(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
08 October 2020 (08.10.2020)

(10) **International Publication Number**
WO 2020/201341 A1

(51) **International Patent Classification:**
H04R 1/10 (2006.01)

(21) **International Application Number:**
PCT/EP2020/059232

(22) **International Filing Date:**
01 April 2020 (01.04.2020)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
PA 2019 00385 01 April 2019 (01.04.2019) DK

(71) **Applicant: GN AUDIO A/S** [DK/DK]; Lautrupbjerg 7, 2750 Ballerup (DK).

(72) **Inventor; and**
(71) **Applicant** *(for US only)*: **FISCHER, Børge** [DK/DK]; c/o GN AUDIO A/S, Lautrupbjerg 7, 2750 Ballerup (DK).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** A HEARING DEVICE WITH CAPACITIVE SENSOR FOR ON-HEAD DETECTION

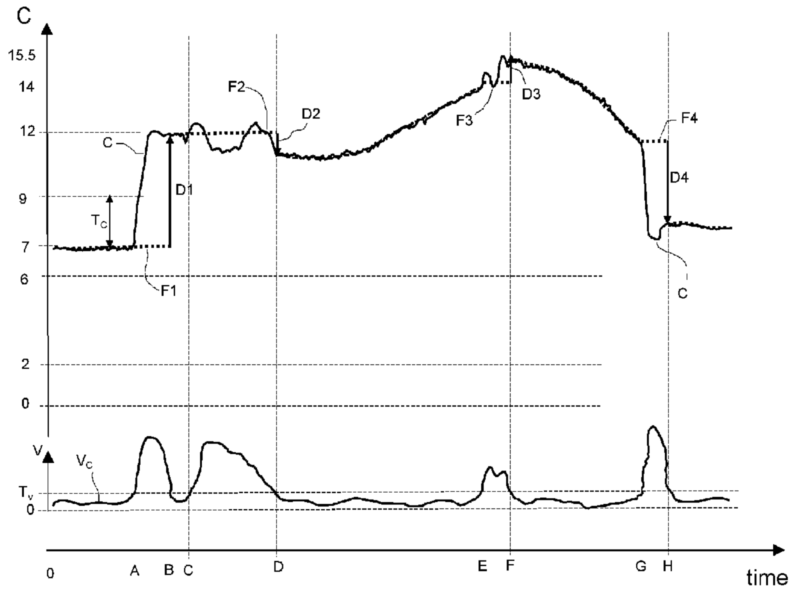

Fig. 5

(57) **Abstract:** A method of determining whether a hearing device (1) is on-head or off-head, wherein the hearing device (1) comprises at least a first capacitive proximity sensor (15). The sensor (15) is adapted to detect a first capacitive load C, which varies in dependence of the proximity of the head or ear of a user. The sensor compensates for drift during use, whereby a reliable on-head detection is obtained.

WO 2020/201341 A1

Title: A hearing device with capacitive sensor for on-head detection

Technical Field

The invention relates to on-head detection of hearing devices, such as headsets or headphones.

Background Art

There exist many solutions toady controlling headset functions based on detecting if the headset is worn on a user's head or not. The headset may be adapted to enter sleep mode or power off f. ex. 20 minutes after off-head state is detected in order to save battery power for a wireless headset. Another function can be to answer an incoming phone call as a result of going from off-head detection to on-head detection. On-head detection can be based on the use of one or more capacitive proximity sensors. A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A capacitive proximity sensor changes capacitance if a target, in this case the head or ear of a user, comes into proximity of the sensor. US 6,532,447 B1 discloses a headset with a capacitive proximity sensor used for on-head detection. A problem with capacitive proximity sensors is that the sensed signal can drift over time due to different factors such as changes in temperature and humidity. When a capacitive proximity sensor is used for a touch button on a device, the circuit should normally just detect a short-termed change in capacitance, which occurs when a user's finger touches the surface of the touch button. A change of sensor signal strength over time does not give any problems as it is the momentary change, that is detected. However, if such a sensor is used for sensing the proximity of the head or ear of a user, this capacity change is over a longer time, maybe several hours. And then it can be problematic to detect off-head state again.

A touch sensor device can incorporate a capacitive proximity sensor to detect a person touching a surface. The electrical circuit, choice of material and dimensions can be selected, such that the touch of a user's finger triggers an off/on function. A proximity sensor device detects proximity alone and does not need touch. It can be designed such, that as soon the part of a person comes into a certain vicinity, the capacitance signal increases enough to trigger an on/off function. This invention relates to a hearing device incorporating such a capacitive proximity sensor device.

There are chipsets on the market adapted to control capacitive touch or proximity sensors, that works well for relatively short touches/proximity detections, where the measured capacitive load is higher for only a short time. However, when the system is used for on-head detection, where the on-head state can be maintained for hours, it may be problematic, due to drift.

Disclosure of Invention

A method of determining whether a hearing device, such as a headset or headphone, is on-head or off-head, wherein the hearing device comprises at least a first capacitive proximity sensor, which sensor is adapted to detect a first capacitive load C, that varies in dependence of the proximity of the head or ear of a user, wherein the following steps are taken to determine on-head state:

1) the first capacitive load C and a variance V_C of the first capacitive load C is currently monitored,
2) when the variance V_C is below a variance threshold T_V, the capacitive load C is stable, and a floor level F of the capacitive load C is determined corresponding to the capacitive load C,
3) when the variance V_C is above the variance threshold T_V, e.g. due to handling of the hearing device (1), the first floor level F1 is frozen at the last stable value of capacitive load C,
4) when the variance V_C is below threshold T_V again, a new floor level F is determined,
5) If the new floor level F is much greater than the first floor level F1, a first floor level jump D1 is defined as F-F1,
6) a first threshold $T_C = h * D1$, where h is between 0.1 and 0.9, is set and the “on-head” state is assumed,

7) otherwise, step 1 is resumed,

and wherein the following steps are taken to determine off-head state:

a) the first capacitive load C is monitored and a floor level F_n corresponding to the latest stable value of the first capacitive load C_n is determined,

b) when the first capacitive load variance V_c is above the variance threshold T_V, e.g. due to handling of the headset, then the floor level F_n is frozen,

c) when the first capacitive load variance V_c is below the variance threshold T_V again, a new floor level F is set and the floor level jump $D_n = F - F_n$ is determined.

d) when the sum of floor level jumps is below the first threshold T_C, then the "off-head" state is assumed.

e) otherwise, step a) is resumed.

According to an embodiment, the "off-head" state is assumed only when the sum of level jumps is below a second threshold T_{C2}, which is slightly below the first threshold T_C.

According to an embodiment, the hearing device comprises a second capacitive proximity sensor, which detects a second capacitive load, which second capacitive proximity sensor is arranged in the headset such that a second the second capacitive load does not change as a result of the user is wearing or handling the hearing device or not, and wherein on-head detection is based on a comparison between measured first capacitive load and measured second capacitive load immediately after switching on the headset.

According to an embodiment, a median filter is used for the measured first capacitive load and/or measured second capacitive load to remove noise spikes.

The invention also relates to a hearing device, such as a headset or headphone, comprising a first capacitive proximity sensor and a circuitry adapted to perform the method described above.

According to an embodiment, the hearing device comprises a headband or neckband and at least a first earphone with a compressible earpad, which headband or neckband presses the first earphone against the head of a user, when the hearing device is worn, and wherein the capacitive proximity sensor is arranged in the first earphone, and wherein the distance between the first capacitive proximity sensor and the user's head varies with the compression of the earpad.

According to an embodiment, the hearing device comprises a second earphone with a compressible earpad, wherein the headband or neckband presses the second earphone against the head of a user, when the headset is worn, and wherein a further first capacitive proximity sensor is arranged in the second earphone, and wherein the distance between the further first capacitive proximity sensor of the second earphone and the user's head varies with the compression of the earpad.

According to an embodiment, the compressibility of the earpad is temperature dependent.

Brief Description of the Drawings

The invention is explained in detail below with reference to the drawing illustrating a preferred embodiment of the invention and in which

Fig. 1 is a perspective view of a headset employing the invention,

Fig. 2 is a schematic cross-sectional view through an earphone of the headset when worn,

Fig. 3 is a schematic front view of a capacitive proximity sensor,

Fig. 4 is an exploded view of the earphone, and

Fig. 5 is a diagram explaining measured sensor data,

Fig. 6 is a diagram explaining measured sensor data in a simplified form, and

Fig. 7 is a curve showing measured sensor data, which includes spikes due to high frequency noise.

Modes for Carrying out the Invention

Fig. 1 is a perspective view of a headset 1 employing the invention. The headset 1 comprises a first earphone 2, a second earphone 3 and a headband 4 connecting the first and second earphones. The headset 1 is circumaural headset, where each ear is completely enclosed by an earphone. Each earphone 2,3 comprises an earpad 10. The headset 1 is a wireless headset comprising a Bluetooth transceiver, microphones arranged in the earphone housings and a rechargeable battery.

Fig. 2 is a cross-sectional view through an earphone 2 of the headset 1 when worn on a user's head. Only essential parts to explain the invention are included in this figure. The earphone 2 comprises an earphone housing 12, a speaker unit 9, an earpad 10, a capacitive proximity sensor 15, a first foam part 7 and a second foam part 8. The earpad 10 encloses an ear 11 of a user wearing the headset 1. The capacitive proximity sensor 15 comprises a pcb (printed circuit board) 5 and a copper layer 6.

Fig. 3 is a schematic front view of the capacitive proximity sensor 15. The pcb 5 comprises an essentially circular opening 19 corresponding to the circumference of the speaker unit 9. On one side of the of the pcb 5 there is a ring-shaped copper electrode 6 making up the electrode of the capacitive proximity sensor 15. When the headset is switched on, a voltage is applied to the electrode 6, and when a user is taking the headset on the head, the ear approaches the electrode 6, whereby a capacitor is dynamically formed between the electrode 6 and the human body. The capacitive load of this can be measured and used to detect whether the headset is worn (On-head) or not (Off-head).

Fig. 4 is an exploded view of the earphone 2. In addition to the above-mentioned parts, the earphone 2 also comprises a protection device 14, which is arranged in front of the speaker, and an ANC (active noise cancelling) feedback microphone 16, which is attached to the protection device 14 in assembled state. An adhesive part 13 adheres the capacitive proximity sensor 15 to the protection device 14 in assembled state. The first foam part 7 is asymmetric, lies around the speaker opening and is somewhat wedge-shaped in order to adapt the enclosure to the ear. The second foam part 8 hides the protection device 14, speaker 9, ANC feedback microphone 16 etc. The proximity sensor 15, comprising the pcb 5 with the copper layer 6 on the backside, is arranged on top of the protection device 14, around audio openings in the protection device 14.

Fig. 5 is a diagram showing the capacitive load measured under different circumstances. The line indicated with C is the measured capacitive load. The line below indicated with V_C shows the variance V_C of the measured capacitive load. This is relatively flat as long as there is no abrupt changes of capacitive load. The initial condition is, that the headset 1 is off-head. At this condition, the capacitive load C is 7. The numbers used here are only fictive and used to explain the principle of the invention. The real values depend on the circuit design, the dimensions of the electrode 6 etc. The measured capacitive load C is currently updated as a "floor level" F as long as the variance V_C is low and below a certain variance threshold T_v. At time A, the user puts on the headset 1, whereby the users ear comes into proximity of the electrode 6. The capacitive load C rises to 12. The list below shows measured values in connection with events:

0	Headset is switched on an is off-head.
0-A	Headset is off-head. The measured capacitive load C is approximately 7. As long as the variance V_C is below T_V, the floor level F follows the measured value of the capacitive load C. At this stage the floor level is designated F1.
A-B	The user puts on the headset. V_C increases above T_V while the user handles the headset and arranges it on the head. The capacitive load C rises to approximately 12. The Floor level F1 is frozen at the value 7 as long as $V_C > T_V$. At B the competitive load C stabilizes at a floor level F around 12, where the system assumes the headset is "on-head". The system sets a first floor level jump D1 = F-F1 = 12-7 = 5. The systems sets a threshold T_C to be 40% of this, which is 2. With other words, the second floor level F2 is 3 units above the threshold T_c. In order to assume the headset to be off-head again, the floor level must jump 3 units. If D1 + D2 + … + DN > T_C, the state is assumed to be on-head. If D1 + D2 + … + DN < T_C, then off-head sate is assumed.
B-C	Headset is on-head. $V_C < T_V$. C is stabilized at the value 12. The floor level F follows the capacitive load C again.
C-D	The user re-arranges the headset on the head because he find it does not sit perfect. $V_C > T_V$ and the floor level F2 is maintained at 12, until $V_C < T_V$ again.

D	The headset is rearranged, and in this position the capacitive load C is stabilized a little different at a new floor level F with the value 11. This can be because the ear is now positioned slightly different in relation to the electrode 6. Thus, there is a floor level jump D2 = F-F2 = 11-12 = -1. As the drop is only 1, the headset is still on-head. D1 + D2 = 5 – 1 = 4. This is greater than Tc, whereby the headset is still on-head.
D-E	The user walks around with the headset on, whereby the temperature of the earpads increases. This brings the capacitive sensor closer to the ear, whereby the measured capacitive load rises slowly from 11 to a third floor level F3 around 14. As the variance $V_C < T_V$ during this period, the floor level F follows the value of the measured capacitive load C. There is no floor level jumps here.
E-F	The user re-arranges the headset again, whereby the measured capacitive load rises to a new floor level of the value 15.5. A third floor level jump D3 = F-F3 = 15.5 – 14 = 1.5. In total: D1 + D2 + D3 = 5 – 1 + 1.5 = 5.5. This is above T_C and the headset is still on-head.
F-G	During this period, the sensor drifts further. The variance V_C is below T_V and there are no floor level jumps.
G-H	The user takes off the headset. $V_C > T_V$. A sixth floor level F6 is frozen at about 11.5.
H-	The user has placed the headset on a table. $V_C < T_V$. A new floor level F is set at about 7.5. A fourth floor level jump D4 is hereby F-F4 = 11.5-7.5 = 4. D1 + D2 + D3 + D4 = 5 – 1 +1.5 – 4 = 1.5 < T_C, thus the state is off-head.

As indicated above, the headset efficiently detects, if the headset is on-head or off-head even if the sensor drifts, f. ex. Due to temperature change. Only jumps in measured capacitive load values are used to determine the on-head state. Even if the user rearranges the headset several times, a relatively precise on-head detection is obtained. It should be noted, that it is not only the sensor itself, that causes drift. Drift is defined as change of a measured signal, although the real value of the measured target has not changed. The device, in which the sensor is installed can cause drift. In this case, it has shown, that if the headset shown in Figures 1-4 is kept at a low temperature, f. ex. in a car during winter and then put on-head, the temperature change causes a change of the earpad's elasticity. Thus, the capacity sensor 15 moves slowly closer to the ear of the user, as the earpad becomes softer due to the increased temperature. If the system did not compensate for drift as explained above, it might not detect off-head, when the headset is taken of again, as the measured capacitive load may have increased slowly due to the temperature rise.

Fig. 6 is a somewhat simplified version of Fig. 5. Only the floor level jumps are shown, not the slow changes taking place when the variance V_C is below the variance threshold T_V. This figure also shows, that there is a hysteresis function in the system. Slightly below the threshold T_C, there is a second threshold T_{C2}. In order to switch from on-head to off-head, the sum of floor level drops must com below T_{C2} and above T_C to switch from off-head to on-head again.

Fig. 7 is a curve showing measured sensor data, which includes spikes due to high frequency noise. High frequency noise, causes spikes S_C, which may produce increased variance levels and disturb the on-head detection if they are not filtered out. The headset circuitry comprises a median filter, which picks the median value from a number of sampled values, whereby the relatively few measured samples with high values is filtered out, such that they do not destroy the on-head calculations.

Both the first earphone 2 and the second earphone 3 of the headset 1 has a proximity sensor as described above. Also, the first earphone 2 and the second earphone 3 has a second capacitive proximity sensor, which is arranged in the housing and dimensioned, such that the proximity of a user does not change the sensor signal. This second sensor is used as a reference sensor to assume on-head or off-head in situations where, the user puts on the headset, before switching power on, or puts the headset on very fast after powering on, so the circuitry is not ready to detect change from off-head to on-head.

The system measures the capacitive load for approximately every 20 milliseconds.

Reference signs:

1	Headset
2	First earphone
3	Second earphone
4	Headband
5	Pcb (printed circuit board)
6	Electrode
7	First foam part
8	Second foam part
9	Speaker unit
10	Earpad
11	Ear
12	earphone housing
13	adhesive part
14	protection device
15	Sensor
16	ANC feedback microphone
C	Capacitive load
F	Floor level (capacitive load)
D	Floor level jump
V_C	variance of measured capacitive load
T_C	First threshold of capacitive load
T_{C2}	Second threshold of capacitive load
T_V	Variance threshold
S_C	Spikes of measured capacitive load
n	factor

Claims

1. A method of determining whether a hearing device (1) is on-head or off-head, wherein the hearing device (1) comprises at least a first capacitive proximity sensor (15), which sensor (15) is adapted to detect a first capacitive load C, that varies in dependence of the proximity of the head or ear of a user, wherein the following steps are taken to determine on-head state:
   1) the first capacitive load C and a variance V_C of the first capacitive load C is currently monitored,
   2) when the variance V_C is below a variance threshold T_V, the capacitive load C is stable, and a floor level F of the capacitive load C is determined corresponding to the capacitive load C,
   3) when the variance V_C is above the variance threshold T_V, e.g. due to handling of the headset (1), a first floor level F1 is frozen at the last stable value of capacitive load C,
   4) when the variance V_C is below threshold T_V again, a new floor level F is determined,
   5) If the new floor level F is much greater than the first floor level F1, a first floor level jump D1 is defined as F-F1,
   8) a first threshold $T_C = h * D1$, where h is between 0.1 and 0.9, is set and the “on-head” state is assumed,
   9) otherwise, step 1 is resumed,

and wherein the following steps are taken to determine off-head state:
   a) the first capacitive load C is monitored and a floor level F_n corresponding to the latest stable value of the first capacitive load C_n is determined,
   b) when the first capacitive load variance V_c is above the variance threshold T_V, e.g. due to handling of the headset, then the floor level F_n is frozen,
   c) when the first capacitive load variance V_c is low again, a new floor level F is set and the floor level jump $D_n = F – F_n$ is determined.
   d) when the sum of flor level jumps is below the first threshold T_C, then the “off-head” state is assumed.

e) otherwise, step a) is resumed.

2. A method according to claim 1, wherein the “off-head” state is assumed only when the sum of level jumps is below a second threshold T_{C2}, which is slightly below the first threshold T_C.

3. A method according to claim 1 or 2, wherein the hearing device (1) comprises a second capacitive proximity sensor (3), which detects a second capacitive load, which second capacitive proximity sensor (3) is arranged in the headset (1) such that the second capacitive load does not change as a result of the user is wearing the headset (1) or not, and wherein on-head detection is based on a comparison between measured first capacitive load and second capacitive load immediately after switching on the headset (1).

4. A method according to any of the preceding claims, wherein a median filter is used for the measured first capacitive load and/or measured second capacitive load to remove noise spikes (S_C).

5. A hearing device (1) comprising a first capacitive proximity sensor (15) and a circuitry adapted to perform the method according to any of the claims 1-4.

6. A hearing device (1) according to claim 5, comprising a headband (4) or neckband and at least a first earphone (2) with a compressible earpad (10), which headband (4) or neckband presses the first earphone (2) against the head of a user, when the headset (1) is worn, and wherein the capacitive proximity sensor (15) is arranged in the first earphone (2), and wherein the distance between the first capacitive proximity sensor (15) and the user’s head varies with the compression of the earpad (10).

7. A hearing device (1) according to claim 6, comprising a second earphone (3) comprising a second earphone (3) with a compressible earpad (10), wherein the headband (4) or neckband presses the second earphone (3) against the head of a

user, when the headset (1) is worn, and wherein a further first capacitive proximity sensor (15) is arranged in the second earphone (3), and wherein the distance between the further first capacitive proximity sensor (15) of the second earphone (3) and the user's head varies with the compression of the earpad (10).

8. A hearing device (1) according to claim 6 or 7, wherein the compressibility of the earpad (10) is temperature dependent.

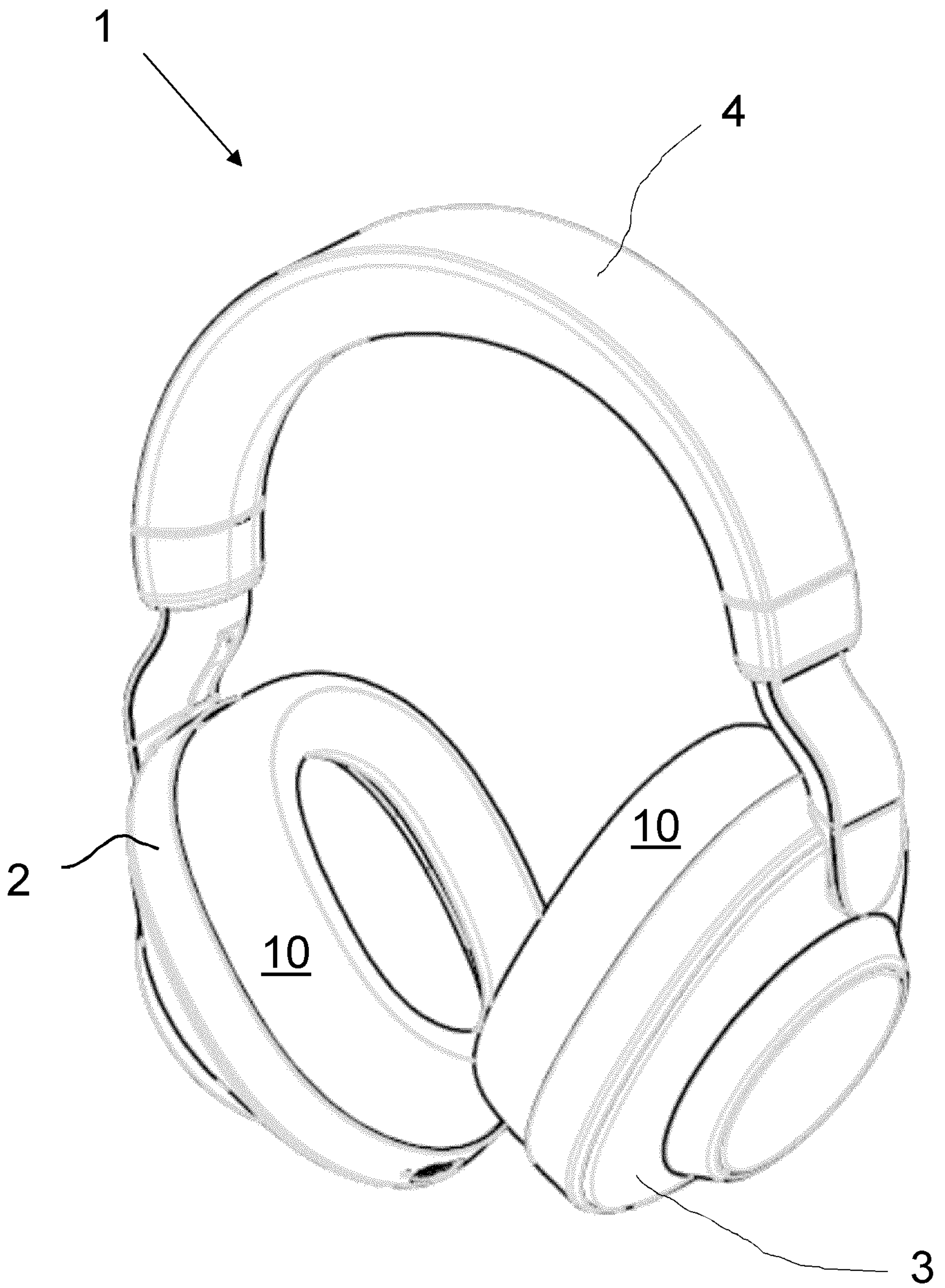

Fig. 1

2/4

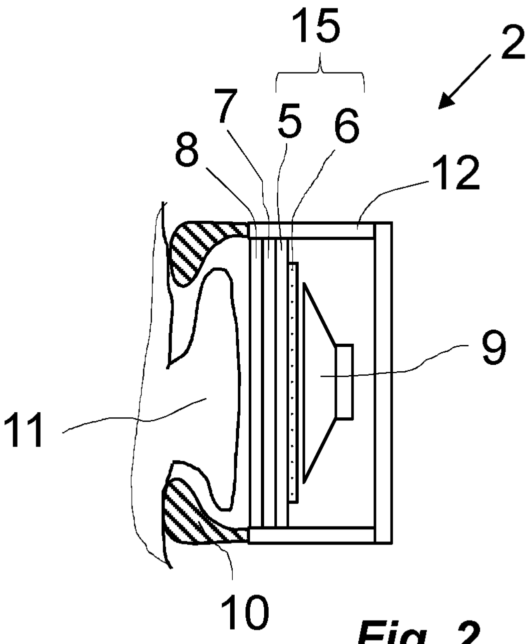

Fig. 2

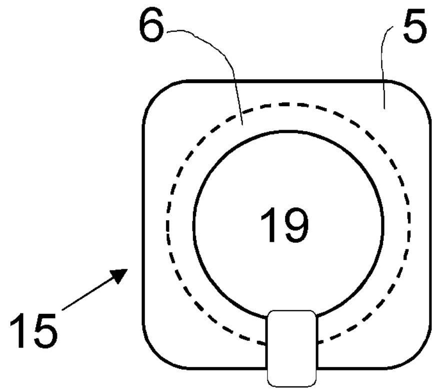

Fig. 3

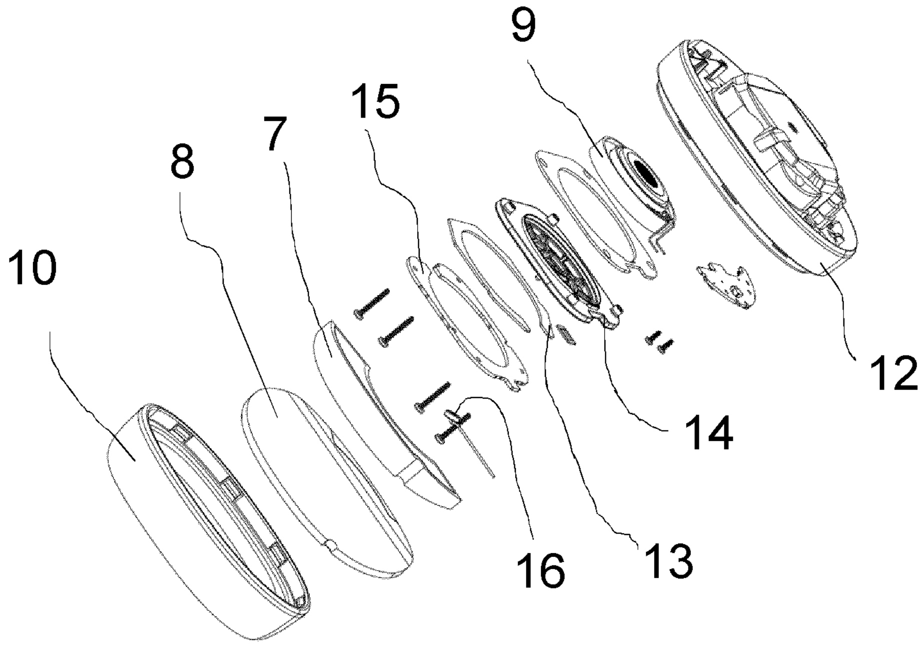

Fig. 4

3/4

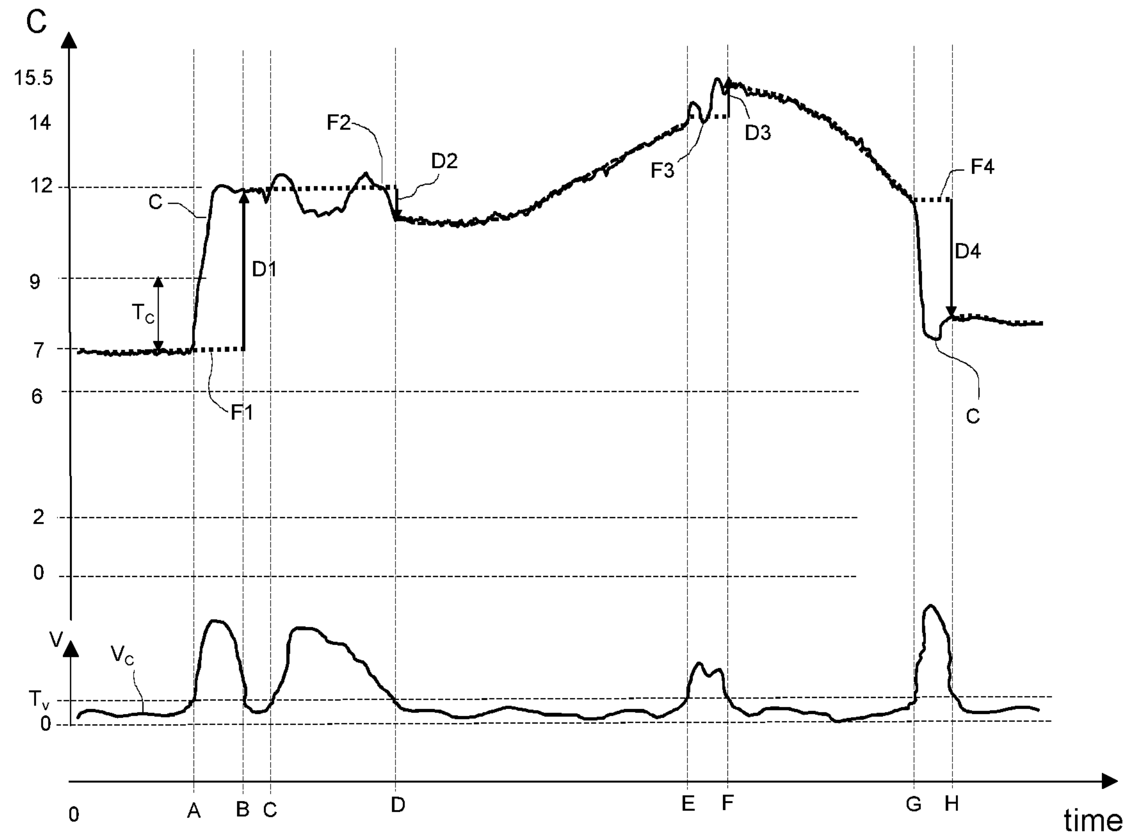
C
15.5
14
12
9
7
6
2
0
F1
F2
F3
F4
D1
D2
D3
D4
T_C
V
V_C
T_v
0
A B C D E F G H
time

Fig. 5

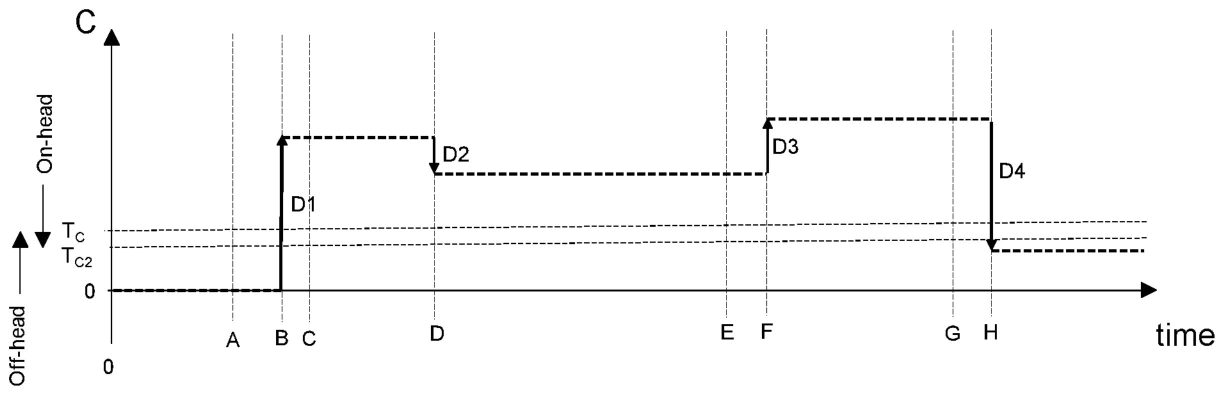
C
On-head
Off-head
T_C
T_{C2}
0
D1
D2
D3
D4
A B C D E F G H
time

Fig. 6

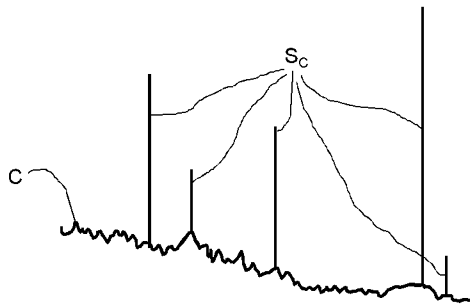

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/059232

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R1/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB 2 431 725 A (PHILIPP HARALD [GB]) 2 May 2007 (2007-05-02) page 4, line 5 - line 21 page 10, line 21 - page 15, line 2; figure 3 page 18, line 6 - page 22, line 21; figures 1,9 the whole document -----	1,2,4-8 3
A	US 10 045 111 B1 (BONNER JORDAN [US] ET AL) 7 August 2018 (2018-08-07) column 6, line 11 - column 8, line 49; figures 1,5-7 -----	1-8
A	GB 2 451 352 A (QRG LTD [GB]) 28 January 2009 (2009-01-28) the whole document ----- -/--	1-8

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 June 2020	26/06/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Borowski, Michael

3

International application No
PCT/EP2020/059232

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/239982 A1 (ALAMEH RACHID M [US] ET AL) 28 August 2014 (2014-08-28) paragraphs [0065] - [0068]; figures 11-15 -----	1-8
Y	CN 103 002 373 B (QINGDAO GOERTEK CO LTD) 27 May 2015 (2015-05-27) the whole document -----	3

3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/059232

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB 2431725	A	02-05-2007	DE 102006046113	A1	16-05-2007
			DE 202006014943	U1	15-03-2007
			GB 2431725	A	02-05-2007
			JP 2007104670	A	19-04-2007
			KR 20070037424	A	04-04-2007
			TW 200718258	A	01-05-2007
			US 2007121959	A1	31-05-2007
US 10045111	B1	07-08-2018	US 10045111	B1	07-08-2018
			WO 2019067088	A1	04-04-2019
GB 2451352	A	28-01-2009	GB 2451352	A	28-01-2009
			US 2009027068	A1	29-01-2009
			US 2011242051	A1	06-10-2011
			US 2014292716	A1	02-10-2014
US 2014239982	A1	28-08-2014	US 2014239982	A1	28-08-2014
			WO 2014130186	A1	28-08-2014
CN 103002373	B	27-05-2015	NONE		