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(54) Title: METHOD FOR LIMITING ELASTICITY OF SELECTED REGIONS IN KNITTED FABRICS

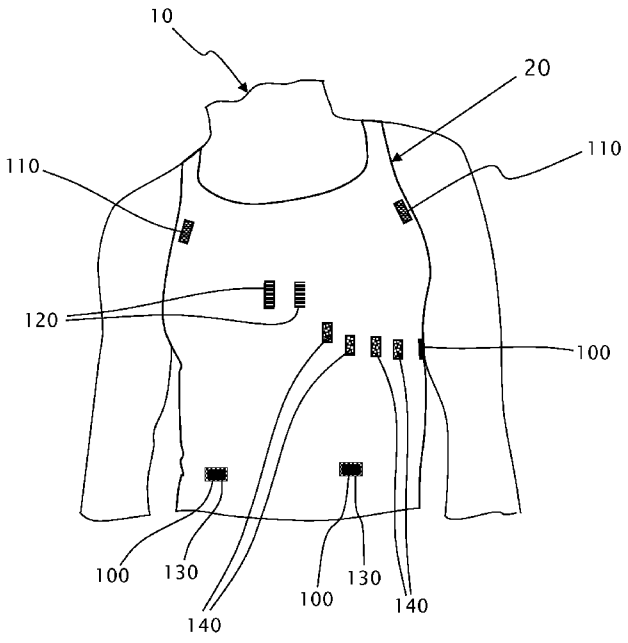

Fig. 1

(57) Abstract: A method for substantially reducing the elasticity of at least one selected textile region of a garment. The method includes producing the garment including a conductive textile electrode and rigidifying the at least one selected textile region. The rigidifying process includes applying rigidifying matter onto or into the at least one selected textile region. The at least one selected textile region is selected from the group consisting of a conductive textile electrode and a region of the garment situated between two adjacent textile electrodes. The invention further provides a garment having a tubular form, knitted by a seamless knitting machine with base-yarns. The garment includes at least one conductive textile electrode, composed of multiple knitted line segments, each knitted with a conductive yarn and a spandex yarn, wherein the spandex yarn and at least one base-yarn are knitted continuously.

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— *with amended claims (Art. 19(1))*

METHOD FOR LIMITING ELASTICITY OF SELECTED REGIONS IN KNITTED FABRICS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 USC 119(e) from US provisional application 61/763,963 filed Feb 13th, 2013, and from US provisional application 61/771,874 filed Mar 3rd, 2013, the disclosures of which are included herein by reference.

FIELD OF THE INVENTION

The present invention relates to knitted fabrics and more particularly, the present invention relates to wearable health monitoring systems, having knitted electrodes, wherein the knitted electrodes and the knitted fabric in the vicinity of the knitted electrodes are devised to maintain substantially steady dimensions and a substantially steady distance from each other, in particular, between horizontally adjacent electrodes.

BACKGROUND OF THE INVENTION AND PRIOR ART

Knitted electrodes in the garment are made of conductive yarn, which conductive yarn is knitted together with other basic yarns such as Nylon, bare spandex, covered spandex and/or other types of yarn.

The positioning of an electrode on a monitored living body is of critical importance for obtaining proper ECG signals, especially when the monitored living body is in motion. Moreover, the repeatability of the electrodes location on the body is of critical importance for comparing ECG signals in separate measurement sessions.

When designing a knitted ECG garment, there is a need to ensure that the electrodes are repeatably positioned at the same respective pre-configured positions with respect to the monitored living body, for a given garment size designated to be worn by a variety people. Usually, people of same size have different body structure, weight and high, which may affect the respective position of the electrodes on their body, although the garment is of the same size.

Being knitted in a fabric, the electrodes gain a natural stretch, which stretch may affect the quality by introducing artifacts and damage the repeatability of the recorded ECG signals. These damaging artifacts may occur because of changes in the electrode

electrical characteristics, and may cause unnecessary noises in the system during breathing and bodily motions, wherein the spatial positioning of an electrode, with respect to the monitored organ, may change.

There is therefore a need and it would be advantageous to have methods for knitting a garment such that the elasticity of one or more selected regions is prevented or at least limited and thereby maintain original dimensions of these regions. Furthermore, there is a need for a stable and repeatable positioning of electrodes at respective pre-configured bodily location, which positioning is of extreme importance to obtain good ECG signals, facilitating clinical level ECG, while the monitored person is either in rest or is moving, jumping or walking.

It should be noted that the term "ECG signals", as used herein, refers the any physiological signal of the monitored living being that can be sensed directly or indirectly by an electrode, including signals for ECG analysis.

The terms “underwear” or "garment", as used herein with conjunction with wearable clothing items, refers to seamless wearable clothing items that preferably, can be tightly worn adjacently to the body of a monitored living being, typically adjacently to the skin, including undershirts, sport shirts, brassiere, underpants, special hospital shirt, socks and the like. Typically, the terms “underwear” or "garment" refer to a clothing item that is worn adjacently to the external surface of the user’s body, under external clothing or as the only clothing, in such way that the fact that there are sensors embedded therein, is not seen by any other person in regular daily behavior. An underwear item may also include a clothing item that is not underwear per se, but still is in direct and preferably tight contact with the skin, such as a T-shirt, sleeveless or sleeved shirts, sport-bra, tights, dancing-wear, and pants. The sensors, in such a case, can be embedded in such a way that are still unseen by external people to comply with the "seamless" requirement.

The phrase “clinical level ECG”, as used herein with conjunction with ECG measurements, refers to the professionally acceptable number of leads, sensitivity and specificity needed for a definite conclusion by most cardiology physicians to suspect a risky cardiac problem (for example, arrhythmia, myocardial ischemia, heart failure) that require immediate further investigation or intervention. Currently, it is at least a 12-leads ECG and preferably 15-lead ECG, coupled with a motion/posture compensation element, and a real-time processor with adequate algorithms.

The phrase "base-yarn", as used herein, refers to the yarn from which the fabric of the garment is knitted from. The fabric is typically knitted with Nylon, bare Spandex and covered spandex. In another example embodiment, the fabric is typically knitted with a base-yarn such as Nylon and covered spandex. It should be noted that such a garment can be knitted with any type of base-yarn including Nylon yarn textured or flat, selected types of Nylons, Polyester, Polypropylene, Acetate, manmade fibers, natural yarns like cotton, bamboo, wool, and blends of the mentioned raw materials. Selection of yarn is also based on fabric weight, body size for men and women, fabric weight and design required.

BRIEF SUMMARY OF THE INVENTION

It is an intention of the present invention to provide methods for knitting a garment such that the elasticity of one or more selected regions is prevented or at least limited and thereby substantially maintaining the original dimensions of these regions.

It should be noted that the present invention will be described in terms of the regions, in which regions elasticity is substantially prevented or at least limited, being knitted electrodes, but these regions are not limited to being knitted electrodes, and may be any knitted region in a knitted fabric.

Knitted electrodes in a garment are made of conductive yarn, which conductive yarn is knitted together with other basic yarns such as Nylon, bare spandex, covered spandex and/or other types of synthetic, manmade, or natural yarn.

It is an intention of the present invention to provide methods for obtaining stable and repeatable positioning of electrodes at respective pre-configured bodily location, which positioning is of extreme importance to obtain good ECG signals, facilitating clinical level ECG, while the monitored person is either in rest or is moving, including running, jumping or walking. It is the intention of the present invention to ensure that the ECG signals are obtained from substantially the same location on the monitored body.

Once the exact locations of electrodes: RA, LA, V1, V2, V3, V4, V5, V6, RL and LL, and optionally, V7, V8 and V9, are selected for each garment size, the electrodes are knitted with their special knitting construction using a conductive yarn having a preconfigured distance from each other.

It is an intention of the present invention to provide methods for maintaining this substantially fixed distance between each of the electrodes, even when the garment is stretched during wearing or the wearer is in motion.

According to teachings of the present invention, there is provided a method for substantially reducing the elasticity of at least one selected textile region of a garment, the method including the steps of producing the garment including at least one conductive textile electrode, and rigidifying the at least one selected textile region. The rigidifying process includes applying rigidifying matter onto or into the at least one selected textile region.

The at least one selected textile region is selected from the group consisting of a conductive textile electrode and a region of the garment situated between two adjacent textile electrodes.

Typically, with no limitation, the garment and the at least one conductive textile electrode are produced by a knitting machine.

Optionally, the rigidifying matter is thermoplastic polyurethane (TPU), wherein the TPU is laminated over the external surface of the at least one selected textile region.

Optionally, the rigidifying matter is fusible knitting yarn having a low melting point, wherein the fusible yarn is knitted over the external surface of the at least one selected textile region. When the fabric of the garment is dyed, the fusible yarn melts and thereby creates a stable and rigidified area.

Optionally, the rigidifying matter is a non-elastic knitting yarn having no or limited elasticity, wherein a frame, having a preconfigured width, is knitted around the at least one conductive textile electrode, using the non-elastic yarn.

Optionally, the rigidifying matter is a non-elastic yarn having no or limited elasticity, wherein the non-elastic yarn is sewn over the at least one selected textile region.

Optionally, the rigidifying matter is a non-elastic knitting yarn having no or limited elasticity, wherein the non-elastic yarn is knitted in a region of the garment between two adjacent textile electrodes.

Optionally, the rigidifying matter is a cross polymer lubricant, wherein the cross polymer lubricant is spayed over the at least one selected textile region.

According to further teachings of the present invention, there is provided a method for knitting a garment having a tubular form being knitted with a base-yarn, including knitting at least one conductive textile electrode, using a knitting machine having N participating feeders and M needles. The method includes the steps of continuously knitting the tubular form with one or more flexible non-conductive base-yarns, and knitting the at least one textile electrode integrally within the tubular form, using a conductive yarn, in addition to the non-conductive yarns.

The conductive yarn is knitted in a float-loop form by knitting a stitch and skipping over y needles, as follows:

a) continue knitting with at least one base-yarn, when start knitting a current line segment of a conductive textile electrode, preferably in a knit&miss knitting scheme.

b) knitting a line segment L_k, using feeder F_i and start stitching with needle D_j.

c) knitting line the next segment L_{k+1}, using the next feeder F_{i+1} and start stitching the first float-loop with needle D_{j+s}, where $0<s<y$.

d) repeat steps (i) and (ii) for N feeders and for a preconfigured number of line segments, wherein each line segment has a preconfigured length.

e) resume knitting with the base-yarns, when completed knitting the current line segment.

The knit&miss scheme is selected from the group of knitting schemes including:

a) knit-one&miss-one knitting pattern.

b) knit-two&miss-one knitting pattern.

c) knit-one&miss-two knitting pattern.

Optionally, a preconfigured region of the tubular form, disposed around and adjacently to the at least one textile electrode, is knitted with higher knitting density than the preconfigured knitting density of the tubular form.

According to further teachings of the present invention, there is provided a garment having a tubular form, being knitted by a seamless knitting machine with base-yarns, the garment including at least one conductive textile electrode, the at least one conductive textile electrode including a multiplicity of knitted line segments, each knitted with a conductive yarn and a spandex yarn, wherein the spandex yarn is knitted continuously.

At least one of the base-yarns continues knitting when the knitting a current line segment of a conductive textile electrode begins, preferably in a knit&miss knitting scheme.

Preferably, the conductive yarn has a float-loop form, forming a multiplicity of the float-loops, wherein each of the float-loops is knitted by skipping over y needles between consecutive stitches. A given line segment starts stitching by needle D_j, and the next line segment starts stitching by needle D_{j+s}, where $0<s<y$.

Optionally, at least one selected textile region of the garment is rigidified by applying rigidifying matter onto or into the at least one selected textile region, wherein the at least one selected textile region is selected from the group consisting of a conductive textile electrode and a region of the garment situated between two adjacent textile electrodes.

Optionally, the at least one selected textile region is rigidified using TPU, and wherein the TPU is laminated over the external surface of the at least one selected textile region.

Optionally, the at least one selected textile region is rigidified using fusible yarn having a low melting point, wherein the a fusible yarn is knitted over the external surface of the at least one selected textile region, and when the garment is dyed, the fusible yarn melts and thereby creates a stable and rigidified area.

Optionally, the at least one selected textile region is rigidified using a non-elastic yarn having no or limited elasticity, wherein a frame, having a preconfigured width, is knitted around the at least one conductive textile electrode, using the non-elastic yarn.

Optionally, the at least one selected textile region is rigidified using a non-elastic yarn having no or limited elasticity, wherein the non-elastic yarn is knitted in the region of the garment between two adjacent textile electrodes.

Optionally, the rigidifying matter is a cross polymer lubricant, and wherein the cross polymer lubricant is spayed over in the at least one selected textile region.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become fully understood from the detailed description given herein below and the accompanying drawings, which are given by way of

illustration and example only and thus not limitative of the present invention, and wherein:

Fig. 1 is a schematic illustration of an exemplary garment, having a tubular form, wherein textile electrodes are knitted therein, and then rigidified according to embodiments of the present invention.

Fig. 2 outlines an example knitting scheme of a conductive electrode designed for a Santoni type knitting machine, according to embodiments of the present invention, wherein the conductive electrode is rigidified with a nylon yarn.

Fig. 3a is a schematic illustration of an exemplary garment, having a tubular form, wherein textile electrodes are knitted therein, and wherein regions of the garment, immediately adjacent to the textile electrodes, are rigidified, according to some embodiments of the present invention.

Fig. 3b is a schematic detailed illustration of a textile structure (160).

DETAILED DESCRIPTION OF THE INVENTION

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided, so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

An embodiment is an example or implementation of the inventions. The various appearances of "one embodiment," "an embodiment" or "some embodiments" do not necessarily all refer to the same embodiments. Although various features of the invention may be described in the context of a single embodiment, the features may also be provided separately or in any suitable combination. Conversely, although the invention may be described herein in the context of separate embodiments for clarity, the invention may also be implemented in a single embodiment.

Reference in the specification to "one embodiment", "an embodiment", "some embodiments" or "other embodiments" means that a particular feature, structure, or characteristic described in connection with the embodiments is included in at least one embodiments, but not necessarily all embodiments, of the inventions. It is understood that the phraseology and terminology employed herein is not to be construed as limiting

and are for descriptive purpose only.

Methods of the present invention may be implemented by performing or completing manually, automatically, or a combination thereof, selected steps or tasks. The term "method" refers to manners, means, techniques and procedures for accomplishing a given task including, but not limited to, those manners, means, techniques and procedures either known to, or readily developed from known manners, means, techniques and procedures by practitioners of the art to which the invention belongs. The descriptions, examples, methods and materials presented in the claims and the specification are not to be construed as limiting but rather as illustrative only.

Meanings of technical and scientific terms used herein are to be commonly understood as to which the invention belongs, unless otherwise defined. The present invention can be implemented in the testing or practice with methods and materials equivalent or similar to those described herein.

It should be noted that orientation related descriptions such as “bottom”, “up”, “horizontal”, “vertical”, “lower”, “top” and the like, assumes that the is worn by a person being in a standing position.

The knitted electrodes in the garment are made of conductive yarns, wherein each conductive yarn is knitted together with other basic yarns such as Nylon, bare spandex, covered spandex and/or other types of yarn. The methods described assume usage of a Santoni knitting machine or an equivalent machine.

The electrodes location and level of pressure of the electrode on the body, in particular for textile electrodes, is critical for measuring electrocardiogram (ECG), electroencephalogram (EEG), electrooculogram (EOG), and other medical parameters. The location, shape, and size of each of the electrodes are critical for good and efficient ECG, EEG, EOG, signals reading, while taking into account the efficiency of ECG reading signals, wearing comfort, correct size for men and women, knitting capabilities, etc. Furthermore, is critical for measuring ECG, EEG, EOG and other medical parameters, that the spacing among the electrodes remains stable.

Fig. 1 is a schematic illustration of an exemplary knitted smart garment **20**, according to embodiments of the present invention, having knitted textile electrodes **100** knitted therein, wherein typically, textile electrodes **100** are interconnect with a processor (not shown) by conductive means (not shown). Knitted smart garment **20** has a tubular

form, wherein textile electrodes **100** are knitted integrally therein. The knitted electrodes are located in the selected areas on the fabric based on the desired ECG signals efficiency.

Various types of rigidifying means are shown in Fig. 1. While textile electrode **100** represents a non-rigidified electrode, textile electrodes **110**, **120**, **130** and **140** represent rigidified electrodes.

Textile electrode **110** represents an electrode rigidified by a film of rigid material such as thermoplastic polyurethane (TPU). Electrode **110** is typically laminated with a rigidifying film of on the surface of electrode **110** distal from the skin of the monitored body (referred to herein as the "external surface" of the electrode), according to some embodiment of the present invention. In some embodiments, the external surface of electrode **110** is the side that does not have the knitted. Typically, there is no need to apply heat or pressure to bond the film.

In some embodiments, special TPU film is used, wherein the film is bonded to the fabric by glue. Optionally, on one side of the film has glue applied thereon, and thus, can be bonded onto a fabric.

Once the TPU is bonded onto selected electrodes, the TPU substantially prevents or at least limits electrodes **110** from stretching and thereby facilitates receiving stable signals reading.

I should be noted that TPU film may have selected colors or may have no color at all.

Textile electrode **120** represents an electrode rigidified by fusible yarn, having a low melting point. The special fusible yarn (white lines in Fig. 1) is knitted together with the electrodes, extending proximal to the external surface of electrode **120**.

Typically, when the fabric is dyed, the fusible yarn melts and thereby creates a stable and rigidified area, which prevents or at least limits the elasticity of electrode **120**.

The amount of fusible yarn in the electrode is determined by the amount of knitted courses in the electrodes with the fusible yarn.

Textile electrode **130** represents an electrode rigidified by building a rigid zone around selected electrodes **100** forming a rigid frame around the selected electrodes **100**,

to thereby prevent or at least limit the elasticity of electrode **130**, according to some embodiment of the present invention.

The knitted frame is made of yarn having no or limited elasticity, around each electrode, except for the edge connected to a conductive trace or a conductive stipe or a conductive wire.

In one example embodiment, the non-stretchable construction, having a preconfigured width, is knitted around the electrode circumference to form the stable frame. For example, the width is formed using 12 adjacent needles.

When the garment is in use and is stretched, the fabric itself does stretch during wearing, however, the electrodes remain substantially in the same size and position.

Textile electrode **140** represents an electrode rigidified by spraying a special cross polymer lubricant on the external surface of electrode **140**, wherein the chemical cross polymer lubricant is absorbed into the yarns of electrode **140** and thereby stabilizes the electrodes dimensions. The special cross polymer lubricant may also be sprayed on selected regions of the garment situated between two adjacent textile electrodes **100**.

Preferably, the special lubricant has the ability to stand at least a preconfigured number of washes, a comfort touch and feel of the garment when in touch with the skin and wearing comfort.

Reference in now made to Fig. 2 that outlines an example knitting scheme **200** of a conductive electrode designed for a Santoni type knitting machine, wherein the conductive electrode is rigidified with a nylon yarn, according to embodiments of the present invention. Thereby, substantially reducing the elasticity of the electrode produced.

It should be noted that in previous electrode knitting construction, the nylon base-yarn that takes part in the knitting program, is not knitted at the electrode area, but is floating at the back side of the electrode. This is done in order to allow the conductive yarn to create the float loops and be in substantive tangible contact with the body.

In this invention the nylon base-yarn is knitted together with the conductive yarn of the electrode to thereby form a more rigid and stable fabric.

The knitted electrode, as described in Fig. 2, is knitted to form float loops made of the conductive yarns (for example, 70/2 Den by Xstatic), which are designed to float over

the fabric surface in the number of needles as designed. The length of the float loop is determines by the number of needles the loop if floating over. This type of knitted textile electrode is described in international pat application PCT/IL2013/050964 ('964), the disclosure of which is incorporated by reference for all purposes as if fully set forth herein.

As described in '964 the length of the float loops, as well as the specific knitting density in the knitted electrode area, and in selected areas in the basic garment, is determined by the desired quality level of ECG signals. Furthermore, the use of float loops in a shifted needle knitting scheme, together with unique digital knitting density control, enables achieving the following important advantages:

- Improve the pressure and the tightness of the electrodes to the body which is a critical parameter for good efficient ECG reading
- Obtaining good conductivity across knitted line segments.
- The electrodes are located well in the designated bodily position even when the body is in motion.
- The float loop electrodes can penetrate the hair on a hairy skin allowing reaching good ECG signals with no need to remove the hair as it is done today in regular ECG check.
- The float loop electrodes eliminating the use of gel or other wetting material used today to reach ECG signals.

The float-loop electrodes are knitted together in same knitting process of knitting the basic garment and coming out the machine as one single unit. The tight float-loop knitting scheme produces a rigid electrode with respect to the fabric situated adjacent to the electrode.

However, to further rigidify the float-loop electrode, the present invention, as outlined in Fig. 2, describes an example knitting method **200** of producing a rigid float-loop electrode. In this example embodiment **200**, the conductive yarn is made of Nylon covered with silver or stainless steel, knitted on an 8-feeds Santoni type circular knitting machine (or machines with equivalent capabilities), together with the non-conductive yarns: covered Spandex **50** (and/or bare spandex). In this example embodiment, the knitting scheme **210** is designed for a 4 (four) feeds system, but is using in the example shown, with no limitations, an 8 feed Santoni type knitting machine, according to variations of the present invention. The 4 feeders knit four knitted lines, being four loops

of the continuous knitting spiral, including respective line segments of each electrode that is situated on the garment section being knitted.

In this embodiment, in all the knitting courses, the float loops that are formed from the conductive yarn **60**, that float over 7 needles, as can be seen and appreciated by a person skilled in the art in Fig. 2, while the non-conductive covered (or optionally, bared) spandex **50** is knitted continuously in the same knitted course. It should be noted that, in this embodiment, the base-yarn is referred to, with no limitations, as a nylon base-yarn.

In the example shown in Fig. 2, four out of eight available feeders are used: feeders 1, 3, 5 and 7 are not used, while feeders 2, 4, 6 and 8 are used. Generally, the same knitting scheme **210** is used in all courses. However, the float-loop stitch starting needle D_j in Feeder $i+2$ is shifted by s needles with respect to the float-loop stitch starting needle in Feeder i. In the example shown in Fig. 4, $s = 1$.

The present invention is not limited to the knitting parameters shown in the example as illustrated in Fig. 2 and corresponding description in the specifications. The example as illustrated in Fig. 2 exemplifies methods for knitting a garment **20** having a tubular form, including knitting at least one conductive textile electrode, using a knitting machine having N feeders and M needles.

In one embodiment the method includes continuously knitting a tubular form **20** with a flexible non-conductive yarn **50** and a nylon base-yarn **70**, knitting the at least one textile electrode integrally within tubular form **20**, using a conductive yarn **60**, in addition to the non-conductive yarns. However, in the electrode region, nylon base-yarn **70** is preferably knitted in a knit&miss scheme. The nylon base-yarn **70** may be knitted in a continuous or a knit&miss scheme, wherein the knit&miss may be in any combination, including knit one and miss one (knit-one&miss-one), knit two and skip one (knit-two&miss-one), knit one and skip two (knit-one&miss-two) and so on and so forth.

The conductive yarn **60** is knitted in a float-loop form by knitting a stitch and then skipping over y needles, as follows:

i) knitting a course k, being a line segment L_k, using feeder F_i and starting at needle D_j, wherein the next float-loop starting stitch is at y needles away from the starting stitch needle of the previous float-loop;

ii) knitting line segment L_{k+1}, using the next participating feeder and starting stitching the first float-loop with needle D_{j+s}, where $0<s<y$ and typically, j=1;

and

iii) repeat steps (i) and (ii) for a preconfigured length of the tubular form **20**, i.e. a preconfigured number of knitting courses.

It should be noted that each line segment has a preconfigured length.

It should be further noted that a preconfigured number of feeders of the knitting machine participate in the knitting process of the garment.

Reference is now made to Fig. 3a, a schematic illustration of an exemplary garment **21**, having a tubular form, wherein textile electrodes **100** are knitted therein, and wherein regions of garment **21**, immediately adjacent to textile electrodes **100**, are rigidified, according to some embodiments of the present invention.

Various types of rigidifying means are shown in Fig. 3a. While textile electrode **100** represents a non-rigidified electrode, textile electrodes **160**, **170** and **180** represent rigidified electrodes.

Textile structure **160**, also shown in details in Fig. 3b, represents a knitted structure for maintaining a substantially stable distance between horizontally adjacent electrodes **100**, wherein non-elastic threads **162** are knitted in between selected horizontally adjacent electrodes **100**, according to some embodiment of the present invention.

At least one substantially non-elastic thread **162** is knitted to interconnect the proximal vertical edges **102** of horizontally adjacent electrodes **100**, wherein a certain amount of allowable controlled suspension is given to each electrode **100** according the expected body dimensions of the wearer. Similarly, a special thread may be knitted to interconnect proximal horizontal edges of vertically adjacent electrodes **100**.

When the knitted garment **21** is stretched on a monitored body (such as in the wearing process), non-elastic thread **162**, knitted between electrodes **100**, is suspended to a preconfigured distance, while electrodes **100** maintain a stable and substantially equal relative distance among the pair of electrodes **100**.

Non-elastic thread **162** may be a Nylon or Polyester yarn with limited elasticity.

Textile structure **180** represents a structure for maintaining a substantially stable distance between horizontally adjacent electrodes **100**, wherein the space in between horizontally adjacent electrodes **110** is rigidified by a film of rigid material such as TPU. Electrode **100** is typically laminated with a rigidifying film of on the external surface of

electrode **100**, according to some embodiment of the present invention. Typically, there is no need to apply heat or pressure to bond the film. The film of rigid material may also be laminated over fabric regions in between vertically adjacent electrodes **100**.

As illustrated in Fig. 3a knitted garment **21** includes at least one laminated structure **180** for substantially reducing the elasticity of the space in between horizontally adjacent electrodes **100**. The TPU film, having limited stretchability, is laminated on the region of garment **21** between selected electrodes **100**.

When the garment **100** is stretched during wearing, the laminated regions **180** between horizontally adjacent electrodes **100** are stretched to a preconfigured distance in between electrodes **100**, as allowed by the TPU film, and thereby keep the selected pair of electrodes **100** in the preconfigured relative positioning, and prevent further stretching.

As illustrated in Fig. 3a knitted garment **21** includes at least one structure **170** for substantially reducing the elasticity of an electrode **100** and the garment fabric surrounding that electrode **100**, according to some embodiment of the present invention, wherein a safety net is built around that electrode **100** or is sewn in between selected adjacent electrodes **100**.

A non-elastic yarn, with limited stretchability, is sewn over an electrode **100** and/or in between selected adjacent electrodes **100**.

When the garment **100** is stretched during wearing, the sewn structure **170** is suspended to a preconfigured distance and stops the electrodes **100** from stretching further, while the garment (**21**) itself continues to stretch.

This will hold and ensure the relative positioning of each of the selected electrodes **100** with respective to each other.

When structure **170** is sewn as safety net over and around a selected electrode **100**, structure **170** rigidifies the selected electrode **100**.

The invention being thus described in terms of embodiments and examples, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the claims.

WHAT IS CLAIMED IS:

1. A method for substantially reducing the elasticity of at least one selected textile region of a garment, the method comprising the steps of:

a) producing the garment including at least one conductive textile electrode; and

b) rigidifying said at least one selected textile region, wherein said rigidifying includes applying rigidifying matter onto or into said at least one selected textile region.

2. The rigidifying method as in claim 1, wherein said at least one selected textile region is a conductive textile electrode.

3. The rigidifying method as in claim 1, wherein said at least one selected textile region is a region of said garment situated between two adjacent textile electrodes.

4. The rigidifying method as in claim 1, wherein said rigidifying matter is thermoplastic polyurethane (TPU), and wherein said TPU is laminated over the external surface of said at least one selected textile region.

5. The rigidifying method as in claim 1, wherein the garment and the at least one conductive textile electrode are produced by a knitting machine,

wherein said rigidifying matter is fusible yarn having a low melting point;

wherein said fusible yarn is knitted over the external surface of said at least one selected textile region; and

wherein when the fabric of said garment is dyed, said fusible yarn melts and thereby creates a stable and rigidified area.

6. The rigidifying method as in claim 1, wherein the garment and said at least one conductive textile electrode are produced by a knitting machine,

wherein said rigidifying matter is a non-elastic yarn having no or limited elasticity; and

wherein a frame, having a preconfigured width, is knitted around said at least one conductive textile electrode, using said non-elastic yarn.

7. The rigidifying method as in claim 1, wherein said rigidifying matter is a non-elastic yarn having no or limited elasticity, and

wherein said non-elastic yarn is sewn over said at least one selected textile region.

8. The rigidifying method as in claim 1, wherein the garment is produced by a knitting machine,

wherein said rigidifying matter is a non-elastic yarn having no or limited elasticity; and

wherein said non-elastic yarn is knitted in said region of said garment between two adjacent textile electrodes.

9. The rigidifying method as in claim 1, wherein said rigidifying matter is a cross polymer lubricant; and

wherein said cross polymer lubricant is spayed over said at least one selected textile region.

10. A method for knitting a garment having a tubular form being knitted with a base-yarn, including knitting at least one conductive textile electrode, using a knitting machine having N participating feeders and M needles, the method comprising the steps of:

a) continuously knitting said tubular form with one or more flexible non-conductive base-yarns; and

b) knitting said at least one textile electrode integrally within said tubular form, using a conductive yarn, in addition to said non-conductive yarns, wherein said conductive yarn is knitted in a float-loop form by knitting a stitch and skipping over y needles, as follows:

i) continue knitting with at least one base-yarn, when start knitting a current line segment of a conductive textile electrode;

ii) knitting a line segment L_k, using feeder F_i and start stitching with needle D_j;

iii) knitting line the next segment L_{k+1}, using the next feeder F_{i+1} and start stitching the first float-loop with needle D_{j+s}, where $0<s<y$;

iv) repeat steps (i) and (ii) for N feeders and for a preconfigured number of line segments, wherein each line segment has a preconfigured length; and

v) resume knitting with the base-yarns, when completed knitting said current line segment.

11. The knitting method as in claim 10, wherein said continued knitting with at least one base-yarn is knitted in a knit&miss knitting scheme.

12. The knitting method as in claim 10, wherein $j=1$.

13. The knitting method as in claim 11, wherein said knit&miss scheme is selected from the group of knitting schemes comprising:

a) knit-one&miss-one knitting pattern;

b) knit-two&miss-one knitting pattern; and

c) knit-one&miss-two knitting pattern.

14. The knitting method as in claim 10, wherein a preconfigured region of said tubular form, disposed around and adjacently to said at least one textile electrode, is knitted with higher knitting density than said preconfigured knitting density of said tubular form.

15. A garment having a tubular form, being knitted by a seamless knitting machine with base-yarns, the garment comprising at least one conductive textile electrode, said at least one conductive textile electrode comprising a multiplicity of knitted line segments, each knitted with a conductive yarn and a spandex yarn,

wherein said spandex yarn is knitted continuously;

wherein at least one of said base-yarns continues knitting when start knitting a current line segment of a conductive textile electrode, in a knit&miss knitting scheme;

wherein said conductive yarn has a float-loop form, forming a multiplicity of said float-loops;

wherein each of said float-loops is knitted by skipping over y needles between consecutive stitches; and

wherein a given of said line segments starts stitching by needle D_j, and the next of said line segments starts stitching by needle D_{j+s}, where $0<s<y$.

16. The garment as in claim 15, wherein said knit&miss scheme is selected from the group of knitting schemes comprising:

a) knit-one&miss-one knitting pattern;

b) knit-two&miss-one knitting pattern; and

c) knit-one&miss-two knitting pattern.

17. The garment as in claim 15, wherein a preconfigured region of said tubular form, disposed around and adjacently to said at least one textile electrode, is knitted with higher knitting density than said preconfigured knitting density of said tubular form.

18. The garment as in claim 15, wherein at least one selected textile region of the garment is rigidified by applying rigidifying matter onto or into said at least one selected textile region.

19. The garment as in claim 18, wherein said at least one selected textile region is a conductive textile electrode.

20. The garment as in claim 18, wherein said at least one selected textile region is a region of said garment situated between two adjacent textile electrodes.

21. The garment as in claim 18, wherein said at least one selected textile region is rigidified using TPU, and wherein said TPU is laminated over the external surface of said at least one selected textile region.

22. The garment as in claim 18, wherein said at least one selected textile region is rigidified using fusible yarn having a low melting point,

wherein said a fusible yarn is knitted over the external surface of said at least one selected textile region; and

wherein when said garment is dyed, said fusible yarn melts and thereby creates a stable and rigidified area.

23. The garment as in claim 18, wherein said at least one selected textile region is rigidified using a non-elastic yarn having no or limited elasticity.

24. The garment as in claim 23, wherein a frame, having a preconfigured width, is knitted around said at least one conductive textile electrode, using said non-elastic yarn.

25. The garment as in claim 23, wherein said non-elastic yarn is knitted in said region of said garment between two adjacent textile electrodes.

26. The garment as in claim 18, wherein said rigidifying matter is a cross polymer lubricant, and wherein said cross polymer lubricant is spayed over in said at least one selected textile region.

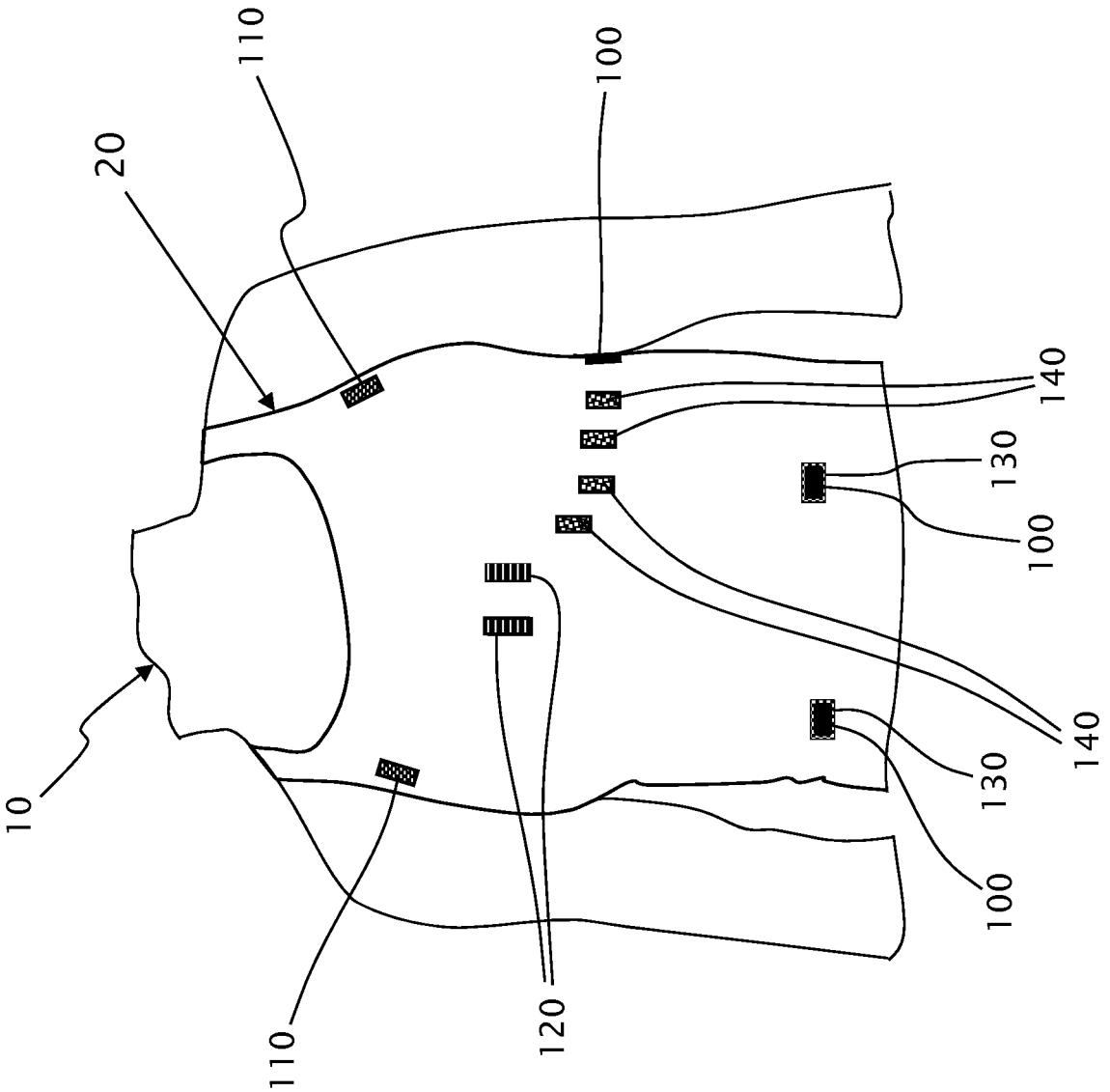

Fig. 1

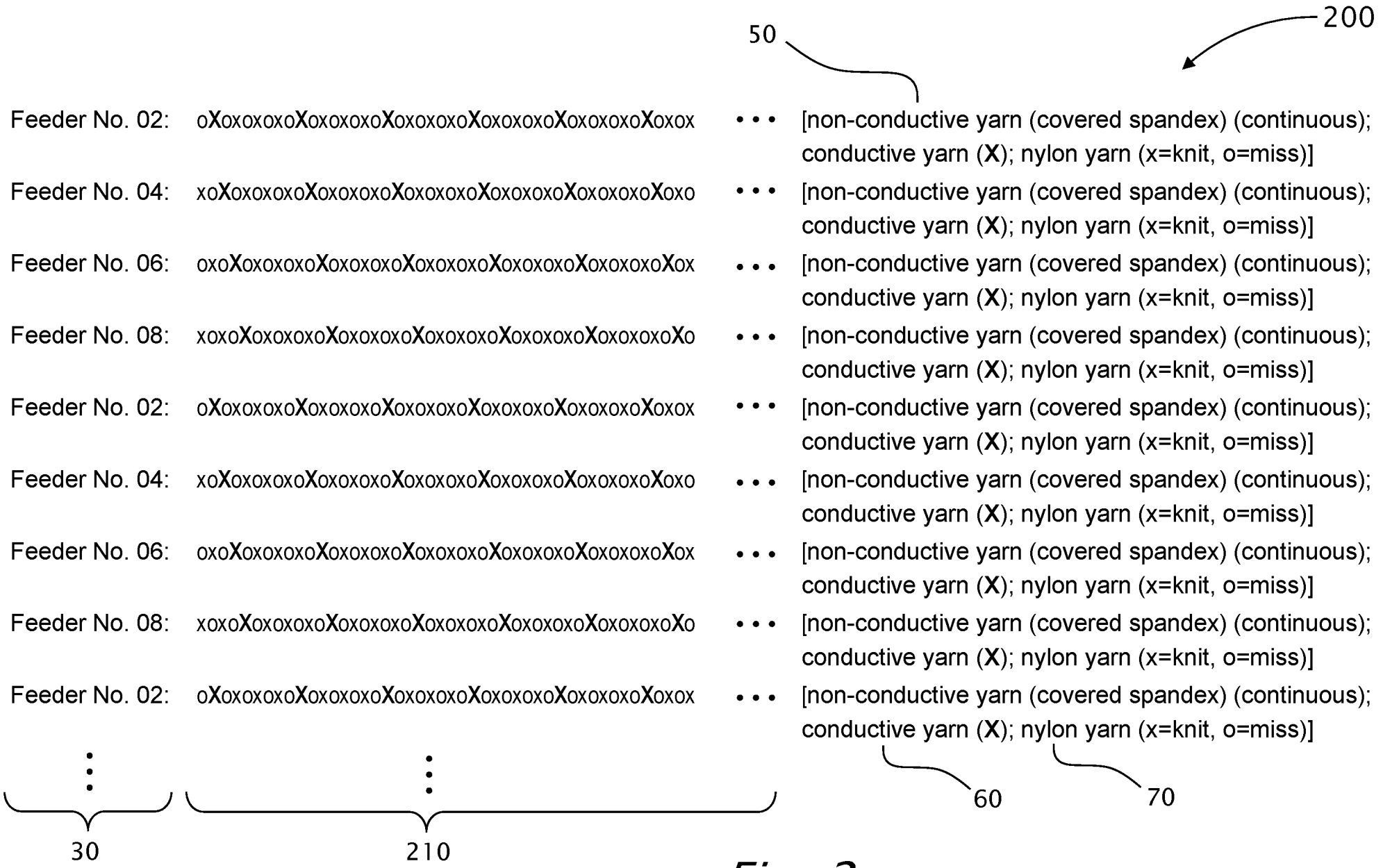
200
50
Feeder No. 02: oXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxox • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
Feeder No. 04: xoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxo • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
Feeder No. 06: oxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXox • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
Feeder No. 08: xoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXo • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
Feeder No. 02: oXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxox • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
Feeder No. 04: xoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxo • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
Feeder No. 06: oxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXox • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
Feeder No. 08: xoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXo • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
Feeder No. 02: oXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxoxoxoXoxox • • • [non-conductive yarn (covered spandex) (continuous); conductive yarn (X); nylon yarn (x=knit, o=miss)]
60
70
30
210

Fig. 2

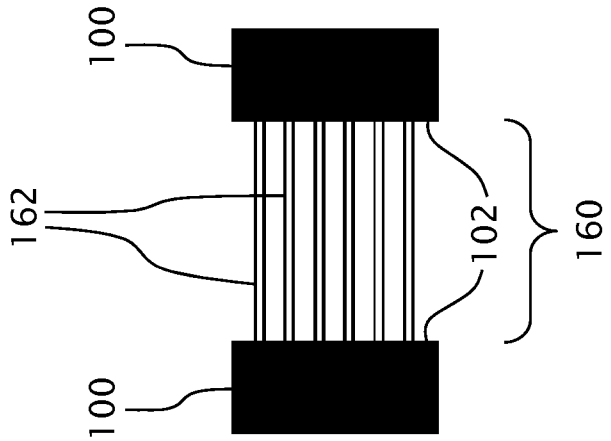

Fig. 3b
Detailed A

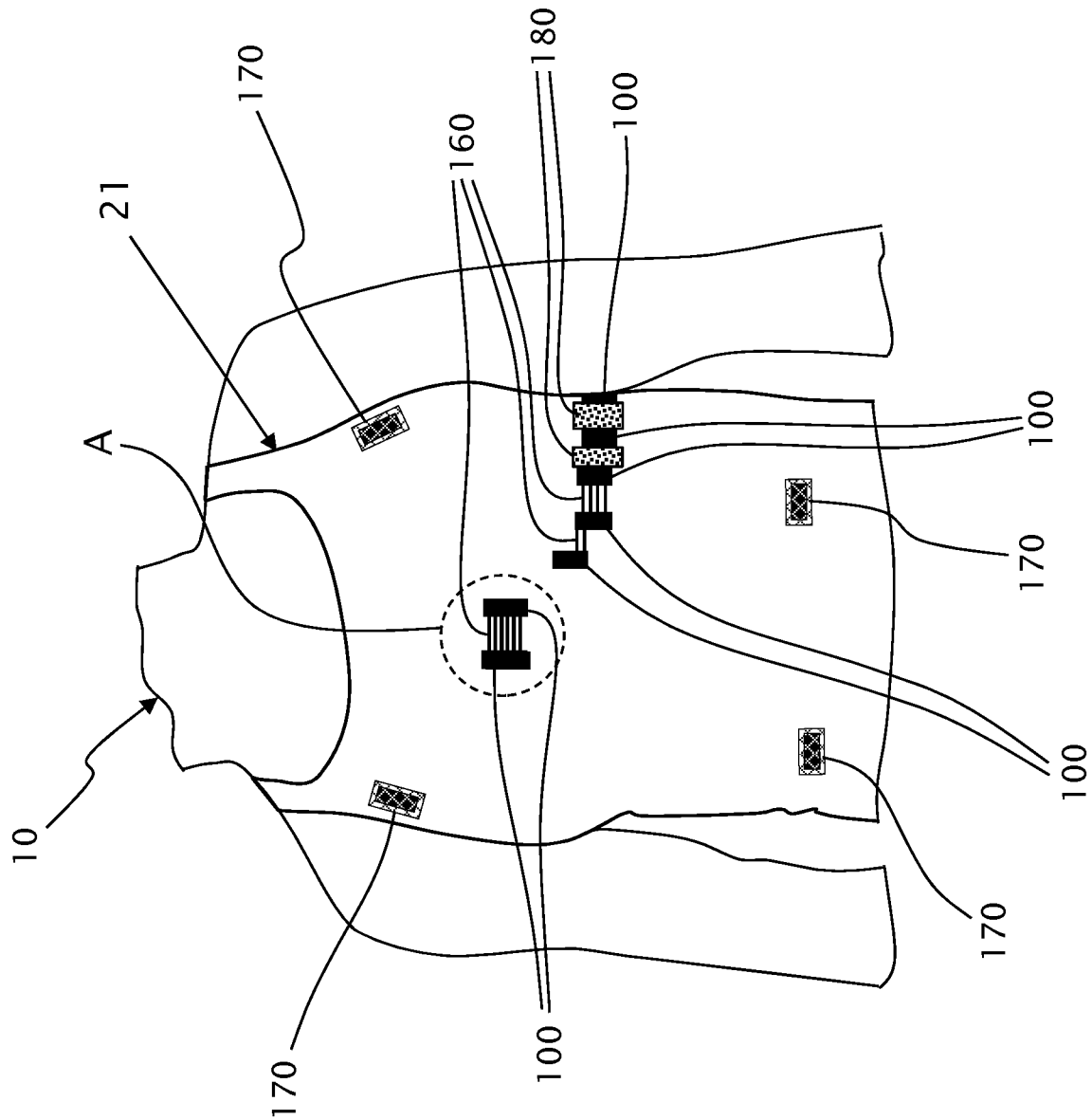

Fig. 3a

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2014/050134

A. CLASSIFICATION OF SUBJECT MATTER

IPC (2014.01) A41D 1/00, A61B 5/053, A61B 5/0402, G06F 1/16

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)

IPC (2014.01) A41D 1/00, A61B 5/053, A61B 5/0402, D04B, G06F 1/16

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 practicable, search terms used)

Databases consulted: PATENTSCOPE, USPTO, Esp@cenet, Google Patents, FamPat database
Search terms used: (rigid OR firm OR stiff OR inflexible OR unflexible OR inelastic OR non-elastic OR unstretch OR patch) AND (fabric or garment OR textile) AND (electrode OR sensor) AND EEG AND spray AND polymer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 Jun 2014	17 Jun 2014
Name and mailing address of the ISA: Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616	Authorized officer JOCHNOWITZ Gershon Telephone No. 972-5651775

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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