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Sharma

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(54) **WIRELESS EARPHONE FOR USE IN BLUETOOTH PICONETS**

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H04B 7/00 (2006.01)

(52) **U.S. Cl.**
USPC **455/41.2**; 455/41.3

(58) **Field of Classification Search** 455/41.3, 455/41.2, 41.1, 575.2, 550.1, 88, 11.1, 13.1; 379/430, 428.02, 420.04; 381/334, 370, 381/74, 309, 379, 330, 380, 381
See application file for complete search history.

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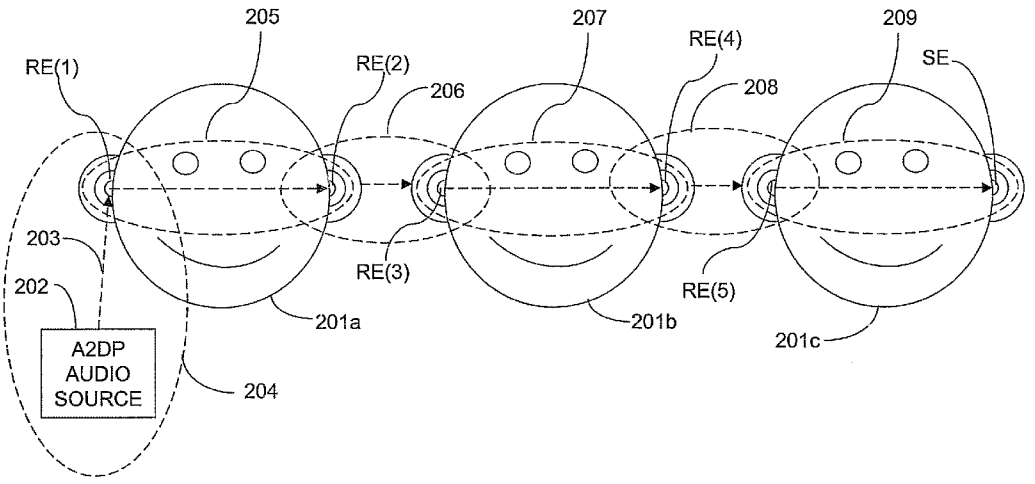
(57) **ABSTRACT**

An audio device includes a Bluetooth receiver, a Bluetooth transmitter, a speaker and a housing. The Bluetooth receiver is capable of wirelessly receiving signals in at least two audio channels. The Bluetooth transmitter is capable of wirelessly retransmitting at least a first one of the two audio channels. The speaker plays the second one of the two audio channels. The housing contains the Bluetooth receiver, the Bluetooth transmitter, and the ear phone. The housing is shaped to fit in or on an ear of a user.

18 Claims, 6 Drawing Sheets



IPR2026-00381
Tesla EX1016 Page 1

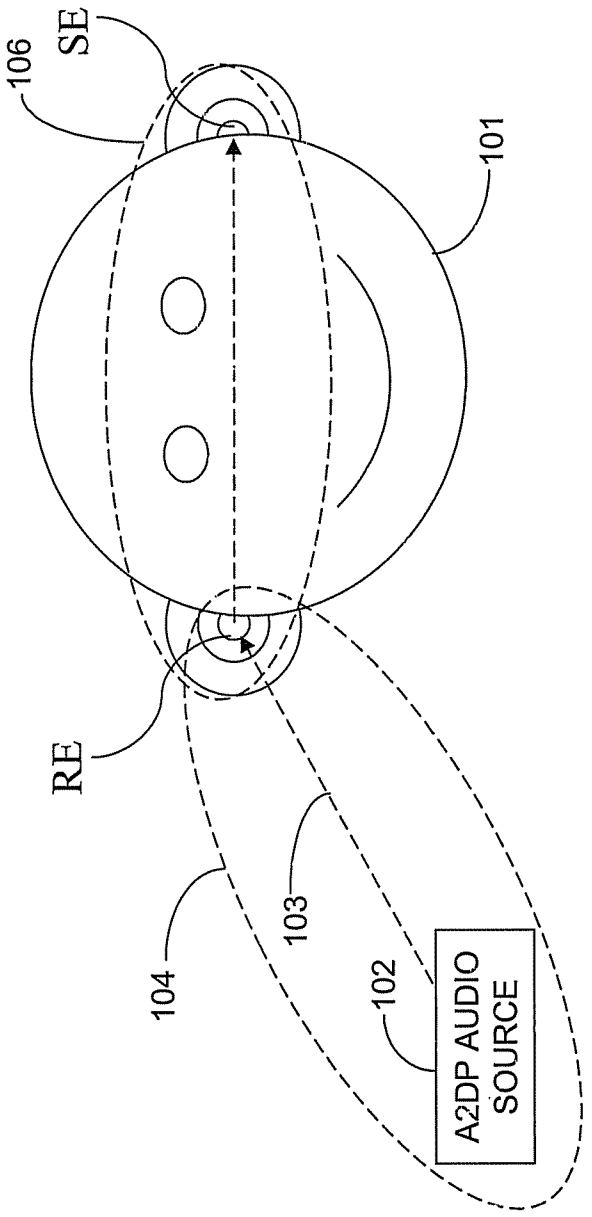


FIG. 1

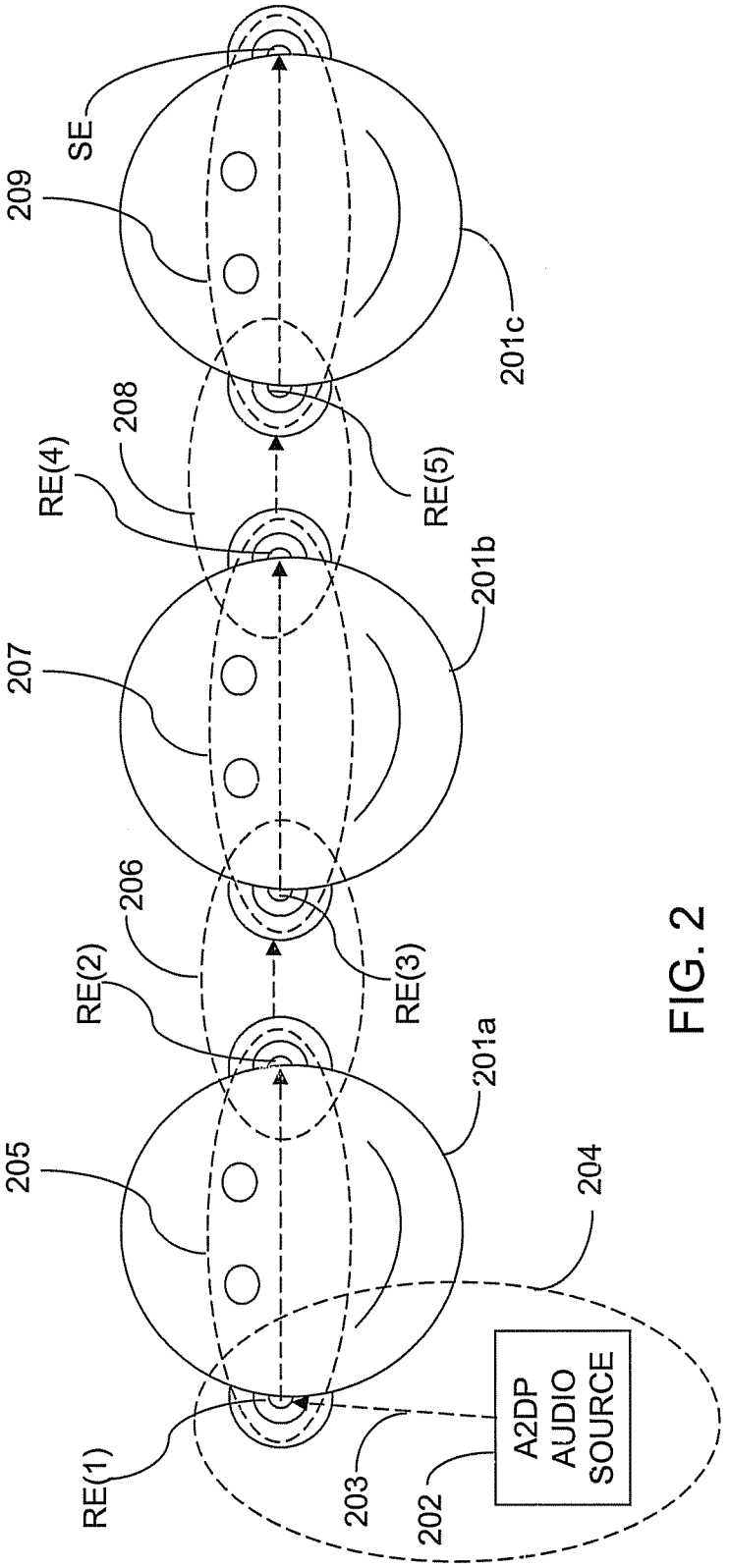

SE
209
201c
208
RE(4)
RE(5)
207
201b
206
RE(2)
RE(3)
205
201a
204
RE(1)
203
202
A2DP AUDIO SOURCE

FIG. 2

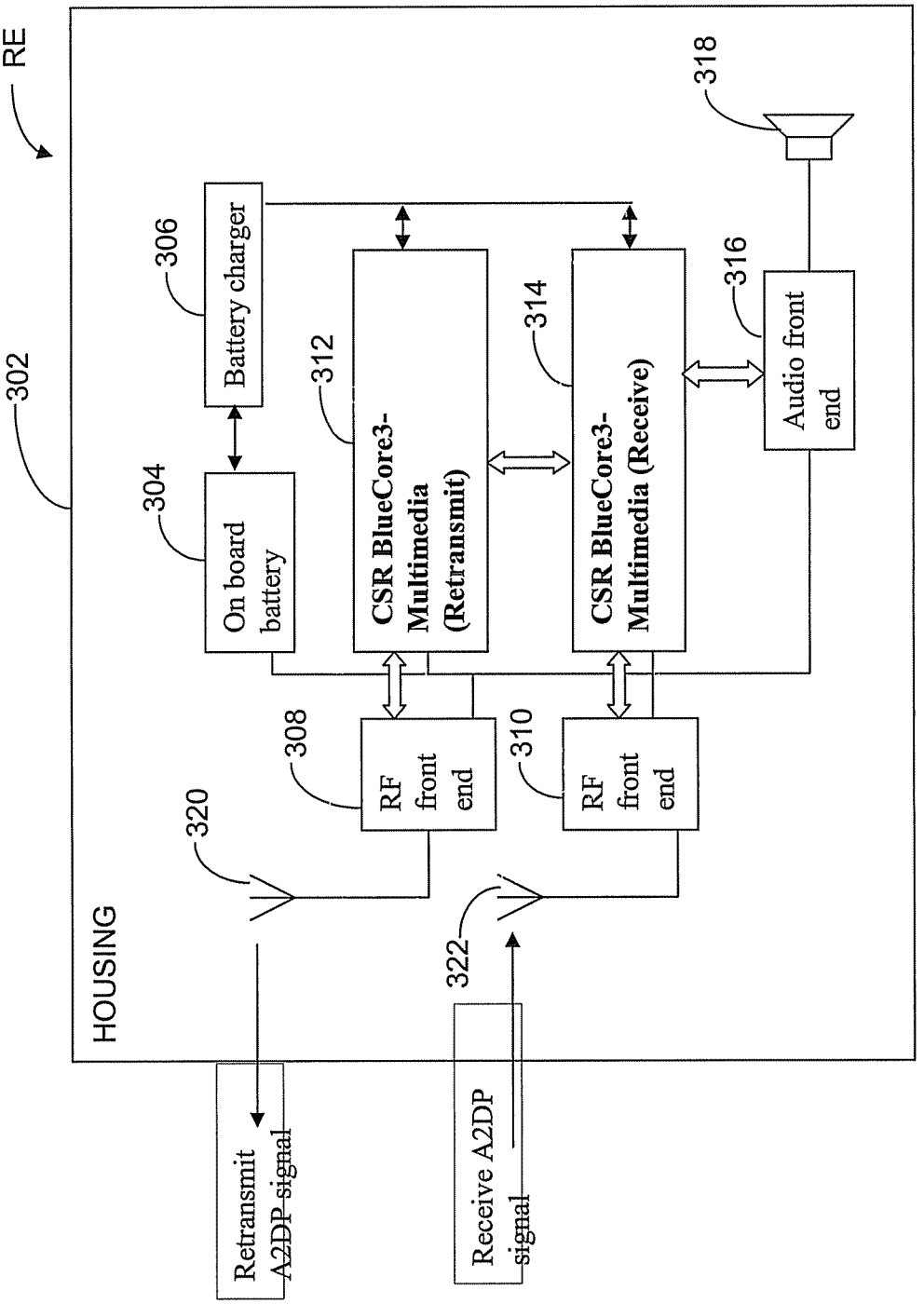

RE
302
HOUSING
306
Battery charger
304
On board battery
312
CSR BlueCore3-Multimedia (Retransmit)
314
CSR BlueCore3-Multimedia (Receive)
316
Audio front end
318
308
RF front end
310
RF front end
320
322
Retransmit A2DP signal
Receive A2DP signal

FIG. 3

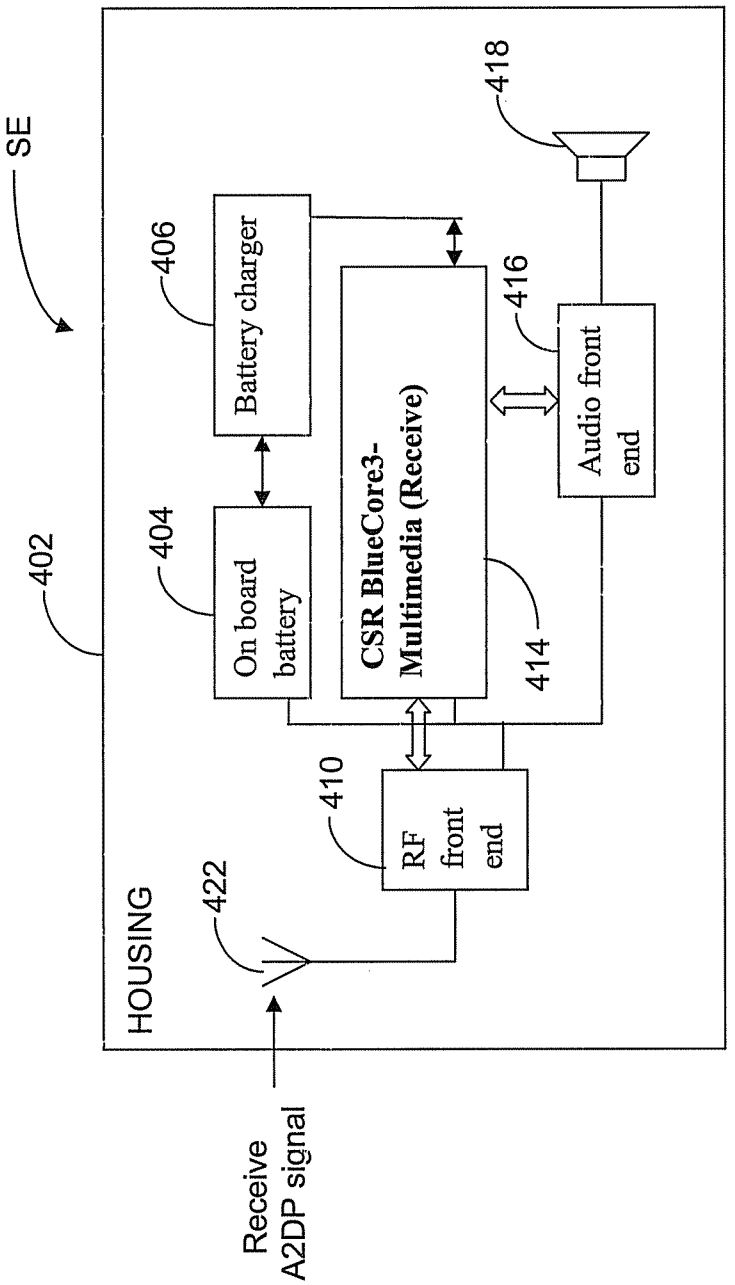

SE
402
HOUSING
404
On board battery
406
Battery charger
410
RF front end
414
CSR BlueCore3-Multimedia (Receive)
416
Audio front end
418
422
Receive A2DP signal

FIG. 4

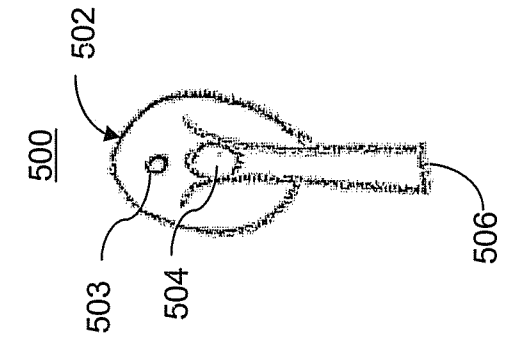


FIG. 5C

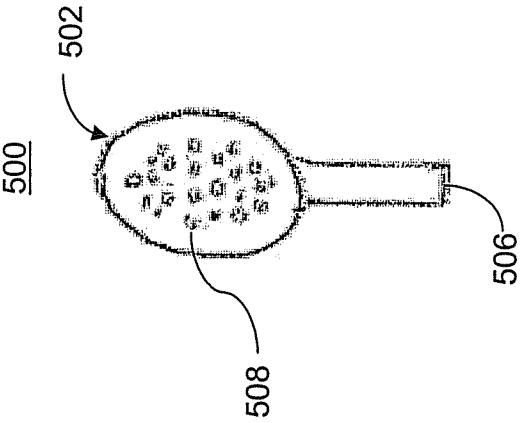


FIG. 5B

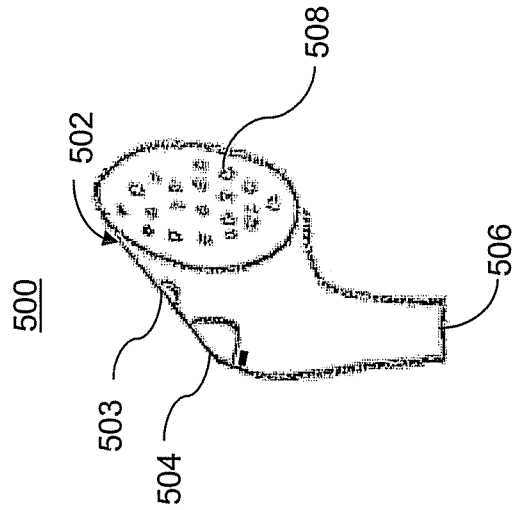


FIG. 5A

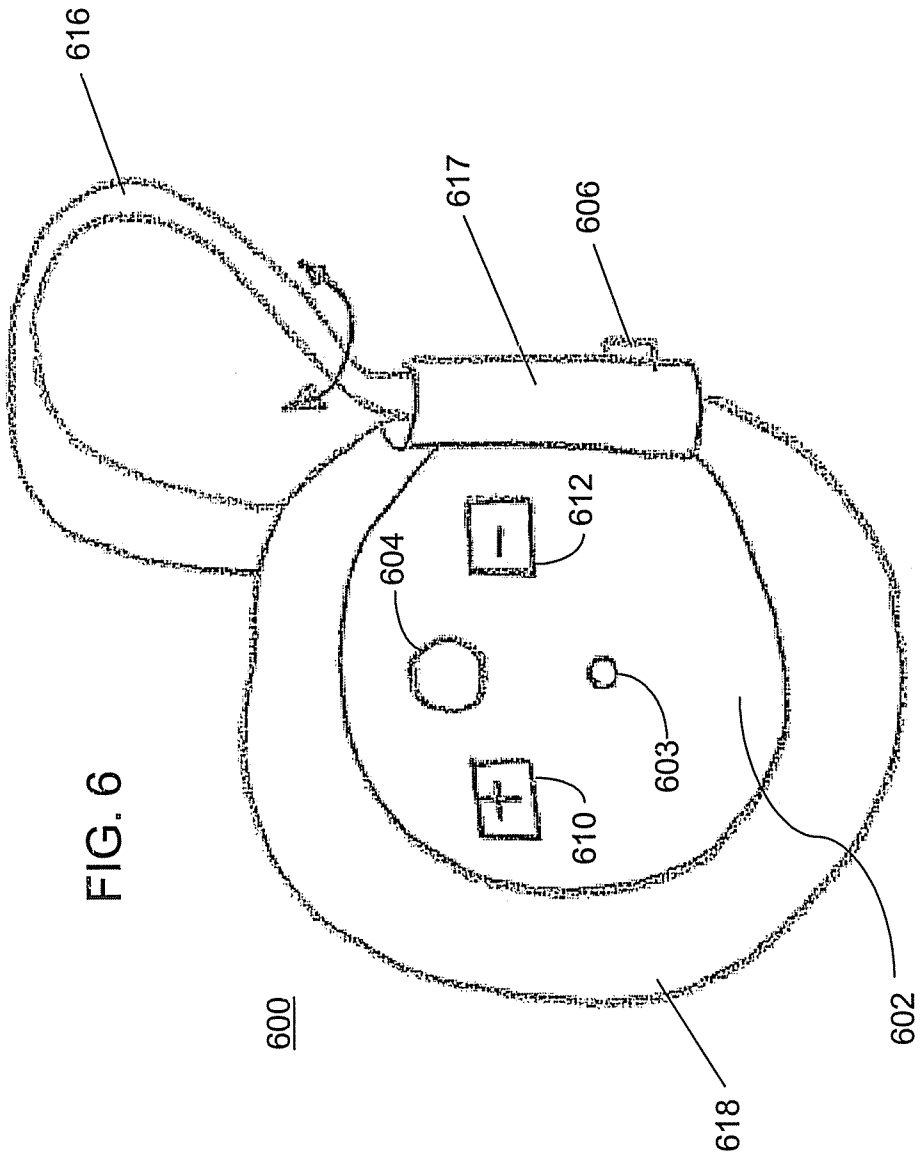


FIG. 6

WIRELESS EARPHONE FOR USE IN BLUETOOTH PICONETS

FIELD OF THE INVENTION

The present invention relates to the field of consumer electronics generally, and earphones in particular.

BACKGROUND

High quality Bluetooth audio earphones conform to the Advanced Audio Distribution Profile (A2DP). Currently, so-called Bluetooth "Wireless" headsets use a wireless connection to transfer stereo audio signals between the audio source and a first one of two earphones. The first earphone contains a wireless receiver. One of the audio channels is played in the first earphone, and the other audio channel is provided to the second earphone by way of a wired link. This increases the physical size of the earphone set and makes the earphones more conspicuous and difficult to use. Also, their large size makes them inconvenient to carry. A typical stereo Bluetooth earphone set is much larger than a typical flash or hard disk based music player, such as an "IPOD"® (sold by Apple, Inc. of Cupertino, Calif.).

Bluetooth A2DP signal sources can theoretically support up to seven earphones—the protocol allows a single Bluetooth master to interleave traffic between up to seven simultaneously active slaves in a single piconet. (A Bluetooth piconet is a temporary wireless network formed between Bluetooth devices. Devices participating in a Bluetooth piconet use the same frequency hop spread spectrum (FHSS) sequence.) In practice, however, the maximum number of A2DP links is fewer than seven, because of the lack of bandwidth inside a single Bluetooth piconet. It is common to aggregate up to five of the available time slots for a transmission to a single slave, reducing the amount of bandwidth available for the rest of the slaves. The inventor is not aware of any commercially available A2DP source that can transmit signals to more than one A2DP earphone at a time.

Improved Bluetooth earphones are desired.

SUMMARY OF THE INVENTION

In some embodiments, an audio device comprises a Bluetooth receiver capable of wirelessly receiving signals in at least two audio channels. A Bluetooth transmitter is capable of wirelessly retransmitting at least a first one of the two audio channels. A speaker plays the second one of the two audio channels. A housing contains the Bluetooth receiver, the Bluetooth transmitter, and the ear phone. The housing is shaped to fit in or on an ear of a user.

In some embodiments, an audio device comprises a Bluetooth Advanced Audio Distribution Profile receiver capable of wirelessly receiving signals in at least one high-fidelity audio channel. A speaker plays the at least one high-fidelity audio channel. A housing contains the Bluetooth Advanced Audio Distribution Profile receiver and the ear phone. The housing is shaped to fit in or on an ear of a user.

In some embodiments an audio system comprises first and second audio devices. The second audio device is mechanically unconnected to, and positionable independently from, the first audio device. The first audio device has a Bluetooth receiver capable of receiving signals in at least two audio channels. The second audio device has a Bluetooth receiver capable of receiving signals in at least a first one of the two audio channels. The first audio device has a Bluetooth transmitter capable of retransmitting at least the first one of the two audio channels to the second audio device. Each audio device has a speaker. The speaker of the first audio device is capable of playing the second one of the two audio channels. The speaker of the second audio device is capable of playing the first one of the two audio channels.

In some embodiments, a method of operating audio equipment comprises: receiving signals representing two audio channels wirelessly with a first Bluetooth audio device; playing a first one of the two audio channels with the first Bluetooth audio device; transmitting signals representing the second one of the two audio channels wirelessly to a second Bluetooth device, the second Bluetooth device mechanically unconnected to the first Bluetooth device; and playing the second audio channel with the second Bluetooth device simultaneously while playing the first audio channel with the first Bluetooth device.

In some embodiments, a method of operating audio equipment comprises: receiving signals representing two audio channels wirelessly with a first pair of Bluetooth audio devices by way of a first Bluetooth piconet; playing the two audio channels with the first pair of Bluetooth audio devices; and transmitting signals representing the two audio channels wirelessly from the first pair of Bluetooth audio devices to a second pair of Bluetooth audio devices by way of a second Bluetooth piconet, the second pair of Bluetooth audio devices mechanically unconnected to the first pair of Bluetooth audio devices.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram showing operation of a pair of audio devices according to one embodiment.

FIG. **2** is a schematic diagram showing operation of a plurality of pairs of audio devices.

FIG. **3** is a block diagram of one exemplary embodiment of the retransmitting earphone (RE) shown in FIG. **1**.

FIG. **4** is a block diagram of one exemplary embodiment of the sink earphone (SE) shown in FIG. **1**.

FIGS. **5**A-**5**C are side, front and rear elevation views of an exemplary ear bud (RE or SE) according to one embodiment of the audio device of FIG. **1**.

FIG. **6** is a diagram of an exemplary earphone (RE or SE) according to one embodiment of the audio device of FIG. **1**.

DETAILED DESCRIPTION

This description of the exemplary embodiments is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description. In the description, relative terms such as "lower," "upper," "horizontal," "vertical," "above," "below," "up," "down," "top" and "bottom" as well as derivative thereof (e.g., "horizontally," "downwardly," "upwardly," etc.) should be construed to refer to the orientation as then described or as shown in the drawing under discussion. These relative terms are for convenience of description and do not require that the apparatus be constructed or operated in a particular orientation. Terms concerning attachments, coupling and the like, such as "connected" and "interconnected," refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise.

FIG. **1** shows a method of operating audio equipment, including earphones. In some embodiments, the earphones may be divided into two subsets. A first subset is referred to herein as "sink earphones" (SE), shown in FIGS. **1**, **2** and **4**,

IPR2026-00381
Tesla EX1016 Page 8

and a second subset is referred to herein as "retransmitter earphones" (RE), shown in FIGS. **1-3**. The SE receives an A2DP transmission and plays it. In some embodiments, the SE decodes and plays a single channel of a stereo transmission depending on the system design. The RE plays one channel and transmits the other channel (or transmits both channels) to a destination. As used herein, the term "earphone" is not limited to a particular shape, and may encompass ear buds (e.g., FIG. **5**), over-the-ear configurations (e.g., FIG. **6**), or other audio device housing shapes.

The first Bluetooth audio device RE is positioned in, on or proximate to a first ear of a user **101**, and the second Bluetooth device SE is positioned in, on or proximate to a second ear of the first user. As used herein, the phrase, "in the ear" refers to embodiments in which the entire device fits in the ear, as well as embodiments in which a first portion of the device fits in the ear and a second portion of the device protrudes from the ear. Signals **103** representing two audio channels are received wirelessly by the first Bluetooth audio device RE. A first one of the two audio channels is played by the first Bluetooth audio device RE. Signals representing the second one of the two audio channels are transmitted wirelessly to a second Bluetooth device SE. The second Bluetooth device SE is not mechanically connected to the first Bluetooth device. The second audio channel is played with the second Bluetooth device SE simultaneously, while playing the first audio channel with the first Bluetooth device RE.

In FIG. **1** the two exemplary audio devices RE, SE are referred to herein as Completely Wireless high fidelity Bluetooth Audio Earphones (CWBAE). CWBAE do not require wired connections between the earphones RE, SE and the audio signal source. Moreover, CWBAE do not require any external wired connection between the left and right earphones RE, SE. One of ordinary skill in the art will understand that an individual CWBAE audio device (RE or SE) may include internal wires, conductors and/or printed circuit wirings within the housing **302**, **402**, **502** or **602** (shown in FIGS. **3-6**, respectively) of a single ear bud **500** or over-the-ear type earphone **600**. CWBAE eliminate the last external connecting wire that was required between the right and left earphones in conventional "wireless" earphone sets.

The audio system of FIG. **1** includes first and second audio devices RE and SE. The second audio device SE is mechanically unconnected to, and positionable independently from, the first audio device RE. The first audio device RE has a Bluetooth receiver **314** (shown in FIG. **3**) capable of receiving signals in at least two audio channels. The second audio device SE has a Bluetooth receiver **414** (shown in FIG. **4**) capable of receiving signals in at least a first one of the two audio channels. The first audio device RE has a Bluetooth transmitter **312** (FIG. **3**) capable of retransmitting at least the first one of the two audio channels to the second audio device SE. Each audio device has a speaker **318**, **418** (FIGS. **3** and **4**). The speaker **318** of the first audio device RE is capable of playing the second one of the two audio channels. The speaker **418** of the second audio device SE is capable of playing the first one of the two audio channels.

As shown in FIG. **1**, the audio device RE is capable of operating with two separate Bluetooth addresses simultaneously, and is capable of participating in two separate Bluetooth piconets **104**, **106** simultaneously using a respectively different Bluetooth address in each of the piconets **104**, **106**. This facilitates the wireless transmission of one (or both) audio channels from the RE to the SE.

FIG. **2** shows a multi-user method of operating the audio devices. At a high level, FIG. **2** shows a method of operating audio equipment, comprising: receiving signals representing two audio channels wirelessly with a first pair of Bluetooth audio devices RE(**1**), RE(**2**) by way of a first Bluetooth piconet **204**; playing the two audio channels with the first pair of Bluetooth audio devices RE(**1**), RE(**2**); transmitting signals representing the two audio channels wirelessly from the first pair of Bluetooth audio devices RE(**1**), RE(**2**) to a second pair of Bluetooth audio devices RE(**3**), RE(**4**) by way of a second Bluetooth piconet **206**, where the second pair of Bluetooth audio devices RE(**3**), RE(**4**) are not mechanically connected to the first pair of Bluetooth audio devices RE(**1**), RE(**2**).

In greater detail, signals **203** representing the two audio channels are transmitted wirelessly from the first Bluetooth device RE(**1**) coupled to an ear of a first user **201***a* to the second Bluetooth device RE(**2**) coupled to the other ear of the first user **201***a*. The second Bluetooth device RE(**2**) is not mechanically connected to the first Bluetooth device RE(**1**). The signals representing the two audio channels are then transmitted wirelessly from the second Bluetooth device RE(**2**) to a third Bluetooth device RE(**3**) coupled to an ear of a second user **201***b*. The third Bluetooth device RE(**3**) is mechanically unconnected to the first and second Bluetooth devices RE(**1**) and RE(**2**). The first audio channel is played by the third Bluetooth device RE(**3**) Signals representing the second one of the two audio channels are transmitted wirelessly from the third Bluetooth device RE(**3**) to a fourth Bluetooth device RE(**4**) coupled to a second ear of the second user **201***b*. The fourth Bluetooth device RE(**4**) is mechanically unconnected to the first, second and third Bluetooth devices RE(**1**)-RE(**3**). The second audio channel is played by the fourth Bluetooth device RE(**4**). One of ordinary skill can readily recognize how the additional transmissions to the fifth and sixth devices RE(**5**) and SE are performed in the same manner.

As shown in FIG. **2**, the first Bluetooth device RE(**1**) is operated in a first Bluetooth piconet **205**. The third Bluetooth device RE(**3**) is operated in a second Bluetooth piconet **206**. The second Bluetooth device RE(**2**) is operated in both the first and second Bluetooth piconets **205** and **206** simultaneously, with the second device RE(**2**) using different Bluetooth addresses and interfaces in the two piconets.

The RE receives an A2DP stream containing stereo signals from an audio source and then retransmits a modified (or unmodifed) version of the A2DP stream to another SE or RE. Thus, the RE operates as a Bluetooth repeater for one or both of the audio channels. In some embodiments (FIG. **2**), the RE simultaneously retransmits the full audio stream (both channels) at the same time that one channel is being played by the RE. In some embodiments (FIG. **1**), the RE only retransmits one of the audio channels while playing the other audio channel (as shown in FIG. **1**). FIG. **1** shows a user wearing a set of earphones, include an SE and an RE. In some embodiments, a delay may be added by the RE or SE to account for the delay in the audio path from RE to SE or from RE to RE. For example, there may be a signal propagation delay or a delay associated with buffering data, to ensure that a continuous stream can be played.

The RE has two completely separate Bluetooth physical interfaces. The RE has two separate Bluetooth addresses and participates in two completely independent Bluetooth piconets simultaneously. In some embodiments, CWBAE devices form a new piconet for each A2DP stream. In FIG. **1**, the audio source and the RE form a first piconet **104** and the RE and SE form a separate piconet **106**.

The RE may be a Bluetooth Master in both piconets, or a slave in both piconets, or a slave in one piconet and a master in another piconet. Even if the RE is master in both piconets, the hopping sequence and the link keys for the Bluetooth link

IPR2026-00381
Tesla EX1016 Page 9

will be different in the two piconets, since the RE uses different Bluetooth addresses and interfaces in the two piconets.

In some embodiments (e.g., FIG. **2**), CWBAE can seamlessly support multiple users **201***a*-**201***c* listening to audio signals from the same audio source **102**, even if the audio signal source **102** is only capable of transmitting signals to a single user **201***a*. CWBAE can also extend the physical range of Bluetooth audio transmission without the need for any change in the existing Bluetooth Advanced Audio Distribution Profile (A2DP) protocol or the existing audio signal source **102**. CWBAE devices are not subject to the limitations on the number of earphones that can be supported in a system having a single Bluetooth A2DP source **102**. Any number of users **201***a*-**201***c* can be supported using CWBAE even if the A2DP audio source is only capable of streaming music to a single one of the earphones.

FIG. **2** shows a plurality of retransmitting earphones RE(**1**) to RE(**5**). Each audio device RE(**1**)-RE(**5**) operates with two separate Bluetooth addresses simultaneously, and participates in two of the separate Bluetooth piconets **204**-**209** simultaneously using a respectively different Bluetooth address in each of the two piconets. This facilitates the wireless transmission of both audio channels from A2DP audio source **202** to RE(**1**) in piconet **204**; from RE(**1**) to RE(**2**) in piconet **205**; from RE(**2**) to RE(**3**) in piconet **206**; from RE(**3**) to RE(**4**) in piconet **207**; from RE(**4**) to RE(**5**) in piconet **208**; and wireless transmission of one or both channels from RE(**5**) to the SE in piconet **209**.

In FIG. **2**, the second audio device RE(**2**) includes two Bluetooth physical interfaces **312**, **314** (shown in FIG. **3**) with respectively different Bluetooth addresses. The Bluetooth transmitter **312** of the first audio device RE(**1**) is capable of transmitting both of the two audio channels to the Bluetooth receiver **314** of the second audio device RE(**2**).

The Bluetooth receiver **314** of the second audio device RE(**2**) is capable of receiving both of the two audio channels from the Bluetooth transmitter of the first audio device RE(**1**). The second audio device RE(**2**) is capable of participating in two separate Bluetooth piconets **205**, **206** simultaneously using a respectively different Bluetooth address in each of the piconets.

Although FIG. **2** shows an example in which the distal earphone of the last user **201***c* in the chain is an SE, the distal earphone of user **201***c* may alternatively be another RE. In some embodiments (not shown), the RE may include a manually operable transmitter switch that enables the user **201***c* to turn off the retransmitter interface **312** within the RE to extend the battery life, if the RE is the last audio device in the last piconet in the chain.

One of ordinary skill in the art recognizes that, by providing two Bluetooth interfaces in each RE device, and operating each RE in a respectively separate piconet, the operating method shown in FIG. **2** avoids degradation in available bandwidth hence audio quality that occurs with a larger number of slaves with one master in a single piconet.

FIG. **2** shows how CWBAE may be used for multiple users listening to music from the same audio source. In FIG. **2**, only the first user **201***a* receives the audio stream directly from the audio source. For the first user **201***a*, both the earphones are of the RE type. The left earphone RE(**1**) receives the audio stream and retransmits it to the right earphone RE(**2**). The right earphone RE(**2**) retransmits to the left earphone RE(**3**) of the second user **201***b*, and so on. As shown in FIG. **2**, a respective piconet is provided for each audio stream. Three users are shown for exemplary purposes, but there is no limit on the number of users than can be chained in the manner shown. The only limiting factor is radio interference. For a large number of users, the users may be physically spread out in such a way that the piconet overlap in space is minimal. Because Bluetooth is intended for relatively short distances, this may be used in several situations. Also, with multi user CWBAE, music may be transmitted using Bluetooth over much larger distance than would be possible using A2DP in a single piconet.

Although examples are described above using CWBAE, in other embodiments, the chaining capability can be used for the design of a wirelessly networked public address system or a public area music system. For example, in a public address system, multiple members of an audience (or the entire audience) can hear a speaker, or a translation of a speech being given, using CWBAE.

FIG. **3** is a block diagram of an exemplary audio device RE, suitable for use according to the methods of FIGS. **1** and **2**. The device RE is contained within a housing **302**, which may be an ear bud type housing **502** (FIG. **5**) or an over-the-ear type housing **602** (FIG. **6**), or another suitable design for coupling the device RE in, on or proximate to an ear of a user. The device RE has an on-board battery **304**, and optionally includes a battery charger **306**. In alternative embodiments, the battery **304** may be a small, replaceable non-proprietary battery, and the battery charger **306** may be omitted. The exemplary RE device includes a Bluetooth A2DP receiver **314** capable of wirelessly receiving signals in at least one high-fidelity audio channel, and an A2DP transmitter **312** for re-transmitting the received signals. The RE device further includes a speaker **318** that plays the at least one high-fidelity audio channel.

The receiver interface **312** and re-transmitter interface **314** may be modules of the same type. For example each of the modules **312** and **314** may be a Bluecore-3 Multimedia Bluetooth module sold by Cambridge Silicon Radio, Ltd. of Cambridge, UK. This module includes receive and transmit functions. Other types of Bluetooth modules may be used, including but not limited to modules implemented in commercially available IC chips, or an application specific integrated circuit (ASIC). Each of the Bluetooth modules **312** and **314** has a respective RF front end **308**, **310** and a respective antenna element **320**, **322**.

The inclusion of separate Bluetooth physical interface modules **312** and **314** allow operation of the retransmission and receiving functions in separate piconets, independently of each other. For example, the two separate Bluetooth physical interface modules **312** and **314** provide a means for enabling the device (e.g., RE(**2**)) to operate as a master in a first one of the Bluetooth piconets (e.g., **206**), while simultaneously operating as a slave in a second one of the Bluetooth piconets (e.g., **205**).

Alternatively, the two separate Bluetooth physical interface modules **312** and **314** can provide a means for enabling the device (e.g., RE(**2**)) to operate as a slave in a first one of the Bluetooth piconets (e.g., **206**), while simultaneously operating as a slave in a second one of the Bluetooth piconets (e.g., **205**).

Alternatively, the two separate Bluetooth physical interface modules **312** and **314** can provide a means for enabling the device (e.g., RE(**2**)) to operate as a master in a first one of the Bluetooth piconets (e.g., **206**), while simultaneously operating as a master in a second one of the Bluetooth piconets (e.g., **205**).

In the audio system of FIGS. **2** and **3**, the second audio device RE(**2**) has a Bluetooth transmitter **312** (FIG. **3**) capable of transmitting both of the two audio channels. The system further comprises a third audio device R(**3**) not mechanically connected to, and positionable independently

IPR2026-00381
Tesla EX1016 Page 10

from, the first and second audio devices R(**1**) and R(**2**). The third audio device R(**3**) comprises a Bluetooth receiver **314** capable of receiving signals in the two audio channels from the second audio device R(**2**), a Bluetooth transmitter **312** capable of retransmitting at least the first two audio channels, and a speaker **318** for playing the second audio channel.

In some embodiments, the RE device has a mechanism for delaying the playing of the second one of the two audio channels by a delay period. For example, the audio front end module **316** may include a delay circuit that delays the playing of the signals in the speaker **318** by a propagation time for the retransmitted signals from the audio device RE to a recipient of the retransmitted signals (such as an SE or RE device worn on the other ear by the same user).

FIG. **4** is a block diagram of an exemplary SE device. In the example of FIG. **4**, the SE comprises a subset of the components included in the RE device of FIG. **3**. Elements of FIG. **4** corresponding to like elements of FIG. **3** are indicated by the same reference numeral, increased by 100 in FIG. **4**. These common elements may include housing **402**, on-board battery **404**, battery charger **406**, Bluetooth receive module **414**, Audio front end **416**, earphone speaker **418**, RF front end **410** and RF antenna **422**. In some embodiments, the Bluetooth receiver module **414** is a fall BlueCore3 system by Cambridge Silicon Radio, Ltd. of Cambridge, UK.

In preferred embodiments, CWBAE earphones do not have any wired connections between earphones **500** or **600**, or between any of the earphones **500**, **600** and the audio signal source **102**. This enables design of very elegant and ergonomic wireless earphones.

FIGS. **5**A-**5**C show an exemplary design for an earphone in the form of an ear bud **500** containing the modules shown in FIG. **3** or **4**, within a housing **502**. Because CWBAE removes the need for any wired connections, the exemplary audio devices can optionally be built as tiny ear buds **500** that fit into each ear, and are barely visible to a person in front of or behind the user. CWBAE earphones **500**, **600** can be designed to be much lighter and smaller physically than typical wireless earphones. This can make them easier to wear for prolonged periods of time.

Ear bud **500** may have a variety of controls. In one example, as shown in FIGS. **5**A to **5**C, a push-button control **504** is provided for power/pairing mode selection. For example, a first push of the button **504** can turn on the device, and subsequent pushes of the button **504** can set the device to operate as an RE node in two piconets or as an SE node in the terminal piconet of a chain of piconets. One or more indicator lights **503** may be provided. For example, one or more indicator LEDs **503** may provide Bluetooth status, charging status, and/or battery level status. A connector **506** may be provided for recharging the battery **304**, **404**. For example, port **506** may be a USB mini-B port, or other interface providing a power connection. A speaker portion **508** may have an ergonomic shape for fitting comfortably in the ear of the user, and one or more vents for audio. This is only one example, and a variety of controls and/or indicators may be included in ear bud **500**.

Although the embodiment of FIG. **5** protrudes from the ear of the user, other embodiments may include smaller components to permit the entire device to fit within the ear.

FIG. **6** shows another example of an earphone **600** shaped to be worn over an ear of the user. Earphone **600** has a housing **602** containing the modules shown in FIG. **3** or **4**. The earphone **600** may include controls similar to those included in the ear bud **500**, such as a push-button control **604** for power/pairing mode selection, a USB mini-B port **608**, or other interface providing a power connection for recharging the battery **304**, **404**, and one or more indicator lights **603** such as LEDs that provide Bluetooth status, charging status, or battery level status. Because of the larger size of housing **602**, additional controls and/or indicators may be provided on the housing **602**. For example, volume control buttons **610** and **612** may be provided.

Earphone **600** may have a clip **616** for supporting the earphone on the ear of the user. The clip **616** may optionally be pivotally mounted to a clip base **617** attached to the housing **602**, or to a sleeve (not shown) integrally formed in the housing. A foam covering **618** may optionally be provided to enhance user comfort. Many other physical configurations may be used.

Although the exemplary embodiments of FIGS. **5** and **6** show earphones that are positioned in or on an ear of the user, other configurations can be used to position the earphones proximate to the ears of the user. For example, earphones according to FIG. **3** or **4** may be built into articles of apparel (such as hats, eyeglasses, barrettes, scrunchies, wigs, toupees, or the like), or may be inserted in suitably sized pockets in such articles of apparel. All of these items of apparel can include the earphones according to FIG. **3** or **4** without requiring external wires to mechanically or electrically connect the pair of earphones within the item of apparel.

Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claims should be construed broadly, to include other variants and embodiments of the invention, which may be made by those skilled in the art without departing from the scope and range of equivalents of the invention.

What is claimed is:

1. An audio device, comprising:

a first Bluetooth physical interface configured to operate as a Bluetooth receiver capable of wirelessly receiving signals in at least two audio channels in a first Bluetooth piconet;

a second Bluetooth physical interface configured to operate as a Bluetooth transmitter capable of wirelessly retransmitting at least a first one of the two audio channels in a second Bluetooth piconet;

a speaker configured to play at least a second one of the two audio channels; and

a housing that contains the Bluetooth receiver, the Bluetooth transmitter, and the speaker, the housing shaped to fit in or on an ear of a user,

wherein the audio device is configured to operate with two separate Bluetooth addresses simultaneously, a first Bluetooth address for the first Bluetooth physical interface, and a second address for the second Bluetooth physical interface, and is capable of communicating with the at least two audio channels in the two separate Bluetooth piconets simultaneously using a respectively different Bluetooth address in each of the piconets, wherein the audio device is configured to operate as a master in the first Bluetooth piconet, while simultaneously operating as a master in the second Bluetooth piconet.

2. The audio device of claim **1**, wherein the Bluetooth transmitter is capable of transmitting both of the two audio channels to a recipient device.

3. The audio device of claim **1**, wherein: the audio device is capable of operating as a master in the first one of the Bluetooth piconets, while simultaneously operating as a slave in the second one of the Bluetooth piconets.

4. The audio device of claim **1**, wherein: the audio device is capable of operating as a slave in the first one of the Bluetooth

IPR2026-00381
Tesla EX1016 Page 11

piconets, while simultaneously operating as a slave in the second one of the Bluetooth piconets.

5. The audio device of claim **1**, wherein the audio device has a mechanism for delaying the playing of the second one of the two audio channels by a delay period.

6. The audio device of claim **5**, wherein the delay period is a propagation time for the retransmitted signals from the audio device in the at least two audio channels to propagate from the Bluetooth transmitter of the audio device to a recipient of the retransmitted channel.

7. The audio device of claim **5**, wherein the delay period is a propagation time for the retransmitted signals from the audio device in the at least one audio channel to propagate from the Bluetooth transmitter of the audio device to a recipient of the retransmitted channel.

8. An audio system, comprising:

first and second audio devices, the second audio device being mechanically unconnected to and positionable independently from the first audio device;

the first audio device having a first Bluetooth physical interface configured to operate as a Bluetooth receiver capable of receiving signals in at least two audio channels, the second audio device having a Bluetooth receiver capable of receiving signals in at least a first one of the two audio channels;

the first audio device having a second Bluetooth physical interface configured to operate as a Bluetooth transmitter capable of retransmitting at least the first one of the two audio channels to the second audio device, each audio device having a speaker, the speaker of the first audio device capable of playing the second one of the two audio channels, the speaker of the second audio device capable of playing the first one of the two audio channels,

wherein the first audio device is capable of operating with two separate Bluetooth addresses simultaneously, and is capable of communicating with the at least two audio channels in two separate Bluetooth piconets simultaneously using a respectively different Bluetooth address in each piconet, wherein the first audio device is configured to operate simultaneously as a master in the two separate Bluetooth piconets.

9. The audio system of claim **8**, wherein:

the Bluetooth transmitter of the first audio device is capable of transmitting both of the two audio channels to the Bluetooth receiver of the second audio device; and

the Bluetooth receiver of the second audio device is capable of receiving both of the two audio channels from the Bluetooth transmitter of the first audio device.

10. The audio system of claim **9**, wherein:

the second audio device has a Bluetooth transmitter capable of transmitting both of the two audio channels; and

the system further comprising a third audio device mechanically unconnected to and positionable independently from the first and second audio devices, the third audio device comprising:

a Bluetooth receiver capable of receiving signals in the two audio channels from the second audio device;

a Bluetooth transmitter capable of retransmitting at least the first two audio channels; and

a speaker for playing the second audio channel.

11. The audio system of claim **8**, wherein the first audio device includes two Bluetooth physical interfaces with respectively different Bluetooth addresses.

12. The audio system of claim **8**, wherein the first audio device has a mechanism for delaying the playing of the second one of the two audio channels by a delay period corresponding to a propagation time for signals of the first audio channel from the Bluetooth transmitter of the first audio device to the Bluetooth receiver of the second audio device.

13. A method of operating audio equipment, comprising:

receiving signals representing two audio channels wirelessly with a first Bluetooth audio device;

playing a first one of the two audio channels with the first Bluetooth audio device;

transmitting signals representing the second one of the two audio channels wirelessly to a second Bluetooth device, the second Bluetooth device mechanically unconnected to the first Bluetooth device;

playing the second audio channel with the second Bluetooth device simultaneously while playing the first audio channel with the first Bluetooth device;

transmitting signals representing the two audio channels wirelessly to the second Bluetooth device;

transmitting signals representing the two audio channels wirelessly from the second Bluetooth device to a third Bluetooth device coupled to an ear of a second user, the third Bluetooth device being mechanically unconnected to the first and second Bluetooth devices;

playing the first audio channel with the third Bluetooth device

operating the first Bluetooth device in a first Bluetooth piconet;

operating the third Bluetooth device in a second Bluetooth piconet; and

simultaneously operating the second Bluetooth device and communicating with the two audio channels in both (i) the first Bluetooth piconet using a first address and a first Bluetooth physical interface and (ii) the second Bluetooth piconet using a second address and a second Bluetooth physical interface, wherein the second Bluetooth device is configured to operate as a master in the first Bluetooth piconet, while simultaneously operating as a master in the second Bluetooth piconet.

14. The method of claim **13**, further comprising positioning the first Bluetooth audio device in, on or proximate to a first ear of a first user; and positioning the second Bluetooth device in, on or proximate to a second ear of the first user.

15. The method of claim **13**, further comprising: transmitting signals representing the second one of the two audio channels wirelessly from the third Bluetooth device to a fourth Bluetooth device coupled to a second ear of the second user, the fourth Bluetooth device mechanically unconnected to the first, second and third Bluetooth devices; and playing the second audio channel with the fourth Bluetooth device.

16. The method of claim **13**, wherein: the second Bluetooth device operates as a slave in the first Bluetooth piconet; and the second Bluetooth device operates as a master in the second Bluetooth piconet.

17. The method of claim **13**, wherein: the second Bluetooth device operates as a master in the first Bluetooth piconet; and the second Bluetooth device operates as a master in the second Bluetooth piconet.

18. The method of claim **13**, wherein: the second Bluetooth device operates as a slave in the first Bluetooth piconet; and the second Bluetooth device operates as a slave in the second Bluetooth piconet.

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