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(54) **PHONO-ELECTRO-CARDIOGRAM MONITORING UNIT**

(71) Applicants: **Siad Sayme**, Hannover (DE); **Corbit Inc.**, San Francisco, CA (US)

(72) Inventor: **Siad Sayme**, Hannover (DE)

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A61B 7/04	(2006.01)

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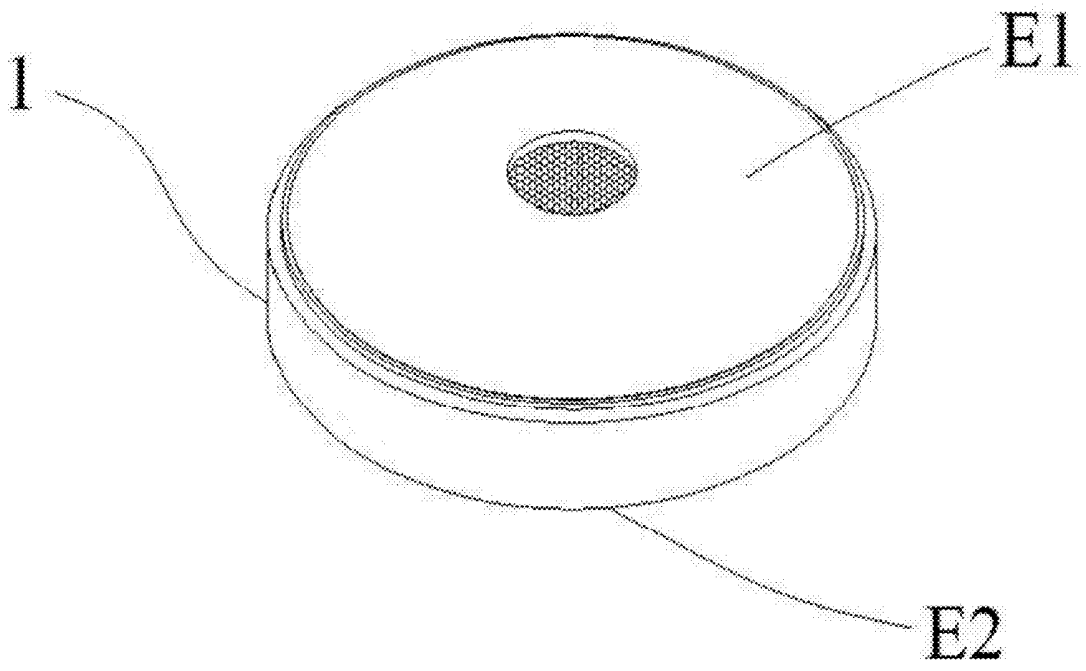
CPC ***A61B 5/02055*** (2013.01); ***H02J 7/025*** (2013.01); ***A61B 5/741*** (2013.01); ***A61B 5/002*** (2013.01); ***A61B 5/0022*** (2013.01); ***A61B 7/04*** (2013.01); ***A61B 5/7455*** (2013.01); ***A61B 5/0006*** (2013.01); ***A61B 5/1117*** (2013.01); ***A61B 5/044*** (2013.01); ***A61B 5/0408*** (2013.01); ***A61B 5/04017*** (2013.01); *A61B 2505/07* (2013.01); *A61B 2560/0214* (2013.01); *A61B 2560/0431* (2013.01)

(57) **ABSTRACT**

A Phono-Electro-Cardiogram Monitoring Unit that detects and monitors ECG and PCG signal comprising a phono-electro-cardiogram sensor button capable of electrical conduction of the electrical potential changes arising from the heart activity of a user or a patient. The sensor button includes a microphone which allows detection of electrocardiography signal and phonocardiogram signal simultaneously and the detected electrocardiography signal and phonocardiogram signal are processed by a multifunction microprocessor and the processed electrocardiography signal and phonocardiogram signal data are stored in a memory or be transmitted to a work station or a personal cloud for further processing and storing where the data can be forwarded to authorized individuals via wireless connectivity for communication, interpretation, service and help.



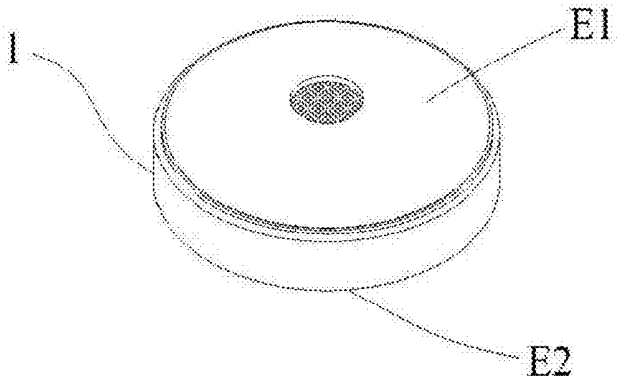


FIG. 1

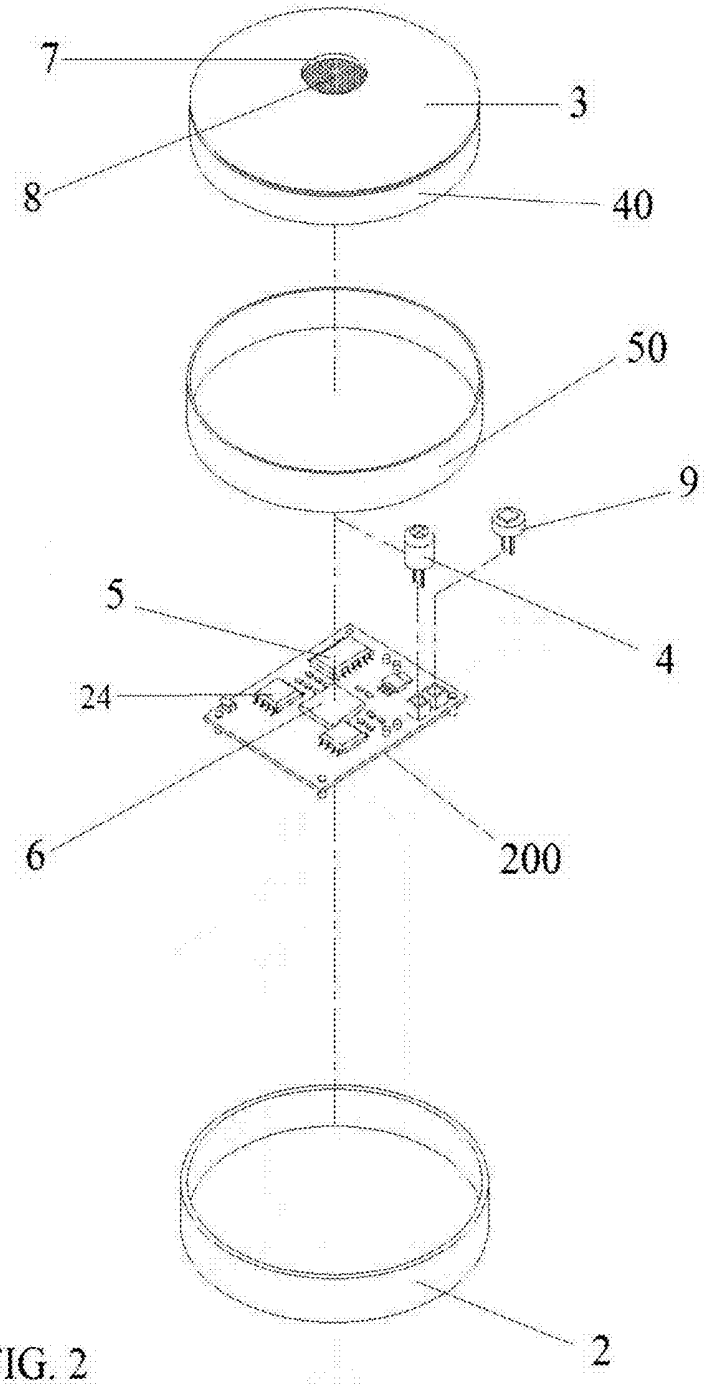


FIG. 2

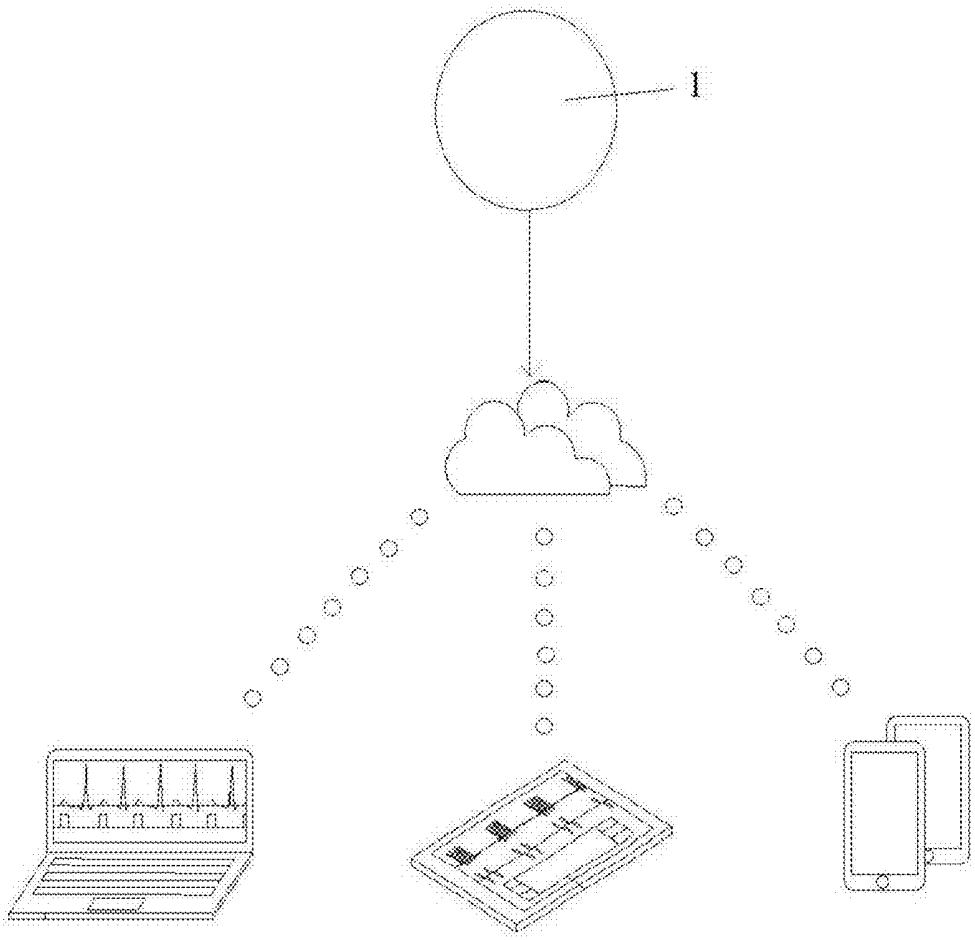


FIG. 3

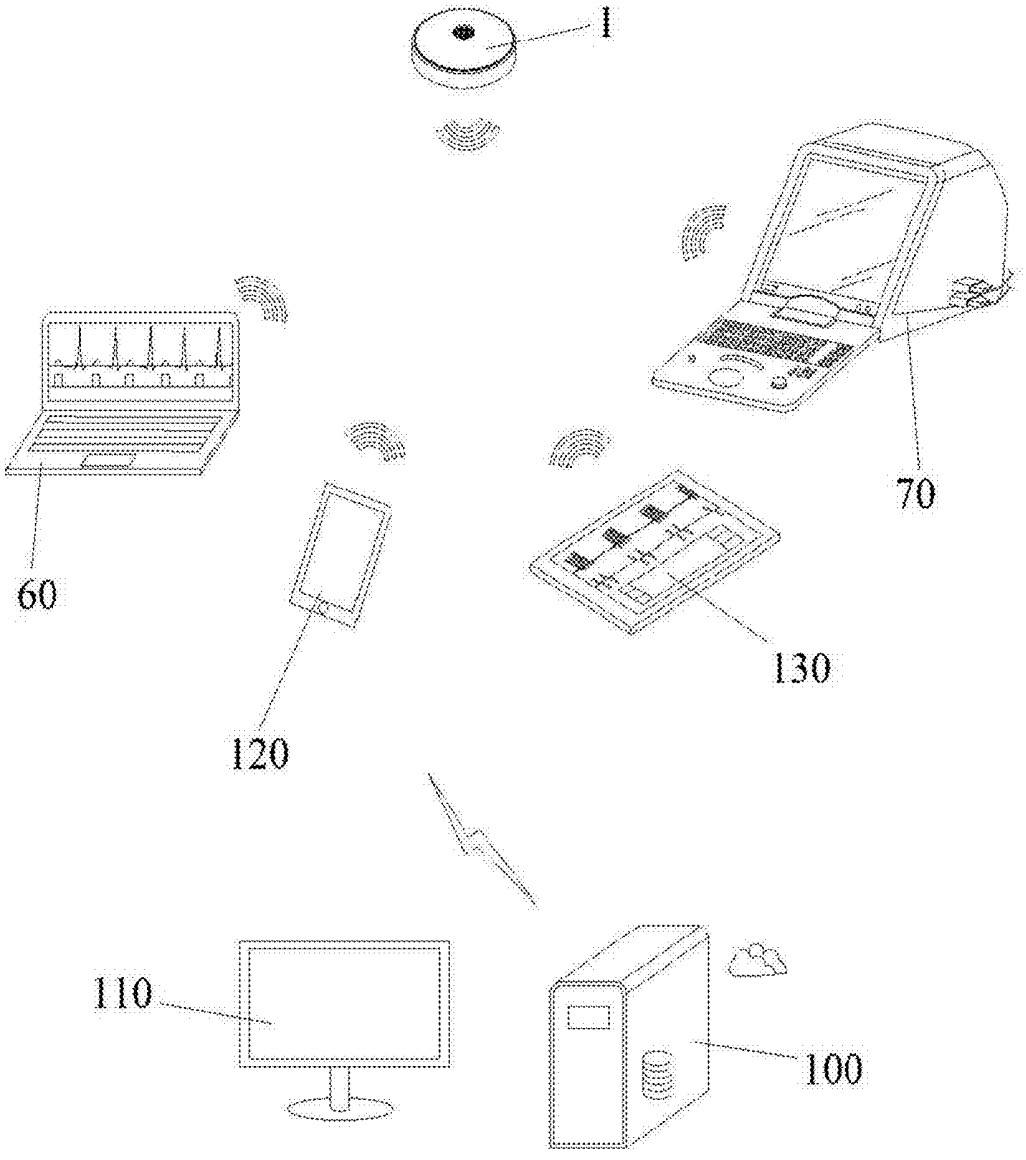


FIG. 4

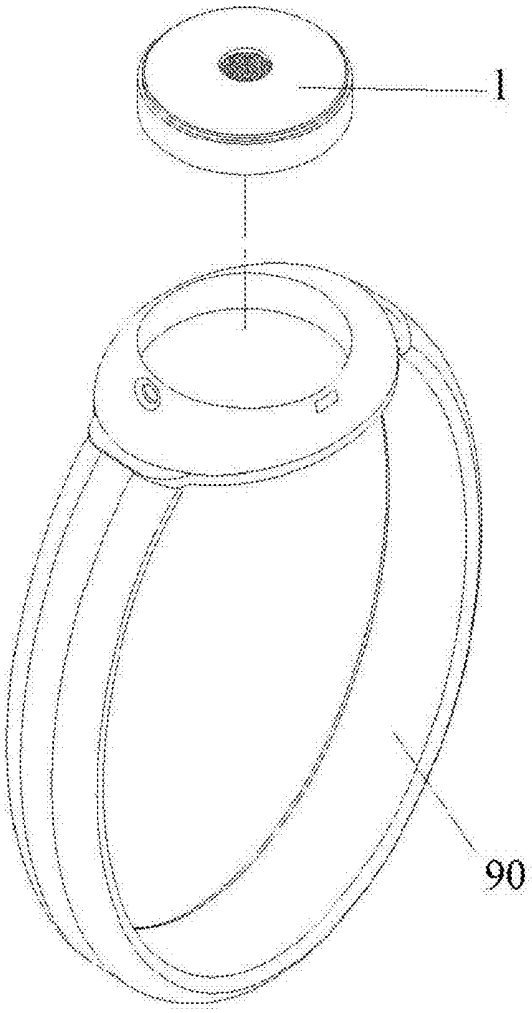


FIG. 5

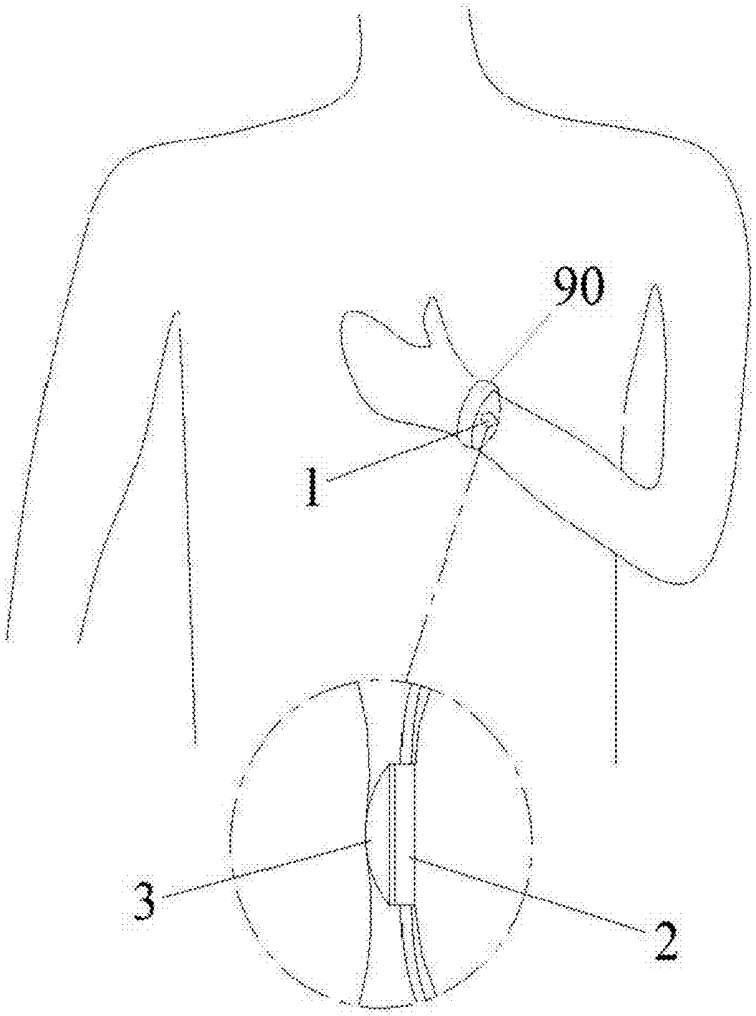


FIG. 6

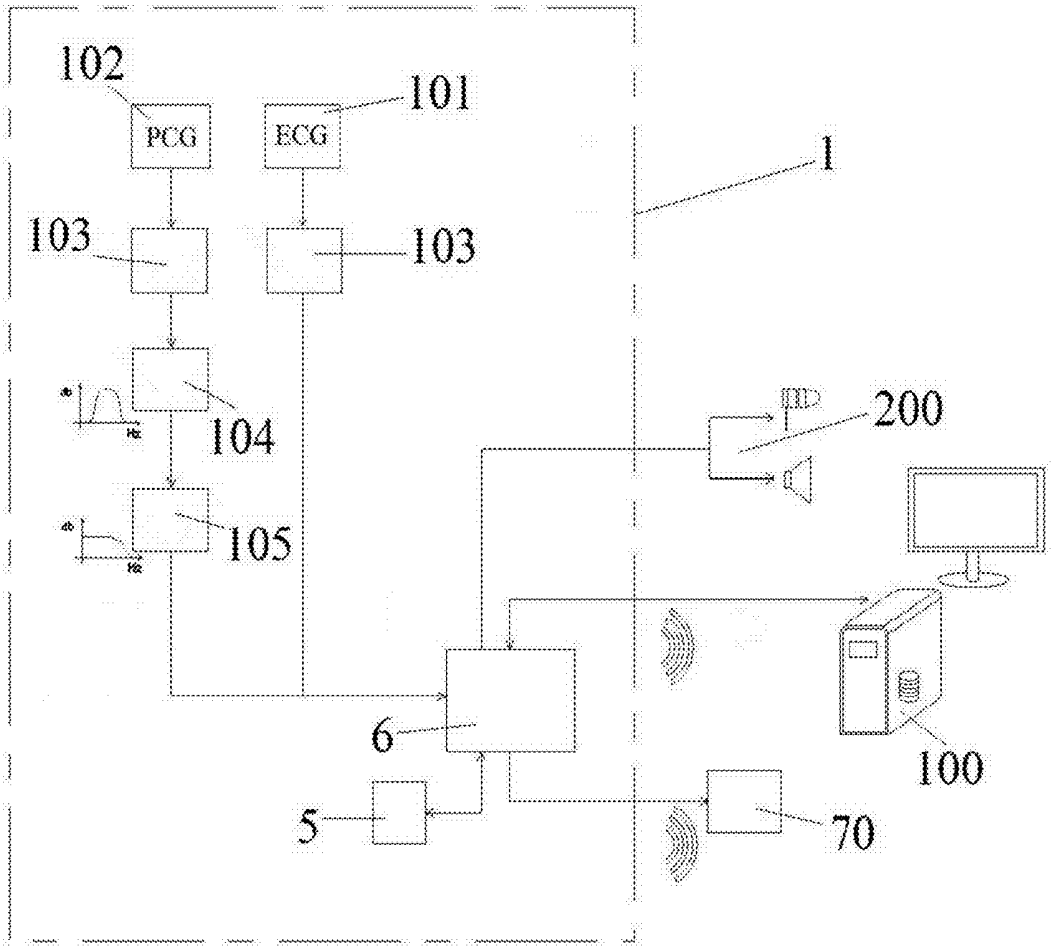


FIG. 7

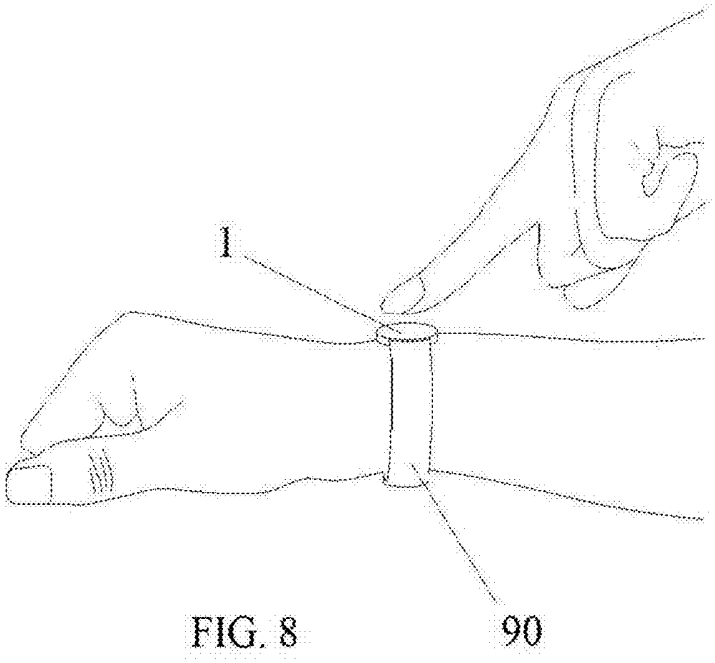


FIG. 8

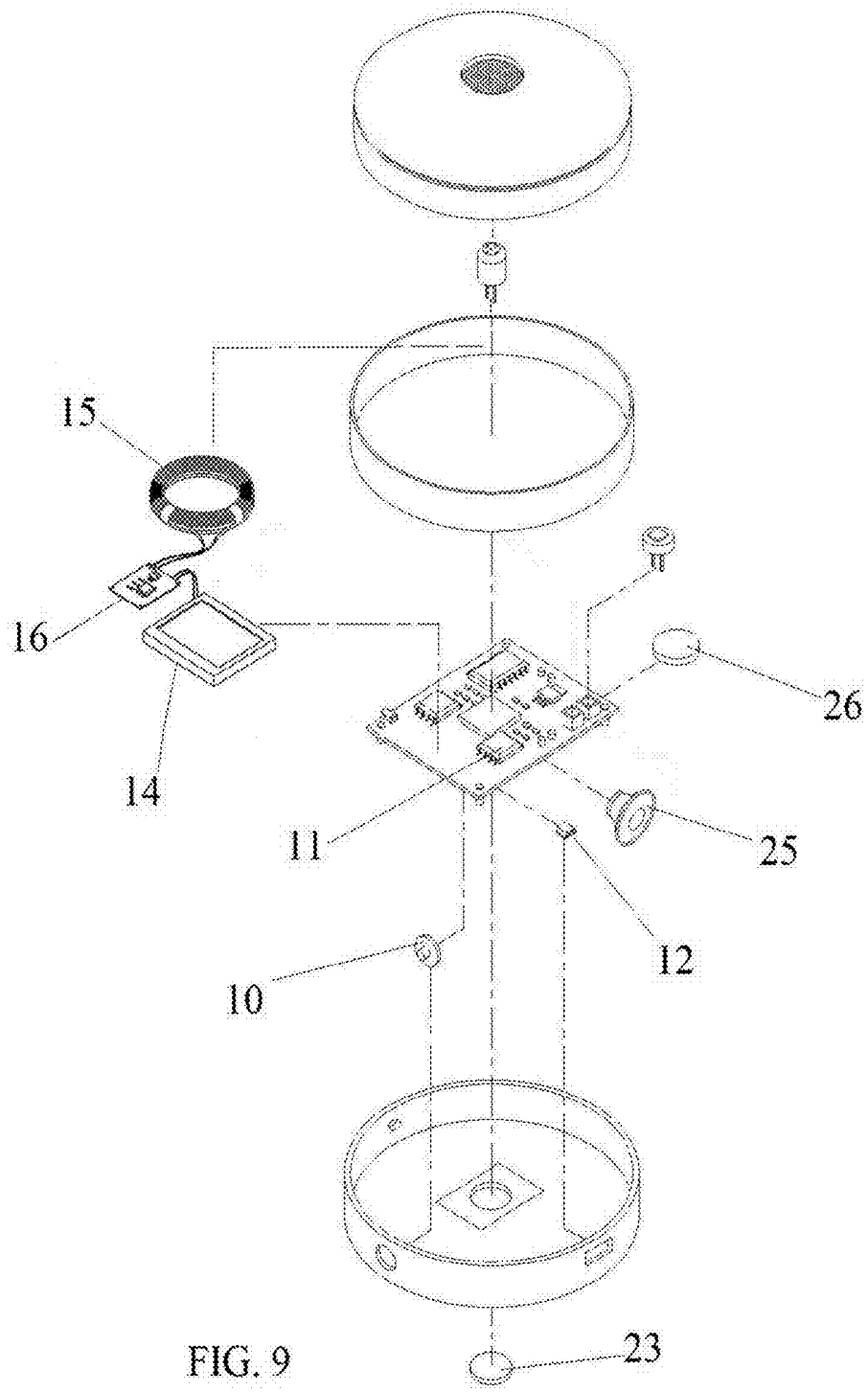


FIG. 9

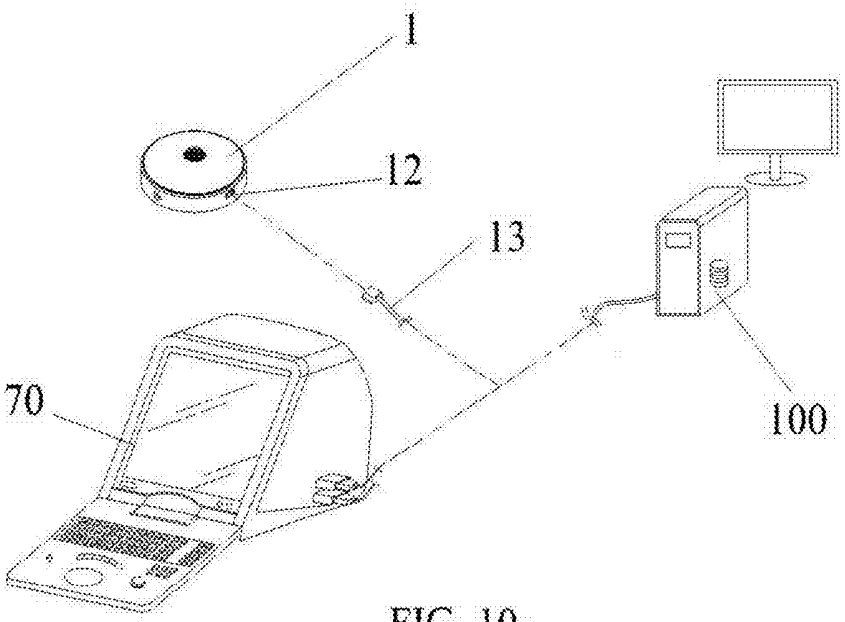


FIG. 10

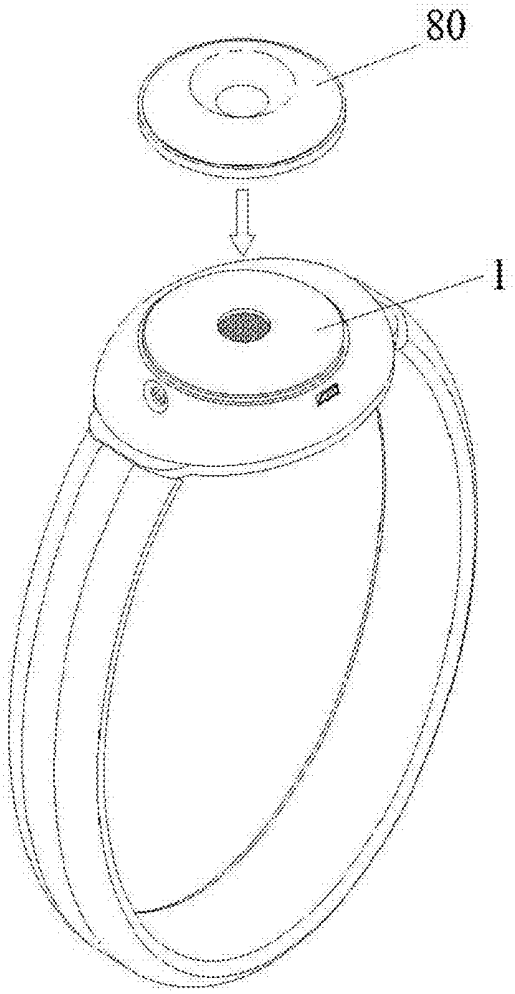


FIG. 11

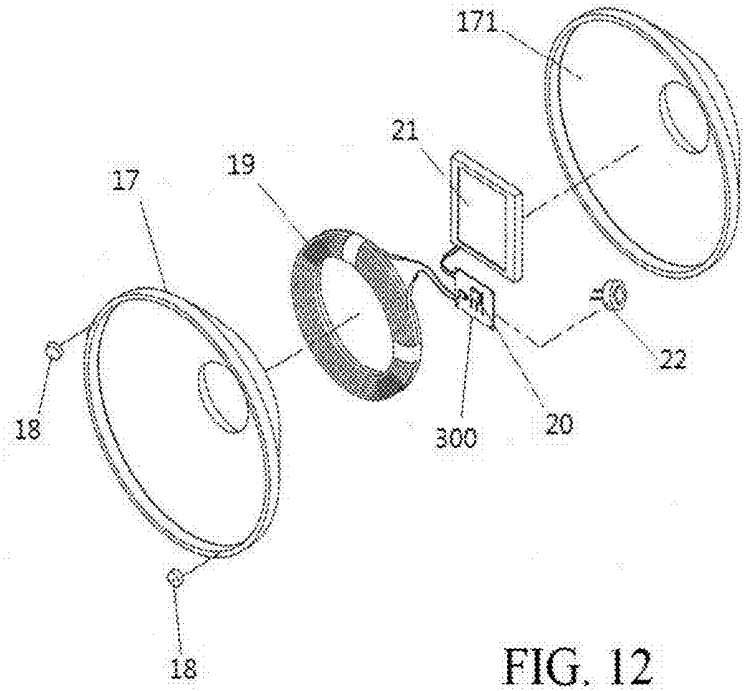


FIG. 12

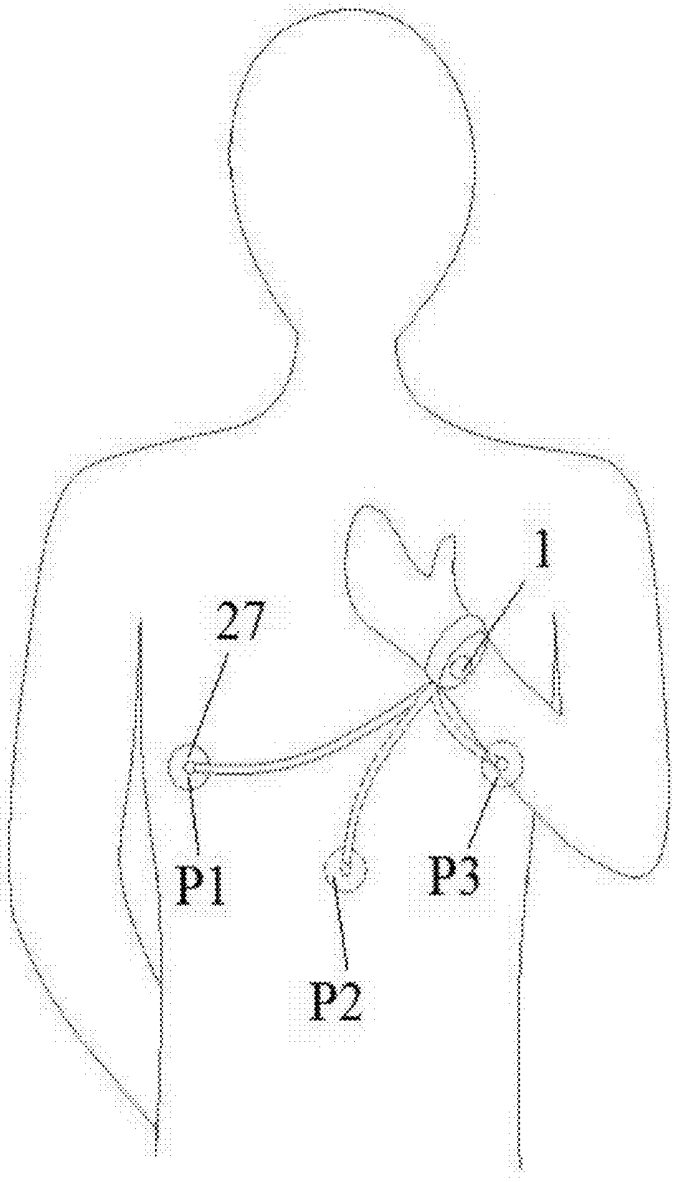


FIG. 13

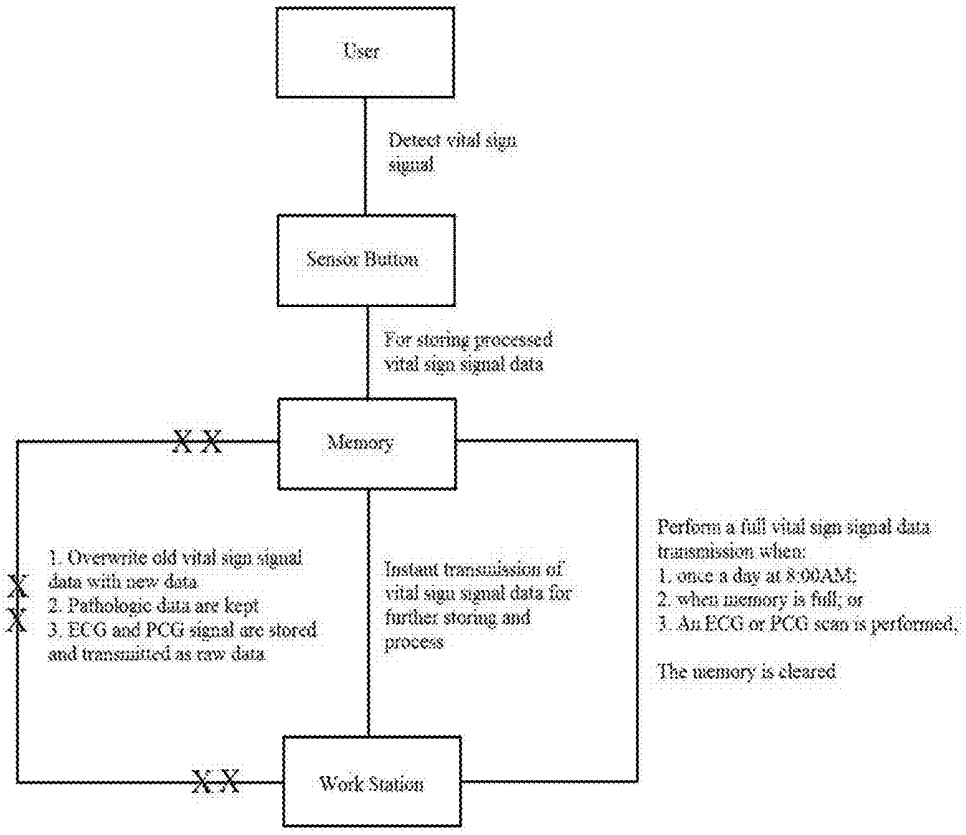

User
Detect vital sign signal
Sensor Button
For storing processed vital sign signal data
Memory
1. Overwrite old vital sign signal data with new data
2. Pathologic data are kept
3. ECG and PCG signal are stored and transmitted as raw data
Instant transmission of vital sign signal data for further storing and process
Perform a full vital sign signal data transmission when:
1. once a day at 8:00AM;
2. when memory is full; or
3. An ECG or PCG scan is performed.
The memory is cleared
Work Station

FIG. 14

Abnormal Vital signs Algorithm:

Abnormal Heart Rate in Beats Per Minute: (G-sensor feedback -> active or inactive)

abnormal:	day (6am-10pm)	→ > 120 without activity, < 40 without activity
		→ > 150 with activity, < 50 with activity
	night (10pm-6am)	→ > 100 without activity, < 35 without activity
		→ > 150 with activity, < 50 with activity
	day and night	→ HR pause > 2 Seconds
	Can be adjustable for individual situation (3 choices: +/-10BPM)	
emergency:	day (6am-10pm)	→ > 180 without activity, < 30 without activity
		→ > 200 with activity, < 35 with activity
	night (10pm-6am)	→ > 180 without activity, < 30 without activity
		→ > 200 with activity, < 35 with activity
	day and night	→ HR pause > 3,5 Seconds
	Can be adjustable for individual situation (3 choices: +/-10BPM)	

FIG. 15

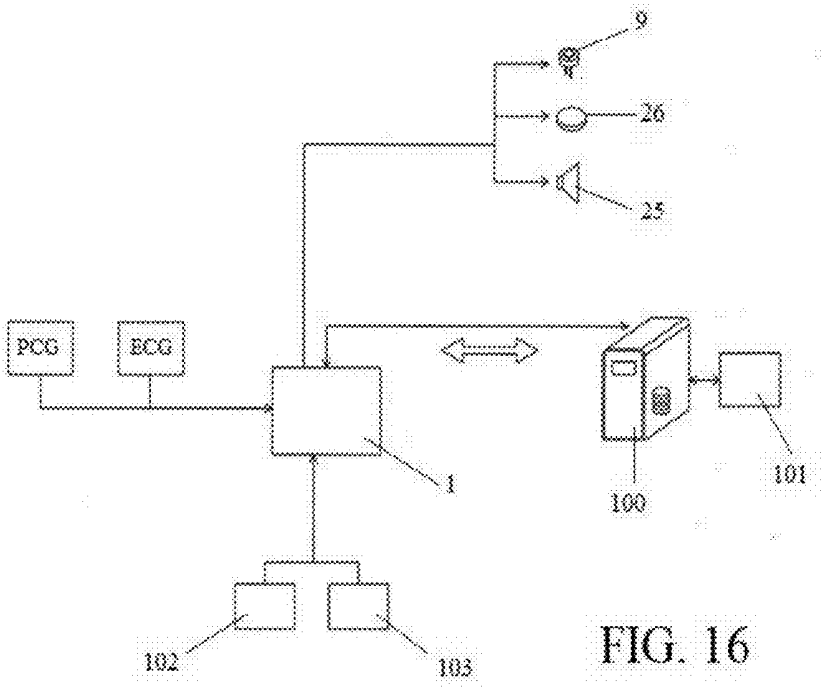


FIG. 16

PHONO-ELECTRO-CARDIOGRAM MONITORING UNIT

BACKGROUND OF INVENTION

1. Field of the Invention

[0001] The present invention relates generally to a vital signs monitoring unit, and more particularly to an electrocardiography (ECG) and phonocardiogram (PCG) vital signs monitoring unit that is compact in size for easy carrying and use by a user or a medical staff and can be incorporated into a wearable device such that the unit can be used at any place, and at any time.

2. Description of Related Art

[0002] Vital signs are used to measure the body's basic functions. These measurements are taken to help assess the general physical health of a person, give clues to possible diseases, and show progress toward recovery. The normal ranges for a person's vital signs vary with age, weight, gender, and overall health. There are four primary vital signs: body temperature, blood pressure, heart rate, and respiratory rate. However, depending on the clinical setting these vital signs may include other measurements such as ECG and PCG for identifiers before providing care, treatment, or service in a clinical setting.

[0003] While vital sign monitoring has traditionally been done by doctors, a number of companies are developing portable monitoring devices which can be used by consumers themselves. One of such devices is described in US 2014/0343389 for wireless monitoring device that is suitable for attachment to the skin of a patient and where the device is capable of continuous wireless real-time measurement of physiological signals and transmission of the measurements to a computer or mobile device.

[0004] While these portable monitoring devices provides the convenience for self and remote monitoring that allows for early discovery and treatment of ailments, however, the design of these portable monitoring devices might not be compact or appeared aesthetics enough for the user when attending social events or during sporting activities. Furthermore, these portable monitoring devices still lack a more comprehensive vital sign monitoring function such as ECG and PCG, and other features that might still need to be improved upon for self-monitoring.

SUMMARY OF THE INVENTION

[0005] The present invention overcomes the above and other drawbacks by providing a Phono-Electro-Cardiogram Monitoring Unit, in particular, the unit is capable for electrical conduction of electrical potential changes arising from the heart activity to sense and record ECG signal and simultaneously sense and record PCG signal generated during each heartbeat of a user or a patient by a microphone in the unit. As a result, the present invention increases the accuracy of various heart rate measurements, and increases the diagnostic relevance and usefulness of vital sign monitoring devices in health field, as well as for health professionals. In addition, the Phono-Electro-Cardiogram Monitoring Unit provided in the present invention can be comfortably carried and used by the user and minimizing any restriction to user's movement. Furthermore, the Phono-Electro-Cardiogram Monitoring Unit is designed in such way that it can be easily concealed, therefore, the Phono-Electro-Cardiogram Monitoring Unit can be easily blended into daily attire that can prevent the user from embarrassment or awkwardness during social events or stigmatization. Finally, the present invention provides a method for collecting, processing and monitoring ECG and PCG, and other vital sign data from the user at any place like home, hospital, caring facility, clinic, office or company and transmit the vital sign data to a secure device, which allows data access for chosen individuals like family, friends, nurses, and family and company doctors, and alert the chosen individuals when the vital data collected indicates that's the user needs immediate medical attention.

[0006] Accordingly, the present invention provides a Phono-Electro-Cardiogram Monitoring Unit for monitoring ECG and PCG of a user without hindering the user's movement and is designed to enhance the user's safety by allowing early detection of health deterioration and connecting clinicians with the user anywhere, and at any time. The Phono-Electro-Cardiogram Monitoring Unit in the present invention which comprising a phono-electro-cardiogram sensor button that is capable of detecting the ECG signal and PCG signal of the user simultaneously. The sensor button which is capable for electrical conduction of electrical potential changes arising from the heart activity of a user and simultaneously detects, stores, processes and monitors ECG signal and PCG signal generated during each heartbeat of the user. The sensor button is designed in such way that it is compact in size for easy carried by a user or be incorporated into a wearable device such that the unit can be used at any place, and at any time. In addition, the sensor button is capable of in-line or wireless communication with a work station or other external device for receiving, processing and storing the ECG and PCG signal data from the sensor button. The work station provided in the present invention comprises at least a memory hard disk integrated with a wireless module for wireless communication with the sensor button, medical algorithms, and a process interface that receives, processes, stores and forwards vital sign data from the sensor button. It is characterized that the work station sends a warning signal to the user's emergency contacts in the event that the medical algorithms result of pathologic measurements that might reflect a change in user's health condition.

[0007] Other objects and advantages of the invention herein will become apparent from the specification herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a structural view of the phono-electro-cardiogram sensor button of the present invention of Phono-Electro-Cardiogram Monitoring Unit;

[0009] FIG. **2** is an explored view of the first preferred embodiment of the phono-electro-cardiogram sensor button thereof;

[0010] FIG. **3** is an illustration of data sharing over a personal cloud;

[0011] FIG. **4** is an illustration of wireless communication between the phono-electro-cardiogram sensor button and the work station and other external devices thereof;

[0012] FIG. **5** is an embodiment view of the phono-electro-cardiogram sensor button with a wrist band thereof;

[0013] FIG. **6** is an operating illustration of the phono-electro-cardiogram sensor button thereof;

[0014] FIG. **7** is a processing illustration of the ECG signal and PCG signal in the phono-electro-cardiogram sensor button thereof;

[0015] FIG. **8** is another operating illustration of the phono-electro-cardiogram sensor button thereof;

[0016] FIG. **9** is an explored view of another preferred embodiment of the phono-electro-cardiogram sensor button thereof;

[0017] FIG. **10** is an illustration of inline connection between the phono-electro-cardiogram sensor button and the work station and a medical device thereof;

[0018] FIG. **11** is a structural view of the inductive battery recharger with the phono-electro-cardiogram sensor button thereof;

[0019] FIG. **12** is an explored view of a preferred embodiment of the inductive battery recharger thereof;

[0020] FIG. **13** is another operating illustration of the phono-electro-cardiogram sensor button;

[0021] FIG. **14** is a diagram illustrating the vital sign signal data transmission and storing steps;

[0022] FIG. **15** is an abnormal vital sign algorithm provided in the present invention; and

[0023] FIG. **16** is a diagram illustrating the method for collecting, process and monitoring vital sign signal data.

DETAILED DESCRIPTION OF THE INVENTION

[0024] A Phono-Electro-Cardiogram Monitoring Unit that simultaneously detects, stores, processes and monitors ECG signal and PCG signal generated during each heartbeat of a user or a patient. As shown in FIG. **1**, the Phono-Electro-Cardiogram Monitoring Unit comprising a phono-electro-cardiogram sensor button **1** for electrical conduction of the electrical potential changes arising from the heart activity and for detecting, storing and transmitting ECG signal and PCG signal generated during each heartbeat of the user or the patient. As a preferred embodiment, the front face of the phono-electro-cardiogram sensor button **1** is used as a first electrode E**1** to be in contact with a part of user's body, and the back face of the phono-electro-cardiogram sensor button **1** is used as a second electrode E**2** to be in contact with another part of user's body for detecting the continuous ECG signal of the user or the patient.

[0025] As shown in FIG. **2**, the phono-electro-cardiogram sensor button **1** comprising an electrical conductive button body **2** as the first electrode E**1** to be used in contact with a part of user's body and an electrical conductive panel **3** as the second electrode E**2** to be used in contact with another part of the user or the patient's body for detecting the continuous ECG signal of the user. It should be noted that any material that is capable of electrical conduction can be used for the electrical conductive button body **2** and the electrical conductive panel **3**.

[0026] As shown in FIG. **1**, the electrical conductive button body **2** and the electrical conductive panel **3** forms a circular phono-electro-cardiogram sensor button **1** that houses various components of the phono-electro-cardiogram sensor button **1** described hereafter. However, any variation of shape of the phono-electro-cardiogram sensor button **1** can be adapted, such as square, oval or any other geometric shapes.

[0027] To prevent electric conduction between the electrical conductive button body **2** and the electrical conductive panel **3**, an insulating medium is provided in between the electrical conductive button body **2** and the electrical conductive panel **3** for electrical isolation. As shown in FIG. **2**, as an insulating medium, the bottom edge **40** or the portion of the electrical conductive panel **3** that inserted into the electrical conductive button body **2** is made of electricity insulating material to prevent electrical conduction between the electrical conductive button body **2** and the electrical conductive panel **3**. In another embodiment, as shown in FIG. **2**, an insulating ring **50** is provided in the electrical conductive button body **2** to prevent electrical conduction between the electrical conductive button body **2** and the electrical conductive panel **3**.

[0028] As shown in FIG. **2**, the phono-electro-cardiogram sensor button **1** further comprising a circuit board **200** provided in the electrical conductive button body **2** and covered by the electrical conductive panel **3**. The phono-electro-cardiogram sensor button **1** further comprising a microphone **4** for detecting PCG signal during each heartbeat of the user, a memory **5** for storing ECG signal and PCG signal data, and at least one multifunction microprocessor **6** that electrically connected to the electrical conductive button body **2** and the electrical conductive panel **3** for processing the detected vital sign signal and controlling various components of the sensor button **1**, all of which, are mounted on the circuit board **200**.

[0029] As a preferred embodiment, the microphone **4** is provided with a sensitivity larger than 7.9 mV/Pa±2 dB at 1 kHz, and a frequency response between 20 Hz to 600 Hz and a S/N ratio of larger than 58 dB for optimal internal heart beat listening.

[0030] As shown in FIG. **2**, as a preferred embodiment, an opening **7** is provided on the electrical conductive panel **3** to allow the PCG signal reaches the microphone **4**. As a preferred embodiment, the opening **7** is covered by a membrane **8** to allow amplification for specific frequencies of PCG signal generated by each heartbeat of the user or the patient to be detected by microphone **4**. The membrane **8** is also useful when the sensor button **1** is placed in other part of user's body rather than the chest to detect other internal organ sound. In this setting, the membrane **8** would allow the sensor button **1** to detect both low and high audio frequencies for cross reference of the diagnosis.

[0031] As shown in FIG. **2**, as a preferred embodiment, the sensor button **1** is provided with a LED light **9** mounted on the circuit board **200** for various operation feedbacks and indicating the area of contact for electrical conduction panel **3** on the user or the patient's body. The LED light **9** may glow through the opening **7** or through the membrane **8** on the electric conductive panel **3**, or a separate opening for the LED light **9** may be provided on the electric conductive panel **3**. Additional LED light may also be added to the sensor button **1** for various indications.

[0032] As shown in FIG. **2**, as a preferred embodiment, the phono-electro-cardiogram sensor button **1** further comprising a first wireless module **24** mounted on the circuit board **200** for wireless communicating and transmitting the ECG signal and PCG signal data detected by the phono-electro-cardiogram sensor button **1** to a work station for further processing and storing and for communication with other external devices. The first wireless module **24** may adapt Wi-Fi, 4G, Bluetooth or other similar communication method.

[0033] As shown in FIG. **3**, as a preferred embodiment, the first wireless module may also be used for uploading ECG

signal and PCG signal data in the phono-electro-cardiogram sensor button **1** to a personal cloud for storing and sharing with authorized individuals. The authorized individuals may download the ECG signal and PCG signal data of the user via a cellphone, tablet computer or other handheld electronic devices.

[0034] As shown in FIG. **4**, as a preferred embodiment, the work station can be placed in a physical location such as home or office of the user. The work station in this embodiment can be a computer **100** which comprising at least a memory hard disk integrated with a second wireless module for wireless communication with the first wireless communication module **24** in the phono-electro-cardiogram sensor button **1** and other authorized devices, medical algorithms, a process interface that receives, processes, stores and forwards vital sign data received from the phono-electro-cardiogram sensor button **1** to other authorized external devices via the second wireless module and a display module that displays graphic representation of the vital sign data received and allowing videoconferencing over the display module. In one embodiment, the display module can be a computer monitor **110** or any other type of display screen. The second wireless module may adapt Wi-Fi, 4G, Bluetooth or other similar communication method. In another embodiment, the work station can also be in the form of a laptop computer **60** or a handheld personal electronic device to be carried by the user or medical staff, such as a cellphone **120** or a tablet computer **130**. In addition, as another preferred embodiment, as shown in FIG. **3**, the phono-electro-cardiogram sensor button **1** can be adapted via the first wireless module **24** to wirelessly connect to other external devices such as a medical device **70** for a more comprehensive medical diagnosis. The medical device **70** in this instance may include heart assist device like LVAD or artificial heart and an implantable pacemaker, defibrillator, as well as implantable devices for heart insufficiency like CRT (Cardiac Resynchronization Therapy) or CCM (Cardiac Contractility Modulation).

[0035] In one embodiment, a communication interface (not shown in the drawing) can be provided for the phono-electro-cardiogram monitoring unit to enable a remote communication and access of the vital sign data store in the phono-electro-cardiogram sensor button and the work station by the user, or by the authorized emergency contacts and the medical service center wirelessly via an external device. This communication interface can be a computer software or a downloadable App.

[0036] As a preferred embodiment, the phono-electro-cardiogram sensor button **1** can be combined with a wearable device or a hand held device or being designed to be used itself as a wearable or portable device or be a portable device able to be transformed to a wearable by getting connected to a bracelet, necklace or belt or be inserted into a clothing. As a preferred embodiment, as shown in FIG. **5**, the phono-electro-cardiogram sensor button **1** is provided in a matching shape to be inserted into a matching cavity provided on an outer surface of a wrist band **90**. As a preferred embodiment, the wrist band **90** is made of soft flexible, waterproof and antibacterial material for comfortable fitting and easy cleaning.

[0037] When using the phono-electro-cardiogram sensor button **1** to detect ECG and PCG signal, as shown in FIG. **6**, for which the phono-electro-cardiogram sensor button **1** is incorporated with a wrist band **90**, the user would place the electrical conductive panel **3** against the chest, and at the same time, the bottom surface of the electrical conductive button body **2** would be pushed against the user's wrist to complete an electrode cycle for ECG reading. During this operation, the microphone **4** in the phono-electro-cardiogram sensor button **1** also detects the user's PCG signal. As shown in FIG. **7**, once the ECG signal **101** and the PCG **102** signal are detected by the sensor button **1**, the ECG signal **101** and the PCG signal **102** are first amplified by an amplifier circuit **103** provided in the phono-electro-cardiogram sensor button **1**. The amplified ECG signal **101** is then processed by the multifunction microprocessor **6**. Such process by the multifunction microprocessor **6** would include processing the ECG signal **101** from analog signal into digital signal. Once processed, the ECG signal **101** is then stored in the memory **5** or be wirelessly transmitted to a work station **100**, such as a computer **100** or other external device such as the medical device **70** for further processing and storing. The amplified PCG signal **102** is then filtered by a bandpass filter circuit **104** mounted on the circuit board **200** in the phono-electro-cardiogram sensor button **1**. The bandpass filter circuit **104** is set at PCG: 20~600 Hz for optimal wireless transmission or output of PCG signal **102** at a later time. Once filtered, the PCG signal **102** is then denoised by a noise reduction chip **105** provided in the phono-electro-cardiogram sensor button **1**. Once denoised, the PCG signal **102** can then be output to an audio device **200**, such as a speaker or an earphone, or is then processed by the multifunction microprocessor **6**. Such process by the multifunction microprocessor **6** would include processing the PCG signal **102** from analog signal into digital signal. Once processed, the PCG signal **102** is then stored in the memory **5** or be wirelessly transmitted to the work station **100** or other external device such as the medical device **70** for further processing and storing.

[0038] In another usage of the phono-electro-cardiogram sensor button **1**, to do a quick ECG reading, as shown in FIG. **8**, for which the phono-electro-cardiogram sensor button **1** is incorporated with a wrist band **90**, the user would simply touch the electrical conductive panel **3** with one finger of the other hand to complete an electrode cycle for ECG reading.

[0039] As shown in FIG. **9** and FIG. **10**, in one embodiment, the phono-electro-cardiogram sensor button **1** is provided with a connecting port **12** mounted on the circuit board **200** and a connecting line **13** for connecting the phono-electro-cardiogram sensor button **1** to a work station **100**, an external power source or other external devices. The work station **100** can be a computer. The other external device can be a handheld personal electronic device or a medical device **70**, such as a blood pressure monitor (Sphygmomanometer), a blood sugar monitor, a blood-clotting monitor, an ECG recorder or an EEG recorder, an ECG Recording devices, like a Holter Monitors and Loop or Event Recorders, a Wearable Cardioverter Defibrillator (WCD), a patient Monitoring systems for ambulatory or intensive care, ambulatory Blood pressure monitoring (ABPM), an echo machine, a stethoscope, a patient Monitoring systems for ambulatory or intensive care, a Heart-Catheter Laboratory, an Intracardial Ultrasound, an IVUS (Intravascular Ultrasound) or Optical Coherence Tomography (OCT) and a heart pressure measurement by heart catheter (CVC, Right and left heart catheter, FFR and iFR) and solutions for cardiac output measurements (PiCCO). The connecting port **12** may be

adapted a micro USB port or other similar port and the connecting line **13** may be adapted a universal connecting cable.

[0040] As shown in FIG. **9**, in one embodiment, the phono-electro-cardiogram sensor button **1** is provided with an on/off switch **10** and a power control chip **11** mounted on the circuit board **200** for operating requests and turning off the phono-electro-cardiogram sensor button **1** when not using the unit to prolong operation time. The phono-electro-cardiogram sensor button **1** can be turned on or off by pressing and holding the switch **10** for two seconds. Once the phono-electro-cardiogram sensor button is turned on, various operation functions can be access by a quick press and release the switch **10**. As an added function, if no vital sign signal is received for a time period of 30 seconds, the power control chip **11** triggers the phono-electro-cardiogram sensor button **1** into a hibernating mode to further minimize power consumption.

[0041] As shown in FIG. **9**, in one embodiment, the phono-electro-cardiogram sensor button **1** is provided with a rechargeable battery **14** mounted on the circuit board **200** for providing an internal power to the phono-electro-cardiogram sensor button **1**. A rechargeable battery **14** can provide the needed power to run the sensor button **1** around the clock. A typical rechargeable battery can provide enough power to run the sensor button 24 hours a day for a number of days before the need to be recharged.

[0042] As shown in FIG. **9** and FIG. **11**, as a preferred embodiment, to allow for uninterrupted vital sign monitoring and to save the trouble and time for replacing the battery, the rechargeable battery **14** is provided with a first inductive charging coil unit for wireless battery charging with an inductive battery charger **80** for attaching to the phono-electro-cardiogram sensor button **1**. The first inductive battery charging coil unit comprising a charging coil **15** and a microchip **16** for which are placed in the electrical conductive button body **2** and are covered by the electrical conductive panel **3**.

[0043] As shown in FIG. **12**, as a preferred embodiment, the inductive battery charger **80** provided in the present invention comprising an electrical conductive panel matching charger casing **17** and a top casing **171** that forms a hollow inductive battery charger body, with at least one magnet **18** provided at bottom side of the charger casing **17** for attaching to the surface of the electrical conductive panel **3**. The charger casing **17** which houses a second inductive charging coil unit which comprising an inductive charging coil **19**, a circuit board **300**, a microchip **20**, a battery **21** and a LED back light **22**. The inductive charging coil **19** and battery **21** are electrically connected to the circuit board **300**, and the microchip **20** and the LED back light **22** are mounted on the circuit board **300**. When recharging the inductive battery charger **80**, the inductive battery charger **80** can be placed at any wireless charging station. Once fully charged, the LED back light **22** on the inductive battery charger **80** will flash rapidly. As shown in FIG. **5**, when the power in the battery of the sensor button **1** is low, which can be indicated by a rapid flash of the LED light **9** on the sensor button **1**, the user can simply attach the inductive battery charger **80** to the surface of the electrical conductive panel **3**, for which, the magnets **18** provided on the inductive battery charger **80** will adhere to any metal surface on the electrical conductive panel **3**. Once adhered, the second inductive charging coil unit in the battery charger **80** will create an electromagnetic field and induces a current in the first inductive charging coil unit and start the charging process of the rechargeable battery **14**. Once the rechargeable battery **14** is fully charged, which can be indicated by the dimming of the LED light **9** on the sensor button **1**, the user can simply reattach the inductive battery charger **80**.

[0044] As shown in FIG. **9**, as a preferred embodiment, the phono-electro-cardiogram sensor button **1** further comprising at least one physiological sensor **23** placed on the bottom of the electrical conductive button body **2**. The physiological sensor **23** can be provided in, but electrically isolated from electrical conductive button body **2** and is covered by the electrical conductive panel **3**. The physiological sensor **23** can be used to measure the user's vital sign which can include heart rate, pulse rate, body temperature, Pulse Oximetry, Respiration Rate, Electrodermal Activity (EDA), Electroencephalography (EEG), Electromyography (EMG), Electroneurography (ENG) and combinations thereof.

[0045] As shown in FIG. **9**, in one embodiment, the phono-electro-cardiogram sensor button **1** further comprising a speaker **25** for voice communication with emergency contacts or medical center and for playing operation, advice and warning messages. An emergency contact or medical service center can be connected to the first wireless module **24** in the sensor button **1** via an external device, such as a cell phone or a computer, to have a wireless conversation with the user on the speaker **25**. Depending on the setting, the speaker **25** can also be set to play various operating and warning messages, as well as the heart sound of the user when using the sensor button **1**.

[0046] As shown in FIG. **9**, in one embodiment, the phono-electro-cardiogram sensor button **1** further comprising a vibration mechanism **26** mounted on the circuit board **200** for additional operation feedbacks. The vibration mechanism **26** may vibrate to alert the user of various operation and warning conditions. The vibration mechanism **26** can also be turned off depending on user's setting.

[0047] As a preferred embodiment, the phono-electro-cardiogram sensor button **1** can wirelessly via the first wireless module **24**, or via the connecting cable **13**, connect to the work station **100** for setting various default functions of the phono-electro-cardiogram sensor button **1**, for manually transferring vital sign data form the memory **5** to the work station **100**, or for setting up contact list by entering contact's phone numbers.

[0048] As a preferred embodiment, the medical algorithms provided in the work station **100** constantly compare the vital sign data received from the phono-electro-cardiogram sensor button **1** for any pathologic measurements that might reflect a change in user's health condition. In the event a pathologic measurement is determined, the work station **100** sends a warning signal to the phono-electro-cardiogram sensor button **1** to alert the user. Depending on the criticalness of the pathologic measurement, the work station **100** can send an alert signal to the phono-electro-cardiogram sensor button **1** to trigger the LED light **9** to flash, the vibration mechanism **26** to vibrate or to send a voice message to be played via the speaker **25**. This alert signal can be sent repeatedly in a preset time interval until the situation has been taken care of. If a more dire pathological measurement is determined, the work station can also send an alert signal to the emergency contacts and medical service center for immediate situation control.

[0049] In one embodiment, the phono-electro-cardiogram sensor button **1** maybe also provided with medical algorithms for comparing the vital sign data within the sensor button **1**. In the event a pathologic measurement is determined, the sensor button **1** triggers a warning signal to alert the user.

[0050] In another embodiment, as shown in FIG. **13**, the Phono-Electro-Cardiogram Monitoring Unit may comprise at least one independent electrode conductive patch **27** as a third electrode to be attached to a part of the user's body. The electrode conductive patch **27** may be connected to the phono-electro-cardiogram sensor button **1** by a connecting line. This connecting line may be permanently fixed onto the phono-electro-cardiogram sensor button **1** or by plug-in. The electrode conductive patch **27** may be placed at right chest apex P**1**, at left chest apex P**3** or at epigastrium P**2**. Other placement of the third electrode conductive patch **27** may be in accordance with augmented unipolar limb lead such as I, II, III (Einthoven leads), aVL, aVF and aVR (Goldberger leads) and in case of positioning all three additional electrodes can virtually calculate the **6** classical left Chest leads (Wilson leads), as well as right chest leads, to more accurately detect a right heart attack. Additional electrode conductive patch can be added to the unit by design. In this preferred embodiment, the second and the third electrode may be used interchangeably with the first electrode for detecting ECG signal of the user.

[0051] The present invention also provides a method for detecting, processing, storing and monitoring PCG signal and PCG signal, and at least one other vital sign of a user comprises a wearable vital sign monitor, such as the phono-electro-cardiogram sensor button **1** described herein, that detects, stores and transmits ECG signal and PCG signal data and at least one other vital sign data group consisting of heart rate, pulse rate, body temperature, blood pressure, respiration rate and combinations thereof. The method also comprises a work station for receiving, processing, storing and transmitting the vital sign data received from the wearable vital sign monitor to other external devices. The work station can be a computer **100** described herein to placed in any physical location such as user's home or office. And finally, the method also including a personal cloud to securely store and share important vital sign data of a user.

[0052] As shown in FIG. **14**, in order to monitor vital sign data and maintain important vital sign data, the method delegates the wearable vital sign monitor to perform a full vital sign data transmission wirelessly to the work station for storing and processing and to the personal cloud for secure storing and sharing in the following events:

(1) once a day at a predetermine time, such as 03:00 AM;

(2) when the wearable vital sign monitor storage is full; and

(3) when the wearable vital sign monitor performs an ECG or PCG scan.

[0053] Once the data is fully transmitted to the work station and the personal cloud all content in the wearable vital sign monitor memory is then cleared to make room for subsequent vital sign data storing.

[0054] In addition, the method also delegates the wearable vital sign monitor to responds to a measurement request sent from the work station and triggers a full data transmission.

[0055] In the event that no connection to the work station and the personal cloud can be established and the memory in the wearable vital sign monitor is full, the method delegates the wearable vital sign monitor to perform as least one of the following actions to make room in the memory for any new vital sign data:

[0056] (1) keeping new data as priority compared to older measurements: cycle storage: erase older data; and

[0057] (2) keep pathologic data as priority before new measurements: don't overwrite important data; and

[0058] (c) by user's selection, the ECG signal and PCG signal detected are immediately transmitted as raw data to the work station for processing and storing to save memory storage.

[0059] As shown in FIG. **15** and FIG. **16**, the work station **100** is provided with algorithms **101** for calculating the abnormal vital signs, such as ECG and PCG signal, or any other above-mentioned vital sign signal received from the phono-electro-cardiogram sensor button **1**. An algorithm for abnormal heart beats per minute is shown in FIG. **14**. As shown in FIG. **15**, in the event of abnormal ECG and PCG activity or abnormal other vital signs detected by the algorithm in the work station, such as heart beats per minute, the work station triggers the the phono-electro-cardiogram sensor button **1** to perform as least one of the following action to alert the user:

(1) a light-emitting diode light status indicator **9** provided in the wearable vital sign monitor flashes;

(2) a vibration mechanism **26** provided in the phono-electro-cardiogram sensor button **1**; and

(3) a voice warning message with a recommended course of action to be taken is played on a speaker **25** in the phono-electro-cardiogram sensor button **1**.

[0060] In the event that any of the above action is triggered the vital sign data is immediately transmitted to the work station and the personal cloud, and the data is marked as abnormal. This step is repeated every 15 seconds until a manual cancellation of monitoring by the user.

[0061] As shown in FIG. **16**, in the event of emergency heart rate activity detected by the algorithm **101** in work station **100**, such as heart beats per minute, the work station triggers the phono-electro-cardiogram sensor button **1** to perform as least one of the following actions:

(1) the light-emitting diode light status indicator **9** provided in the phono-electro-cardiogram sensor button **1**;

(2) the vibration mechanism **26** provided in said wearable vital sign monitor vibrates; and

(3) a voice warning message with a recommended course of action to be taken is played on a speaker **25** in the phono-electro-cardiogram sensor button **1**.

[0062] In the event any of the above action is triggered the vital sign data is immediately transmitted to the work station **100** and the personal cloud, and the data is marked as emergency.

[0063] In the event that no manual cancellation of the monitoring by the user is recorded within two minutes from the first instance of the data that is marked as emergency, an alert from the work station is sent to designated emergency contacts or medical service center for immediate attention.

[0064] The method also allows user to configure the work station to set three levels of attention modes for vital sign data transmitting to designated emergency contacts or medical service center:

[0065] (a) First level: Daily Healthcare Mode: a default mode, the data is transmitted to the work station and the personal cloud at a daily basis at a predetermined time;

[0066] (b) Second level: Watch Me Mode: the data is transmitted to the work station and the personal cloud once every 15 minutes; and

[0067] (c) Third level: Hospital Mode: the data is sent to the work station and the personal cloud once every minute.

[0068] In addition, a designated emergency contact or medical service center is allowed to request the most recent data from the work station via a hand held device or a computer. Such request triggers a new measurement request to the wearable vital sign monitor and the new data is transmitted and processed in the work station and then transmitted to the requested designated emergency contact or medical service center's hand held device or computer.

[0069] And finally, as shown in FIG. **16**, the method also incorporates a gravity sensor **102** and a proximity sensor **103** along with the microphone in the wearable vital sign monitor for fall down detection of the user and increasing accuracy to avoid false alarm by additionally sensing sudden change in heart rate or artefact and impact sound.

[0070] Although the invention has been explained in relation to its preferred embodiment, it is to be understood that many other possible modifications and variations can be made without departing from the spirit and scope of the invention as hereinafter claimed.

1. A Phono-Electro-Cardiogram Monitoring Unit comprising a phono-electro-cardiogram sensor button for electrical conduction of the electrical potential changes arising from the heart activity; wherein said phono-electro-cardiogram sensor button comprising an electrical conductive button body as a first electrode to be used in contact with a part of a user or a patient's body and an electrical conductive panel as a second electrode to be used in contact with another part of the user or the patient's body for detecting the continuous electrocardiography signal of the user; wherein, an insulating ring is provided in said electrical conductive button body for electrical isolation between said electrical conductive button body and electrical conductive panel; wherein said phono-electro-cardiogram sensor button further comprising a circuit board provided in said electrical conductive button body and covered by said electrical conductive panel; wherein a microphone for detecting phonocardiogram signal during each heartbeat of the user, a memory, at least one multifunction microprocessor all of which are mounted on said circuit board; wherein, said electrical conductive button body and electrical conductive panel are electronically connected to said multifunction microprocessor; wherein, an opening is provided on said electrical conductive panel to allow the heart sound signal reaches said microphone; and wherein, said phono-electro-cardiogram sensor button detects electrocardiography signal and phonocardiogram signal simultaneously and said detected electrocardiography signal and phonocardiogram signal are processed by said multifunction microprocessor and the processed electrocardiography signal and phonocardiogram signal data are stored in said memory.

2. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said microphone has a sensitivity larger than 7.9 mV/Pa±2 dB at 1 kHz, and a frequency response between 20 Hz to 600 Hz and a S/N ratio of larger than 58 dB for the best result but not necessary limited to this range.

3. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said opening is covered by a membrane to allow amplification for specific frequencies of signal generated by each heartbeat of the user to be detected by said phono-electro-cardiogram sensor button.

4. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button is provided in a matching shape to be inserted into a matching cavity provided on an outer surface of a wearable device or a hand held device.

5. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising at least one physiological sensor mounted on said circuit board; and wherein, said physiological sensor measures the user's vital sign is selected from a group consisting of heart rate, pulse rate, body temperature, blood pressure, respiration rate and combinations thereof.

6. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising a connecting port mounted on said circuit board for connecting said phono-electro-cardiogram sensor button to a work station or an external device; wherein, said connecting port is provided with a cable line for connecting said phono-electro-cardiogram sensor button to said work station or external device; and wherein, said external device is a computer, a handheld personal electronic device, a medical device, or a power source.

7. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising a first wireless module mounted on said circuit board for wireless communication and transmitting the electrocardiography signal and phono-cardiogram signal data detected by said phono-electro-cardiogram sensor button to a work station, a personal cloud or an external device for processing, storing and sharing data; and wherein, said external device is a computer, a handheld personal electronic device, or a medical device.

8. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **7** wherein, said phono-electro-cardiogram sensor button further comprising a bandpass filter circuit mounted on said circuit board; and wherein, said bandpass filter circuit is set at 20~600 Hz for optimal wireless transmission of the electrocardiography signal and phono-cardiogram signal to said work station or other external devices.

9. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising a rechargeable battery mounted on said circuit board for providing internal power to said phono-electro-cardiogram sensor button.

10. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **9** wherein, said rechargeable battery is provided with a first inductive charging coil unit for wireless battery charging with an inductive battery charger; and wherein, said first inductive charging coil unit comprising a charging coil and a microchip.

11. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **10** wherein, said inductive battery charger comprising an electrical conductive panel matching charger casing and a top casing with at least one magnet provided at bottom side of said charger casing for attaching to said electrical conductive panel; and wherein, said charger casing which houses a second inductive charging coil unit; and said second inductive charging coil unit comprising an inductive

charging coil, a circuit board, a microchip, a battery and a light-emitting diode back light.

12. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising an on/off switch and a power control chip mounted on said circuit board for operating requests and turning off the unit or said switching phono-electro-cardiogram sensor button to hibernating mode when not using to prolong operation time.

13. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising a speaker mounted on said circuit board for voice communication with emergency contacts or medical service center, and for playing operation, advice and warning messages.

14. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising a light-emitting diode light mounted on said circuit board for operation feedback and indicating the area for electrical conduction panel of the said phono-electro-cardiogram sensor button on the user's body.

15. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising a vibration mechanism mounted on said circuit board for operation feedbacks.

16. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **6** wherein, said work station is to be placed in a physical location such as home or office of the user or in the form of a hand held device to be carried by the user or medical staff; it is characterized that said work station comprising at least a memory hard disk integrated with a second wireless module for wireless communication with the first wireless communication module in said phono-electro-cardiogram unit and other authorized external devices, medical algorithms, a process interface that receives, processes, stores and forwards vital sign data from said phono-electro-cardiogram sensor button to other authorized external devices via the second wireless module and a display module that displays graphic representation of the vital sign data received and allowing videoconferencing with the user over the display module; and it is characterized that said work station sends a warning signal to emergency contacts or medical service center in the event that said medical algorithms determines a pathologic measurement that might reflect a change in user's health condition.

17. The Phono-Electro-Cardiogram Monitoring Unit as claimed in claim **1** wherein, said phono-electro-cardiogram sensor button further comprising at least one independent electrode conductive patch as a third electrode to be attached to a part of the user or the patient's body; and wherein, said electrode conductive patch is connected to said phono-electro-cardiogram sensor button by a connecting line.

18. A method for detecting, processing, storing and monitoring electrocardiography signal and phonocardiogram signal, and at least one other vital sign of a user or a patient comprising:

a phono-electro-cardiogram monitoring sensor button that detects, stores and transmits electrocardiography signal and phonocardiogram signal, and at least one other vital sign data group consisting of heart rate, pulse rate, body temperature, respiration rate and combinations thereof; wherein,

a work station that receives, stores, processes and transmits vital sign data received from said phono-electro-cardiogram monitoring sensor button;

a personal cloud that receives, stores and shares vital sign data received from said phono-electro-cardiogram monitoring sensor button; wherein,

said phono-electro-cardiogram monitoring sensor button performs a full vital sign data transmission wirelessly to the work station and the personal cloud in the following events:

(1) once a day at a predetermine time;

(2) when said phono-electro-cardiogram monitoring sensor button memory is full; and

(3) when said phono-electro-cardiogram monitoring sensor button performs a electrocardiography or phono-cardiogram scan; wherein,

once the data is fully transmitted to said work station and the personal cloud all content in a memory in said phono-electro-cardiogram monitoring sensor button is then cleared to make room for subsequent vital sign data storing; wherein,

said phono-electro-cardiogram monitoring sensor button also responds to a measurement request sent from said work station and triggers a full data transmission; and wherein, in the event no connection to said work station or the personal cloud is established and the storage is full said phono-electro-cardiogram monitoring sensor button performs as least one of the following actions:

(1) keeping new data as priority compared to older measurements: cycle storage: erase older data; and

(2) keep pathologic data as priority before new measurements: don't overwrite important data; and

(3) by selection, the electrocardiography signal and phonocardiogram signal are raw data transmitted to said work station and personal cloud for processing and storing to save memory storage.

19. The method for collecting, processing, storing and monitoring vital sign of a user as claimed in claim **18** wherein, in the event of abnormal electrocardiography signal and phonocardiogram signal activity or abnormal other vital signs detected by the work station, the work station triggers said phono-electro-cardiogram monitoring sensor button to perform as least one of the following actions to alert the user:

(1) a light-emitting diode light status indicator provided on said phono-electro-cardiogram monitoring sensor button flashes;

(2) a vibration mechanism provided in said phono-electro-cardiogram monitoring sensor button vibrates; and;

(3) a voice warning message with a recommended course of action to be taken is played on said phono-electro-cardiogram monitoring sensor button; wherein, in the event that any of the above action is triggered the vital sign data is immediately transmitted to said work station and the data is marked as abnormal; and this step is repeated every 15 seconds until a manual cancellation of said phono-electro-cardiogram monitoring sensor button by the user.

20. The method for collecting, processing, storing and monitoring vital sign of a user as claimed in claim **18** wherein, in the event of emergency heart rate activity detected by the work station, said phono-electro-cardiogram monitoring sensor button performs as least one of the following actions:

(1) a light-emitting diode light status indicator provided on said phono-electro-cardiogram monitoring sensor button flashes;

(2) a vibration mechanism provided in said phono-electro-cardiogram monitoring sensor button vibrates; and;

(3) a voice warning message with a recommended course of action to be taken is played on said phono-electro-cardiogram monitoring sensor button; wherein,

in the event any of the above action is triggered the vital sign data is immediately transmitted to the work station and the data is marked as emergency; and in the event that no manual cancellation of the monitoring by the user is recorded within two minutes from the first instance of the data is marked as emergency, an alert from the work station is sent to designated emergency contacts, medical service center or emergency department.

21. The method for collecting, processing, storing and monitoring vital sign of a user as claimed in claim **18** wherein, said work station is configured to allow the user to set three levels of attention modes for data transmitting to designated emergency contacts or medical service center:

(a) First level: Daily Healthcare Mode: a default mode, the data is transmitted to the work station and the personal cloud at a daily basis at a predetermined time;

(b) Second level: Watch Me Mode: the data is transmitted to the work station and the personal cloud once every 15 minutes; and

(c) Third level: Hospital Mode: the data is sent to the work station and the personal cloud once every minute; and wherein,

a designated emergency contact or medical service center is allowed to request the most recent data from said work station via hand held device or a computer, such request triggers a new measurement request to said phono-electro-cardiogram monitoring sensor button and the new data is transmitted and processed in said work station and then transmitted to the requested designated emergency contact or medical service center's hand held device or computer.

22. The method for collecting, processing, storing and monitoring vital sign of a user as claimed in claim **18** wherein, said wearable vital sign monitor incorporates a gravity sensor and a proximity sensor with a microphone in said phono-electro-cardiogram monitoring sensor button for fall down detection of the user and increasing accuracy to avoid false alarm by additionally sensing sudden change in heart rate or artefact and impact sound.

* * * * *

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CPC分类号	A61B5/02055 A61B2505/07 A61B5/0408 A61B5/04017 A61B5/044 A61B5/741 A61B5/7455 A61B5/1117 A61B5/0006 A61B5/0022 A61B5/002 H02J7/025 A61B2560/0214 A61B2560/0431 A61B7/04 A61B5/0205 A61B5/0404 A61B5/681 A61B2562/227 G16H40/67 H02J7/00034 H02J50/10		
外部链接	Espacenet USPTO		

摘要(译)

一种声 - 电 - 心电图监测单元，其检测和监测ECG和PCG信号，其包括能够电传导由用户或患者的心脏活动引起的电位变化的声电心电图传感器按钮。传感器按钮包括允许同时检测心电图信号和心音图信号的麦克风，并且检测到的心电图信号和心音图信号由多功能微处理器处理，并且处理后的心电图信号和心音图信号数据存储在存储器中或传输到工作站点或个人云，用于进一步处理和存储数据可以通过无线连接转发给授权个人进行通信，解释，服务和帮助。