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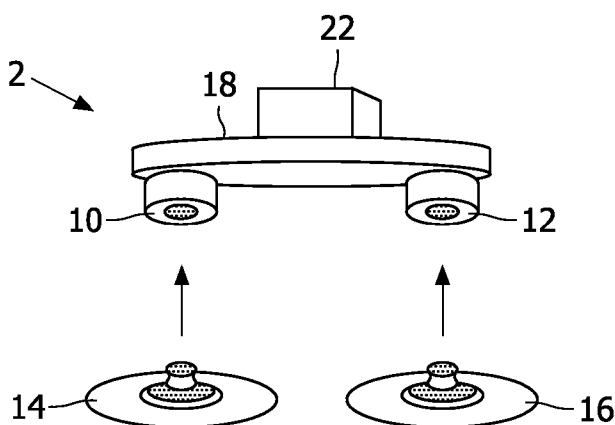


FIG. 1

(57) Abstract: A measuring device for attaching to the human body includes a number of ECG electrodes (14,16) supported on a deformable bridge (18) with a strain sensor (20). The unit can be attached to the upper body of a patient, for example with one electrode (14) on the sternum and the other (16) on the abdomen, and the strain sensor used to measure respiration using the electrodes as purely mechanical couplings whilst the electrodes are used at the same time to measure the electrical excitation of the heart, which is the ECG.

MEASUREMENT APPARATUS AND METHOD

FIELD OF THE INVENTION

The invention relates to a measurement apparatus and method for measuring a number of parameters, including in particular an electrocardiogram (ECG).

BACKGROUND OF THE INVENTION

A particular measurement that is often required in a clinical setting is an electrocardiogram (ECG) measurement. An ECG is generally measured using a number of electrodes placed on the body of a subject some distance apart. Electrical signals measured between pairs of electrodes make up the ECG.

SUMMARY OF THE INVENTION

According to the invention, there is provided a measurement device according to claim 1.

The electrodes required for the ECG measurement are affixed to a deformable mechanical bridge, and a deformation sensor is provided integrated with this bridge. While the electrodes stick to the skin, they will pick up ECG, but they will also transfer the mechanical chest deformation caused by respiration to the deformable bridge. The bridge will give way, such that the force is exerted on the deformation sensor embedded into it. This way, the deformation sensor will respond to respiratory action deforming the chest, while the electrodes will pick up the ECG.

In particular, the use of a deformable bridge between the glued ECG electrodes adds additional functionality without requiring additional electrodes to be fixed to the upper body of the subject and provides a reliable respiration measurement through the deformation sensor integrated in the bridge.

The use of glued ECG electrodes significantly improves the reliability of the respiration measurement compared with an alternative not using glued electrodes. Also for the ECG measurement, it is advantageous to use glued electrodes because they allow a very high signal quality immediately after gluing them on the skin. Achieving excellent signal

quality immediately is particularly important in a hospital or emergency setting, since the speed of obtaining reliable measurements can be critical in a life-threatening situation.

With dry electrodes that are for example integrated in a chest strap and not glued to the skin, this is not possible, because they require several minutes before the signal quality is acceptable for a clinical setting.

The measurement device can be a compact unit, which allows to apply it rapidly, even if the subject is unconscious, which again can be of particular importance in an emergency setting. It is not necessary to turn or lift the patient in order to apply the device, as it would be required in order to apply a strap running around the chest, for example.

The device is simply put / glued on the chest of the patient and can then immediately deliver both ECG and respiration measurements. Preferably, one of the electrodes is glued on the abdomen, in order to maximize the mechanical deformation due to respiration and hence to maximize the measurement effect for the deformation sensor located inside the deformable bridge between the electrodes.

An accelerometer can be integrated into the measurement device. This provides additional information, in particular about the activities of the subject. By monitoring the movement of the subject, artefacts in the ECG and respiration measurements caused by the movement can be detected and reduced with the help of signal processing techniques, increasing the reliability of the measurements and reducing the number of false alarms. In particular, movement caused by exercise can be detected and increases in heart rate caused by such exercise can be discounted as a medical problem.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, embodiments will now be described, purely by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows an embodiment of the invention

Fig. 2 shows the embodiment after assembly for use;

Fig. 3 shows the measurement using a sensor; and

Fig. 4 shows a block diagram of the embodiment of Figs. 1 to 3.

Like or similar components are given the same reference numbers in different Figures. The Figures are schematic and not to scale.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Referring to Figs. 1 to 4, an embodiment of the invention is a unit 2 including a first fitting 10, and a second fitting 12. These fittings are designed to accept a first ECG electrode 14 and a second ECG electrode 16. In a preferred setting, the first electrode is glued to the sternum and the second electrode is glued to the abdomen. The fittings 10,12 are made of metal to provide both a good mechanical attachment of the electrodes 14,16 as well as a reliable electrical contact to the electrodes.

A deformable bridge 18 spans the two fittings 10, 12. A strain sensor 20 (Fig. 3) is included in the deformable bridge 18. In one embodiment, the deformation sensor is a strain gauge sensor. In another embodiment, the deformation sensor is a piezo-resistive element that changes its electrical impedance in response to deformation. In the example, the strain sensor 20 is a piezo-resistive element.

The deformable bridge 18 is the only element linking the fittings 10, 12 which constitute a pair of fittings. In one embodiment the deformable bridge 18 is sized so that the distance between the fittings 10, 12 of the pair is suitable for mounting the first ECG electrode 14 on the sternum and the second ECG electrode 16 on the abdomen. Thus, the spacing between the centers of the fittings 10, 12 of the pair of fittings may be in the range 8 cm to 25cm. The deformable bridge may be in this range or slightly larger, say 8cm to 30cm, and the strain sensor 20 mounted between this pair.

In embodiments, additional ECG electrode fittings may be used other than the pair of ECG electrode fittings 10,12 around the strain sensor 20 since it is often needed to use more than two ECG electrodes.

The deformable bridge is relatively stiff in the sense that it returns to its natural shape when unstressed. It is substantially flat and flexes elastically. Nor does it plastically deform in use to any significant extent, i.e. it returns to its original size and shape when unstressed.

In one embodiment, the deformable bridge is made of a silicone material, e.g. Dow Corning Sylgard 186.

In another embodiment, the deformable bridge is a thin printed circuit board (PCB) that may also carry electrical components suitable for the analog and / or digital signal processing of the signals obtained from the electrodes and the other sensors.

In the preferred embodiment the bridge is sufficiently flexurally stiff that it holds the two fittings apart at the correct distance for mounting. If the bridge were a flexible strap or the like, during compression a strap would simply flex. In contrast, the use of glue

and a sensor allows the measurements to be carried out even when the bridge is in compression.

A further disadvantage of using a strap is that it would be much more difficult to mount the unit in a single operation on the patient. Instead it would be necessary to correctly position each of the electrodes and apply strain on the strap to ensure that during respiration the strap was under tension.

The bridge of the present invention is sufficiently stiff that it holds the two electrodes a suitable distance apart during mounting.

Control unit 22 is provided on the deformable bridge 18. The control unit is shown schematically in Fig. 4. It includes a small battery 24 and a wireless transceiver 26. The control unit also includes an analog to digital (A/D) converter 28 and a microcontroller 30.

The control unit also includes drive electronics 32 which includes a constant current source 34 which feeds a constant current through strain sensor 20, the voltage across the strain sensor 20 being measured by the A/D electronics. The measurement is illustrated in Fig. 3.

An accelerometer 36 is also provided, integrated in the control unit 22.

In use, the electrodes 14, 16 are fitted in fittings 10,12 (Fig. 2).

The sternum electrode is glued to the region of the sternum and the abdomen electrode is glued to the abdomen. This may be done using glue attached to the electrodes. A protective piece of plastic may cover the glue which can be removed to expose the glue to allow the electrodes to be glued to the skin.

The relative rigidity of the elastic bridge 18 allows the unit to be relatively simply affixed in a simple operation without requiring accurate alignment of multiple electrodes. The unit with electrodes can be simply attached without requiring complex belts or wiring, and without having to disturb a patient lying on his or her back since the unit can be simply applied on the front of the upper body. This can be of importance, especially in cases of emergency.

However, the relatively small size of the unit means that it can also be worn for extended periods. The unit is also suitable for patients not in an emergency or intensive care situation since the use of wireless communications means that the subject can move around. Further, the unit can be worn under clothing. Thus, the unit can be used to monitor subjects at risk of some condition even as they go about their daily routines.

This flexibility of the unit, in that it is usable in many applications from the emergency room to routine day to day monitoring, is a significant advantage.

As the subject breathes, the strain sensor is strained by the expansion and contraction of the chest. The location of the sensors on the abdomen and sternum maximizes the deformation of the mechanical bridge. The voltage across strain sensor 20 varies, and this is picked up by A/D converter 28 and passed to the microcontroller or processor 30.

Note that for the respiration measurement the electrodes 14, 16 are used solely as mechanical couplings. This allows both respiration and ECG measurements to be made continuously and simultaneously: there is no need to switch the electrodes electrically between one function and another that might be required using electrical respiration measurements of some kind, like a bio-impedance measurement of the chest, for example. This allows the electronics to reach a stable state more easily and hence enhances measurements, especially the ECG measurements which involve small signals and which could otherwise be easily disturbed.

The use of glued electrodes provides good coupling of the body and the strain sensor 20 and hence reliable results.

The use of the fittings 10,12 allows the electrodes 14,16 to be thrown away or sterilized and reused after each use.

At the same time, ECG measurements are made using the electrodes 14, 16, in this case as electrical contacts to the subject's body, again using A/D converter 28 and microcontroller 30.

Measurements of acceleration are also made by accelerometer 36 and these are likewise passed to microcontroller 30. The microcontroller processes the sensor signals in order to extract the respiration rate and heart rate information. The results are then transmitted through transceiver 26 to a processing unit.

The processing unit may be arranged to check the results and issue an alarm if certain predetermined limits are passed. The use of the acceleration sensor 36 as well as the strain sensor 20 allows the strain sensor measurements to be validated reducing the risk of false alarms.

Variations from the embodiment described above are of course possible.

Firstly, although in the embodiment the fittings are made of metal, other materials are possible. Separate connection may be made to the ECG electrodes if required.

Also, it is not necessary to use only the two ECG electrodes attached to the bridge. For some applications, one or more additional electrodes may be attached to the

bridge. Alternatively or additionally, additional ECG electrodes may be attached at other parts of the subject's body.

The sensor used to measure respiration need not be a piezoelectric sensor but other sensors suitable for measuring the strain or flexing of the bridge 18 may be used.

Some or all of the processing can be carried out in an additional unit, not in the control unit 22. Such an additional unit may be for example a Holter monitor or a monitoring unit in a hospital.

Wires may be used to connect to the unit, for example to reduce the dependence on the battery.

Instead of using removable electrodes 14, 16, the electrodes used may be permanently fixed to the bridge, in which case the bridge and electrodes represent a single unit. In this case, the electrode fittings may be nothing more than holes in the deformable bridge in which the electrodes are permanently mounted.

CLAIMS:

1. A measurement device, comprising:
 - a plurality of ECG electrode fittings (10,12) for accepting ECG electrodes (14,16) for gluing to the upper body of a subject;
 - an elastically deformable bridge (18) spanning the ECG electrode fittings holding the electrodes a predetermined distance apart in an unstrained state; and
 - a strain sensor (20) integrated into the bridge for measuring the deformation of the bridge.
2. A measurement device according to claim 1 wherein the elastically deformable bridge has a length between 8 cm and 30cm along the greatest linear dimension of the bridge, the elastically deformable bridge including a pair of the electrode fittings (10,12) spaced apart by between 5cm and 20cm with the strain sensor (20) mounted between the pair of electrode fittings (10,12).
3. A measurement device according to claim 2, wherein the ECG electrodes include a sternum electrode (14) for attaching to the sternum of a patient, and an abdomen electrode (16) for attaching to the abdomen of the patient, wherein the electrode fittings (10,12) for the sternum and the abdomen are spaced apart by the bridge to have a distance between the centers of the electrodes when the electrodes are fitted of between 8 cm and 25 cm.
4. A measurement device according to claim 1, 2 or 3 further comprising a control unit (22) for calculating heart and respiration activity from the ECG electrodes and strain sensor (20) respectively, the control unit (22) being mounted on the bridge (18).
5. A measurement device according to any preceding claim wherein the control unit includes:
 - a battery (24) for powering the unit;
 - a wireless transmitter (26) for transmitting data emitted by the unit; and

- a processor (30) for processing data captured by the ECG electrodes and strain sensor and for passing the output to the wireless transmitter.
6. A measurement device according to any preceding claim, further comprising an accelerometer (36) supported by the bridge (18).
7. A measurement device according to claim 6 when dependent on claim 5 wherein the processor is arranged to measure respiration rate both using the strain sensor (20) and the accelerometer (36) to validate the measured results.
8. A measurement device according to any preceding claim with the ECG electrodes (14,16) attached in the fittings (10,12) and with glue on the surfaces of the ECG electrodes (14) for attachment to a patient.
9. A method of fitting a measurement device according to any of claims 1 to 7, comprising:
- fitting electrodes (14,16) to the electrode fittings (10,12); and
 - gluing one electrode to the sternum and another to the abdomen of a patient.
10. A method according to claim 10 further comprising capturing ECG measurements using the ECG electrodes (14, 16) and respiration measurements using the strain sensor (20).

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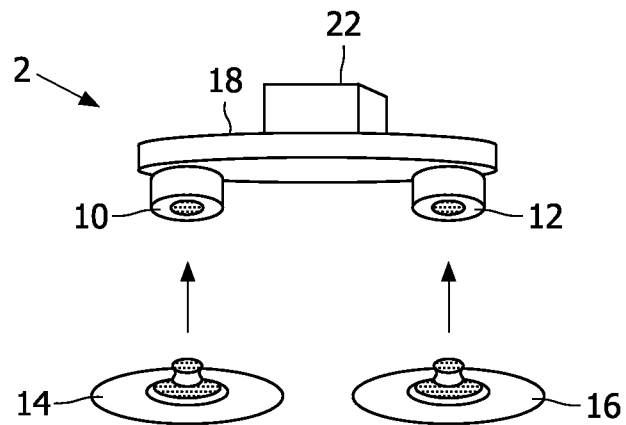


FIG. 1

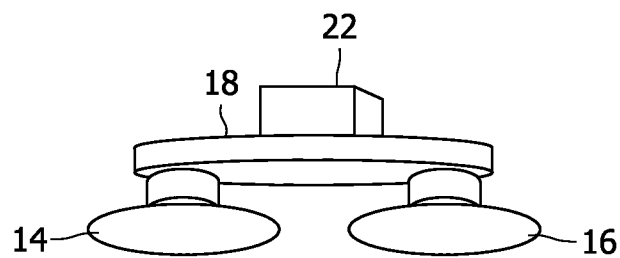


FIG. 2

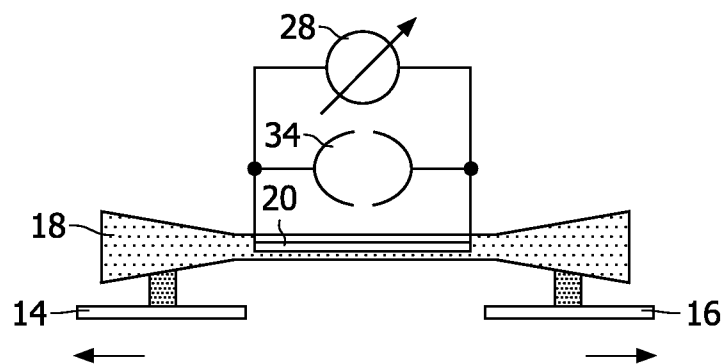


FIG. 3

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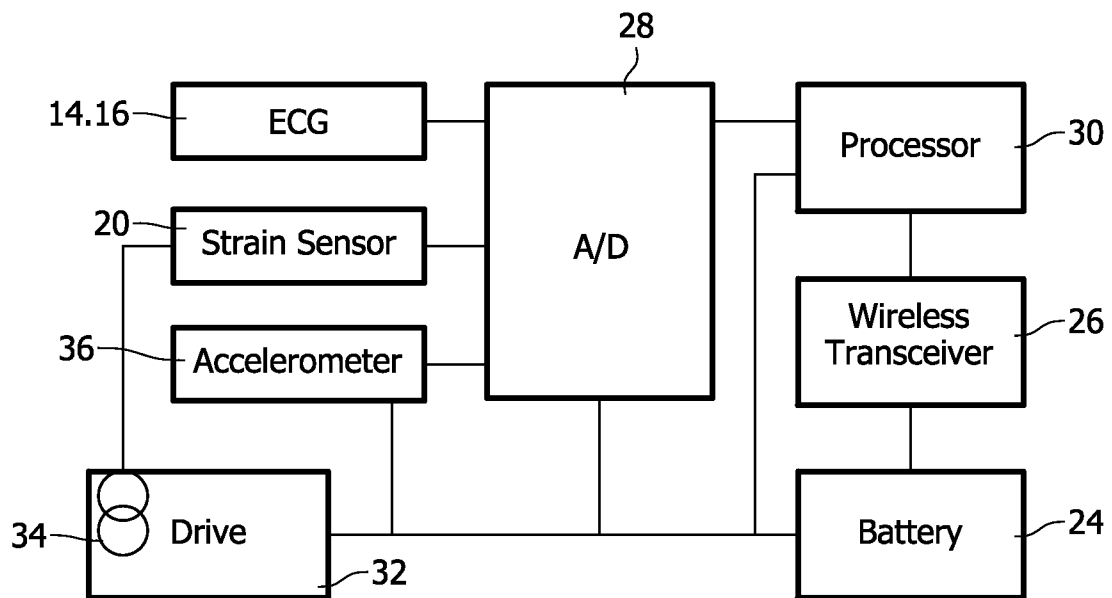


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No

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A. CLASSIFICATION OF SUBJECT MATTER
 INV. A61B5/0408 A61B5/113
 ADD. G01L1/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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