(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 508 187 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.07.2019 Bulletin 2019/28

(21) Application number: **18150657.7**

(22) Date of filing: **08.01.2018**

(51) Int Cl.:
A61H 9/00 (2006.01) *A61G 7/057* (2006.01)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

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(54) **AN APPARATUS AND ASSOCIATED METHODS FOR DETECTING A VARIABLE FORCE**

(57) An apparatus comprising an inflatable bladder connectable to a pressure sensor, the pressure sensor configured to detect changes in pressure within the inflatable bladder caused by a variable force applied to the inflatable bladder, wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

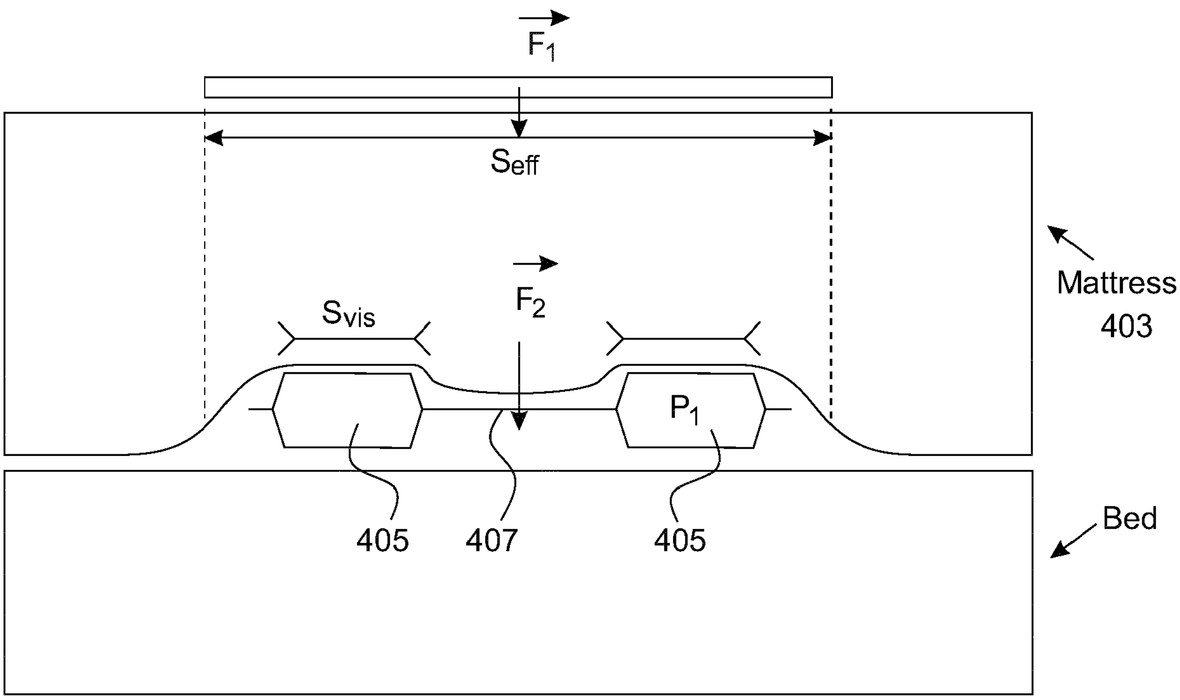

Figure 4

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Description

Technical Field

[0001] The present disclosure relates to an apparatus and associated methods for substantially matching a range of pressure within an inflatable bladder to a predefined range of a pressure sensor.

Background

[0002] Research is currently being done to develop pressure sensors for detecting a variable force.

[0003] The listing or discussion of a prior-published document or any background in this specification should not necessarily be taken as an acknowledgement that the document or background is part of the state of the art or is common general knowledge.

Summary

[0004] According to a first aspect, there is provided an apparatus comprising an inflatable bladder connectable to a pressure sensor, the pressure sensor configured to detect changes in pressure within the inflatable bladder caused by a variable force applied to the inflatable bladder, wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

[0005] The predefined range of the pressure sensor may be a detectable range of the pressure sensor or a sub-range of the detectable range.

[0006] The inflatable bladder may comprise one or more non-inflatable regions.

[0007] The inflatable bladder may comprise a plurality of interconnected inflatable regions configured to enable the inflated volume of the inflatable bladder to be controlled by selectively inflating and/or deflating one or more of the plurality of interconnected inflatable regions.

[0008] The inflatable bladder may comprise a plurality of interconnected inflatable regions separated by non-inflatable regions, and the inflated thickness and separation of the inflatable regions may be chosen to ensure that the variable force is distributed over the plurality of interconnected inflatable regions.

[0009] The inflatable bladder may comprise a plurality of interconnected inflatable regions separated by non-inflatable regions, and the apparatus may comprise a substantially rigid structure configured to distribute the variable force over the plurality of interconnected inflatable regions.

[0010] The plurality of interconnected inflatable regions may have substantially the same inflated thickness.

[0011] The plurality of interconnected inflatable regions may have one or more of a substantially tubular, cylindrical, spherical or cubic inflated shape.

[0012] The inflatable bladder may comprise two sheets of fluid-impermeable material which have been hermetically sealed together to define an inflated volume therebetween.

[0013] The fluid-impermeable material may comprise one or more of a thermoplastic, polyvinyl chloride, thermoplastic polyurethane, a fabric impregnated with polyvinyl chloride, and a fabric impregnated with thermoplastic polyurethane.

[0014] The apparatus may comprise the pressure sensor.

[0015] The apparatus may be at least part of a sleep monitor.

[0016] According to a further aspect, there is provided a method comprising:

detecting a variable force applied to an inflatable bladder based on detected changes in pressure within the inflatable bladder caused by the variable force, wherein the changes in pressure are detected using a pressure sensor connected to the inflatable bladder, and wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

[0017] The inflatable bladder may comprise a plurality of interconnected inflatable regions configured to enable the inflated volume of the inflatable bladder to be controlled by selectively inflating and/or deflating one or more of the plurality of interconnected inflatable regions, and the method may comprise selectively inflating and/or deflating one or more of the plurality of interconnected inflatable regions to produce an inflated volume such that the range of pressure corresponding to the variable force substantially matches the predefined range of the pressure sensor.

[0018] The method may comprise selectively inflating/deflating the one or more interconnected inflatable regions dynamically and/or automatically.

[0019] The inflatable bladder may be positioned between a mattress and a bed such that the variable force is applied to the inflatable bladder via the mattress.

[0020] According to a further aspect, there is provided a method comprising:

forming an inflatable bladder connectable to a pressure sensor, the pressure sensor configured to detect changes in pressure within the inflatable bladder caused by a variable force applied to the inflatable bladder, wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

[0021] The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated or understood by the skilled person.

[0022] According to a further aspect, there is provided a computer program comprising computer program code instructions that, when executed by at least one processor, cause:

detecting a variable force applied to an inflatable bladder based on detected changes in pressure within the inflatable bladder caused by the variable force, wherein the changes in pressure are detected using a pressure sensor connected to the inflatable bladder, and wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

[0023] Corresponding computer programs for implementing one or more steps of the methods disclosed herein are also within the present disclosure and are encompassed by one or more of the described example embodiments.

[0024] One or more of the computer programs may, when run on a computer, cause the computer to configure any apparatus, including a battery, circuit, controller, or device disclosed herein or perform any method disclosed herein. One or more of the computer programs may be software implementations, and the computer may be considered as any appropriate hardware, including a digital signal processor, a microcontroller, and an implementation in read only memory (ROM), erasable programmable read only memory (EPROM) or electronically erasable programmable read only memory (EEPROM), as non-limiting examples. The software may be an assembly program.

[0025] One or more of the computer programs may be provided on a computer readable medium, which may be a physical computer readable medium such as a disc or a memory device, or may be embodied as a transient signal. Such a transient signal may be a network download, including an internet download.

[0026] The present disclosure includes one or more corresponding aspects, example embodiments or features in isolation or in various combinations whether or not specifically stated (including claimed) in that combination or in isolation. Corresponding means for performing one or more of the discussed functions are also within the present disclosure.

[0027] The above summary is intended to be merely exemplary and non-limiting.

Brief Description of the Figures

[0028] A description is now given, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 shows one example of a sensor apparatus in plan-view;

Figure 2 shows the apparatus of Figure 1 in cross-section;

Figures 3a-d show different examples of the present apparatus in plan-view;

Figure 4 shows the apparatus of Figure 3c in cross-section;

Figure 5 shows another example of the present apparatus in plan-view;

Figure 6a shows one example of the present apparatus in cross-section with a particular inflated thickness and separation of the inflated regions;

Figure 6b shows another example of the present apparatus in cross-section with a different inflated thickness and separation of the inflated regions;

Figure 7 shows a method of making the present apparatus;

Figure 8 shows a method of using the present apparatus; and

Figure 9 shows a computer-readable medium comprising a computer program configured to perform, control or enable a method described herein.

Description of Specific Aspects/Embodiments

[0029] As mentioned in the background section, research is currently being done to develop pressure sensors for detecting a variable force. One example is a sleep monitor configured to detect one or more of a user's heartbeat, movement and respiration.

[0030] Figures 1 and 2 show an existing sleep monitor in plan-view and cross-section, respectively. The sleep monitor comprises an inflatable bladder 101 configured to be positioned between a mattress 203 and a bed 204 such that a variable force $\vec{F}_1$ applied to a surface area S_{eff} of the mattress 203 by the user's heartbeat, movement or respiration is at least partially imparted to a surface area S_{vis} of the inflatable bladder 101 in contact with the mattress 203 as force $\vec{F}_2$. The variable force $\vec{F}_1$ and imparted force $\vec{F}_2$ are both vector quantities having a substantially vertical direction as indicated by the downward pointing arrows in Figure 2.

[0031] The inflatable bladder 101 comprises two sheets of fluid-impermeable material which have been hermetically sealed together to define an inflated volume therebetween. In the example of Figure 1, the inflated volume comprises a plurality of interconnected inflatable regions 105, 205 (i.e. in fluid communication with one another), and the crosshatched areas 102 are where the sheets of fluid-impermeable material have been welded together. The inflatable bladder 101 also comprises a portion 106 via which a pump and pressure sensor can be connected to inflate the inflatable regions 105, 205 and detect the pressure therein, respectively. The variable force $\vec{F}_2$ imparted to the inflatable bladder 101 causes corresponding changes in pressure P_1 within the inflatable bladder 101 which are detected by the pressure sensor connected thereto. The variable force $\vec{F}_1$ associated with the user's heartbeat, movement or respiration can therefore be detected based on the detected changes in pressure Pi.

[0032] An issue with existing sleep monitors is that the range of pressure P_1 corresponding to the variable force $\vec{F}_1$ does not necessarily match the detectable range (or at least the most accurately measured range) of the pressure sensor. This is because the pressure sensor used with the inflatable bladder 101 is not typically designed for this application specifically. As such, the signal-to-noise ratio of existing sleep monitors tends to suffer.

[0033] One option to address this issue would be to introduce an additional component to multiply the pressure P_1 in the inflatable bladder 101 such that it substantially matches the range of the pressure sensor. A problem with this approach, however, is the unwanted friction and inertia imparted on the inflatable bladder 101 by the additional component. There will now be described an apparatus and associated methods that may address the above-mentioned issues.

[0034] Figures 3a-3d show different examples of the present apparatus in plan-view. The apparatus comprises an inflatable bladder 301 connectable to a pressure sensor. The pressure sensor may or may not form part of the present apparatus, and is configured to detect changes in pressure within the inflatable bladder 301 caused by a variable force applied to the inflatable bladder 301. Unlike the inflatable bladder 101 shown in Figures 1 and 2, the inflatable bladder 301 of the present apparatus is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor. The predefined range of the pressure sensor may be a detectable range of the pressure sensor or a sub-range of the detectable range. For example, the sub-range may be a range of pressure which is compatible with the inflatable bladder 301 (e.g. would not cause the inflatable bladder 301 to burst) or a range of pressure within which the accuracy of the pressure sensor is above a predefined threshold.

[0035] A specific inflated volume can be achieved by configuring the inflatable bladder 301 to have a particular shape, configuration and/or dimensions when inflated. In each of the examples in Figures 3a-3d, for instance, the inflatable bladder 301 comprises one or more non-inflatable regions 307 (although in some cases, these "non-inflatable" regions 307 may be inflatable but are not inflated, i.e. "non-inflated" regions). In Figures 3a and 3d, the non-inflatable regions 307 comprise two elongated channels extending parallel to one another along the length of the inflatable bladder 301; in Figure 3b, the non-inflatable regions 307 comprise two islands; and in Figure 3c, the non-inflatable region 307 comprises a single longitudinally-extending elongated channel. In each case, the non-inflatable regions 307 are at least partially surrounded by interconnected inflatable regions 305.

[0036] Figure 4 shows the inflatable bladder 301 of Figure 3c in cross-section. The presence of the non-inflatable region 407 (assuming that the overall dimensions of the inflatable bladder remain the same) results in a lower inflated volume and surface area S_{vis} in contact with the mattress 403 relative to the inflatable bladder 101 of Figures 1 and 2. As such, the force $\vec{F}_2$ imparted to the inflatable bladder is distributed over a smaller surface area S_{vis} and inflated volume resulting in a greater change in pressure P_1 within the inflatable bladder. The ratio between the surface area S_{vis} **in** contact with the mattress 403 and the surface area S_{eff} of the mattress 403 to which the variable force $\vec{F}_1$ is applied (i.e. $S_{vis}:S_{eff}$) essentially acts as a gain factor that is tuned to the predefined range of the pressure sensor. If the pressure sensor connected to the inflatable bladder of Figures 1 and 2 was not sensitive enough to accurately detect the variable force, then the greater change in pressure P_1 caused by the lower inflated volume and surface area S_{vis} in Figures 3a-3d may be sufficient to enable more accurate detection of the variable force $\vec{F}_1$.

[0037] It is important to note, however, that the inflated volume and surface area S_{vis} in contact with the mattress may alternatively be increased rather than decreased to match the range of pressure P_1 corresponding to the variable force $\vec{F}_1$ with the predefined range of the pressure sensor. This could be achieved, for example, by increasing the number and/or size of the interconnected inflatable regions 105, 205 of Figures 1 and 2, and may be useful if the changes in pressure P_1 caused by the variable force $\vec{F}_1$ are too large for the pressure sensor.

[0038] Theoretically, a change in force applied to the inflatable bladder causes the transformation (F_0, P_0, V_0, S_0) to (F_0+dF, P_0+dP, V_0+dV, S_0+dS), where F_0, P_0, V_0 and S_0 are the initial force, pressure, volume and contact surface area of the inflatable bladder, respectively, and dF, dP, dV and dS are the respective changes in force, pressure, volume and contact surface area. Also, since $P_0=F_0/S_0$, the change in pressure dP may be given by $1/S_0(dF-P_0dS)$. In effect, therefore, the range of pressure corresponding to the variable force can be controlled based on one or more of the initial pressure and surface area in contact with the mattress. Furthermore, since a change in contact surface area (e.g. by increasing or decreasing the number and/or size of the inflatable regions) causes a proportional change in the inflated volume (provided that the inflatable regions have substantially the same inflated thickness), the range of pressure corresponding to the variable force can be controlled using the inflated volume of the inflatable bladder as described previously.

[0039] Figure 5 shows another example of the present apparatus in plan-view. In this example, the inflatable bladder 501 comprises a plurality of interconnected inflatable regions 505 configured to enable the inflated volume of the inflatable bladder 501 to be controlled by selectively inflating and/or deflating one or more of the plurality of interconnected inflatable regions 505. As shown, different inflatable regions 505 can be selected by opening or closing valves 508 connecting adjacent inflatable regions 505. Although the interconnected inflatable regions 505 in Figure 5 are substantially cubic in shape when inflated, an individual inflatable region 505 could be any three-dimensional shape (e.g. one or more of substantially tubular, cylindrical or spherical in shape). Furthermore, the plurality of interconnected inflatable regions 505 may all have substantially the same shape, may each have a different shape, or may comprise two or more different shapes with at least two of the inflatable regions having substantially the same shape.

[0040] This feature enables the same inflatable bladder 501 to be adapted (manually or automatically) to suit pressure sensors with different predefined ranges. In addition, the inflatable bladder 501 may be adapted dynamically to account for variations in the applied force. For example, the inflated volume may be initially set when the user first lies on the mattress such that the range of pressure corresponding to the variable force applied by his/her heartbeat, movement or respiration substantially matches a predefined range of the pressure sensor. If the user's heartbeat, movement or respiration then changes (e.g. as a result of a medical condition whilst they are sleeping) sufficiently to cause a relatively large change in pressure within the inflatable bladder 501, the inflated volume may be varied to ensure that the variable force remains detectable by the pressure sensor. In this scenario, the magnitude of the pressure within the inflatable bladder 501 may be monitored to determine whether or not it falls outside the predefined range of the pressure sensor, and if so, the inflated volume of the inflatable bladder 501 may be automatically adjusted such that the pressure falls within the predefined range.

[0041] Figures 6a and 6b show how the inflated thickness e and separation d of the inflatable regions 605 can also influence the ability of the pressure sensor to detect changes in pressure caused by the variable force. In these examples, the inflatable bladder comprises a plurality of interconnected inflatable regions 605 separated by non-inflatable regions 607. In the example of Figure 6a, however, the inflated thickness e and separation d of the inflatable regions 605 are such that the portion 609 of the mattress 603 overlying the non-inflatable regions 607 is not supported by the inflatable bladder. As a result, the readings from the pressure sensor may not accurately reflect the variable force applied to the mattress 603. In the example of Figure 6b, on the other hand, the inflated thickness e and separation d of the inflatable regions 605 have been respectively increased and decreased such that the variable force is distributed over the plurality of interconnected inflatable regions 605. This helps to ensure that the changes in pressure caused by the variable force are more accurately detected by the pressure sensor.

[0042] The sensitivity issue described above in relation to Figure 6a is also dependent upon the rigidity of the mattress 603. If a more rigid self-supporting mattress 603 was used instead, the inflated thickness e and separation d of the inflatable regions 605 may not need to be varied. Additionally or alternatively, the apparatus may comprise an additional substantially rigid structure (i.e. distinct from the mattress 603) to distribute the variable force over the plurality of interconnected inflatable regions 605. The additional structure could be positioned between the mattress 603 and inflatable bladder in use.

[0043] Although the above-mentioned description focusses predominantly on sleep monitors, the present apparatus is not limited exclusively to this application. Rather, the present apparatus could be used in any application where a pressure sensor is used to detect changes in pressure within an inflatable bladder caused by a variable force. For example, the present apparatus could be installed beneath a platform positioned on a road to monitor the number of vehicles travelling on the road during a particular time period. The present apparatus may be advantageous in this scenario due to the variety of different possible vehicle weights (and therefore corresponding pressures) that would need to be accounted for on an average road.

[0044] Figure 7 shows the main steps 710-711 of a method of making the present apparatus. The method comprises: forming an inflatable bladder connectable to a pressure sensor configured to detect changes in pressure within the inflatable bladder caused by a variable force applied to the inflatable bladder, wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor 710; and connecting the inflatable bladder to the pressure sensor 711. The forming 710 and connecting 711 steps may be performed by different parties (e.g. manufacturer vs user). As such, the connection step 711 is optional (as indicated by the dashed box).

[0045] The inflatable bladder may be formed by hermetically sealing two sheets of fluid-impermeable material together to define an inflated volume therebetween. This may be achieved by gluing, thermal welding and/or ultrasonic welding the two sheets of fluid-impermeable material together. Furthermore, the fluid-impermeable material may comprise one or more of a thermoplastic, polyvinyl chloride, thermoplastic polyurethane, a fabric impregnated with polyvinyl chloride, and a fabric impregnated with thermoplastic polyurethane.

[0046] Figure 8 shows the main steps 812-813 of a method of using the present apparatus. The method comprises: detecting changes in pressure within an inflatable bladder caused by a variable force applied to the inflatable bladder, using a pressure sensor connected to the inflatable bladder, wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor 812; and detecting the variable force applied to the inflatable bladder based on the detected changes in pressure 813.

[0047] Figure 9 illustrates schematically a computer/processor readable medium 914 providing a computer program according to one embodiment. The computer program may comprise computer code configured to perform, control or enable one or more of the method steps

710-711 of Figures 7 using existing manufacturing/assembling equipment.

[0048] Additionally or alternatively, the computer program may comprise computer code configured to perform, control or enable one or more of the method steps 812-813 of Figure 8 using at least part of the apparatus described herein. In this example, the computer/processor readable medium 914 is a disc such as a digital versatile disc (DVD) or a compact disc (CD). In other embodiments, the computer/processor readable medium 914 may be any medium that has been programmed in such a way as to carry out an inventive function. The computer/processor readable medium 914 may be a removable memory device such as a memory stick or memory card (SD, mini SD, micro SD or nano SD).

[0049] Other embodiments depicted in the figures have been provided with reference numerals that correspond to similar features of earlier described embodiments. For example, feature number 1 can also correspond to numbers 101, 201, 301 etc. These numbered features may appear in the figures but may not have been directly referred to within the description of these particular embodiments. These have still been provided in the figures to aid understanding of the further embodiments, particularly in relation to the features of similar earlier described embodiments.

[0050] The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the present specification as a whole, in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of the claims. The applicant indicates that the disclosed aspects/embodiments may consist of any such individual feature or combination of features. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the disclosure.

[0051] While there have been shown and described and pointed out fundamental novel features as applied to different embodiments thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices and methods described may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Moreover, it should be recognized that structures and/or elements and/or method steps shown and/or described in connection with any disclosed form or embodiment may be incorporated in any other disclosed or described or suggested form or embodiment as a general matter of design choice. Furthermore, in the claims means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures.

Claims

1. An apparatus comprising an inflatable bladder connectable to a pressure sensor, the pressure sensor configured to detect changes in pressure within the inflatable bladder caused by a variable force applied to the inflatable bladder, wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

2. The apparatus of claim 1, wherein the inflatable bladder comprises one or more non-inflatable regions.

3. The apparatus of claim 1 or 2, wherein the inflatable bladder comprises a plurality of interconnected inflatable regions configured to enable the inflated volume of the inflatable bladder to be controlled by selectively inflating and/or deflating one or more of the plurality of interconnected inflatable regions.

4. The apparatus of any preceding claim, wherein the inflatable bladder comprises a plurality of interconnected inflatable regions separated by non-inflatable regions, and wherein the inflated thickness and separation of the inflatable regions are chosen to ensure that the variable force is distributed over the plurality of interconnected inflatable regions.

5. The apparatus of any preceding claim, wherein the inflatable bladder comprises a plurality of interconnected inflatable regions separated by non-inflatable regions, and wherein the apparatus comprises a substantially rigid structure configured to distribute the variable force over the plurality of interconnected inflatable regions.

6. The apparatus of any of claims 3 to 5, wherein the plurality of interconnected inflatable regions have substantially the same inflated thickness.

7. The apparatus of any preceding claim, wherein the inflatable bladder comprises two sheets of fluid-impermeable material which have been hermetically sealed together to define an inflated volume therebetween.

8. The apparatus of any preceding claim, wherein the apparatus comprises the pressure sensor.

9. The apparatus of any preceding claim, wherein the apparatus is at least part of a sleep monitor.

10. A method comprising:
detecting a variable force applied to an inflatable bladder based on detected changes in pressure within the inflatable bladder caused by the variable force, wherein the changes in pressure are detected using a pressure sensor connected to the inflatable bladder, and wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

11. The method of claim 10, wherein the inflatable bladder comprises a plurality of interconnected inflatable regions configured to enable the inflated volume of the inflatable bladder to be controlled by selectively inflating and/or deflating one or more of the plurality of interconnected inflatable regions, and wherein the method comprises selectively inflating and/or deflating one or more of the plurality of interconnected inflatable regions to produce an inflated volume such that the range of pressure corresponding to the variable force substantially matches the predefined range of the pressure sensor.

12. The method of claim 11, wherein the method comprises selectively inflating/deflating the one or more interconnected inflatable regions dynamically and/or automatically.

13. The method of any of claims 10 to 12, wherein the inflatable bladder is positioned between a mattress and a bed such that the variable force is applied to the inflatable bladder via the mattress.

14. A method comprising:
forming an inflatable bladder connectable to a pressure sensor, the pressure sensor configured to detect changes in pressure within the inflatable bladder caused by a variable force applied to the inflatable bladder, wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

15. A computer program comprising computer program code instructions that, when executed by at least one processor, cause:
detecting a variable force applied to an inflatable bladder based on detected changes in pressure within the inflatable bladder caused by the variable force, wherein the changes in pressure are detected using a pressure sensor connected to the inflatable bladder, and wherein the inflatable bladder is configured to have an inflated volume such that the range of pressure corresponding to the variable force substantially matches a predefined range of the pressure sensor.

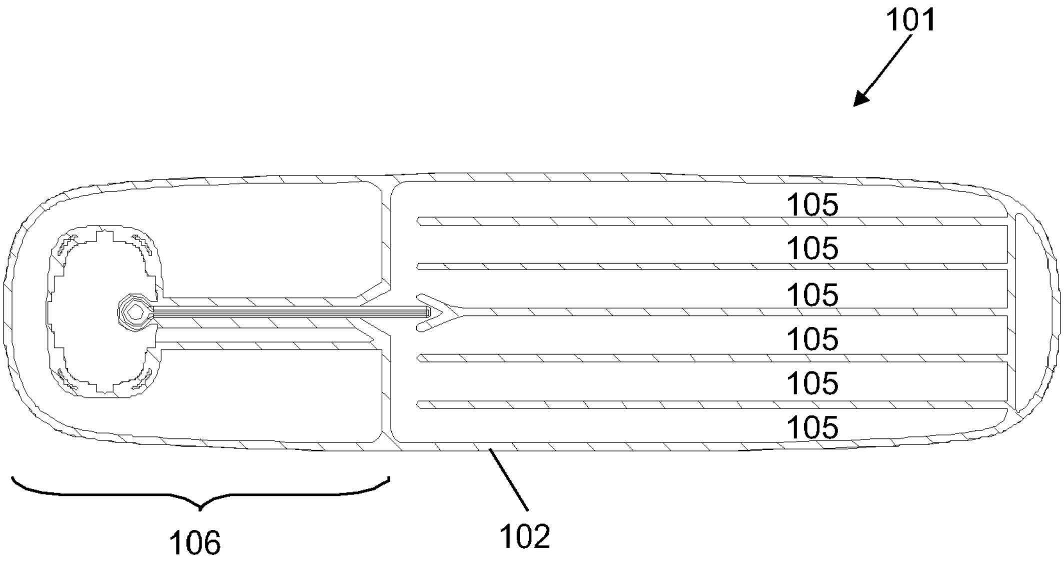

Figure 1

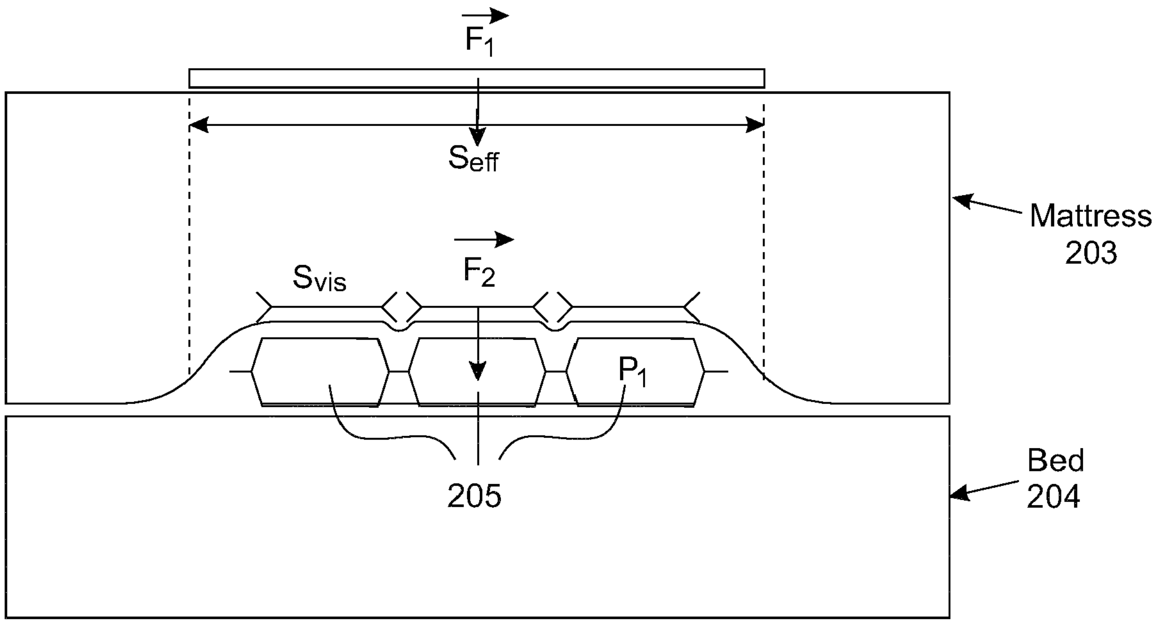

Figure 2

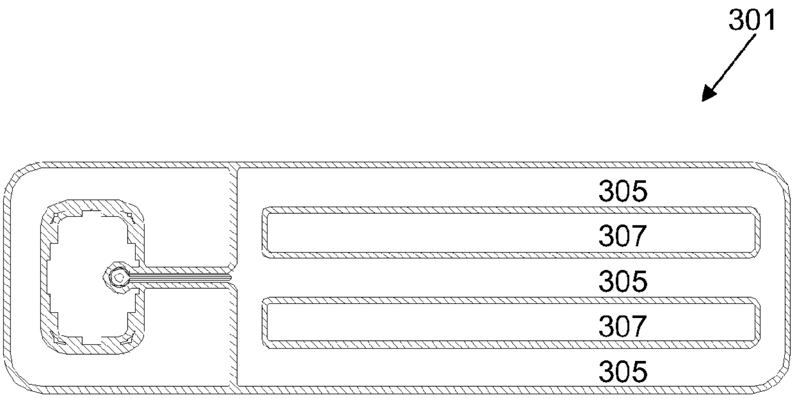

Figure 3a

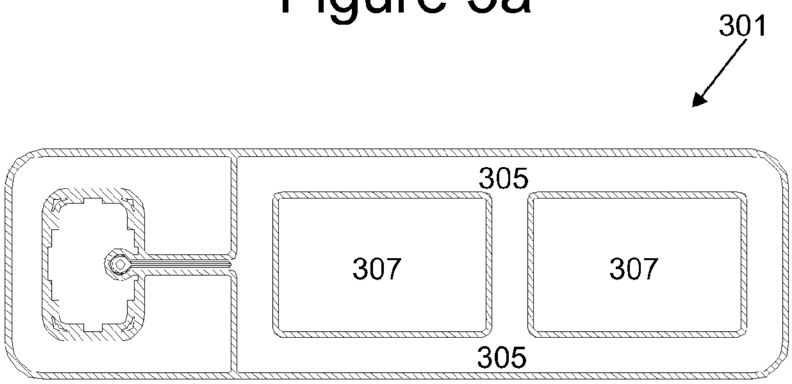

Figure 3b

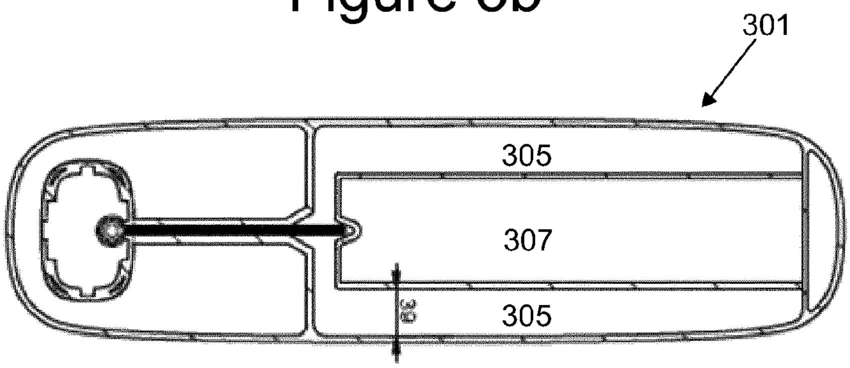

Figure 3c

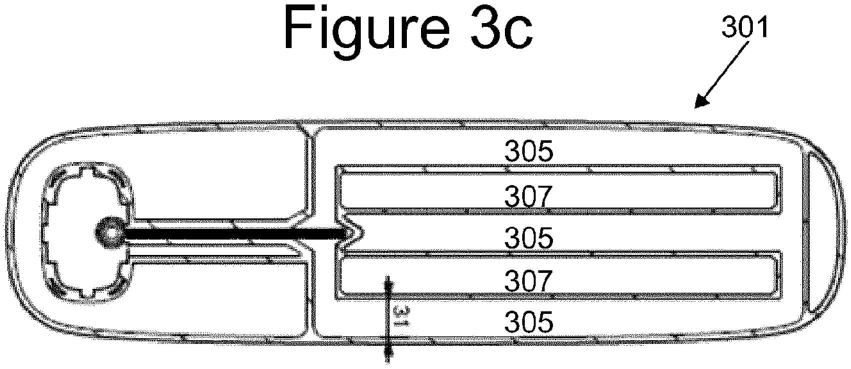

Figure 3d

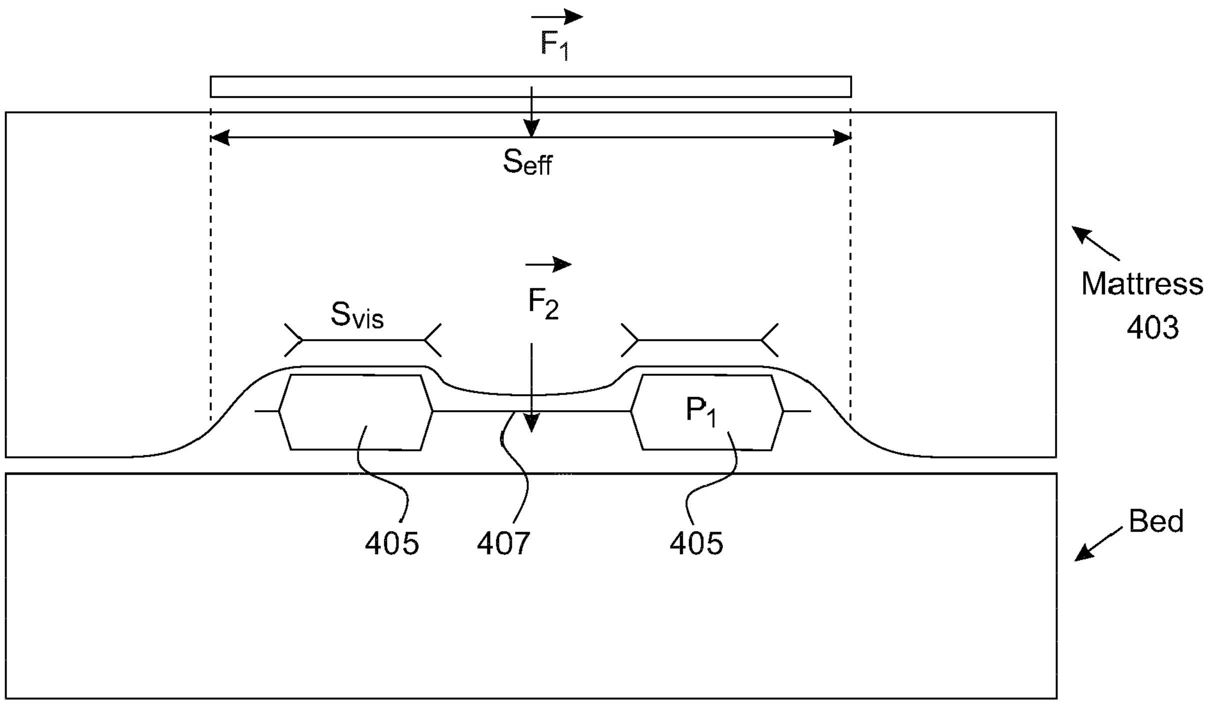

Figure 4

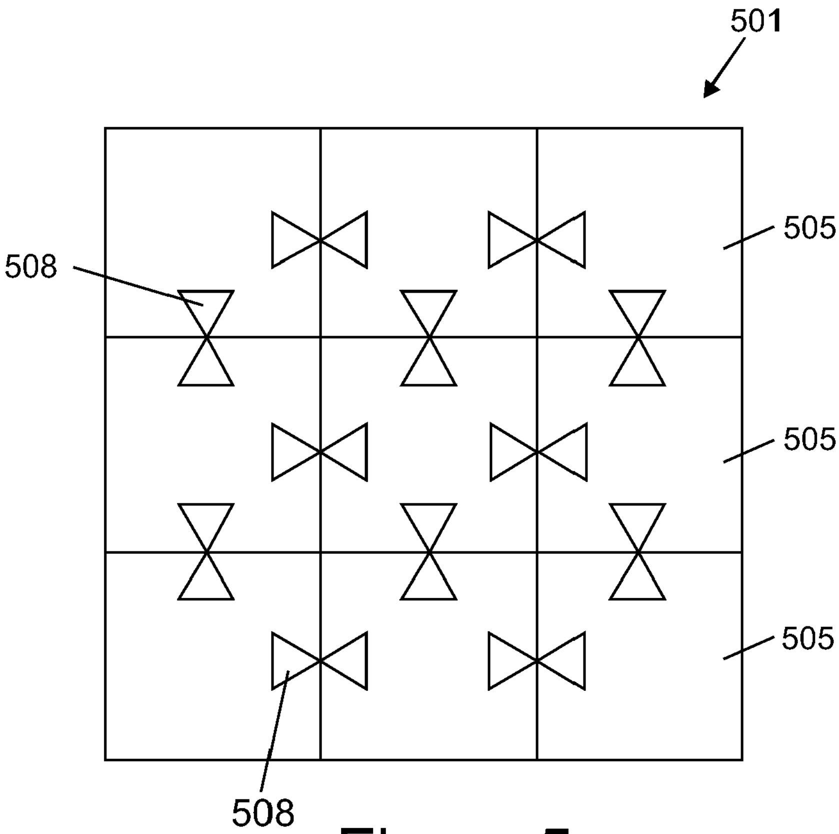

Figure 5

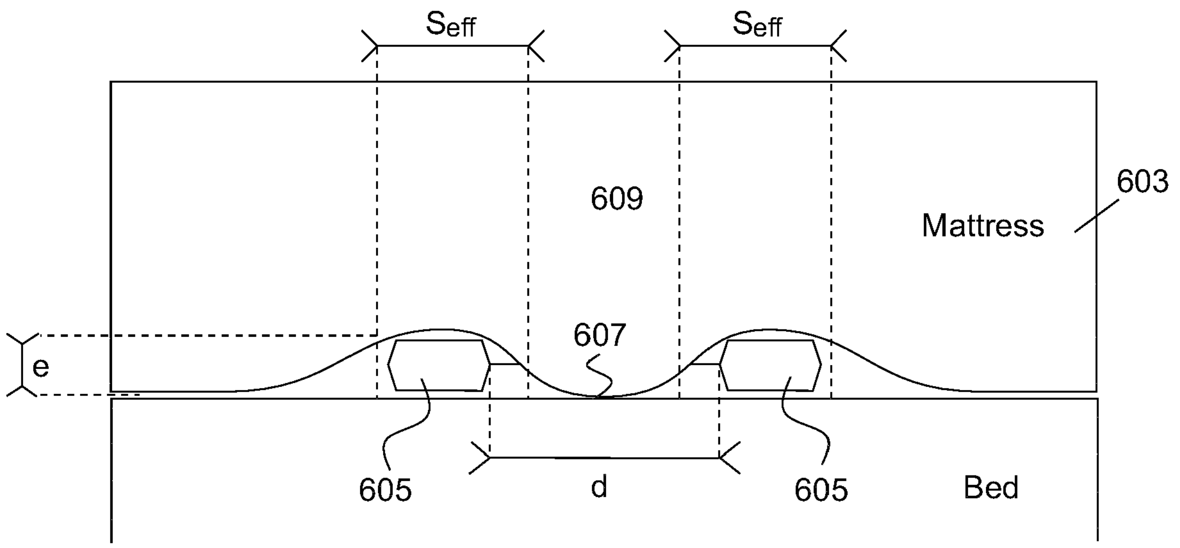

Figure 6a

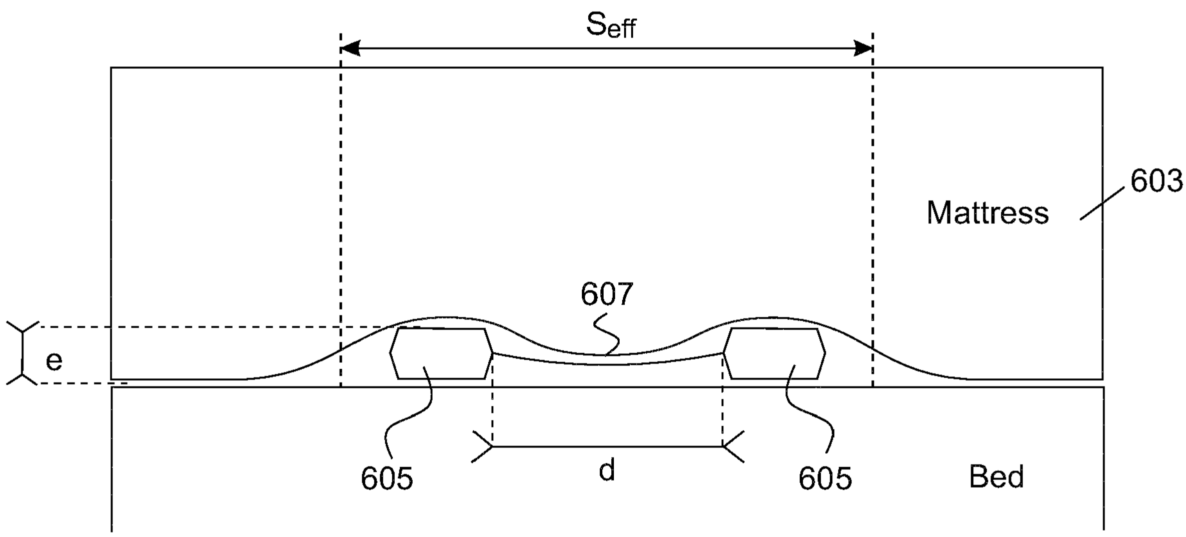

Figure 6b

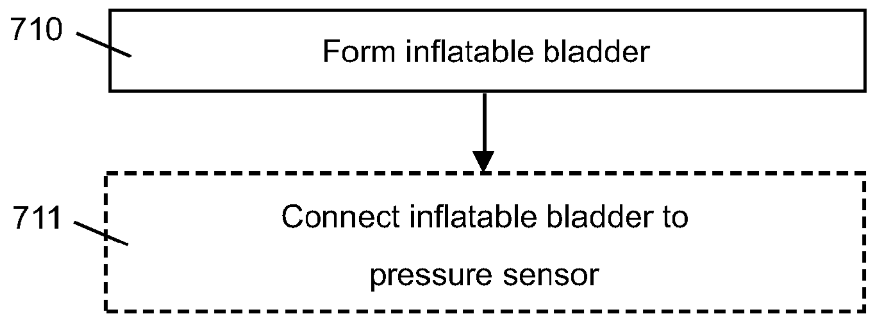

Figure 7

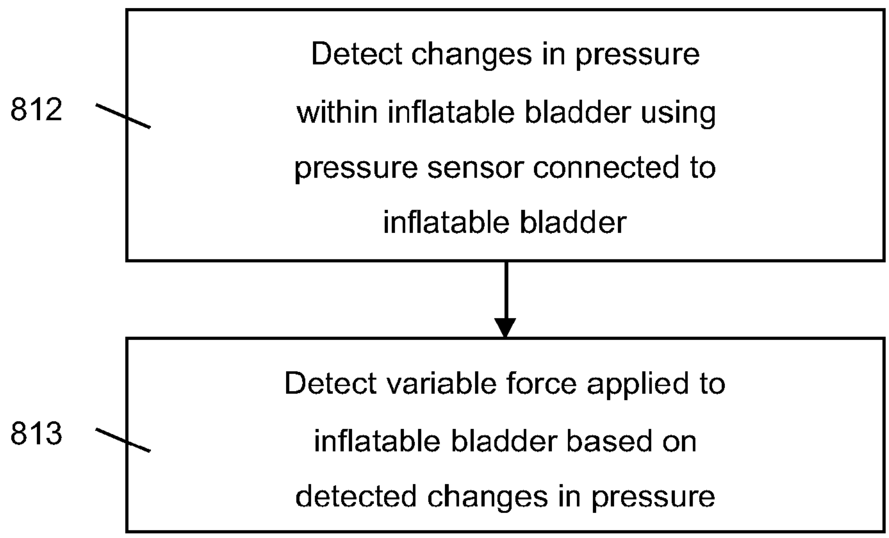

Figure 8

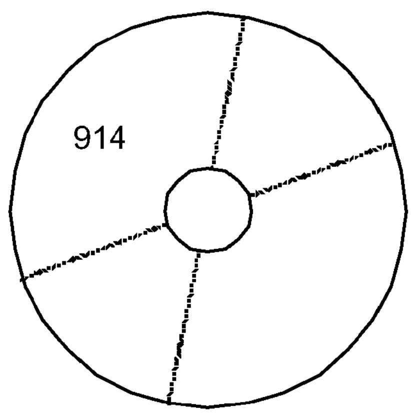

Figure 9

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EUROPEAN SEARCH REPORT

Application Number
EP 18 15 0657

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

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