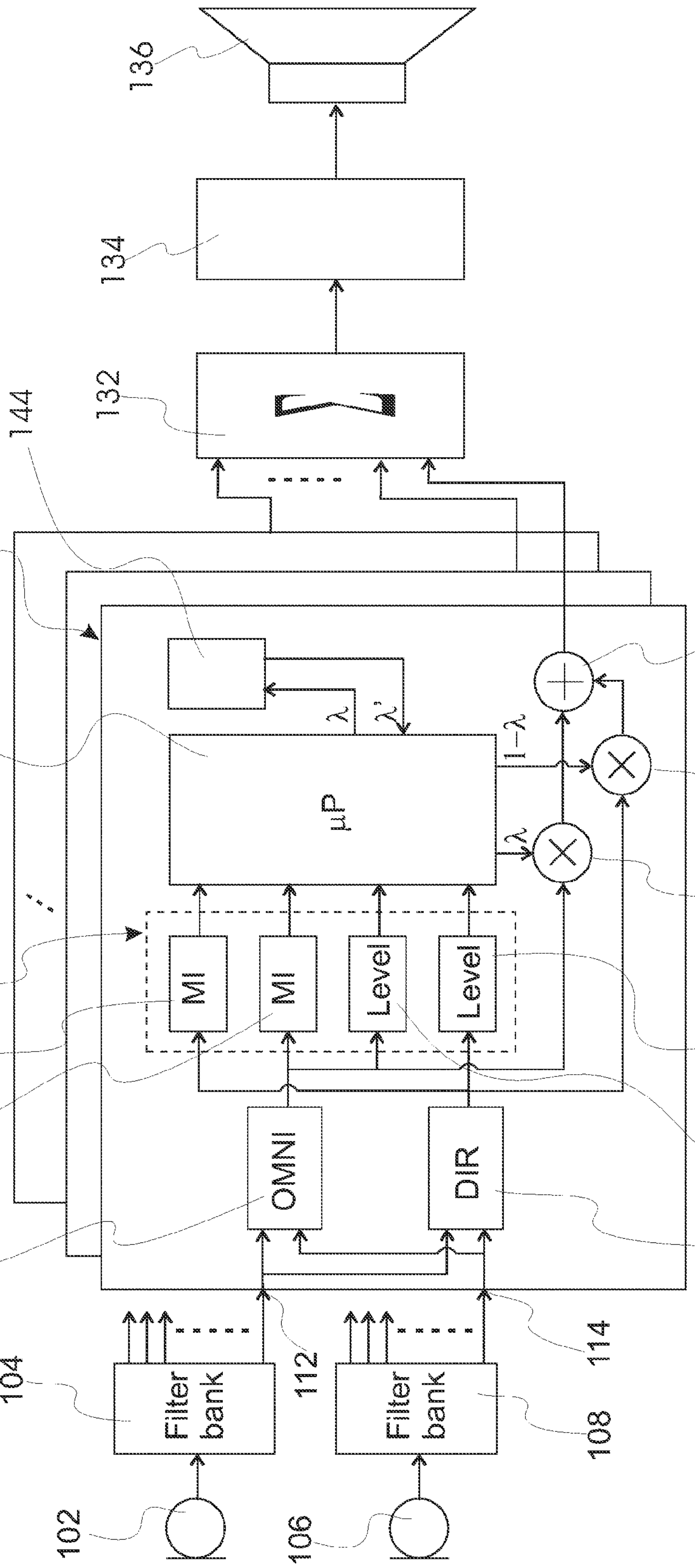
4. A hearing device according to any of claims 1 to 3, wherein said mixing module comprises a detector element connected to said first and second summing element and adapted to determine whether said first and second directional signal has a level and/or modulation index above or below a predetermined threshold and to generate a detector signal based thereon.

5. A hearing device according to any of claims 1 to 4, wherein said mixing module further comprises a processor element connected to said detector element and adapted to generate a control parameter based on said detector signal.

6. A hearing device according to claim 5, wherein said control parameter is in the range between 0 and 1, where "0" provides only said second directional signal and "1" provides a only said first directional signal as said channel-specific signal, and wherein said mixing module is adapted to factorize said first directional signal by said control parameter and said second directional signal by one minus said control parameter.

7. A method for processing sound and comprising converting a first and second spatial sound to a first and second electric sound signal, splitting said first and second electric sound signals individually into a first and second series of frequency channel signals, summing said first and second frequency channel signals of specific frequency channels thereby generating a first and second directional signal for each specific frequency channel, mixing said first and second directional signal according to content thereof, generating a channel-specific signal based on said mixing, merging said channel-specific signals into an output signal, and generating a processed sound from said output signal.

8. A decision unit comprising a summing module connected to specific frequency channels of filterbanks and adapted to sum frequency channel signals of said specific frequency channels thereby generating a omni-directional and directional signal and a mixing module connected to said summing module and adapted to mix said omni-directional signal and directional signal according to content thereof and to generate a channel-specific output signal based thereon.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116
110
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Filter bank
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OMNI
DIR
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136
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120

Fig.1

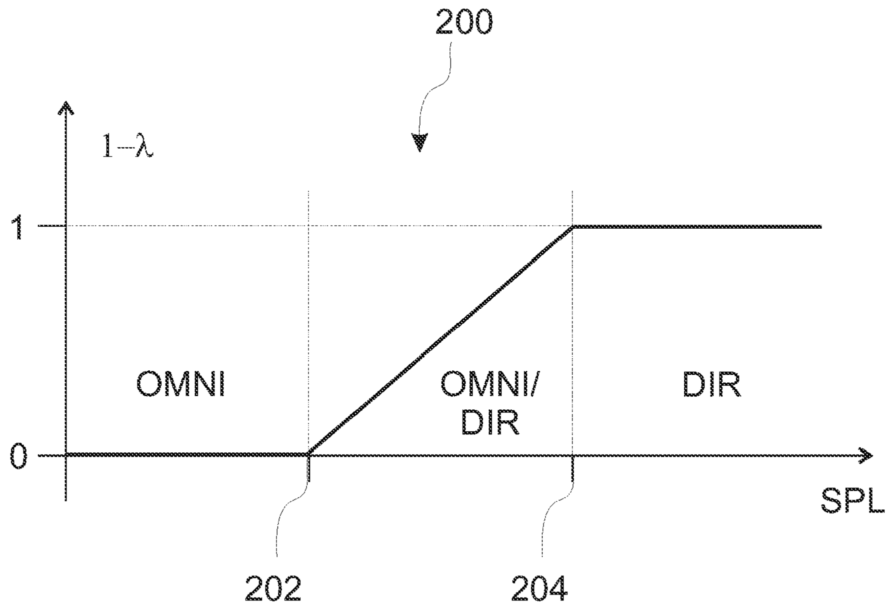

Fig.2

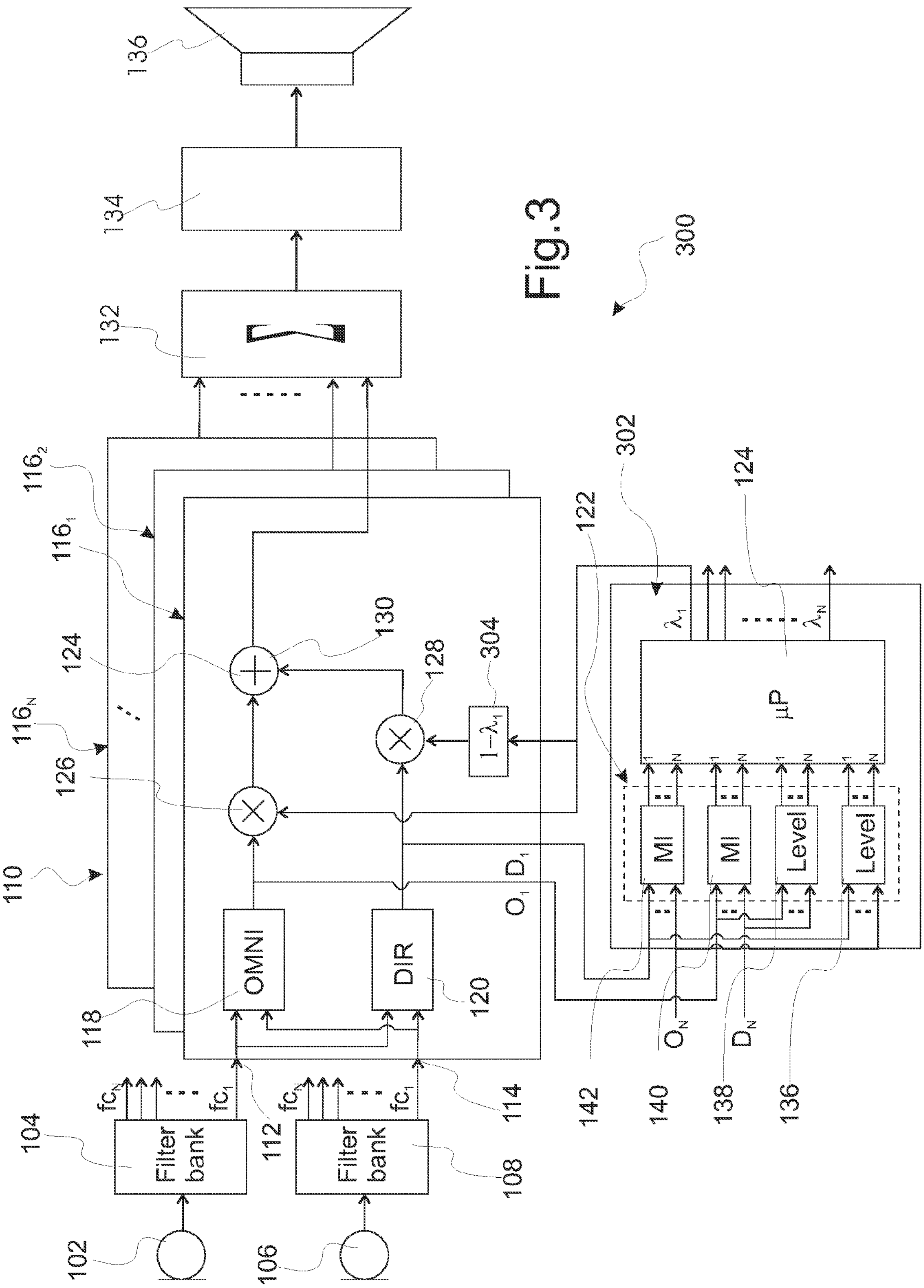
Fig.3
300
Filter bank
Filter bank
OMNI
DIR
MI
MI
Level
Level
μP
1−λ1
λ1
λN
O1
D1
ON
DN
fc1
fcN
102
104
106
108
110
112
114
116N
1161
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EUROPEAN SEARCH REPORT

Application Number
EP 06 11 0278

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2004/258249 A1 (NIEDERDRANK TORSTEN ET AL) 23 December 2004 (2004-12-23) * the whole document *	1,7,8 2-6	INV. H04R25/00
Y	EP 1 251 715 A (GENNUM CORPORATION) 23 October 2002 (2002-10-23) * paragraphs [0002], [0003], [0026], [0033] - [0038]; figures *	2-6	
X Y	US 2005/025325 A1 (FISCHER EGHART) 3 February 2005 (2005-02-03) * paragraphs [0002], [0004], [0010], [0011], [0013] - [0016], [0018] - [0020], [0024], [0026]; figures *	1,7,8 2-6	

TECHNICAL FIELDS SEARCHED (IPC)

H04R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14 August 2006	Fobel, O

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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2

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004258249 A1	23-12-2004	AU 2004202682 A1	13-01-2005
		EP 1489882 A2	22-12-2004
EP 1251715 A	23-10-2002	AT 318062 T	15-03-2006
		CA 2382362 A1	18-10-2002
		DK 1251715 T3	19-06-2006
US 2005025325 A1	03-02-2005	AU 2004202688 A1	13-01-2005
		CN 1575042 A	02-02-2005
		DE 10327890 A1	20-01-2005
		EP 1489884 A2	22-12-2004

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- EP 1192838 A **[0003]**

Non-patent literature cited in the description

- **STEPHEN C. THOMPSON.** Directional patterns obtained from two or three microphones. *Knowles Electronics,* 29 September 2000 **[0029]**
- **GARY ELKO et al.** A simple adaptive first-order differential microphone. *Proc. 1995 IEEE ASSP Workshop on Applications of Signal Proc. to Audio & Acoustics,* October 1995 **[0029]**