Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2903680 A1 2017/03/11

(21) 2 903 680

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2015/09/11

(41) Mise à la disp. pub./Open to Public Insp.: 2017/03/11

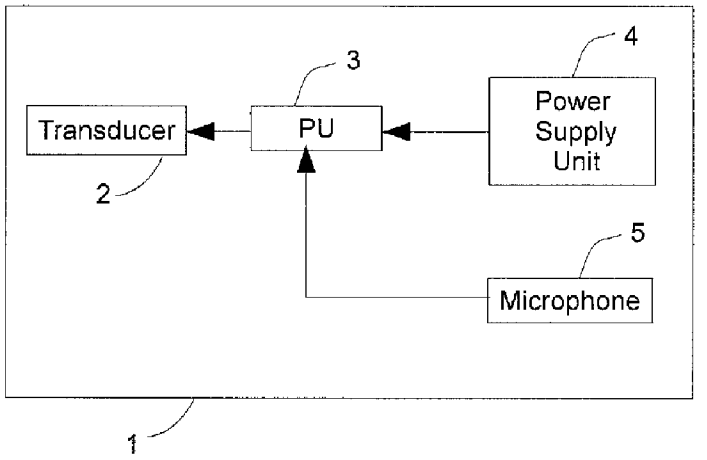
(51) Cl.Int./Int.Cl. *H02J 7/00* (2006.01), *H01M 10/44* (2006.01), *H02J 50/12* (2016.01), *H04R 25/00* (2006.01)

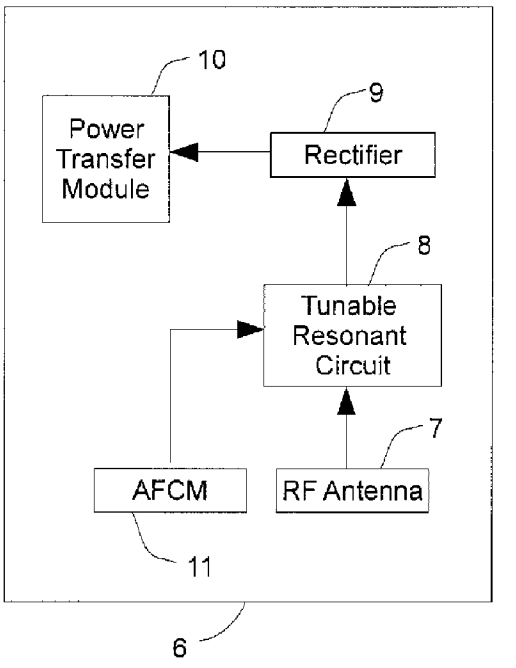
(71) Demandeur/Applicant:
PONOMAREV, VLADIMIR, CA

(72) Inventeur/Inventor:
PONOMAREV, VLADIMIR, CA

(74) Agent: NA

(54) Titre : DISPOSITIF D~AIDE AUDITIVE
(54) Title: HEARING ASSISTANCE SYSTEM





(57) Abrégé/Abstract:
The hearing assistance system is related to hearing aids having an earpiece (hearing assistance device) worn in or at the ear and a storage container. The earpiece comprises a microphone, a processor, an antenna unit, and a power supply unit with a

(21) 2 903 680

(13) A1

(57) Abrégé(suite)/Abstract(continued):
rechargeable battery that is being recharged when placed in the storage container by electromagnetic energy from ambient sources of electromagnetic waves of radio frequency. The sources used are existing radio and TV stations by using an automatically tunable resonance circuit located in the storage container.

Abstract

The hearing assistance system is related to hearing aids having an earpiece (hearing assistance device) worn in or at the ear and a storage container. The earpiece comprises a microphone, a processor, an antenna unit, and a power supply unit with a rechargeable battery that is being recharged when placed in the storage container by electromagnetic energy from ambient sources of electromagnetic waves of radio frequency. The sources used are existing radio and TV stations by using an automatically tunable resonance circuit located in the storage container.

Hearing Assistance System

Field of the Invention

The present invention is related to hearing aids, and in particular to hearing aid systems and devices having an earpiece worn in or at the ear.

Background of the Invention and Prior Art

Hearing aids are wearable hearing devices used to assist persons with impaired hearing. To meet the numerous individual requirements different designs of hearing aid have been developed, such as behind-the-ear (BTE), in-the-ear (ITE), in-the-canal (ITC), completely-in-the-canal (CIC), and receiver-in-canal (RIC) hearing aids. The typical hearing aids mentioned are worn on the outer ear or in the auditory canal. There are also bone conduction and implantable hearing aids. Hearing aids main components are a microphone, an amplifier or digital sound processor (usually combined with an amplifier), and a speaker or electroacoustic converter (transducer). A power source is usually rechargeable or non-rechargeable batteries of very small size that makes it difficult to replace and/or re-charge in a charging device having metal contacts or coils for inductive charging.

The modular charger for hearing aid of U.S. Patent Number 8,126,177, issued on February 28, 2012, to Lars Tuborg Jensen., describes a charger with a group of contacts. It does not improve convenience of charging the hearing aid.

The rechargeable hearing aid of U.S. Patent number 7,062,057, issued on February 24, 2005, to Chih Hsien Wu, describes a rechargeable hearing aid comprises a battery charger and a hearing aid body. The battery charger presents an easily carried case, which is provided with a receiving groove and a battery chamber, which contains a dry battery for power supply. It uses dry batteries requiring periodic replacement or recharging using household power and AC/DC transformer thus causing inconvenience for the user.

The closest prior art is a storage system for a hearing aid of Canadian Patent Number 2,770,800 , issued on February 17, 2011, to Soren Mollskov Larsen, describes a hearing aid device with wireless charging capability. It comprises a hearing aid with a rechargeable battery, storage means, information system, and power supply. However, it requires periodic recharging from an external electrical source thus causing inconvenience for the user.

Summary of the Invention

The hearing assistance system of the present invention addresses the issue of re-charging the earpiece by recharging it when it is not used and stored in the storage container using energy received from electromagnetic emission predominantly from existing radiocommunication stations operating in the area of location of said hearing assistance system.

A hearing assistance system consists of a hearing assistance device and a storage container. A hearing assistance device (an earpiece module being worn at the head of a user, in or at the ear) comprises a sound signal processing unit, an electroacoustic transducer, configured to convert an electrical signal to sound and electrically coupled with said sound signal processing unit, a microphone, electrically coupled with said sound signal processing unit, a power supply unit electrically coupled with said sound signal processing unit. A power supply unit comprises a first rechargeable battery, a means to receive energy from the storage container (electrical terminals or a coil antenna) that is electrically coupled with the rechargeable battery

A storage container comprises a chamber arranged to receive and hold hearing assisstance device, a power transfer module, a rectifier, arranged to supply electrical energy to said power transfer module, a tunable resonant circuit electrically coupled with said rectifier, an antenna electrically coupled with said tunable resonant circuit. The antenna is configured to receive an electromagnetic emission from an ambient source of electromagnetic waves of radio frequency. A power transfer module comprises a means to transfer energy to the power supply unit of the hearing assistance device (electrical terminals or a coil antenna).

The antenna directs the radio frequency electromagnetic signal received by the antenna from existing radiocommunication stations at the frequency determined by the resonance frequency of the resonant circuit to the rectifier. The direct current (DC) from the rectifier is used either to charge the hearing assistance device when in it is positioned in the storage container or re-charge the second rechargeable battery in the power storage module. The storage module can also comprise a charging control circuitry that is well known in the art.

Charging and/or recharging process continues during any time when the user of the hearing assistance system is located in the zone covered by radio and TV transmission. As a backup source of power, when the user temporarily is far from zones of coverage of the existing radiocommunication stations, a non-rechargeable batteries can be used or an external electrical energy source (household electrical supply via a AC/DC transformer). Several tunable resonant circuits can be used to increase availalbe recharging current. It is achieved by periodic tuning of the resonant circuits by the automatic frequency control module (well known in the art) to the radiocomunication or TV stations having the strongest signal to maximize the power output available from the tunable resonant circuits.

Another embodiment of the hearing assistance system also comprises a storage container having an electromagnetic wave generator, a power transmitting antenna, electrically coupled with the electromagnetic wave generator. The power supply unit of the hearing assistance device comprises an energy receiveing antenna, a power supply unit rectifier, electrically coupled with the energy receiving antenna and with the first rechargeable battery. The energy receiveing antenna is arranged to receive energy from the power transmitting antenna of the power transfer unit when the hearing assistance device is positioned in said chamber of the storage container.

Brief Description of the Drawings

FIG. 1 shows a block diagram of a hearing assistance system according to an embodiment, wherein a hearing assistance device (an earpiece module) has an electroacoustic transducer (a speaker), a sound signal processing unit, a microphone, and a power supply unit having a first rechargeable battery. A storage container consists of a power transfer module, a rectifier, a tunable resonant circuit, an antenna and an automatic frequency control module.

FIG. 2 shows a block diagram of a hearing assistance system according to an embodiment that differs by having a power supply unit of the hearing assistance device comprising an energy receiveing antenna, a power supply unit rectifier, electrically coupled with the energy receiving antenna and with the first rechargeable battery.

FIG. 3 shows a block diagram of a hearing assistance system according to an embodiment, that differs by the storage container having a power storage module, and a charging control module.

FIG. 4 shows a block diagram of a hearing assistance system according to an embodiment, that differs by the storage container having several (three) individually tunable resonant circuits and several (three) antennas.

On the drawings, the same numbers are assigned to similar components. The easier understanding of the invention is assured by using the component names or acronyms in addition to the component numbers.

Detailed Description of the Invention

Referring of FIG. 1 of the drawings, a hearing assistance system comprises a hearing assistance device 1 (an earpiece module) being worn at the head of a user (in or at the ear) and a storage container 6. The hearing assistance device 1 has an electroacoustic transducer 2 (a speaker), a sound signal processing unit 3, electrically connected to a microphone 5, to the electroacoustic transducer 2, and to a power supply unit 4 having a first rechargeable battery (not illustrated). The power supply unit 4 comprises a means to receive energy, specifically electrical terminals.

A storage container 6 consists of a power transfer module 10, a first rectifier 9, a tunable resonant circuit 8, a radio frequncy antenna 7 (RF antenna) and an automatic frequency

control module 11 (AFCM). The storage container 6 has a chamber (not illustrated) arranged to receive and hold at least one hearing assisstance device 1. The first rectifier 9 is arranged to supply electrical energy to said power transfer module 10 received from the tunable resonant circuit 8 that is electrically coupled with the first rectifier 9. The antenna 7 is electrically coupled with the tunable resonant circuit 8 and configured to receive an electromagnetic emission from an ambient source of electromagnetic waves of radio frequency, for example, from local radio communication stations (radio stations), television (TV) stations, and similar sources. The automatic frequency control module 11 is electrically coupled with the tunable resonant circuit 8 and arranged to keep the tunable resonant circuit 8 automatically tuned to the frequency of the electromagnetic emission providing maximum power output of the antenna. Automatic tuning and automatic frequency control modules (devices) are well known for specialists in electronics and radiocommunication. Automatic tuning can be performed by periodic (one time in 10 minutes, for example) scanning in the predeternined range of frequencies and subsequently tuning the tunable resonant circuit 8 to the frequency of that external radio frequency (RF) signal from radiocommunication station, TV station, or any other source of the RF signal that provides maximum power output to the first rectifier 9.

A power transfer module 10 of the storage container 6 comprises a means to transfer energy to the power supply unit 4 of the hearing assistance device 1, specifically electrical terminals. The means to transfer energy of the power transfer module 10 comprises a first group of electrical terminals, the means to receive energy of the power supply unit 4 comprises a second group of electrical terminals, arranged to contact the electrical terminals of the first group of electrical terminals of the power transfer module 10 when the hearing assistance device 1 is positioned in the chamber of the storage container 6.

The antenna 7 directs the radio frequency electromagnetic signal received by the antenna 7 from existing radiocommunication stations at the frequency determined by the resonance frequency of the tunable resonant circuit 8 to the first rectifier 9. The direct current (DC) from the rectifier 9 is used to charge the hearing assistance device 1 when in it is positioned in the storage container. Charging (recharging) process continues during any time when the user of the hearing assistance system is located in the zone covered by radio and TV transmission and the hearing assistance device 1 is positioned in the storage container 6.

Referring of FIG. 2 of the drawings, a hearing assistance system comprises a hearing assistance device 1 (an earpiece module) being worn at the head of a user (in or at the ear) and a storage container 6. The hearing assistance device 1 has an electroacoustic transducer 2 (a speaker), a sound signal processing unit 3, electrically connected to a microphone 5, to the electroacoustic transducer 2, and to a power supply unit 4 having a first rechargeable battery (not illustrated). The power supply unit 4 comprises a means to receive energy, specifically an energy receiving antenna 14 (ERA), preferably of a coil type, and a second rectifier 13, connected to a first rechargeable battery 12.

A storage container 6 consists of a power transfer module 10, a first rectifier 9, a tunable resonant circuit 8, a radio frequncy antenna 7 (RF antenna) and an automatic frequency control module 11 (AFCM). The storage container 6 has a chamber (not illustrated) arranged

to receive and hold at least one hearing assisstance device 1. The first rectifier 9 is arranged to supply electrical energy to said power transfer module 10 received from the tunable resonant circuit 8 that is electrically coupled with the first rectifier 9. The antenna 7 is electrically coupled with the tunable resonant circuit 8 and configured to receive an electromagnetic emission from an ambient source of electromagnetic waves of radio frequency, for example, from local radio communication stations, TV stations, and similar sources. The automatic frequency control module 11 is electrically coupled with the tunable resonant circuit 8 and arranged to keep said tunable resonant circuit 8 automatically tuned to the frequency of the electromagnetic emission providing maximum power output of the antenna 7.

The power transfer module 10 of the storage container 6 comprises a means to transfer energy to the power supply unit 4 of the hearing assistance device 1. The means to transfer energy of the power transfer module 10 comprises an electromagnetic wave generator (an alternating current (AC) preferably in the range from tens kilohertz to tens of megahertz), a power transmitting antenna (preferably of a coil type), electrically coupled with the electromagnetic wave generator (not illustrated), the means to receive energy of the power supply unit 4 comprises an energy receiveing antenna 14 (ERA), a second rectifier, electrically coupled with said energy receiving antenna 14 and with said first rechargeable battery, wherein the energy receiveing antenna 14 is arranged to receive energy from the power transmitting antenna of the power transfer module 10 when the hearing assistance device 1 is positioned in the chamber of the storage container 6.

The antenna 7 directs the radio frequency electromagnetic signal received by the antenna 7 from existing radiocommunication stations at the frequency determined by the resonance frequency of the tunable resonant circuit 8 to the first rectifier 9. The direct current (DC) from the rectifier 9 is used to charge the hearing assistance device 1 when in it is positioned in the storage container. Charging (recharging) process continues during any time when the user of the hearing assistance system is located in the zone covered by radio and TV transmission and the hearing assistance device 1 is positioned in the the storage container 6.

Referring of FIG. 3 of the drawings, a hearing assistance system comprises a hearing assistance device 1 (an earpiece module) and a storage container 6. It differs from the hearing assistance system shown on the Fig. 2 by a different arrangement of the storage container 6 that additionally comprises a power storage module 15, having the first rectifier 9 of said storage container 6 being electrically coupled with said power storage module 15 and arranged to supply electrical energy to the power transfer module 10 through the power storage module 15. The power storage module 15 comprises a second rechargeable battery arranged to receive charging from the first rectifier 9 (not shown). The power storage module 15 can have an additional non-rechargeable battery (not shown) arranged to supply electrical energy to said power transfer module. The storage container 6 additionally comprises a charging control module 16, electrically coupled with the power storage module 15 and with the power transfer module 10 and arranged to control the charging current of the power transfer module 15. The charging control module 16 comprises a charging control circuitry is well known in the art.

As a backup source of power, when the user of the hearing assistance system temporarily is far from zones of coverage of the existing radiocommunication and TV stations, a non-rechargeable batteries can be used or an external electrical energy source (household electrical supply via a AC/DC transformer). In the latter case, the power storage module 15 additionally comprises a third group of electrical terminals configured to receive electrical energy from an external electrical energy source and charge the second rechargable battery of the power storage module15.

Charging (recharging) process of the first rechargeable battery of the power supply unit 4 of the hearing assistance device continues during any time when the hearing assistance device 1 is positioned in the the storage container 6.

Charging (recharging) process of the second rechargeable battery of the power storage module 15 of the storage container 6 continues during any time when the user of the hearing assistance system is located in the zone covered by radio and TV transmission.

Referring of FIG. 4 of the drawings, a hearing assistance system comprises a hearing assistance device 1 (an earpiece module) and a storage container 6. It differs from the hearing assistance system shown on the Fig. 3 by a different arrangement of the storage container 6 that additionally comprises two additional rectifiers 9, two additional tunable resonant circuits 8 electrically coupled with the automatic frequency control module 11, with the antenna 7 and with additional rectifiers.

Several tunable resonant circuits can be used to increase availalbe recharging current. It is achieved by periodic tuning of the resonant circuits by the automatic frequency control module (well known in the art) to the radiocomunication or TV stations having the strongest signal to maximize the power output available from the tunable resonant circuits. The tunable resonant circuits can also be connected to one common antenna provided the tunable resonant circuits and the antenna have the same or overlapping frequency ranges.

Charging (recharging) process of the first rechargeable battery of the power supply unit 4 of the hearing assistance device continues during any time when the hearing assistance device 1 is positioned in the the storage container 6.

Charging (recharging) process of the second rechargeable battery of the power storage module 15 of the storage container 6 continues during any time when the user of the hearing assistance system is located in the zone covered by radio and TV transmission. If the energy accumulated in the second rechargeable battery of the power storage module 15 is not sufficient for recharging the first rechargeable battery of the power suppply unit 4 of the hearing assistance device 1, it will be supplemented by a non-rechargeable battery or an external source of energy.

The hearing assistance system can be provided with a remote control unit that can be separate or combined with the storage container in the same housing. The remote control units are well known in the industry and being practically a standard component of the hearing aids used for various adjustments of the hearing assistance system output such as volume

and mode of operation that is outside of the scope of this invention.

The hearing assistance device 1 (earpiece) can be positioned in an ear canal of the user or behind the ear of the user. For binaural hearing, one storage container can be used for both earpieces (hearing assistance devices). Frequency of the electromagnetic wave generator for the inductive short-range energy transfer can be selected in a range between 0.5 MHz and 30 Mhz.

Assuming daily usage of 10 to 12 hours, the 312 size NiMH rechargeable batteries with capacity of 23 mAh for the earpiece module will be sufficient for 2 days for the most hearing assistance devices having the average current consumption of 1 mA. The charging current produced by the rectifier 9 (group of rectifiers) should be equal or exceed 0.5 mA that is achievable in the most populated areas.

It should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the claims within their meaning and range of equivalency.

What is claimed is:

1. A hearing assistance system, comprising:

a hearing assistance device, comprising a sound signal processing unit, an electroacoustic transducer, configured to convert an electrical signal to sound and electrically coupled with said sound signal processing unit, a microphone, electrically coupled with said sound signal processing unit, a power supply unit electrically coupled with said sound signal processing unit,

a storage container, comprising a chamber arranged to receive and hold said hearing assisstance device, a power transfer module, a first rectifier, arranged to supply electrical energy to said power transfer module, a tunable resonant circuit electrically coupled with said first rectifier, an antenna electrically coupled with said tunable resonant circuit,

wherein said power supply unit comprises a first rechargeable battery, a means to receive energy from said power transfer module and electrically coupled with said first rechargeable battery, said power transfer module comprises a means to transfer energy, said means to transfer energy configured to deliver energy to said means to receive energy of said power supply unit, said antenna is configured to receive an electromagnetic emission from an ambient source of electromagnetic waves.

2. A hearing assistance system according to claim 1, wherein said antenna is configured to receive an electromagnetic emission from existing radiocommunication stations operating in the area of location of said hearing assistance system.

3. A hearing assistance system according to claim 1, wherein said antenna comprises an radio frequency antenna.

4. A hearing assistance system according to claim 1, wherein said tunable resonant circuit configured to have its resonanse frequncy tunable in the range of operating frequencies of existing radiocommunication stations operating in the area of location of said hearing assistance system.

5. A hearing assistance system according to claim 1, wherein said storage container additionally comprises an automatic frequency control module being electrically coupled with said resonant circuit and arranged to keep said resonant circuit automatically tuned to the frequency of said electromagnetic emission providing maximum power output of said antenna.

6. A hearing assistance system according to claim 1, wherein said means to transfer energy of said power transfer module comprises a first group of electrical terminals, said means to receive energy of said power supply unit comprises a second group of electrical terminals, arranged to contact said electrical terminals of said first group of electrical terminals of said power transfer module when said hearing assistance device is positioned in said chamber of said storage container.

7. A hearing assistance system according to claim 1, wherein said means to transfer energy of said power transfer module comprises an electromagnetic wave generator, a power transmitting antenna, electrically coupled with said electromagnetic wave generator, said

means to receive energy of said power supply unit comprises an energy receiveing antenna, a second rectifier, electrically coupled with said energy receiving antenna and with said first rechargeable battery, wherein said energy receiveing antenna arranged to receive energy from said power transmitting antenna of said power transfer module when said hearing assistance device is positioned in said chamber of said storage container.

8. A hearing assistance system according to claim 1, wherein said storage container comprises a power storage module, said first rectifier of said storage container is electrically coupled with said power storage module and arranged to supply electrical energy to said power transfer module through said power storage module.

9. A hearing assistance system according to claim 8, wherein said power storage module comprises a second rechargeable battery arranged to receive charging from said first rectifier.

10. A hearing assistance system according to claim 8, wherein said power storage module additionally comprising a non-rechargeable battery arranged to supply electrical energy to said power transfer module.

11. A hearing assistance system according to claim 8, wherein said storage container additionally comprising a charging control module, electrically coupled with said power storage module and with power transfer module and arranged to control the charging current of said power transfer module.

12. A hearing assistance system according to claim 5, wherein said storage container additionally comprising at least one additional rectifier, at least one additional tunable resonant circuit electrically coupled with said automatic frequency control module, with said antenna and with said additional rectifier.

13. A hearing assistance system according to claim 5, wherein said storage container additionally comprising at least one additional antenna, at least one additional rectifier, and at least one additional tunable resonant circuit electrically coupled with said additional antenna, with said automatic frequency control module and with said additional rectifier.

14. A hearing assistance system according to claim 8, wherein said power storage module additionally comprising a third group of electrical terminals configured to receive electrical energy from an external electrical energy source and charge said second rechargable battery of said power storage module.

What is claimed is:

1. A hearing assistance system, comprising:

a hearing assistance device, comprising a sound signal processing unit, an electroacoustic transducer, configured to convert an electrical signal to sound and electrically coupled with said sound signal processing unit, a microphone, electrically coupled with said sound signal processing unit, a power supply unit electrically coupled with said sound signal processing unit,

a storage container, comprising a chamber arranged to receive and hold said hearing assisstance device, a power transfer module, a first rectifier, arranged to supply electrical energy to said power transfer module, a tunable resonant circuit electrically coupled with said first rectifier, an antenna electrically coupled with said tunable resonant circuit,

wherein said power supply unit comprises a first rechargeable battery, a means to receive energy from said power transfer module and electrically coupled with said first rechargeable battery, said power transfer module comprises a means to transfer energy, said means to transfer energy configured to deliver energy to said means to receive energy of said power supply unit, said antenna is configured to receive an electromagnetic emission from an ambient source of electromagnetic waves.

2. A hearing assistance system according to claim 1, wherein said antenna is configured to receive an electromagnetic emission from existing radiocommunication stations operating in the area of location of said hearing assistance system.

3. A hearing assistance system according to claim 1, wherein said antenna comprises an radio frequency antenna.

4. A hearing assistance system according to claim 1, wherein said tunable resonant circuit configured to have its resonanse frequncy tunable in the range of operating frequencies of existing radiocommunication stations operating in the area of location of said hearing assistance system.

5. A hearing assistance system according to claim 1, wherein said storage container additionally comprises an automatic frequency control module being electrically coupled with said resonant circuit and arranged to keep said resonant circuit automatically tuned to the frequency of said electromagnetic emission providing maximum power output of said antenna.

6. A hearing assistance system according to claim 1, wherein said means to transfer energy of said power transfer module comprises a first group of electrical terminals, said means to receive energy of said power supply unit comprises a second group of electrical terminals, arranged to contact said electrical terminals of said first group of electrical terminals of said power transfer module when said hearing assistance device is positioned in said chamber of said storage container.

7. A hearing assistance system according to claim 1, wherein said means to transfer energy of said power transfer module comprises an electromagnetic wave generator, a power transmitting antenna, electrically coupled with said electromagnetic wave generator, said means to receive energy of said power supply unit comprises an energy receiveing antenna, a second rectifier, electrically coupled with said energy receiving antenna and with said first rechargeable battery, wherein said energy receiveing antenna arranged to receive energy

from said power transmitting antenna of said power transfer module when said hearing assistance device is positioned in said chamber of said storage container.

8. A hearing assistance system according to claim 1, wherein said storage container comprises a power storage module, said first rectifier of said storage container is electrically coupled with said power storage module and arranged to supply electrical energy to said power transfer module through said power storage module.

9. A hearing assistance system according to claim 8, wherein said power storage module comprises a second rechargeable battery arranged to receive charging from said first rectifier.

10. A hearing assistance system according to claim 8, wherein said power storage module additionally comprising a non-rechargeable battery arranged to supply electrical energy to said power transfer module.

11. A hearing assistance system according to claim 8, wherein said storage container additionally comprising a charging control module, electrically coupled with said power storage module and with power transfer module and arranged to control the charging current of said power transfer module.

12. A hearing assistance system according to claim 5, wherein said storage container additionally comprising at least one additional rectifier, at least one additional tunable resonant circuit electrically coupled with said automatic frequency control module, with said antenna and with said additional rectifier.

13. A hearing assistance system according to claim 5, wherein said storage container additionally comprising at least one additional antenna, at least one additional rectifier, and at least one additional tunable resonant circuit electrically coupled with said additional antenna, with said automatic frequency control module and with said additional rectifier.

14. A hearing assistance system according to claim 8, wherein said power storage module additionally comprising a third group of electrical terminals configured to receive electrical energy from an external electrical energy source and charge said second rechargable battery of said power storage module.

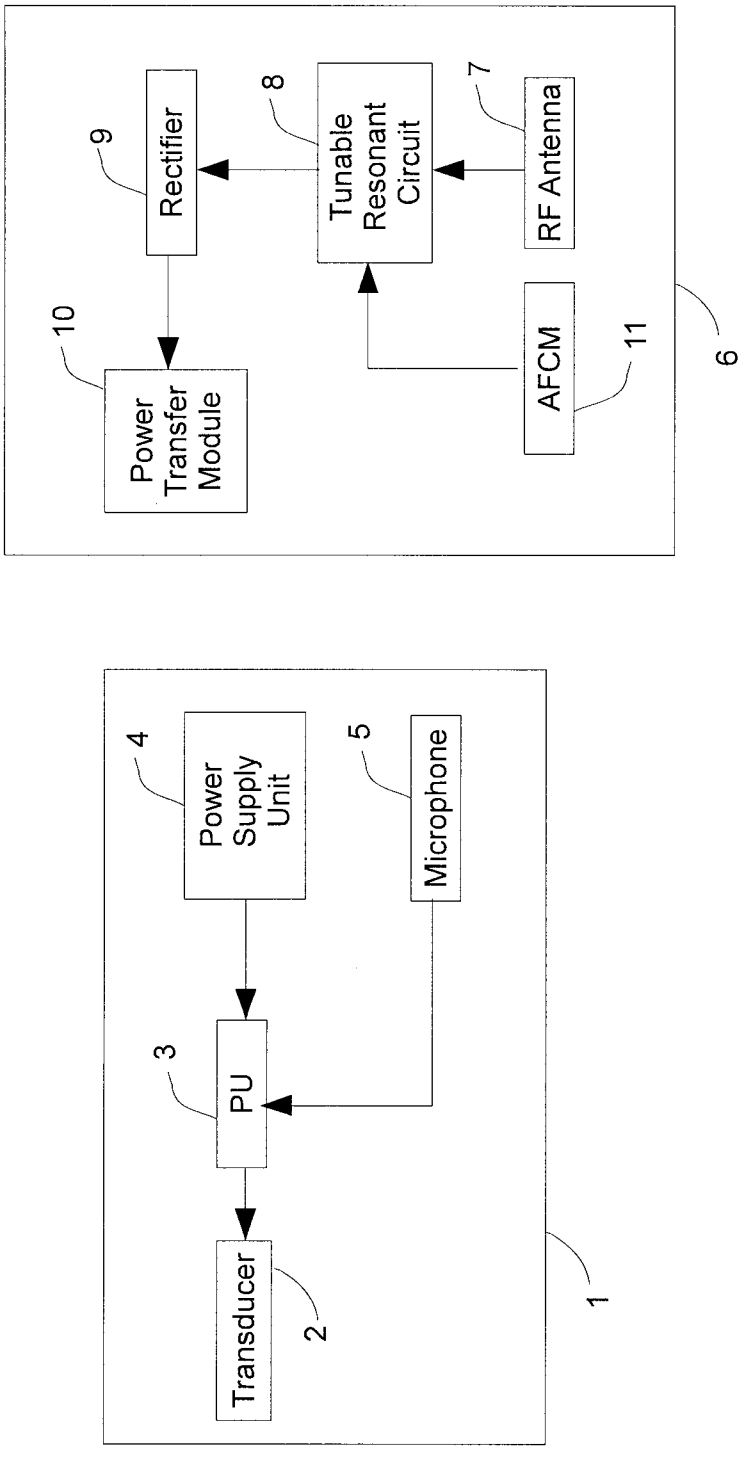

Power Transfer Module
10
Rectifier
9
Tunable Resonant Circuit
8
RF Antenna
7
AFCM
11
6
Power Supply Unit
4
Microphone
5
PU
3
Transducer
2
1

Fig. 1

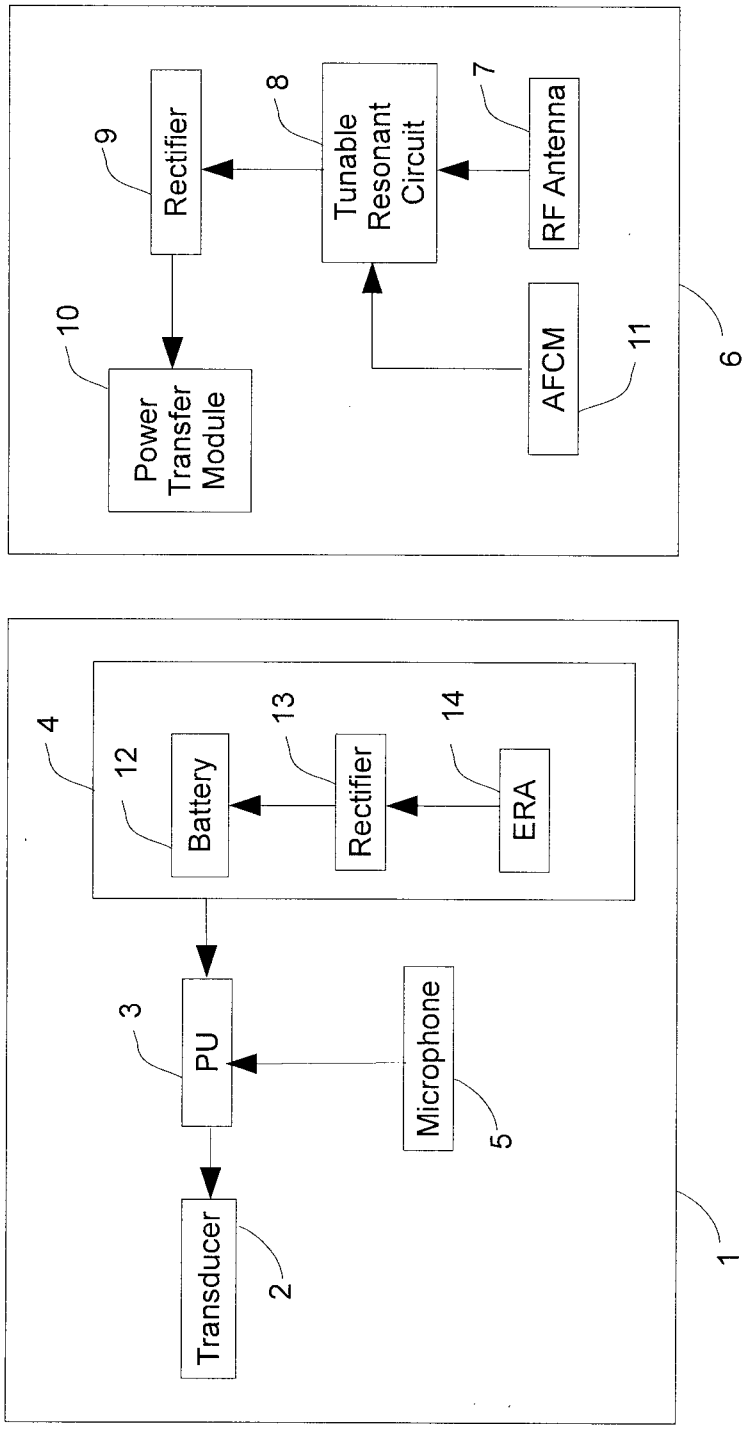
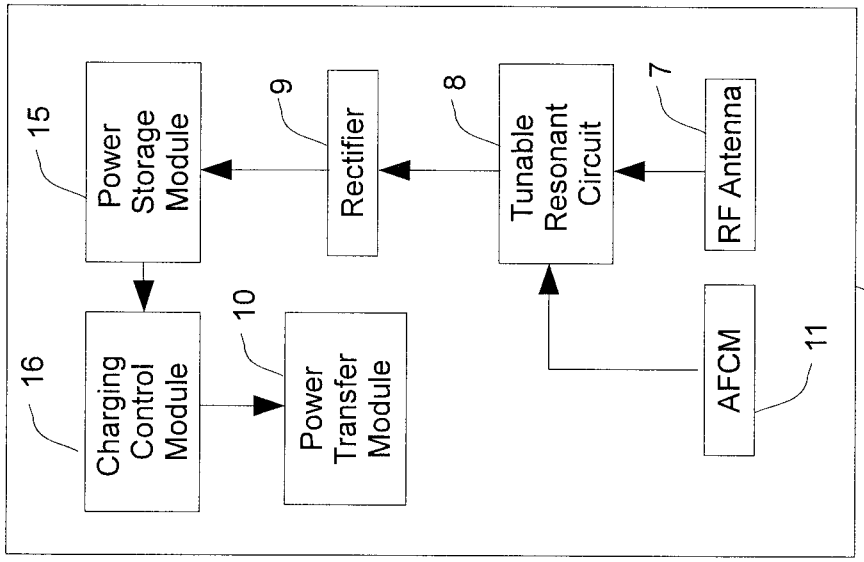

Transducer
2
PU
3
4
Battery
12
Rectifier
13
ERA
14
Microphone
5
1
Power Transfer Module
10
Rectifier
9
Tunable Resonant Circuit
8
RF Antenna
7
AFCM
11
6

Fig. 2


Power Storage Module
15
Rectifier
9
Tunable Resonant Circuit
8
RF Antenna
7
Charging Control Module
16
Power Transfer Module
10
AFCM
11
6

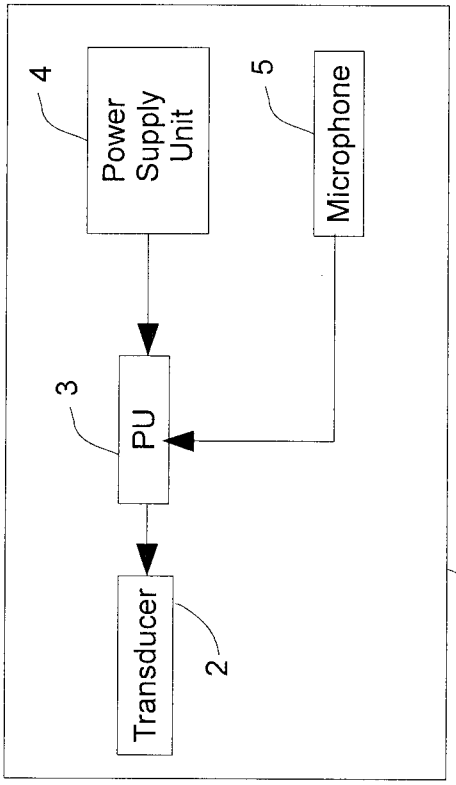

Power Supply Unit
4
Microphone
5
PU
3
Transducer
2
1

Fig. 3

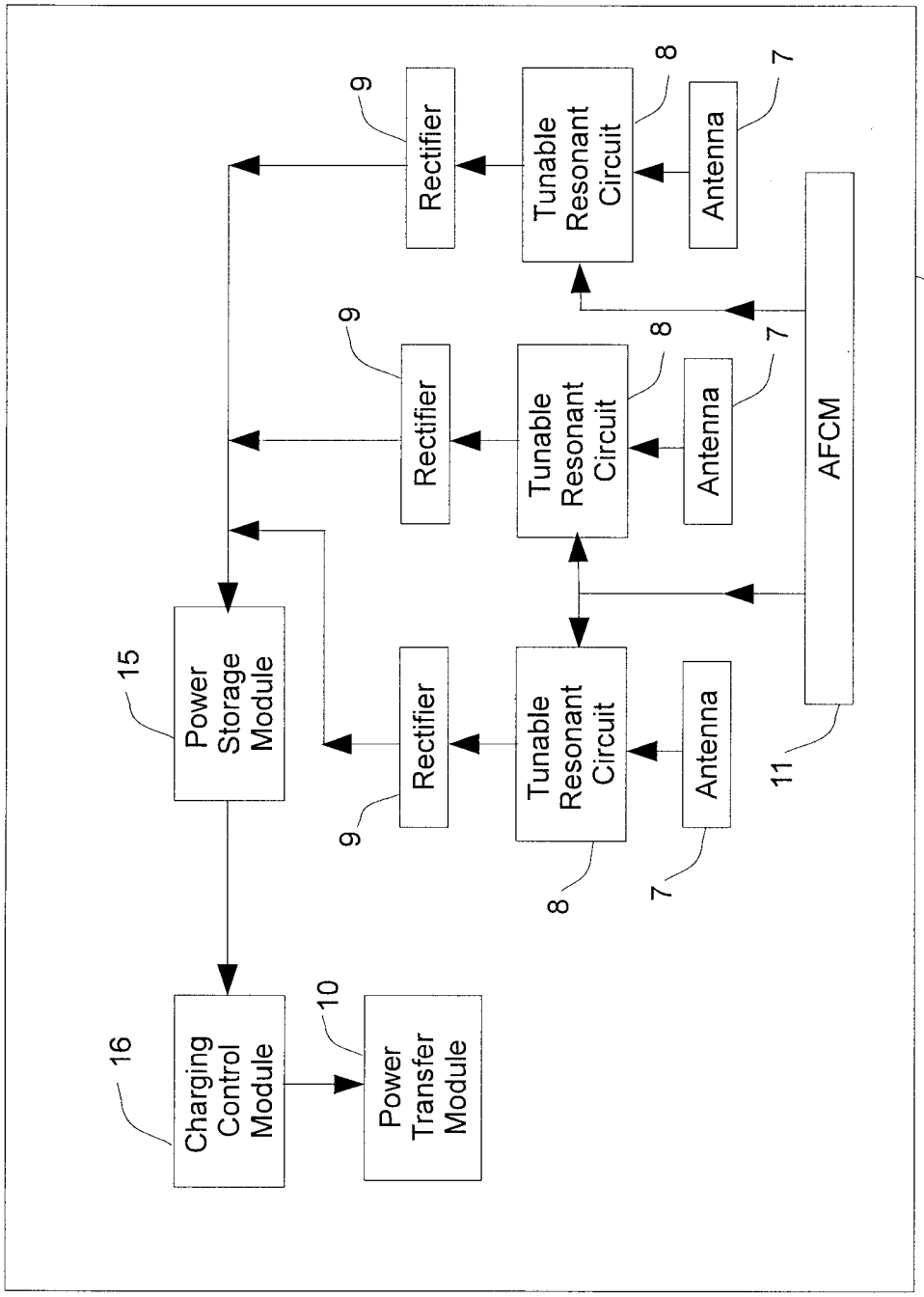
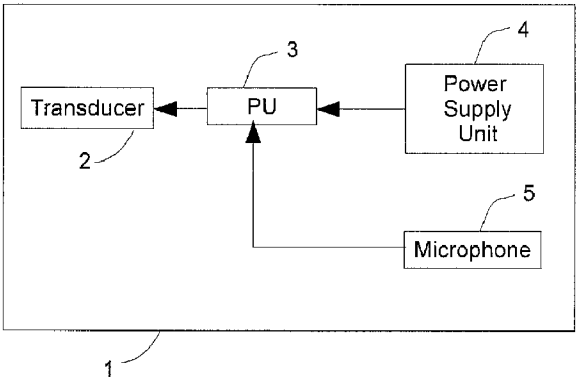
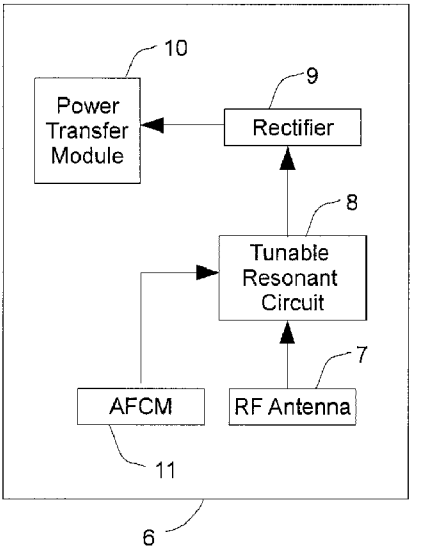

Rectifier
Tunable Resonant Circuit
Antenna
AFCM
Power Storage Module
Charging Control Module
Power Transfer Module
6
7
8
9
10
11
15
16

Fig. 4


Transducer
PU
Power Supply Unit
Microphone
1
2
3
4
5


Power Transfer Module
Rectifier
Tunable Resonant Circuit
AFCM
RF Antenna
6
7
8
9
10
11