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(54) Title: EARPHONE AND METHOD FOR UPLINK CANCELLATION OF AN EARPHONE

(57) Abstract: The present invention discloses an earphone and a method for uplink noise cancellation of an earphone. The earphone comprises: at least one earpiece, which includes at least one speaker; a connector for connecting with an electronics apparatus; and a control box, which is connected to the earpiece and is arranged along an earphone wire between the earpiece and the connector, wherein at least three microphones for uplink noise cancellation are provided in the control box.

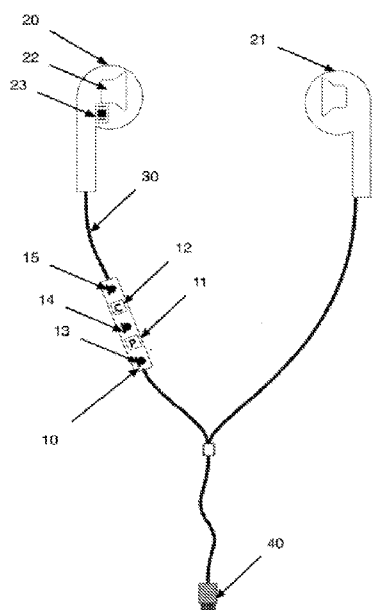


FIG. 1

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EARPHONE AND METHOD FOR UPLINK CANCELLATION OF AN EARPHONE

FIELD OF THE INVENTION

The present invention relates to the technical area of earphone, and more specifically, to
5 an earphone and a method for uplink noise cancellation of an earphone.

BACKGROUND OF THE INVENTION

Currently, more and more earphones incorporate noise cancellation functions, including
uplink noise cancellation and downlink noise cancellation. Uplink noise cancellation is to
attenuate noise and enlarge audio components in signals to be played to a user, so that the user
10 can hear the played sound clearly. In downlink noise cancellation, a microphone is used to
capture ambient sound (noise) and generate a waveform that is the negative of the ambient sound.
The waveform is mixed with the signal to cancel the noise. For example, the earphones from
Bose and Sony adopt such noise cancellations.

Traditional earphones in the market usually adopt a two-microphones solution for uplink
15 noise cancellation. In most of the case the microphones are located either on a boom-arm or
directly on the earbud of the earphone. This usually has the advantage to seal a fix position
between the microphones and the user's mouth, but it is constrained with microphone's
placement due to lack of space. Furthermore, their close distance relative to the earbud speaker
leads to difficult acoustic echo problem.

20 Therefore, there is a demand in the art that a new solution for uplink noise cancellation
of a headphone shall be proposed to address at least one of the problems in the prior art.

SUMMARY OF THE INVENTION

One object of this invention is to provide a new technical solution for uplink noise
cancellation of an earphone.

25 According to a first aspect of the present invention, there is provided an earphone,
comprising: at least one earpiece, which includes at least one speaker; a connector for connecting

with an electronics apparatus; and a control box, which is connected to the earpiece and is arranged along an earphone wire between the earpiece and the connector, wherein at least three microphones for uplink noise cancellation are provided in the control box.

Alternatively or optionally, the earphone comprises three microphones for uplink noise
5 cancellation, the three microphones are in a linear topology, and the orientation of the linear topology is one of vertical orientation, horizontal orientation and diagonal orientation.

Alternatively or optionally, the three microphones are configured to be able to be steered to any direction from a mouth of a user to the control box.

Alternatively or optionally, distances between two adjacent microphones are equal or
10 unequal, wherein in a case where distances between two adjacent microphones are unequal, a distance between a first and second microphones of the three microphones is twice of that between the second microphone and a third microphone of the three microphones, the first and second microphones are adjacent and the second and third microphones are adjacent.

Alternatively or optionally, an accelerometer is arranged in the earpiece, and the
15 accelerometer captures vibrations to obtain a vibration signal, and the earphone determines whether an incoming audio signal component is an uncorrelated noise component by calculating correlation between the vibration signal and incoming audio signals captured by the microphones.

Alternatively or optionally, the earphone further comprises a processing circuit arranged in the control box, wherein the processing circuit is connected to the microphones to receive the
20 incoming audio signals captured by the microphones, and the processing circuit is configured to perform the following processes: estimating a direction of arrival of a target sound, to obtain a orientation information of the target sound; adjusting beam-forming parameters for the microphones according to the orientation information of the target sound, to perform a beam-forming; and cancelling noise from undesired direction.

25 Alternatively or optionally, the processing circuit is configured to, prior to estimating a direction of arrival of a target sound, perform the following processes: detecting uncorrelated noise component; and cancelling the uncorrelated noise component.

Alternatively or optionally, the processing circuit is configured to, prior to detecting uncorrelated noise component, perform the following processes: performing a gain-matching or

gain compensation on the incoming audio signals captured by the microphones; and transforming the incoming audio signals into frequency domain as the incoming audio signal components by using a Fast Fourier Transform; wherein, after cancelling noise from undesired direction, the method further comprises: transforming the processed incoming audio signal components into
5 time domain as output audio signals by an Inverse Fast Fourier Transform.

Alternatively or optionally, the at least one earpiece includes a first earpiece and a second earpiece, the first earpiece is a circumaural headphone, and the second earpiece is one of earbud and in-ear earphone.

Alternatively or optionally, the earphone further comprises a processing circuit arranged
10 in the control box, wherein the processing circuit is connected to the microphones to receive incoming audio signals captured by the microphones, and the processing circuit is configured to perform the following process: performing an uplink noise cancellation and a downlink noise cancellation for the first earpiece; and performing an uplink noise cancellation without a downlink noise cancellation for the second earpiece.

15 Alternatively or optionally, the connector is a USB type-C connector.

According to a second aspect of the present invention, there is provided a method for uplink noise cancellation of an earphone, comprising: providing at least one earpiece in the earphone, which includes at least one speaker; providing a connector for connecting with an electronics apparatus; providing a control box, which is connected to the earpiece and is arranged
20 along an earphone wire between the earpiece and the connector; providing at least three microphones for uplink noise cancellation in the control box; and performing uplink noise cancellation on incoming audio signals captured by the microphones.

Alternatively or optionally, three microphones for uplink noise cancellation are provided in the earphone, and the three microphones are in a linear topology, and the orientation of the
25 linear topology is one of vertical orientation, horizontal orientation and diagonal orientation.

Alternatively or optionally, the three microphones are configured to be able to be steered to any direction from a mouth of a user to the control box.

Alternatively or optionally, distances between two adjacent microphones are equal or unequal, wherein in a case where distances between two adjacent microphones are unequal, a

distance between a first and second microphones of the three microphones is twice of that between the second microphone and a third microphone of the three microphones, the first and second microphones are adjacent and the second and third microphones are adjacent.

Alternatively or optionally, the method further comprises: arranging an accelerometer
5 in the earpiece to capture vibrations to obtain a vibration signal; and determining whether an incoming audio signal component is an uncorrelated noise component by calculating correlation between the vibration signal and incoming audio signals captured by the microphones.

Alternatively or optionally, the method further comprises: estimating a direction of arrival of a target sound, to obtain a orientation information of the target sound; adjusting
10 beam-forming parameters for the microphones according to the orientation information of the target sound, to perform a beam-forming; and cancelling noise from undesired direction.

Alternatively or optionally, prior to estimating a direction of arrival of a target sound, the method further comprises: detecting uncorrelated noise component; and cancelling the uncorrelated noise component.

Alternatively or optionally, prior to detecting uncorrelated noise component, the method further comprises: performing a gain-matching or gain compensation on the incoming audio signals captured by the microphones; and transforming the incoming audio signals into frequency domain as the incoming audio signal components by using a Fast Fourier Transform; wherein, after cancelling noise from undesired direction, the method further comprises: transforming the
20 processed incoming audio signal components into time domain as output audio signals by an Inverse Fast Fourier Transform.

Alternatively or optionally, the method further comprises: performing an uplink noise cancellation and a downlink noise cancellation for a first earpiece; and performing an uplink noise cancellation without a downlink noise cancellation for a second earpiece.

Alternatively or optionally, the control box is arranged along an earphone wire connected to the second earpiece.

According to an embodiment of this invention, it can offer a greater freedom for positioning of microphones for uplink noise cancellation.

Further features of the present invention and advantages thereof will become apparent

from the following detailed description of exemplary embodiments according to the present invention with reference to the attached drawings.

BRIEF DISCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description thereof, serve to explain the principles of the invention.

Fig. 1 shows a schematic diagram of an earphone according to an embodiment of this disclosure.

Fig. 2 shows a schematic diagram of an earphone according to another embodiment of this disclosure.

Fig. 3 shows a schematic block diagram of uplink noise cancellation modules in an earphone according to an embodiment of this disclosure.

Fig. 4 shows a flow chart of method for uplink noise cancellation of an earphone according to an embodiment of this disclosure.

Fig. 5 shows a beam steering based on direction of arrival measurement.

Fig. 6 shows arrangements of the microphones for uplink noise cancellation.

Fig. 7 shows further arrangements of the microphones for uplink noise cancellation.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Various exemplary embodiments of the present invention will now be described in detail with reference to the drawings. It should be noted that the relative arrangement of the components and steps, the numerical expressions, and numerical values set forth in these embodiments do not limit the scope of the present invention unless it is specifically stated otherwise.

The following description of at least one exemplary embodiment is merely illustrative in nature and is in no way intended to limit the invention, its application, or uses.

Techniques, methods and apparatus as known by one of ordinary skill in the relevant art may not be discussed in detail but are intended to be part of the specification

where appropriate.

In all of the examples illustrated and discussed herein, any specific values should be interpreted to be illustrative only and non-limiting. Thus, other examples of the exemplary embodiments could have different values.

5 Notice that similar reference numerals and letters refer to similar items in the following figures, and thus once an item is defined in one figure, it is possible that it need not be further discussed for following figures.

Embodiments and examples will be described below in detail with reference to the drawings.

10 Generally, there are three kinds of earpieces for an earphone, such as in-ear earphone, earbud and circumaural headphone. The earbud and in-ear earphone is a small, discreet earpiece that fits in an ear. Generally, the in-ear earphone is inserted into the ear canal while the earbud rests outside the ear canal. The circumaural headphone is a earpiece with a cup to cover an ear.

A control box (also, called as “controller” or “conbox”) for an earphone is a unit which
15 is usually provided along a signal cord for the earphone. It provides some control functions, such as playing, picking up a phone call, backward, forward and so on.

Fig. 1 shows a schematic diagram of an earphone according to an embodiment of this disclosure.

As shown in Fig. 1, the earphone comprises: at least one earpiece 20, 21, which includes
20 at least one speaker 22; a connector 40 for connecting with an electronics apparatus; and a control box 10, which is connected to the earpiece 20 and is arranged along an earphone wire 30 between the earpiece 20 and the connector 40, wherein at least three microphones 13, 14, 15 for uplink noise cancellation are provided in the control box 10.

Here, DSP 11, Codec 12 and other processing circuits for the earphone can also be
25 arranged in the control box together with the microphones 13, 14, 15. For example, the DSP 11, Codec 12 can be arranged in the gaps between adjacent microphones to efficiently use room in the control box.

As shown in Fig. 1, the earphone comprises at least one earpiece 20, 21. In this example, the earphone comprises two earpieces 20, 21. As shown in Fig.1, each of the earpieces includes a

speaker 22. It would be appreciated by a person skilled in the art that each earpiece can include more than one speaker to play sound into an ear canal of a user. Generally, an earphone includes two earpieces, and the earpieces could be earbud, in-ear earphone or circumaural headphone.

The earphone further comprises a control box 10, which is connected to the earpiece 20, 21. The control box 10 contains processing circuits such as a DSP 11, a Codec 12 and so on. It can process the signals to be sent to the speakers 22 and provide control functions such as play, picking up a call, forward and backward.

Here, for example, the DSP 11 is arranged between the microphones 13, 14, and the Codec 12 is arranged between the microphones 14, 15. In this manner, the room in the control box can be efficiently used.

As shown in Fig. 1, three microphones 13, 14, 15 for uplink noise cancellation are provided in the control box 10. It would be understood by a person skilled in the art that extra microphones can also be provided in the earphone, either in the control box or on the earbud. As long as an earphone has at least three microphones for uplink noise cancellation in the control box, it will be covered by the claims.

Compared with the prior art solution in which the microphones are positioned in boom-arms or directly on earbud, the control box 10 offers a greater freedom for the microphones' positioning. In this regard, it will be easier to improve microphone beam forming algorithms in a lower frequency range and beam control.

In addition, compared with the prior art two-microphones solutions on boom-arm or earbud, the distance between the three microphones in the control box and the speakers are increased. This will tremendously limit the effect of acoustic echo problem in the earphone.

Furthermore in the prior art, the two-microphones solutions usually operate within an angular region of $\pm 30^\circ$. The performance rapidly deteriorates when operating outside that range.

In this embodiment, three microphones are provided in the control box. They enable an easier steering of the incoming sound beam (listening area). Consequently, they can cover orientation between the user's mouth and the microphone array, like a radar would do. Fig. 5 shows a beam steering based on direction of arrival measurement. As shown in Fig. 5, the operation orientations of the microphones can be steered to different directions such as direction 71 and direction 72.

For example, the three microphones 13, 14, 15 can be configured to be able to be steered to any direction from a mouth of a user to the control box 10.

The microphones 13, 14, 15 can be arranged in various topologies in the control box 10. Since they are arranged in the control box, the inter distance among them are constant. So, it is easier to provide a constant uplink noise cancellation compared with the prior art solution. The microphone topology can be linear. Fig. 6 shows arrangements of the microphones for uplink noise cancellation. In Fig. 6, reference sign A shows a vertical topology, reference sign B shows a horizontal topology, and reference C shows a diagonal topology. The distance between adjacent two microphones is 15mm. Generally, the greater the distances between two adjacent microphones are, the precision of a beam-forming is higher. However, the dimension of control box is limited. So, the distance of 15mm is preferable.

Fig. 7 shows distances between two adjacent microphones can be equal (reference sign E) or unequal (reference sign F). As indicated by reference sign E, the distances between two adjacent microphones are d . For example, in a case where distances between two adjacent microphones are unequal, a distance c between a first and second microphones of the three microphones is twice of that ($2*c$) between the second microphone and a third microphone of the three microphones, the first and second microphones are adjacent and the second and third microphones are adjacent. For example, the first, second and third microphones can be microphones 13, 14, 15 in sequence. Alternatively, they can be microphones 15, 14, 13 in sequence.

As shown in Fig. 1, an accelerometer 23 is arranged in the earpiece 20. The accelerometer 23 captures vibrations to obtain a vibration signal. The earphone can determine whether an incoming audio signal component is an uncorrelated noise component by calculating correlation between the vibration signal and incoming audio signals captured by the microphones 13, 14, 15. It would be appreciated by a person skilled in the art that the above processing can be performed in a processing device in the earpiece or in the DSP in the control box. Alternatively, it can be performed partly in the processing device and partly in the DSP. The accelerometer 23 can send the vibration signal directly to the DSP in the control box for processing.

Here, the accelerometer 23 is used for an extended sound detector. Indeed, the accelerometer is immune to background noise. It can capture a user's voice as vibration through the skull, which is highly correlated to the microphones signal. The correlation can be measured in this manner to cover the user immersion into different type of noisy environment such as car, pub, street noise, wind noise and so on. For example, the accelerometer 23 is provided in one of the earpieces 20, 21.

As shown in Fig. 1, audio signals can be transmitted and/or received from an electrical apparatus such as a mobile phone, a pad and so on, via a USB-C connector and an Audio Class 2 Driver. In this regard, the earphone can be used with high quality audio applications over USB protocol, digital communication. The earphone can be used with laptop, tablet, TV and so on.

Fig. 3 shows a schematic block diagram of uplink noise cancellation modules in the earphone. As shown in Fig. 3, a processing circuit 16 and the microphones 13, 14, 15 are arranged in the control box. The processing circuit 16 may includes the DSP 11 and codec 12 shown in Fig. 1. The processing circuit 16 is connected to the microphones 13, 14, 15 to receive the incoming audio signals captured by the microphones. For example, the incoming audio signals are digital signals. The accelerometer 23 is also connected to the processing circuit 16 to provide a vibration signal.

The processing circuit 16 can configured to perform at least one of the following processes: correcting an near-field effect and production drift for the incoming audio signals; converting the incoming audio signals into frequency domain to obtain incoming audio signal components; cancelling uncorrelated noise component; estimating a direction of arrival and steering the audio signal components to the estimated direction; cancelling noise from undesired direction; and converting the processed audio signal components into time domain to obtain an outcome audio signal. These processes can be those of the prior art. A person skilled in the art would understand how to carry out them under the teaching of this disclosure, and the detail thereof will not be described here. Furthermore, the processing circuit 16 can further detect uncorrelated noise of high-uncorrelated frequency component that could be due to wind noise, clothe fiddling, microphone input obstruction (e.g. one finger on the microphone hole) or one

deficient microphone, by calculating the correlation between the vibration signal from the accelerometer 23 and the incoming audio signals captured by the microphones 13, 14, 15.

In an example, the processing circuit 16 is configured to perform the following processes: estimating a direction of arrival of a target sound, to obtain a orientation information of the target sound; adjusting beam-forming parameters for the microphones according to the orientation information of the target sound, to perform a beam-forming; and cancelling noise from undesired direction. For example, the processing circuit 16 may be further configured to, prior to estimating a direction of arrival of a target sound, perform the following processes: detecting uncorrelated noise component; and cancelling the uncorrelated noise component. For example, the processing circuit 16 may be further configured to, prior to detecting uncorrelated noise component, perform the following processes: performing a gain-matching or gain compensation on the incoming audio signals captured by the microphones; and transforming the incoming audio signals into frequency domain as the incoming audio signal components by using a Fast Fourier Transform; wherein, after cancelling noise from undesired direction, the method further comprises: transforming the processed incoming audio signal components into time domain as output audio signals by an Inverse Fast Fourier Transform.

For example, the processing in the frequency domain can run at different sampling rate such as 8Khz, 16kHz and 24 kHz. The incoming signal is buffered within a time frame for further processing. The time frame can vary from 10 to 20 ms. The earphone may support a sampling rate up to 24kHz. For example, the earphone can capture a speech in a range 1 from 150hz to 8kHz.

It will be understood by a person skilled in the prior art that a software is equivalent to a hardware except for some of the mechanical components such a speaker, a microphone and so on. In this regard, a person skilled in the art can conceive, under the teaching of this disclosure, that the processing of the processing circuit 16 can be carried out through a hardware manner, a software manner and/or a combination thereof. For example, it can be carried out through discrete devices, a programmable device such PLD, DSP, FPGA. Alternatively, it can be implemented in a combination of a computing device such as a CPU or a MPU and a memory, wherein instructions are stored in the memory and are used to control the computing device to performing

corresponding operations during the running of the earphone. In this regard, this disclosure will not limit the implementation manners of the processing circuit 16. A person skilled in the art can choose the implementation manners under the teaching of this disclosure in consideration of the cost, the market availability and so on.

5 Fig. 2 shows a schematic diagram of an earphone according to another embodiment of this disclosure. In Fig. 2, there are two earpieces, including a first earpiece 20 and a second earpiece 60. The two earpieces 20, 60 are connected via a support beam 50. The first earpiece is a circumaural headphone, and the second earpiece is one of earbud and in-ear earphone. Other elements of Fig. 2 may be the same as those shown in Fig. 1 and thus the description thereof is
10 omitted.

 In this regard, a user can enjoy a quiet listening experience while he can also be notified of any urgent sound. This is especially advantageous when a user is walking on a street, is taking a subway and so on. Furthermore, since a user can hear his voice, it can also avoid an awful situation in which a user wearing a noise cancellation earphone answers a phone call with a very
15 loud voice, for example, in a public area such as a conference room, a bus and so on. Because the microphones are arranged in the control box, it is much easier to provide an earphone with the arrangement shown in Fig. 2.

 In an example, as shown in Fig. 3, the earphone comprises a processing circuit 16 arranged in the control box 10. The processing circuit 16 is connected to the microphones 13, 14,
20 15 to receive incoming audio signals captured by the microphones. The processing circuit is configured to perform the following process: performing an uplink noise cancellation and a downlink noise cancellation for the first earpiece; and performing an uplink noise cancellation without a downlink noise cancellation for the second earpiece. Here, the second earpiece 20 is just provided with an uplink noise cancellation so that a user can be aware of the ambient
25 notification, while he can also enjoy a pure music through the first earpiece 60.

 For example, the control box is arranged along an earphone wire connected to the first earpiece. This arrangement will provide a better experience for a user. Furthermore, this arrangement may provide a better uplink noise cancellation effect for the above usage scenario.

 Fig. 4 shows a flow chart of method for uplink noise cancellation of an earphone

according to an embodiment of this disclosure.

As shown in Fig. 4, at step S1100, at least one earpiece is provided in the earphone, which includes at least one speaker.

At step S1200, a connector is provided for connecting with an electronics apparatus.

5 At step S1300, a control box is provided, which is connected to the earpiece and is arranged along an earphone wire between the earpiece and the connector.

At step S1400, at least three microphones for uplink noise cancellation is provided in the control box.

For example, three microphones for uplink noise cancellation are provided in the
10 earphone, and the three microphones are in a linear topology, and the orientation of the linear topology is one of vertical orientation, horizontal orientation and diagonal orientation.

For example, the three microphones are configured to be able to be steered to any direction from a mouth of a user to the control box.

For example, distances between two adjacent microphones are equal or unequal, wherein
15 in a case where distances between two adjacent microphones are unequal, a distance between a first and second microphones of the three microphones is twice of that between the second microphone and a third microphone of the three microphones, the first and second microphones are adjacent and the second and third microphones are adjacent.

At step S1500, uplink noise cancellation is performed by using incoming audio signals
20 captured by the microphones.

Preferably, the method further comprises: arranging an accelerometer in the earpiece to capture vibrations to obtain a vibration signal; and determining whether an incoming audio signal component is an uncorrelated noise component by calculating correlation between the vibration signal and incoming audio signals captured by the microphones

25 Preferably, the method further comprises: estimating a direction of arrival of a target sound, to obtain a orientation information of the target sound; adjusting beam-forming parameters for the microphones according to the orientation information of the target sound, to perform a beam-forming; and cancelling noise from undesired direction. Preferably, the method further comprises, prior to estimating a direction of arrival of a target sound: detecting uncorrelated noise

component; and cancelling the uncorrelated noise component. Preferably, the method further comprises, prior to detecting uncorrelated noise component: performing a gain-matching or gain compensation on the incoming audio signals captured by the microphones; and transforming the incoming audio signals into frequency domain as the incoming audio signal components by using
5 a Fast Fourier Transform; wherein, after cancelling noise from undesired direction, the method further comprises: transforming the processed incoming audio signal components into time domain as output audio signals by an Inverse Fast Fourier Transform..

In an example, the at least one earpiece includes two earpieces, and the earpieces are at least one of earbud, in-ear earphone and circumaural headphone. For example, the at least one
10 earpiece includes a first earpiece and a second earpiece, the first earpiece is a circumaural headphone, and the second earpiece is one of earbud and in-ear earphone. In this regard, both of an uplink noise cancellation and a downlink noise cancellation may be performed for the first earpiece; and just an uplink noise cancellation may be performed without a downlink noise cancellation for the second earpiece. For example, the control box is arranged along an earphone
15 wire connected to the second earpiece.

Although some specific embodiments of the present invention have been demonstrated in detail with examples, it should be understood by a person skilled in the art that the above examples are only intended to be illustrative but not to limit the scope of the present invention.

CLAIMS

What is claimed is:

1. An earphone, comprising:

at least one earpiece, which includes at least one speaker;

5 a connector for connecting with an electronics apparatus; and

a control box, which is connected to the earpiece and is arranged along an earphone wire between the earpiece and the connector,

wherein at least three microphones for uplink noise cancellation are provided in the control box.

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2. The earphone according to claim 1, wherein the earphone comprises three microphones for uplink noise cancellation, the three microphones are in a linear topology, and the orientation of the linear topology is one of vertical orientation, horizontal orientation and diagonal orientation.

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3. The earphone according to claim 2, wherein the three microphones are configured to be able to be steered to any direction from a mouth of a user to the control box.

4. The earphone according to any of claims 1-3, wherein distances between two adjacent
20 microphones are equal or unequal,

wherein in a case where distances between two adjacent microphones are unequal, a distance between a first and second microphones of the three microphones is twice of that between the second microphone and a third microphone of the three microphones, the first and second microphones are adjacent and the second and third microphones are adjacent.

25

5. The earphone according to any of claims 1-4, wherein an accelerometer is arranged in the earpiece, and the accelerometer captures vibrations to obtain a vibration signal, and

the earphone determines whether an incoming audio signal component is an uncorrelated noise component by calculating correlation between the vibration signal and incoming audio signals captured by the microphones.

5 6. The earphone according to any of claims 1-5, further comprising a processing circuit arranged in the control box, wherein the processing circuit is connected to the microphones to receive the incoming audio signals captured by the microphones, and the processing circuit is configured to perform the following processes:

 estimating a direction of arrival of a target sound, to obtain a orientation information of
10 the target sound;

 adjusting beam-forming parameters for the microphones according to the orientation information of the target sound, to perform a beam-forming; and

 cancelling noise from undesired direction.

15 7. The earphone according to claims6, wherein the processing circuit is configured to, prior to estimating a direction of arrival of a target sound, perform the following processes:

 detecting uncorrelated noise component; and

 cancelling the uncorrelated noise component.

20 8. The earphone according to claims7, wherein the processing circuit is configured to, prior to detecting uncorrelated noise component, perform the following processes:

 performing a gain-matching or gain compensation on the incoming audio signals captured by the microphones; and

 transforming the incoming audio signals into frequency domain as the incoming audio
25 signal components by using a Fast Fourier Transform;

 wherein, after cancelling noise from undesired direction, the method further comprises:

 transforming the processed incoming audio signal components into time domain as output audio signals by an Inverse Fast Fourier Transform.

9. The earphone according to any of claims 1-8, wherein the at least one earpiece includes a first earpiece and a second earpiece, the first earpiece is a circumaural headphone, and the second earpiece is one of earbud and in-ear earphone.

5 10. The earphone according to claim 9, further comprising a processing circuit arranged in the control box, wherein the processing circuit is connected to the microphones to receive incoming audio signals captured by the microphones, and the processing circuit is configured to perform the following process:

 performing an uplink noise cancellation and a downlink noise cancellation for the first
10 earpiece; and

 performing an uplink noise cancellation without a downlink noise cancellation for the second earpiece.

 11. The earphone according to any of claims 1-10, wherein the connector is a USB
15 type-C connector.

 12. A method for uplink noise cancellation of an earphone, comprising:
 providing at least one earpiece in the earphone, which includes at least one speaker;
 providing a connector for connecting with an electronics apparatus;
20 providing a control box, which is connected to the earpiece and is arranged along an earphone wire between the earpiece and the connector;
 providing at least three microphones for uplink noise cancellation in the control box; and
 performing uplink noise cancellation on incoming audio signals captured by the microphones.

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 13. The method according to claim 12, wherein three microphones for uplink noise cancellation are provided in the earphone, and the three microphones are in a linear topology, and the orientation of the linear topology is one of vertical orientation, horizontal orientation and diagonal orientation; and

the three microphones are configured to be able to be steered to any direction from a mouth of a user to the control box.

14. The method according to claim 12 or claims 13, wherein distances between two adjacent microphones are equal or unequal,

wherein in a case where distances between two adjacent microphones are unequal, a distance between a first and second microphones of the three microphones is twice of that between the second microphone and a third microphone of the three microphones, the first and second microphones are adjacent and the second and third microphones are adjacent.

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15. The method according to any of claims 12-14, further comprising:

arranging an accelerometer in the earpiece to capture vibrations to obtain a vibration signal; and

determining whether an incoming audio signal component is an uncorrelated noise component by calculating correlation between the vibration signal and incoming audio signals captured by the microphones.

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16. The method according to any of claims 12-15, further comprising:

estimating a direction of arrival of a target sound, to obtain a orientation information of the target sound;

20

adjusting beam-forming parameters for the microphones according to the orientation information of the target sound, to perform a beam-forming; and
cancelling noise from undesired direction.

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17. The method according to claims 16, prior to estimating a direction of arrival of a target sound, further comprising:

detecting uncorrelated noise component; and
cancelling the uncorrelated noise component.

18. The method according to claims 17, prior to detecting uncorrelated noise component, further comprising:

performing a gain-matching or gain compensation on the incoming audio signals captured by the microphones; and

5 transforming the incoming audio signals into frequency domain as the incoming audio signal components by using a Fast Fourier Transform;

wherein, after cancelling noise from undesired direction, the method further comprises:

transforming the processed incoming audio signal components into time domain as output audio signals by an Inverse Fast Fourier Transform.

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19. The method according to any of claims 12-18, further comprising:

performing an uplink noise cancellation and a downlink noise cancellation for a first earpiece; and

15 performing an uplink noise cancellation without a downlink noise cancellation for a second earpiece.

20. The method according to claims 19, wherein the control box is arranged along an earphone wire connected to the second earpiece.

20

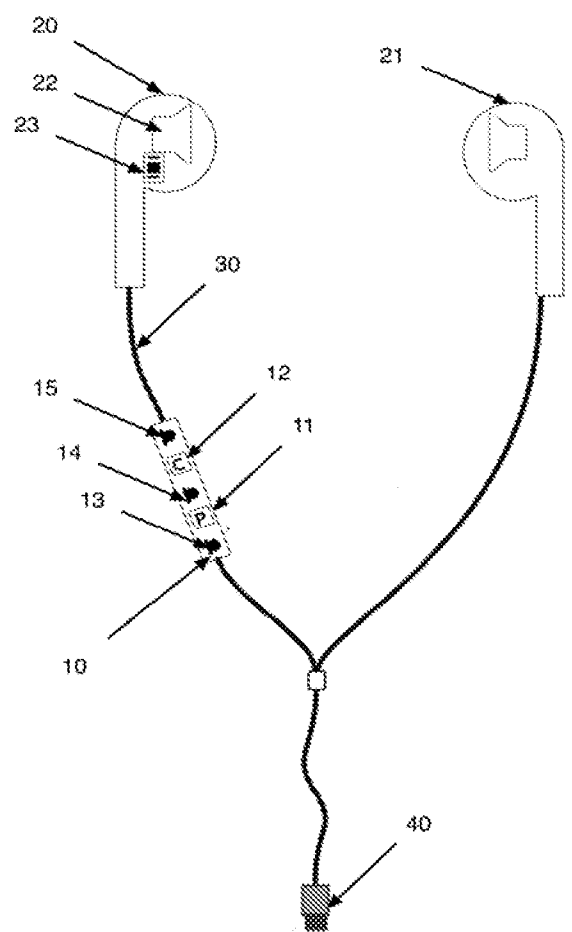


FIG. 1

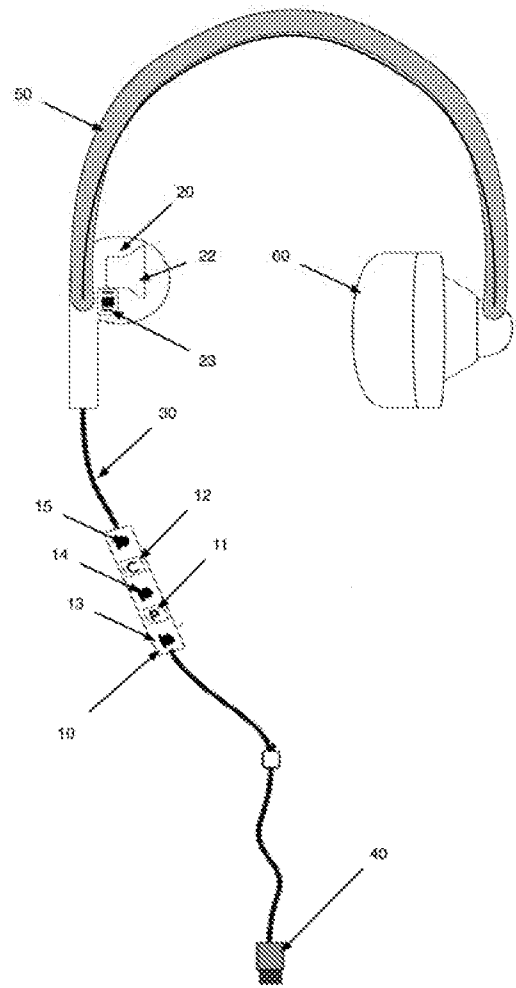


FIG. 2

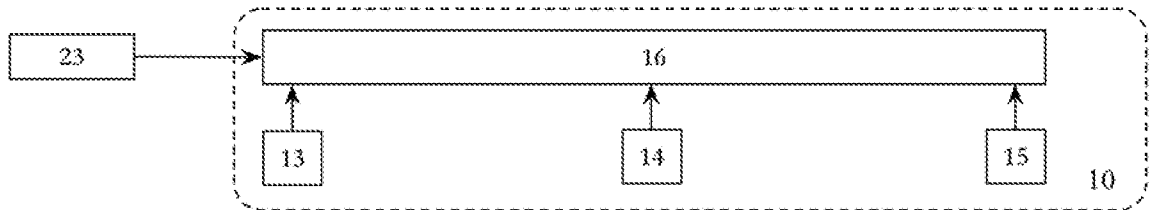


FIG. 3

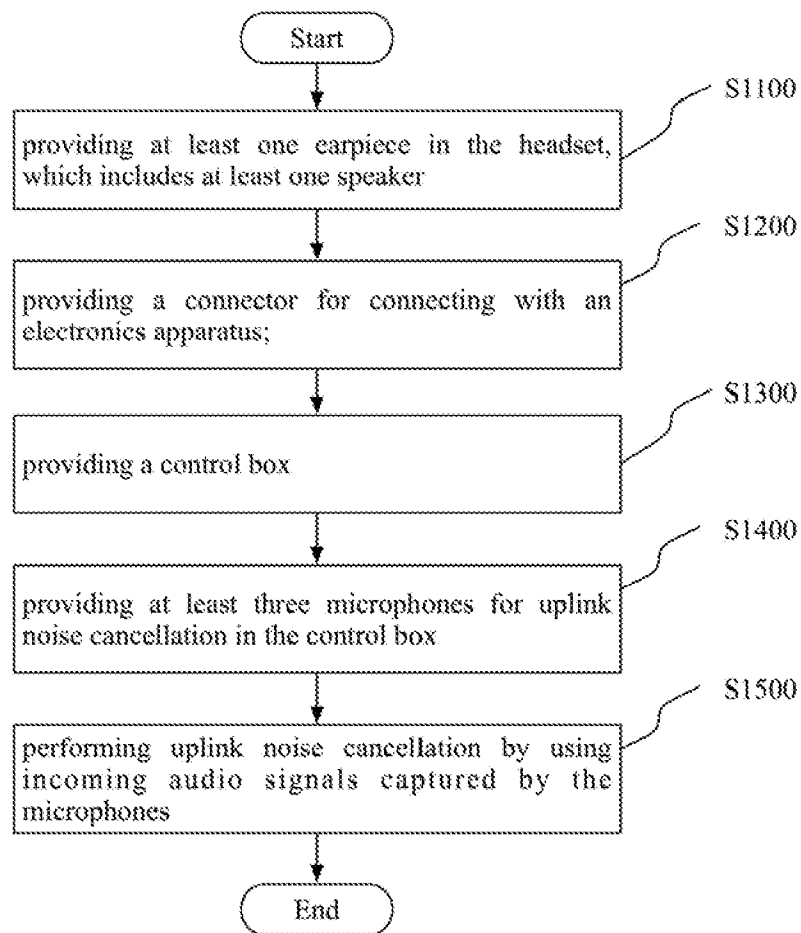


FIG. 4

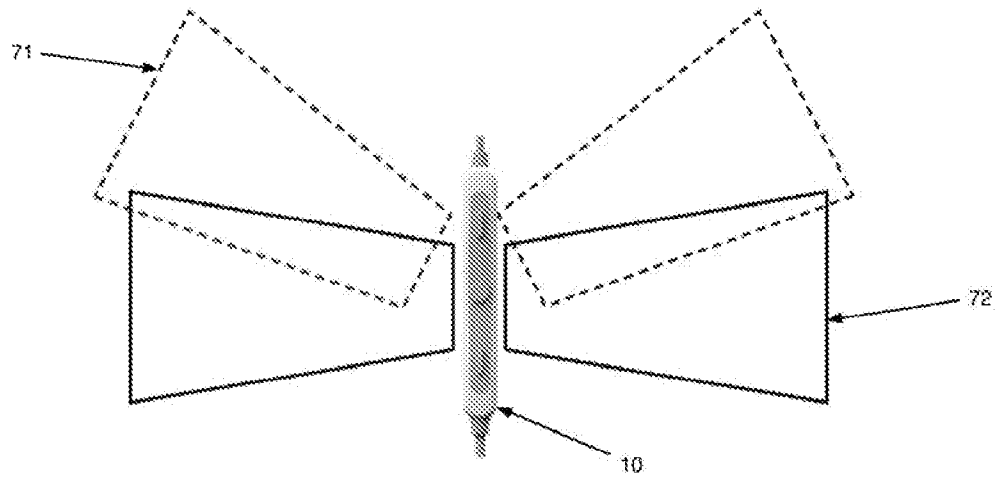


FIG. 5

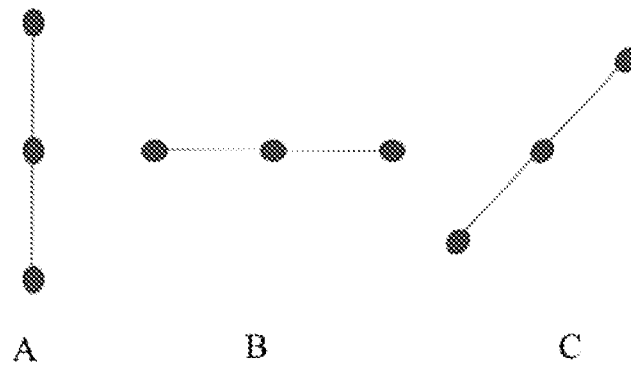


FIG. 6

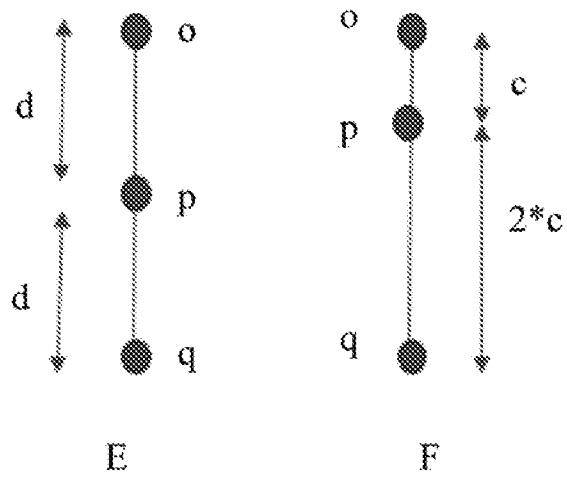


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/117848

A. CLASSIFICATION OF SUBJECT MATTER		
H04R 1/10(2006.01)i		
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)		
CNABS,CNKI,CNTEXT,VEN:earphone,earpiece,three,microphones,array,control,box,line,wire,switch,housing,noise,uplink,cancellation		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014093091 A1 (APPLE INC.) 03 April 2014 (2014-04-03) description paragraph [0031] to paragraph [0046]	1-20
Y	CN 102026058 A (AAC ACOUSTIC TECHNOLOGIES HOLDINGS INC.) 20 April 2011 (2011-04-20) description paragraph [0006] to paragraph [0023]	1-20
A	CN 102165521 A (APPLE INC.) 24 August 2011 (2011-08-24) the whole document	1-20
☐ Further documents are listed in the continuation of Box C. ☒ 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
03 September 2018		19 September 2018
Name and mailing address of the ISA/CN		Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088 China		YAN,Yan
Facsimile No. (86-10)62019451		Telephone No. 86-(010)-62089959

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2017/117848

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2014093091	A1	03 April 2014	WO	2014051969	A1	03 April 2014
				US	9438985	B2	06 September 2016
				US	9313572	B2	12 April 2016
CN	102026058	A	20 April 2011	None			
CN	102165521	A	24 August 2011	EP	2324476	B1	15 August 2012
				HK	1158353	A1	30 November 2012
				US	9723401	B2	01 August 2017
				WO	2010039437	A1	08 April 2010
				CN	102165521	B	07 November 2012
				EP	2324476	A1	25 May 2011
				US	2010081487	A1	01 April 2010
				US	2013216050	A1	22 August 2013
				US	8401178	B2	19 March 2013
				HK	1158353	A0	13 July 2012