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- **OCHSENBEIN, André**
8633 Wolfhausen (CH)
- **PEREZ DE LA SOTA, Gabriel**
8708 Maennedorf (CH)
- **PERRI, Antonio**
1568 Portalban (CH)
- **LEIST, Christoph**
8640 Rapperswil (CH)

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(71) Applicant: **Sonova AG**
8712 Stäfa (CH)

(74) Representative: **Schwan Schorer & Partner mbB**
Patentanwälte
Bauerstrasse 22
80796 München (DE)

(72) Inventors:
• **OESCH, Yves**
2000 Neuchâtel (CH)

(54) **ITE HEARING DEVICE**

(57) There is provided an ITE hearing device comprising a housing comprising a shell and a faceplate (16); electronic components located in the housing and including at least one microphone (20), a signal processing unit (24), a loudspeaker (26), an antenna (30) and a battery (28); and a flexible main PCB (20) for electrically connecting at least the at least one microphone, the signal processing unit and the battery, wherein the loudspeaker is connected to the flexible main PCB by litz wires (44) soldered to loudspeaker pads (42) of the PCB and having a length from 2 mm to 15 mm.

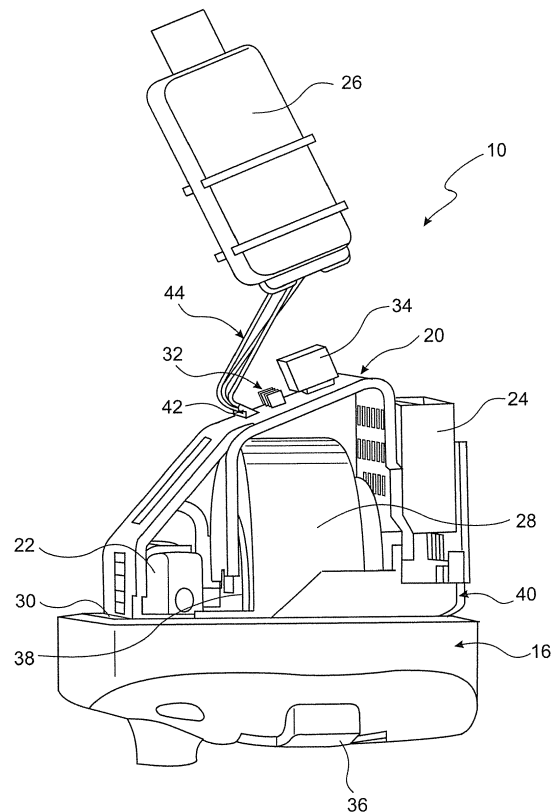


FIG. 1

Description

[0001] The disclosure relates to an ITE (In-The-Ear) hearing device.

[0002] Due to placement in the ear channel, space is very limited in ITE hearing devices. Such space limitation may be particularly critical in case that the ITE hearing device includes an antenna for wireless communication, which may result in electromagnetic interference issues of the antenna with other electronic components. While fitting of the ITE hearing device within the ear channel may be optimized by using a customized shell which is specifically shaped according to the individual shape of the ear channel, such individual shaping introduces some uncertainty concerning the final shape of the shell in the manufacturing process of the hearing device.

[0003] US 6,324,907 B1 relates to a hearing aid microphone on a flexible PCB (Printed Circuit Board) including EMI (Electromagnetic Interference) decoupling features, so that the PCB may act as an EMI shield against interfering signals, such as DECT or GSM signals.

[0004] US 6,845,167 B1 relates to a microphone capsule for use in a mobile phone or dictation device, which is carried by a flex print and includes a preamplifier, wherein the flex print connects the microphone capsule to a another PCB carrying a post amplifier.

[0005] US 7,961,899 B2 relates to a detachable hearing aid microphone; it is mentioned that a hearing aid loudspeaker may be detachable in a similar manner.

[0006] US 9,401,575 B2 relates to a hearing aid loudspeaker which is connected to a flex print via specific solder bumps.

[0007] US 2009/0262970 A1 relates to a headset having ferrite beads on an ear jack PCB for improving performance of an antenna provided within a cable of the headset.

[0008] It is an objective of the disclosure to provide for an ITE hearing device including an antenna and having relatively low electromagnetic interference between the antenna and the other electronic components, while allowing for relatively efficient manufacturing.

[0009] According to some embodiments of the disclosure, this objective is achieved by an ITE hearing device as defined in claim 1.

[0010] According to the present disclosure, a flexible main PCB is provided for electrically connecting the at least one microphone, the signal processing unit and the battery, wherein the loudspeaker is connected to the flexible main PCB by litz wires soldered to loudspeaker pads of the PCB and having a length from 2 mm to 15 mm. By using a flexible main PCB - rather than litz wires - for connecting electronic components of the hearing instrument a relatively clearly defined spatial positioning of the electronic components, including the electric conductors, relative to the antenna is achieved, thereby reducing electromagnetic interference of the electronic components with the antenna. By connecting the loudspeaker by relatively short litz wires to the PCB the flexibility with

regard to the final spatial positioning of the loudspeaker relative to the faceplate and the other electronic components is increased, so as to optimize positioning of the loudspeaker. The latter is particularly helpful in cases in which the shell is a customized shell; in such cases, the optimal relative position of the loudspeaker may be different from user to user due to the individual (customized) shape of the shell.

[0011] The relatively short length of the litz wires connecting the loudspeaker to the loudspeaker pads on the PCB, such as less than 15 mm or less than 12 mm, helps to reduce the influence of the litz wires on electromagnetic interference. The use of litz wires for connecting the loudspeaker to the PCB also helps to reduce acoustic feedback problems, compared to, e.g., placement of the loudspeaker on the PCB.

[0012] According to some implementations, the antenna may be designed to operate in the 2.4 GHz ISM band, with the antenna being a magnetic loop antenna integrated within the faceplate. According to some implementations, at least one ferrite bead is provided on the main PCB in each of the traces connecting the loudspeaker pads and the signal processing unit, so as to further reduce electromagnetic interferences.

[0013] Some embodiments are defined in the dependent claims.

[0014] Examples of the disclosure are illustrated by reference to the drawings, wherein:

Fig. 1 is a perspective view of an example of an ITE hearing aid, with the shell having been removed; and

Fig. 2 is a block diagram of the electronic components of an example of an ITE hearing aid.

[0015] The drawings have not necessarily been drawn to scale. Similarly, some components and/or operations may be separated into different blocks or combined into a single block for the purposes of discussion of some of the embodiments of the disclosure. Moreover, while the disclosure is amenable to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and are described in detail below. The invention, however, is not to limit the disclosure to the particular embodiments described. On the contrary, the disclosure is intended to cover all modifications, equivalents, and alternatives falling within the scope of the disclosure as defined by the appended claims.

[0016] An example of an ITE hearing aid is illustrated in Figs. 1 and 2. The hearing aid 10 comprises a housing 12 including a shell (not shown in the Figs.) and a faceplate 16 for covering an outwardly facing opening of the shell, a plurality of electronic components and a flexible main PCB 20 for electrically connecting at least part of the electronic components.

[0017] The electronic components comprise a micro-

phone unit 22 comprising at least one microphone for capturing audio signals from ambient sound (in the example illustrated in Fig. 2, the microphone unit 22 comprises two spaced-apart microphones 22A, 22B), a signal processing unit 24, a loudspeaker 26 ("loudspeaker" herein is used in the sense of "loudspeaker unit", so that it actually may include more than one loudspeaker), a battery 28, a magnetic loop antenna 30, ferrite beads 32, a telephone coil ("T-coil") 34 and a volume control 36.

[0018] In the example of Figs. 1 and 2 the main PCB carries the microphone unit 22, the signal processing unit 24, the ferrite beads 32, the T-coil 34, and battery contacts 38, with these components being soldered to the main PCB 20; also the volume control 36 may be soldered to and carried by the main PCB 20. The T-coil 34 may be implemented as an SMD (surface mounted device) component. The main PCB 20 is fixed at the faceplate 16.

[0019] In the example of Fig. 1 the magnetic loop antenna 30 is formed on a flexible antenna PCB 40 which is electrically and mechanically connected to the signal processing unit 24, with the antenna loop being integrated within a groove of the faceplate 16. Thereby the antenna 30 is fixed with regard to the main PCB 20 and the electronic components carried by the main PCB 20. The antenna 30 is provided for operation in the 2.4 GHz ISM band (which is from 2.4 to 2.5 GHz). The signal processing unit 24 is a hybrid which includes a transmitter, or, more generally, a transceiver for the antenna 30.

[0020] The main PCB 20 comprises loudspeaker pads 42 to which litz wires 44 are soldered, so as to electrically connect the loudspeaker pads 42 - and thus the main PCB 20 - to the loudspeaker 26. The litz wires 44 have a length of from 2 mm to 15 mm, or from 5 mm to 15 mm, or from 8 mm to 12 mm, so as to keep the impact of the litz wires 44 on electromagnetic interference low while allowing for some mechanical adjustment. According to some implementations, the length of the litz wires may be about 10 mm.

[0021] The signal processing unit 24 not only includes a transceiver but also is provided for processing of the audio signals captured by the microphone unit 22 and for processing of audio signals received by the antenna 30 and/or by the T-coil 34, with the processed audio signals being supplied to the loudspeaker 26.

[0022] In some implementations, the shell is a customized shell shaped according to the individual shape of the ear channel of the user, as it is known in the art. For example, the individual shape of the ear channel may be determined by taking an impression of the ear channel, with the impression then being laser scanned, or by direct laser scanning of the ear channel, and the shell then may be manufactured by a 3D-printing process from a digital model of the individual ear channel obtained from the laser scanning data.

[0023] During the manufacturing process of an ITE hearing aid it is one of the last steps to verify that the acoustic feedback between the loudspeaker 26 and the microphone unit 22 is as low as possible, so as to avoid

acoustic oscillations. To this end, the operator manufacturing the ITE device may rotate the loudspeaker 26 around its axis to find the orientation of the loudspeaker 26 providing for the least feedback. The litz wires 44 are configured to provide for an electrical connection between the loudspeaker 26 and the main PCB 20 which allows such movements required for optimizing the loudspeaker orientation with regard to acoustic feedback. Further, the litz wires 44 provide for a relatively soft coupling between the loudspeaker 26 and the microphone unit 22 (as compared to a relatively hard coupling if the loudspeaker 26 were mounted directly on the main PCB 20), thereby reducing acoustic feedback.

[0024] By keeping the litz wires 44 connecting the loudspeaker 26 to the main PCB 20 relatively short, the influence of the litz wires on antenna performance and noise / electromagnetic interference can be minimized. By providing most of the electrical conductors on a PCB, the geometrical environment near the loop antenna 30 can be kept relatively stable, so that antenna performance is accordingly maintained. In particular, by routing the loudspeaker signals mostly on a PCB, the geometrical location of those signals within the ITE hearing aid is well defined. This keeps the radiation pattern of the loop antenna under control. In particular, any metallic wire or trace in the proximity of the loop antenna 26 has to be taken into account for antenna design, so that a well-defined and stable location of these components permits a proper antenna design.

[0025] The loudspeaker signals generate noise in the 2.4 GHz band due to the pulse width modulation (PWM) of the loudspeaker signals. PWM signals are rectangular pulses of variable width, having flanks, which results in a spectral content which extends largely beyond the audio frequencies into the radio frequency region. Thus, the conductors carrying PWM signals should be kept away from the antenna 30 as far as possible or at least in a position where the coupling to the antenna 30 can be controlled. In this regard, providing the conductors as traces on a PCB is superior over litz wires conductors, so that the use of litz wires is reduced as far as possible (e.g., by providing only the last 10 mm of the conductor to the loudspeaker 26 as a litz wire).

[0026] Another measure to reduce interferences due to steep signal flanks is to add the serial ferrite beads 32 in the conductors towards the loudspeaker 26 (alternatively, or in addition, parallel capacitors could be added in the conductors leading to the loudspeaker 26. Such ferrite beads act as a "lossy inductive" load at high frequencies, such as in the 2.4 GHz band, while having only a small resistance at audio frequencies. In the example of Fig. 1, the ferrite beads 32 are provided as SMD components on the main PCB 20 in each of the traces connecting the loudspeaker pads 42 to the signal processing unit 24. Ideally, the ferrite beads 32 should be placed near the pads provided for connecting to the signal processing unit 24. It is to be noted that at 2.44 GHz the wavelength is 12 cm, so that a quarter of a wave has a

length of 3 cm. In some cases, the connections between the transceiver and the loudspeaker 26 may approach a length that is comparable to that, so that the loudspeaker connection could start to interfere with the antenna resonance. Placing the ferrite beads 32 in the middle of the connection length would prevent such parasitic resonance.

[0027] The phrases "in some implementations," "according to some implementations," "in the implementations shown," "in other implementations," and generally mean the particular feature, structure, or characteristic following the phrase is included in at least one implementation of the disclosure, and may be included in more than one implementation. In addition, such phrases do not necessarily refer to the same embodiments or different implementations.

[0028] The above detailed description of examples of the disclosure is not intended to be exhaustive or to limit the disclosure to the precise form disclosed above. While specific examples for the disclosure are described above for illustrative purposes, various equivalent modifications are possible within the scope of the disclosure, as those skilled in the relevant art will recognize. For example, while processes or blocks are presented in a given order, alternative implementations may perform routines having steps, or employ systems having blocks, in a different order, and some processes or blocks may be deleted, moved, added, subdivided, combined, and/or modified to provide alternative or subcombinations. Each of these processes or blocks may be implemented in a variety of different ways. Also, while processes or blocks are at times shown as being performed in series, these processes or blocks may instead be performed or implemented in parallel, or may be performed at different times. Further any specific numbers noted herein are only examples: alternative implementations may employ differing values or ranges.

Claims

1. An ITE hearing device comprising:

a housing comprising a shell and a faceplate (16);
 electronic components located in the housing and including at least one microphone (20), a signal processing unit (24), a loudspeaker (26), an antenna (30) and a battery (28); and
 a flexible main PCB (20) for electrically connecting at least the at least one microphone, the signal processing unit and the battery, wherein the loudspeaker is connected to the flexible main PCB by litz wires (44) soldered to loudspeaker pads (42) of the PCB and having a length from 2 mm to 15 mm.

2. The hearing device of claim 1, wherein the length of

the litz wires (44) is from 5 mm to 15 mm, preferably from 8 mm to 12 mm.

3. The hearing device of one of the preceding claims, wherein at least one ferrite bead (32) is provided on the main PCB (20) in each of the traces connecting the loudspeaker pads (42) and the signal processing unit (24), wherein the ferrite beads preferably are SMD components (32).

4. The hearing device of one of the preceding claims, wherein at least one parallel capacitor is provided on the main PCB (20) for each of the traces connecting the loudspeaker pads (42) and the signal processing unit, wherein the capacitors preferably are SMD components.

5. The hearing device of one of the preceding claims, wherein the main PCB (20) is fixed at the faceplate (16).

6. The hearing device of one of the preceding claims, wherein the signal processing unit (24) is soldered to and carried by the main PCB (20).

7. The hearing device of one of the preceding claims, wherein the main PCB (20) includes battery contacts (38).

8. The hearing device of one of the preceding claims, wherein the at least one microphone (22) is soldered to and carried by the PCB (20).

9. The hearing device of one of the preceding claims, wherein the antenna (30) is fixed with regard to the main PCB (20).

10. The hearing device of one of the preceding claims, wherein the antenna (30) is a magnetic loop antenna integrated within the faceplate (16).

11. The hearing device of one of the preceding claims, wherein the signal processing unit (24) comprises a transmitter (24) connected to the antenna (30), the transmitter configured to operate in the 2.4 GHz ISM band.

12. The hearing device of one of the preceding claims, wherein the antenna (30) is formed on a flexible antenna PCB (40) electrically and mechanically connected to the transmitter (24).

13. The hearing device of one of the preceding claims, wherein the ITE hearing device (10) comprises a T-coil (34) which is implemented as an SMD component soldered to and carried by the main PCB (20).

14. The hearing device of one of the preceding claims,

wherein the ITE hearing device (10) comprises a manual volume control (36) soldered to and carried by the main PCB (20).

15. The hearing device of one of the preceding claims, 5
wherein the shell is a customized shell shaped according to the individual shape of the ear canal of the user of the ITE hearing device (10).

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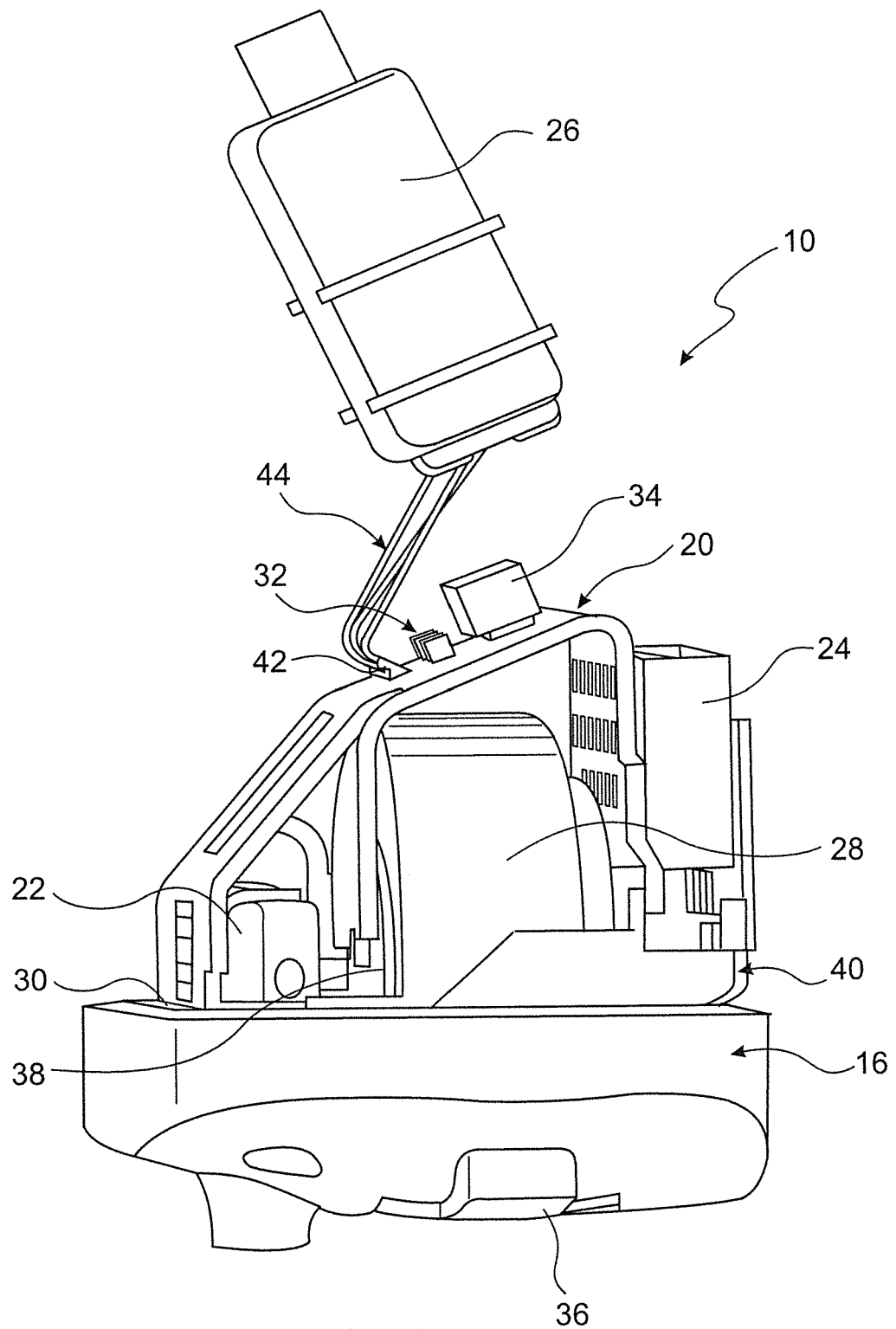


FIG. 1

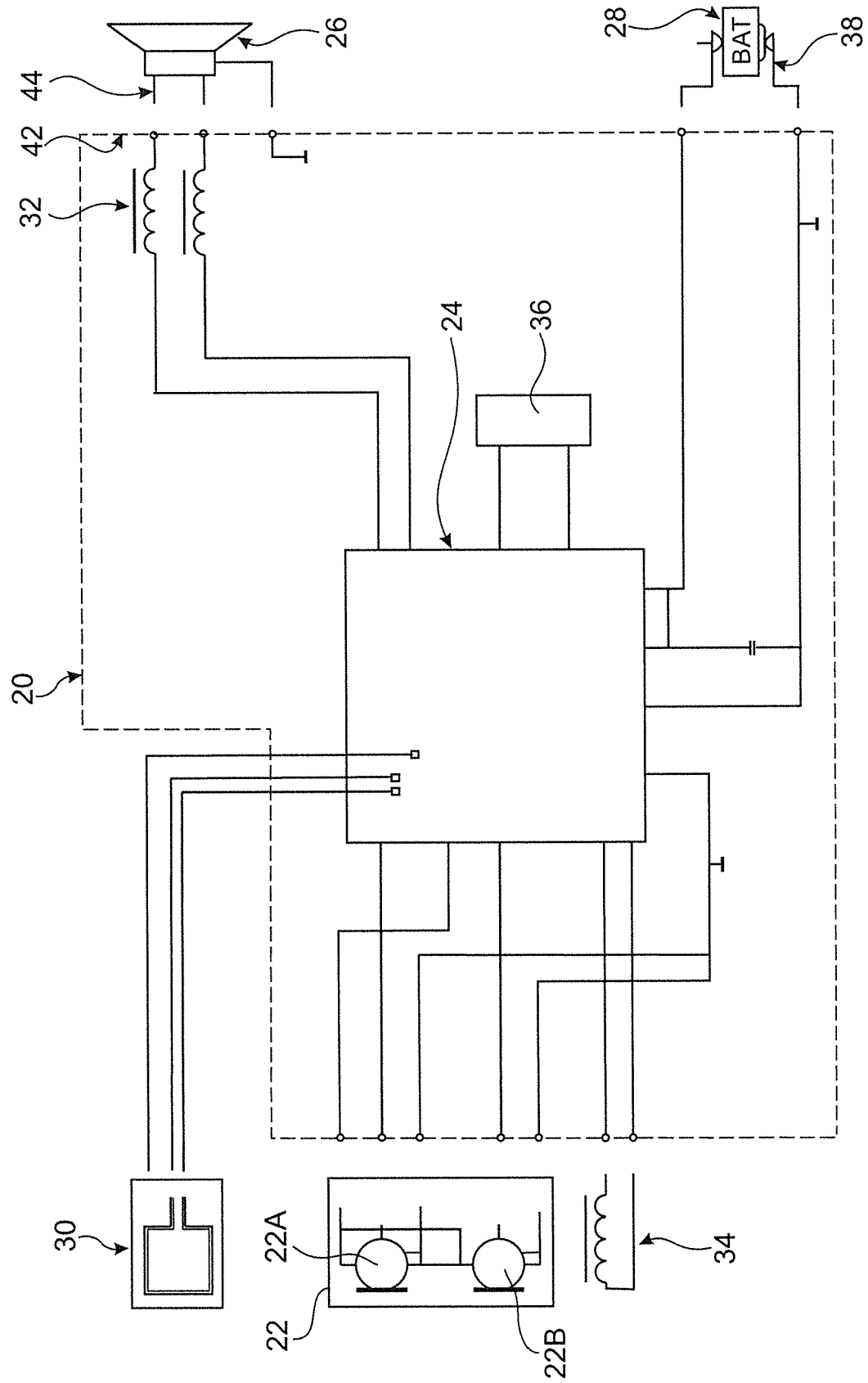


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 18 19 4325

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	EP 2 393 308 A1 (OTICON AS [DK]) 7 December 2011 (2011-12-07) * paragraph [0050] - paragraph [0056] *	1-15	INV. H04R25/00
Y	WO 02/03399 A1 (BELTONE ELECTRONICS CORP [US]) 10 January 2002 (2002-01-10) * column 2, line 15 - line 65 * * column 4, line 40 - line 65 * * column 5, line 55 - column 6, line 20 *	1-15	
A	US 2012/087526 A1 (HIGGINS SIDNEY A [US] ET AL) 12 April 2012 (2012-04-12) * paragraph [0047] - paragraph [0072] *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			H04R
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 January 2019	Examiner Coda, Ruggero
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
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 19 4325

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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ORM P0459

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
EP 2393308	A1	07-12-2011	AU 2011202692 A1	22-12-2011
			CN 102271305 A	07-12-2011
			CN 105872926 A	17-08-2016
			EP 2393308 A1	07-12-2011
			US 2011299713 A1	08-12-2011
			US 2016295336 A1	06-10-2016
			US 2018084353 A1	22-03-2018

WO 0203399	A1	10-01-2002	AU 7157201 A	14-01-2002
			US 2003066676 A1	10-04-2003
			WO 0203399 A1	10-01-2002

US 2012087526	A1	12-04-2012	CN 103348702 A	09-10-2013
			DK 2625871 T3	14-11-2016
			EP 2625871 A2	14-08-2013
			JP 5818332 B2	18-11-2015
			JP 2013546231 A	26-12-2013
			US 2012087526 A1	12-04-2012
			US 2012087527 A1	12-04-2012
			US 2012087528 A1	12-04-2012
			US 2015215713 A1	30-07-2015
			WO 2012048232 A2	12-04-2012

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6324907 B1 [0003]
- US 6845167 B1 [0004]
- US 7961899 B2 [0005]
- US 9401575 B2 [0006]
- US 20090262970 A1 [0007]