



US 20030233051A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0233051 A1**

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(43) **Pub. Date: Dec. 18, 2003**

(54) **PORTABLE EQUIPMENT FOR MEASURING AND/OR MONITORING THE HEART RATE**

Publication Classification

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(51) **Int. Cl.⁷** **A61B 5/02**
(52) **U.S. Cl.** **600/528**

(57) **ABSTRACT**

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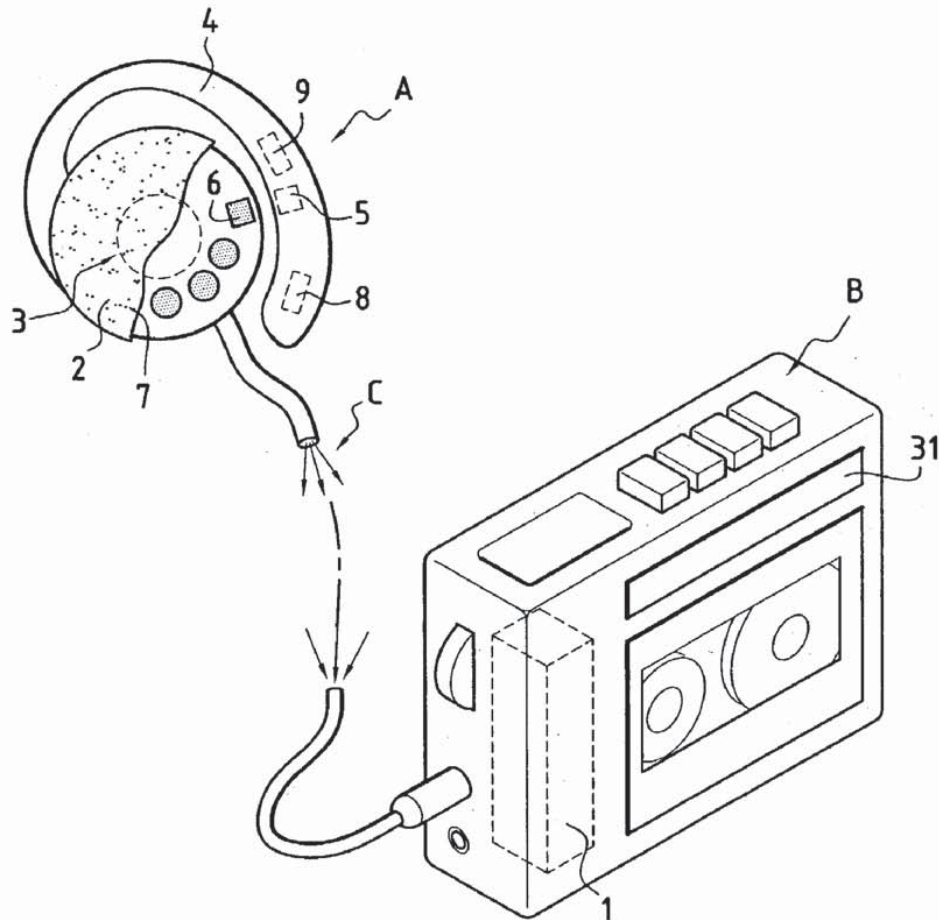
Portable equipment including in combination a heart rate measuring device and a sound reproduction unit including means for supplying a signal representative of the sound reproduction and for supplying sound information to a sound transducer, wherein said measuring device and said sound transducer are mounted at least in part in an assembly adapted to be fixed to an ear of a wearer of the equipment and, wherein said sound reproduction unit includes means for optionally substituting for and/or superimposing on said signal representative of said sound reproduction a signal generated from signals from said measuring device and representative of said heart rate. The equipment can take the form of a walkman, for example, or a hearing aid for the hard of hearing.

(21) Appl. No.: **10/463,530**

(22) Filed: **Jun. 18, 2003**

(30) **Foreign Application Priority Data**

Jun. 18, 2002 (FR)..... 02 07465



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APL1007

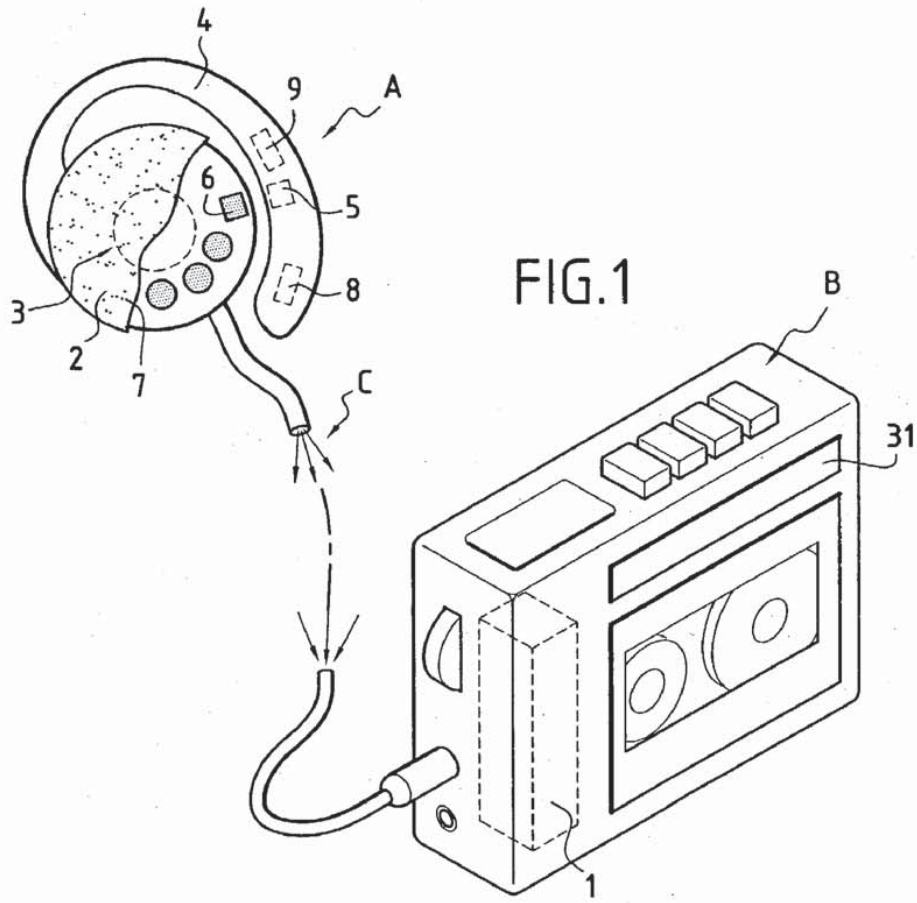


FIG. 1

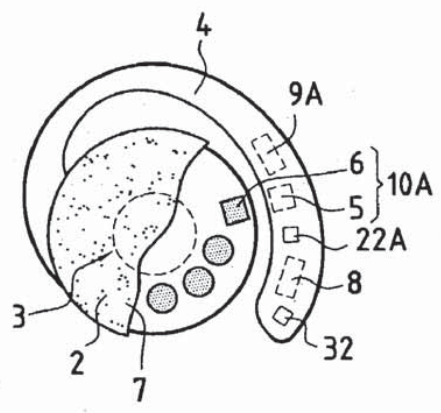


FIG. 3

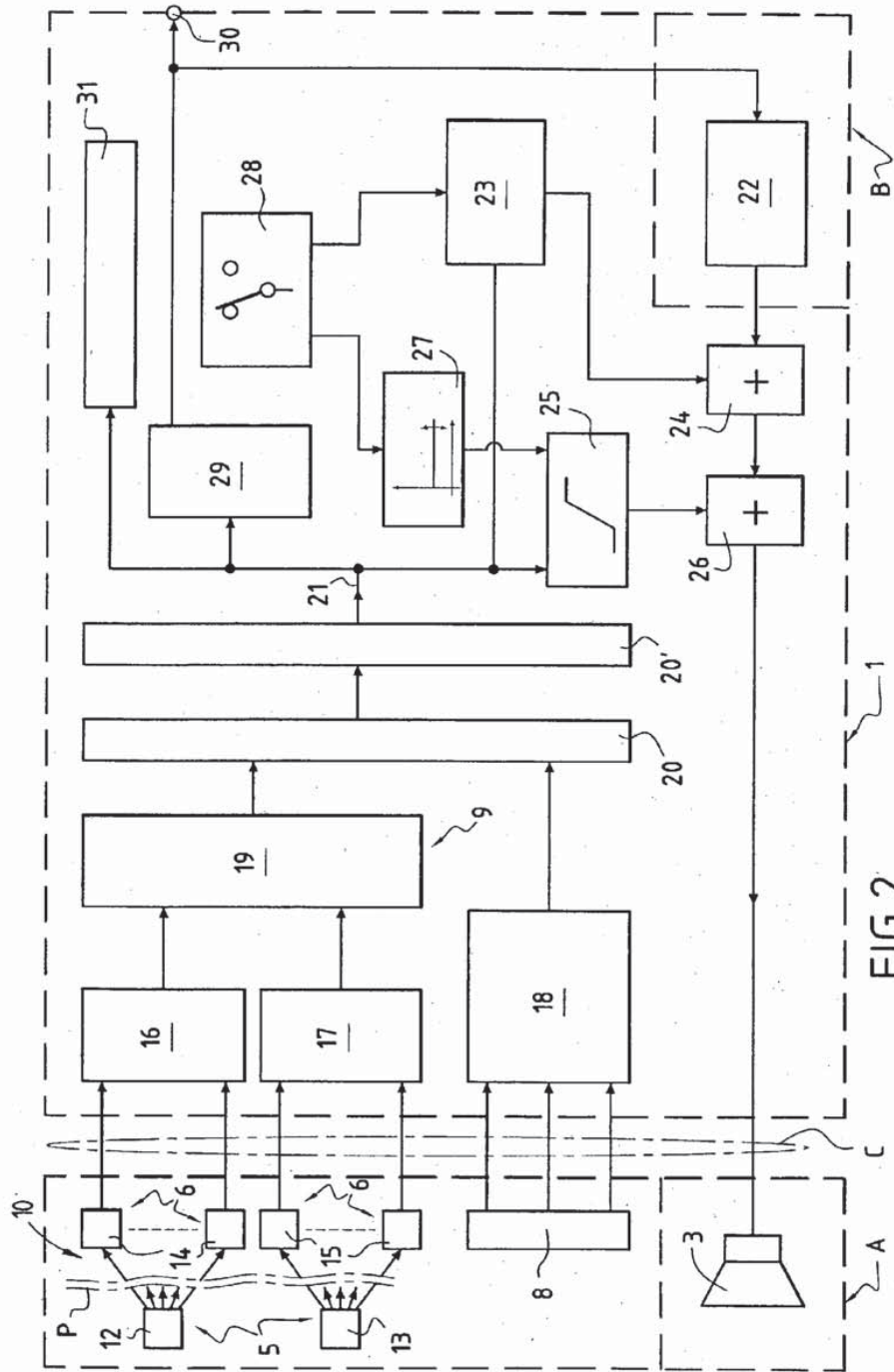


FIG. 2

PORTABLE EQUIPMENT FOR MEASURING AND/OR MONITORING THE HEART RATE

FIELD OF THE INVENTION

[0001] The present invention relates to portable equipment for optically measuring and/or monitoring the heart rate.

BACKGROUND OF THE INVENTION

[0002] Many variants of this type of equipment exist already. They include an optical probe designed to be placed on a region of the skin of a user. The probe includes an emitter for radiating light into the tissue of that region and a receiver for picking up energy coming from the tissue (for example as a result of reflection on the tissue or transmission through the tissue) whose optical characteristics vary in dependence upon the circulation of the blood. The signal supplied by the receiver is analyzed and artifacts caused in particular by the movements of the user, ambient light, etc. are removed in an electronic processing unit whose output signal can be made perceptible in any appropriate manner, for example by displaying it on a screen, by reproducing it audibly, etc. The output signal can be compared to a threshold and an alarm tripped if the heart rate crosses the threshold.

[0003] Equipment having the above features is described in EP 01203686.9, filed Sep. 28, 2001 and entitled "Wrist located pulse detection using infra-red signals, activity and nonlinear artefact cancellation". That document describes in particular a probe intended to be worn on the wrist, the useful signal being extracted by a device for detecting movements of the wearer.

[0004] In another prior art device, the probe is incorporated into a chest strap and the useful signal is transmitted by radio to a display device, such as a wristwatch.

[0005] An object of the invention is to provide equipment of the kind indicated above that provides reliable information concerning the heart rate of the wearer whilst being convenient to use and particularly suitable for use by persons exercising an activity, for example a sports activity.

SUMMARY OF THE INVENTION

[0006] The invention therefore provides a portable equipment including in combination a measuring device for measuring the heart rate and a sound reproduction unit including means for supplying a signal representative of the sound reproduction and for supplying sound information to a sound transducer, wherein said measuring device and said sound transducer are mounted at least in part in an assembly adapted to be fixed to an ear of a wearer of the equipment, wherein said sound reproduction unit includes substitution/superimposition means for optionally substituting for and/or superimposing on said signal representative of said sound reproduction a signal generated from signals from said measuring device and representative of said heart rate, wherein said assembly takes the form of an ear cushion including a casing accommodating said sound transducer and adapted to be placed in front of the external auditory meatus opening of a wearer and a horn attached to said casing and adapted to be placed behind the external ear of a wearer and said measuring device is accommodated at least in part in said casing and at least in part in said horn, and

wherein said assembly further includes an accelerometric device delivering motion signals representative of the motion of a wearer when the assembly is fixed to an ear of said wearer and said measuring device including signal processing means using said motion signals for removing at least partially artifacts due to motion in said signal representative of said heart rate.

[0007] Because of the above features, the heart rate measuring function can be associated with that of a sound reproduction device, like for example a walkman. Sound reproduction devices of this kind are very widely used, especially by persons exercising a sporting activity. The information concerning the heart rate can therefore be provided as a complement to the reproduced sound signal, which is generally entertaining and that the wearer of the equipment is used to listening to. Also, the complementary information is presented by means of a sound reproduction component (an ear cushion) that is of the usual kind and is placed over the ear of the wearer of the equipment in the usual way, the exterior shape of the probe placed over the ear being intentionally no different from that of a standard ear cushion. Furthermore, the heart rate measurement function is implemented very discreetly, which users of the equipment may see as an advantage. It will finally be noted that an ear cushion is held in place without problems despite the movements of the wearer, while the connection between the ear cushion and the body of the walkman is not modified either (at least externally), and requires only a connecting cable slightly modified compared to the usual cable. It can therefore be very robust.

[0008] In addition prior art portable devices which are in the form of an ear clip, besides the fact they pinch the ear lobe and therefore hinder its vascularization, are fixed on a flexible part of the ear (the ear lobe) and it is therefore difficult to remove in such devices the artifacts due to the motion of the body of the wearer. According to the present invention, the detecting unit being incorporated in an ear cushion, it is advantageously adapted to be worn in contact with a stiff part of the ear (the cartilage) and therefore it becomes easier to remove the artefacts due to the motion of the body.

[0009] According to other advantageous features of the invention:

[0010] said measuring device includes an optical radiation emitter and an optical radiation receiver respectively placed in said casing and in said horn so that a light path between them can pass through a portion of the external ear of a wearer,

[0011] said optical radiation emitter includes a plurality of light sources emitting at separate wavelengths that are preferably near infra-red wavelengths,

[0012] said receiver includes the same number of groups of optical radiation detectors as there are light sources in said emitter and said measuring device further includes means for calculating the average of signals supplied by the detectors of each group,

[0013] said substitution/superimposition means of said sound reproduction unit include a mixer circuit adapted to receive said signal representative of said heart rate supplied by said measuring device and

connected between said sound transducer and said means supplying said signal representative of the sound reproduction,

[0014] said sound reproduction unit includes voice synthesizer means connected between said probe and said mixer circuit,

[0015] said portable equipment further includes a comparator having a first input adapted to receive said signal representative of said heart rate and a second input connected to a threshold generator whose threshold is representative of a predetermined heart rate value and whose output is connected to said mixer circuit to send alarm information to said sound transducer if the heart rate supplied by said measuring device exceeds said predetermined heart rate value,

[0016] a selector is adapted to select reproduction by said sound transducer either of said alarm information or of said signal representative of said heart rate supplied by said measuring device,

[0017] said sound reproduction unit includes a reader of a sound information medium, such as an audio cassette, a compact disc or a digital versatile disc, connected to said assembly by a cable,

[0018] said sound reproduction unit includes a microphone and constitutes a hearing aid.

[0019] Other features and advantages of the present invention will become apparent in the course of the following description, which is given by way of example only and with reference to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1 is a diagrammatic representation of portable sound reproduction equipment combined with a heart rate measuring and/or monitoring function.

[0021] FIG. 2 is a block diagram of the equipment shown in FIG. 1.

[0022] FIG. 3 is a diagrammatic representation of another embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] FIG. 1 shows a first embodiment of portable equipment according to the invention.

[0024] The equipment comprises a first unit A adapted in particular to measure the heart rate and a second sound reproduction unit B adapted in particular to reproduce sound, the two units being interconnected by a cable C. In the embodiment shown, the unit B is an audiocassette player, preferably adapted to be easily worn by a user, as is usual for the devices usually known as "walkmans". Of course, the invention applies to other sound reproduction devices using other recording media, such as compact disks (CD), digital versatile disks (DVD), etc. The cassette player B is of standard design and is therefore not described in detail. Suffice to say that its sound reproduction electrical circuit has added components that are schematically represented in FIG. 1 by a functional unit 1 that is described later.

[0025] The unit A takes the form of an ear cushion comprising a generally circular casing 2 adapted to be placed inside the external ear (auricle) of a user in front of the external auditory meatus opening, the side of the casing 2 that can be seen in FIG. 1 facing toward the latter opening. The casing 2 of the ear cushion contains a sound transducer symbolized by the dashed line circle 3. This transducer is conventional, and any design available off the shelf may be used.

[0026] The casing 2 is fastened to a horn 4 whose free end part is adapted to hook behind the external ear of a user, as is usual for ear cushions used with off the shelf walkmans. An optical emitter 5 is placed in the horn 4 so that it directs radiation toward the casing 2. In other words, looking at FIG. 1, the emitter 5 is on the non visible side of the horn 4.

[0027] An optical radiation receiver 6 is disposed in the casing 2 so that it can pick up the portion of the optical radiation emitted by the emitter 5 that has passed through the thickness of the external ear. Consequently, the received radiation is a function of variations in the optical characteristics of the portion of the external ear through which the radiation has passed, which variations are caused in particular by variations in the circulation of blood in the external ear. The variations in the electrical signal delivered by the receiver 6 are therefore representative in particular of the pulsation of the blood and therefore of the heart rate.

[0028] The casing 2 can be covered with a foam material cushion 7 (only part of which is shown) to protect the portion of the ear surrounding the external auditory meatus opening.

[0029] An accelerometric device 8 is placed in the horn 4 for measuring acceleration along three axes. Its function is explained later.

[0030] FIG. 2 is a block diagram of the equipment shown in FIG. 1. It shows that the unit A comprises the sound reproduction transducer 3 and a measuring probe 10 which comprises the emitter 5, the receiver 6 and the accelerometric device 8. The emitter 5 comprises one or more sources of optical radiation (two sources 12 and 13 in the example shown) emitting at two different wavelengths, for example, in this example two wavelengths λ_1 and λ_2 . These sources irradiate a portion P of the cartilage of the external ear. As already described, the receiver 6 is on the opposite side of this portion P of the external ear when the ear cushion is in place thereon.

[0031] In corresponding relationship to each source 12, 13, the receiver 6 comprises respectively a plurality of optical detectors 14 and 15, whose sensitivity ranges are adjusted to the respective wavelengths of the sources 12 and 13. In one embodiment, the sources 12 and 13 are modulated by a control signal so as to be active alternately. Wideband receivers 14 and 15 can then be used and a time division demultiplexing enables to retrieve the two-optical signals with wavelengths λ_1 and λ_2 .

[0032] In the preferred embodiment of the invention, the wavelengths λ_1 and λ_2 are near infra-red wavelengths, the sources are light-emitting diodes, and the detectors are photosensitive diodes.

[0033] The outputs of the group of detectors 14 and 15, of the accelerometric device 8 and of the transducer 3 are

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