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(54) AN APPARATUS COMPRISING A FABRIC SUBSTRATE AND ELECTRODES

(57) An apparatus comprising: a fabric substrate; at least one sensing electrode at an interior surface of the fabric substrate for placement adjacent a first portion of a subject's body; at least one reference electrode at the interior surface of the fabric substrate for placement adjacent a second portion of a subject's body; and a first conductive interconnect connecting to the at least one reference electrode wherein the first conductive interconnect is arranged and positioned on a portion of the fabric substrate other than the interior surface of the fabric substrate to provide part of a shield to the at least one sensing electrode.

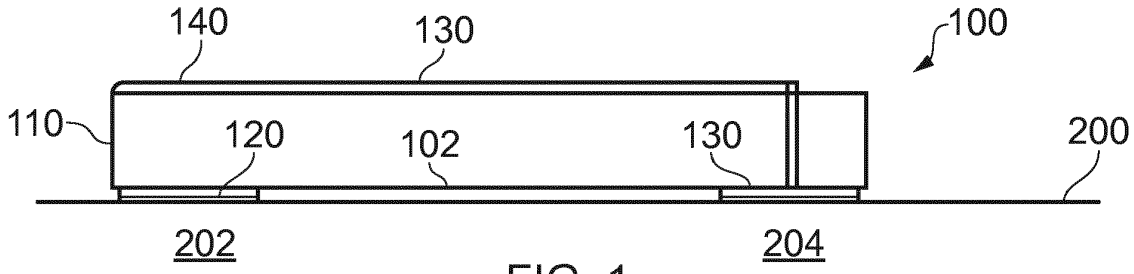

FIG. 1

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Description

TECHNOLOGICAL FIELD

[0001] Embodiments of the present invention relate to an apparatus comprising a fabric substrate and multiple sensing electrodes.

BACKGROUND

[0002] A sensing electrode may be placed adjacent a portion of a subject's body to sense a bio signal from the subject's body. This may, for example, be useful in impedance tomography, sensing of electrocardiograms (ECG) or in other measurements of electrical signals and/or impedance.

[0003] In some circumstances, the anxiety induced by taking measurements in a clinical situation can change measurements.

[0004] Also it may be uncomfortable or inconvenient for a subject when measurements need to be taken over an extended period of time.

[0005] It would therefore be desirable to be able to take measurements using an electrode outside of a clinical environment and/or over an extended period of time in a manner that is comfortable to the subject.

BRIEF SUMMARY

[0006] According to various, but not necessarily all, embodiments of the invention there is provided an apparatus comprising: a fabric substrate; at least one sensing electrode at an interior surface of the fabric substrate for placement adjacent a first portion of a subject's body; at least one reference electrode at the interior surface of the fabric substrate for placement adjacent a second portion of a subject's body; and a first conductive interconnect connecting to the at least one reference electrode wherein the first conductive interconnect is arranged and positioned on a portion of the fabric substrate other than the interior surface of the fabric substrate to provide part of a shield to the at least one sensing electrode.

[0007] In some, but not necessarily all examples, the first conductive interconnect is a fabric conductive-interconnect at a first surface of the fabric substrate that is not an interior surface of the fabric substrate.

[0008] In some, but not necessarily all examples, the at least one sensing electrode is a fabric electrode at a second surface, the interior surface, of the fabric substrate and/or

the at least one reference electrode is a fabric electrode at a second surface, the interior surface, of the fabric substrate.

[0009] In some, but not necessarily all examples, the apparatus comprises at least one second conductive interconnect connecting to the at least one sensing electrode, wherein each at least one second conductive interconnect is a fabric conductive-interconnect.

[0010] In some, but not necessarily all examples, the apparatus comprises flexible circuitry operatively interconnected to the at least one sensing electrode and the at least one reference electrode for producing a sensing signal.

[0011] In some, but not necessarily all examples, the apparatus is configured as a chest strap configured to position the at least one sensing electrode in contact with a front or side portion of a subject's thorax and to position the at least one reference electrode in contact with a rear portion of a subject's thorax. In some, but not necessarily all examples, the chest strap is configured to maximize a distance of separation between the at least one sensing electrode and the at least one reference electrode.

[0012] In some, but not necessarily all examples, the apparatus comprises: a first sensing electrode at a position on an interior surface of the fabric substrate for placement adjacent a portion of a subject's body; a second sensing electrode at a different position on the interior surface of the fabric substrate for placement adjacent a different portion of a subject's body; circuitry configured to provide a common mode voltage at the reference electrode.

[0013] In some, but not necessarily all examples, the apparatus comprises: a first sensing electrode at a position on an interior surface of the fabric substrate for placement adjacent a portion of a subject's body; a second sensing electrode at a different position on the interior surface of the fabric substrate for placement adjacent a different portion of a subject's body; ECG circuitry configured to provide an ECG signal from the first sensing electrode and the second sensing electrode; input circuitry configured to apply a time-varying input signal at the first sensing electrode; and output circuitry configured to detect a time-varying output signal at the second sensing electrode.

[0014] In some, but not necessarily all examples, the apparatus is configured to tension the fabric substrate in use, the fabric substrate comprising at least a fabric conductive-interconnect configured to resiliently change impedance with a change in tension during use. In some, but not necessarily all examples, an electric path between input circuitry and output circuitry comprises the at least one fabric conductive-interconnect configured to resiliently change impedance with a change in tension during use. In some, but not necessarily all examples, the fabric conductive-interconnect comprises a resiliently extendible filament stitched into the fabric substrate. In some, but not necessarily all examples, the fabric conductive-interconnect comprises a resiliently extendible filament stitched into the fabric substrate so that it extends along a surface of the fabric substrate in a series of alternating curves.

[0015] In some, but not necessarily all examples, the apparatus is clothing, wherein the fabric substrate is part of the clothing.

[0016] According to various, but not necessarily all, embodiments of the invention there is provided a method

comprising: providing a fabric substrate; providing at least one sensing electrode at an interior surface of the fabric substrate for placement adjacent a first portion of a subject's body; providing at least one reference electrode at the interior surface of the fabric substrate for placement adjacent a second portion of a subject's body; and providing a first conductive interconnect connecting to the at least one reference electrode wherein the first conductive interconnect is arranged and positioned on a portion of the fabric substrate other than the interior surface of the fabric substrate to provide part of a shield to the at least one sensing electrode. According to various, but not necessarily all, embodiments of the invention there is provided examples as claimed in the appended claims.

BRIEF DESCRIPTION

[0017] For a better understanding of various examples that are useful for understanding the detailed description, reference will now be made by way of example only to the accompanying drawings in which:

Fig. 1 illustrates an example of an apparatus comprising a fabric substrate and electrodes;
Figs 2A, 2B, 2C illustrates examples of fabric substrates;
Fig. 3 illustrates an example of an apparatus comprising a fabric substrate with fabric electrodes and fabric interconnects;
Fig. 4A illustrates a plan view of an example of the interior surface of the fabric substrate illustrated in Fig 3 and Fig. 4C illustrates a plan view of the exterior surface of the fabric substrate illustrated in Fig 3;
Fig 5 illustrates an example of a reference electrode;
Fig. 6 illustrates an example of the apparatus comprising circuitry;
Fig. 7 illustrates an example of the apparatus comprising electrocardiograph (ECG) circuitry, and signal-source circuitry and signal receive circuitry;
Fig. 8A illustrates a perspective view of the apparatus configured as a strap and Fig. 8B illustrates a view of the apparatus configured as a strap from a plan view;
Fig. 9 illustrates an example of a suitable fabric conductive interconnect configured to cause a change in impedance with a change in tension during use; and
Fig 10 illustrates an example of a method.

DETAILED DESCRIPTION

[0018] Fig. 1 illustrates an example of an apparatus 100 comprising: a fabric substrate 110; at least one sensing electrode 120 at an interior surface 102 of the fabric substrate 110 for placement adjacent a first portion 202 of a subject's body 200; at least one reference electrode 130 at the interior surface 102 of the fabric substrate 110 for placement adjacent a second portion 204 of the subject's body 200; and a first conductive interconnect 130 connecting to the at least one reference electrode 130, wherein the first conductive interconnect 130 is arranged and positioned on a portion of the fabric substrate 110 other than the interior surface 102 of the fabric substrate 110 to provide at least part of a shield 140 to the at least one sensing electrode 120.

[0019] The apparatus 100 has the advantage that it is comfortable and flexible in the long term because it comprises a fabric substrate 110.

[0020] The sensing electrode is placed adjacent a portion of a subject's body in use to sense a bio signal from the subject's body. This may, for example, be useful in impedance tomography, sensing of electrocardiograms (ECG), arterial pulse sensing or in other measurements of electrical signals and/or impedance.

[0021] Examples of fabric substrates 110 are illustrated in Figs. 2A, 2B and 2C. In each of the examples a fabric substrate 110 comprises filaments 112. Fig. 2A illustrates a fabric substrate 110 that is knitted. Fig. 2B illustrates an example of a fabric substrate 110 that is woven. Fig. 2C illustrates an example of a fabric substrate 110 with a stitched filament 112. In these examples, a single layer of fabric is illustrated. The fabric substrate 110 may be a single layer substrate or a multi-layer substrate.

[0022] The term 'filament' is used in this document to describe a material that can be used to create fabric (synonymous with textile, cloth). It is elongate and has a small thickness and/or cross-sectional area (e.g. less than 4 mm^2). It may be made of any suitable flexible material and manufactured in any suitable way. It may also be described as a thread or yarn. A filament 112 may be a single filament or a composite of intertwined filaments.

[0023] A filament 112 extends in a longitudinal direction (a longitudinal filament) and contacts adjacent filaments 112 at distances along the longitudinal direction to create a fabric

[0024] In a knitted fabric (Fig 2A), the longitudinal filament 112 extends in the longitudinal direction in a series of transverse loops (a row). The longitudinal filament 112 contacts the adjacent parallel longitudinal filaments 112 (adjacent rows) via the loops which are at distances along the longitudinal direction. The adjacent rows are interlooped by having each loop of one row passing through one adjacent loop in one of the adjacent rows.

[0025] In a woven fabric (Fig 2B), the longitudinal filament 112 extends in the longitudinal direction without loops (a row). The longitudinal filament 112 contacts filaments 112 extending in the transverse direction (transverse filaments), perpendicular to the longitudinal direction. The transvers filaments 112 are spaced at distances along the longitudinal direction, and they alternately overlie and underlie the longitudinal filaments 112. This creates an interlaced structure of perpendicular warp and weft filaments 112.

[0026] In a felted fabric (not illustrated), the longitudinal

filament 112 is pressed together with other filaments.

[0027] Filaments 112 may thus be used to form the fabric substrate 110. Filaments 112 may also be added to augment the fabric substrate 110 by being stitched (e.g. inter-looped or inter-weaved or embroidered) into a fabric substrate 110 (Fig 2C). Where the fabric substrate 110 is multi-layered each fabric layer may be separately augmented with one or more filaments by stitching. It is thus possible to create three-dimensional, multi-layer textile substrates 110.

[0028] In a conductive fabric, one of more of the filaments 110 are electrically conductive for all or part of their length. Other filaments 110 may provide electrical insulation/isolation for the conductive filament.

[0029] A fabric conductive-interconnect 114 is that portion of a filament 112 that is electrically conductive and provides an electric current path. The filament 112 may be electrically conductive for all or part of its length. Other non-conductive filaments/portions may provide electrical insulation/isolation for the fabric conductive-interconnect. The fabric conductive-interconnect 114 may be part of the fabric substrate 110, for example a longitudinal filament, that is looped in a knitted fabric (Fig 2A) or a warp or weft in woven fabric (Fig 2B) or an addition to the fabric substrate 110, for example, by stitching (Fig 2C).

[0030] A fabric electrode 116 is a conductive portion of fabric formed from multiple fabric conductive-interconnects 114.

[0031] Fig. 3 illustrates an example of the apparatus 100 similar to the apparatus 100 illustrated in Fig. 1, and similar references are used for similar features.

[0032] The apparatus 100 comprises: a fabric substrate 110 comprising filaments 112; at least one sensing electrode 120 at an interior surface 102 of the fabric substrate 110 for placement adjacent a first portion 202 of the subject's body 200; at least one reference electrode 130 at the interior surface 102 of the fabric substrate 110 for placement adjacent a second portion 204 of the subject's body 200 and a first conductive interconnect 130 connecting to the at least one reference electrode 130.

[0033] The first conductive interconnect 130 is arranged and positioned on a portion of the fabric substrate 110 other than the interior surface 102 of the fabric substrate 110 to provide at least part of a shield 140 to the at least one sensing electrode 120.

[0034] The fabric substrate 110 may be a fabric substrate as previously described.

[0035] In this example, the first conductive interconnect 130 is a fabric conductive interconnect 114. In this example the first conductive interconnect 130 is formed from a filament 112 of the fabric substrate 110 at a first exterior surface 104 of the fabric substrate 110 that is not the interior surface 102 of the fabric substrate 110.

[0036] In this example, the at least one sensing electrode 130 is a fabric electrode 116. In this example, the at least one sensing electrode 130 is formed from one or more filaments 112 of the fabric substrate 110 at the interior surface 102 of the fabric substrate 110.

[0037] Also, in this example the at least one reference electrode 130 is a fabric electrode 116. In this example the at least one reference electrode 130 is formed from one or more filaments 112 of the fabric substrate 110 at the interior surface 102 of the fabric substrate 110.

[0038] In this example there is a second conductive interconnect 132 connecting to the at least one sensing electrode 120. In this example, the at least one second conductive electrode 132 is a fabric conductive interconnect 114. In this example, the at least one second conductive electrode 132 is formed from a filament of the fabric substrate 110 at a first surface 104 of the fabric substrate 110 that is not an interior surface 102 of the fabric substrate.

[0039] As previously described, the fabric conductive interconnects 114 may each be an integral part of the fabric substrate 110 as illustrated in Figs. 2A and 2B or may be an addition to the fabric substrate 110 as illustrated in Fig. 2C.

[0040] Fig. 4A illustrates a plan view of an example of the interior surface 102 of the fabric substrate 110 illustrated in Fig 3 and Fig. 4B illustrates a plan view of the exterior surface 104 of the fabric substrate 110 illustrated in Fig 3.

[0041] It can be seen that the first conductive interconnect 130 extends along the exterior surface 104 of the fabric substrate 110 and is not present on the interior surface 102. The first conductive interconnect 130 forms shield 140.

[0042] It can be seen that the second conductive interconnect 132 extends from the sensing electrode 120 on the interior surface 102, through the thickness of the fabric substrate 110 to the exterior surface 104 of the fabric substrate 110. The second conductive interconnect 132 then extends along the exterior surface 104 of the fabric substrate 110.

[0043] In the example illustrated there are multiple sensing electrodes 120 (e.g. 120_1, 120_2...) illustrated and multiple second conductive interconnects 132 (e.g. 132_1, 132_2...) each connecting to a respective one of the multiple sensing electrodes 120. As illustrated in Fig. 4B, both of the second conductive interconnects 132 extend along the exterior surface 104 of the fabric substrate 110 but are separate and independent.

[0044] It will therefore be appreciated that the apparatus 100 comprises one or more sensing electrodes 120 that may be positioned at any desired location on the interior surface 102 of the fabric substrate 110 either during the manufacture of the fabric substrate (Figs. 2A, 2B) or added after manufacture (Fig. 2C). Likewise, the reference electrode 130 can also be positioned at an any desired location on the exterior surface 104 of the fabric substrate 110 either during the manufacture of the fabric substrate (Figs. 2A, 2B) or added after manufacture (Fig. 2C).

[0045] Each of the conductive interconnects 130, 132 may be a fabric conductive interconnect 114 formed from

a filament 112 of the fabric substrate 110. Each of the sensing electrodes 120 may be a fabric electrode 116. The reference electrode 130 may be a fabric electrode 116.

[0046] The use of fabric conductive interconnects 114 and fabric electrodes 116 results in a wholly fabric apparatus 100. It avoids the need for laminating and gluing or for solid structures which may make the fabric substrate 110 stiff and uncomfortable to wear.

[0047] As illustrated in Figs. 4A and 4B, the apparatus 100 extends over a first area. The conductive interconnects 130, 132 and electrodes 120, 130 are flexible over this first area providing and maintaining flexibility of the apparatus 100 over the first area. This flexibility is maintained and enhanced by, for example, the use of fabric conductive interconnects 114, fabric electrodes 116, and flexible circuitry and by not using stiff laminated conductors or circuitry.

[0048] The shield 140 shields the sensing electrode 120, or if there are more than one sensing electrode 120 it may shield one, or some, or all of the sensing electrodes 120. This can be understood from Fig. 4B. The first conductive interconnect 130, as illustrated in Fig. 4B, extends over the exterior surface 104, overlying the sensing electrodes 120 on the interior surface 102 and provides a shield 140 to the sensing electrodes 120. In this example the width of the first conductive interconnect 130 is wider than the width of the sensing electrodes 120 such that the first conductive interconnect entirely overlies the sensing electrodes 120.

[0049] The first conductive interconnect 130 shields the at least one sensing electrode 120 from the effects of electric fields for example those caused by electrostatic charges and, in particular, electric charges arising from the triboelectric effect. The triboelectric effect describes a contact electric field arising from frictional contact between two materials. One of these materials may, for example, be the fabric substrate 110. One of the material may, for example, be the body 200 of the subject or other fabric or clothing worn by the subject, if any.

[0050] In order to provide a shield 140, the first conductive interconnect 130 need not form a continuous conductive structure. It may, for example, form a mesh structure 150 as illustrated in Fig. 5. In this example, the first conductive interconnect 130 forms a shield 140 in the form of a Faraday cage or Faraday shield that covers the at least one sensing electrode 120.

[0051] The first conductive interconnect 130 provides a shield for triboelectric charging 140.

[0052] Fig. 6 illustrates an example of the apparatus 100 comprising additional circuitry 60. The circuitry 60 is interconnected to the one or more sensing electrodes 120 (e.g. 120_1, 120_2 ...) by one or more second interconnects 132 (e.g. 132_1, 132_2 ...) and is interconnected to the reference electrode 130 via the first interconnect 130. The reference electrode 130, sensing electrode(s) 120 and interconnects 130, 132 may for example be as described in any of the preceding description.

[0053] The reference electrode 130 provides a low-input impedance discharge path for static charges for example those generated by the triboelectric effect. In one example, the first interconnect 130 is a passive conductive path to ground. In another example, the reference electrode 130 is driven, via the first interconnect 130, by a voltage signal to create a virtual ground.

[0054] In the example illustrated, the apparatus 100 comprises a first sensing electrode 120_1 at a position on an interior surface 102 of the fabric substrate 110 for placement adjacent a portion 202 of the subject's body and a second sensing electrode 220_2 at a different position of the interior surface 102 of the fabric substrate 110 for placement adjacent a different portion 203 of the subject's body 200, as illustrated in Fig. 4A.

[0055] In this example, but not necessarily all examples, the circuitry 60 may be configured to provide a common-mode voltage to the reference electrode 130. For example, the common-mode voltage between the sensing electrodes 120 (e.g. 120_1, 120_2) may be obtained, and inverted and then driven back to the subject body 200 via the reference electrode 130. This makes the reference electrode 130 active, but still provides a low input impedance for the triboelectric charges to be discharged.

[0056] The circuitry 60 may be flexible circuitry such that it does not compromise or overly compromise the flexibility of the apparatus 100.

[0057] The apparatus 100 is therefore flexible because the fabric substrate 110 is flexible and the other components of the apparatus 100 are also flexible including the circuitry 60.

[0058] Fig. 7 illustrates an example of the apparatus 100, similar to that illustrated in Fig 6, in which the circuitry 60 additionally or alternatively comprises electrocardiograph (ECG) circuitry 64 and signal-source circuitry 62 and signal-receiver circuitry 70.

[0059] The ECG circuitry 64 comprises an op-amp that has one input connected to one sensing electrode 120_1 and the other input connected to another sensing electrode 120_2. The op-amp produces, at its output, a signal 67 representative of the voltage between the sensing electrodes 120_1, 120_2. The signal 67 is an ECG signal (a signal dependent upon the polarization and de-polarization of the subject's heart) when the sensing electrodes 120_1, 120_2 are correctly positioned on the subject's body 200.

[0060] The signal-source circuitry 62 is configured to provide a time varying signal 63 as an input signal to one of the sensing electrodes 120_1. This signal travels through the subject's body 200 and is received at the other of the sensing electrodes 120_2 as a received time varying signal 65.

[0061] The frequency of the time varying signal 63 is preferably outside the frequency band of the signal of interest. For example, if it is desired to measure ECG using the sensing electrodes 120, it is desirable to have the frequency of the input signal 63 outside the ECG band (for example, the input signal 63 has a frequency in the

range 4 kHz to 1 MHz). This input signal 63 is modulated by the impedance between the signal-source circuitry 62 and the signal-receiver circuitry 70.

[0062] Signal-receiver circuitry 70 measures changes in the received time-varying signal 65 arising from changes in electrical impedance between the signal-source circuitry 62 and the signal-receiver circuitry 70.

[0063] The signal-receiver circuitry 70 may comprise a high pass filter 72, so that it represents a high impedance to the ECG signal.

[0064] After filtering, the signal-receiver circuitry 70 may comprise an op-amp 74 that has one input coupled to the sensing electrode 120_1 through the filter 70 and the other input connected to the sensing electrode 120_2 through the filter 70. The op-amp 74 produces, at its output, a signal 77 representative of the impedance from the signal-source circuitry 62, via the sensing electrodes 120_1, 120_2 to the signal-receiver circuitry 70.

[0065] Where variations in the impedance from the signal-source circuitry 62, via the sensing electrodes 120_1, 120_2 to the signal-receiver circuitry 70 is dominated by variation in impedance of the body 200, the apparatus 100 is configured to determine a variable internal impedance of the body 200. This variable impedance may for example be used for impedance tomography or arise from changing fluid in the thorax, for example liquid in the lung.

[0066] In some examples, the apparatus 100 is designed so that the impedance from the signal-source circuitry 62, via the sensing electrodes 120_1, 120_2 to the signal-receiver circuitry 70 is dominated by variation in an impedance other than that of the body 200.

For example, the electric path between the signal-source circuitry 62 and the signal-receiver circuitry 70 may comprise the at least one fabric conductor interconnect 114 configured to change impedance with a change in tension during use. In this example, the apparatus 100 is capable of detecting a change in resistance arising from the tensioning or a change in tensioning of the fabric conductive-interconnect 114. Such a change may be caused by breathing of the subject.

[0067] Fig. 8A illustrates a perspective view of the apparatus 100 configured as a strap 200, to be placed around a body portion of the subject. In some, but not necessarily all examples, the strap is a chest-strap designed to be placed around the thorax of the subject. Fig. 8B illustrates a view of the apparatus 100 from a plan view.

[0068] The apparatus 100 may be configured as described with reference to Fig 7 to provide an ECG signal 67 and a signal 77 dependent upon breathing, for example.

[0069] The dimensions of the strap 200 along its length is shorter than the chest circumference of the user so that when the chest strap 200 is in place, it is under tension. There may be a buckle or clasp 202 that allows the strap 200 to be closed around the thorax of the user. There may also be a tensioning means 204 that allows the effective length of the strap to be varied and thereby control the tension within the strap 200 when it is in use. The apparatus 100 is therefore configured to tension the fabric substrate 110 in use.

[0070] As illustrated in Fig. 8B, the chest strap 200 is configured to position the at least one sensing electrode 120 in contact with a front or side portion of the subject's thorax and to position the at least one reference electrode 130 in contact with a rear portion of the subject's thorax. In this example the chest strap 200 is configured to maximize a distance of separation between the at least one sensing electrode 120 and the at least one reference electrode 130 when measured along the exterior of the subject's thorax.

[0071] The apparatus 100 is configured to tension the fabric structure 110 in use. In some examples, the fabric structure 110 comprises at least one fabric conductive interconnect 114 configured to produce a change in impedance with a change in tension during use. Such a change in impedance may be dependent upon breathing.

[0072] The fabric conductive interconnect 114 may be positioned in the electric path between the signal-source circuitry 62 and the signal-receiver circuitry 70.

[0073] Fig. 9 illustrates an example of a suitable fabric conductive interconnect 114 configured to cause a change in impedance with a change in tension during use. In this example, the fabric conductive interconnect 114 comprises a resiliently extendable filament 112 stitched into the fabric substrate 110. By controlling the length of the filament 112 it is possible to control the ratio of the impedance in the body to the ratio of any resistance change in the resiliently extendable filament 114.

[0074] In the example illustrated the fabric conductive interconnect 114 comprises a resiliently extendible filament 112 stitched into the fabric structure substrate 110 so that it extends along a surface 104 of the fabric substrate 104 in a series of alternating curves 115. This gives it a switch-back shape.

[0075] Any of the apparatus 100 described may be in the form of clothing, where the fabric substrate 110 is part of the clothing.

[0076] In some but not necessarily all examples, the apparatus 100 is configured to communicate data from the apparatus 100 with or without local storage of the data in a memory at the apparatus and with or without local processing of the data by circuitry or processors at the apparatus 100.

[0077] The data may, for example, be measurement data from one or more sensing electrodes 120 or data produced by the processing of measurement data from one or more sensing electrodes 120, such as, for example, an ECG signal 57 and/or an impedance signal 77.

[0078] The data may be stored in processed or unprocessed format remotely at one or more devices. The data may be stored in The Cloud.

[0079] The data may be processed remotely at one or more devices. The data may be partially processed locally and partially processed remotely at one or more

devices.

[0080] The data may be communicated to the remote devices wirelessly via short range radio communications such as Wi-Fi or Bluetooth, for example, or over long range cellular radio links such a E-UTRANS. The apparatus may comprise a communications interface such as, for example, a radio transceiver for communication of data.

[0081] The apparatus 100 may be part of the Internet of Things forming part of a larger, distributed network.

[0082] The processing of the data, whether local or remote, may be for the purpose of health monitoring, data aggregation, patient monitoring, vital signs monitoring or other purposes.

[0083] The processing of the data, whether local or remote, may involve artificial intelligence or machine learning algorithms. The data may, for example, be used as learning input to train an acyclic machine learning network such as a multilayer neural network or may be used as a query input to a machine learning network, which provides a response.

[0084] The processing of the data, whether local or remote, may produce an output. The output may be communicated to the apparatus 100 where it may produce an output sensible to the subject such as an audio output, visual output or haptic output.

[0085] It will be appreciated from the foregoing that the preceding description describes examples of a method 200, as illustrated in Fig 10. The method 200 comprises:

at block 202, providing a fabric substrate 110;
at block 204, providing at least one sensing electrode 120;
at block 206, providing at least one sensing electrode 120 at an interior surface 102 of the fabric substrate 110 for placement adjacent a first portion 204 of the subject's body;
at block 208, providing at least one reference electrode 130 at the interior surface 102 of the fabric substrate 110 for placement adjacent a second portion 202 of the subject's body 200; and
at block 210, providing a first conductive interconnect 130 connecting to the at least one reference electrode 130 where the first conductive interconnect 130 is arranged and positioned on a portion of the fabric substrate 110 other than the interior surface of the fabric substrate 110 to provide part of a shield to the at least one sensing electrode 130.

[0086] As used in this application, the term 'circuitry' refers to all of the following:

(a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and
(b) to combinations of circuits and software (and/or firmware), such as (as applicable): (i) to a combination of processor(s) or (ii) to portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions and
(c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

This definition of 'circuitry' applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" would also cover, for example and if applicable to the particular claim element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, or other network device.

[0087] Where a structural feature has been described, it may be replaced by means for performing one or more of the functions of the structural feature whether that function or those functions are explicitly or implicitly described.

[0088] The term 'comprise' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising Y indicates that X may comprise only one Y or may comprise more than one Y. If it is intended to use 'comprise' with an exclusive meaning then it will be made clear in the context by referring to "comprising only one.." or by using "consisting".

[0089] In this brief description, reference has been made to various examples. The description of features or functions in relation to an example indicates that those features or functions are present in that example. The use of the term 'example' or 'for example' or 'may' in the text denotes, whether explicitly stated or not, that such features or functions are present in at least the described example, whether described as an example or not, and that they can be, but are not necessarily, present in some of or all other examples. Thus 'example', 'for example' or 'may' refers to a particular instance in a class of examples. A property of the instance can be a property of only that instance or a property of the class or a property of a subclass of the class that includes some but not all of the instances in the class. It is therefore implicitly disclosed that a feature described with reference to one example but not with reference to another example, can where possible be used in that other example but does not necessarily have to be used in that other example.

[0090] Although embodiments of the present invention have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the invention as claimed.

[0091] Features described in the preceding description

may be used in combinations other than the combinations explicitly described.

[0092] Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

[0093] Although features have been described with reference to certain embodiments, those features may also be present in other embodiments whether described or not.

[0094] Whilst endeavoring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

Claims

1. An apparatus comprising:

a fabric substrate;
at least one sensing electrode at an interior surface of the fabric substrate for placement adjacent a first portion of a subject's body;
at least one reference electrode at the interior surface of the fabric substrate for placement adjacent a second portion of a subject's body; and
a first conductive interconnect connecting to the at least one reference electrode wherein the
first conductive interconnect is arranged and positioned on a portion of the fabric substrate other than the interior surface of the fabric substrate to provide part of a shield to the at least one sensing electrode.

2. An apparatus as claimed in claim 1, wherein the first conductive interconnect is a fabric conductive-interconnect at a first surface of the fabric substrate that is not an interior surface of the fabric substrate.

3. An apparatus as claimed in claim 1 or 2 or, wherein the at least one sensing electrode is a fabric electrode at a second surface, the interior surface, of the fabric substrate and/or
the at least one reference electrode is a fabric electrode at a second surface, the interior surface, of the fabric substrate.

4. An apparatus as claimed in any preceding claim, comprising at least one second conductive interconnect connecting to the at least one sensing electrode, wherein each at least one second conductive interconnect is a fabric conductive-interconnect.

5. An apparatus as claimed in any preceding claim, comprising flexible circuitry operatively interconnected to the at least one sensing electrode and the at least one reference electrode for producing a sensing signal.

6. An apparatus as claimed in any preceding claim configured as a chest strap configured to position the at least one sensing electrode in contact with a front or side portion of a subject's thorax and to position the at least one reference electrode in contact with a rear portion of a subject's thorax.

7. An apparatus as claimed in claim 6, configured to maximize a distance of separation between the at least one sensing electrode and the at least one reference electrode.

8. An apparatus as claimed in any preceding claim, comprising
a first sensing electrode at a position on an interior surface of the fabric substrate for placement adjacent a portion of a subject's body;
a second sensing electrode at a different position on the interior surface of the fabric substrate for placement adjacent a different portion of a subject's body;
circuitry configured to provide a common mode voltage at the reference electrode.

9. An apparatus as claimed in any preceding claim, comprising
a first sensing electrode at a position on an interior surface of the fabric substrate for placement adjacent a portion of a subject's body;
a second sensing electrode at a different position on the interior surface of the fabric substrate for placement adjacent a different portion of a subject's body;
ECG circuitry configured to provide an ECG signal from the first sensing electrode and the second sensing electrode;
input circuitry configured to apply a time-varying input signal at the first sensing electrode; and
output circuitry configured to detect a time-varying output signal at the second sensing electrode.

10. An apparatus as claimed in any preceding claim configured to tension the fabric substrate in use, the fabric substrate comprising at least a fabric conductive-interconnect configured to resiliently change impedance with a change in tension during use.

11. An apparatus as claimed in claim 10, when dependent upon claim 9, wherein an electric path between input circuitry and output circuitry comprises the at least one fabric conductive-interconnect configured to resiliently change impedance with a change in tension during use.

12. An apparatus as claimed in claim 12 or 13, wherein the fabric conductive-interconnect comprises a re-

siliently extendible filament stitched into the fabric substrate.

13. An apparatus as claimed in claim 14, wherein the fabric conductive-interconnect comprises a resiliently extendible filament stitched into the fabric substrate so that it extends along a surface of the fabric substrate in a series of alternating curves.

14. An apparatus as claimed in any preceding claim in the form of clothing, wherein the fabric substrate is part of the clothing.

15. A method comprising:

providing a fabric substrate;
providing at least one sensing electrode at an interior surface of the fabric substrate for placement adjacent a first portion of a subject's body;
providing at least one reference electrode at the interior surface of the fabric substrate for placement adjacent a second portion of a subject's body; and
providing a first conductive interconnect connecting to the at least one reference electrode
wherein the
first conductive interconnect is arranged and positioned on a portion of the fabric substrate other than the interior surface of the fabric substrate to provide part of a shield to the at least one sensing electrode.

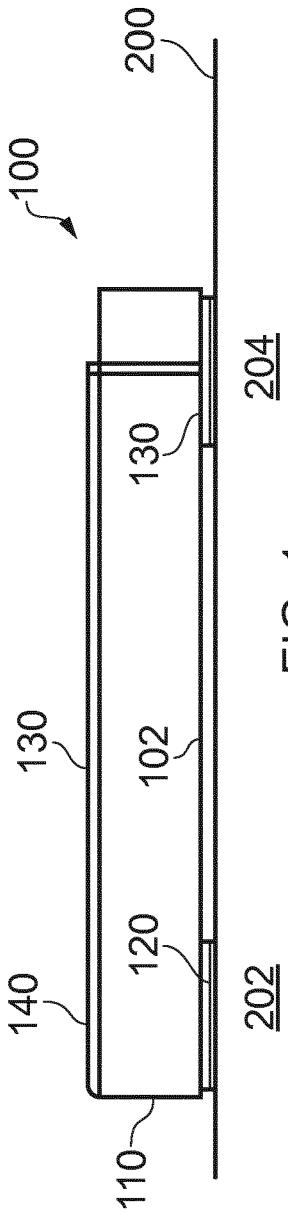

FIG. 1

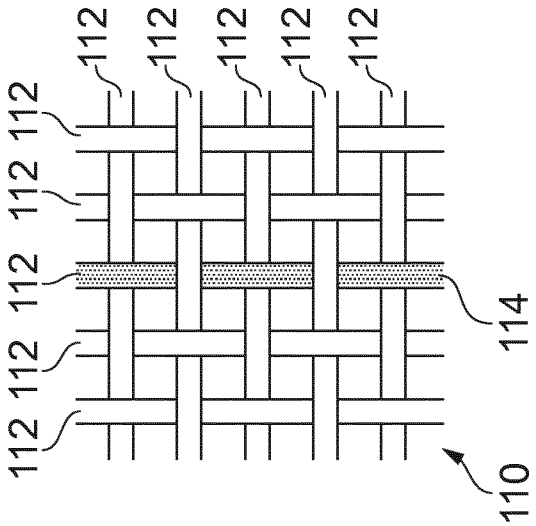

FIG. 2B

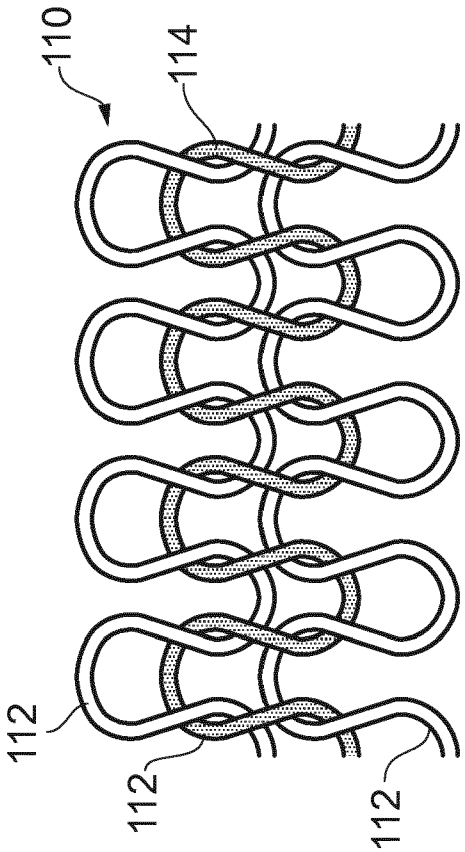

FIG. 2A

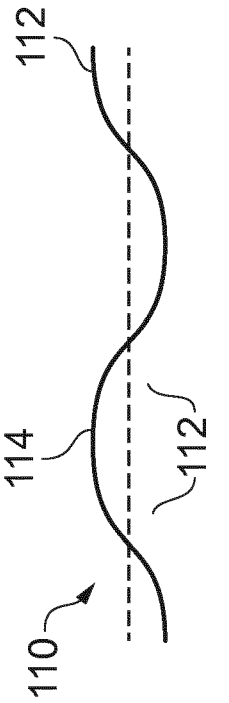

FIG. 2C

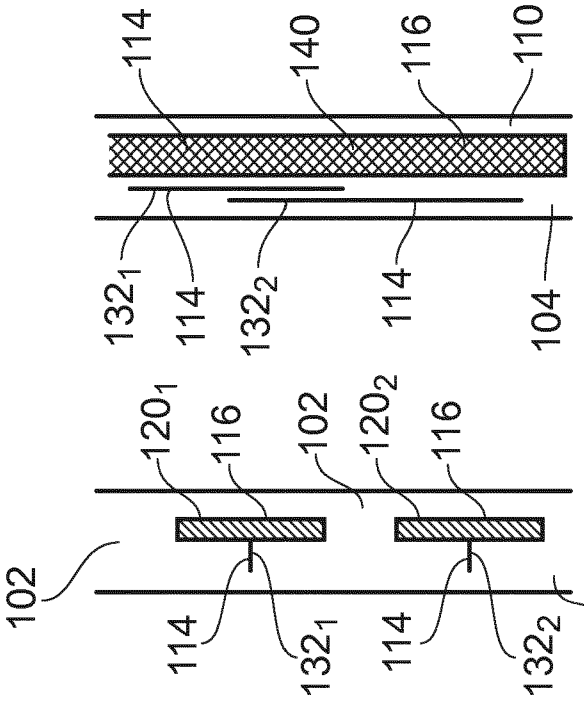

FIG. 4B

FIG. 4A

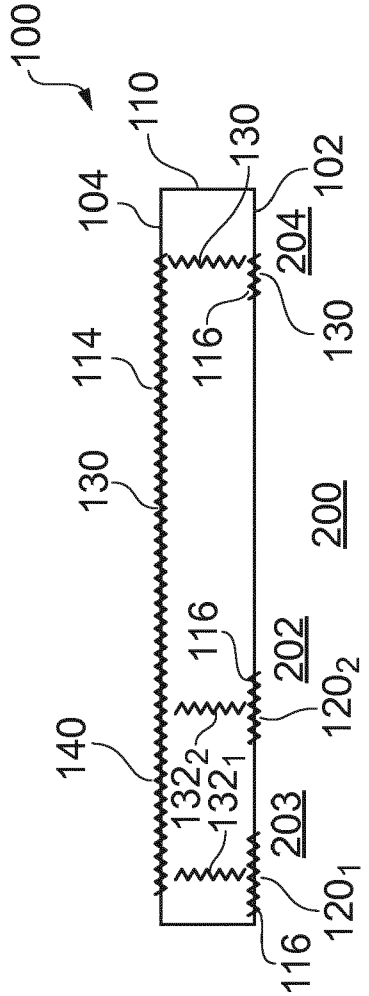

FIG. 3

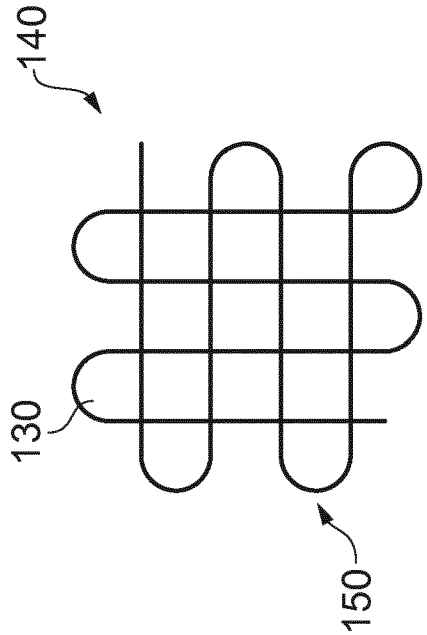

FIG. 5

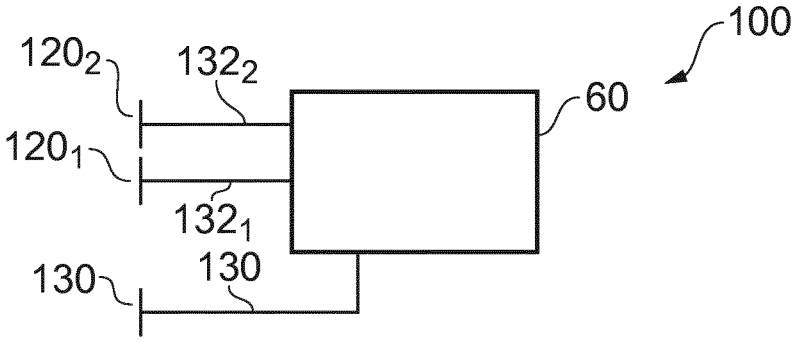

FIG. 6

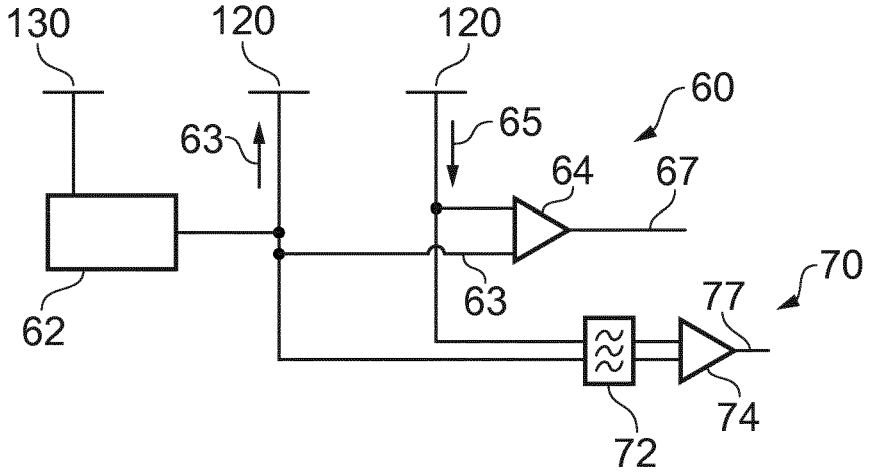

FIG. 7

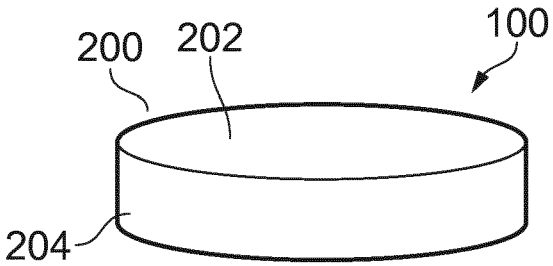

FIG. 8A

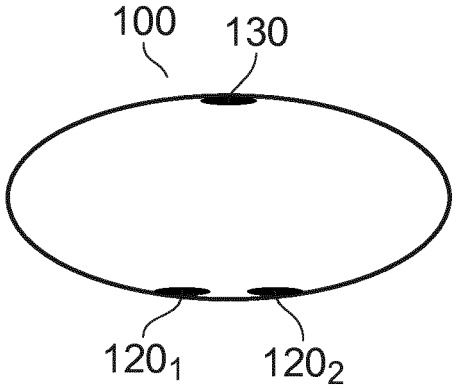

FIG. 8B

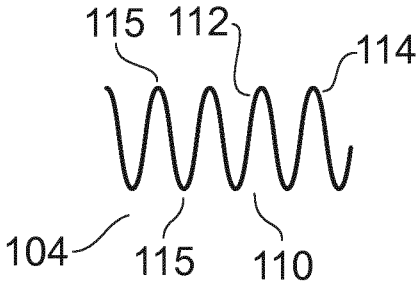

FIG. 9

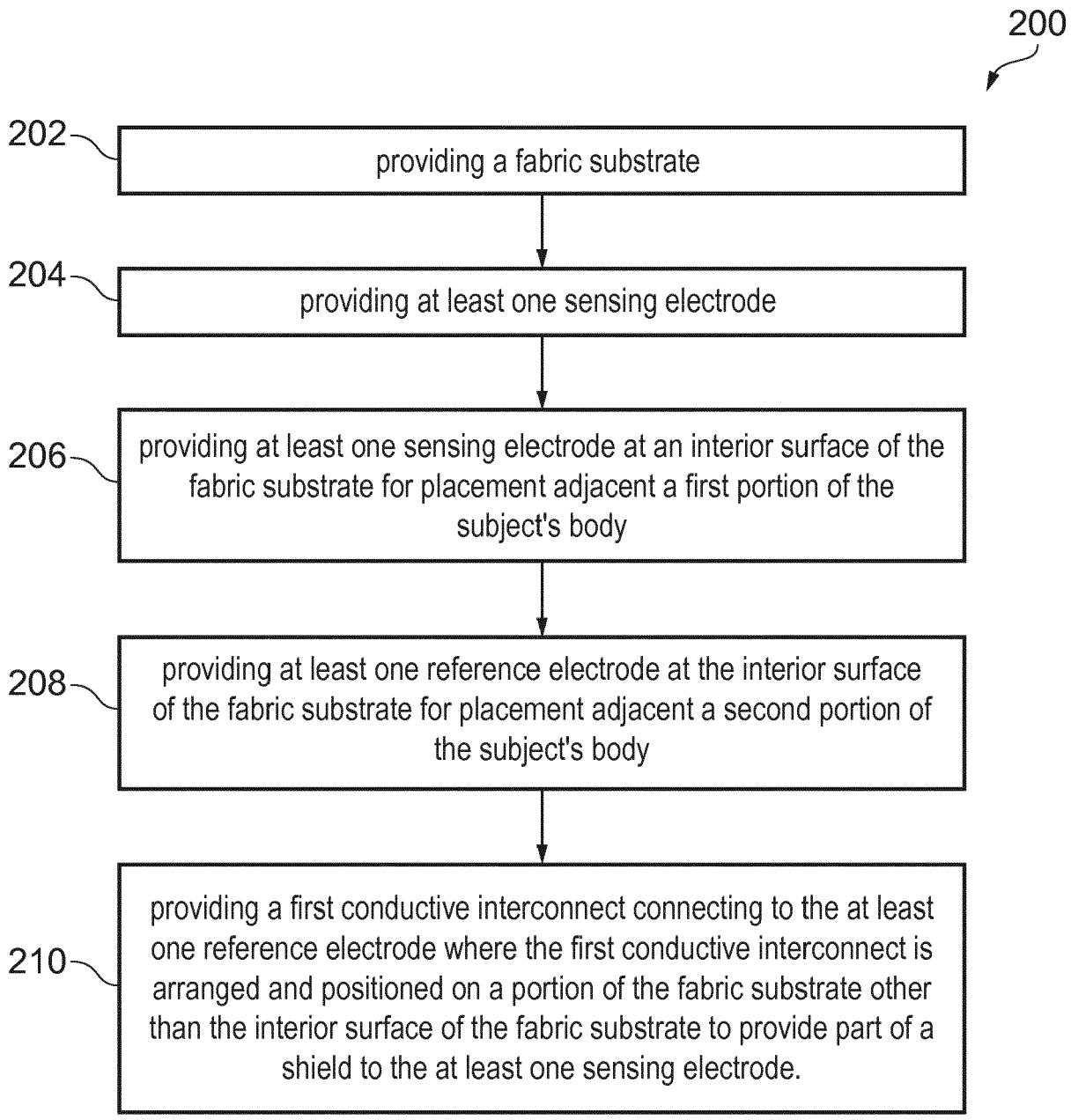
200
202
providing a fabric substrate
204
providing at least one sensing electrode
206
providing at least one sensing electrode at an interior surface of the fabric substrate for placement adjacent a first portion of the subject's body
208
providing at least one reference electrode at the interior surface of the fabric substrate for placement adjacent a second portion of the subject's body
210
providing a first conductive interconnect connecting to the at least one reference electrode where the first conductive interconnect is arranged and positioned on a portion of the fabric substrate other than the interior surface of the fabric substrate to provide part of a shield to the at least one sensing electrode.

FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 4514

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	US 2006/111640 A1 (SHEN CHIEN-LUNG [TW] ET AL) 25 May 2006 (2006-05-25) * paragraph [0023] - paragraph [0030]; figures 2,3 *	3,4,6,7,14	D03D1/00 A61B5/113
Y	Texas Instruments: "microPower, Single-Supply, CMOS Instrumentation Amplifier", , 1 February 2006 (2006-02-01), XP055450956, Retrieved from the Internet: URL:http://www.ti.com/lit/ds/sbos168d/sbos168d.pdf [retrieved on 2018-02-14] * page 14; figure 9 *	8	
Y	US 2010/324404 A1 (HARROLD LEWIS NORMAN [US] ET AL) 23 December 2010 (2010-12-23) * paragraph [0009]; figure 7 *	9-13	TECHNICAL FIELDS SEARCHED (IPC) A61B A41D D03D
Y	WO 2007/126435 A2 (VIVOMETRICS INC [US]; GAL YOAV [US]) 8 November 2007 (2007-11-08) * page 5, line 24 * * page 8, line 27 - page 10, line 19; figure 8 *	10-13	
A	US 2017/303808 A1 (STONE ROBERT T [US]) 26 October 2017 (2017-10-26) * paragraph [0042] - paragraph [0050]; figures 1-3 *	1-15	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	5 March 2018	Konstantinou, G

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 4514

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2007/083096 A1 (PARADISO RITA [IT]) 12 April 2007 (2007-04-12) * paragraph [0023] - paragraph [0032] * * paragraph [0041] - paragraph [0046]; figures 1,4,5 *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	5 March 2018	Konstantinou, G

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A : technological background
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E : earlier patent document, but published on, or after the filing date
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& : member of the same patent family, corresponding document

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05-03-2018

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

专利名称(译)	一种装置，包括织物基底和电极		
公开(公告)号	EP3492009A1	公开(公告)日	2019-06-05
申请号	EP2017204514	申请日	2017-11-29
[标]申请(专利权)人(译)	诺基亚技术有限公司		
申请(专利权)人(译)	NOKIA TECHNOLOGIES OY		
当前申请(专利权)人(译)	NOKIA TECHNOLOGIES OY		
[标]发明人	BLOMQVIST KIM LASAROV HARRI		
发明人	BLOMQVIST, KIM LASAROV, HARRI		
IPC分类号	A61B5/053 A61B5/00 A61B5/0408 A41D13/12 D03D1/00 A61B5/113		
CPC分类号	A61B5/0006 A61B5/04085 A61B5/053 A61B5/1135 A61B5/6804 A61B2562/125		
代理机构(译)	HIGGIN，PAUL		
外部链接	Espacenet		

摘要(译)

一种装置，包括：织物基底;在织物基底的内表面上的至少一个感应电极，用于放置在受试者身体的第一部分附近;在织物基底的内表面上的至少一个参比电极，用于放置在受试者身体的第二部分附近;连接到所述至少一个参考电极的第一导电互连件，其中所述第一导电互连件布置并定位在所述织物基板的除所述织物基板的内表面之外的一部分上，以为所述至少一个感测提供屏蔽的一部分。电极。

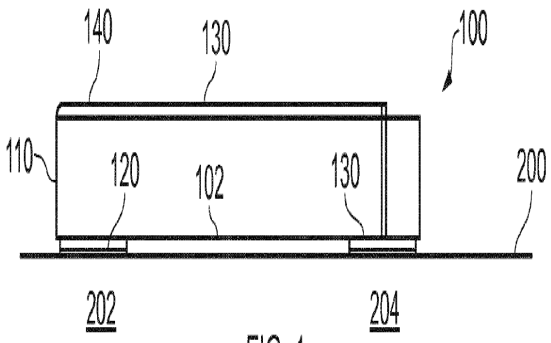

FIG. 1