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(54) **WEARABLE HEART MONITORING APPARATUS**

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A61B 5/024	(2006.01)

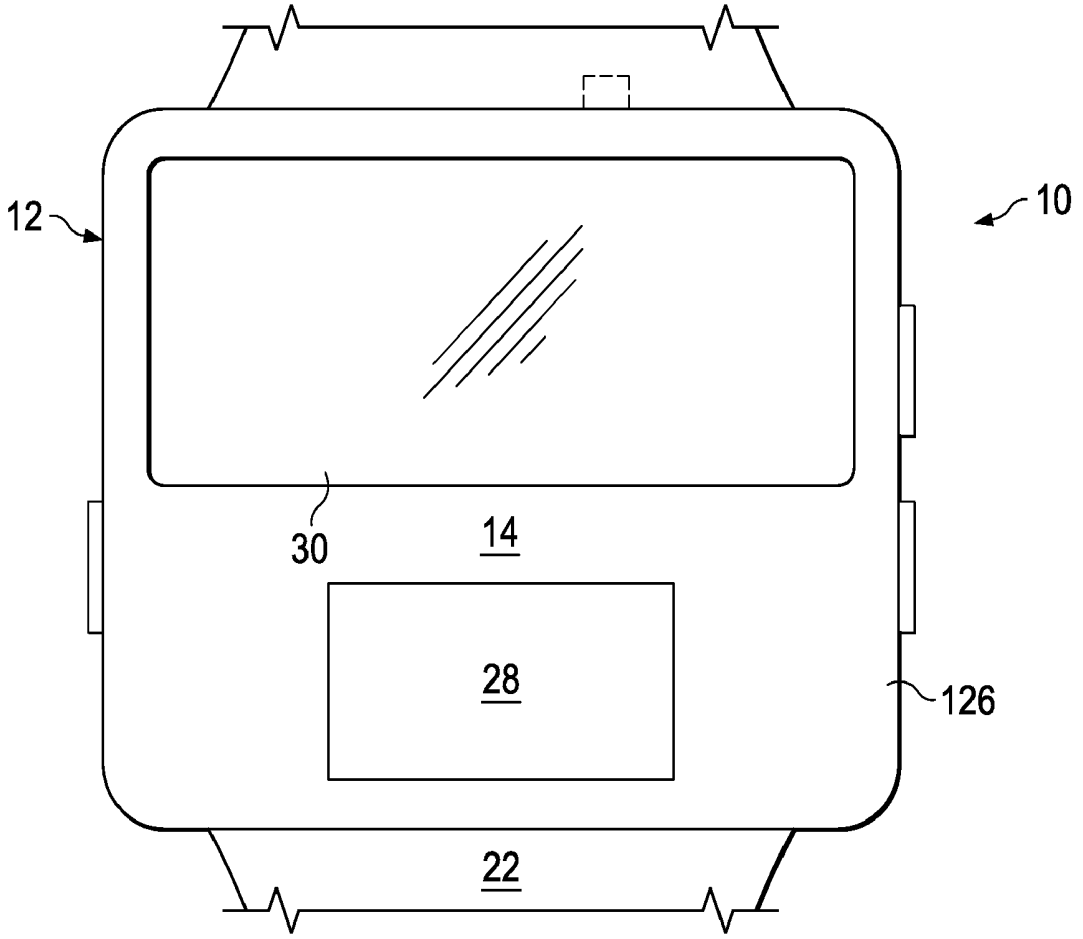
(52) **U.S. Cl.**

CPC ***A61B 5/681*** (2013.01); ***A61B 5/021*** (2013.01); ***A61B 5/02416*** (2013.01); ***A61B 5/0245*** (2013.01); ***A61B 5/6826*** (2013.01); ***A61B 5/742*** (2013.01); ***H05K 13/0023*** (2013.01)

USPC **600/301**; 600/479; 29/592.1

(57) **ABSTRACT**

An apparatus mountable on a wearer's wrist includes a housing having at front portion and an opposite a back portion. The back portion is wearably positionable in contact with the wearer's wrist. The apparatus includes a PPG circuit for generating a PPG signal. The PPG circuit includes a light source and a photosensor on the housing back portion. The PPG signal may be used to continuously determine the wearer's a pulse rate. The PPG signal may also be used in combination with an ECG signal to determine the wearer's instantaneous blood pressure. The ECG signal may also be used to determine the wear's heart rate. The ECG signal may be generated with an electrode mounted on the back of the housing and another electrode mounted on another portion of the housing, such as the back or one or more of the sides.



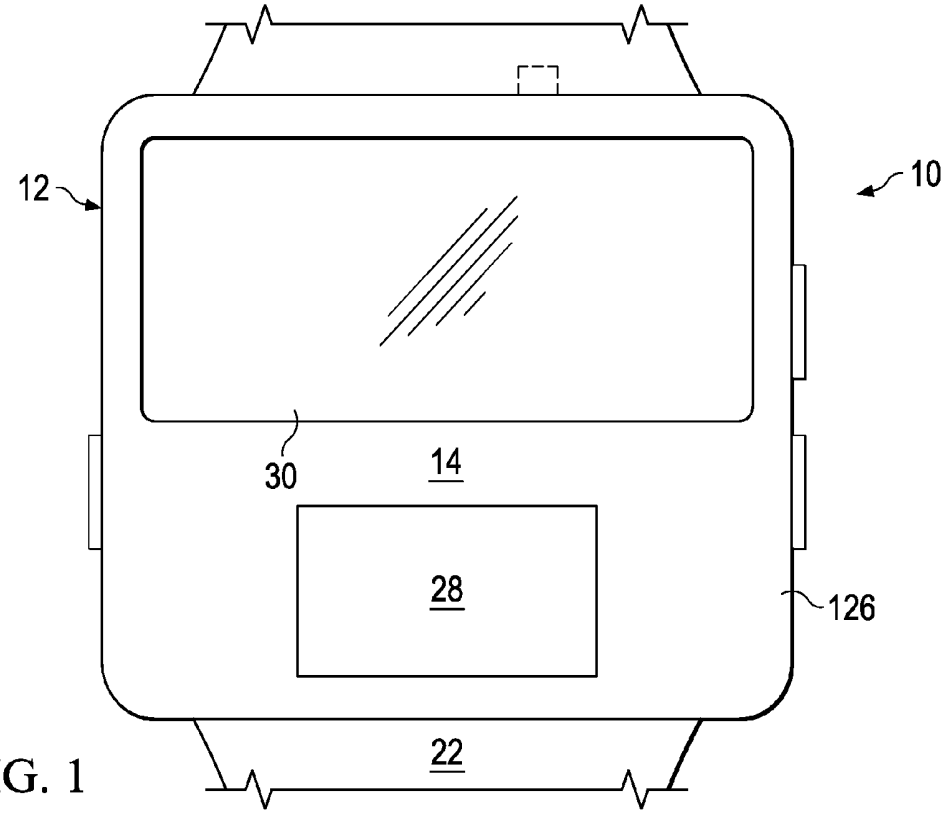


FIG. 1

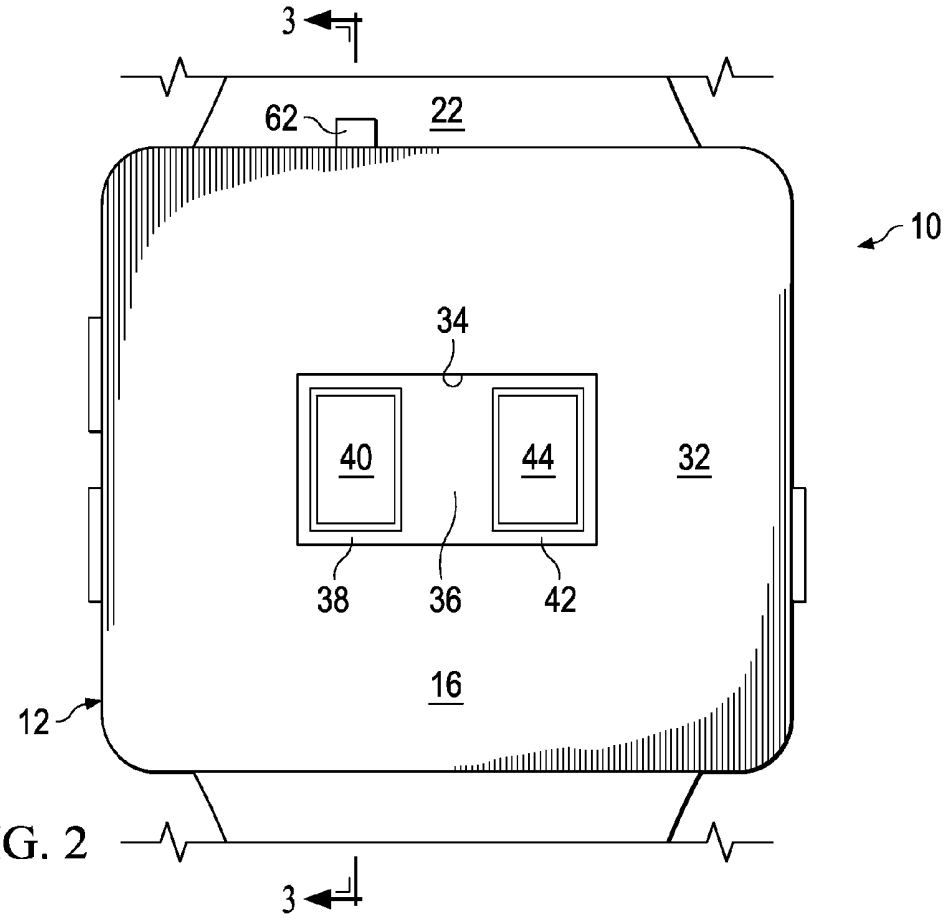


FIG. 2

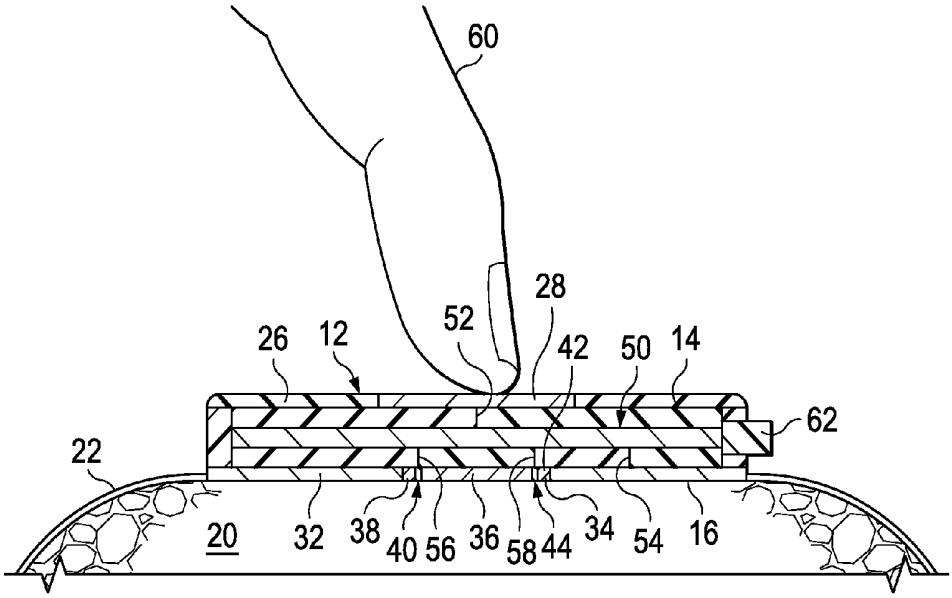

60
28
52
26
12
42
50
14
62
22
20
32
38
40
56
36
58
44
34
54
16

FIG. 3

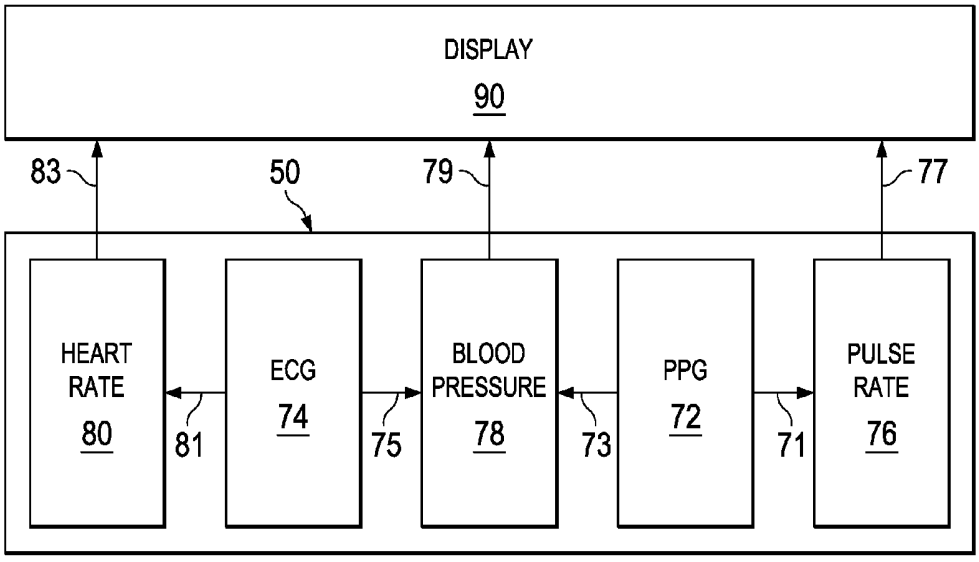

DISPLAY
90
83
50
79
77
HEART RATE
80
81
ECG
74
75
BLOOD PRESSURE
78
73
PPG
72
71
PULSE RATE
76

FIG. 4

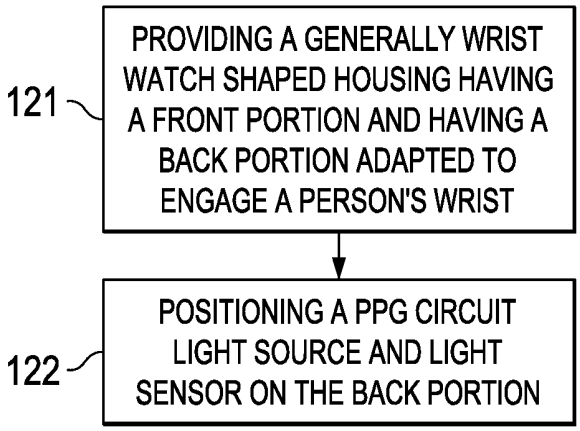

121
PROVIDING A GENERALLY WRIST WATCH SHAPED HOUSING HAVING A FRONT PORTION AND HAVING A BACK PORTION ADAPTED TO ENGAGE A PERSON'S WRIST
122
POSITIONING A PPG CIRCUIT LIGHT SOURCE AND LIGHT SENSOR ON THE BACK PORTION

FIG. 5

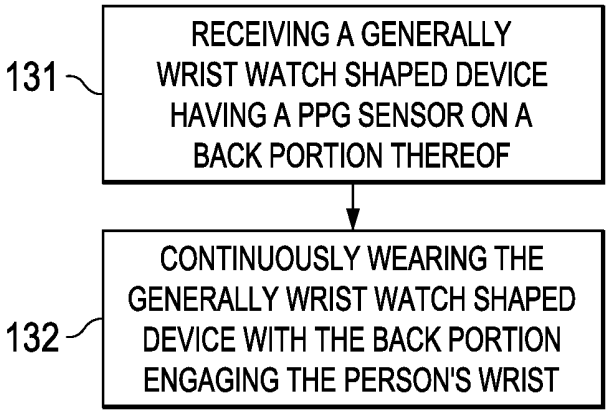

131
RECEIVING A GENERALLY WRIST WATCH SHAPED DEVICE HAVING A PPG SENSOR ON A BACK PORTION THEREOF
132
CONTINUOUSLY WEARING THE GENERALLY WRIST WATCH SHAPED DEVICE WITH THE BACK PORTION ENGAGING THE PERSON'S WRIST

FIG. 6

WEARABLE HEART MONITORING APPARATUS

BACKGROUND

[0001] A photoplethysmogram ("PPG") is an optically obtained plethysmogram, a volumetric measurement of an organ. A PPG may be obtained by using a device known as a "pulse oximeter," which illuminates a person's skin with a light emitting diode ("LED") and measures light absorption or reflection with a photodiode. The photodiode produces a PPG signal indicative of the measured light absorption or reflection. Changes in this PPG signal may be used to detect the pulse rate of the heart.

[0002] An electrocardiogram ("ECG") is a test used to monitor the electrical activity of the heart. An ECG signal is produced by an electric current flowing between electrodes contacting different sites on a person's body. An ECG signal can be processed along with a PPG signal to determine a person's blood pressure.

[0003] During the past two decades a number of relatively inexpensive portable heart monitors have been developed, which operate through use of PPG signals and/or ECG signals. Such heart monitors enable a person to view and/or record his/her heart pulse rate and/or blood pressure during active exercise and without visiting a medical facility. Patents directed to heart monitors include the following U.S. Pat. No. 5,316,008 of Suga, et al., issued May 31, 1994; U.S. Pat. No. 5,865,755 of Golub, issued Feb. 2, 1999; U.S. Pat. No. 6,599,251 of Chen, et al., issued Jul. 29, 2003; U.S. Pat. No. 6,723,054 of Baruch, et al., issued Apr. 20, 2004; and U.S. Pat. No. 7,993,275 of Banet, et al., issued Aug. 9, 2011, which are all hereby incorporated by reference for all that is disclosed therein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is a schematic front view of a wearable heart monitoring apparatus.

[0005] FIG. **2** is a schematic back view of the wearable heart monitoring apparatus of FIG. **1**.

[0006] FIG. **3** is a schematic cross sectional view of the wearable heart monitoring apparatus of FIGS. **1** and **2** mounted on a user's wrist.

[0007] FIG. **4** is a block diagram of functional units of a circuit board and display assembly.

[0008] FIG. **5** is a flow chart of a method of making a heart monitor.

[0009] FIG. **6** is a flow chart of a method for a person to monitor at least one of his/her pulse rate and blood pressure.

DETAILED DESCRIPTION

[0010] With reference to FIGS. **1-3**, this specification, in general, discloses a heart monitoring apparatus **10** mountable on a human limb such as, for example a wrist **20**. The apparatus includes a housing **12** having at front portion **14** and an opposite back portion **16**. The back portion **16** is wearably positionable in contact with the wearer's limb. A PPG circuit for generating a PPG signal includes a light source, such as one or more LED's **44**, on the housing back portion **16** and a photosensor, such as one or more photodiodes **40**, also positioned on said housing back portion **16**. The PPG circuit may be used to generate a pulse rate signal during the period that the apparatus **10** is worn. The apparatus **10**, in one embodiment, also includes a ECG circuit. An ECG signal generated by the ECG circuit may be used in combination with the PPG signal to generate a blood pressure signal while a person touches a finger **60** to an electrode **32** positioned on the front surface **14**. The ECG signal may also be processed to generate a heart rate signal. Having thus generally described an embodiment of a heart monitoring apparatus **10**, various details thereof and related methods will now be described.

[0011] FIGS. **1-3** illustrate a wearable heart monitoring apparatus **10** having a generally wristwatch shaped housing **12**. The housing has a front portion **14**, FIG. **1**, and an opposite back portion **16**, FIG. **2**. The back portion **16** is adapted to be positioned in touching engagement with the surface of a person's limb, for example it may be placed against his wrist **20**. The apparatus **10** may be secured to the person's wrist **20** with a conventional watch band **22** or the like.

[0012] As illustrated by FIGS. **1** and **3**, the front portion **14** of the housing **12** may be constructed primarily from a non-conductive material **26**. A first electrode **28** of an ECG circuit, which is made from conductive material, is mounted on the front portion **14**. An LCD display **30**, FIG. **2**, may also be provided on the front portion **14**. The LCD display **30** may be adapted to display the user's heart rate, pulse rate or the user's blood pressure or any combination of the three. As used herein "heart rate" refers to the rate that the user's heart is beating. "Pulse rate refers to the rate at which the user's arteries pulse, i.e., go through expansion/contraction cycles. Although a user's heart rate and pulse rate are generally the same or about the same, there can be differences resulting from blockage in the arteries, etc.

[0013] As best illustrated in FIGS. **2** and **3**, the back portion **16** of the housing **12** may be formed primarily from conductive material, which provides a second electrode **32** of the ECG circuit. An opening **34** is provided in the conductive material on the back portion **16**. The opening **34** is divided by a partition **36** into a first section **38** having a photo diode **40** positioned therein and a second section **42** having an LED **44** positioned therein. The photo diode **40** and LED **44** are constructed and arranged such that the photo diode **40** only receives reflected light of the LED **44**. The photo diode **40** generates a signal indicative of the reflected light from the person's skin that it receives. The photo diode **40** and LED **44** are part of a PPG circuit, which is further described below.

[0014] Referring to FIG. **3**, a circuit board **50** is positioned in the wristwatch shaped housing **12** between the front portion **14** and the back portion **16**. A first conductive wire **52** connects the first electrode **28** to the circuit board **50**. A second conductive wire **54** connects the second electrode **32** to the circuit board **50**. A third conductive wire **56** connects the photo diode **40** to the circuit board **50**, and a fourth conductive wire **58** connects the LED **44** to the circuit board **50**.

[0015] As shown by FIG. **4**, the photo diode **40** and the LED **44** and circuitry within the circuit board **50** connected thereto comprise PPG circuitry **72** that generates a signal **71** which may be processed by conventional pulse rate processing circuitry **76** to determine the user's pulse rate. In operation, the LED **44** illuminates an oppositely positioned portion of the user's wrist **20**. The light from the LED returns from the person's skin to the photo diode **40**, which generates a PPG signal **71** that may be conventionally processed in a manner known in the art to produce a signal **77** representative of the user's pulse rate. The photo diode **40**, third conductive wire **56**, LED **44**, fourth conductive wire **58** and associated circuitry within the circuit board **50** constitute a PPG circuit **72**.

The generation of an PPG signal based on the amount of light reflected from human skin is known in the art, such is shown for example by U.S. Pat. No. 5,316,008 incorporated by reference above, and is thus not further described herein.

[0016] The first electrode **28**, first conductive wire **52**, second electrode **32**, second conductive wire **54** and associated circuitry within the circuit board **50** provides an ECG signal **75** when a person's finger **60** engages the electrode **28** while the second electrode **32** engages the surface of the user's wrist **20**. This circuitry **28**, **32**, **52**, **54** and associated circuitry within the circuit board **50** that generate the ECG signal comprise the ECG circuitry **74**, FIG. **4**. The generation of an ECG signal based on contact with two electrodes engaged by different parts of a person's body is known in the art, such is shown for example by U.S. Pat. No. 5,316,008 incorporated by reference above, and is thus not further described herein.

[0017] In one mode of operation, a PPG signal **71** may be generated continuously in response to actuation of a control surface such as push button **62** situated on the side of the housing and connected to circuit board **50**. In a second mode of operation, which may be initiated by pushing button **62** in a preselected pattern, an ECG signal **75** is generated when the second electrode **32** on the back **16** of the housing **12** is engaged with a person's wrist **20** and a finger **60** of the user's other hand is engaged with the first electrode **28**. The first and second mode of operation may occur simultaneously, such as by proper actuation of button **62**. As illustrated by FIG. **4**, during the first mode of operation, a first PPG signal **71** is sent to PPG processing circuitry **76** that processes the PPG signal **71** and generates a pulse rate signal **77**. The pulse rate signal **77** may be sent to a display assembly **90** that generates a display representative of the person's pulse rate. In alternative embodiments the pulse rate signal **77** is transmitted to a remote station (not shown) for storage or viewing. In another embodiment the pulse rate signal **77** is stored in memory (not shown) in the apparatus **10**.

[0018] As further illustrated by FIG. **4**, in another mode of operation a second PPG signal **73**, which may be the same as the first pulse signal **71**, is input to blood pressure processing circuitry **78**. In this mode of operation, the ECG circuitry **74** also sends an ECG signal **75** to the blood pressure processing circuitry **78**. The processing circuitry **78**, in this mode of operation, processes both the PPG signal **73** and the ECG signal **75** to generate a signal **79** representative of the wearer's blood pressure. This blood pressure signal **79** may be sent to the display assembly **90**, and/or is transmitted to a remote station, and/or is stored either remotely or in the apparatus **10**. It is known in the art to process an ECG signal and a PPG signal together to obtain a person's blood pressure such as disclosed, for example, in U.S. Pat. No. 5,316,008 incorporated by reference above. The techniques described in that patent or other similar known techniques may be used to produce the blood pressure signal **79**, and thus the specifics of the ECG circuitry **74** and processing circuitry **78** are not further described herein.

[0019] As also illustrated by FIG. **4**, in a still another mode of operation, the ECG circuitry **74** sends an ECG signal **81** to heart rate processing circuitry **80**. The ECG signal **81** may be identical to ECG signal **75**. The heart rate processing circuitry **80**, in this fourth mode of operation, processes the ECG signal **81** to generate a signal **83** representative of the wearer's heart rate. This heart rate signal **83** may be sent to the display assembly **90**, and/or is transmitted to a remote station, and/or is stored either remotely or in the apparatus **10**. It is known in the art to process an ECG signal to obtain a person's heart rate, and thus the specifics of the ECG circuitry **74** and heart rate processing circuitry **80** are not further described herein.

[0020] It will be understood from the above that the pulse rate of the person wearing the heart rate monitoring apparatus **10** may be continuously calculated and updated and displayed during the entire period that the person is wearing the apparatus **10**. It will also be understood that the person's blood pressure may be detected and displayed when the person is wearing the heart monitoring apparatus **10** on one wrist and is touching the front electrode **28** with a finger of the other hand, since both the ECG signal and the PPG signal are needed to determine the user's blood pressure. Also, the person's heart rate may be displayed when the person is wearing the heart monitoring apparatus **10** on one wrist and is touching the front electrode **28** with a finger of the other hand. The ECG signal can be processed without the PPG signal to generate and display the person's heart rate. Of course all or any combination of the pulse rate, blood pressure and heart rate may be determined and displayed when the person is wearing the apparatus on one limb and is touching the front electrode with another body part.

[0021] Although use of the heart monitoring apparatus **10** on a person wrist **20** is described, the apparatus could be worn other places, such as an ankle or upper arm or other body part. Also, rather than touching the electrode **28** on the front **14** of the apparatus with a finger **60** as described, the electrode could be touched with some other body part, for example a toe, located sufficiently distant from the site where the device is being worn. Furthermore, the apparatus **10** could be used on an animal other than a human so long as the LED **44** and photo diode **40**, when worn by the animal, engage and unobstructed region of the animal's skin and the animal is caused to touch the front electrode **28** with the exposed skin of another body part.

[0022] It will be appreciated from the above that, as shown by FIG. **5**, a method of making a heart monitor has been described which comprises providing a generally wristwatch shaped housing having a front portion and having a back portion adapted to engage a person's wrist, block **121**. The method also comprises positioning a PPG circuit light source and light sensor on the back portion, as illustrated in block **122**.

[0023] It will also be appreciated from the above, that a method for a person to monitor at least one of his/her pulse rate and blood pressure may comprise, as shown in FIG. **6**, block **131**, receiving a generally wristwatch shaped device having a PPG photo sensor on a back portion thereof. The method may further comprise, as shown at block **132**, continuously wearing the generally wristwatch shaped device with the back portion engaging the person's wrist.

[0024] Various embodiments of a wearable heart monitoring apparatus and methods of monitoring a person's pulse rate, heart rate and blood pressure have been described in detail herein. It is to be understood that the inventive concepts disclosed herein may be otherwise embodied, as will be obvious to those skilled in the art after reading this disclosure. It is intended that the appended claims be broadly construed to cover all such alternative embodiments, except as limited by the prior art.

What is claimed is:

1. An apparatus mountable on a human limb comprising:

a housing having at front portion and an opposite back portion, said back portion being wearably positionable in contact with a wearer's limb; and

a PPG circuit for generating a PPG signal including a light source on said housing back portion and a photosensor on said housing back portion.

2. The apparatus of claim **1** further comprising:

an ECG circuit for generating an ECG signal, said ECG circuit comprising:

a first electrode on said housing front portion; and

a second electrode on said housing back portion engageable with said wearer's limb.

3. The apparatus of claim **2**, said first electrode being engageable with a wearer's finger.

4. The apparatus of claim **1** further comprising processing circuitry connected to said PPG circuit for continuously processing said PPG signal to generate a signal indicative of a wearer's pulse rate.

5. The apparatus of claim **2** further comprising processing circuitry for processing said PPG signal and said ECG signal to generate a signal indicative of a wearer's blood pressure when he is touching said first electrode.

6. The apparatus of claim **2** further comprising processing circuitry connected to said ECG circuit for processing said ECG signal to generate a signal indicative of a wearer's heart rate.

7. The apparatus of claim **4** further comprising a display operably connected to said processing circuitry for displaying indicia indicative of a wearer's pulse rate

8. The apparatus of claim **5**, further comprising a display connected to said processing circuitry adapted to display indicia indicative of a wearer's blood pressure.

9. The apparatus of claim **6**, further comprising a display adapted to display indicia indicative of a wearer's heart rate.

10. The apparatus of claim **1**, said housing comprising a generally wristwatch shaped housing attachable to a wearer's wrist with a wrist band.

11. The apparatus of claim **2**, said housing comprising a generally wristwatch shaped housing attachable to a wearer's wrist with a wrist band.

12. A method of making a heart monitor comprising:

providing a generally wristwatch shaped housing having a front portion and having a back portion adapted to engage a wearer's limb;

positioning a PPG circuit light source and light sensor on the back portion.

13. The method of claim **12** comprising mounting processing circuitry in the housing adapted to process a signal from the PPG circuit to determine the pulse rate of a wearer wearing the wristwatch shaped housing.

14. The method of claim **13** comprising mounting ECG signal generating circuitry in the housing including a first ECG circuit electrode mounted on the back portion of the housing and a second ECG circuit electrode mounted on the front portion of the housing.

15. The method of claim **14** comprising mounting further signal processing circuitry in the housing adapted to process signals from the PPG circuit and the ECG circuit to determine the instantaneous blood pressure of the wearer.

16. The method of claim **14** comprising mounting further signal processing circuitry in the housing adapted to process a signal from the ECG circuit to determine the heart rate of the wearer.

17. The method of claim **2** comprising mounting a display on the front portion of the housing adapted to display at least one of the wearer's pulse rate, heart rate and blood pressure determined using at least one of the PPG signal and the ECG signal.

18. A method for a person to monitor at least one of his/her pulse rate, heart rate and blood pressure comprising:

receiving a generally wristwatch shaped device having a PPG photosensor on a back portion thereof; and

continuously wearing the generally wristwatch shaped device with the back portion engaging the person's wrist.

19. The method of claim **18** wherein said continuously wearing the device comprises wearing the device with a first ECG electrode on the back portion of the device engaged with the person's wrist and further comprising engaging a second ECG electrode on a front portion of the device with one of the user's fingers.

20. The method of claim **19** further comprising reading at least one of a pulse rate, heart rate and blood pressure on a display on the front portion of the generally wristwatch shaped device.

* * * * *

专利名称(译)	可穿戴式心脏监测仪		
公开(公告)号	US20140257049A1	公开(公告)日	2014-09-11
申请号	US14/190834	申请日	2014-02-26
[标]申请(专利权)人(译)	德州仪器公司		
申请(专利权)人(译)	得克萨斯仪器公司		
当前申请(专利权)人(译)	得克萨斯仪器公司		
[标]发明人	SOUNDARAPANDIAN KARTHIKEYAN BURNHAM ROBERT		
发明人	SOUNDARAPANDIAN, KARTHIKEYAN BURNHAM, ROBERT		
IPC分类号	A61B5/00 H05K13/00 A61B5/0245 A61B5/021 A61B5/024		
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优先权	61/769088 2013-02-25 US		
外部链接	Espacenet USPTO		

摘要(译)

可安装在佩戴者手腕上的装置包括具有前部和相对的后部的壳体。后部可穿戴地定位在与佩戴者的手腕接触的位置。该装置包括用于产生PPG信号的PPG电路。PPG电路在壳体后部包括光源和光电传感器。PPG信号可用于连续确定佩戴者的脉搏率。PPG信号还可以与ECG信号组合使用以确定佩戴者的瞬时血压。ECG信号也可用于确定磨损的心率。ECG信号可以通过安装在壳体背面的电极和安装在壳体的另一部分上的另一电极（例如背面或一个或多个侧面）产生。