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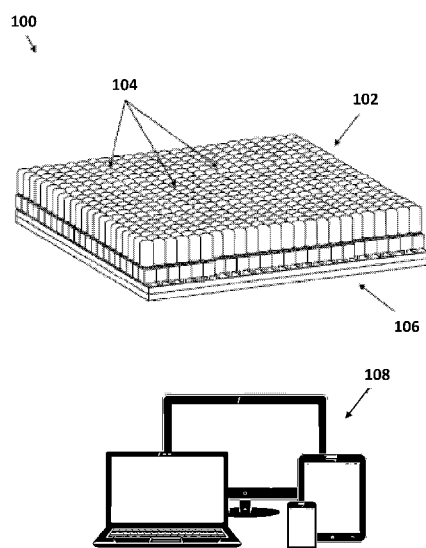


Figure 1

(57) **Abstract:** The invention discloses a system for preventing or treating a sensitive location of a user, comprising: a mattress comprising an array of inflatable cells; circuitry configured to apply instructions to modify a parameter related to one or more of said inflatable cells in a location associated with said sensitive location, according to at least one protocol based on said sensitive location and/or at least one input from said user.



SMART DYNAMIC MATTRESS FOR PREVENTION AND TREATMENT OF PRESSURE WOUNDS

5 RELATED APPLICATION/S

This application claims the benefit of priority under 35 USC §119(e) of U.S. Provisional Patent Application No. US62/802,224 filed 07 February 2019, the contents of which are incorporated herein by reference in their entirety.

10 FIELD AND BACKGROUND

The present invention, in some embodiments thereof, relates to a smart mattress and, more particularly, but not exclusively, to a smart dynamic mattress for prevention and treatment of pressure wounds.

Cushions, mattresses and mattress overlays intended for use by patients to help prevent skin and tissue damage or pressure sores are provided as fiber or foam filled cushions or mattresses, inflatable cushions or mattresses or inflatable cushions or mattresses comprising a plurality of individual inflatable air cells of various configurations. In general, the goal of such products is to distribute contact pressure or diffuse load over a wider area of the anatomy to reduce pressure points and thereby prevent or ameliorate pressure sores or decubitus ulcers.

Additional background art includes U.S. Patent No. US8893338B2 discloses “a cushion or mattress comprising a base and a plurality of linearly aligned individual air cells across the base. Groups of individual air cells can be interconnected and in fluid cooperation with an inflation source, such as a pump. In one aspect of the invention, the inflation of adjacent cells is staggered, for example, in a checkerboard-like inflation pattern that helps diffuse load over a wider area.”

U.S. Patent No. US7849544B2 discloses “a mattress has at least one inflatable top layer made up of a plurality of adjacent elements that are individually inflatable by a pneumatic inflation and pressure regulation device and at least one bottom layer supporting the top layer. The bottom layer has a recess for receiving a sensor connected to the pneumatic inflation and pressure regulation device, and making it possible to determine the pressure applied by the body of an individual bearing against the inflatable top layer and to regulate the inflation pressures of the elements of the top layer. In at least one support zone designed to support the sacrum of an individual, the top layer is made up of a plurality of inflatable elements that are of a width smaller than their height.”

U.S. Patent No. US8598893B2 discloses “a sensor for detecting and measuring a load pressure applied to a support device comprises at least one capacitive cell including a flat condenser comprising at least one layer of a compressible insulating dielectric material interposed between

two layers of conductive material. A support device capable of supporting the body of a person comprises at least one top layer composed of a plurality of air-filled inflatable cells communicating with inflation elements, characterized in that it comprises a sensor, of which said condenser is disposed under said top layer and connected to an electronic control and regulation device capable of controlling inflation or deflation elements".

U.S. Patent No. US5983428A discloses "in operation of a support for a patient's body, used in medical or veterinary treatment, which applies alternating-pressure to the body in order to reduce or minimize the risk of pressure sores caused by prolonged pressure on the skin, inflatable cells of the support are inflated and deflated cyclically in a predetermined sequence. To provide improved effect in relieving or preventing pressure sores, the cells are deflated in the sequence in such a manner that the interior pressure falls from 10 mmHg (135 Pa) to 0 mmHg in a time period of not more than 15 s. Preferably the interior pressure falls to below 0 mmHg (ambient atmospheric pressure). A vacuum pump or pumps may be employed to achieve this result."

U.S. Patent No. US7409735B2 discloses "a person support surface comprising a multitude of inflatable cells. The cells are inflated and deflated to adjust an interface pressure between the person support surface and a person supported by the surface."

U.S. Patent No. US8341786B2 discloses "an apparatus and method providing variable support and variable comfort control of a sleep system, the apparatus including a sleep support member including: a comfort layer including: a plurality of comfort layer inflatable members; and a comfort layer sensor configured to provide data relating to respective pressures of the comfort layer inflatable members; a data analysis unit configured to analyze data provided by the comfort layer sensor and to generate analyzed comfort layer data; and a control unit configured to control a pressure within each of the respective comfort layer inflatable members using the analyzed comfort layer data."

U.S. Patent No. US9591995B2 discloses a "digital bed system comprised of an array of support cells. Each support cells is capable of communicating with a controller and increasing and decreasing in firmness in response to commands issued by a controller. The support cells are operatively connected to a communication channel that is also connected to a controller. The controller is capable of receiving data from the support cells and is also capable of issuing commands to each of the support cells. The controller is programmed issue commands to increase or decrease the firmness of individual support cells within the support cells".

U.S. Patent No. US10238561B2 discloses "a system for preventing and treating pressure sores of a bed-ridden patient including an array of expandable and collapsible supports to support and provide pressure relief to a patient in pressure locations where the expandable and collapsible

supports support the patient; pressure sensors associated with the expandable and collapsible supports to monitor pressure locations where the expandable and collapsible supports support the patient; and a patient lift movable between the expandable and collapsible supports to raise and lower the patient between at least a position where the patient is primarily supported by the array of expandable and collapsible supports and a position above the expandable and collapsible supports where the patient is primarily supported by the patient lift”.

U.S. Patent No. US10463526B1 discloses “a support surface having a plurality of small, independent, cylinder shape, vertically mounted air cells integrated on a hospital bed, nursing home or home care beds or as a mattress replacement. The pneumatic support surface is electronically controlled and operated by a caregiver through the only external part of the system: a smartphone or a tablet. The support surface is capable to perform separately or in succession, within two hours, several cycles of a plurality of known procedures for the prevention of pressure sores plus a unique procedure focused on the most-risky parts of the body combined with a program that provides optimum conditions for best and faster healing of existing pressure injuries”.

SUMMARY

According to an aspect of some embodiments of the present invention there is provided a system for preventing or treating a sensitive location of a user, comprising: a. a mattress comprising an array of inflatable cells; b. circuitry configured to apply instructions to modify a parameter related to one or more of said inflatable cells in a location associated with said sensitive location, according to at least one protocol based on said sensitive location and/or at least one input from said user.

According to some embodiments of the invention, said parameter comprises one or more of inflation and deflation.

According to some embodiments of the invention, the system further comprising at least one electronic device in communication with said circuitry.

According to some embodiments of the invention, said at least one electronic device comprises at least one display.

According to some embodiments of the invention, said inflatable cells comprise an integrated pressure sensor.

According to some embodiments of the invention, said circuitry is configured to apply instructions to generate a pressure map based on pressure measurements performed by said integrated pressure sensor in said inflatable cells.

According to some embodiments of the invention, said at least one electronic device is configured to display said pressure map in said display.

According to some embodiments of the invention, said protocol comprises instructions to deflate one or more of said inflatable cells in locations of high pressure according to said pressure map.

According to some embodiments of the invention, said at least one electronic device is used to deliver said at least one input.

According to some embodiments of the invention, said input is a verbal input.

According to some embodiments of the invention, said circuitry is configured to apply instructions to generate a body outline based on pressure measurements performed by said integrated pressure sensor in said inflatable cells.

According to some embodiments of the invention, said at least one electronic device is configured to display said body outline in said display.

According to some embodiments of the invention, said location associated with said sensitive location comprises one or more of the actual location of said sensitive location, a zone adjacent to said actual location, a plurality of zones adjacent to said actual location.

According to some embodiments of the invention, said location associated with said sensitive location comprises a location located a distance from about 1cm to about 100cm.

According to some embodiments of the invention, said inflatable cells comprise an integrated temperature sensor.

According to some embodiments of the invention, said circuitry is configured to apply instructions to generate a temperature map based on temperature measurements performed by said integrated temperature sensor in said inflatable cells.

According to an aspect of some embodiments of the present invention there is provided a method for controlling pressure from at least one sensitive location in a user, comprising: a. receiving at least one input from said user regarding said at least one sensitive location; b. modifying a parameter related to one or more inflatable cells in a location associated with said sensitive location, according to at least one protocol based on said sensitive location and/or said at least one input from said user.

According to some embodiments of the invention, the method comprising measuring pressure applied on a body of said user while being on a surface, said surface comprising an array of inflated inflatable cells configured to measure said pressure.

According to some embodiments of the invention, the method comprising generating a pressure map using said pressure measurements.

According to some embodiments of the invention, the method comprising displaying said pressure map on at least one electronic device.

According to some embodiments of the invention, said receiving at least one input from said user is performed on said at least one electronic device.

5 According to some embodiments of the invention, said modifying said parameter comprises one or more of deflating or inflating those inflatable cells that correspond with said sensitive location.

According to some embodiments of the invention, said modifying said parameter comprises completely deflating those inflatable cells that correspond with said sensitive location.

10 According to some embodiments of the invention, said modifying said parameter comprises one or more of partially deflating and partially inflating inflatable cells around said completely deflated inflatable cells in a temporal and spatial manner.

According to an aspect of some embodiments of the present invention there is provided a method for controlling pressure from at least one sensitive location in a user, comprising: a.
15 generating a pressure map comprising pressure zones, said pressure zones representing pressure levels; b. calculating a relative spatial pressure profile based on said pressure zones; c. identifying zones having the highest pressure levels; d. removing pressure from said zones having the highest pressure levels; e. distributing pressure between more than one pressure zones while preserving said relative spatial pressure profile.

20 According to some embodiments of the invention, said distributing comprises one or more of decreasing and increasing the pressure in said more than one pressure zones.

According to an aspect of some embodiments of the present invention there is provided a method of tracking a user, comprising: a. a. receiving at least one input from said user regarding at least one sensitive location; b. monitoring movements of said user; c. modifying the location of
25 said at least one sensitive location in relation with said monitored movements.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are
30 described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

As will be appreciated by one skilled in the art, some embodiments of the present invention may be embodied as a system, method or computer program product. Accordingly, some

embodiments of the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module” or “system.” Furthermore, some embodiments of the present invention may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon. Implementation of the method and/or system of some embodiments of the invention can involve performing and/or completing selected tasks manually, automatically, or a combination thereof. Moreover, according to actual instrumentation and equipment of some embodiments of the method and/or system of the invention, several selected tasks could be implemented by hardware, by software or by firmware and/or by a combination thereof, e.g., using an operating system.

For example, hardware for performing selected tasks according to some embodiments of the invention could be implemented as a chip or a circuit. As software, selected tasks according to some embodiments of the invention could be implemented as a plurality of software instructions being executed by a computer using any suitable operating system. In an exemplary embodiment of the invention, one or more tasks according to some exemplary embodiments of method and/or system as described herein are performed by a data processor, such as a computing platform for executing a plurality of instructions. Optionally, the data processor includes a volatile memory for storing instructions and/or data and/or a non-volatile storage, for example, a magnetic hard-disk and/or removable media, for storing instructions and/or data. Optionally, a network connection is provided as well. A display and/or a user input device such as a keyboard or mouse are optionally provided as well.

Any combination of one or more computer readable medium(s) may be utilized for some embodiments of the invention. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage

medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave.

5 Such a propagated signal may take any of a variety of forms, including, but not limited to, electromagnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

10 Program code embodied on a computer readable medium and/or data used thereby may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

Computer program code for carrying out operations for some embodiments of the present invention may be written in any combination of one or more programming languages, including
15 an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario,
20 the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

Some embodiments of the present invention may be described below with reference to
25 flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer,
30 special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

Some of the methods described herein are generally designed only for use by a computer, and may not be feasible or practical for performing purely manually, by a human expert. A human expert who wanted to manually perform similar tasks, such as inflating and deflating the inflatable cells, calculating the quantity of inflation and deflation of an inflatable cell in view of real-time information, might be expected to use completely different methods, e.g., making use of expert knowledge and/or the pattern recognition capabilities of the human brain, which would be vastly more efficient than manually going through the steps of the methods described herein.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

Figure. 1 is a schematic illustration of a smart mattress system, according to some embodiments of the invention;

Figure 2 is a schematic general representation of the components of the mattress, according to some embodiments of the invention;

Figures 3a-3b1-b3 are illustrations of exemplary inflatable cells, according to some embodiments of the invention;

Figure 4 is a flowchart of the calibration method, according to some embodiments of the invention;

Figure 5a is an illustration of a smart mattress on a bed frame, according to some embodiments of the invention;

Figure 5b is a schematic representation of a division by pressure zones, according to some embodiments of the invention;

5 Figure 5c is an exemplary pressure map showing the measured pressures in a part of a body and the division of the pressures by pressure zones, which are used for the exemplary method of calculating the correlation of the pressures between zones, according to some embodiments of the invention;

10 Figure 6 is a flowchart of an exemplary method of prevention of pressure sores, according to some embodiments of the invention;

Figure 7 is a flowchart of an exemplary method of action of the smart mattress in the presence of pressure sores, according to some embodiments of the invention;

Figure 8 is a flowchart of an exemplary method of generating a 3D map, according to some embodiments of the invention;

15 Figure 9 is an illustration of the back side of the pelvic zone used to explain Example 1;

Figures 10a-d are schematic representations of the “clock-like” movement of the reduction of the pressure, according to some embodiments of the invention;

Figures 11a-b are illustrations of the lower leg;

20 Figure 12 a pressure map of a user laying down on a lateral position and a zoom in window of the pelvic zone;

Figures 13a-b are pressure maps of a user in a sitting position.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

25 The present invention, in some embodiments thereof, relates to a smart mattress and, more particularly, but not exclusively, to a smart dynamic mattress for prevention and treatment of pressure wounds.

Overview

30 An aspect of some embodiments of the invention relates to preventing the development of pressure sores on sensitive locations in a user constrained, for example, to a bed and/or a chair. In some embodiments, preventing the development of pressure sores comprises dynamically changing the exposure of pressure on the sensitive locations to lower pressures over a period of time. In some embodiments, the zones are selected from in input from the user. In some embodiments, the input is provided vocally and/or using a screen. In some embodiments, prevention includes reducing the pressure in the sensitive locations. In some embodiments, the reduction is performed for a

determined period of time. In some embodiments, reduction is performed in different zones of the body of the user.

An aspect of some embodiments of the invention relates to modifying a parameter in a smart mattress with the potential advantage of reducing and/or preventing damage on a sensitive location in a user. In some embodiments, the modification is increasing the pressure that some parts of the smart mattress apply on the user while reducing the pressure that other parts of the mattress apply on the user. In some embodiments, the modification is performed over an extended period of time. In some embodiments, the parameter is the pressure applied by at least part of the smart mattress on the sensitive location. In some embodiments, the modification is either increasing the pressure or decreasing the pressure in the sensitive location.

An aspect of some embodiments of the invention relates to generating a pressure map of a user and using the pressure map to actuate sore-developing preventive measures in locations of high pressure and/or in sensitive locations. In some embodiments, the sore-developing preventive measures comprise generating a relative spatial pressure profile of the user. In some embodiments, the sore-developing preventive measures comprise generating a relative temporal pressure profile of the user. In some embodiments, the sore-developing preventive measures comprise generating a relative spatial-temporal pressure profile of the user. In some embodiments, the sore-developing preventive measures follow a protocol based on location associated with one or more of said relative spatial pressure profile, said relative temporal pressure profile and said relative spatial-temporal pressure profile.

An aspect of some embodiments of the invention relates to generating a pressure map of a user and manually or verbally insert sensitive locations in said pressure map and using the amended pressure map to actuate sore-developing preventive measures in locations of high pressure and/or in sensitive locations; and to actuate anti-sore-deterioration measures in the sensitive zones.

An aspect of some embodiments of the invention relates to the generation of a pressure map comprising one or more pressure zones. In some embodiments, each pressure zone represents a level of exposure of pressure on the user. In some embodiments, there is a correlation between the pressures of the different zones. In some embodiments, the correlation is used to generate one or more of said relative spatial pressure profile, said relative temporal pressure profile and said relative spatial-temporal pressure profile, when modifying the pressure of a smart mattress with the potential advantage of reducing and/or preventing damage on sensitive location in a user.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details of construction and the arrangement of the components and/or methods set forth in the following description and/or

illustrated in the drawings and/or the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

Exemplary Mattress

Referring now to the drawings, Figure 1 illustrates a schematic illustration of a smart mattress system **100**, according to some embodiments of the invention. In some embodiments, the system comprises a mattress **102** comprising a plurality of removable inflatable cells **104** individually connected to an inflation machine (not shown) and mounted on a frame **106**, and one or more electronic devices **108** configured to communicate with the mattress **102**. In some embodiments, the plurality of inflatable cells are covered by an elastic cover configured to restrain them inside the cover and protect them from potential external damages (i.e. liquids, dirt, etc.). In some embodiments, the frame **106** comprises a plurality of tubes configured to connect the inflation machine and the inflatable cells **104**. In some embodiments, there are tubes for the insertion of air into the inflatable cells and tubes for the removal of air from the inflatable cells. In some embodiments, the frame **106** is made of a single piece. In some embodiments, the frame **106** is made of a plurality of pieces that are reversibly connected to each other. A potential advantage of a configuration of multiple pieces is the possibility of assembling different sizes of mattresses.

Referring now to Figure 2, illustrating a schematic general representation of the components of the mattress, according to some embodiments of the invention. In some embodiments, the mattress comprises a plurality of inflatable cells **104** individually connected to an inflation machine **202**. In some embodiments, the plurality of inflatable cells **104** are also individually connected to a controller **204**. In some embodiments, the controller **204** commands over the activation and deactivation of the inflatable machine **202**. In some embodiments, the controller **204** commands over valves located in the inflatable cells, which allow either the inflation or the deflation of the inflatable cells. In some embodiments, the mattress comprises a power source **206**, which provides the necessary power to the different components of the mattress (i.e. the cells, the inflation machine, the controller, sensors, etc.). In some embodiments, the controller **204** is in communication with a communications module **208**, configured to allow the communication between the controller **204** and the one or more electronic devices **108**.

Exemplary inflatable cell

Referring now to Figure 3a, illustrating an exemplary inflatable cell, according to some embodiments of the invention. In some embodiments, the inflatable cell comprises three main parts: a base **302**, a bracket **304** and balloon **306**.

In some embodiments, the base **302** is connected to the frame **106**. In some embodiments, the base **302** comprises at least 2 valves configured to control the inlet and outlet of air from the inflatable cell **104**. In some embodiments, the bracket **304** is connected to the base **302**. In some embodiments, the bracket **304** can be made from a variety of materials, for example: metal (steel, aluminum alloy) or plastic. In some embodiments, the bracket **304** further comprises one or more sensors, for example: a pressure sensor and/or a temperature sensor. In some embodiments, the pressure sensor is configured to monitor the internal pressure of the balloon **306**. In some embodiments, the balloon **306** is connected to the bracket **304**. In some embodiments, comprises 2 or more layers of latex rubber. In some embodiments, between each layer there is a mesh, which prevents the balloon from over swelling and determines the final shape of the balloon **306**, but still allows the balloon to shrink, even to the point of zero volume. In some embodiments, at the base of the balloon **306** there is a closing ring configured to prevent the release of the balloon **306** from the bracket **304**. Optionally, a plurality of small plastic balls are inserted inside the balloon **306**. In some embodiments, this is used to mask possible noises from the insertion and/or removal of air from the balloon **306**. Optionally, a sponge is inserted inside the balloon **306**. In some embodiments, the sponge is used to absorb possible humidity, which preserves the inflatable cells and avoids the creation of mold inside the system. In some embodiments, the sponge can comprise perforations configured to allow the passage of low airflow. In some embodiments, a potential advantage of having a sponge is the potential reduction of noise made by the inflation/deflation actions, since the sponge will act as an isolator. In some embodiments, another potential advantage of using a sponge is protection of the base of the inflatable cell from external forces, for example, body parts of the user that may press strongly on the inflatable cell, which can damage the base of the cell. In these cases, the sponge will act as a protector of the cell. In some embodiments, each inflatable cell is configured to be individually dismounted from the frame without disturbing the correct functioning of the rest of the inflatable cells.

In some embodiments, the inflatable cells comprise a thin cell wall. In some embodiments, this allows adjacent cells to slide over one another even when the cell density is high. In some embodiments, this allows the inflatable cells to change their shape, allowing each inflatable cell to receive side support from the inflatable cells next to it.

In some embodiments, the system is configured to detect, by means of sensors for example, when an inflatable cell is not working properly. In some embodiments, when the system detects that an inflatable cell is not working properly, the system actuates the base **302** to empty the inflatable cell from air. In some embodiments, since the damaged inflatable cell is made of flexible latex material, the inflatable cell will collapse (whether due to system-controlled deflation or due

to problems with the balloon – a hole for example). In some embodiments, due to the high density of inflatable cells on the frame, when one inflatable cell fails, those around it will compensate for the loss of one inflatable cell, so the performance of the mattress will not be compromised. In some embodiments, due to this compensation mechanism, the user does not feel any difference in the performance of the mattress albeit the failure of an inflatable cell. In some embodiments, the mattress compensates for the loss of up to 10% of the inflatable cells in a frame.

In some embodiments, when the system detects that an inflatable cell is not working, the system will isolate the airflow from that specific inflatable cell. In some embodiments, the system is configured to perform routine checks of the inflatable cells for pressure leaks, for constant pressure drops of pressure and/or for increase of pressure in particular inflatable cells. In some embodiments, if the system suspects an inflatable cell to be faulty, the system will try to add/remove air from the cell and monitor if the pressure drops slowly/rapidly. In some embodiments, if the leak is not significant, for example between about 0.05% and about 1% reduction of pressure per minute, the system will keep the cell operational, and will provide more air to compensate for the losses. In some embodiments, the system is further configured to send an alert to the user notifying of the faulty, but still operational, inflatable cell. In some embodiments, if the leak is significant, for example more than 1% reduction of pressure per minute, the system will mark the inflatable cell as faulty, and will open the valve to completely drain the inflatable cell. In some embodiments, the system is further configured to send an alert to the user notifying of the faulty inflatable cell.

In some embodiments, each inflatable cell can be independently detached from the frame and replaced by a new inflatable cell, without affecting the performance or the activity of the mattress. A potential advantage of this quick, hot-swap, repair mechanism is to avoid shutting down a while smart mattress due to the failure of one inflatable cell, or a combination of inflatable cells.

In some embodiments, there can be two types of inflatable cells, soft inflatable cells and hard inflatable cells. In some embodiments, soft inflatable cells comprise a balloon having a thin material, which allows them to completely collapse and not occupy any space in the grid of inflatable cells. In some embodiments, when a soft inflatable cell collapses, near inflatable cells can occupy the space of the previous and perform in place of the previous. In some embodiments, hard inflatable cells comprise a balloon having a thick material, which allows them to not completely collapse and still occupy space in the grid of inflatable cells even in the case where all the air is retracted from the inflatable cell. In some embodiments, both soft and hard inflatable cells are limited in their capacity to be inflated by means of a mesh, as disclosed above.

In some embodiments, the sizes of an exemplary balloon in an inflatable cell are as following:

Width: between about 0.5cm to about 10cm; for example 1cm, 2cm, 5cm, 7cm, and any interval of centimeters between them.

5 Length: between about 0.5cm to about 10cm; for example 1cm, 2cm, 5cm, 7cm, and any interval of centimeters between them.

Therefore, the top area of a single inflatable cell is calculated according to the width and length, for example an area of a single inflatable cell is 25cm^2 (meaning 5cm length x 5cm width); or for example an area of a single inflatable cell is 1cm^2 (meaning 1cm length x 1cm width).

10 Height (**H**): Deflated: Soft inflatable cell: between about 1cm to about 5cm; for example 1cm, 2cm, 5cm, and any interval of centimeters between them. Deflated: Hard inflatable cell: between about 5cm to about 15cm; for example 5cm, 7cm, 9cm, and any interval of centimeters between them. Inflated: both soft and hard inflatable cell: between about 20cm and about 40cm; for example 25cm, 30cm, 35cm, and any interval of centimeters between them.

15 Referring to Figures 3b1-3, showing inflatable cells in three exemplary, not limiting, inflated configurations. Figure 3b2 shows an example of a basal line of the height in which the inflatable cell is inflated to a height (**H2**) higher than zero (or optionally higher than the minimum deflated height without the collapsing of the cell) but lower than maximum. Figure 3b1 shows the inflatable cell after being deflated to a height (**H1**), for example to allow a reduction of the pressure
20 from a body part of the user. Figure 3b3 shows the inflatable cell after being inflated at the maximum and achieving the maximum height (**H3**).

Exemplary organization of inflatable cells on the frame

In some embodiments, the inflatable cells are arranged in horizontal and vertical rows. In
25 some embodiments, the inflatable cells comprise a high density of units on the frame. In some embodiments, a 100% of the area of the frame is covered with inflatable cells. Optionally, between 70% and 99% of the area of the frame is covered with inflatable cells. In some embodiments, there are about 1000 inflatable cells on a single frame. In some embodiments, the number of inflatable cells is from about 500 to about 5000. In some embodiments, the number of inflatable cells on a
30 frame depends on the area that each inflatable cell occupy. In some embodiments, the area of a single inflatable cell is 25cm^2 (meaning 5cm length x 5cm width). In some embodiments, the area of a single cell is from about 1cm^2 (meaning 1cm length x 1cm width) to about 100cm^2 (meaning 10cm length x 10cm width). It should be understood that other sizes of areas of inflatable cells are possible according to the possible requirements of the mattress.

Exemplary inflation machine

In some embodiments, the inflation machine is configured to blow dry air. A potential advantage of dry air is avoiding the creation of mold inside the system.

5 Exemplary sensor array

In some embodiments, the smart mattress comprises a plurality of sensors that allow the activation, deactivation and monitoring of the plurality of inflatable cells. In some embodiments, each inflatable cell comprises a pressure sensor configured to measure the pressure applied on the inflatable cell itself, for example, by a body part of the person laying on the smart mattress. In some
10 embodiments, each inflatable cell comprises a pressure sensor for the inflatable balloon configured to measure the pressure of the balloon when inflated and/or deflated. In some embodiments, each inflatable cell comprises a sensor that monitors the performance of the valves in the base, and are configured to send a signal when and if an inflatable cell does not work properly. In some
15 embodiments, each inflatable cell comprises a temperature sensor configured to measure the temperature of the inflatable cell and the immediate area around it. See below Exemplary methods use of heat map.

It should be noted that, in some embodiments, each inflatable cell comprises two types of pressure sensors:

Internal pressure sensors: which are configured to monitor in the internal pressure inside
20 the balloon and detect if there are technical problems with the functioning of the balloon.

External pressure sensors: which are configured to monitor the pressure applied from the top onto the balloon. The measured pressures are then converted and correspond to the pressure applied on the user at that point. For example, the sensor measures an external pressure of 50mmHg, which means that at that point, where the cell measures that external pressure, the user
25 receives the same pressure on his body. These measurements are used for the creation of the pressure map of the user.

Exemplary power source

In some embodiments, all the parts of the smart mattress are connected to at least one power
30 source. In some embodiments, the power source can be an electrical outlet and/or a battery configured for providing enough power to all the parts of the system.

Exemplary controller of the smart mattress

In some embodiments, the smart mattress system comprises a controller configured to control each inflatable cell independently to each other. In some embodiments, the controller is configured identify each inflatable cell, each inflatable cell position, each inflatable cell status and/or each inflatable cell performance. In some embodiments, the controller activates the inlet/outlet valves in each inflatable cell. In some embodiments, the controller controls the activation or deactivation of the inflation machine. In some embodiments, the information provided by the sensors is sent to the controller, where it is processed and then inflatable cells are either inflated/deflated/not activated according to the requirements (see below exemplary methods). In some embodiments, the controller comprises all the necessary computational software and hardware to allow a smooth operation of the smart mattress.

In some embodiments, the system detects patient movement through a "motion detection" algorithm and monitors patient movements using a "body tracking" algorithm that will use Machine Learning and Image Processing methods to identify the user's position on the mattress. In some embodiments, the system regulates the pressure in the mattress personally to the patient at any given time and as needed. In some embodiments, the pressure adjustment is performed following an "inverted pressure image" method (see below). In some embodiments, the system follows a risk focus and abnormal pressure detection algorithm, which is configured to read the patient's pressure map on the mattress cells and identify areas at increased risk of developing pressure sores. In some embodiments, the algorithm uses a learning system as well as uses Big Data (stored from previous users) to help improve the prediction of areas that are prone to pressure sores.

Exemplary communication module

In some embodiments, the smart bed comprises a communication module in communication with the controller and configured to transmit the information to at least one electronic device. In some embodiments, the connection between the communication module and the electronic device is wired. In some embodiments, the connection between the communication module and the electronic device is wireless.

Exemplary electronic device

In some embodiments, at least one electronic device is in communication with the controller via the communications module, for example, electronic devices can be a cellphone, a tablet, a computer, a dedicated screen in communication with the mattress, and any combination thereof. In some embodiments, the electronic device comprises a software, which allows a user to see the

pressure map on the mattress, provide commands and/or information to the smart bed (see below exemplary methods). In some embodiments, the electronic device includes a screen showing the pressure map applied by the patient's body on the mattress. Optionally, the screen is a touch screen. In some embodiments, the electronic device comprises a software that allows the user to intuitively operate the mattress, for example, the user can select the desired pressure at a specific location in the body by clicking on the same area in the pressure map on the screen and/or reduce the pressure of a specific area by selecting the area on the map. In some embodiments, the electronic device is a listening device configured to receive vocal input from the user, for example: the smart mattress is connected to a device configured to receive voice commands, like Alexa®, Siri® and Google Assistant®. In some embodiments, the user can inform the device by using voice command where is located a problematic area.

Exemplary 3D playback

In some embodiments, the electronic device is configured to display a 3D-user body imaging, which will provide a simple and clear quantitative and qualitative view of the pressure areas. In some embodiments, quantitative view of the pressure areas means showing the actual pressure number measured at that point by the inflatable cell. In some embodiments, qualitative view of the pressure means providing, for example, different colors to different ranges of pressure, in which, for example, zones having higher pressure are shown in red, while zones having a lower pressure are shown in blue (see below for an example). In some embodiments, the user is able to rotate the image, zoom in/out and select a point where he wants to change the pressure.

Exemplary camera

In some embodiments, the system comprises a camera configured to monitor and track the movements of the user. In some embodiments, the monitoring of the user by the camera is used to complement the pressure map used by the system, for example, to verify the actual position of the user, to monitor actual movements of the user, to monitor for abnormal movements of the user.

Exemplary methods

Exemplary calibration method

In some embodiments, on the first time a user will use the smart bed, a calibration procedure must be performed. In some embodiments, the smart bed is first inflated to an internal pressure of about 20mmHg. Optionally it can be 15mmHg, or 25mmHg, or 30mmHg. In some embodiments, this is equal to a height of the balloon in an inflated configuration from about 5cm to about 10cm.

In some embodiments, this will be the basal line from which the smart mattress will inflate or deflate the inflatable cells to perform the treatments. Then the user lays on the bed for the first time and the system commences to create the pressure maps specific to the user. The user then changes positions to create a variety of basal positions, which will be then used to monitor the movements of the user while in bed and to adapt the performance of the inflatable cells according to the position of the user and the exact location of the injury on the user.

Referring now to Figure 4, showing a flowchart of the calibration method, according to some embodiments of the invention. In some embodiments, the smart bed undergoes calibration at the first use of the smart bed. In some embodiments, the calibration method includes:

a. Inflating all the inflatable cells to a fixed internal pressure of from about 10mmHg to about 25mmHg, for example 15mmHg, 20mmHg or 22mmHg (402), thereby bringing all inflatable cells to a height base line.

b. The user lays on the smart bed. (404)

c. The smart bed calculates BMI by measuring weight and height. (406)

d. The system creates a pressure map of the body of the user and identifies body parts. (408)

e. Optionally, the user is asked to provide several laying positions to be used as base line for future measurements. (410)

Exemplary secondary calibration method

In some embodiments, secondary calibrations are performed over time based on data collected by the system on the specific usage of the user. For example, when the system senses a new position, the system will add it to the database. In some embodiments, known positions will be updated over time when the system senses the known position. In some embodiments, a potential advantage of updating known position is to keep the database updated with the changes of the user over time, for example, during the recovery time of a user after an accident.

In some embodiments, the system will periodically ask the user to update the positions recorded on the first calibration. For example once a month, every two weeks, once every three months, etc. Optionally, the user and/or the physician/nurse can actively request to update the calibration information of the positions.

Exemplary fine tuning calibration method

In some embodiments, after the first calibration is performed, a second calibration can be performed to fine-tune the activity of the inflatable cells according to the specific needs of the user. For example, while laying on the bed, the user and or the physician/nurse, can inflate/deflate

specific zones of the body to set personalized intervals of inflation/deflation according to the needs and/or requests and/or limitations of the user.

Exemplary method of providing pressure imaging

5 In some embodiments, the smart mattress generates a pressure map according to the data received from each individual inflatable cell. Referring now to Figure 5a showing an illustration of a smart mattress **100** on a bed frame **500** showing an illustrative phantom image **502** of a user laying on the smart mattress **100** and the pressure map **504** recovered from it. In some embodiments, when a user lays on the mattress, the external sensors of certain inflatable cells will
10 measure the pressure applied by the user on the inflatable cells and therefore the pressure applied on the user by the inflatable cells. In some embodiments, according to the quantity of pressure detected, the system creates a map of the pressures collected from the overall inflatable cells sensors. In some embodiments, the map shows different measurements of pressure in a different way, for example, lower pressure having cold colors (i.e. blue) while higher pressure having warm
15 colors (i.e. red).

In Figure 5a can be seen the phantom image **502** of a user laying on the smart bed **100**. Each measurement is then shown in the pressure map **504**.

In some embodiments, after the collection of the pressure measurements, the system is configured to identify: highest points of pressure, similar points of pressure and relative location
20 of the points of pressure according to the anatomy of the body. In some embodiments, the identification of pressure zones is performed according to the organs of the user, for example: right leg, left leg, right arm, left arm, head, upper torso, lower torso. In some embodiments, the identification of pressure zones is performed within each organ, for example: within right leg: heel, calf, knee, etc. Referring now to Figure 5b, showing a schematic representation of a division by
25 pressure zones, according to some embodiments of the invention. In some embodiments, the system divides the pressure map by pressure zones. In Figure 5b, an exemplary pressure map of the head is shown. For example, the zone of the highest pressure is nominated Zone A. Then, similar pressure zones around Zone A, that have a lower pressure measured in relation to Zone A, will create the second zone, for example Zone B. Then, similar pressure zones around Zone B, that have
30 a lower pressure measured in relation to Zone B, will create the third zone, for example Zone C (and so on until Zone H). This division of zones will enable the system to perform the treatment methods as will be further explained below and in the examples. In some embodiments, each zone (A, B, C... H) can optionally be further divided into sub-zones. In some embodiments, the number of zones, sub-zones and even sub-sub-zones depend on the size and configuration of the inflatable

cells. For example, smaller inflatable cells can provide a high-resolution pressure image, while bigger inflatable cells can provide a medium pressure image resolution.

In some embodiments, the system calculates the difference of pressure between zones and creates a correlation of the pressures between the zones. In some embodiments, this correlation of the pressures between the zones are used to perform the treatment methods as will be further explained below and in the examples.

Exemplary method of calculating the correlation of the pressures between zones

Referring now to Figure 5c, showing an exemplary pressure map showing the measured pressures in a part of a body and the division of the pressures by pressure zones, which will be used for the exemplary method of calculating the correlation of the pressures between zones, according to some embodiments of the invention. Figure 5c shows a partial pressure map of the body where 7 zones were created (Zones A-G). In some embodiments, an average of pressures inside each zone is calculated. For example, Zone A comprises two pressure readings: 133mmHg and 136mmHg. Therefore, the average of the pressure in Zone A will be: $(133+136)/2=134.5\text{mmHg}$. Same calculation is performed for all the zones. Then, a correlation between averages is performed between zones. In some embodiments, the correlation is calculated between adjacent zones. In some embodiments, the correlation is calculated in reference to the Zone A. The following table summarizes an exemplary calculation of the correlation of the pressures with reference to the map as shown in Figure 5c:

Zone What	A	B	C	D	E	F	G
Measured pressures in zone	133, 136	113, 115, 112, 113, 114	103, 105, 110, 104	90, 88, 94, 100, 86, 92, 85	78, 81, 73, 82, 84, 78, 73, 81, 84, 70, 86,	70, 58, 70, 57, 73, 70, 73, 78	44, 46, 59, 45, 44, 56, 54, 46, 40
Average	134.5	113.4	105.5	90.8	79.1	68.6	48.2
Correlations between adjacent zones	1:0.84						
		1:0.93					
			1:0.86				
				1:0.87			

		1:0.87	
			1:0.7

In some embodiments, as mentioned above, the correlation is calculated in reference to the Zone A, for example:

Correlation between Zones A/B: 1:0.84 / Correlation between Zones A/C: 1:0.78 / Correlation
 5 between Zones A/D: 1:0.67 / Correlation between Zones A/E: 1:0.59 / Correlation between Zones A/F: 1:0.51 / Correlation between Zones A/G: 1:0.35.

In some embodiments, the correlation is used to generate one or more of a relative spatial pressure profile, a relative temporal pressure profile and a relative spatial-temporal pressure profile.

10 In some embodiments, a relative temporal pressure profile comprises the overall data as disclosed above, the correlation between zones, the pressures in each zone and the overall pressure measured within the whole area.

In some embodiments, a relative temporal pressure profile means the timing of activation of a certain protocol in relation with the pressure map, for example, for zones having higher pressure, a duration of the treatment could be either longer or shorter, according to the needs.

15 In some embodiments, a relative spatial-temporal pressure profile means the combination of the type of treatment (i.e. either inflating or deflating) with the specific timing of the activation of the treatment in the specific areas. See examples below.

Exemplary treatment method of pressure sores

20 In some embodiments, after the calibration is finished the smart bed is ready to be used, the user lays on the smart bed and, using the electronic device, the user and/or the physician/nurse can review the pressure map. In some embodiments, the user and/or the physician/nurse use the pressure map as displayed by the electronic device to mark, on the pressure map, one or more of the following:

25 1. The location of possible places where pressure sores can develop over time. This is mainly used for preventive purposes.

2. The location of pressure sores already found in the user. This is used for the treatment of pressure sores.

30 3. The location of places of interest, not related to pressure sores. For example, if the user has a cast, or if the user does not want treatment on a specific limb, etc. This is used to guide the system to specific personalized configurations that will affect the treatment protocols, for example, zones where no treatment should be applied.

In some embodiments, after marks were inserted to the system using the pressure map on the electronic device, the system commences the protocols for preventing pressure sores and/or for treating zones with pressure sores.

5 Exemplary protocols

In some embodiments, the first thing that the system does is reducing the external pressure on the marked zone, the zone where pressure sores will probably develop or where pressure sores are actually located, to a lower pressure, for example to a pressure lower than 32mmHg, or to an interval of pressures from about 20mmHg to about 30mmHg.

10 In some embodiments, reducing the pressure from the marked zones is done by deflating the inflatable cells in that location. Since the basal line of the height of the inflatable cells is higher than zero and lower than the maximum height of the inflatable cells, the inflatable cells can be either inflated or deflated according to the need, which means increasing the pressure or decreasing the pressure, accordingly.

15 In some embodiments, after the reduction of the pressure in the relevant area, Zone A for example, the system commences a protocol of dissipating the pressure that will automatically fall to all the tissue surrounding the relevant area (Zone A).

In some embodiments, the method of dissipation of the pressure across the surrounding tissue is guided principally by three principles:

20 1. Distributing the pressure across more than one zone, not just the zone in proximity (Zone B) to the relevant zone (Zone A); for example, distributing the pressure across Zones B, C, D and E.

2. Cycling the distribution of the pressure across the larger area in a location and temporal manner; for example, rotating the additional pressure to Zones B, C, D and E so parts of each zone will bear the additional pressure for 20 minutes, and then other parts will bear the pressure for 20 minutes, etc. See examples below for further description and examples of cycling the distribution of pressure.

3. Preserving the correlation of the pressures between the zones; for example, if before the removal of the pressure from Zone A, the correlation between Zone B and Zone C was 1:0,8; and the correlation between Zone C and Zone D was 1:0,6; and the correlation between Zone D and Zone E was 1:0,5; therefore during the distribution of the extra pressure between Zones B, C, D and E, the system will distribute the extra pressure so that the correlations of the pressure between the zones will remain.

In some embodiments, the smart mattress utilizes a reverse pressure image algorithm as the main pressure distribution algorithm in the mattress. In some embodiments, the algorithm for lowering and dissipating pressure will build around the principle of pressure dissipation in the opposite image. In some embodiments, reverse image distribution method comprises distributing the pressure in the inverse gradient to the original pressure around the pressure wound. Optionally, after the user chooses the desired pressure at a specific point in the body. In some embodiments, the inverted pressure image algorithm will adjust all the stresses inversely to the stresses in the regions surrounding the same point. In some embodiments, when sleep data is accumulated from multiple users, the Big Data algorithm for sleep pattern analysis can be used, thus optimizing the pressure distribution on the smart mattress.

Exemplary methods for adjusting body pressure distribution in accordance with the natural body and anatomical structure of the user

The following 4 categories of pressure will be used to explain the methods:

Category 1. Low pressure - the pressure adjusted on the wound itself, for example from about 0mmHg to about 20 mmHg.

Category 2. Healthy pressure – any pressure that is less than 32 mmHg.

Category 3. Natural pressure – is the natural pressure of the body on a calibrated mattress as was measured before activating the mattress and/or as was last updated.

Category 4. High “proportional” pressure – is the pressure when the additional pressure is distributed between the zones but with the preservation of the correlation of the pressures between the zones as measured in the “natural pressure” (see point 3 above).

In some embodiments, Zone A of the pressure wound will be adjusted according to Category 1. Then, in some embodiments, cyclic activation of dissipation of the pressure according to Categories 3 and 4 will be performed, as will be further explained below. In addition, in some embodiments, for patients where general pressure wound prevention methods are in action, the pressure for all of the surrounding zones will be adjusted according to categories 2, 3 and 4, so that “Healthy pressure” cycles are added as well.

Exemplary types of cycles:

1. Symmetrical cycles: a) cyclic “clock-like” movement; b) up/down, left/right, and diagonals (up + left)/(down + right).

2. Not symmetrical cycles: especially useful for example for wounds located closer to the side of the body: Moving pressure around the center axis of the body part in a way that may (but not must) turn the body part, as shown for example in Figures 10b and 11b.

3. Special cases: a) working on both the healthy and wounded parts (left and right heel, left and right buttocks) in symmetry; b) constantly reducing pressure, not just from the wound itself but also from the “near wound” zone; c) constantly reducing pressure or keeping “natural pressure” on specific areas (like the Achilles heel); d) Assisting in nearby bony structures, for example, the “sitting bones” (Ischial tuberosity) can carry high weight (periodically) from the wounded Sacrum area.

4. Sub Symmetrical / Not symmetrical methods: All “up”, “down”, “left”, “right” groups can be divided to subgroups, for example Up(B,D,F).

Exemplary cycles (Following the Zone letters as shown in Figure 9):

CYCLE 1: **Category 4:** up (B, D) + down (B, D), **Category 3:** up (C, E) + down (C, E).

CYCLE 2: **Category 4:** up (C, E) + down (C, E), **Category 3:** up (B, D) + down (B, D).

CYCLE 3: **Category 4:** up (B, D) + down (B, D), **Category 2:** up (C, E) + down (C, E).

Exemplary movement of the basal line of the height

In some embodiments, when necessary, the smart mattress can modify the basal line of the height according to the needs of the user. For example, if the basal line of the height is set to 10cm, allowing each inflatable cell to deflate to a minimum height of 5cm (top of the cell descends 5cm) and to inflate to a maximum height of 40cm (top of the cell ascends 30cm), when necessary the system can alter the basal line of the height, for example to 15cm, which will allow each inflatable cell to deflate to a minimum height of 5cm (top of the cell descends 10cm) and to inflate to a maximum height of 40cm (top of the cell ascends 25cm). In some embodiments, a potential advantage of this method is to allow more possibilities of ranges of inflation/deflation where and when necessary.

Exemplary motion detection threshold method

In some embodiments, in order to provide comfort to the user, a motion detection algorithm is used and it is configured to only allow for pressure changes in the mattress if there is real patient movement, so there will be no pressure changes resulting from secondary movements that do not affect the patient's posture, such as breathing or small movements. In some embodiments, the motion detection algorithm will wait until the patient stabilizes in order to transmit to the controller that can commence adjusting the pressures in the mattress using the methods disclosed above and below in the examples.

Exemplary body position tracking method

In some embodiments, the system comprises a body position-tracking algorithm configured to actuate the smart mattress according to different positions taken by the user. For example, the user enters the preferences through the electronic device before and/or during changing a body position. In some embodiments, this information is stored, and if and when the patient moves to a recorded position, the system will immediately adjust the mattress configuration to the new position. Another example, if the patient has a pressure sore below the left side of the pelvis, with the patient moving right on the mattress, the tracking algorithm will know exactly where the patient is now and the system will adjust the pressures to maintain low pressure below the left side of the pelvis. In some embodiments, the algorithm will use Machine Learning and Image Processing to identify the position of the user's body.

Exemplary Risk Focus methods and Exceptional Pressure methods

In some embodiments, the system comprises a risk focus algorithm and/or an exceptional pressure algorithm, configured to read the patient's stress map on the mattress, locate and track problematic areas. In some embodiments, the system runs the inverse pressure image algorithm on those high-risk points for pressure sores. In some embodiments, in addition, the user may choose to lower the pressure, a priori, in some of the areas recommended by the system. In some embodiments, the algorithm will use a learning system as well as Big Data, which is stored by a large number of patients to improve the prediction of areas that are prone to pressure sores.

Display of high-risk pressure zones

In some embodiments, the system will use risk focus detection algorithm to search for unusual sensed pressures and alert the user to areas of the body where pressure sores may develop. In some embodiments, the system will produce a pressure-dispersion map as the user exerts pressure on the mattress, and will mark the points that have the potential for pressure sores in the human body, for example the back of the head, shoulders, elbows, lower back and buttocks, inner knees, ankles and heels. In some embodiments, the system will offer the user optimum pressure dissipation options. In some embodiments, the recommendation will be a personalized recommendation according to the user's data (age, weight, and other characteristics known to contribute to pressure ulcer formation) and taking into account a number of factors such as: statistics and medical information on pressure ulcer formation, for example, most of the lower body wounds, from the waist down, and about half are found in the pelvic region.

Exemplary heat image

In some embodiments, each inflatable cell comprises a heat sensor, for example an infrared-meter, which are configured to detect the temperature at the top of the inflatable cell, that is, the temperature of the surface of the inflatable cell where the inflatable cell touches the patient's body.

5 In some embodiments, the sensor is located at the bottom of the inflatable cell and it directed to measure temperature at the top of the inflatable cell, therefore measuring the heat at the head of the inflatable cell.

In some embodiments, the heat measurement is used for:

10 a) Complement the reverse pressure image algorithm with the information collected from the heat map, which optionally, should correspond with the pressure map, since more pressure means more contact with the mattress, which also should correspond with a higher heat signature measured from the contact of the body with the mattress. In some embodiments, the information from the heat map will be used to improve the dispersion of the pressure. In some embodiments, it will improve the results of the pressure dissipation algorithms and adjust the pressure dissipation in a
15 personalized manner to the user.

b) Allowing the system to detect areas that are too hot or too cold in the patient's body, which may indicate a potential medical risk to the patient. In some embodiments, in order to detect problematic areas in terms of temperature, the system utilizes the heat image algorithm, which optionally also uses the pressure image, to assess the patient's shape and check whether the temperatures on the
20 patient's body are normal.

For example, in some embodiments, the user and/or the person following the status of a user (i.e. a physician and/or a nurse), perform periodical risk assessments of the 5 parameters, as recommended by the Centers for Medicine and Medicaid Services (CMS), which include skin temperature, skin color, skin texture/turgor, skin integrity and moisture status. In some
25 embodiments, while attempting to prevent pressure sores, changes in skin temperature are used to indicate a possible development of skin sore (i.e. indicate hyperemia or a Stage I pressure ulcer). In another example, when a decrease in temperature is sensed (from an expected and/or a set temperature), this may indicate a decrease in blood flow to the area, which in turn may potentially increase the likelihood of developing a pressure sore. In another example, an increase in
30 temperature may indicate a Stage 3 or 4 of developing a pressure wound. In some embodiments, discovery of possible pressure sores by use of temperature sensors may assist in marking on the pressure map, areas with already developed pressure sores that were not manually inserted by the user and/or the physician. In another example, monitoring skin temperature is used to assess Skin Temperature Multiscale Entropy (MSE) and provide further indication of the possibility of

developing pressure sores, and possibly differentiating between high-risk points and low risk points.

Exemplary use of historical data

5 In some embodiments, the smart mattress is configured to adjust the pressures according to historical data concerning previous pressure images and adjustments performed during that time. In some embodiments, the system is configured to provide a solution to the situation, meaning adjusting the pressure of inflatable cells according to the location of the sores, when the user for example moves the hand and body to grasp the remote, and this displacement of the body will cause
10 the smart mattress to change the pressure on some inflatable cells without being the intention of the user, who just moved to reach for the remote control. In some embodiments, the system enables the user to return the mattress to the configuration that it was before the user moved. Therefore, the patient will be able to use the "historical data" to return to a previous stable pressure image. In some embodiments, the use of historical data is simple by providing, for example, a horizontal drag
15 button that the user can drag back (similar to those used for playing digital movies). In some embodiments, the interface will show the user those time points where the user was laying motionless, so that the user can more easily select his or her preferred pressure image and therefore the preferred pressure map of the inflatable cells.

Exemplary methods of use of the smart mattress

20 In some embodiments, there two possible scenarios of use for the smart bed: sore prevention and activation in the presence of pressure sores.

Exemplary sore prevention method

25 Referring now to Figure 6, showing a flowchart of an exemplary method of prevention of pressure sores, according to some embodiments of the invention. In some embodiments, when a new user is brought to the smart bed and no signs of pressure sores can be seen, the smart bed can be used to reduce the chances of pressure sores. In some embodiments, the smart bed will identify the inflatable cells sensing the highest pressure and/or the inflatable cells sensing a pressure above
30 30mmHg (**602**). Then, the system will reduce the pressure applied to those areas by removing air from the inflatable cells (**604**) and begin a cyclic movement of the inflatable cells around the inflatable cell from which the air was removed (**606**), so the areas around it will bear the pressure in a not continuous matter.

Exemplary sore treatment method

Referring now to Figure 7, showing a flowchart of an exemplary method of action of the smart mattress in the presence of pressure sores, according to some embodiments of the invention. In some embodiments, the user marks the pressure sore on the pressure map showed on the electronic device (702). In some embodiments, the smart bed will identify the inflatable cells at the marked location (704). In some embodiments, the smart bed will identify the inflatable cells sensing the highest pressure and/or the inflatable cells sensing a pressure above 30mmHg at the marked location (706). Then, the system will reduce the pressure applied to those areas by removing air from the inflatable cells (708) and begin a cyclic movement of the inflatable cells around the inflatable cell from which the air was removed (710), so the areas around it will bear the pressure in a not continuous matter.

Exemplary optional embodiments to the systemExemplary Double bed, two users

In some embodiments, if there are two users on the mattress, the system is configured to adapt the inflatable cells to each one separately. In some embodiments, each user can control his or her side of the smart mattress. In some embodiments, if one of the users does not have a pressure sore or does not need the mattress treatment mechanisms, the user can simply adjust the mattress to a level that is comfortable.

Exemplary Reduction of frictional forces and shear effort

Friction is the force resisting relative motion between two surfaces, and is the precursor to shear. It develops between the patient's skin and any number of contact surfaces, including the patient's bedding, transfer devices such as sheets, rollers, or slide boards, various appliances and orthotics, and mobility devices such as wheelchair cushions. Excess friction may result in superficial skin injury such as abrasions, blisters, and even skin tears in patients with fragile skin. Shear is a risk factor for developing decubitus ulcers, noting that patients developed more sacral pressure sores when the head of their bed was elevated. Shear develops when friction adheres skin and superficial tissues to sheets or bedding which are then stretched tightly over deeper structures. The underlying blood vessels are then stretched, angulated, and may be injured by this stress. Subcutaneous tissue in particular lacks tensile strength and is particularly susceptible to shear stress.

In some embodiments, when the mattress is at an elevated angle, frictional and shear forces can be reduced by inflating the mattress cells. In some embodiments, in this way the system avoids the body from "sliding" on the mat, for example:

1. The buttocks area: if the back of the mattress is raised, inflating the cells around the buttocks and hips in a way that will maintain the natural pressure pattern, will provide support and will prevent slippage from the smart mattress and will reduce the shear stress on the buttocks area.

2. The heel area: if the knees area in the mattress is raised, inflation of the cells around the heels (left and right) while keeping the natural pressure pattern around the foot will support the heels, preventing the friction of the heel on the mattress and reduce the shear on the heel tissue.

Exemplary additional uses of the smart mattress

Exemplary 3D mapping of a user

Referring now to Figure 8, showing a flowchart of an exemplary method of generating a 3D map, according to some embodiments of the invention. In some embodiments, the smart mattress can be used to create a 3D map of the user. In some embodiments, an exemplary method of creating a 3D map of the user comprises:

1. Inflating all inflatable cells to the maximum height;
2. Requesting from the user to lay on the mattress;
3. Deflating inflatable cells according to a specified order, for example, deflating inflatable cells from the highest external pressure measured to the lowest or none pressure measured.

In some embodiments, during the deflation process, in those areas where high pressure is measured, the pressure will remain stable (always high), while in other areas the pressure will increase due to the newly and/or increased contact between cells and the parts of the body. Therefore, the method continues as following:

4. Monitoring the change in pressure from areas other than the areas sensing the highest pressure.
5. Commencing the deflation of inflatable cells (other than those having the highest pressure) when there is a change, usually an increase, in the pressure.
6. Continuing the deflation process until those inflatable cells having the highest pressure arrive to the maximum deflation level.
7. Translating the deflation movement of the inflatable cells to a 3D map.

Exemplary monitoring of respiration

In some embodiments, using the motion detection threshold method as disclosed above, the system is configured to monitor the small movements below the threshold to enable monitoring of

the respiration of the user. In some embodiments, a potential advantage of this feature is the ability to reduce the use of additional sensors in beds. In some embodiments, this feature is used to monitor newborns, infants, healthy adults, sick adults and/or the elderly.

5 Exemplary use of the smart mattress to provide massages

 In some embodiments, the inflatable cells can be used to provide massages to certain parts of the body. For example, for a user laying on the belly, the inflatable cells can be activated to massage and stimulate the digestive system. This feature is potentially useful for users having problems in the digestive system, like the stomach and the intestines. Another example, the use of
10 the smart mattress to massage areas afflicted by pain diseases, for example fibromyalgia. In some embodiments, the database will comprise a library of relevant protocols from which the user can choose. In some embodiments, more than one protocol can be activated at the same moment.

Exemplary use of the smart mattress for increasing venous return

15 In some embodiments, the inflatable cells can be used to raise the area of the legs of a user or induce a wave-like movement to increase the venous return blood flow. In some embodiments, the database will comprise a library of relevant protocols from which the user can choose. In some embodiments, more than one protocol can be activated at the same moment.

20 Exemplary use of the smart mattress to stimulate the body of vegetative and/or quasi-vegetative state patients

 In some embodiments, the inflatable cells can be further activated to provide positive physical stimuli to the body. In some embodiments, the database will comprise a library of relevant protocols from which the user can choose. In some embodiments, more than one protocol can be
25 activated at the same moment.

Exemplary use of the smart mattress to overflow tactile sensitivity to reduce the feeling of pain

 In some embodiments, the random activation of inflatable cells can be used to overflow the overall sensitivity threshold of the body of the user to mask the feelings of pain below the sensitivity
30 threshold. In some embodiments, the database will comprise a library of relevant protocols from which the user can choose. In some embodiments, more than one protocol can be activated at the same moment.

Exemplary use of the smart mattress for babies

In some embodiments, the smart mattress can be used to monitor babies for respiration and to stimulate babies, for example, after eating to increase the exit of gases. In some embodiments, the database will comprise a library of relevant protocols from which the user can choose. In some
5 embodiments, more than one protocol can be activated at the same moment.

Exemplary use of the smart mattress for recreational uses

In some embodiments, the smart mattress can be used for recreational uses. For example, activate protocols that stimulate selected chosen areas of the body. In some embodiments, the
10 database will comprise a library of relevant protocols from which the user can choose. In some embodiments, more than one protocol can be activated at the same moment.

It is expected that during the life of a patent maturing from this application many relevant inflatable cells and/or smart mattresses will be developed; the scope of the terms used herein are
15 intended to include all such new technologies *a priori*.

As used herein with reference to quantity or value, the term “about” means “within $\pm 20\%$ of”.

The terms “comprises”, “comprising”, “includes”, “including”, “has”, “having” and their conjugates mean “including but not limited to”.

20 The term “consisting of” means “including and limited to”.

The term “consisting essentially of” means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure.

25 As used herein, the singular forms “a”, “an” and “the” include plural references unless the context clearly dictates otherwise.

Throughout this application, embodiments of this invention may be presented with reference to a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope
30 of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as “from 1 to 6” should be considered to have specifically disclosed subranges such as “from 1 to 3”, “from 1 to 4”, “from 1 to 5”, “from 2 to 4”, “from 2 to

6", "from 3 to 6", etc.; as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Whenever a numerical range is indicated herein (for example "10-15", "10 to 15", or any pair of numbers linked by these another such range indication), it is meant to include any number (fractional or integral) within the indicated range limits, including the range limits, unless the context clearly dictates otherwise. The phrases "range/ranging/ranges between" a first indicate number and a second indicate number and "range/ranging/ranges from" a first indicate number "to", "up to", "until" or "through" (or another such range-indicating term) a second indicate number are used herein interchangeably and are meant to include the first and second indicated numbers and all the fractional and integral numbers therebetween.

Unless otherwise indicated, numbers used herein and any number ranges based thereon are approximations within the accuracy of reasonable measurement and rounding errors as understood by persons skilled in the art

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Various embodiments and aspects of the present invention as delineated hereinabove and as claimed in the claims section below find calculated support in the following examples.

EXAMPLES

Reference is now made to the following examples, which together with the above descriptions illustrate some embodiments of the invention in a non-limiting fashion.

Background of the examples

It has been shown that external pressure of more than 32 mm Hg occludes the blood vessel so that the underlying and surrounding tissues become anoxic and if the pressure continues for a critical duration, cell death will occur, resulting in soft tissue necrosis and eventual ulceration. The average pressure over the ischial tuberosity and the surrounding area can exceed 100 mmHg during sitting, at the sacral region it is 40-60 mm Hg in the supine position, while laying down on the lateral position, the pressure on the greater trochanter area can arrive up to 70-80mmHg.

The most common, but not exclusive sites of occurrence of pressure ulcers include the ischium (28%), the sacrum (17-27%), the Greater trochanter (12-19%), and the heel (9-18%).

Example number 1

5 A patient suffers from one pressure sore in the pelvic area and it is located at the sacrum. The patient BMI is 18. Since the system undergoes calibration before the user lays on the mattress, during calibration, the cells are filled with until they reach a fixed pressure, so when a user is laying on the mattress, the system can calculate its weight (total pressure change cells). Because the system can also calculate the patient's height from the pressure image, having the weight and the
10 height of the user, the system can calculate the BMI of the user laying on the smart mattress. This calculation can provide a potential advantage over other systems because thinness increases the chance of pressure sores, it affects the pressure map and can influence the desired pressure distribution.

Actions taken:

- 15 1. The user marks the pressure sore on the tablet (or any electronic device) at the sacrum location.
2. The system then will map the body of the user on the mattress and will locate the pelvic area and then, specifically, the sacrum.
3. The system will then identify the inflatable cells sensing the highest pressure measured at the location of the sacrum. The system will then reduce the pressure from the inflatable cell and,
20 optionally, from a plurality of inflatable cells located near the one sensing the highest pressure measured, to a pressure between 0mmHg and 20mmHg. As stated above, external pressure of more than 32 mm Hg occludes the blood vessel.
4. The system then will identify the ischial tuberosity bones and will increase the pressure under them until the inflatable cells around the sacrum will sense a pressure below a pressure of between
25 30mmHg and 32mmHg. The system is configured to find the ischial tuberosity bones using at least one of the following methods: i) it should be expected to find high pressure points around the ischial tuberosity bones on the pressure map; ii) using the known location of the pelvic area; and iii) using of historical data regarding the location of the ischial tuberosity bones.
5. Applying cyclic movements, for example, moving from the right side of the ischial tuberosity
30 bones to the left side of the ischial tuberosity bones by also providing a maximum pressure allowed to apply on them. Another example is moving from the right side of the ischial tuberosity bones to the left side of the ischial tuberosity bone around the sacrum. While this may cause the pressure applied to the body to go above 32mmHg, it will be done for a period of time of about 20 minutes or less. Another example could be to do a cyclic movement that skips the sacrum (about 20 minutes

per cycle) so that at one time, the pressure will be above the sacrum area, and at another time, the pressure will be under the sacrum area. In this example, during the cyclic movement of changing the pressure of the cells, there will be inflatable cells having low pressure and inflatable cells having high pressure. The inflatable cells having a low pressure will have a pressure below 30-32mmHg, while the inflatable cells having a high pressure will be inflated so each inflatable cell will have proportional pressure to the “natural pressure”, which is the same pressure that was sensed in the inflatable cell at the first moment the user lay on the mattress (after the calibration) and got into the relevant “position”.

6. Referring now to Figure 9 showing an illustration of the backside of the pelvic zone. In the Figure, different zones are marked. Zone 1 is the zone of the sacrum, in this zone the pressure is maintained between about 0mmHg to about 20mmHg. Zone 2 is the immediate zone around the sacrum, in this zone the pressure should cycle between about 30mmHg and about 40mmHg. Zone 3 is the zone around Zone 2, in this zone the pressure should cycle be between about 20mmHg and about 32mmHg. Zone 4 is the zone around Zone 3, in this zone the pressure should cycle be between about 10mmHg and about 32mmHg. In some embodiments, the zones have a width from about 2cm to about 6cm. In some embodiments, the zones are built according to the natural anatomy of the body of the user, as shown for example in Figure 9. In some embodiments, more zones are created according to the resolution of the smart mattress, and resolution means the number and size of inflatable cells in the smart mattress.

7. Still referring to Figure 9, each zone can be further divided in sub-zones, where the smart mattress may be inflated or deflated according to the requirements. For example, in Zone 1 there is a sub-zone called A. In zone 2 there are two sub-zones B. In Zone 3 there are two sub-zones C and two sub-zones D. In this example, sub-zone D are the locations of the ischial tuberosity bones. In Zone 4 there are two sub-zones E, and outside Zone 4 there are as many sub-zones F as necessary. In order to facilitate the explanation of the cyclic movement of the different changes in the pressure in the different zones, main zones and sub-zones will be used.

For example, in Zone 1, sub-section A, on every inflatable cell that a pressure is measured and it is above 30mmHg, the pressure will be reduced to from about 0mmHg to about 20mmHg. In Zone 2, sub-zones B, the pressure will be reduced to from about 20mmHg to about 30mmHg. In sub-zones C through F, the pressure will be changed cyclically. For example, the sub-zones can be divided to “all the sub-zones above the sacrum” and “all the sub-zones below the sacrum including all sub-zones D”. Then, the pressure will be moved from “all of the above” to “all of the below”, 20 minutes each side. It should be understood that any division of zones and sub-zones can be done, and any combination of movement of pressure between sub-zones can be done, and each cycle could be of

any time length as necessary. Therefore, another example could be the division of zones above the sacrum and below the sacrum, and then a further subdivision of those zones as well. Then the cycle can be any combination of those subdivided zones.

5 Exemplary cyclic “clock-like” movement

In some embodiments, a cyclic movement around Zone 1 (for this example), could be characterized as a “clock-like” configuration in which one or more “arms” (like the arms of a clock) of pressure reduction / deduction around the sacrum move clockwise and/or counter-clockwise. Referring now to Figure 10, showing schematic representations of the “clock-like” movement of the reduction of the pressure, according to some embodiments of the invention. In the Figure are shown four exemplary clock-like” movement representations. Each example shows a representative grid of the inflatable cells. In the center, there is inflatable cell **1002**, which represents the location of the injury in which the inflatable cell is deflated, as represented by a group of black squares. In each example, there is also an exemplary representation of the “arms” **1004**, in example A there are two arms, one at 12 o’clock and one at six o’clock. Example B shows 3 “arms”, one at 12 o’clock, one at six o’clock and one at 9 o’clock. Example C shows 4 “arms” at 12, 3, 6, and 9 o’clock, while example D shows 3 “arms” at about 1:45, 4:45 and 9 o’clock. In some embodiments, each “arm” can rotate either clockwise or counter clockwise. In some embodiments, the “arms” can have any form, thickness or shape, for example, a stripe, a triangle, a rectangular, etc. In some embodiments, some “arms” rotate while others are still. In some embodiments, the “arms” may not have full length, they may have nonconsecutive lines. In some embodiments, the “arms” represent areas of low pressure, for example from about 10mmHg to about 20 mmHg. In some embodiments, the “arms” can be distanced at equal distances and/or at variable distances from each other. In some embodiments, the pressures inside the “arm” are not be equal. For example, if an arm is composed at a specific moment of four adjacent cells (A, B, C, D) then there may be a condition where the arm will maintain low pressure once again in cells A, C and another time in cells B, D. In some embodiments, the controller comprises several methods that can be applied to the user and it is configured to try to find which method (or combination of methods) is more convenient for the user.

30 Example number 2

A patient suffers from one pressure sore in right heel. In this example, BMI may play a less crucial role in pressure mapping of the immediate zones of the pressure wound but will influence the treatment and pressure distribution over the zones located further from the heel.

Actions taken:

1. The user marks the pressure sore on the tablet at the right heel.
2. The system then will map the body of the user on the mattress and will locate the right leg, then the right foot and then, specifically, the right heel.
- 5 3. The system will then identify the inflatable cells sensing the highest pressure measured and/or the inflatable cells sensing a pressure above 30mmHg, at the location of the right heel. The system will then reduce the pressure from the inflatable cell and, optionally, from a plurality of inflatable cells located near the one sensing the highest pressure, to a pressure between 0mmHg and 20mmHg. As stated above, external pressure of more than 32 mm Hg occludes the blood vessel.
- 10 4. Referring now to Figure 11a showing an illustration of the lower leg. In the Figure, different zones are marked. Zone A is the zone of below the heel. Zone B is the heel. Zone C is above the heel. Zone D is the zone of the Achilles tendon. Zone E is the lower-lower calf. Zone F is the lower calf. Zone G is the middle calf. Zone H is the upper calf. Zone I is the upper-upper calf.
- 5 5. The system will reduce the pressure from Zone A and/or Zone B to a pressure from about 15 0mmHg to about 20mmHg.
6. Similarly to Example 1 points 5, 6 and 7, sub-zones are used to calculate and activate the correct combination of zones and/or subzones to be deflated and the cyclic configuration to be used.
- It should be noted that there are a number of fundamental differences between the protocols to be used in, for example, the heel and the sacrum. For example, the heels and/or the shoulder are
- 20 configured as not "symmetrical" areas in terms of pressure dissipation. That is, in the area "above" the heel there is the calf, while "below" the heel there is nothing. Therefore, Protocols will ensure the correct inflation/deflation of cells whether the location of the injury is in a symmetrical or asymmetrical location.
- Another differences maybe, for example, there will be a special consideration for delicate areas,
- 25 and therefore, for example, low pressure of about 20 mmHg to Zone D (the Achilles tendon) will be kept, either continuously or in a period of about 20 minutes.
- In another example, the system will apply cyclic movement between zones D-I or E-I but on the axis of left-right not up-down (D to I), as shown for example in Figure 11b.
- In another example, the system will apply left / right cyclic movement on both legs, even if the
- 30 other leg is healthy. This symmetry may potentially help the efficiency of treatment and may feel better for the user.
- In another example, the system will apply "mixed" left / right cyclic movement: For example: cycle 1 elevated pressure: E-left, F-right, G-left, H-right... (and so on), then cycle 2 elevated pressure: E-right, F-left, G-right, H-left ... (and so on).

Example number 3

A patient laying down in the lateral position and suffers from one pressure sore in the greater trochanter area on the right side.

5 Actions taken:

1. The user marks the pressure sore on the tablet at the greater trochanter area while the device is showing a pressure map showing the user in the lateral position.

2. The system then will map the body of the user on the mattress and will locate the right leg, then the right side of the pelvic area and then, specifically, greater trochanter area.

10 3. While laying down on the lateral position, the pressure on the greater trochanter area can arrive up to 70-80mmHg. Therefore, the system will then identify the inflatable cells sensing the highest pressure measured at the location of the greater trochanter area. The system will then reduce the pressure from the inflatable cell and, optionally, from a plurality of inflatable cells located near the one sensing the highest pressure and/or the inflatable cells sensing a pressure above 30mmHg, to a
15 pressure between 0mmHg and 20mmHg.

4. Referring to Figure 12, showing a pressure map of a user laying down on a lateral position and a zoom in window of the pelvic zone. The whole area is divided according to the pressure map zones, for example, Zone A, which is the greater trochanter area has a pressure reading of higher than 30mmHg. Zone B has a pressure reading of about 20mmHg. Zone C has a pressure reading of
20 about 10mmHg. Zone D has a pressure reading of less than 10mmHg.

The system then will identify Zone A and will reduce the pressure on that area to about 0mmHg to about 20mmHg.

5. The system will then apply cyclic movements between the zones, besides Zone A, as previously explained.

25 Example number 4

A patient suffers from one pressure sore in the pelvic area and it is located at the left ischial tuberosity area. The patient sits on a wheelchair.

In another example, the patient is laying on a fowler bed in a Semi-Fowler's position at 45 degrees.

30 Actions taken:

1. The user marks the pressure sore on the tablet at the left ischial tuberosity area while the device is showing a pressure map of the user in a sitting position.

In some embodiments, the pressure map shown on the screen is divided into sub zones. For example, in a typical fowler's bed there are 4 sub zones, one for the back, one for the pelvic area and two for the legs. So in that case, the electronic device will show 4 different sub screens - for easier access and for better visibility of the state of the user. Another example, for a wheelchair, there will be 2 sub screens, one for the vertical orientation and one for the axial orientation. Another example, the chair comprises a support that includes the vertical orientation and the axial orientation. In some embodiments, the support is supplemental to an already existing chair. Another example, the support can be used on any surface and/or furniture (i.e. sofa, floor, hammock, etc.).

2. The system then will map the body of the user on the mattress and will locate the pelvic area and then, specifically, the ischial tuberosity area.

3. While sitting, the pressure on the ischial tuberosity and its surrounding area can exceed 100 mmHg. Therefore, the system will then identify the inflatable cells sensing one or more of: a) the highest pressure measured at the location of the left ischial tuberosity area; b) a pressure above from about 70mmHg to about 100mmHg; c) a marked area by the user and/or the physician/nurse.

The system will then reduce the pressure from the inflatable cell in those zones and, optionally, from a plurality of inflatable cells located near the one sensing one or more of the above, to a pressure between from about 0mmHg to about 20mmHg.

4. While in sitting position, the pressure over the different pelvic area zone could be in most parts higher than 32 mmHg. Therefore, in order to decrease the pressure from Zone A, the pressures in the other zones will be increased over their "natural pressure" which is already, in most parts, higher than 32 mmHg. In that case, it is important to apply cyclic movements between the zones for both treatment of the pressure wound in the left ischial tuberosity area and preventing new pressure wounds.

Referring now to Figures 13a-b showing an illustration of the "back side" of the pelvic zone. In figure 13a it is shown the pressure map of the pelvic zone showing the actual numerical pressure measurements. In addition are shown the zones grouping similar pressure measurements. In Figure 13b, the different zones shown in Figure 13a are marked (named). The map is shown without the number to facilitate the visualization of the zones. Zone A, is the zone of the left ischial tuberosity, in this zone the pressure should be maintained between about 0 mmHg to about 20 mmHg.

Zones B to J are holding pressure gradient with differences of about 10mmHg to about 20 mmHg between zone B to C, zone C to D and so on, until Zone J who has a pressure reading of less than 10 mmHg.

In another example, a Zone could have multiple "unlinked" parts or "non-continuous zones", for example as shown with "*" in the right side of Figure 13b.

4. The system then will identify Zone A and will reduce the pressure on that area to from about 0 mmHg to about 20 mmHg.

5. The system will then apply cyclic movements between the zones, besides Zone A, it will be focusing on the right ischial tuberosity area, the zones surrounding the right ischial tuberosity area and the zones surrounding the left ischial tuberosity, as previously explained.

6. In another example, the system will reduce pressure from both left and right ischial tuberosity areas simultaneously, while maintaining the movement in a symmetrical manner around the body. In some embodiments, a potential advantage of this is to provide more comfort to the user.

7. It has been seen that on both “sitting in an upright position” and “semi sitting” on a partially/fully upright flower’s bed, the body might slide forward and this creates shear forces on the body and friction between the skin and the bed. Therefore, in some embodiments, the system will reduce shear forces and friction between the skin and the bed by reducing pressure on the backside of the pelvic area in a way that will prevent the patient from sliding down the upright bed or chair.

Example number 5

The system of the invention can be potentially useful in the following environments:

- Hospital setting - adults with a tendency to develop pressure sores and those with existing moderate-high pressure sores / burns / recovery after surgery.

- Private use - pressure sores / Orthopedic uses, for example, low back stretching / Detecting sleep disorders that cause blood flow disorders by using the smart mattress and moving the patient to replenish blood flow / Preventing snoring.

- Wheelchairs - a huge population that has no real answer in the field of pressure sores / dynamic pillows. This is probably because a dynamic pillow is a very uncomfortable product so the disabled patient would prefer to lie in bed and avoid sitting on a wheelchair just so as not to sit on a dynamic pillow. The system presented herein answers this without compromising patient comfort.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this

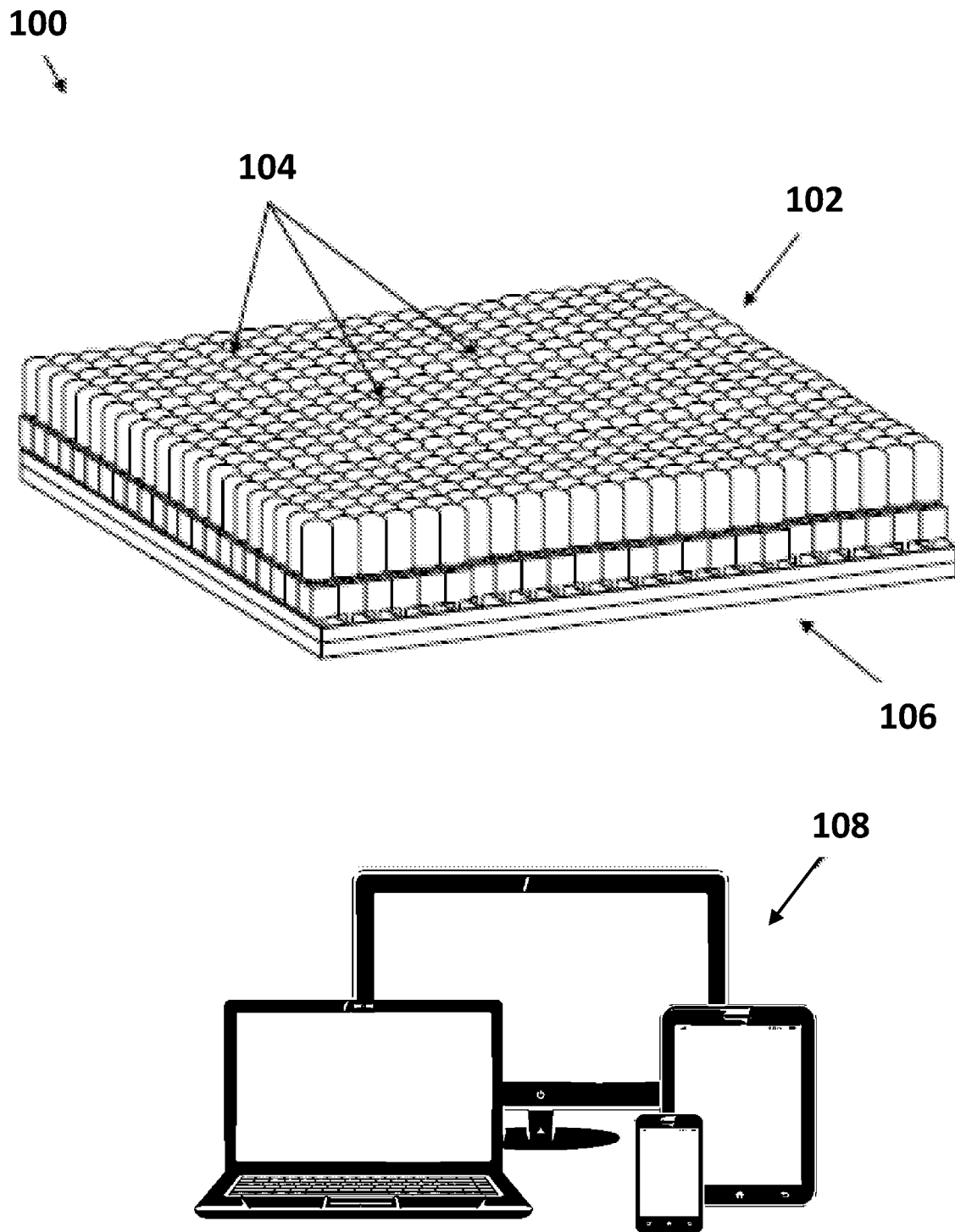
application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting. In addition, any priority document(s) of this application is/are hereby incorporated herein by reference in its/their entirety.

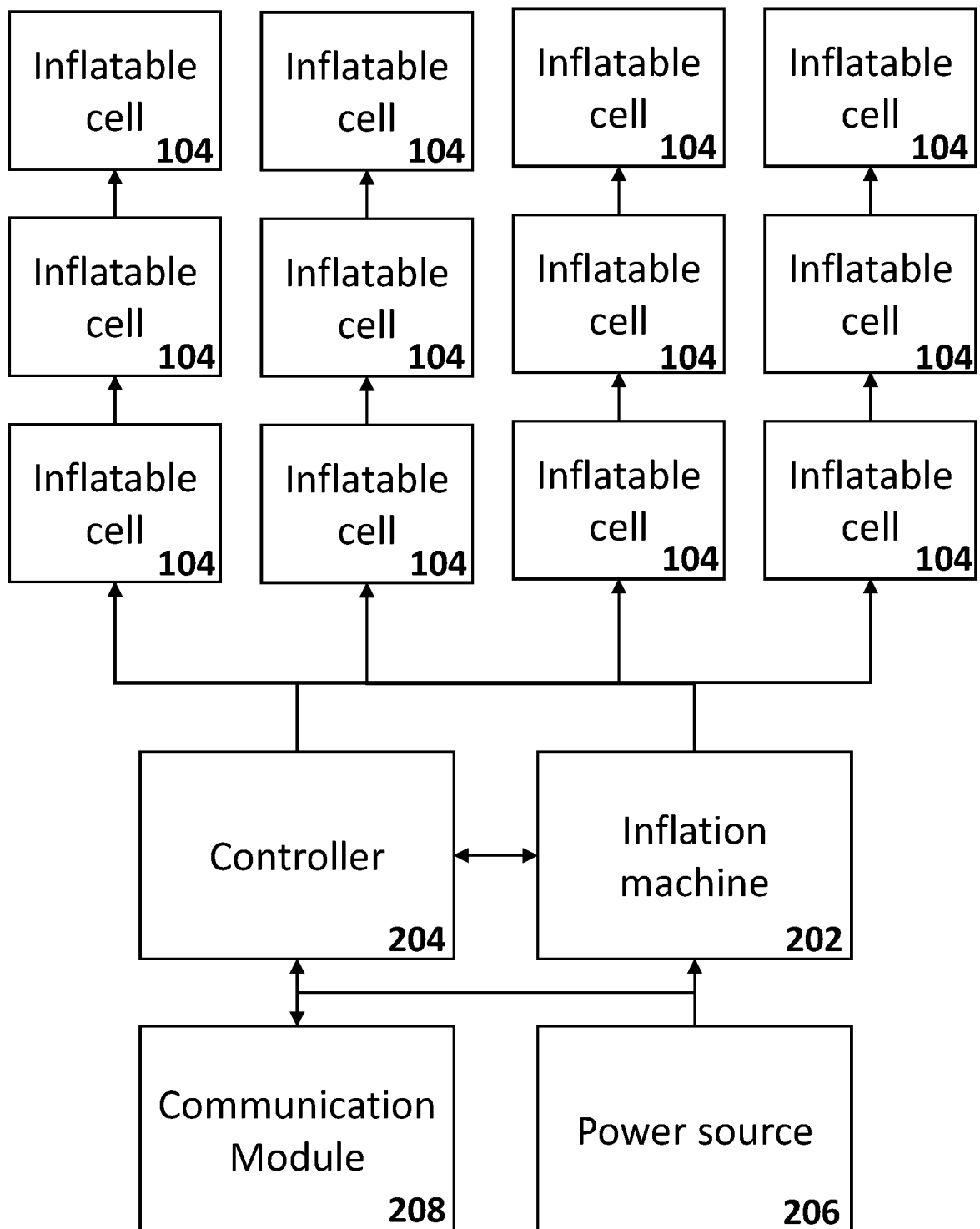
WHAT IS CLAIMED IS:

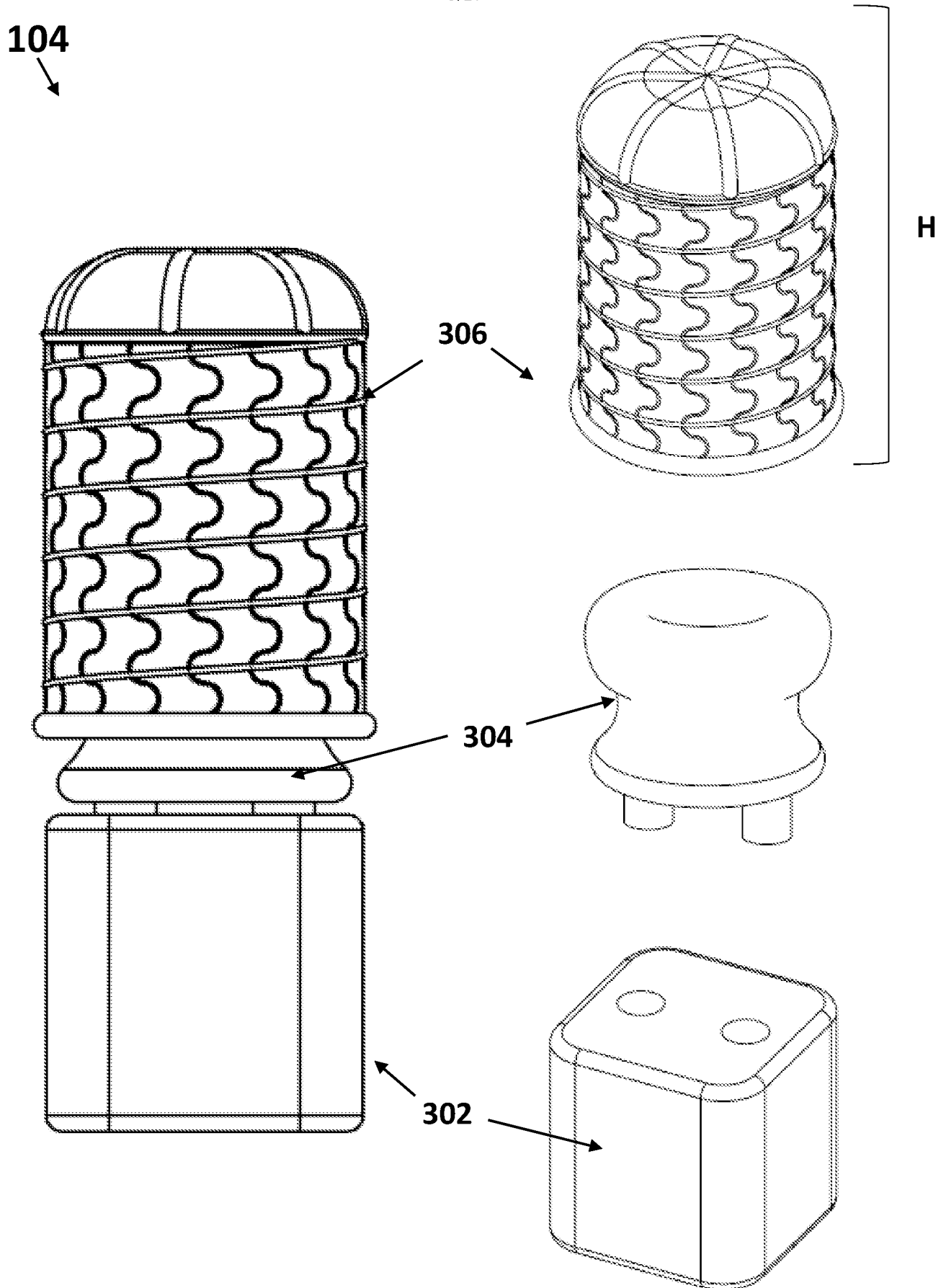
1. A system for preventing or treating a sensitive location of a user, comprising:
 - a. a mattress comprising an array of inflatable cells;
 - b. circuitry configured to apply instructions to modify a parameter related to one or more of said inflatable cells in a location associated with said sensitive location, according to at least one protocol based on said sensitive location and/or at least one input from said user.
2. The system according to claim 1, wherein said parameter comprises one or more of inflation and deflation.
3. The system according to claim 1, further comprising at least one electronic device in communication with said circuitry.
4. The system according to claim 3, wherein said at least one electronic device comprises at least one display.
5. The system according to claim 1, wherein said inflatable cells comprise an integrated pressure sensor.
6. The system according to claim 5, wherein said circuitry is configured to apply instructions to generate a pressure map based on pressure measurements performed by said integrated pressure sensor in said inflatable cells.
7. The system according to claim 6, wherein said at least one electronic device is configured to display said pressure map in said display.
8. The system according to claim 6, wherein said protocol comprises instructions to deflate one or more of said inflatable cells in locations of high pressure according to said pressure map.
9. The system according to claim 3, wherein said at least one electronic device is used to deliver said at least one input.
10. The system according to claim 1, wherein said input is a verbal input.

11. The system according to claim 5, wherein said circuitry is configured to apply instructions to generate a body outline based on pressure measurements performed by said integrated pressure sensor in said inflatable cells.
12. The system according to claim 11, wherein said at least one electronic device is configured to display said body outline in said display.
13. The system according to claim 1, wherein said location associated with said sensitive location comprises one or more of the actual location of said sensitive location, a zone adjacent to said actual location, a plurality of zones adjacent to said actual location.
14. The system according to claim 1, wherein said location associated with said sensitive location comprises a location located a distance from about 1cm to about 100cm.
15. The system according to claim 1, wherein said inflatable cells comprise an integrated temperature sensor.
16. The system according to claim 15, wherein said circuitry is configured to apply instructions to generate a temperature map based on temperature measurements performed by said integrated temperature sensor in said inflatable cells.
17. A method for controlling pressure from at least one sensitive location in a user, comprising:
- a. receiving at least one input from said user regarding said at least one sensitive location;
 - b. modifying a parameter related to one or more inflatable cells in a location associated with said sensitive location, according to at least one protocol based on said sensitive location and/or said at least one input from said user.
18. The method according to claim 17, comprising measuring pressure applied on a body of said user while being on a support, said support comprising an array of inflated inflatable cells configured to measure said pressure.
19. The method according to claim 18, comprising generating a pressure map using said pressure measurements.

20. The method according to claim 19, comprising displaying said pressure map on at least one electronic device.
21. The method according to claim 20, wherein said receiving at least one input from said user is performed on said at least one electronic device.
22. The method according to claim 17, wherein said modifying said parameter comprises one or more of deflating or inflating those inflatable cells that correspond with said sensitive location.
23. The method according to claim 17, wherein said modifying said parameter comprises completely deflating those inflatable cells that correspond with said sensitive location.
24. The method according to claim 23, wherein said modifying said parameter comprises one or more of partially deflating and partially inflating inflatable cells around said completely deflated inflatable cells in a temporal and spatial manner.
25. A method for controlling pressure from at least one sensitive location in a user, comprising:
- a. generating a pressure map comprising pressure zones, said pressure zones representing pressure levels;
 - b. calculating a relative spatial pressure profile based on said pressure zones;
 - c. identifying zones having the highest pressure levels;
 - d. removing pressure from said zones having the highest pressure levels;
 - e. distributing pressure between more than one pressure zones while preserving said relative spatial pressure profile.
26. The method according to claim 25, wherein said distributing comprises one or more of decreasing and increasing the pressure in said more than one pressure zones.
27. A method of tracking a user, comprising:
- a. receiving at least one input from said user regarding at least one sensitive location;
 - b. monitoring movements of said user;
 - c. modifying the location of said at least one sensitive location in relation with said monitored movements.

**Figure 1**

**Figure 2**

**Figure 3a**

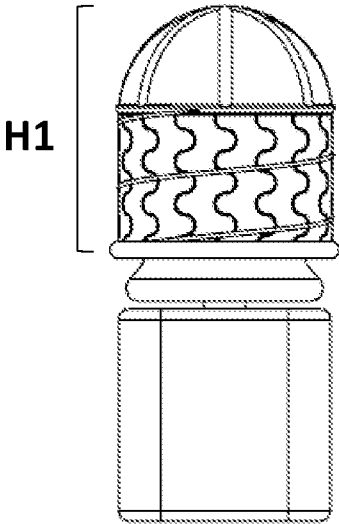


Figure 3b1

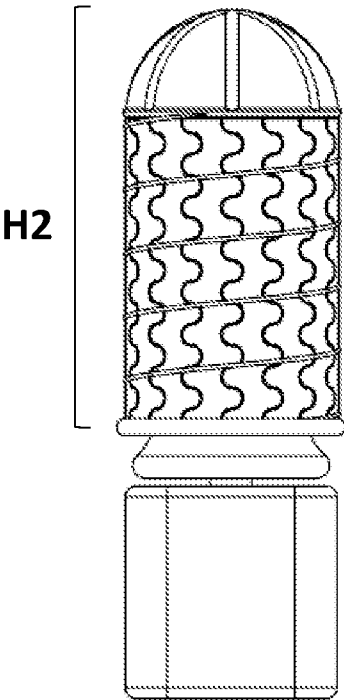


Figure 3b2

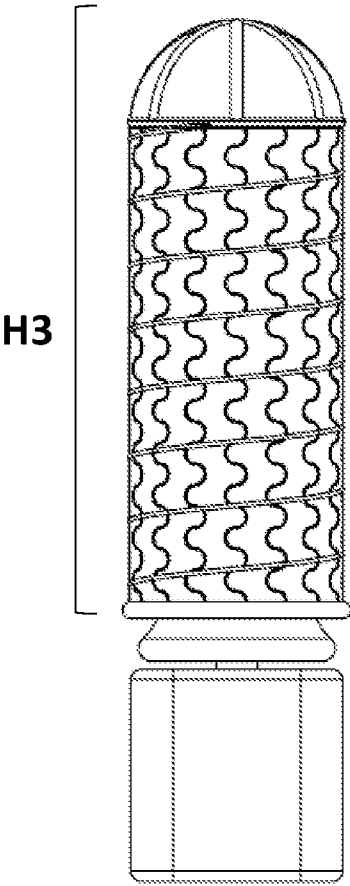


Figure 3b3

402

Inflating all inflatable cells to a fixed internal pressure
bringing all inflatable cells to a height base line

**404**

Laying the user on the bed

**406**

Calculating BMI

**408**

Create pressure map of user and identify body parts

**410**

Optionally, provide several laying position for base line

Figure 4

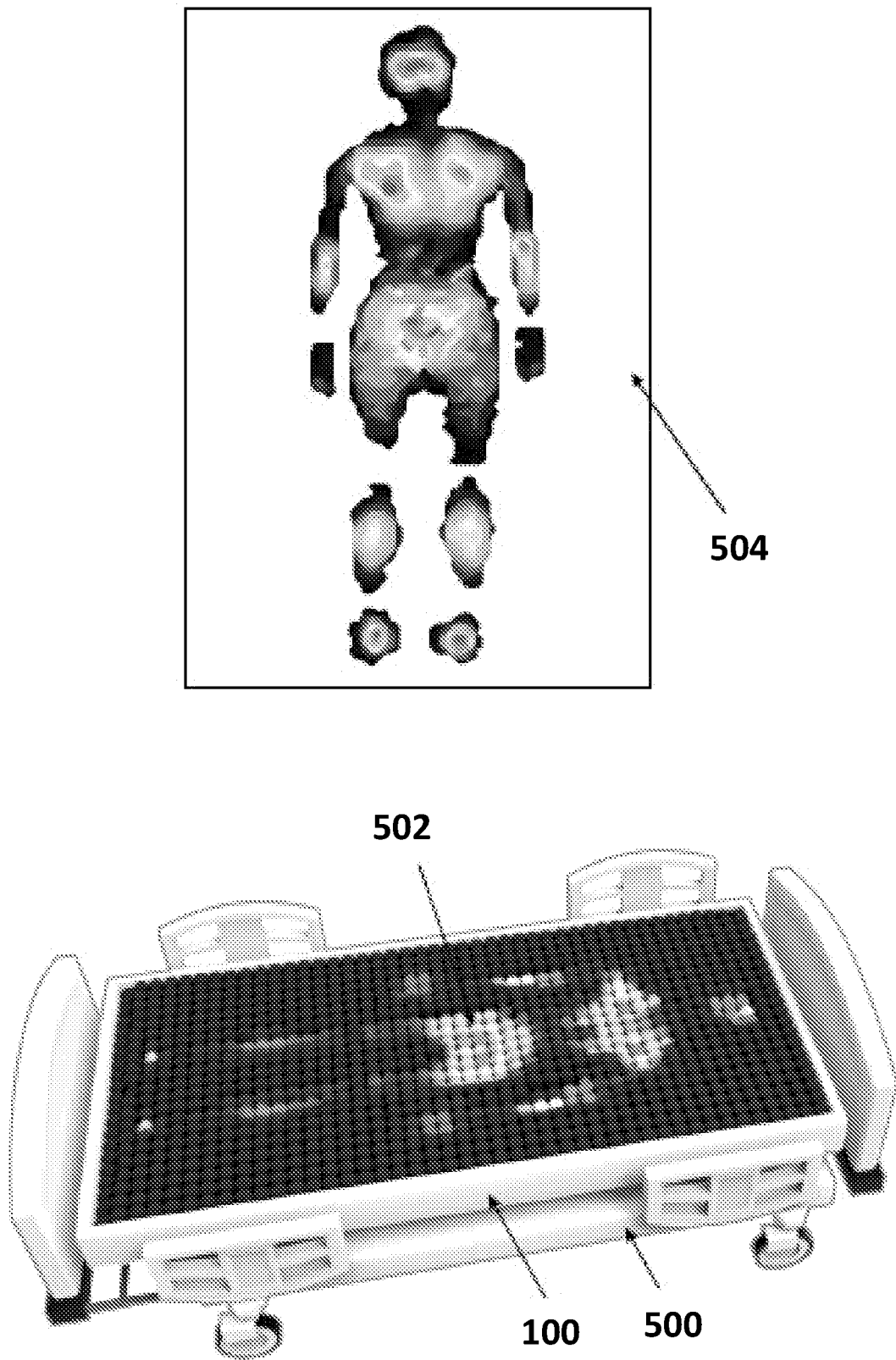


Figure 5a

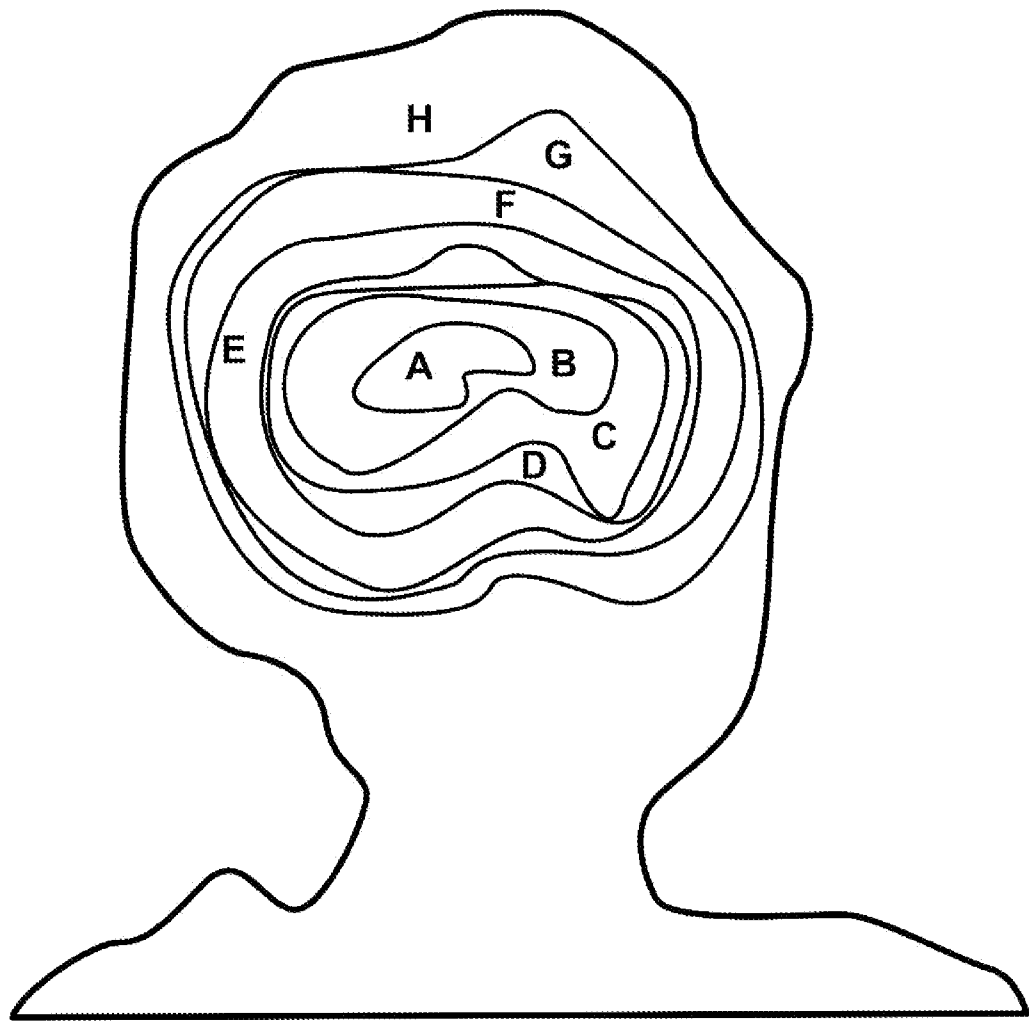


Figure 5b

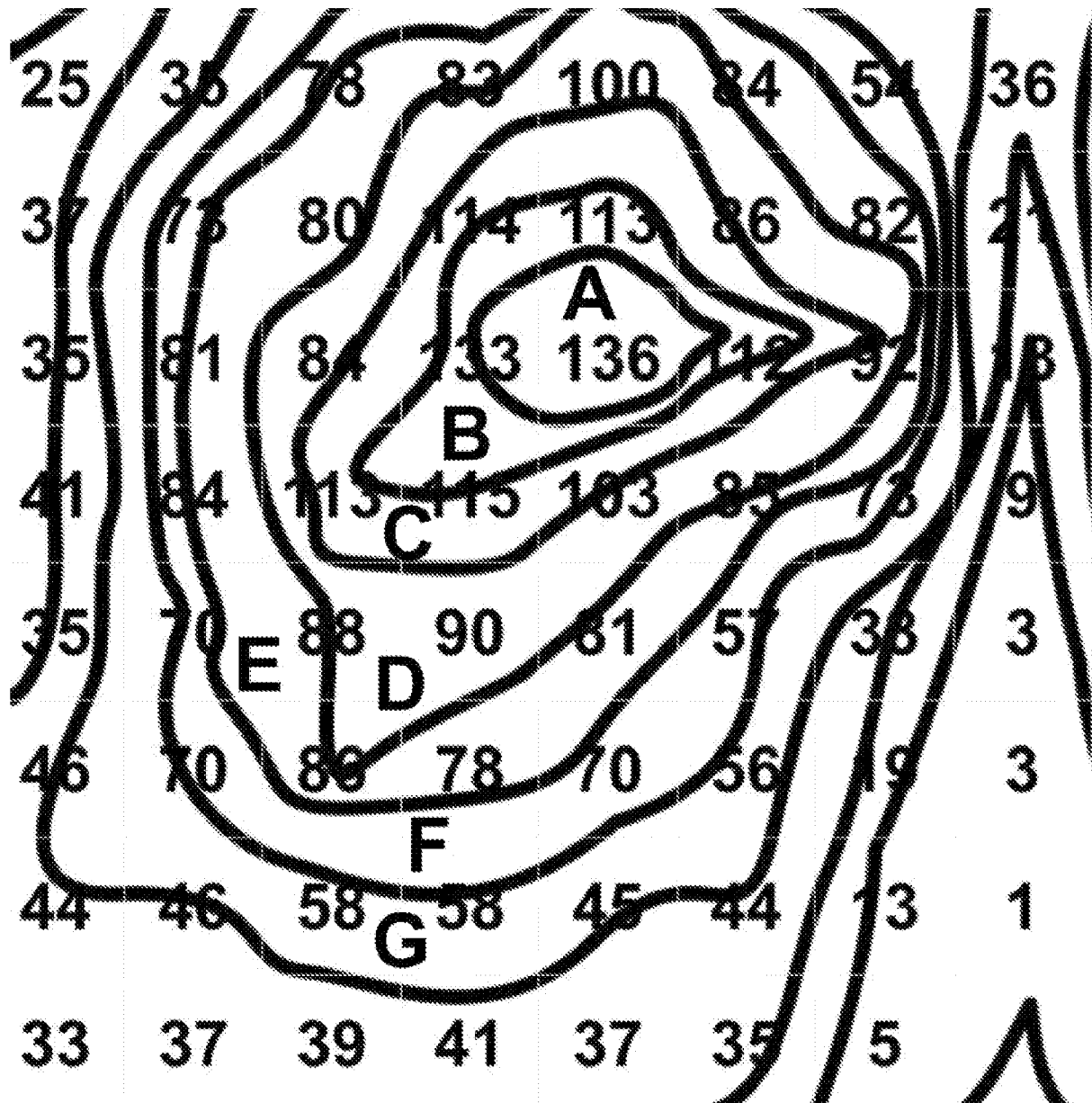


Figure 5c

602

Identify inflatable cells sensing the highest pressure

604

Removing air from inflatable cells sensing the highest pressure

606

Beginning cyclic movement of the inflatable cells around the inflatable cells from which air was removed

Figure 6

702

User marks the area where the pressure sore is located

704

System will locate inflatable cells corresponding to area

706

Identify inflatable cells sensing the highest pressure at the marked location

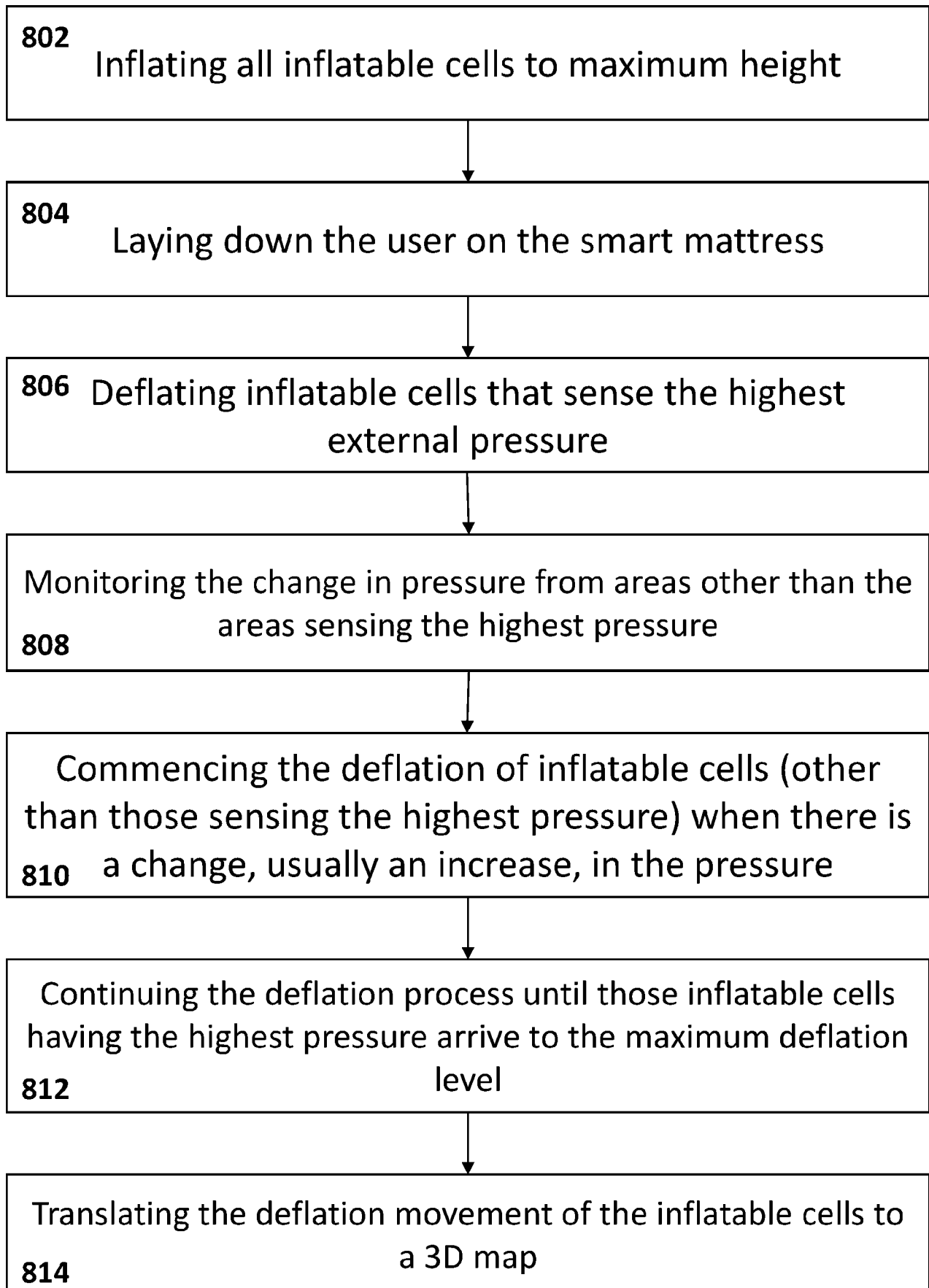
708

Removing air from inflatable cells sensing the highest pressure

710

Beginning cyclic movement of the inflatable cells around the inflatable cells from which air was removed

Figure 7

**Figure 8**

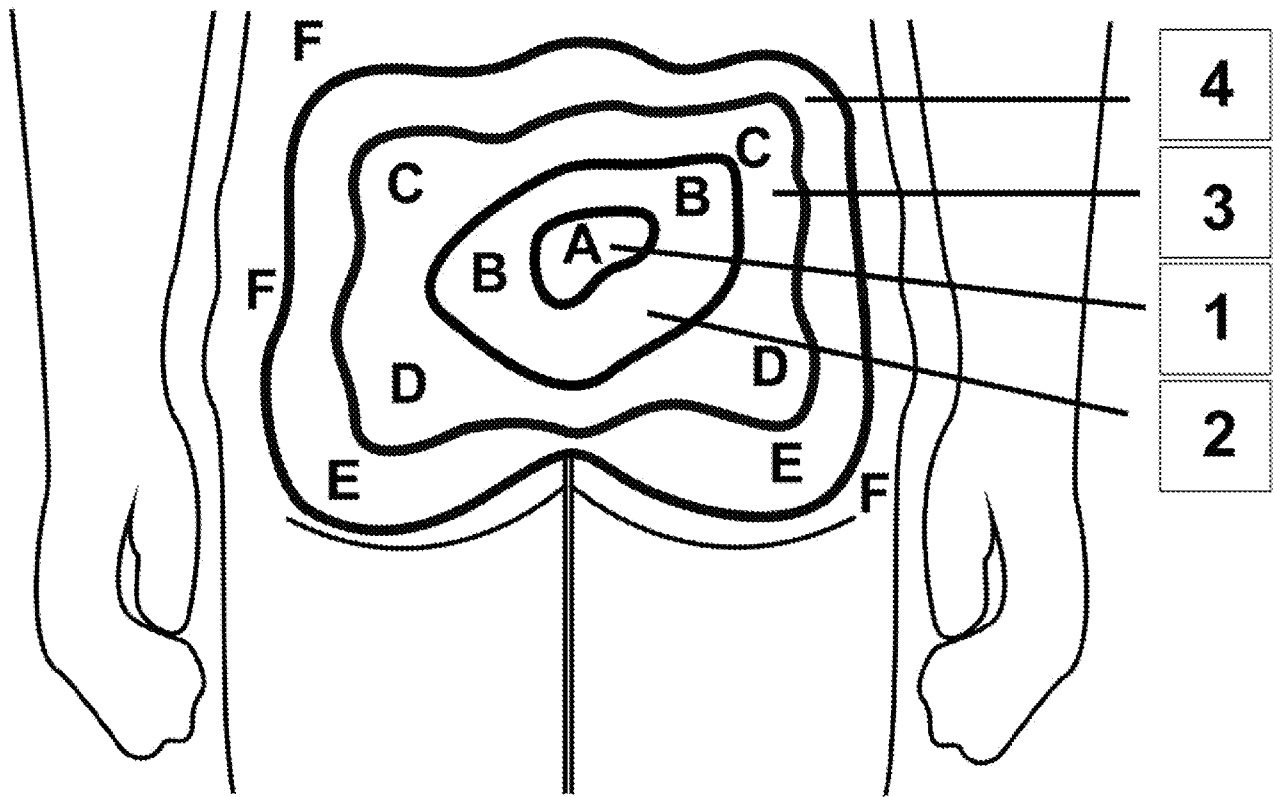


Figure 9

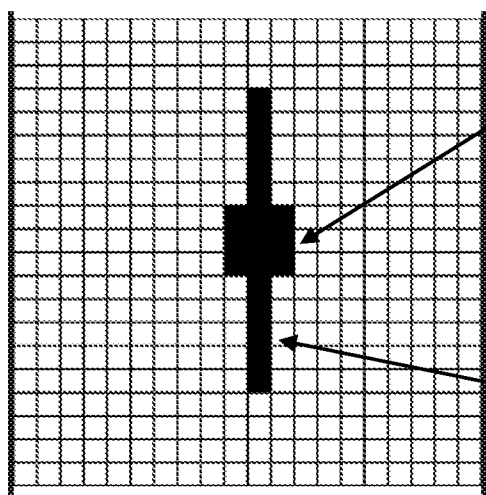


Figure 10a

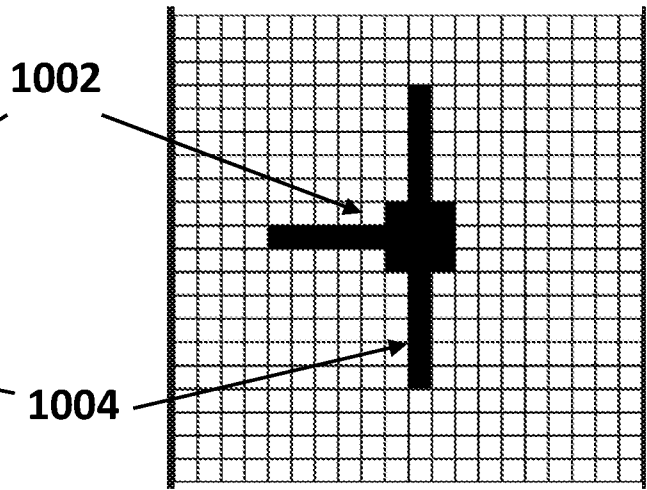


Figure 10b

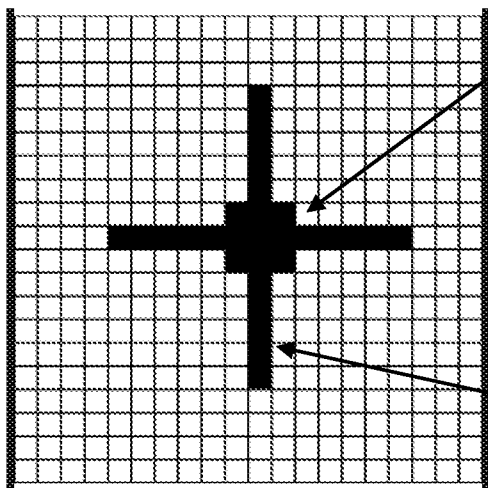


Figure 10c

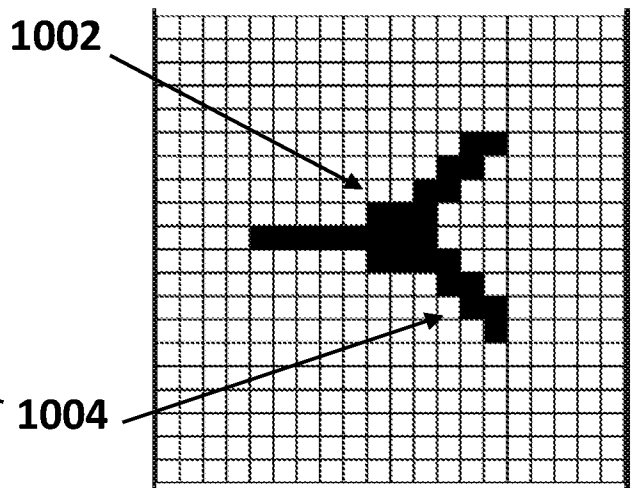
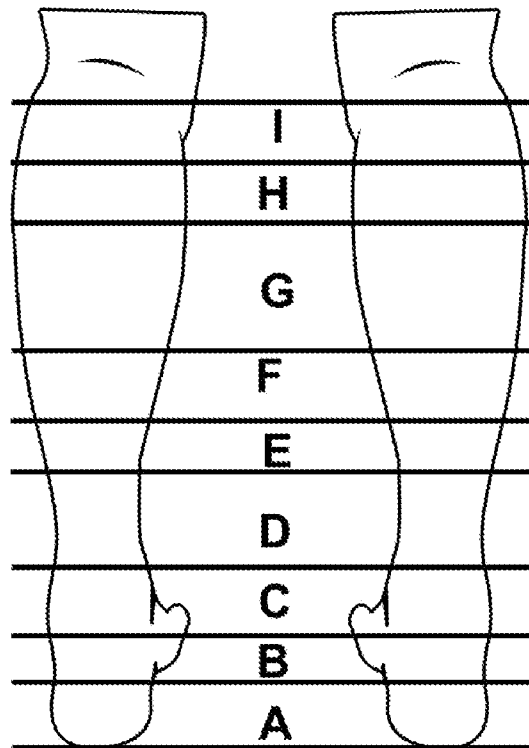
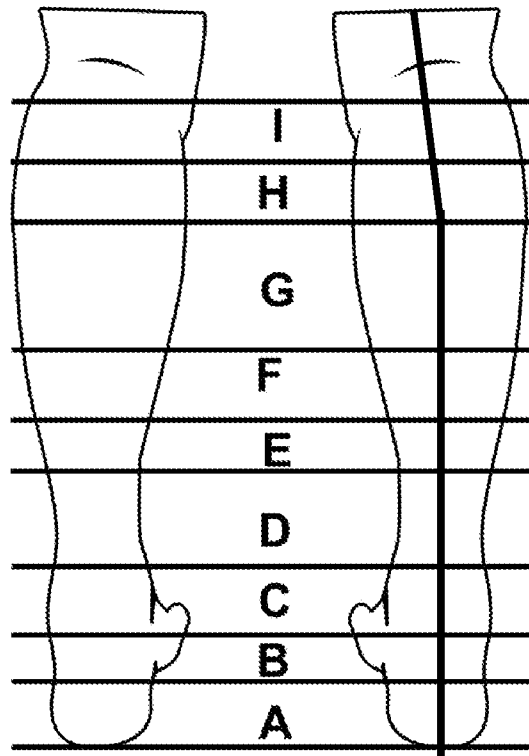


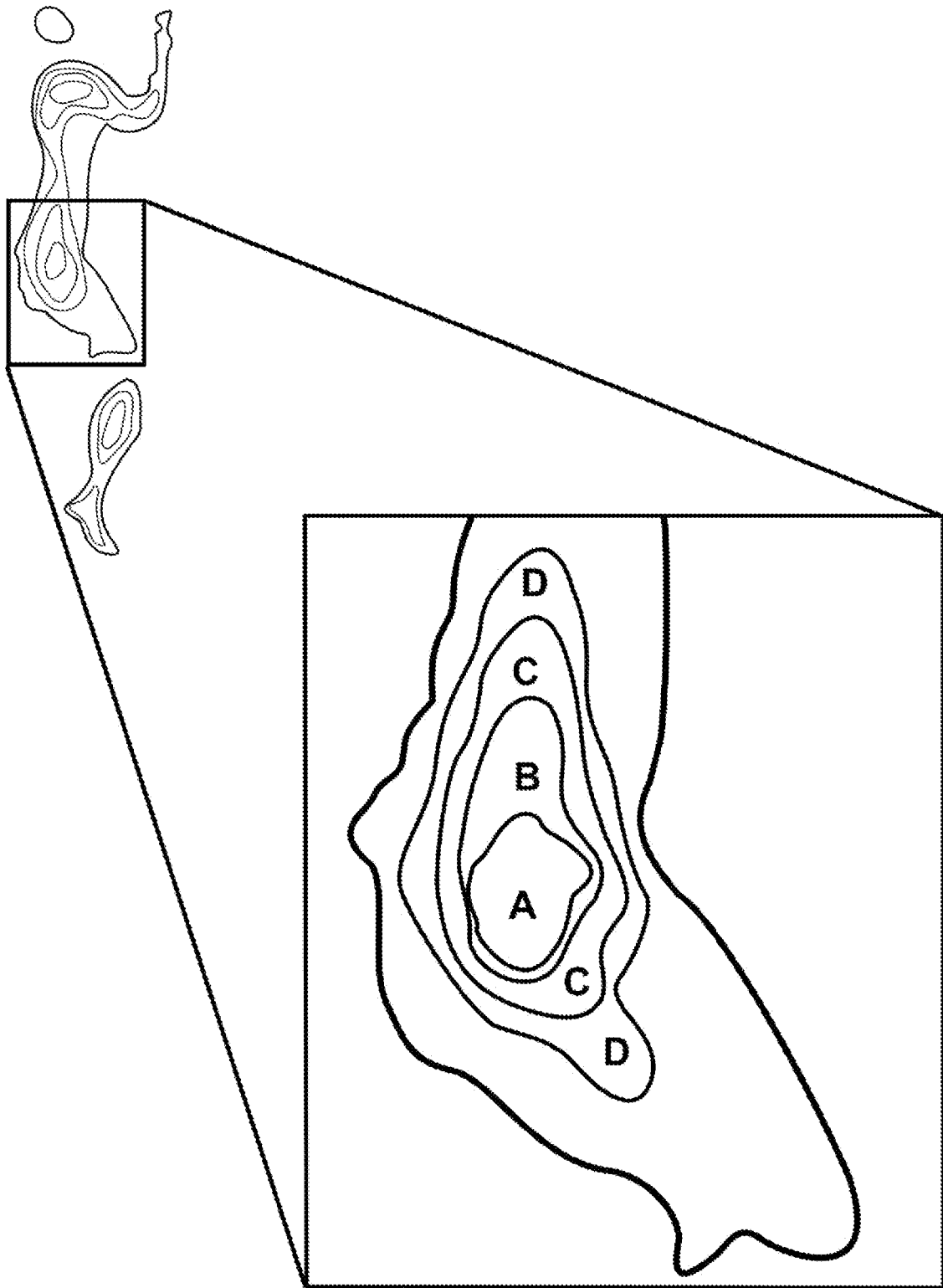
Figure 10d

14/17

**Figure 11a**

Left/Right Axis

Figure 11b

**Figure 12**

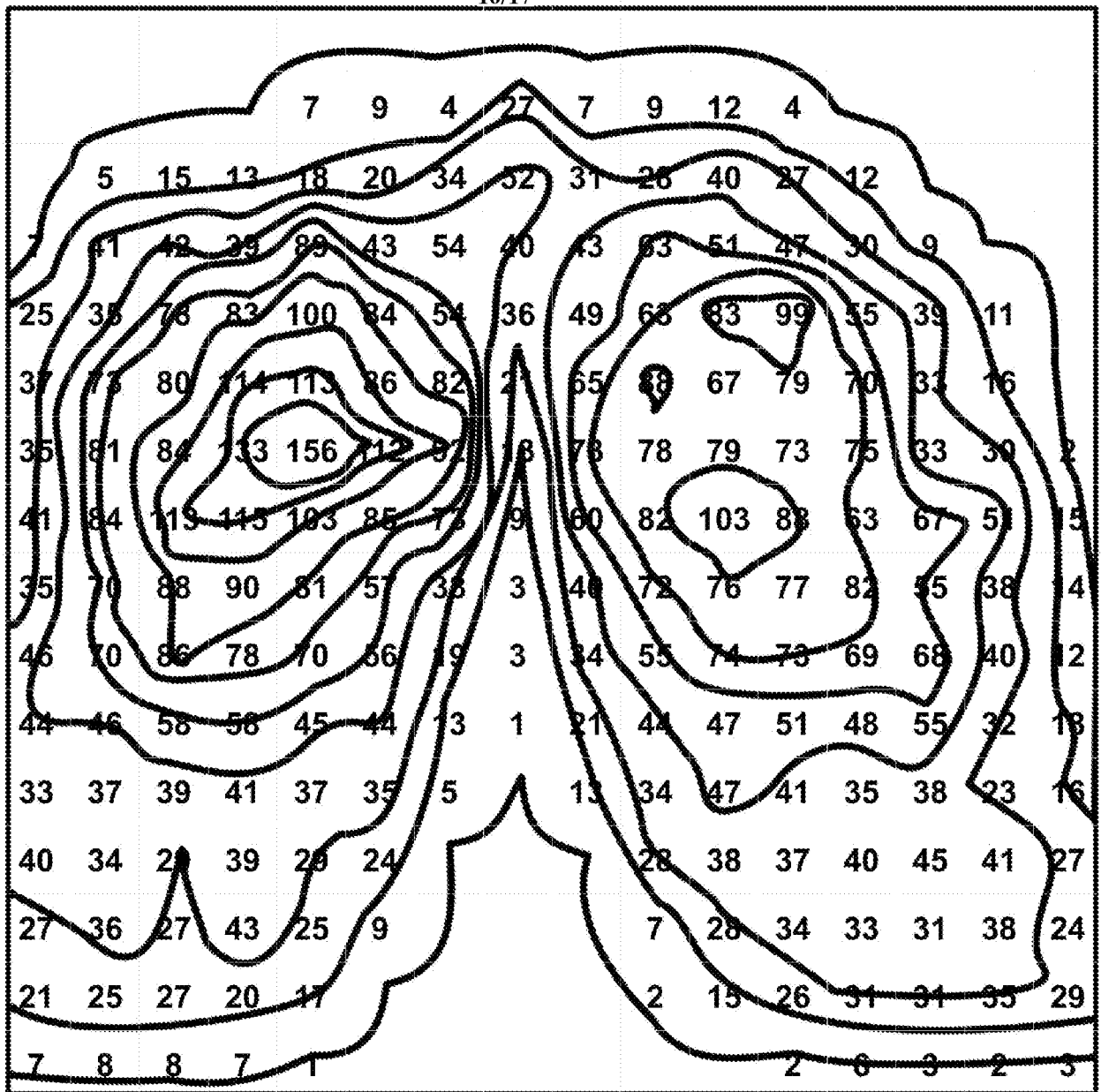
**Figure 13a**



Figure 13b

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL2020/050152

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet.

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)

See extra sheet.

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: Esp@cenet, Google Patents, Orbit

Search terms used: dynamic, mattress, pressure, sore, inflate, adjust, sensor, map, control, temperature, display.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2018032089 A1 ETLEB, Abdul-Hakim et al 22 Feb 2018 (2018/02/22) The whole document	1-27
P,X	WO 2019035762 A1 NGEE ANN POLYTECHNIC 21 Feb 2019 (2019/02/21) The whole document	1-27
A	US 2016317370 A1 1834958 ALBERTA INC 03 Nov 2016 (2016/11/03) The whole document	1-27



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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“D” document cited by the applicant in the international application

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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

07 May 2020

Date of mailing of the international search report

07 May 2020

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Telephone No. 972-2-5651680

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/IL2020/050152

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
WO 2018032089 A1	22 Feb 2018	WO 2018032089 A1	22 Feb 2018
		CA 3073285 A1	22 Feb 2018
		CN 109952082 A	28 Jun 2019
		EP 3500224 A1	26 Jun 2019
		EP 3500224 A4	25 Mar 2020
		US 2019175100 A1	13 Jun 2019
WO 2019035762 A1	21 Feb 2019	WO 2019035762 A1	21 Feb 2019
US 2016317370 A1	03 Nov 2016	US 2016317370 A1	03 Nov 2016
		CA 2928511 A1	01 Nov 2016

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL2020/050152

A. CLASSIFICATION OF SUBJECT MATTER:

IPC (20200101) A61G 7/057, A61B 5/00, A61B 5/01, A61B 5/103, G16H 50/20, A61H 9/00

CPC (20130101) A61G 7/05776, A61G 2203/20, A61G 2203/30, A61G 2203/34, A61G 2203/46, A61B 2562/0247, A61B 2562/046, A61G 7/05761, A61B 5/447, A61B 5/0022, A61B 5/015, A61B 5/1036, A61B 5/6892, A61B 5/7275, G16H 50/20, A61B 5/742, A61H 9/0078

B. FIELDS SEARCHED:

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

IPC (20200101) A61G 7/057, A61B 5/00, A61B 5/01, A61B 5/103, G16H 50/20, A61H 9/00

CPC (20130101) A61G 7/05776, A61G 2203/20, A61G 2203/30, A61G 2203/34, A61G 2203/46, A61B 2562/0247, A61B 2562/046, A61G 7/05761, A61B 5/447, A61B 5/0022, A61B 5/015, A61B 5/1036, A61B 5/6892, A61B 5/7275, G16H 50/20, A61B 5/742, A61H 9/0078