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(54) **BELT FOR ELECTRO IMPEDANCE MEASUREMENT AND METHOD USING SUCH BELT**
BAND FÜR ELEKTROIMPEDANZMESSUNG UND VERFAHREN MIT EINEM SOLCHEN BAND
SANGLE DE MESURE D'IMPÉDANCE ÉLECTRIQUE ET PROCÉDÉ ASSOCIÉ

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EP 2 806 792 B1

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The field of the invention relates to a an electro impedance measurement belt according to the preamble of claim 1 and a method of electro impedance measurement using such a belt.

BACKGROUND OF THE INVENTION

[0002] Electrical impedance tomography (EIT) is a non-invasive imaging technique used to investigate and measure regional lung ventilation and perfusion (flow of blood) in humans and animals. In contrast to conventional methods, EIT does not require the patient to breathe through a tube or sensor, does not apply ionizing X-rays and can be used for extended periods, say 24 hours or even longer. EIT can be used continuously and is therefore suited for monitoring treatment effects in real time and over time. HIT was first used to monitor respiratory function in 1983 and remains the only bedside method that allows continuous, non-invasive measurements of regional changes in lung volume, blood flow, and cardiac activity. More details of this technique can be found in "Electrical impedance tomography" by Costa E.L., Lima R.G., and Amato M.B. in Curr Opin Crit Care, Feb. 2009, 15(1), p. 18-24.

[0003] Traditionally electrodes used for electro impedance measurements and in particular electro impedance tomography (EIT) are placed individually on the thoracic surface to form an electrode plane. Such individual electrodes are cumbersome to handle and are bound to be dislocated with patient movement. In order to overcome the above problem, belts (or belt-like structures) have been designed on which electrodes are mounted The conventional belt is placed around the chest, thereby forming a transverse EIT plane. For example document US 2009/0084674 A1 discloses an electrode assembly for electrical impedance tomography comprising a plurality of different electrode modules. Each module contains a support strap carrying a predetermined number of electrodes with a distance between each two consecutive electrodes predetermined as a function of a specific operational pattern. Also here the belt is placed around the chest, thereby forming a transverse EIT plane.

[0004] While such conventional belts solve the problem of electrode handling, despite the fact that they are often elastic, they restrict the breathing of the patient particularly by preventing the ribs from lifting upwards during respiration. Conventionally the belt is placed at an angle with respect to the extension of the ribs around the chest. As this angle is bigger than zero, there is a force preventing the free movement of the ribs. Consequently, to some extent the natural movement of the chest during respiration is restricted.

[0005] Such external restriction of the chest movement during respiration however can prevent optimal ventila-

tion of a patient or produce artefacts during EIT examination.

[0006] In EIT, as disclosed by US patent 5,626,146, a plurality of electrodes, typically 8 to 32, are arranged on the surface of the body to be examined, A control unit ensures that an electrical signal, for example a current is applied to one or several pairs of electrodes on the skin to establish an electrical field which in turn is measured by the other electrodes,

[0007] Typically the electrodes are arranged on the surface of the body to be examined in such a way that they surround the body girth. Conveniently a belt structure supports the electrodes and is located about the chest of the patient in a transverse plane. Such positions have been shown e.g. in patent application EP 1 000 580 A1.

[0008] A good contact of the electrodes with the body of a test subject is essential to the EIT method. In order to establish good contact electrode belts have been proposed which are elastic, see e.g. patent specification GB 2 400 915 B. An elastic belt is under a certain pre-tension, as a result of which a radial force component acts as a pressing force on the electrodes and also on the test subject's body. To a certain extent such forces impede normal chest movement and extension during breathing. Due to the elasticity of the belt special provisions for electrode supply lines need to be made, such as folding supply lines in zigzag or meandering manner, to compensate for expansion of the belt material. Moreover, in order to ensure further improved electrode contact also at body areas with inward curvatures, air-tight elements filled with air, liquid or gel are placed at the back of the electrodes.

[0009] Patent application US 2004/0236202 A1 proposes an alternative expandable electrode belt made of material that is flexible and bendable, yet inelastic. Hereby waves or bends in the belt allow the belt to be extended, while the electrodes remain spaced apart equidistantly as the strap extends - either during application onto or respiration by a patient. Physically, such belt will buckle as it is extended, which is disadvantageous where the test subject is a patient lying in bed.

[0010] Other belt-type garments are designed for the purpose of carrying sensors. For example patent application US 2008/0287770 A1 discloses a garment for ambulatory, physiological monitoring of a patient comprising a belt, having first and second end portion with closures at the end portions to wrap around a user's chest, a pair of shoulder strap portions, and a back portion, with at least one of the belt portions, the strap portions and the back portion having an accommodation for carrying one or more singular sensors, such as an ECG sensor. Another example is given in patent specification US 5,353,793 A. Here is disclosed another harness-like garment enabling measurements of physiological parameters of a patient. This garment comprises a chest band, an optional shoulder band(s), and an optional abdominal band that can house respiration, pulse and ECG sensors for impedance pneumography. The garment is stretcha-

ble and all bands are worn on the body under tension. In a presented example several electrodes are arranged on the front of the shoulder band(s) and at some parts of the chest band. The chest band apparently forms a transverse sensor plane.

[0011] Furthermore, in patent US8019402 B1 an electrode harness is disclosed which can be used in ECG (or EKG), EEG, EMG, and other such biopotential measurement applications. The electrode harness can be adjusted for application to various sized and shaped subjects, in that the electrode harness features (a) at least one electrode with adjustable connector; (b) a material operable to mechanically and electrically interconnect at least two electrodes; (c) a track system attached to or integral to the material wherein the at least one electrode is movable along the track system with the adjustable connector.

[0012] In further patent application EP2072009 A1 is disclosed a garment comprising an integrated electrocardiogram sensor. The garment includes an electrode arranged to contact a user's skin and a resilient compressible filler provided between the garment and the electrode such that, in use, the electrode is held substantially in place against the skin when the garment moves relative to the user's skin.

OBJECT OF THE INVENTION

[0013] It is an object of the present invention to provide a device and method for allowing an optimal electro impedance measurement representation, in particular electro impedance tomographic representation of the lung and heart. Ideally, also the movement of the diaphragm should be traceable.

[0014] Furthermore, it is an object of the present invention to perform electro impedance imaging, in particular EIT imaging, without at the same time obstructing the thoracic respiration movement with the electro impedance equipment respectively the EIT equipment

[0015] It is a further object of the present invention to provide a device designed and manufactured in such a way as to guarantee compatibility between the materials of the device and biological tissues, cells and body fluids, taking account of the intended purpose of the device and for a sufficient duration of use.

[0016] Moreover it is an object of the present invention to provide a non-obstructive electro impedance measuring electrode belt design, in particular to provide a non-obstructive EIT electrode belt design.

[0017] It is an object of the present invention to provide a new and improved EIT imaging electrode belt and method of EIT imaging.

[0018] It is an object of the present invention to provide a new and improved electro impedance measuring belt and method of electro impedance imaging.

[0019] It is another object to provide a cost efficient and low cost EIT belt and EIT belt manufacturing method so that it can be disposed after use.

[0020] Several examples and exemplary embodiments are laid out in the present text. Nevertheless, the embodiments which encompass the scope of protection are exclusively defined by the appended claims.

SUMMARY OF THE INVENTION

[0021] According to present invention the inventive electro impedance measuring electrode belt (herein also called electrode belt) is designed to follow the anatomy of the ribs. Thus, the electrode array (array of lined up electrodes) of the belt follows the space between two ribs (intercostal space) or a rib from the upper dorsal thorax towards the lower front at the sternum. The design of the electro impedance measuring belt electrode is such that the belt and therefore the electrodes are placed in such a way that the array's longitudinal extension follows the extension of the ribs at both sides of the thorax. In a preferred embodiment an essentially transverse centre piece of the electrode impedance measuring electrode belt lying across the spine acts as a hinge-like fixture of the right and left electrode impedance measuring belt extensions alongside the ribs as well as their electrical connection, Next to the mechanical advantages with regards to the breathing there are also at least two other key advantages of such a belt design,

[0022] Preferably the electro impedance measuring electrode belt is an electro impedance tomography belt (EIT-belt) and the electro impedance measuring method is an electro impedance tomography method (EIT-method). The inventive electro impedance measuring belt may be used for any impedance measurements and measurement methods.

[0023] The oblique application of the electrode belt on the thorax following the ribs leads to a better representation of the thoracic cavity, including heart and lungs, as more of their tissue can be subjected to EIT measurements. By using the oblique belt design, extreme transverse traditional electrode positions such as a low belt position below the breast (showing little lung and considerable amounts of liver tissue) or a high belt position above the breast (where very little or no more heart tissue can be detected and where the lungs become small) can be avoided reliably,

[0024] As the ribs are neither distensible nor elastic or stretchable, a belt following the ribs closely does not need to be stretchable, elastic, extendable, distensible or alike. All such a belt needs to be is flexible and/or curved so that it can follow the ribs along the body contour in order to adapt to a patient's anatomy.

[0025] Advantageously, such electrode belt or electrode band, respectively, can be made of non-distensible, non-stretchable, non extendable and non-elastic but flexible materials, such as e.g. flexible printed electronic circuit boards. Such electrode belt can be produced in a cheaper and cost efficient way. This inventive type of electrode contacting is technically less challenging and less delicate.

[0026] In consequence, EIT measuring belts designed according to the above principles are more comfortable to wear and cheap to produce while achieving more representative EIT images.

[0027] The objects of the invention can be achieved when a support structure with an array of a plurality of electrodes comprises two angulated legs such that, when the belt is applied around the thorax of a patient, the array of a plurality of electrodes extends from the back of the patient, in particular from the spinal column, where the apex of the angulated legs or the transverse part connecting them are to be located, essentially parallel to the ribs (i.e. along the extension of the ribs) to the lower part of the breastbone (sternum) of the patient. This has the advantage that - in contrast to the prior art - no elastic or extendable electrode belt is required. This allows to reduce the manufacturing costs of the electrode belt. In addition, by placing the electrodes along the ribs or preferably in the intercostal space between two neighboring ribs an even more meaningful EIT image can be obtained.

[0028] Thus, the inventive electro impedance measuring belt (herein also called electrode belt) for placing electrodes around the thorax of a patient comprises, an array of a plurality of spaced apart electrodes, and a support structure, on which the electrodes are arranged, wherein the support structure with the electrode array comprises two angulated legs on which the electrodes are lined up, the two legs spread out from an apex at an angle, such that, when the belt is put around the thorax of a patient, the array of electrodes extends from the back of the patient, where the apex of the angulated legs or the transverse part connecting them are to be located, essentially parallel to the ribs to the lower part of the breastbone of the patient. Preferably, the apex is situated at the back part of the belt and from the apex the legs spread out in a descending manner, i.e. obliquely downwards, towards the front part, so that an angle opens up between the two legs. Consequently, e.g. when worn by a patient or another test person, the apex of the two angulated legs or the transverse part connecting them are arranged on the spinal column and then following the oblique orientation of the ribs. Preferably, the angle (α) formed between the legs is between 80 and 170 degree, preferably between 90 and 160 degree, more preferably between 110 and 150 degree and most preferably between 120 and 140 degree.

[0029] According to a preferred embodiment of the invention the two legs are connected by a transverse middle part, the angle (β) between the longitudinal axis of the transverse middle part and the longitudinal axis of the legs being between 5 and 50 degree, preferably between 10 and 45 degree, even more preferably between 15 and 35 degree and most preferably between 20 and 30 degree. The provision of a transverse extending middle part has the advantage that two electrodes can be placed just near the spinal column and in a region where valuable diagnostic information can be gained.

[0030] Advantageously, the legs are designed as

straps comprising first fastening means at their ends for connecting their ends together, This design has the advantage that the belt can relatively easily be mounted on bedridden patients.

[0031] In the following the combination of support structure and electrodes may also be called electrode band, since in one embodiment said combination of support structure and electrodes advantageously is designed as a band.

[0032] According to a preferred embodiment of the invention additionally an attachment structure or attachment means is provided for holding the support structure with the array of electrodes in position, so that essentially no relative movement between the electrodes and the body of the patient occurs during breathing. Due to the attachment structure it is no longer necessary to resort to a stretchable electrode belt. Thus, the electrode belt may be inelastic. At the same time preferably the electrode belt is bendable for better wearability, A characteristic of the attachment means or attachment structure is that it allows to position the electrodes of the array with respect to the craniocaudal axis at the back of a body at a more elevated level, which is closer to the head-end than at its front.

[0033] Different embodiments for allowing to hold the support structure and electrodes are feasible, The attachment structure can be designed to be connected on the one hand directly or indirectly to the body of the patient and on the other hand to the support structure. Alternatively, the attachment structure could be a separate belt wrapped around the body and connected to the lower part of the support structure (e.g. an electrode band) near or at its lowest point, i.e. in the region of the breastbone. In order to allow for the expansion of the thorax during breathing, preferably the attachment structure is at least partially elastic.

[0034] Different designs of the attachment structure is feasible without deviating from the gist of the invention. For instance, the attachment structure can be a kind of a harness adapted to hold the support structure in position. The attachment structure can comprise one or more suspenders designed to be put over the shoulders of a patient. It can be designed as a kind of harness, a vest-like clothing or vest adapted to position and carry said support structure with the electrode array. Preferably, the vest-like clothing or vest is manufactured at least partially from an elastic textile in order to allow movement of the thorax during breathing. For example, elastic textiles comprise woven, non-woven, knitted or other kind of textiles. However, alternatively the attachment structure may be inelastic (i.e. for example made of a non-elastic material). The attachment structure and the support structure can be releasably or permanently connected with each other. Alternatively or in addition, the attachment structure may comprise adhesive elements restricting relative movement between electrodes respectively the electrode carrying support structure and a patient

[0035] Advantageously the attachment means or

structure allow to position the electrodes of the array with respect to the craniocaudal axis at the back of a body at a more elevated level (which is closer to the head-end) than at its front

[0036] The attachment structure comprises preferably at least a first strap or suspender for leading over at least one shoulder and/or around the neck (e.g. from the dorsal part to the ventral part of the belt), which serves to position the dorsal part of the belt at the desired position, and optionally a second strap connected to at least the ventral part of the belt and leading around the torso and/or past the crotch, which serves to position the ventral part of the belt at the desired position and in particular inhibiting the ventral part of the belt from slipping upwards or cranially on the chest region. Advantageously, said optional second straps may be at least partially elastic.

[0037] The electrode array and its support structure form an integral element comprising at least two layers, wherein a first layer comprises a skin-contacting cloth with electrically conducting pathways for establishing contact between the skin and the electrodes and a second layer comprises an electronic circuit board. Optionally, the electronic circuit board has also the function of the support structure, defines a plurality of electrode positions, and comprises supply lines, control lines and/or data lines for connecting the electrodes with an analysing and control instrument

[0038] Optionally, the electronic circuit board is placed in a tube-like structure formed by the skin-contacting cloth with electrically conducting pathways for establishing contact between the skin and the electrodes. The tube-like structure may be an integral part of the attachment structure.

[0039] Advantageously, the electrode array (or rather the support structure or electrode band), when attached to the attachment structure, in particular to the harness or vest-like clothing, and spread out flat, shows a bent or curved shape, preferably an upside down v-like shape for allowing alignment with the rib inclination.

[0040] For the purpose of ensuring non-slip fitting of the belt, the attachment structure can comprise an enlarged contact area particularly in the lower dorsal area.

[0041] It is possible that the support structure of the array is essentially non-stretchable and/or non-elastic, in particular e.g. an electronic circuit board is usually non-stretchable and non-elastic.

[0042] However the support structure of the array may be flexible and bendable which is advantageous for the purpose of fitting the belt on and around the thorax of a patient.

[0043] It is preferred that the material of the support structure, in particular of the harness or vest-like clothing, is breathable and/or at least partially elastic.

[0044] Such electro impedance measuring belt can be designed for single use.

[0045] The object of the invention can be achieved by an electro impedance measuring method comprising the application of an electrode impedance measuring belt

which belt comprises an array of electrodes arranged in a spaced apart manner along the longitudinal extension of the belt, wherein the array of electrodes is placed essentially along the ribs or in the intercostal region of two neighbouring ribs around the thorax of a human being. For the purpose of placing an array of electrodes essentially along the ribs or in the intercostal region of two neighbouring ribs around the thorax of a human being an electro impedance measuring belt as described herein may be used. Preferably such belt comprises an array of a plurality of lined up, spaced apart (preferably evenly spaced apart) electrodes. The array (i.e. the line) in which the electrodes are lined up comprises preferably two straights connected via a bend; wherein said bend comprises an angle (α) advantageously between 80 and 170 degree, preferably between 90 and 160 degree, more preferably between 110 and 150 degree and most preferably between 120 and 140 degree.

[0046] Preferably the array of a plurality of electrodes defines an oblique oval electrode plane at an angle (γ) with respect to the transverse plane (i.e. transverse body plane 55) due to inclination about a transverse axis running from the left to the right side of a body. Said angle (γ) with respect to the transverse plane approximately corresponds to the rib inclination with respect to the dorsoventral axis. Moreover, said angle (γ) comprises preferably approximately 20 to 60 degree. If the electrode impedance measuring belt is adjusted, the array of electrodes follows one specific rib on one side of the body and the corresponding specific rib on the other side of the body. Consequently, the array of electrodes with respect to the craniocaudal axis surrounds the body posteriorly at a higher level than anteriorly. It is preferred that the electrodes are positioned between the 4th and the 7th rib. Alternatively the electrodes are positioned at the level of a specific intercostal space, preferably between the 4th and 5th or between the 5th and 6th rib, and most preferably between the 6th and 7th rib. It was found that EIT image data measured in these positions (i.e. in these oblique body planes) allow for an optimal analysis of the conditions of lung and heart.

[0047] The inventive electro impedance measuring method delivers particularly useful results for the purpose of further lung diagnosis, if the array of electrodes comprises at least 8 electrodes, preferably 16 electrodes, more preferably at least 30 electrodes, and further preferably spans in an evenly spaced apart manner at least 70%, preferably at least 80%, of the circumferential length of a patient in its oblique thoracic measurement plane.

[0048] From above follows that an electro impedance belt according to present invention may be used for performing electro impedance measurements and/or for performing electro impedance imaging methods.

DETAILED DESCRIPTION OF THE INVENTION

[0049] Other objects and advantages of the present

invention will become apparent to those skilled in the art upon reading the following detailed description of preferred embodiments, in conjunction with the accompanying drawings. The invention will be described in detail hereinafter with reference to the figures, in which, schematically:

Figure 1 shows a first embodiment of the inventive EIT measuring belt comprising a support structure and an array of electrodes forming together an electrode band and an attachment structure connected with the electrode band

a) view from the inside and
b) view from the outside;

Figure 2 shows a support structure with electrodes and an interface in the form of an electrically conductive textile in a sandwich-like structure with a permanent contact to the support structure;

Figure 3 shows a support structure with electrodes being placed in a tube-like conductive textile which can be an integral part of the attachment structure or a vest-like harness;

Figure 4 shows an interior view of an inventive EIT belt with the support and attachment structure when stretched out;

Figure 5: shows a further embodiment of an EIT belt with the electrodes arranged along two angulated legs attached to a vest of stretchable material

(a) an electrode band (i.e. a support structure with attached electrodes) alone,

(b) an inside view of an electrode belt comprising an electrode band attached to a vest,

(c) a partial front view of a closed EIT belt when wrapped around the thorax of a patient;

Figure 6: shows a further embodiment of an EIT belt similar to that of Figure 1 showing

(a) the electrode band with a transverse part connecting the two angulated legs of support structure with attached electrodes alone,

(b) an inside view of an electrode belt comprising an electrode band attached to a

vest,

(c) a partial front view of a closed EIT belt when wrapped around the thorax of a patient;

Figure 7 shows two persons of different shape wearing art inventive EIT measuring belt;

Figure 8: shows a view of the back of a patient carrying an inventive EIT measuring belt, (a) belt with suspenders and (b) vest-like belt;

Figure 9 shows a patient with the inventive EIT belt during EIT measurement.

Figure 10: shows a 3-D computer tomographic reconstruction of a healthy lung of a test person indicating the traditional transverse and the proposed new oblique electrode plane; and

Figure 11: shows (a) a 3D computed tomography representation of the heart and lung indicating conceptionally the best position of the electrode array at the 6th intercostals space, recording condition: distance 5.0 mm, thickness 5.0 mm; (b) tomographic 2D image obtained from an oblique cut through the 3D computed tomography representation at the 6th intercostal space (i.e. oblique body plane between ribs 6 and 7).

DETAILED DESCRIPTION OF THE DRAWINGS

[0050] The EIT measuring belt 11 of Figures 1 to 4 comprises a support structure 13 carrying a plurality of electrodes 15 and a attachment structure 17 to which the support structure 13 is affixed. The support structure 13 with the electrodes 15 thereby forms an electrode band 16. The electrodes are connectable to an EIT measurement module (not shown here). The characteristic of the inventive EIT measuring belt is that it is designed to be wrapped around the thorax of a patient in an oblique angle so that the plurality of electrodes extends essentially parallel to the ribs of a patient (i.e. along the longitudinal extension of the ribs or their intercostals space). Thus, the electrodes lined up in an array; which array essentially can be fitted to a patient in a parallel row along the longitudinal extension of the ribs or their intercostals space. In other words, the electrode band 16 is designed such that it can be placed around the chest at an angle to the transverse plane of the human body. Deviation from the transverse plane is such that the angle between an oblique plane, which is defined by the plurality of the electrodes, and the longitudinal extension of the ribs or their intercostals space around the chest (preferably the angle between said oblique plane and one of the central ribs,

such as e.g. the 4th, 5th, 6th or 7th rib) is approximately zero.

[0051] This novel electrode arrangement means that the EIT image now approximately corresponds to a larger cross-sectional area of the human thorax due to a larger anterior-posterior dimension compared to a traditional transverse cross-section as it is the case with conventional EIT measurements performed with EIT electrodes arranged in a transverse plane. Said conventional EIT measuring devices are wrapped around the thorax at essentially the same height of the body, usually at the lower section of the breastbone, so that the EIT image corresponds essentially to a cross-section extending orthogonally or transverse to the longitudinal axis of the body.

[0052] The advantage of the inventive EIT measuring belt is that the support structure 13 for the electrodes 15 can now be a non-stretchable band, since it is designed to extend parallel to the ribs. A further advantage is that also upper lung sections can be made visible. In order that the support structure 13 with the electrodes 15 is kept in place on the thorax during breathing, the attachment structure 17 is provided. The attachment structure 17 can be a kind of harness 19 as shown in Fig. 1. It comprises two straps 21 and 21' extending from a middle portion 23 having fixation means 25 and 25', e.g. Velcro fasteners, at their ends allowing to connect their ends together. The middle portion 23 is further equipped with one or two suspenders 27, which are to be put over the shoulders of a patient. Preferably, the straps 21, 21' comprise at least partially a stretchable portion which allows expansion due to the breathing of the patient. Fig. 1 shows an inside view (upper image) and an outside view (lower image) of the harness 19.

[0053] The support structure 1.3 with the electrodes 15 comprises a middle part 29, from which a leg 31, 31' extends on either side at an angle β of about between 5 to 50 degree with respect to the transverse right to left axis 33 of the middle part 29. Although not compulsory, the support structure 13 is preferably releasably or permanently affixed to the attachment structure 17. For this purpose loops 35 (e.g. cut out from the harness material as shown in fig. 1), glue, adhesive tape or Velcro fasteners can be provided for affixing the electrode band 16 to the attachment structure.

[0054] According to one embodiment angle α is preferably between 110 to 130 degree, and β (which equals to $90-\alpha/2$) is preferably between 25 and 35 degree.

[0055] According to the embodiment shown in Figures 1 to 4 the electrode band 16 is received in an envelope 37 or 37' of an electrically conducting material. Said electrically conducting material functions as interface between the electrically conducting electrode surface and the skin of a patient. The electrically conducting material is subject of the co-pending published application WO 2012/006753 A1.

[0056] As shown in Figures 2, 3, 5 and 6, the electrodes preferably are lined up in spaced apart manner. Advantageously the gaps between successive electrodes are

approximately equidistant.

[0057] In Fig. 4 it is visible that an optional preferably stretchable and/or elastic cloth 41 is provided between the suspenders 27 of harness 19'. The cloth has an indentation 43, which can serve as indicator for the right positioning of the EIT belt. Preferably also indicators for indicating the midline 45 as well as further folding lines 47 are provided. This alleviates the positioning and dressing of the EIT belt to a bedridden patient. In this alternative harness design 19' the electrode band 16 is received in envelope 37", which is attached to the harness 19' along the upper rim of the straps 22, 22'.

[0058] The embodiment of Fig. 5 distinguishes from that of Figure 1 insofar as no middle part is provided so that the electrode band 16 is angulated in the middle so that the two legs of the band are separated by a bend. The angle α between the legs 31 can be in the range between 80° and 170°, preferably between 90° and 160°, more preferably between 110° and 150°, or most preferably between 120° and 140°. Fig. 5a shows an angle α of exemplary 132 degrees. The electrode band 16 is attached to a vest 49 which preferably is made of a stretchable material. The vest 49 (which is similar to the harness 19 or 19' of Fig. 1-4) has essentially the shape of a triangle whose lateral corners are cut off. Figure 5b shows a vest 49 in differently stretched positions whereby the length of the electrode band 16 is unaltered. In Fig. 5b and Fig. 5c is depicted a connector 52 for connecting the electrode band to a control unit (not shown). Fig. 5c shows a vest with joined strap ends. At the same time the connector 52 connects the array of electrodes to a control unit which further is connectable to a EIT instrument. The vest 49 can be equipped with ears 51 through which the suspenders can be drawn.

[0059] The embodiment of Fig. 6 is provided with a middle part 29 to which the legs 31 of the electrode band are hingedly connected. The provision of the middle part 29 has the advantage that the apex of the electrode band is at a lower position than with a configuration as shown in Figure 5 so that the bends or hinges 53 and 53' are located behind the respective rib joints on both sides of the spinal column. This has the advantage that any movement of the belt is well coordinated with the movement of the ribs.

[0060] Figure 7 shows two persons with different physique being equipped with an inventive EIT measuring belt. In Figures 8 and 9 a test person is shown wearing a vest 49 equipped with an electrode band 16 (not visible here). At the neck, marker VP indicates the anatomic reference point of the vertebra prominens (C7). In Fig. 8a, advantageously, the electrode belt 49 is equipped with suspenders. In Fig. 8b an exemplary vest-like electrode belt 49 is presented. At the neck portion, correct fitting of the belt may be verified in reference to marker VP. Connector 52 serves to establish contact between the array of electrodes and an EIT instrument.

[0061] In Figure 10 a computed tomography 3-D reconstruction (lateral view) of the lung of a test person is

shown. The horizontal line 55 thereby illustrates the location of the traditional transverse electrode plane which has been used so far for recording EIT images. The curved oblique line 57 illustrates the location of the novel oblique electrode plane proposed by the present inventors. The oblique oval electrode plane is at an angle γ with respect to the transverse plane (i.e. transverse body plane). Angle γ with respect to the transverse plane approximately corresponds to the rib inclination with respect to the dorsoventral axis. Moreover, angle γ comprises preferably approximately 20 to 60 degree. Angle γ determines angle δ between above mentioned transverse body plane and the longitudinal axis of the body following the relation $\gamma + \delta = 90^\circ$.

[0062] Fig. 11a shows a 3D computed tomography (CT) reconstruction images of a lung. The CT image presents the lung at a spin of -105 degrees and a tilt of 13 degree. Fig. 11b shows a computed tomography 2D image obtained from an oblique cut through the 3D CT scan of Fig. 11 a at an angle as indicated by tripple line 59 at the 6th intercostal space. One can recognize in the upper middle the heart 61 which is surrounded on both sides by the lung 63 and 63' within the thorax 65. The body plane circumscribed by the 6th intercostal space on both sides of the thorax as indicated by line 59 shows a wide area of lung and heart tissue. An EIT image at this position therefore allows a representative determination of heart and lung conditions of a patient.

[0063] In the following further details or advantageous features of the EIT measuring belt are summarized:

The electrode belt may be designed as a stretchable or a non-stretchable type belt. The non-stretchable belt type is preferred. For closing the two overlapping ends of the belt a Velcro closing is proposed although any other appropriate closing means could be used. In particular, it is preferred that the support structure 13 is non-stretchable (thus the electrode band 16 is non-stretchable), while the attachment structure 19, 19' or 49 may or may not be stretchable.

[0064] The vest comprises slots, in particular vertical slots, or other fixation means for attaching the electrode band or support structure. These slots may be formed by cutting preferably parallel slot pairs into the vest material. Each slot pair functioning as a fastener or loop for accommodating and holding a belt-like support structure or electrode band. Alternatively, a thread may be affixed to the vest or other attachment device forming a strap or loop. Further alternative fixation means are push-buttons, Velcro fasteners or other means (e.g. glue or adhesive tape) resulting in a fixed connection of electrode band and vest-like garment.

[0065] The vest-like garment comprises preferably at least one fixation point with a fastener such as a loop 35 or Velcro fastener, preferably several such fixation points, more preferably 2 to 8 fixation points.

[0066] At one or both of the elongate ends of the vest, for holding the ends of the electrode band, the vest material may be folded back to form a pocket for enclosing

the ends of electrode band.

[0067] The fasteners or loops of the fixation point hold the support structure and therefore the electrode array in place. Pre-fabricated folds prevent the electrode band from shifting and inhibit the blocking of sensors.

[0068] Preferably, there is a strict distinction (and physical separation) between the functional belt-like support structure carrying the EIT electronics (electrode band) and the preferably textile attachment structure or vest-like garment. The vest-like garment is merely considered an attachment means to fix such belt-like support structure on the patient's body.

[0069] The electronics preferably is provided in a belt-like sandwich structure as shown in Fig. 2 or in a tube-like fashion as shown in Fig. 3. The belt-like sandwich structure, comprises a married relation between electronics and conductive material. In particular it is preferably a sandwich of electronic belt (i.e. support structure with electrodes) and soft padding together with conductive material (Fig. 2). The soft padding of the tubular structure 37' comprises conductive lines 38 which serve as an electrode-to-skin contacting means.

[0070] While a tubular structure 37 comprises a married relation between an electrically conductive material and the attachment structure or vest 19 (Fig. 3), a soft spacer fabric with integrated conductive pathways or such pathways extending around it creates a tube-like pocket for holding the support structure carrying the electrode sensors and at the same time connecting the electrode sensors electrically to a body, i.e. to skin.

[0071] Where body surface area is covered by the vest-like support in order to reliably fix the EIT electrode sensors on the body, it is desirable to use appropriate skin-friendly materials.

[0072] Further it is desirable that the belt is adapted to be opened and closed easily and also multiple times (possibly 5-10 times a day), e.g. for patient care, medical examination or patient transport.

[0073] It has been found that a sufficiently wide area of materials at the caudal edge of the belt should be provided in order to: Firstly, keep the sensors in place and to secondly, prevent the electrode band's ventral portion from moving cranially. This can best be achieved by a vest or vest-like harness. A respective downward / caudal movement is preferably prevented by appropriate shoulder straps or suspenders.

[0074] For manufacturing the vest an appropriately thin textile material is preferred, so that auscultation could even be performed through the vest material without having to remove it for such examination. A thin breathable textile or non-woven material does qualify for such use.

[0075] The presence of chest tubes in some patients can be taken into account for the vest layout However, dire to the fact that the vest is preferably a disposable for single patient use, simple holes or cuts could easily be performed or applied according to the individual patient's needs, provided the material does not disintegrate in the presence of thereby inflicted discontinuities.

[0076] The vest material in contact with the skin preferably has one or more of the following characteristics:

- disposable (ideally recyclable or with the least environmental impact);
- breathable;
- as thin as reasonably possible;
- materials directly touching the skin should not cause its irritation or allergic sensitization, but rather act like a second skin (see respective standards on biocompatibility);
- elasticity should ideally be spread over the material and not confined to specific (small) areas thereby imitating a second skin in the best possible way;
- repellent for water, body fluids and dirt;
- vest material should not cause artifacts in the patients CT images so that the belt can be worn even during CT exams; and/or
- in order to ensure best possible fit (like a "second skin") vests can be delivered in different sizes.

[0077] In order to facilitate usage and application of the vest, markers or "help lines" may be provided, such as e.g. the following:

- at the site of closure to indicate the exact current closing position e.g. of a Velcro closing, to facilitate adjustment, re-positioning or re-closure by such visual clues,
- an indicator of a midline (to run along the patient's spine),
- a physical marker of the distance to points of anatomic reference, such as e.g. the "vertebra prominens" (C7) ("Sports-Bra-Design"),
- lines indicating the best position for folding the vest during application on both sides, and/or
- indication and numbering of electrodes at their respective positions shall ideally be provided on the surface of the vest so as to allow to draw inferences from the electrode numbers as shown on the display of the medical device to the anatomical location of such (potentially failing) electrodes.

[0078] It is preferred that a docking station (e.g. a connector 52) can be placed on the EIT measuring belt at a position which is at the front of a patient, i.e. on the patient's chest, when wearing the belt. Preferably the belt connector plug (and its docking station) is aligned with the patient's longitudinal axis (Fig. 9). The docking station of the belt connector preferably is tightly fixed to the vest to facilitate handling. An automatic click-fix system might be desirable.

[0079] While the invention has been described above with reference to specific embodiments thereof, it is apparent that many changes, modifications, and variations can be made without departing from their inventive concept disclosed herein. The scope of protection is defined in the appended claims.

LEGEND / KEY:

[0080]

| | | |
|----|------------------|--|
| 5 | 1.1 | EIT measuring belt |
| | 13 | support structure |
| | 15 | electrodes |
| | 16 | electrode band |
| | 17 | attachment structure |
| 10 | 18 | longitudinal axis of a patient's body |
| | 19, 19' | harness |
| | 21, 21', 22, 22' | straps |
| | 23 | middle portion |
| | 25, 25' | fixation means |
| 15 | 27 | suspenders |
| | 29 | middle part of the support structure and the electrode array, respectively |
| | 31, 31' | leg |
| | 33 | longitudinal axis of the middle part |
| 20 | 35 | loop |
| | 37, 37', 7" | envelope |
| | 38 | conductive line |
| | 39 | electrode surface |
| | 41 | cloth between suspenders |
| 25 | 43 | indentation |
| | 45 | midline |
| | 47 | folding lines |
| | 49 | harness or vest |
| | 51 | ear |
| 30 | 52 | connector |
| | 53, 53' | hinge |
| | 55 | transverse electrode plane |
| | 57 | oblique electrode plane |
| | 59 | lines illustrating the 6 th intercostal space |
| 35 | 61 | heart |
| | 63, 63' | lung |
| | 65 | thorax |

Claims

1. An electro impedance measuring belt for placing electrodes around the thorax of a patient comprising,

- an array of a plurality of spaced apart electrodes (15), and
- a support structure (13), on which the electrodes are arranged,

wherein the support structure with the electrode array comprises two angulated legs (31, 31') on which the electrodes are lined up,

characterized in that,

the two legs spread out from an apex at an angle, such that, when the belt is put around the thorax of a patient, the array of electrodes extends from the back of the patient, where the apex of the angulated

- legs is to be located, essentially parallel to the ribs to the lower part of the breastbone of the patient.
2. Belt according to claim 1, **characterized in that** the angle formed between the legs is between 80 and 170 degree, preferably between 90 and 160 degree and most preferably between 110 and 150 degree.
 3. Belt according to claim 1 or 2, **characterized in that** the legs are connected by a transverse middle part whereas the angle between the longitudinal axis of the middle part and the longitudinal axis of the legs is between 5 and 50 degree, preferably between 10 and 45 degree and most preferably between 15 and 35 degree.
 4. Belt according to any one of claims 1-3, **characterized in that** the legs are designed as electrode band, preferably comprising first fastening means (25, 25') at their ends for connecting their ends together.
 5. Belt according to any one of the claims 1-4, **characterized in that** an attachment structure (17) is provided for holding the support structure with the array of electrodes in position, so that essentially no relative movement of the electrodes and the body of the patient occurs during breathing.
 6. Belt according to claim 5, **characterized in that** the attachment structure is designed to be connected on the one hand directly or indirectly to the body of the patient and on the other hand to the support structure.
 7. Belt according to any one of claims 5-6, **characterized in that** the attachment structure is a harness (19, 19', 49) adapted to hold the support structure in position preferably further **characterized in that** the harness essentially consists of a vest-like clothing or vest adapted to position and carry said support structure with the electrode array.
 8. Belt according to any one of claims 5-7, **characterized in that** the support structure, preferably such as a vest-like clothing or vest, is manufactured from a breathable material and/or at least partially from an elastic textile.
 9. Belt according to any one of claims 5-8, **characterized in that** the attachment structure and the support structure are releasably connected with each other or permanently connected with each other.
 10. Belt according to any one of claims 5-9, **characterized in that** the electrode array when attached to the attachment structure, in particular to the harness or vest-like clothing, and spread out flat shows a bent or curved shape, preferably a v-like-shape for allowing alignment with the rib inclination.
11. Belt according to any one of claims 1-10, **characterized in that** the electrode array and its support structure form an integral element comprising at least two layers,
 - a first layer comprising a skin-contacting cloth with electrically conducting pathways for establishing contact between the skin and the electrodes, and
 - a second layer comprising an electronic circuit board, optionally having also the function of the support structure, defining a plurality of electrode positions, and comprising supply lines, control lines and/or data lines for connecting the electrodes with an analysing and control instrument.
 12. Belt according to any one of claims 1-11, **characterized in that** the support structure of the array
 - is essentially non-stretchable and/or non-elastic, in particular the electronic circuit board is non-stretchable and/or non-elastic, and/or
 - is flexible and bendable for fitting the belt on and around the thorax of a patient.
 13. Belt according to any one of claims 1-12, **characterized in that** it is designed for single use.
 14. Electro impedance measuring method comprising the application of an electrode impedance measuring belt comprising an array of electrodes arranged in a spaced apart manner along the longitudinal extension of the belt, wherein,
 - the electrodes (15) are lined up in two angulated legs (31, 31'), which spread out from an apex at an angle, and
 - the array of electrodes is placed essentially along the ribs or in the intercostal region of two neighbouring ribs around the thorax of a human being,**characterized in that,** the array of electrodes extends from the back of the patient, where the apex of the angulated legs is to be located, essentially parallel to the ribs to the lower part of the breastbone of the patient.
 15. Method according to claim 14, **characterized in that** the array of electrodes defines an oblique oval plane at an angle with respect to the transverse plane due to inclination about a transverse axis running from the left to the right side of a body, optionally further **characterized in that** the angle approximately cor-

responds to the rib inclination with respect to the dorsoventral axis.

16. Method according to any one of claims 14-15, **characterized in that** the array of electrodes follows one specific rib on one side of the body and the corresponding specific rib on the other side of the body and preferably **characterized in that** the electrodes are positioned between the 4th and the 7th rib preferably positioned at the level of a specific intercostal space, preferably between the 4th and 5th or between the 5th and 6th rib, and most preferably between the 6th and 7th rib.

Patentansprüche

1. Gurt für die Messung der elektrischen Impedanz zum Anlegen von Elektroden um den Thorax eines Patienten, umfassend:

- eine Reihe mehrerer, voneinander beabstandeter Elektroden (15) und
- eine Trageanordnung, auf der die Elektroden angebracht sind, wobei die Trageanordnung der Elektrodenreihe zwei angewinkelte Arme (31, 31') aufweist, auf denen die Elektroden aufgereiht sind, **dadurch gekennzeichnet, dass** die beiden Arme, wenn der Gurt um den Thorax eines Patienten angelegt ist, von einem Scheitelpunkt in einem Winkel ausgehen, derart, dass die Elektrodenreihe vom Rücken des Patienten, wo der Scheitelpunkt der angewinkelten Arme zu positionieren ist, im Wesentlichen parallel zu den Rippen zum unteren Teils des Brustbeins des Patienten verläuft.

2. Gurt nach Patentanspruch 1, **dadurch gekennzeichnet, dass** der Winkel, der zwischen den Armen eingeschlossen wird, zwischen 80 und 170 Grad beträgt, vorzugsweise zwischen 90 und 160 Grad und besonders bevorzugt zwischen 110 und 150 Grad.

3. Gurt nach Patentanspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Arme durch einen quer verlaufenden Mittelteil verbunden sind, während der Winkel zwischen der Längsachse des Mittelteils und der Längsachse der Arme zwischen 5 und 50 Grad beträgt, vorzugsweise zwischen 10 und 45 Grad und besonders bevorzugt zwischen 15 und 35 Grad.

4. Gurt nach irgendeinem der Patentansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die Arme als Elektrodenband konstruiert sind, vorzugsweise erste Befestigungsmittel (25, 25') an ihren Enden zur Verbindung ihrer Enden miteinander umfassend.

5. Gurt nach irgendeinem der Patentansprüche 1 bis

4, **dadurch gekennzeichnet, dass** eine Anlegeanordnung (17) vorgesehen ist, um die Trageanordnung mit der Elektrodenreihe in Stellung zu halten, so dass während des Atmens im Wesentlichen keine Bewegung der Elektroden relativ zum Körper des Patienten stattfindet.

6. Gurt nach Patentanspruch 5, **dadurch gekennzeichnet, dass** die Anlegeanordnung dafür entworfen ist, einerseits direkt oder indirekt am Körper des Patienten befestigt zu werden, und andererseits an der Trageanordnung.

7. Gurt nach irgendeinem der Patentansprüche 5 bis 6, **dadurch gekennzeichnet, dass** die Anlegeanordnung ein Geschirr (19, 19', 49) ist, dafür eingerichtet, die Trageanordnung in Position zu halten, vorzugsweise außerdem **dadurch gekennzeichnet, dass** das Geschirr im Wesentlichen aus einer westenartigen Bekleidung oder Weste besteht, dafür ausgebildet, die genannte Trageanordnung der Elektrodenreihe in Stellung zu bringen und zu tragen.

8. Gurt nach irgendeinem der Patentansprüche 5 bis 7, **dadurch gekennzeichnet, dass** die Trageanordnung, vorzugsweise etwa eine westenartige Bekleidung oder Weste, aus einem atmungsfähigen Werkstoff und/oder mindestens teilweise aus einem elastischen Gewebe besteht.

9. Gurt nach irgendeinem der Patentansprüche 5 bis 8, **dadurch gekennzeichnet, dass** die Anlegeanordnung und die Trageanordnung abnehmbar miteinander verbunden sind oder permanent miteinander verbunden sind.

10. Gurt nach irgendeinem der Patentansprüche 5 bis 9, **dadurch gekennzeichnet, dass** die Elektrodenreihe, an der Anlegeanordnung, insbesondere am Geschirr oder der jackenartigen Bekleidung, angebracht und flach ausgebreitet, eine gebogene oder gekrümmte Form annimmt, vorzugsweise eine v-Form, um die Ausrichtung mit der Rippenneigung zu ermöglichen.

11. Gurt nach irgendeinem der Patentansprüche 1 bis 10, **dadurch gekennzeichnet, dass** die Elektrodenreihe und ihre Trageanordnung ein einstückiges Teil bilden, das mindestens zwei Schichten aufweist,

- eine erste Schicht, ein Hautkontakttuch mit elektrisch leitenden Bahnen zur Herstellung des Kontaktes zwischen der Haut und den Elektroden umfassend, und
- eine zweite Schicht, einen elektronischen Schaltkreis aufweisend, optional auch die Funktion der Trageanordnung übernehmend, die

mehrere Elektrodenstellen definiert und Versorgungsleitungen, Steuerleitungen und/oder Datenleitungen zum Anschluss der Elektroden an ein Analysier- und Steuergerät umfasst.

12. Gurt nach irgendeinem der Patentansprüche 1 bis 11, **dadurch gekennzeichnet, dass** die Trageanordnung der Elektrodenreihe

- im Wesentlichen nicht dehnbar und/oder nicht elastisch ist, insbesondere der elektronische Schaltkreis nicht dehnbar und/oder nicht elastisch ist, und/oder
- flexibel und biegsam ist, um den Gurt an und um den Thorax eines Patienten anzulegen.

13. Gurt nach irgendeinem der Patentansprüche 1 bis 12, **dadurch gekennzeichnet, dass** er für einmaligen Gebrauch entworfen ist.

14. Verfahren zur Messung der elektrischen Impedanz, die Anwendung eines Gurtes für die Messung der elektrischen Impedanz umfassend, der eine Reihe voneinander beabstandeter Elektroden längs der Längserstreckung des Gurtes umfasst, wobei

- die Elektroden (15) auf zwei angewinkelten Armen (31, 31') aufgereiht sind, die von einem Scheitelpunkt in einem Winkel ausgehen, und
- die Elektrodenreihe im Wesentlichen längs der Rippen oder im Zwischenrippenbereich zweier benachbarter Rippen um den Thorax eines Menschen angeordnet sind,

dadurch gekennzeichnet, dass

die Elektrodenreihe vom Rücken des Patienten, wo der Scheitelpunkt der angewinkelten Arme zu positionieren ist, im Wesentlichen parallel zu den Rippen zum unteren Teil des Brustbeins des Patienten verläuft.

15. Verfahren nach Patentanspruch 14, **dadurch gekennzeichnet, dass** die Elektrodenreihe aufgrund der Neigung um eine Querachse, die von der linken zur rechten Körperseite verläuft, eine schräge, ovale Ebene in einem Winkel zur Querebene definiert, optional außerdem **dadurch gekennzeichnet, dass** der Winkel ungefähr der Neigung der Rippen relativ zur dorsoventralen Achse entspricht.

16. Verfahren nach irgendeinem der Patentansprüche 14 bis 15, **dadurch gekennzeichnet, dass** die Elektrodenreihe einer bestimmten Rippe auf einer Körperseite folgt und der entsprechenden bestimmten Rippe auf der anderen Körperseite und vorzugsweise **dadurch gekennzeichnet, dass** die Elektroden zwischen der 4. und der 7. Rippe vorzugsweise in Höhe eines bestimmten Rippenzwischenraumes

positioniert sind, vorzugsweise zwischen der 4. und 5. oder zwischen der 5. und 6. Rippe, und besonders bevorzugt zwischen der 6. und der 7. Rippe.

5

Revendications

1. Ceinture de mesure d'impédance électrique pour placer des électrodes autour du thorax d'un patient comprenant :

- un réseau d'une pluralité d'électrodes espacées (15) et
- une structure de support (13) sur laquelle les électrodes sont arrangées,

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la structure de support avec le réseau d'électrodes comprenant deux branches angulées (31, 31') sur lesquelles les électrodes sont alignées,

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caractérisée en ce que les deux branches déployées à partir d'un sommet en formant un angle de telle manière que, lorsque la ceinture est mise autour du thorax d'un patient, le réseau d'électrodes s'étend à partir du dos du patient, où le sommet des branches angulées doit être situé substantiellement parallèlement aux côtes vers la partie inférieure du sternum du patient.

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2. Ceinture selon la revendication 1, **caractérisée en ce que** l'angle formé entre les branches est entre 80 et 170 degrés, de préférence entre 90 et 160 degrés et de manière particulièrement préférée entre 110 et 150 degrés.

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3. Ceinture selon la revendication 1 ou 2, **caractérisée en ce que** les branches sont reliées par une partie médiane transversale, tandis que l'angle entre l'axe longitudinal de la partie médiane et l'axe longitudinal des branches est entre 5 et 50 degrés, de préférence entre 10 et 45 degrés et de manière particulièrement préférée entre 15 et 35 degrés.

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4. Ceinture selon l'une quelconque des revendications 1 à 3, **caractérisée en ce que** les branches sont conçues comme une bande d'électrodes, de préférence comprenant des premiers moyens de fixation (25, 25') à leurs extrémités pour relier leurs extrémités ensemble.

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5. Ceinture selon l'une quelconque des revendications 1 à 4, **caractérisée en ce qu'**une structure de fixation (17) est prévue pour maintenir en position la structure de support avec le réseau d'électrodes si bien que quasiment aucun mouvement relatif des électrodes et du corps du patient n'a lieu pendant la respiration.

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6. Ceinture selon la revendication 5, **caractérisée en**

- ce que** la structure de fixation est conçue pour être reliée d'un côté directement ou indirectement au corps du patient et de l'autre côté à la structure de support.
7. Ceinture selon l'une quelconque des revendications 5 à 6, **caractérisée en ce que** la structure de fixation est un harnais (19, 19', 49) adapté pour maintenir en position la structure de support, de préférence **caractérisée en ce que** le harnais consiste principalement d'un vêtement de type veste ou d'une veste adaptée pour positionner et porter ladite structure de support avec le réseau d'électrodes.
8. Ceinture selon l'une quelconque des revendications 5 à 7, **caractérisée en ce que** la structure de support, de préférence conçue comme un vêtement de type veste ou une veste, est fabriquée en une matière respirante et/ou au moins partiellement en un textile élastique.
9. Ceinture selon l'une quelconque des revendications 5 à 8, **caractérisée en ce que** la structure de fixation et la structure de support sont reliées de manière amovible l'une à l'autre ou sont reliées de manière permanente l'une à l'autre.
10. Ceinture selon l'une quelconque des revendications 5 à 9, **caractérisée en ce que** le réseau d'électrodes, lorsqu'il est fixé à la structure de fixation, en particulier au harnais ou au vêtement de type veste, et qu'il est déployé à plat a une forme coudée ou courbée, de préférence une forme de type en V pour permettre l'alignement avec l'inclinaison des côtes.
11. Ceinture selon l'une quelconque des revendications 1 à 10, **caractérisée en ce que** le réseau d'électrodes et sa structure de support forment un élément indissociable comprenant au moins deux couches,
- une première couche comprenant un tissu en contact avec la peau avec des voies conductrices d'électricité pour établir le contact entre la peau et les électrodes et
 - une seconde couche comprenant un circuit imprimé électronique qui a en option également la fonction de structure de support, qui définit une pluralité de positions d'électrodes et qui comprend des conduites d'alimentation, des conduites de commande et/ou des lignes de données pour relier les électrodes à un instrument d'analyse et de commande.
12. Ceinture selon l'une quelconque des revendications 1 à 11, **caractérisée en ce que** la structure de support du réseau
- est substantiellement non extensible et/ou non élastique, en particulier le circuit imprimé électronique est non extensible et/ou non élastique et/ou
 - est flexible et pliable pour ajuster la ceinture sur et autour le thorax d'un patient.
13. Ceinture selon l'une quelconque des revendications 1 à 12, **caractérisée en ce qu'**elle est conçue pour un usage unique
14. Procédé de mesure de l'impédance électrique comprenant l'application d'une ceinture de mesure de l'impédance électrique comprenant un réseau d'électrodes arrangées en étant espacées le long de l'extension longitudinale de la ceinture, cependant que
- les électrodes (15) sont alignées en deux branches angulées (31, 31') qui sont déployées à partir d'un sommet en formant un angle et
 - le réseau d'électrodes est placé substantiellement le long des côtes ou dans la région intercostale de deux côtes voisines autour du thorax d'un être humain,
- caractérisé en ce que** le réseau d'électrodes s'étend à partir du dos du patient où le sommet des branches angulées doit être situé substantiellement parallèlement aux côtes vers la partie inférieure du sternum du patient.
15. Procédé selon la revendication 14, **caractérisé en ce que** le réseau d'électrodes définit un plan ovale oblique en formant un angle par rapport au plan transversal dû à l'inclinaison par rapport à un axe transversal qui part du côté gauche au côté droit d'un corps, en option **caractérisé de plus en ce que** l'angle correspond approximativement à l'inclinaison des côtes par rapport à l'axe dorsoventral.
16. Procédé selon l'une quelconques des revendications 14 à 15, **caractérisé en ce que** le réseau d'électrodes suit une côte spécifique sur un côté du corps et la côte spécifique correspondante sur l'autre côté du corps et caractérisé de préférence **en ce que** les électrodes sont positionnées entre la 4ème et la 7ème côte, de préférence positionnées au niveau d'un espace intercostal spécifique, de préférence entre la 4ème et la 5ème ou entre la 5ème et la 6ème côte et de manière particulièrement préférée entre la 6ème et la 7ème côte.

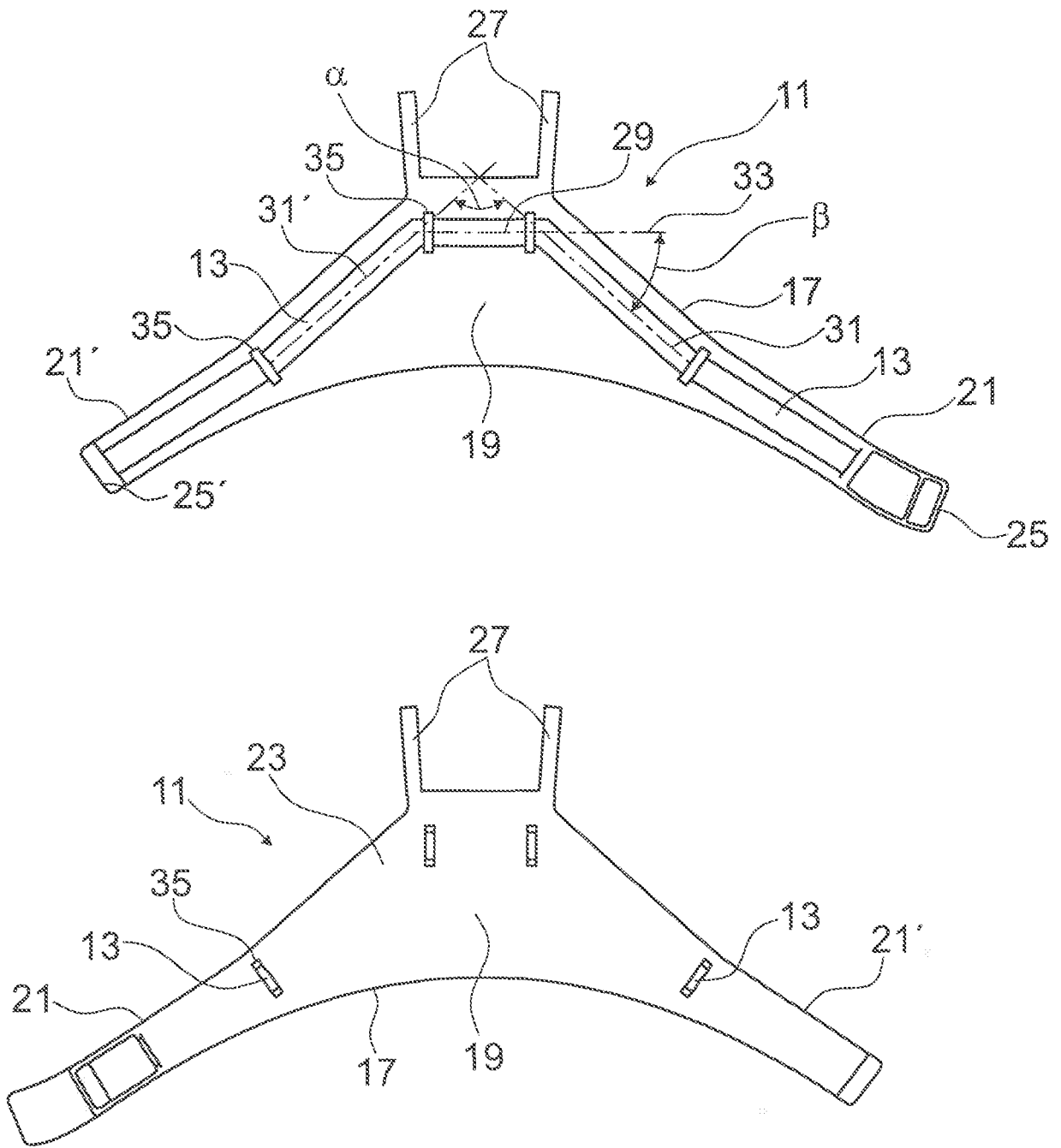


Fig. 1

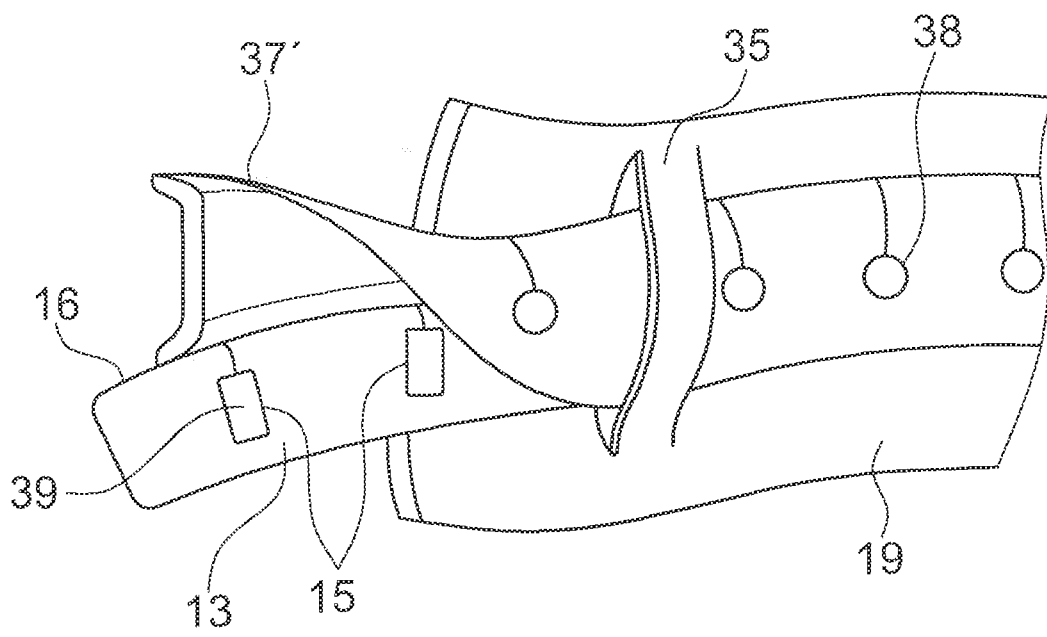


Fig. 2

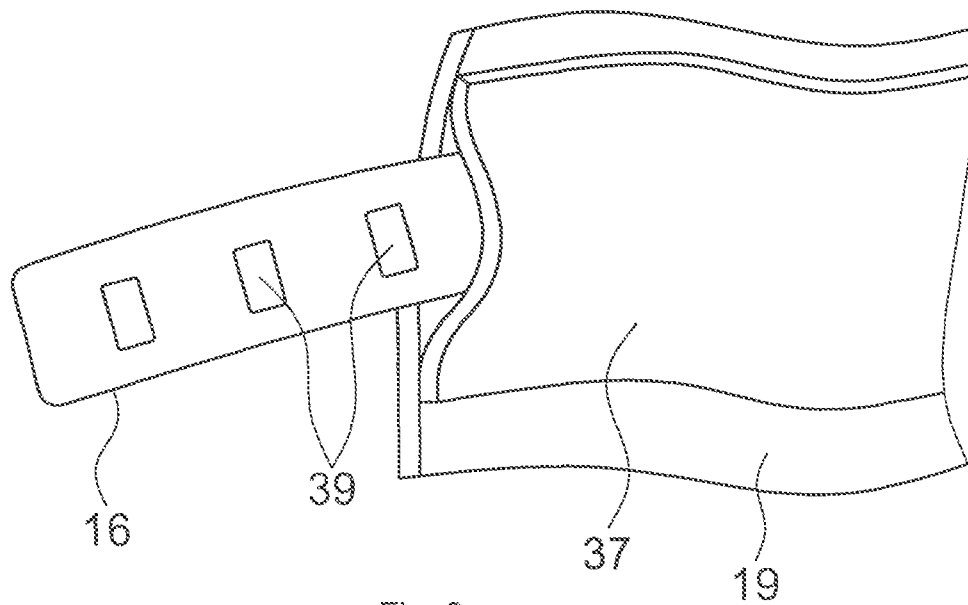


Fig. 3

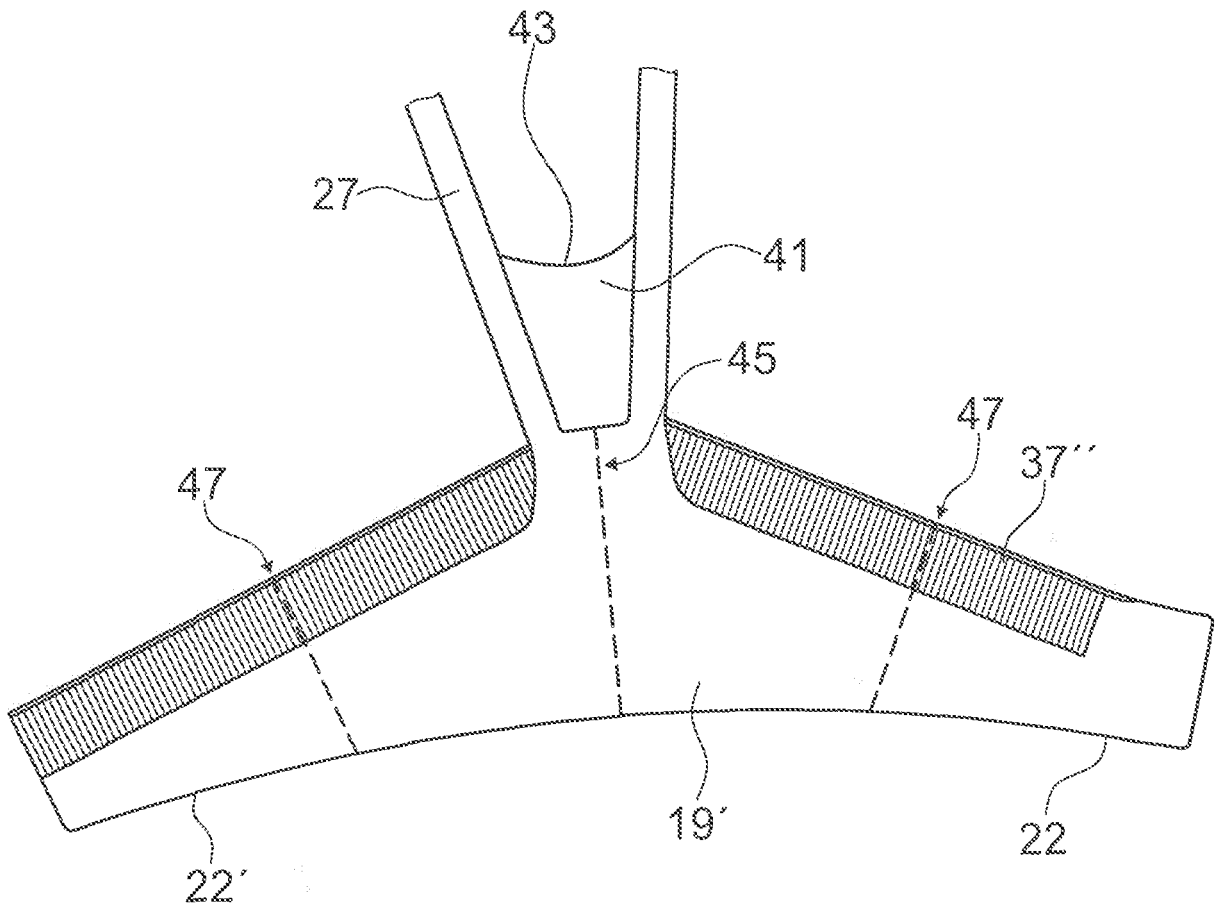


Fig. 4

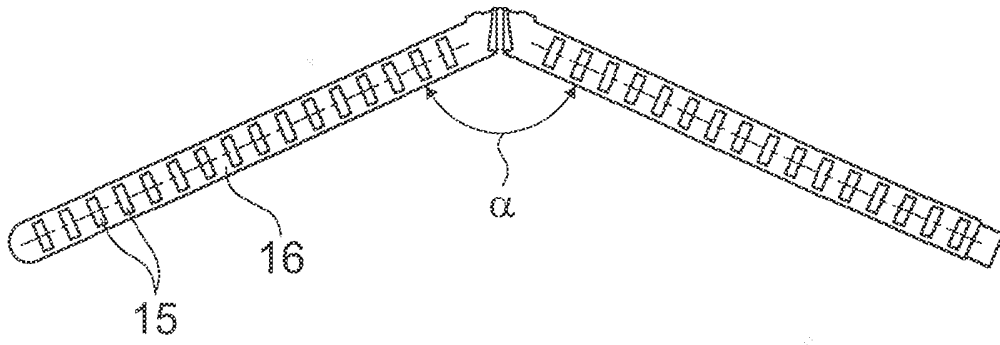


Fig. 5a

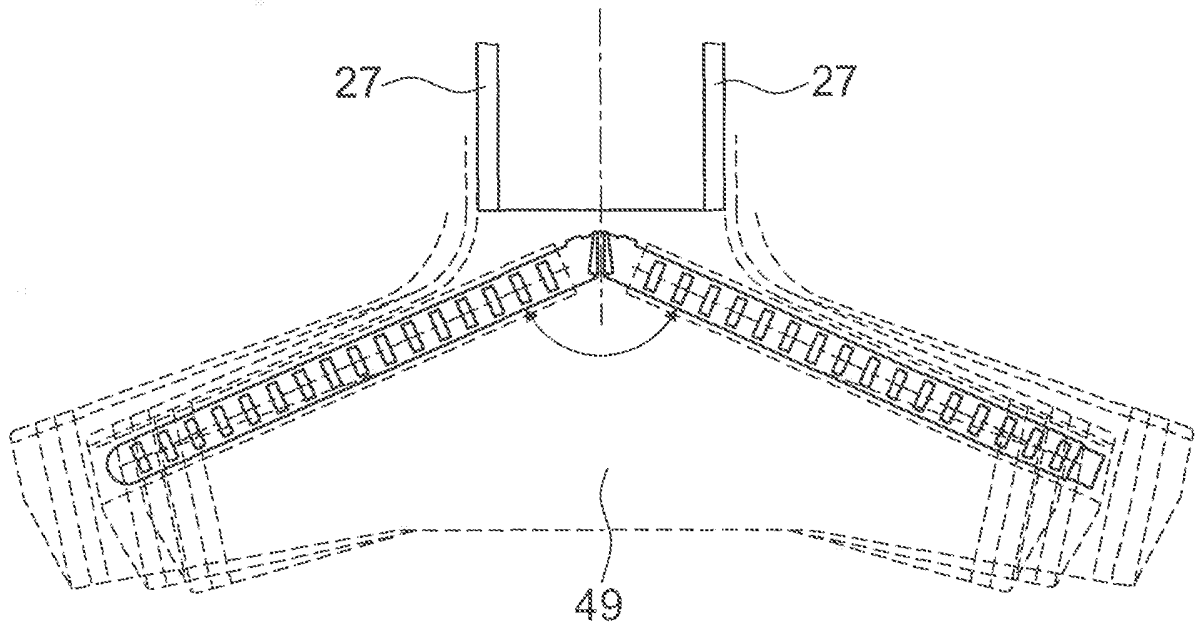


Fig. 5b

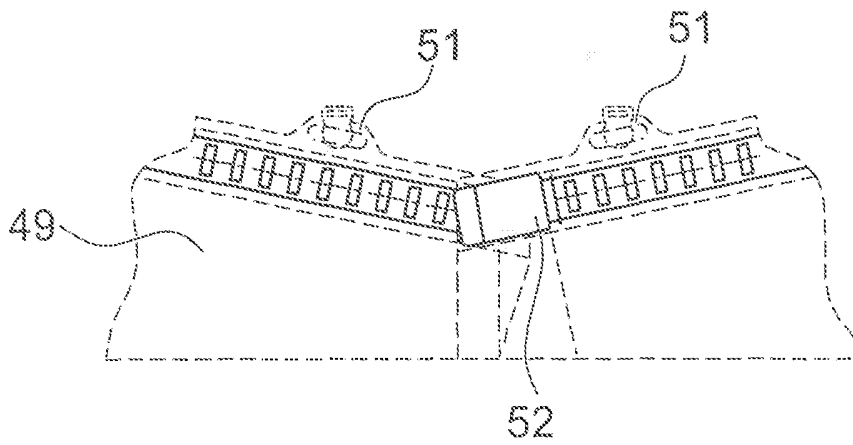


Fig. 5c

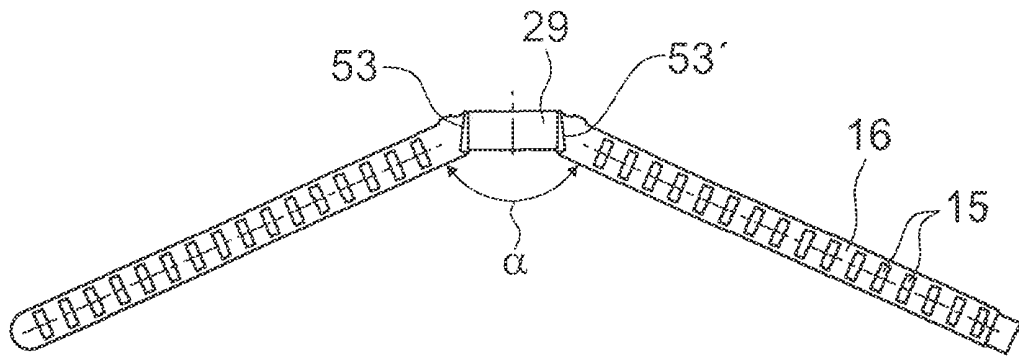


Fig. 6a

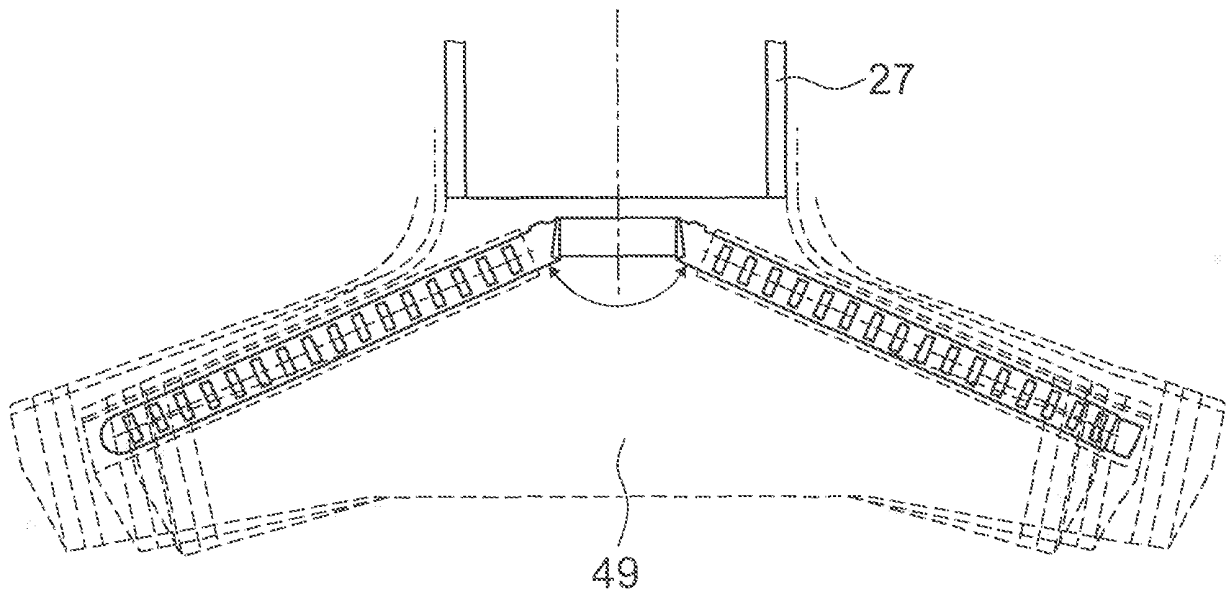


Fig. 6b

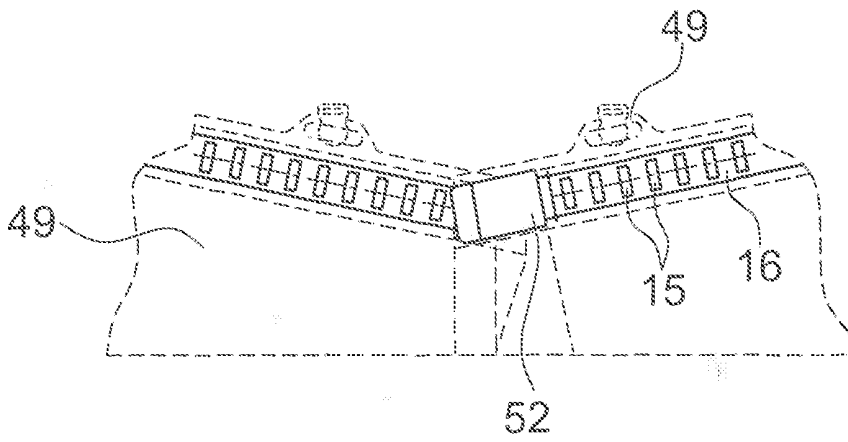


Fig. 6c

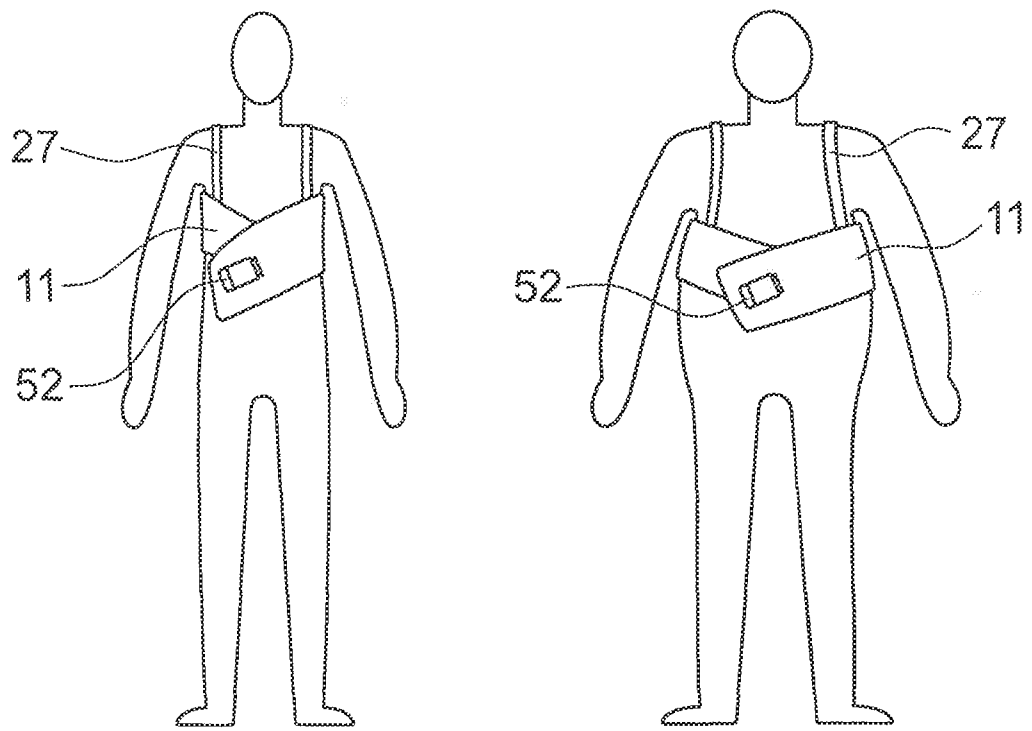


Fig. 7

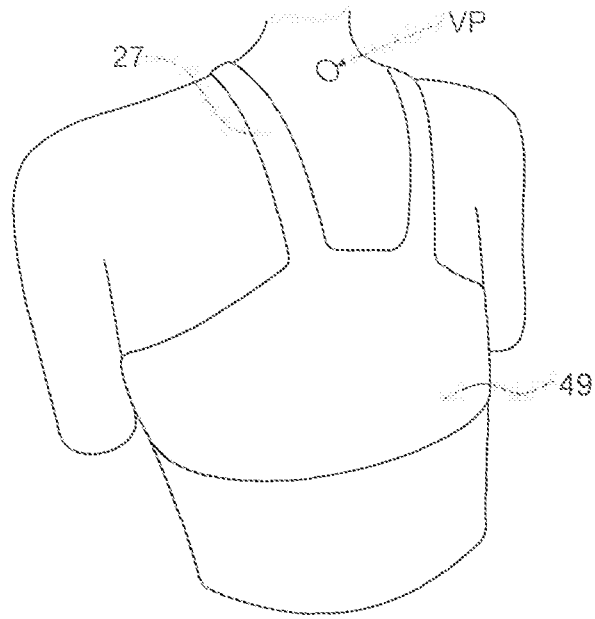


Fig. 8a

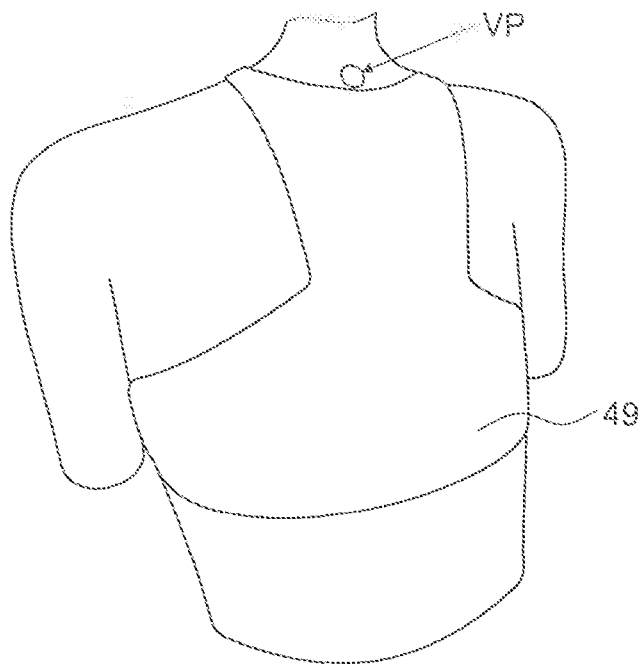


Fig. 8b

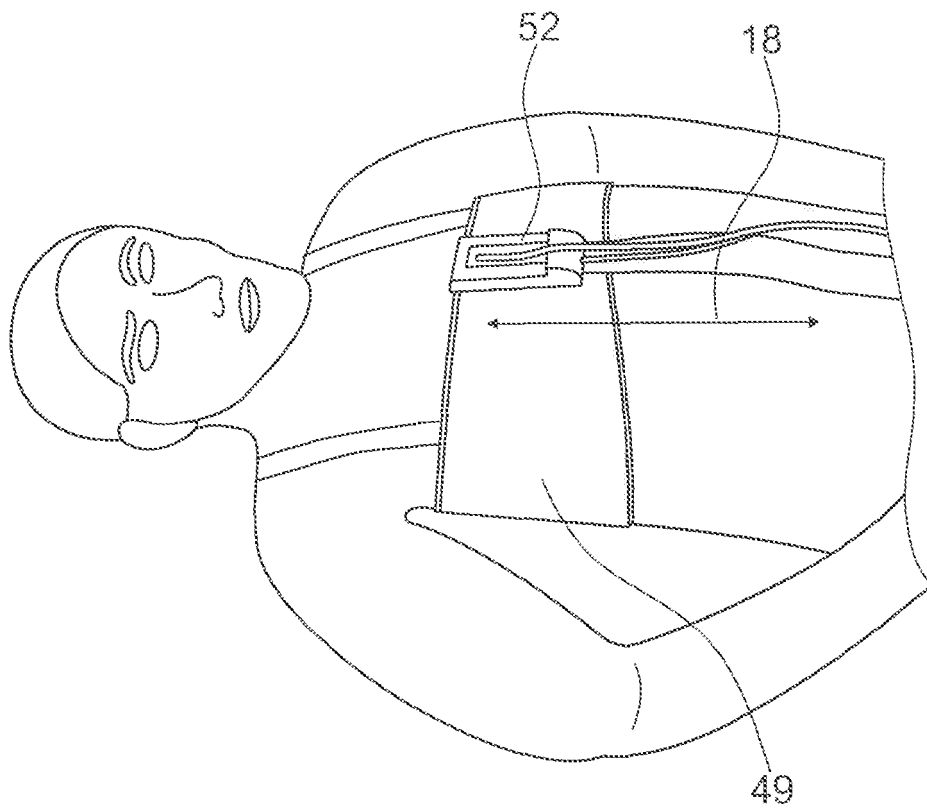


Fig. 9

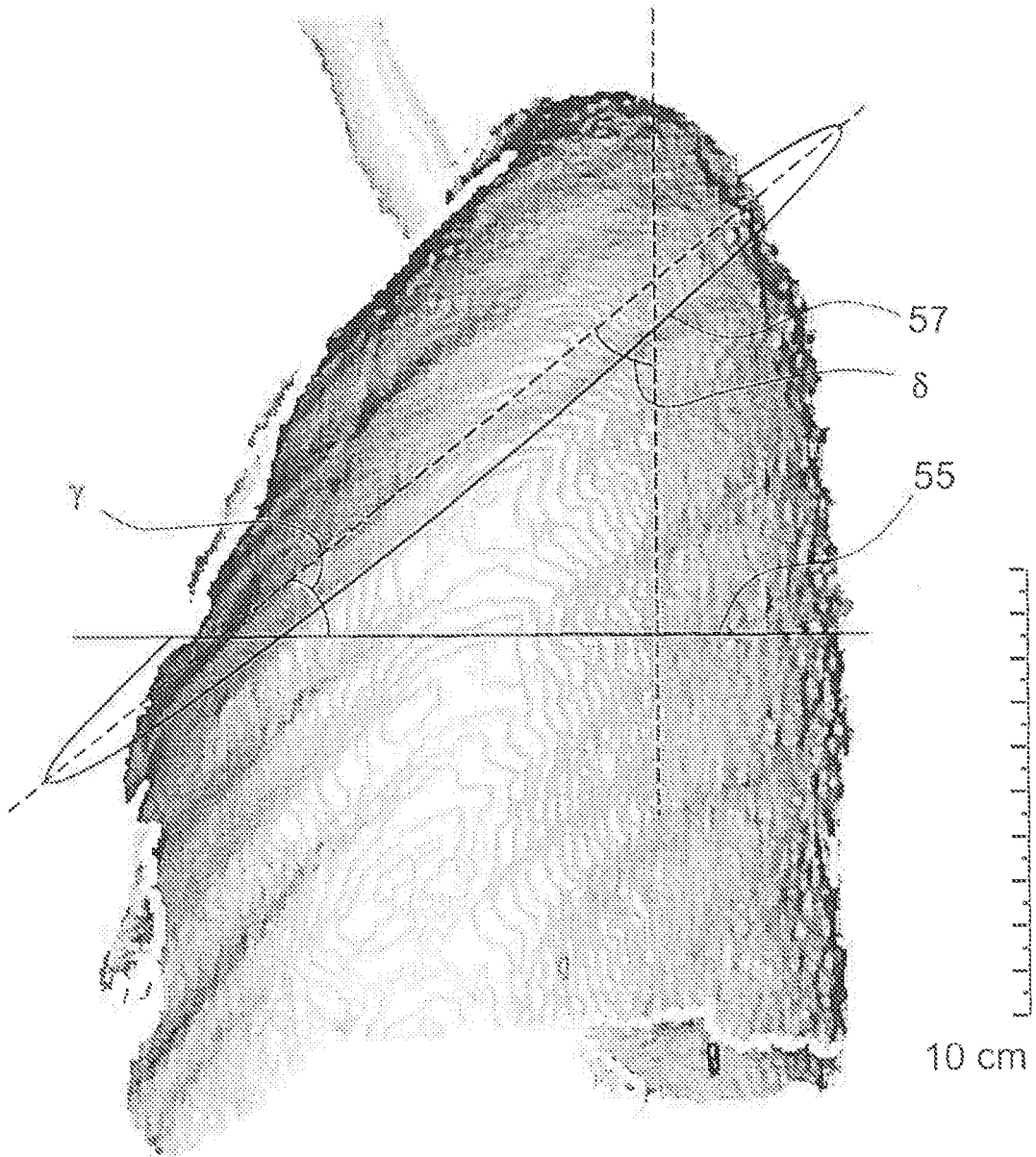


Fig. 10

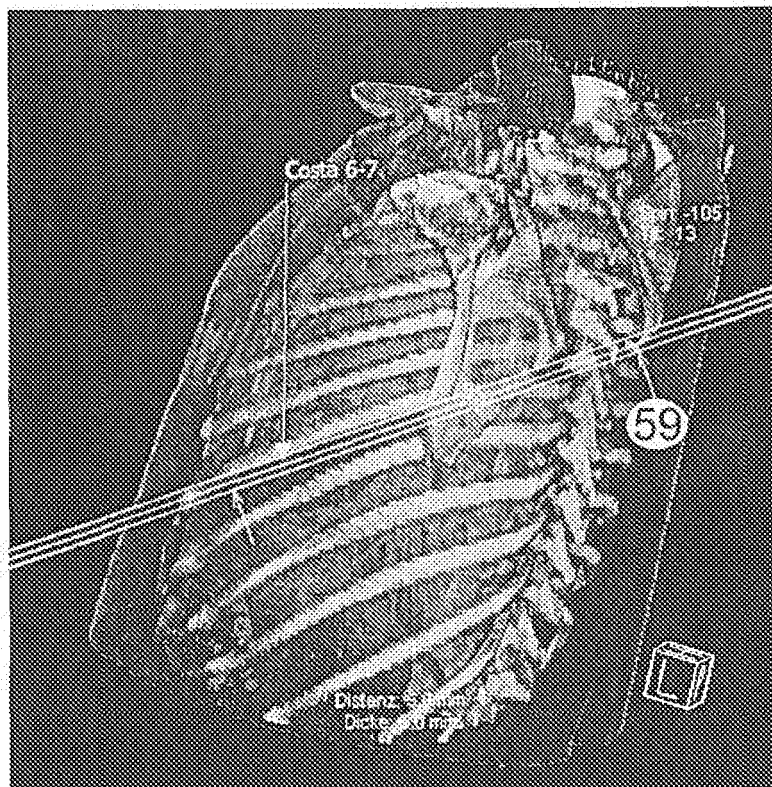


Fig. 11a

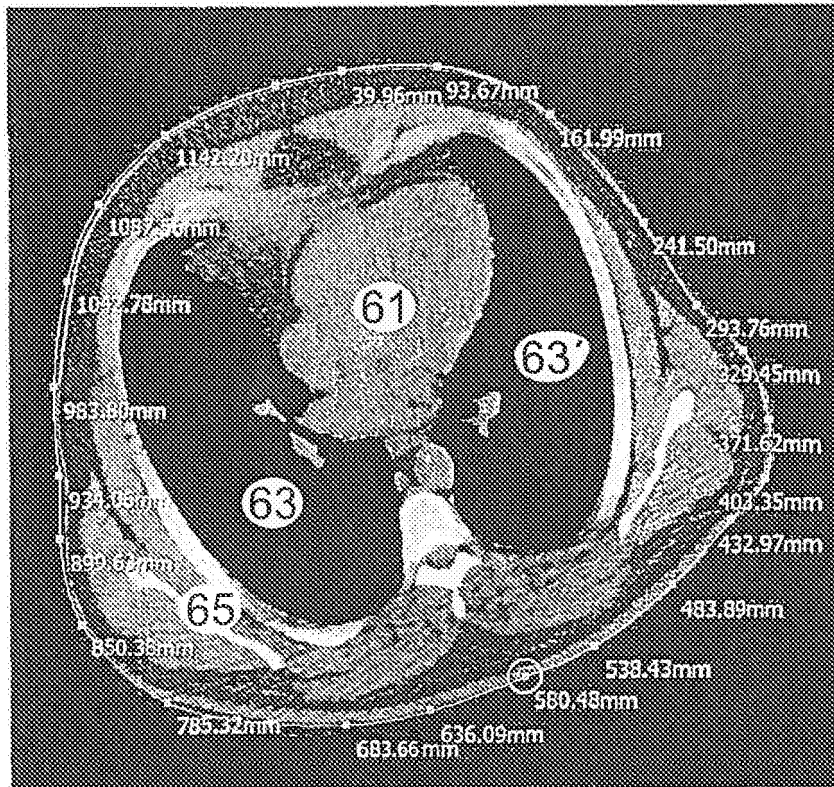


Fig. 11b

REFERENCES CITED IN THE DESCRIPTION

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|----------------|---|---------|------------|
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| 申请号 | EP2013703721 | 申请日 | 2013-01-28 |
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| 优先权 | 2012000116 2012-01-27 CH | | |
| 其他公开文献 | EP2806792A1 | | |
| 外部链接 | Espacenet | | |

摘要(译)

一种用于在患者的胸腔周围放置电极的电阻抗测量带包括多个间隔开的电极的阵列，以及支撑结构，电极布置在该支撑结构上。具有电极阵列的支撑结构包括两个成角度的腿，电极排列在两个成角度的腿上，两个腿从一个顶点以一定角度展开，使得当带放在患者的胸部周围时，电极阵列从患者的背部延伸，其中要定位有角度的腿的顶点，基本上平行于肋骨到患者的胸骨的下部。

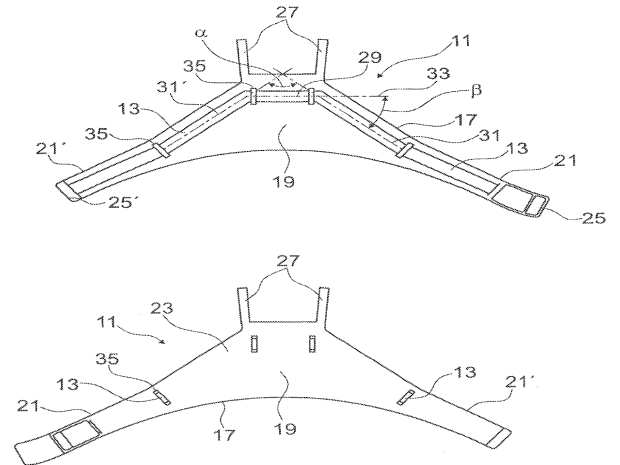


Fig. 1