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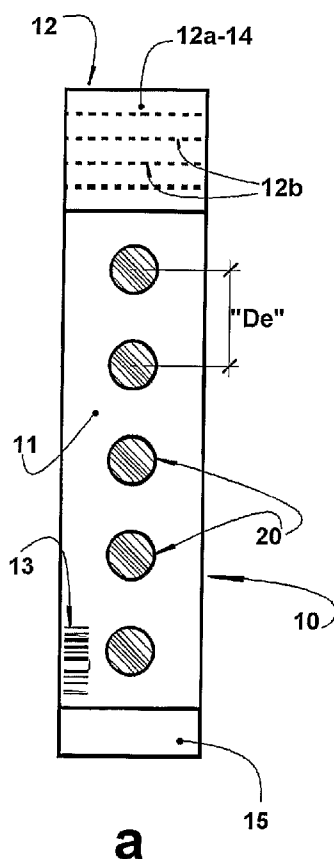
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(54) Title: ELECTRODE ASSEMBLY FOR ELECTRICAL IMPEDANCE TOMOGRAPHY



(57) Abstract: An electrode assembly for electrical impedance tomography comprising a plurality of different electrode modules (10), each containing a support strap (11) made of a flexible material that presents a reduced longitudinal deformability and carrying a predetermined number of electrodes (20), each support strap (11) being dimensioned to be seated and retained onto a respective extension portion of a body segment (C) of a patient. Each electrode module (10) presents the number of electrodes (20) and a distance "De" between each two consecutive electrodes (20) predetermined as a function of a specific operational pattern to be obtained from each electrode module (10). The assembly can further comprise an electrical conducting cable (30) having an end connected to a monitoring apparatus (M) and a free end provided with a connector (33) to be coupled to a respective electrode (20) of an electrode module (10).

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"ELECTRODE ASSEMBLY FOR ELECTRICAL IMPEDANCE TOMOGRAPHY"

Field of the Invention

The present invention is related to the provision of electrode modules, each containing a plurality of electrodes to be applied around a body segment of a human patient or an animal, in order to carry out the Electrical Impedance Tomography (EIT).

Background of the Invention

The Electrical Impedance Tomography (EIT) allows visualizing and monitoring a cross-section of parts of the human body, by capturing its electrical potential. An electrical current around the surface is conducted inside the body in a rotative pattern, generating a gradient of electrical potential on the surface. The electrical impedance distribution measured in the body parts is transformed, with the help of an image reconstruction algorithm, in a two-dimensional image. For this reason, the EIT has a great potential to be used in the medical field, mainly for image visualization in real-time of the cardiopulmonary functions, for example, in situations in which patients need to be ventilated or have suffered an accident, trauma, etc.

A typical biomedical EIT apparatus utilizes the concept of placing a plurality of equidistantly spaced electrodes, surrounding totally one part of the body. Generally, in the monitoring system it is necessary the precise placement of 16 to 32 electrodes around the desired surface. Since the use of multiple electrodes is needed, it is difficult to precisely place the electrodes one-by-one around the body, mainly in an equidistant form and in the same cross-section. Furthermore, it is a laborious process that requires time, attention and skilled personnel.

A solution for the problem above makes use of an elastic belt with electrodes. The basic idea of the electrode belt is to install a plurality of electrodes in an elastic material. In this way, the placement of the

electrodes around a body would be quick and the elastic material would provide equidistant electrodes, at the same time. However, it is difficult to guarantee an equidistant position of the electrodes by using an elastic material. Furthermore, to avoid the electrodes from moving on the body during the data acquisition, this belt has to be tightly placed on the desired surface. Accordingly, this elastic force applied to the surface of the thorax can provoke scabs and make breathing difficult. For an adequate fixation of the belt it is necessary to provide several belt sizes due to, for example, the existence of several thorax perimeters, which generates a high cost inventory and the necessity of a large stock. Another problem is the possibility of occurring bad contact of the electrodes with the external part of the body under observation, due to the existence of different thorax anatomies, which problem cannot be solved by using an elastic material. Such differences occur as a function of the sex and muscular structure of the patient, for example, male patients who have large chest muscles present a depression in the middle of the chest and, similarly, in the middle of the back as a consequence of the muscular structure of the back; in women, there are anatomical variations of the thorax, mainly regarding the different breast sizes.

Situations that require discontinuity in the electrode line around the thorax, or situations that do not allow the electrodes to totally surround the body, cannot be monitored by the current EIT systems, such as, for example, post-operative period of cardiac surgeries, lesions caused by side arms or firearms, burns, skin lesions that result in bloody areas due to dermatological or infectious diseases, or a situation in which there is no access to a part of the body, for example, when the victim is trapped in the accident site or has injured the spinal cord, making difficult or even impeding his/her movement.

Moreover, the present state of the art does not allow optimizing the image resolution and definition in a region of interest. For example, US patent application 2004/0260167 A1 describes an electrode elastic belt that
5 can be formed by joining belt segments, said segments presenting the same number of electrodes that can be equally spaced from each other. In accordance with the teachings of the document above, the formation of the electrode belt in multiple interconnected segments
10 connected presents the advantage of reducing the number of electrical conducting cables disposed along the belt, besides leading to a quick and easy application of the electrodes to unconscious patients or that cannot be moved.

15 Despite the benefits regarding facility of application and reduction of the extension of the conducting cables along the electrode belt, this prior art solution proposes an electrode distribution surrounding totally a body segment, making impossible its use in situations in
20 which the electrode belt has to be interrupted in one or more regions of the body segment.

Due to the constructive form of the electrode elastic belt, it is not possible to provide concentration of electrodes in specific regions, that is, an irregular
25 electrode distribution, aiming at obtaining images with higher definition in certain areas of interest, even in situations in which the electrode belt has to be interrupted in one or more regions of the body segment.

Summary of the Invention

30 The present invention has a different approach for the problem. Instead of focusing a way of placing the electrodes equidistantly and totally surrounding an object defined by a body segment of a human patient or an animal, an EIT apparatus has been developed which allows
35 both planning and informing the relative position of the electrodes. Thus, this apparatus permits the use of a variable number of electrodes and of spacings and it may

be utilized in situations in which there is also a discontinuity in the electrode line, besides not requiring to place the electrodes around the entire external contour of a body segment being analyzed.

5 The main object of the present invention is to provide an assembly of electrodes arranged in modules which can be applied, in a practical and precise manner, to different thorax shapes and perimeters, such as of newborn children, children e adults and animals.

10 Another object of the present invention is to provide an electrode assembly in modular arrangement, as mentioned above, with a small number of parts that are capable of covering a broad variation of morphological characteristics of the body segments to be analyzed.

15 Consequently, there is a cost reduction with stocks and the operation becomes easier. Moreover, electrode failures in a belt requires replacing the entire belt; in the case of the modular arrangement, only the worn out or defective module is replaced.

20 It is also an object of the present invention to provide an electrode assembly as cited above, which permits to maximize the resolution and quality of the image in regions of interest, such as: heart, right or left lung, parts subject to infection, etc, by positioning the
25 electrodes in relation to the region of interest.

A further object of the present invention is to provide an electrode assembly as mentioned above, which permits a practical, precise and quick application, even in situations in which there are restrictions to access the
30 perimeter of the body segment to be analyzed, for example, due to accidents, injuries, traumas or surgeries.

According to the invention, the electrode assembly comprises a plurality of different electrode modules,
35 each comprising a support strap made of a flexible material that presents a reduced longitudinal deformability and carrying a desired number of electrodes

to be electrically connected to a monitoring apparatus, one of the modules comprising at least two electrodes, each electrode module having its respective support strap dimensioned to be seated and retained on a respective
5 extension portion of a body segment to be analyzed, according to a plane of interest sectioning said body segment, each of the different electrode modules presenting the number of electrodes and a distance between each two consecutive electrodes predetermined as
10 a function of a specific operational pattern to be obtained from each electrode module.

In one embodiment, each electrode of an electrode module is electrically connected to a monitoring apparatus by means of an electrical conducting cable.

15 According to the invention, each electrode module comprises a certain number of electrodes disposed with a spacing between each two consecutive electrodes which can have the same value or distinct values, allowing some modules to have electrodes equally spaced apart along a
20 median longitudinal alignment of the module, and other electrode modules to have the electrodes concentrated in one or more of the regions of the module and dispersed in others.

The constructive variations existing for the modules, regarding the number, arrangement and extension of the
25 respective support strap, allows having a suitable module for each region of a body segment of the patient and for the resolution degree desired for this or that region.

For example, in a situation in which it is not possible
30 to place electrode modules in the region of the right chest, a possible solution for this problem would be to place a module with 8 electrodes on the left chest and a module with 12 electrodes installed on the back of the patient.

35 The electrode assembly of the present invention has been developed to be applied in an EIT system which preferably utilizes an image reconstruction algorithm, which

operates analogously as a finite element mesh, whereby the image resolution generated by EIT will be optimized by increasing the number of electrodes near the desired region. On the other hand, the lower the number of
5 electrodes, the lower will be the image resolution generated.

Thus, the combinations of different modules permit that the EIT system be utilized in the case of a pulmonary tomography, in a more precise, practical and quick manner
10 for any perimeter of patient, newborn children and adults and with any thorax shape, both for females and males and for different clinical situations, even those which require an interference in the electrode line.

In order to provide the correct operation of the EIT apparatus, the latter must be informed about the position
15 of the electrodes, which can be achieved electronically through the algorithm or the identification codes present in each electrode module and through the combination of these identification codes and their respective
20 distances. For this purpose, each electrode module can have a device for providing and indicating a precise spacing and an identification code.

The spacing device, if existing, can comprise a material with a distance graduation installed in one of the module
25 ends. Then, the distance between the electrodes will be informed by the value indicated by the spacing system. This spacing system is a practical and simple tool which permits the correct spacing of the electrode modules. A more complex system can be made with a variable
30 resistance installed in the spacing device. Since a variable resistance presents a specific value in ohms for each distance, then the distance between the electrodes will be determined by the value of this resistance, which can be informed by the electrode itself to the monitoring
35 system.

The identification codes inform the characteristics of the electrode modules through numbers or bar code, said

characteristics comprising, for example: distance between the electrodes of each module, module size, the electrode arrangement (concentrated or not) in the module, and if the distances between electrodes are equal.

- 5 Consequently, these last two tools make possible to inform the monitoring system about the exact position of each electrode in relation to a point of reference on the body being examined.

The operation of the image reconstruction algorithm can
10 be based on a finite element mesh adapted to each case in particular.

One of the aspects related to the operation of the electrode assembly of the present invention refers to the insertion of the actual electrode arrangement in the
15 reconstruction algorithms, said arrangement being two-dimensional or three-dimensional. Except the classical back-projection algorithm, most of the image reconstruction algorithms mold the plane through a finite element mesh which represents the body section to be
20 studied. The position of the measuring electrodes is necessarily identified, consisting in a prior information of the model. An interesting aspect of the model based on the finite element mesh is that the distance between the electrodes has to be only informed, not being necessary
25 to be the same between all the electrodes.

The application of a greater number of electrodes allows obtaining a greater number of independent measures, leading to an increased spatial resolution of the image, which justifies utilizing a more advanced finite element
30 mesh. As part of the present invention, it is contemplated to place a higher number of modular electrodes close to a region of interest, by selecting the most suitable electrode module.

For example, in case the priority is the cardiac
35 monitoring, one can work with a greater number of electrodes next to the sternum, and also increase said number in other spatial planes, obtaining information in

three spatial dimensions, which permits a better estimate of volumetric calculation (for example, estimate of the systolic volume in each cardiac cycle).

Other interesting aspect is to place the electrodes only
5 in the frontal region of the thorax, this procedure being useful in situations of emergency or trauma, when the patient must not be moved, under the risk of aggravating a pre-existing marrow lesion.

Brief Description of the Drawings

10 The invention will be described below, with reference to the enclosed drawings, given by way of example of possible embodiments of the invention and in which:

Figures 1a, 1b and 1c illustrate schematic lower plan views of three different lengths of electrode modules,
15 presenting the same number of electrodes, equally spaced from one another in each module, but by different and specific distances for each module;

Figures 2a and 2b illustrate schematic lower plan views of two electrode modules with the same length, but
20 containing different numbers of electrodes;

Figures 3a and 3b illustrate schematic lower plan views of two electrode modules with different lengths and with different numbers of electrodes in each of them, but the electrodes of the two modules being equally spaced apart
25 by the same distance;

Figure 4 represents a schematic lower plan view of the two electrode modules longitudinally coupled to each other to form an electrode belt extension;

Figures 5a and 5b illustrate schematic lower plan views
30 of two electrode modules with the same length and number of electrodes, but with the latter being arranged in different manners regarding the distribution along the support strap;

Figures 6a and 6b represent schematic plan view of two
35 different arrangements of electrical conducting cables with the respective end connectors;

Figure 7 represents a rather schematic perspective view

of another arrangement of electrical conducting cables with the respective end connectors;

Figure 8 represents a frontal view of a patient's torso, to which is applied a plurality of electrodes, which are
5 spaced apart by a distance that may vary along the contour of the body segment, an interruption being provided in the sequence of electrode modules in the frontal region of the thorax in which there is an injury, said interruption defining a certain interruption
10 distance between the electrodes adjacent to said interruption and pertaining to the two spaced apart modules;

Figure 8a represents a simplified cross-sectional view of the body torso illustrated in figure 8, showing the
15 arrangement of thirty-one electrodes around the body segment, taken according to line A-A in figure 8;

Figure 8b is a view similar to that of figure 8a, but schematically illustrating the arrangement of the electrodes in the finite element mesh upon which the
20 operation of the image reconstruction algorithm is based; Figures 9a, 9b, 9c, 9d, 9e and 9f are views similar to that of figure 8a, but illustrating different combinations of the electrode modules to surround the body segment illustrated in cross section, some of the
25 modules presenting the same number of electrodes and the same distance between the electrodes; and

Figure 10 represents a plan view of a support strap extension provided with holes disposed according to a median longitudinal alignment, an electrode being then
30 mounted in at least one of said holes;

Figure 11 represents a lower plan view of support strap extension similar to that of figure 10, but carrying coupling means and coupling receiving means in its ends and also elements for retaining the electrodes around the
35 holes of the support strap;

Figure 12 represents a diametrical sectional view of an electrode mounted through a respective hole of the

support strap of figure 11;

Figure 13 represents a lower plan view of the electrode of figure 12;

Figure 14 represents a lower plan view of the support
5 strap of figure 11, carrying an electrode in each hole;

Figure 15 represents a perspective view of a continuous support strap provided with a median longitudinal alignment of holes and illustratively shown in the form of a coil;

10 Figure 16 represents a perspective view of a strap extension for the formation of an electrode module presenting a construction which allows adjusting it to the longitudinal extension of each support strap; and

Figure 17 represents a partially sectioned perspective
15 view of an assembly comprising two support straps of the type illustrated in figure 10 and provided with coupling means and end coupling receiving means, as well as a connecting module for interconnecting the two support straps.

20 Description of the Invention

Figures 1a, 1b and 1c illustrate three electrode modules 10, each comprising a respective extension of support strap 11 constructed in any suitable material that presents flexibility without, however, presenting elastic
25 deformation in the longitudinal direction. In said figures each electrode module 10 presents a determined length different from that of the other electrode modules 10, each module comprising the same number of five electrodes 20 equidistant from one another by a certain
30 distance "De", which generally varies between said electrode modules 10.

Thus, the electrodes 20 of the support strap 11 of smaller length are equally spaced, but with a distribution according to which the electrodes are closer
35 to each other in relation to the mutual spacing of the electrodes 20 from the other two electrode modules 10.

Figures 2a and 2b illustrate two electrode modules 10

formed by support straps 11 of the same length, one of the modules carrying five electrodes 20, while the other carries only three electrodes 20 which keep from one another a distance "De" greater than that of the electrodes 20 of the other electrode module 10.

Figures 3a and 3b illustrate more two examples of electrode modules 10 presenting support straps 11 with different lengths, said electrode modules 10 presenting different numbers of electrodes 20 but being equally spaced apart.

Figure 4 represents an electrode belt extension defined by the longitudinal junction of the two support straps 11, said electrode belt extension being dimensioned to cover a respective extension of a body segment C of the patient.

As further discussed below, the different electrode modules 10 are dimensioned in extension, number and distribution of electrodes 20 to comply with different conditions of application to the body to be analyzed. It should be understood that the electrode modules 10 can be applied spaced from one another along the same plane of interest sectioning said body segment C, or even in generally parallel different planes, so as to produce a three-dimensional image of the body section being analyzed.

In the situations in which the electrode modules 10 are applied to the same plane, said electrode modules 10 can be provided with a positioning means 12 which, as illustrated in figures from 1a to 5b, takes the form of a prolongation 12a incorporated to one of the ends of the support strap 11 and provided with marks 12b that allow determining the spacing distance "Da" between two adjacent electrodes 20 for each two consecutive electrode modules 10. In determined circumstances, the different electrode modules 10 can be coupled longitudinally to one another, through their adjacent ends (see figure 4). In this case, one of the ends of each support strap 11 can

incorporate, in the longitudinal direction, a coupling means 14 constructed in different ways such as, for example, a strap made of a material known by the brand "Velcro". The other end of each support strap 11 carries
5 a coupling receiving means 15 schematically illustrated in the drawings and which is constructed to receive and interlock the coupling means 14 of another electrode module 10. Thus, the coupling receiving means 15 can take the form of a strap made of an adhesive material to be
10 adhered to the coupling means 14.

In the embodiment illustrated in figures 1a-5b, the coupling means 14 is defined in the positioning means 12 itself of the support strap 11, mingling with the respective prolongation 12a of the support strap 11.
15 However, it should be understood that the coupling means 14 is not obligatorily constructed in conjunction with the positioning means 12.

As discussed below, each electrode module 10 may contain, in its support strap 11, an individual identification
20 code 13 that can take the form of a bar code or an alphanumeric identification. The reading of said individual identification code 13 allows determining the longitudinal extension of the module, the number of electrodes 20 and the arrangement of the electrodes 20
25 along the extension of the support strap 11, since the arrangement of the modules on each respective support strap 11 can vary from module to module, as illustrated in figures 5a and 5b.

It should be understood that the provision of the
30 individual identification codes 13 of the support straps 11 is not obligatory, since the number of electrodes, the distance "De" between the electrodes 20 of each electrode module 10 and the spacing distance "Da" between each two consecutive electrode modules 10 can be measured and
35 informed to a monitoring apparatus (not illustrated), before starting the tomography.

Considering the possibility of providing electrode

modules 10 presenting more concentrated or more disperse arrangements of electrodes 20 on the respective support straps 11, the operator can select the more suitable electrode modules 10 to provide a sharper image of a determined region of interest of the body segment C. In the regions of less interest, an electrode module 10 with a smaller number of electrodes 20 can be used, while in the regions of greater interest, one can use electrode modules 10 containing a higher concentration of electrodes 20 or even a localized concentration of electrodes, as illustrated in figures 5a and 5b. The electrode modules 10 can be longitudinally coupled to each other or only seated against the body segment C, according to different combinations of number and concentration of electrodes 20. The fixation of the support straps 11 against the body segment C of the patient can be effected in different manners, with or without the assistance of the auxiliary positioning belt. The support straps 11 of each electrode module 10 can be built in any suitable electrically non-conductive material such as, for example, non-woven fabric, foam and polymers that impart characteristics of flexibility to the support straps 11.

Although not being illustrated and described in details herein, since it is not the object of the invention, each electrode 20 can be constructed in different ways, known or unknown in the prior art, as long as they present, as exemplified in figures 12, 13 and 14, a contact portion 21 surrounded by a seating ring 22 and to be seated against the body segment C, and a connecting portion 23 projecting upwardly from the support strap 11 and configured to receive and retain an end connector of a respective electrical conducting cable 30 arranged to connect each electrode 20 to a monitoring apparatus M, schematically represented in figures 6a and 6b.

Figures 6a and 6b illustrate two different arrangements of electrical conducting cables 30, which after passing

together through a distribution box 31, are distributed in respective connecting legs 32, whose free ends carry, each one, a respective connector 33 to be releasably coupled to the connecting portion of a respective electrode 20. Due to the flexibility of the connecting legs 32 of the electrical conducting cables 30, they can be utilized for adapting the electrical conducting cables 30 of electrode modules with different lengths and distribution arrangements of electrodes 20.

10 In figure 7 is illustrated an arrangement of five connecting legs 32, projecting outwardly from a distribution box 31, for having in the end portions thereof and retained, at predetermined spacings, a positioning plate 34 which maintains the connectors 33 in a predetermined positioning. In this case, the positioning plate 34 makes the arrangement of electrical conducting cables 30 be designed to a certain specific type of electrode module 10, facilitating to mount the connecting legs 32 in the connecting portions of the electrodes 20 of the respective electrode module 10.

Figures 8, 8a and 8b illustrate the application of electrode modules in a body segment C defined by the thorax of the patient who presents an injury F in the right region of his chest. In order to avoid placing electrodes 20 in the injured region of the patient, the arrangement of electrode modules 10 around said body segment C presents an interruption, making the two electrodes 20 adjacent to the interruption define therebetween an interruption distance "Di" sufficient to set free the region of said injury F. The electrode distribution in the arrangement of these figures follows a different distance pattern "De" between the electrodes 20, making possible to observe a greater concentration of the electrodes in the frontal left region of the body segment C (figure 8a). Figure 8b illustrates the operational mode of the image reconstruction algorithm based upon the insertion of the actual arrangement of the

electrodes 20 in the finite element mesh. The thorax image resolution of the injury region will be different in case the electrodes 20 are positioned in an equidistant way.

5 An interesting aspect of the model based on the finite element mesh is that the distance "De", "Da" or "Di" between the electrodes 20 of the same module and of different modules needs only to be informed to the monitoring M apparatus, not requiring to be constant.

10 Figures 9a, 9b, 9c, 9d, 9e and 9f illustrate different combinations of electrode modules 10 surrounding a body segment C.

In figure 9a it is illustrated the positioning of a pair of electrode modules 10 around a body segment C of a newborn child presenting a thorax of about 25cm of perimeter, the two electrode modules 10 being identical.

In figure 9b it is illustrated a positioning different from that presented in figure 9a, but also utilizing a pair of electrode modules 10 of the same construction.

20 Figures 9c and 9d illustrate two different arrangements containing three electrode modules 10 disposed around a body segment C, the electrodes of the modules presenting different number and distribution.

Figures 9e and 9f illustrate the utilization of four and six electrode modules 10, respectively, the electrodes 20 of the modules of figure 9e being provided with the same number and equidistantly disposed. Figure 9f illustrates the arrangement of electrode modules 10 around an adult thorax of about 80 cm of perimeter, with one of the modules differing from the others by the number and by the distance between the electrodes.

35 The constructions of electrode modules 10 described above refer to embodiments in which each module is formed by an extension of support strap 11, previously sectioned to a pattern length predetermined for that module, and in which it is mounted an also predetermined and standardized number of electrodes 20 disposed according

to equal or different, but also predetermined, distances "De".

However, as illustrated in figure 10, each electrode module can be formed by the operator himself, or by the
5 EIT application staff, from an extension of support strap 11 sectioned from a continuous strap, which can be provided, for example, in a coil as illustrated in figure 15. A continuous support strap 11 is provided with a median longitudinal alignment of holes 18 spaced from one
10 another by the same distance "De" that can correspond to the minimum possible distance "De" between two electrodes 20 or a distance "De" predetermined as a basic pattern of concentration of the electrodes 20 in an extension of the body segment C to be analyzed.

15 After defining the extension of the module support strap 11 to be formed, the operator can secure the electrodes 20 in the holes 18 of the support strap 11.

The extension of support strap 11 illustrated in figures 10, 11 and 14, presents five holes 18, and each can
20 receive a respective electrode 20. In the example of figures 11 and 14, each of the five holes of the support strap 11 receives an electrode 20. However, it should be understood that the electrodes 20 can be mounted in only one or some of the holes 18, depending on the operational
25 pattern to be obtained by the module to be formed.

In the case the extension of support strap 11 is sectioned from a continuous strap previously provided with the holes 18, each extension of support strap 11 usually does not incorporate the positioning means 12,
30 the coupling means 14 and the coupling receiving means 15, as illustrated in figure 10. Nevertheless, as illustrated in figures 11 and 14, the extensions of the already perforated support strap 11 can receive and secure, in their opposite ends, by any suitable process,
35 a positioning means 12, a coupling means 14 and a coupling receiving means 15.

It should be further understood that the continuous

support strap 11 can be supplied to the EIT system operator already with the electrodes 20 mounted in the holes 18 of the support strap 11. In this case, there should be provided different patterns of continuous support straps 11, each pattern defining a particular distance "De" for the electrodes 20, but allowing the operator to select the number of electrodes 20 in each desired module.

In figure 11 it is illustrated an extension of support strap 11 under which is applied, around each hole 18 that will receive a respective electrode 20, an adhesive element 25 which can be defined by an annular portion of a double-face adhesive tape. The adhesive element 25 retains the seating ring 22 of an electrode 20 against the lower face of the support strap 11, while the connecting portion 23 of the electrode 20 is fitted through the respective hole 18, projecting upwardly from the upper face of the support strap 11 to be coupled to an electrical conducting cable 30.

As it can be noted in figure 16 of the enclosed drawings, each extension of support strap 11 can be provided between each two consecutive electrodes 20 or between each two consecutive holes 18 for the subsequent mounting of respective electrodes 20, with a pair of longitudinal parallel slots 11a which are spaced from one another and from the adjacent longitudinal lateral edges of the extension of support strap 11.

In this figure 16 it is exemplified an extension of support strap 11 of the type illustrated in figure 10, i.e., an extension of support strap 11 sectioned from a continuous strap or otherwise produced and presenting only the holes 18 for placing the electrodes, but without the latter, for better visualizing the constructive alternative proposed herein. In this constructive alternative of figure 16, each two slots 11a of the extension of support strap 11 define a median lug 11b incorporated by its ends into the strap itself, only one

of these lugs 11b being deformed by inserting a spacer 19 between a lug 11b and the adjacent lateral portions of the support strap 11, making both the lug 11b and the adjacent region of the support strap 11 be deformed to
5 reduce the extension of the support strap 11.

In this way, there is obtained an extremely simple constructive solution which allows the support strap 11 to be easily and quickly adapted along the circumferential extension of a body segment C of the
10 patient. The placement of the extension of the support strap 11 on a body segment C of the patient, with one or more lugs 11b being deformed by a respective spacer 19, can be thus effected with the support strap 11 presenting a dimension that is more or less contracted as a function
15 of the number of spacers 19 adapted under the respective lugs 11b. After the adaptation of the support straps 11, the spacers 19 can be removed to permit the support straps 11 to present a longitudinal extension adequate to the circumferential extension of the body segment C,
20 considering the patient's respiratory movements.

It should be further understood that the spacers 19 can be placed to provide a dimensional adjustment for reducing the longitudinal extension of each support strap, to better adjust it to a reduction in the contour
25 of said body segment C, after the strap has been applied under an anomalous respiratory condition or body volume condition.

As illustrated in figure 17, two consecutive support straps 11 can be connected to each other by means of a
30 connecting module 60, generally defined by an extension of support strap made of a material identical to the one used in the support straps 11 which define the electrode modules, or also constructed in any suitable material, said connecting modules 60 being dimensioned to provide a
35 certain predetermined distance with different values between two consecutive support straps 11, each connecting module being further provided, in their

opposite ends, with a coupling means 14 and a coupling receiving means 15 constructed to mate with the coupling means 14 and coupling receiving means 15 provided in the support straps 11.

5 In the illustrated configuration, the coupling means 14 and the coupling receiving means 15 respectively take the form of small hooks and rods, which are mutually connected upon uniting two extensions of support strap 11, directly or by using an intermediate connecting
10 module 60.

As described above, the electrode assembly disclosed by the present invention provides the EIT system operator with different electrode modules constructed to provide specific operational patterns in the system, said
15 patterns being predetermined in the project of the modules, in order to allow the latter to comply with the different conditions of application and diagnosis.

CLAIMS

1. An electrode assembly for electrical impedance tomography (EIT), characterized in that it comprises a plurality of different electrode modules (10), each comprising a support strap (11) made of a flexible material that presents a reduced longitudinal deformability and carrying a desired number of electrodes (20) to be electrically connected to a monitoring apparatus (M), one of the electrode modules (10) comprising at least two electrodes (20), each electrode module (10) having its respective support strap (11) dimensioned to be seated and retained onto a respective extension portion of a body segment of a patient, according to a plane of interest sectioning said body segment (C), each of the different electrode modules (10) presenting the number of electrodes (20) and a distance (De) between each two consecutive electrodes predetermined as a function of a specific operational pattern to be obtained from each electrode module (10).
2. The electrode assembly, as set forth in claim 1, characterized in that the electrodes (20) of a first group of electrode modules (10) are spaced from one another by the same distance (De) and provided in the same number in each of said electrode modules (10).
3. The electrode assembly, as set forth in claim 1, characterized in that the electrodes (20) of a second group of electrode modules (10) are spaced from one another by the same distance (De) and provided in different numbers in each of said electrode modules (10).
4. The electrode assembly, as set forth in claim 1, characterized in that the electrodes (20) of a third group of electrode modules (10) are provided in the same number in each electrode modules (10), but spaced from one another by different distances (De).
5. The electrode assembly, as set forth in claim 1, characterized in that the electrodes (20) of a fourth group of electrode modules (10) are provided in different

numbers and also spaced from one another by different distances (De) in each of said electrode modules (10).

6. The electrode assembly, as set forth in claim 1, characterized in that each electrode module (10) is
5 provided with an individual identification code (13).

7. The electrode assembly, as set forth in claim 1, characterized in that the number of electrodes (20) of each electrode module (10) varies from 1 to 32.

8. The electrode assembly, as set forth in claim 1,
10 characterized in that the support strap (11) of each electrode module (10) is provided with a positioning means (12) in one of the ends of the respective support strap (11).

9. The electrode assembly, as set forth in claim 8,
15 characterized in that each positioning means (12) comprises a prolongation (12a) incorporated in one of the ends of the respective support strap (11) and provided with marks (12b) indicative of the relative positioning between two electrode modules (10).

20 10. The electrode assembly, as set forth in claim 9, characterized in that the marks (12b) of the positioning means (12) of each support strap (11) define respective spacing distances (Da) between two adjacent electrodes (20) for each two consecutive electrode modules (10).

25 11. The electrode assembly, as set forth in any one of the claims 1 or 8, characterized in that the support strap (11) of each electrode module (10) is provided, in one of the ends, with a coupling means (14) and, in the other end, with a coupling receiving means (15), the
30 coupling means (14) of an electrode modules (10) being connectable to the coupling receiving means (15) of another electrode module (10).

12. The electrode assembly, as set forth in claim 11, when depending from claim 8, characterized in that the
35 coupling means (14) is defined in the positioning means (12), taking the form of a prolongation (12a) of one of the ends of the support strap (11).

13. The electrode assembly, as set forth in claim 1, characterized in that the electrode modules (10) are each formed by a respective extension of support strap (11), previously defined with a pattern length predetermined for that module and in which is mounted an also
5 standardized and predetermined number of electrodes (20) spaced from one another by predetermined distances (De).

14. The electrode assembly, as set forth in claim 1, characterized in that the electrode modules (10) are each
10 formed by a respective extension of support strap (11), previously defined with a pattern length predetermined for that module and provided with a median longitudinal alignment of holes (18) spaced from one another by a predetermined distance (De), at least one hole (18) of
15 the extension of support strap (11) receiving and retaining the respective electrode (20).

15. The electrode assembly, as set forth in claim 1, characterized in that each electrode module (10) is formed by an extension of support strap (11) presenting a
20 length determined by the EIT system operator as a function of a specific dimensioning desired in one application, said extension of support strap (11) carrying electrodes (20) spaced from one another by the same predetermined distance (De).

25 16. The electrode assembly, as set forth in claim 15, characterized in that the extension of support strap (11) of each electrode module (10) is cut from a continuous support strap carrying electrodes (20) that are mounted spaced from one another by the same predetermined
30 distance (De).

17. The electrode assembly, as set forth in claim 1, characterized in that each electrode module (10) is formed by an extension of support strap (11) provided with a median longitudinal alignment of holes (18) which
35 are spaced from one another by the same predetermined distance (De), said extension of support strap (11) presenting a length determined by the EIT system operator

as a function of a specific dimensioning desired in one application, each hole (18) of the extension of support strap (11) receiving and retaining one electrode (20).

18. The electrode assembly, as set forth in claim 17,
5 characterized in that the extension of support strap (11) of each electrode module (10) is cut from a continuous support strap provided with a median longitudinal alignment of holes (18).

19. The electrode assembly, as set forth in claim 1,
10 characterized in that each support strap (11) presents, between the positions of each two consecutive electrodes (20), a pair of longitudinal slots (11a) spaced from one another and from the adjacent longitudinal lateral edges of the extension of support strap (11), so as to define
15 therebetween a lug (11b), selectively deformable outwardly from the plane of the adjacent region of the support strap (11) upon the introduction of a spacer (19) between the lower face of the lug (11b) and the upper face of the adjacent lateral regions of the support strap
20 (11).

20. The electrode assembly, as set forth in claim 1,
characterized in that it comprises the electrical
conducting cables (30) connecting each electrode of an
electrode module (10) to the monitoring apparatus (M) and
25 being distributed to the different electrodes (20) of each electrode module (10) by means of connecting legs (32) projecting from a distribution box (31).

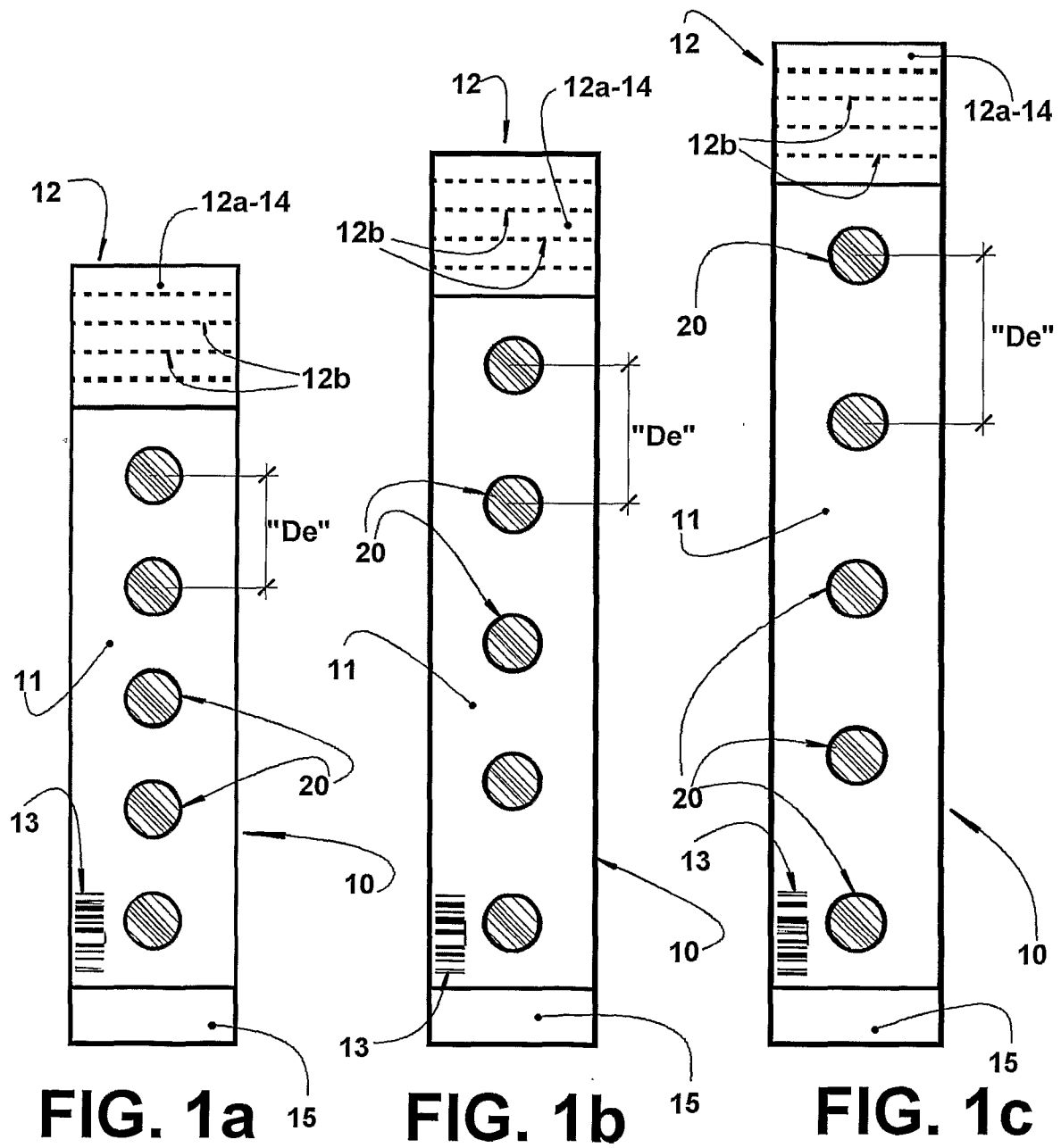
21. The electrode assembly, as set forth in claim 20,
characterized in that the connecting legs (32) have their
30 end portions retained, at predetermined spacings, to a positioning plate (34).

22. The electrode assembly, as set forth in claim 1,
characterized in that at least two consecutive support
straps (11) are longitudinally connected to each other,
35 by means of a connecting module (60) defined by a predetermined extension of support strap (11).

23. The electrode assembly, as set forth in claim 22,

characterized in that the support strap (11) of each electrode module (10) is provided, in one of the ends, with a coupling means (14) and, in the other end, with a coupling receiving means (15), the connecting module (60) being provided, in one of its ends, with a coupling means (14) and, in the other end, with a coupling receiving means (15), the coupling means (14) of the connecting module (60) being connectable to the coupling receiving means (15) of a support strap (11) and the coupling receiving means (15) of the connecting module (60) to receive the coupling means (15) of another support strap (11).

24. The electrode assembly, as set forth in claim 23, characterized in that the coupling means (14) and the coupling receiving means (15) are formed by a rod that is bent in the form of a hook and by a rod, which are respectively affixed to the opposite ends of the support straps (11) and to the connecting modules (60).



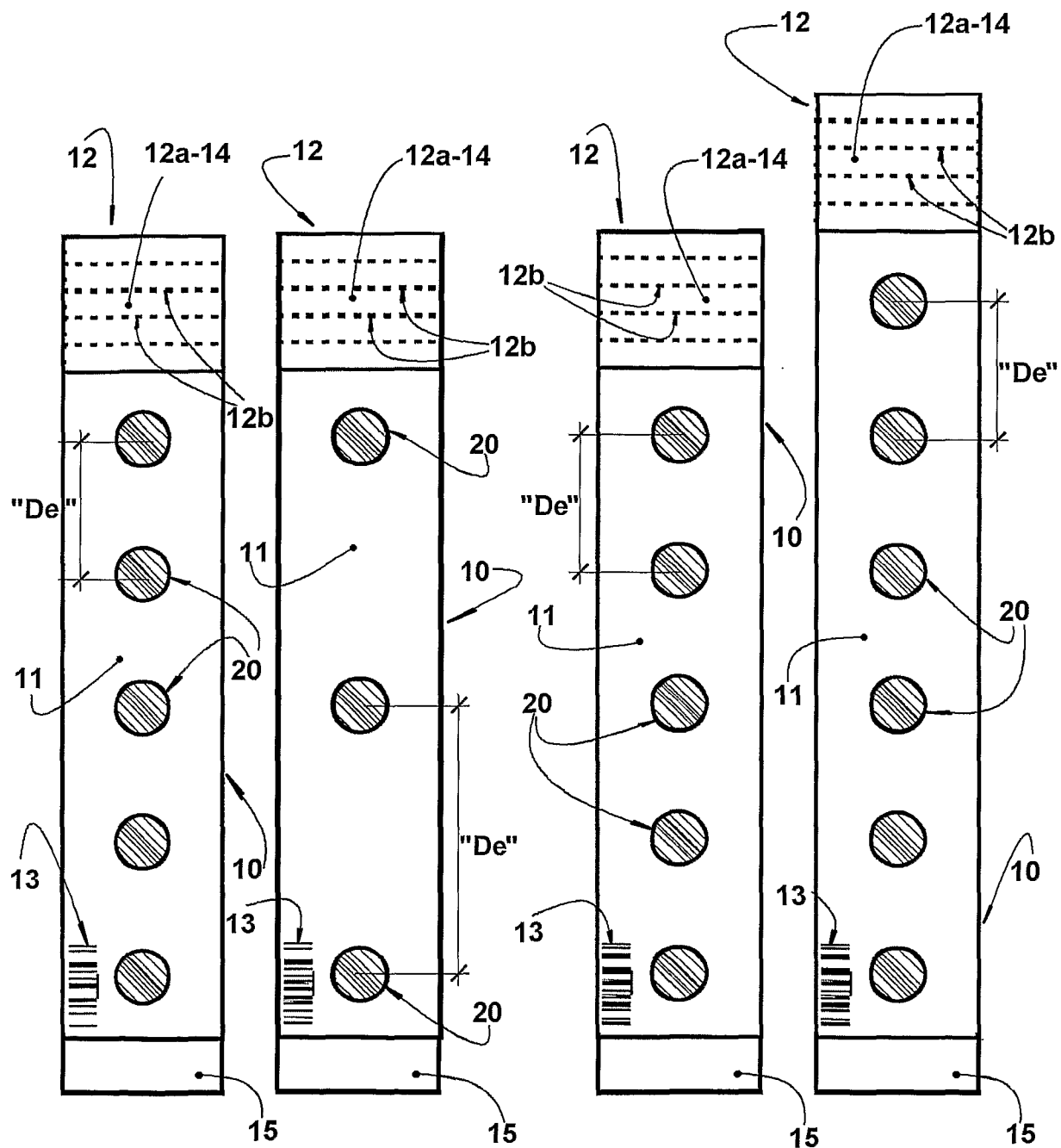
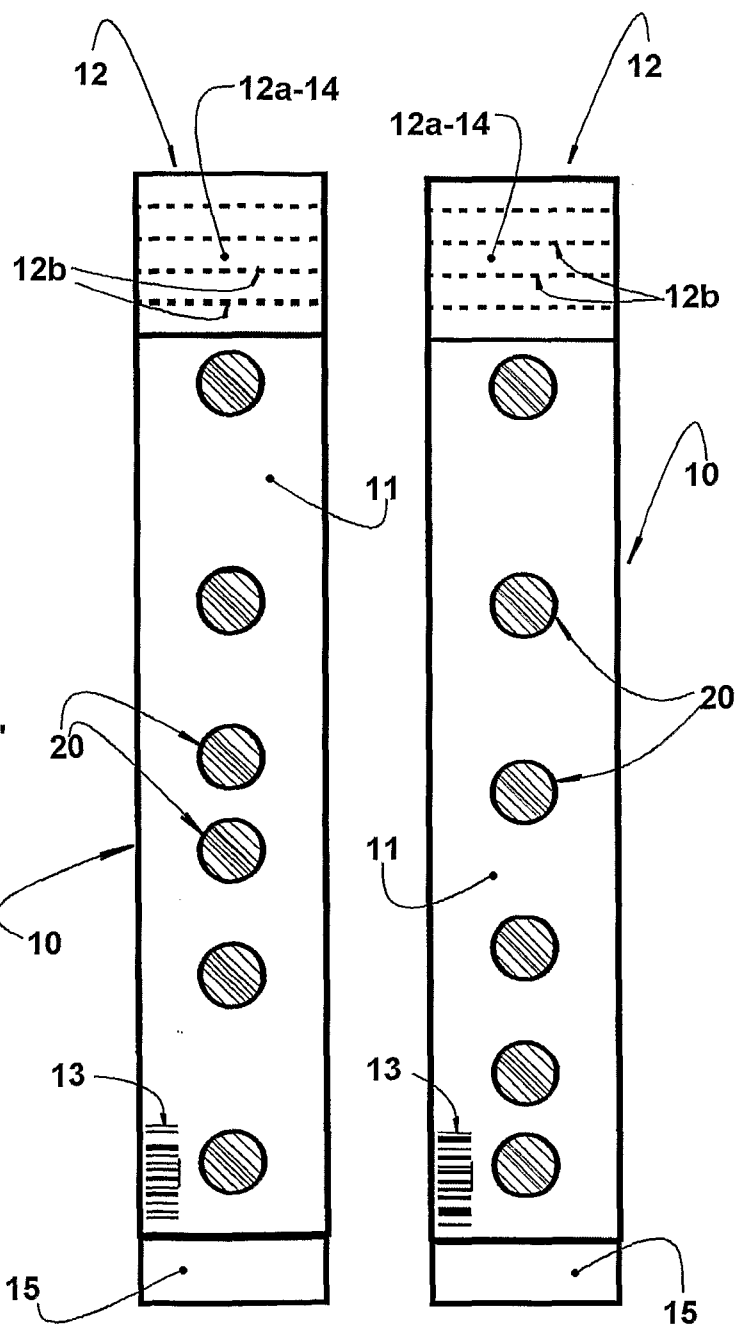
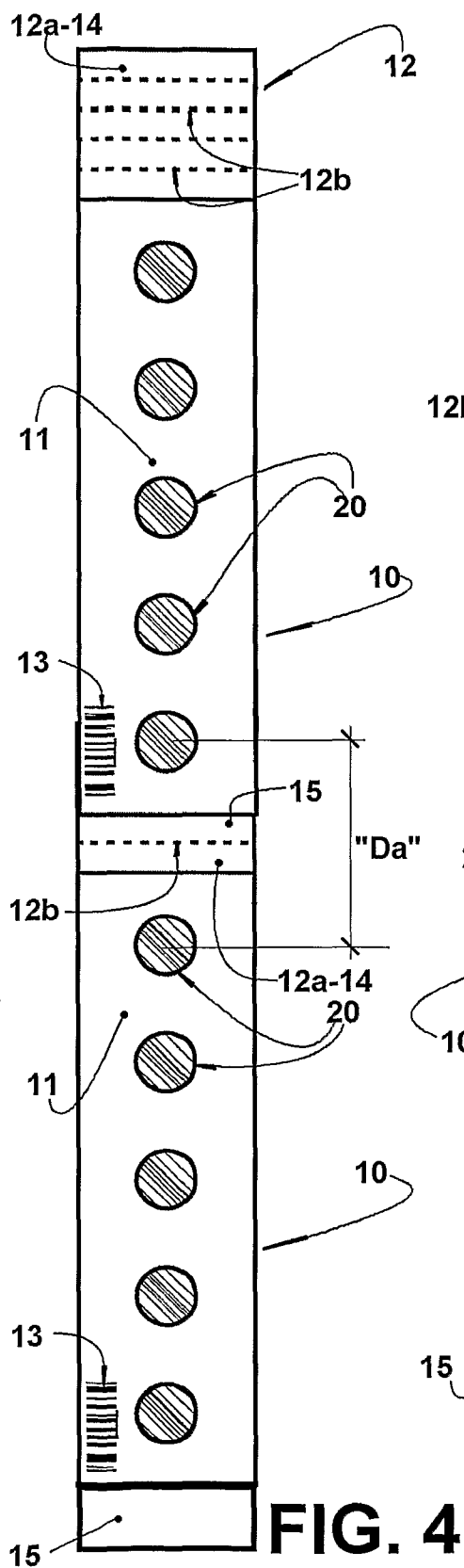


FIG. 2a FIG. 2b FIG. 3a FIG. 3b



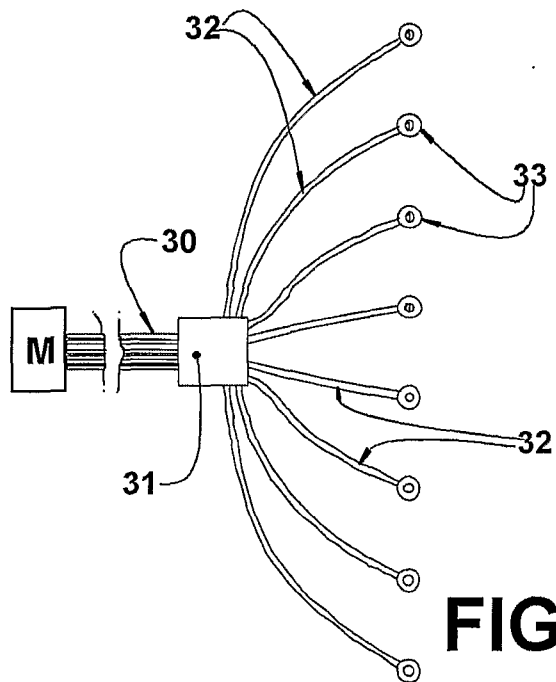


FIG. 6a

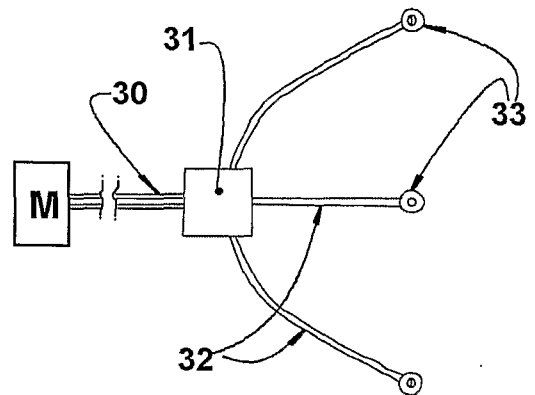


FIG. 6b

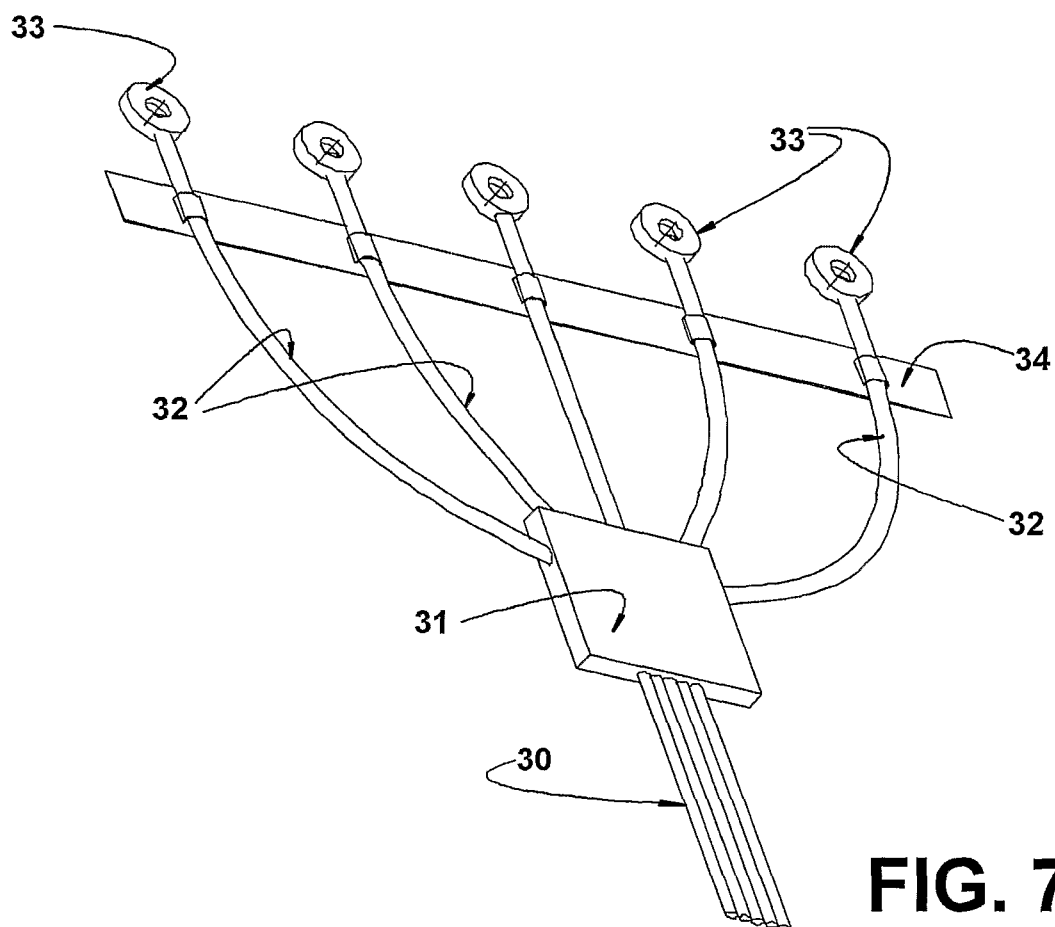


FIG. 7

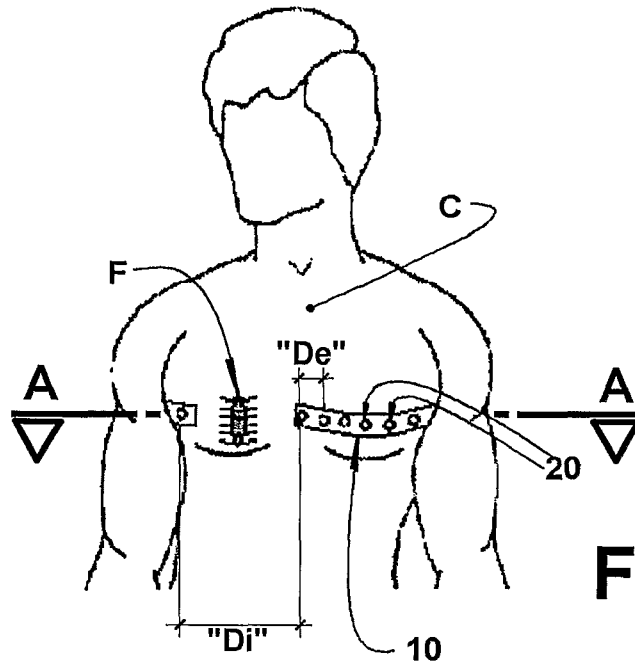


FIG. 8

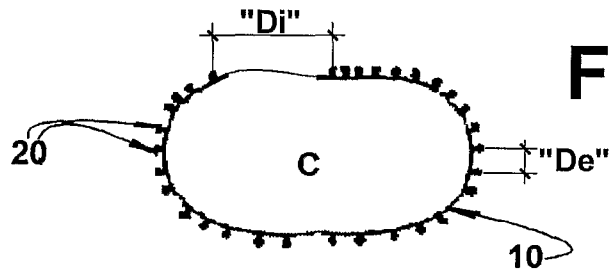


FIG. 8a

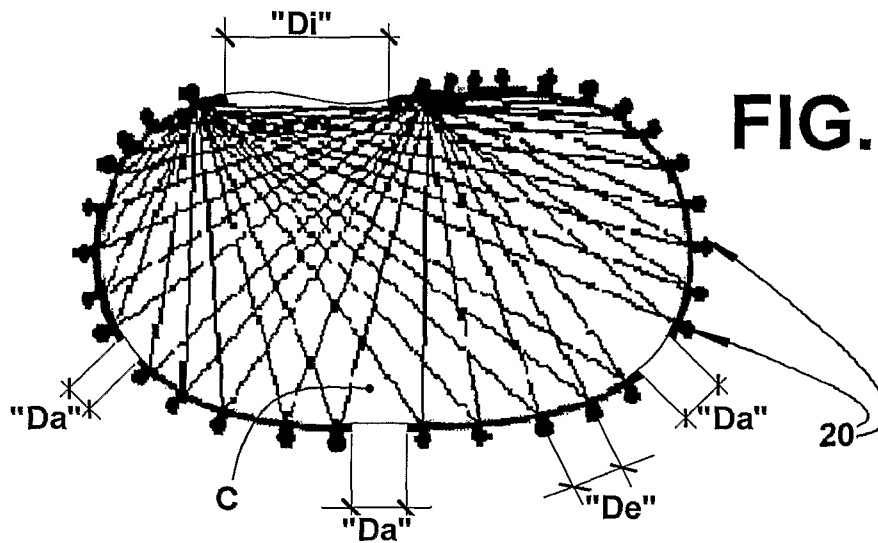


FIG. 8b

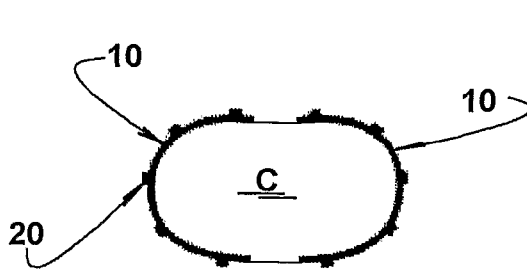


FIG. 9a

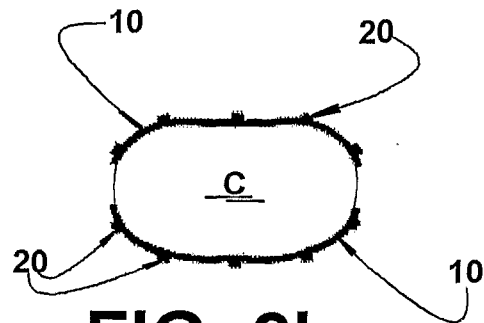


FIG. 9b

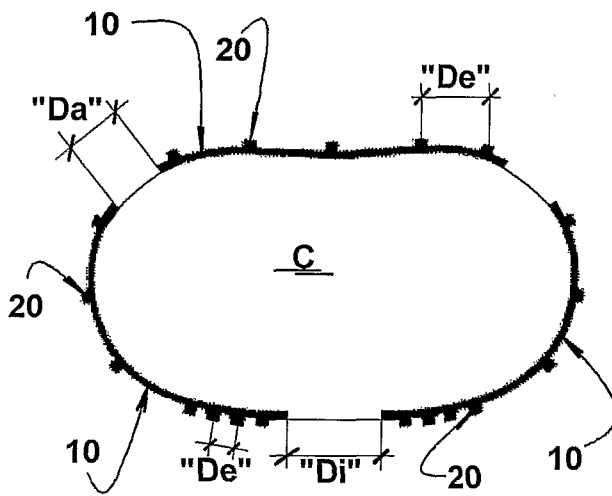


FIG. 9c

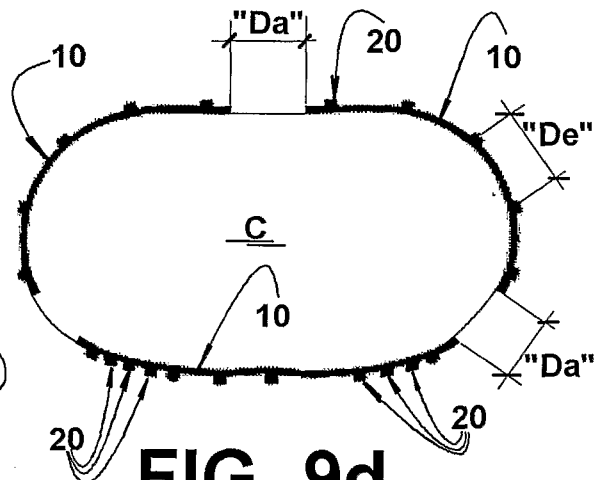


FIG. 9d

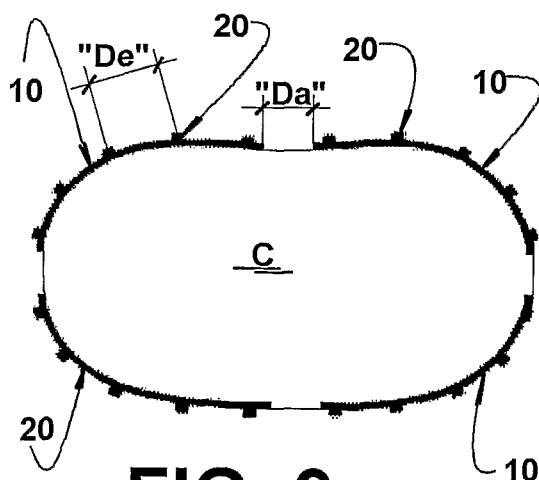


FIG. 9e

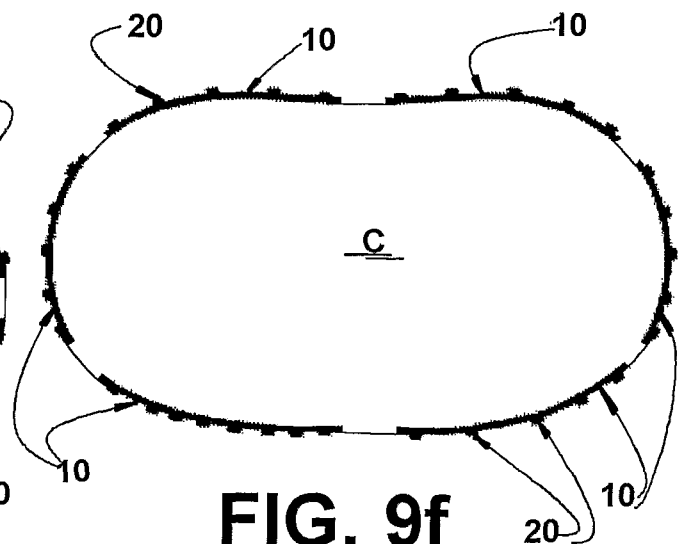


FIG. 9f

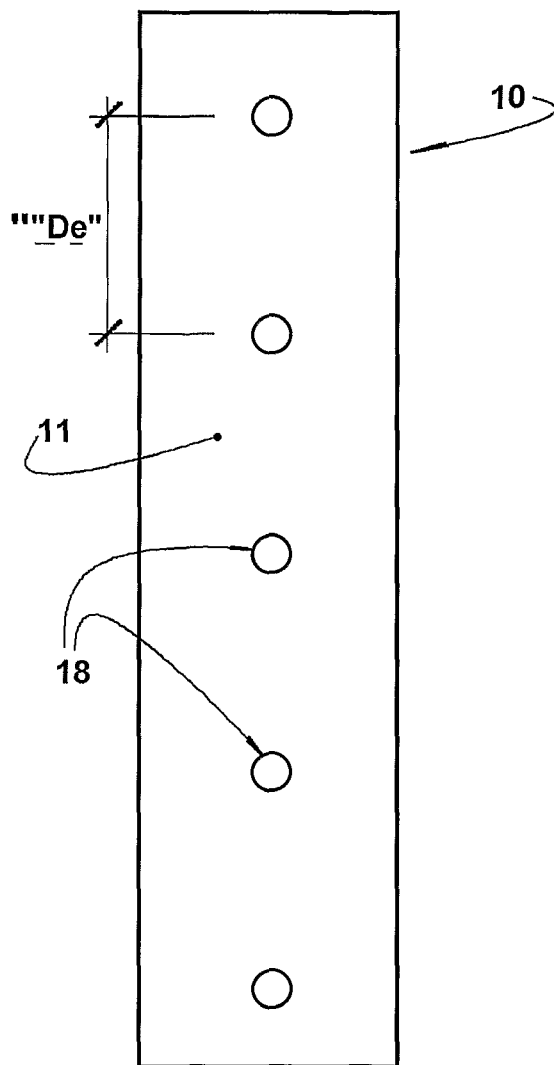


FIG. 10

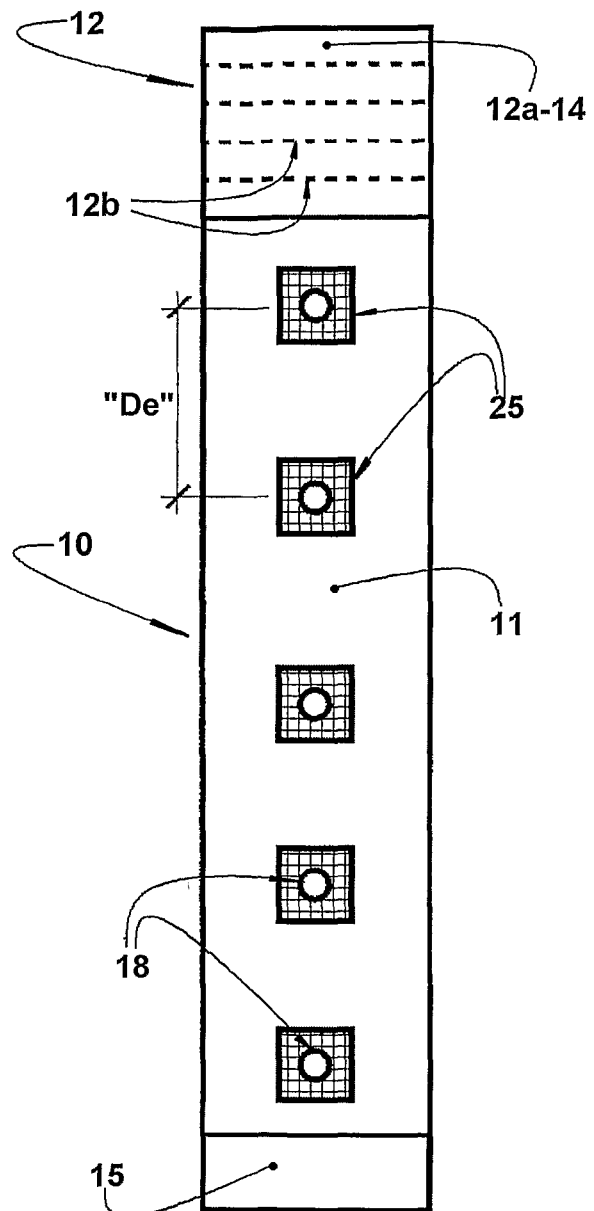


FIG. 11

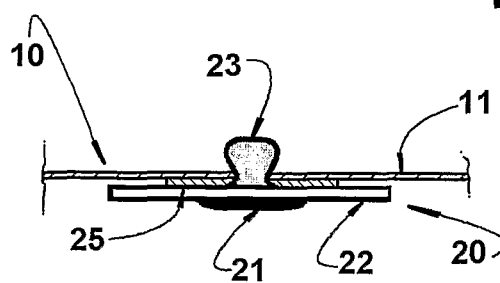


FIG. 12

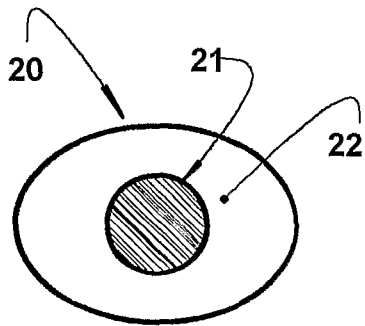


FIG. 13

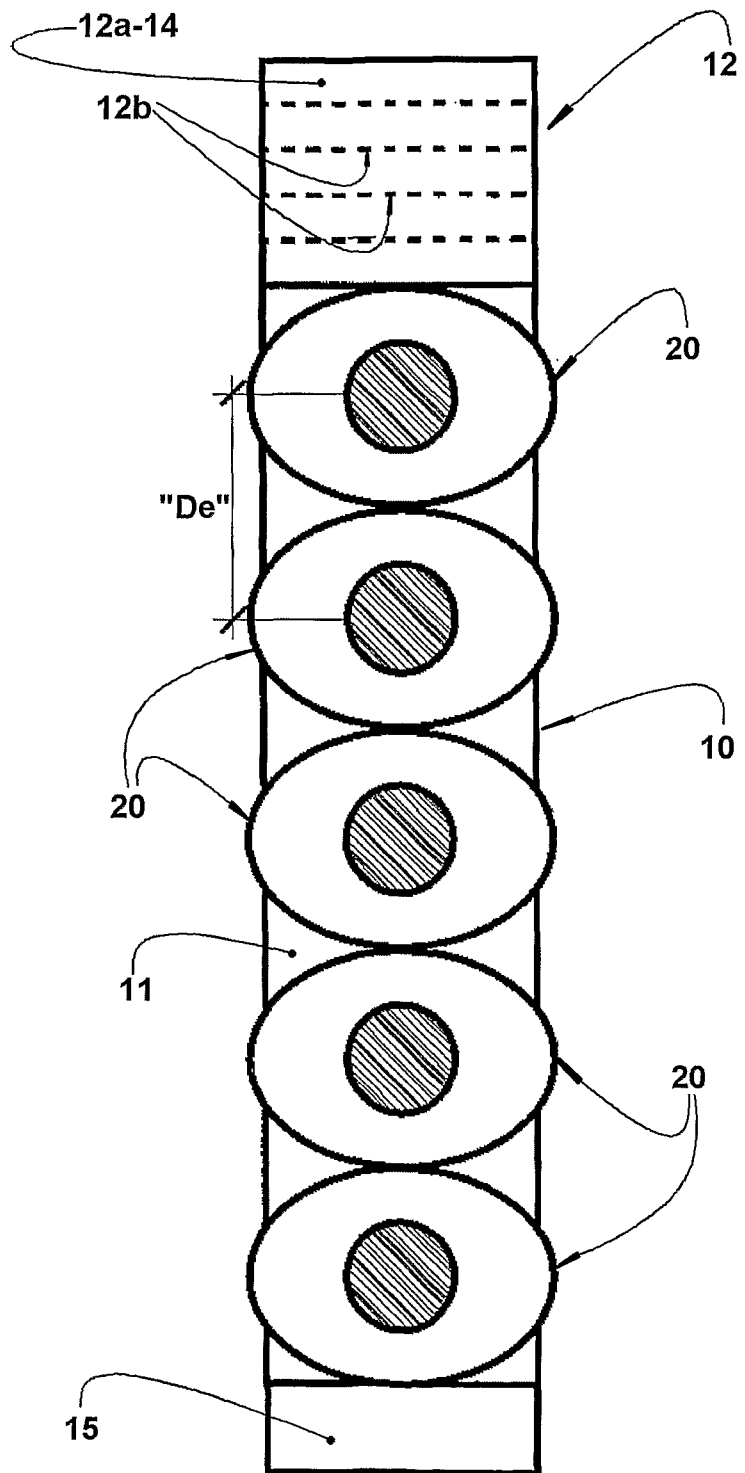


FIG. 14

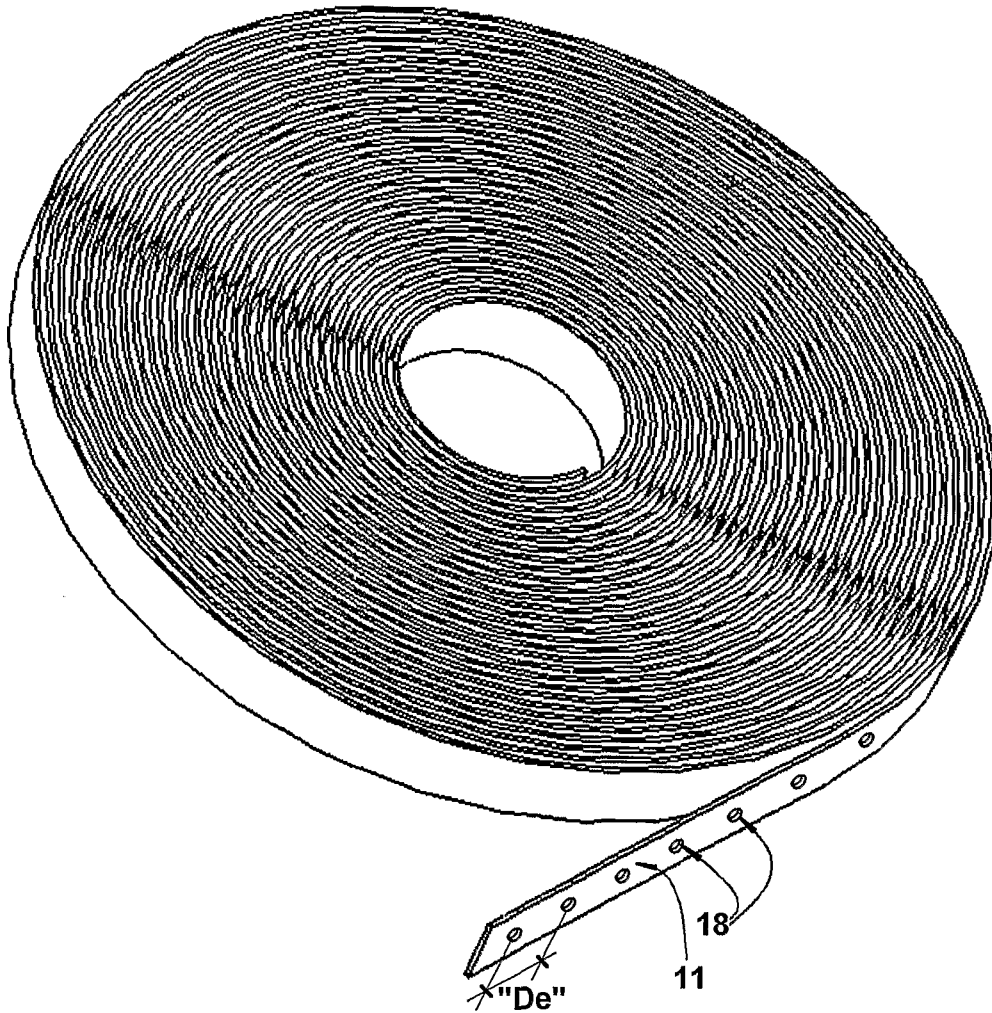


FIG. 15

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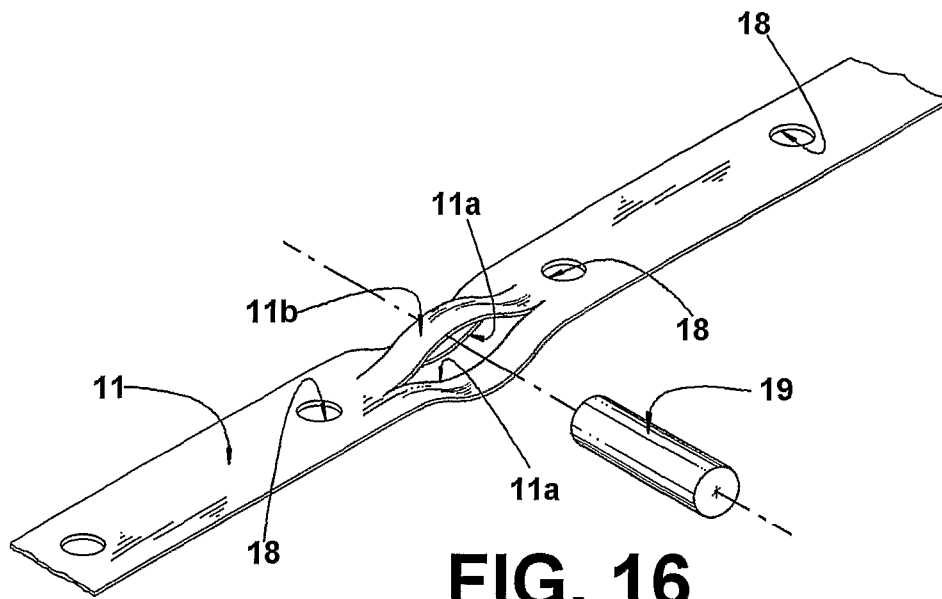


FIG. 16

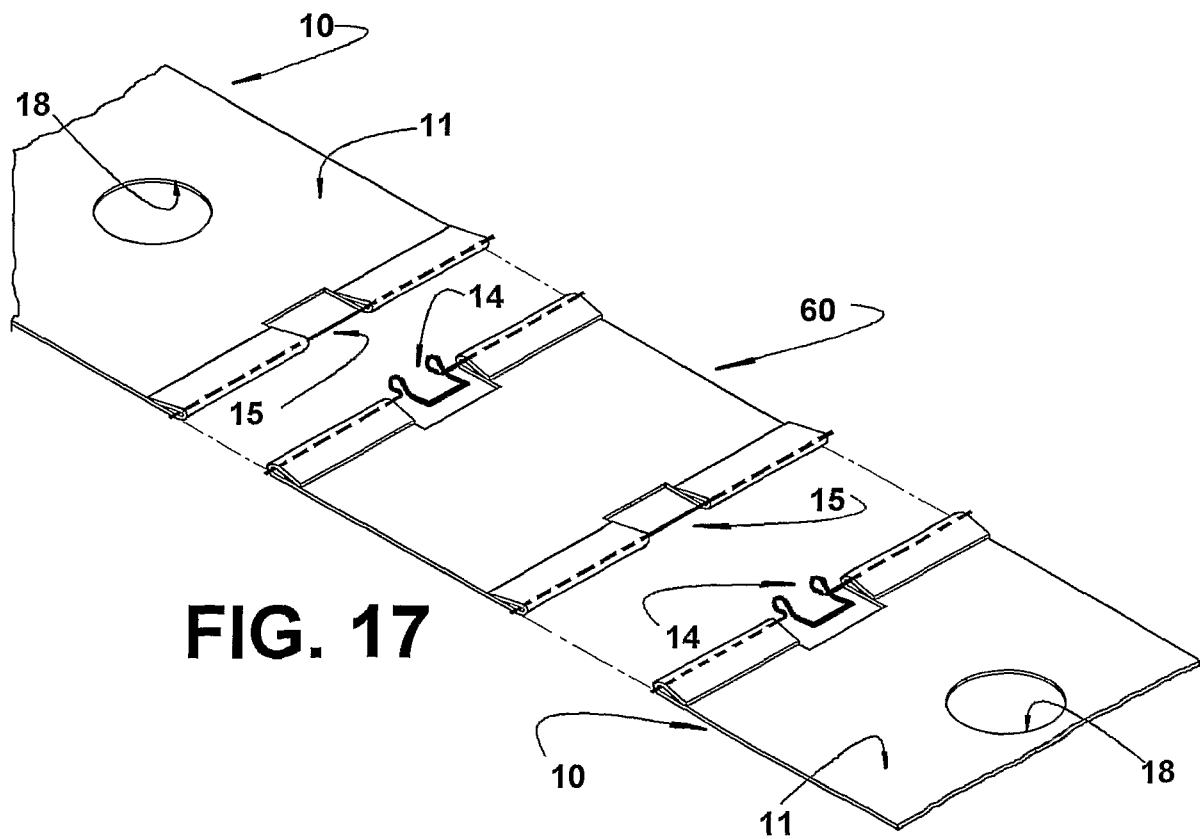


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No

PCT/BR2006/000284

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/053

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/021880 A (VIASYS HEALTHCARE GMBH [DE]; EICHLER RUEDIGER [DE]) 18 March 2004 (2004-03-18) page 2, line 12 – page 3, line 26 page 6, line 9 – line 16 page 10, line 3 – page 11, line 23; figure 1 -----	1-24
X	US 2004/260167 A1 (LEONHARDT STEFFEN [DE] ET AL) 23 December 2004 (2004-12-23) cited in the application paragraph [0007] – paragraph [0020] -----	1-3, 6-18, 20-24
X	US 2004/236202 A1 (BURTON STEVEN ANGELL [US]) 25 November 2004 (2004-11-25) paragraph [0027] paragraph [0031] – paragraph [0034] ----- -/-	1-24

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

24 April 2007

Date of mailing of the international search report

07/05/2007

Name and mailing address of the ISA/

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Trachterna, Morten

INTERNATIONAL SEARCH REPORT

International application No

PCT/BR2006/000284

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 184 624 A (BROWN BRIAN H [GB] ET AL) 9 February 1993 (1993-02-09) column 2, line 31 - column 3, line 68 -----	1
A	WOO E J ET AL: "FINITE-ELEMENT METHOD IN ELECTRICAL INPEDANCE TOMOGRAPHY" MEDICAL AND BIOLOGICAL ENGINEERING AND COMPUTING, SPRINGER, HEILDELBERG, DE, vol. 32, no. 5, 1 September 1994 (1994-09-01), pages 530-536, XP000469343 ISSN: 0140-0118 abstract -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/BR2006/000284

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