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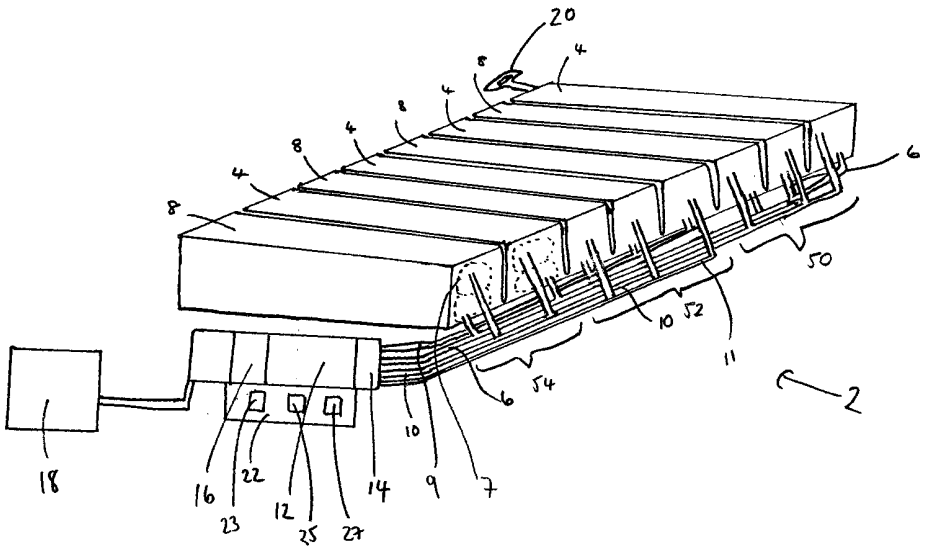
(54) Title: INFLATABLE MATTRESS SYSTEM AND METHOD OF USE THEREOF



(57) Abstract: There is provided an inflatable mattress system and method of use thereof. The mattress system includes a number of inflatable cells containing air, the air pressure therein being controlled by a pump which allows inflation and/or deflation of the cells. Solenoid valves communicate with the cells to monitor fluid flow and detect pressure feedback therefrom. Processing means are provided for controlling the inflation and/or deflation of one or more of the cells in a pre-determined configuration, via the pump. The processing means adjusts and/or sets the pressure in the cells in response to variations in pressure readings measured by the solenoid valves over pre-determined time intervals, relative to expected or pre-defined pressure readings stored in memory provided in or connected to the processing means. The processing means further limits the adjustment or setting of the pressure in the cells between pre-defined pressure ranges.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Inflatable Mattress System And Method of Use Thereof

This invention relates to an inflatable mattress system, and particularly to an inflatable mattress system for use by persons requiring prolonged periods of bed rest, and a method of use thereof.

Prolonged periods of bed rest may be required as a result of a disability, an illness, following an accident, as a result of old age and/or the like. A common problem with patients undergoing prolonged periods of bed rest is that they become susceptible to bed sores and areas of skin, which are in contact with the bed surface for extended periods of time, begin to break down. This problem can be alleviated by medical staff or home helpers regularly turning the person to ensure that pressure does not build up between the mattress and any part of the patient's body. A problem with turning the patient is that it is tiring and time consuming for the member of staff or home helper whose job it is to do this. In addition, the disturbance to the patient is undesirable and in some cases inappropriate.

A solution to this problem has been the provision of a mattress which moves instead of the patient having to move. The movement of the mattress is such that the patient is unlikely to be able to detect the movement. The mattresses typically comprise a plurality of cells in which the air pressure varies over time, thus varying the pressure between the areas of the body of the user contacting the mattress surface and preventing bed sores and break down of skin.

An example of a conventional mattress, typically comprises the mattress cells arranged in rows, with even rows communicating with a first hose and odd rows communicating with a second hose. The

cell pressure is varied cyclically by inflation/deflation of the cells using a pump communicating with the first and second hoses. The pump is provided with a timer such that air is alternately pumped through the first and second hoses, thus the even rows and odd rows are alternately inflated. The cycles of cell inflation typically vary between 2 – 20 minutes. Deflation of the cells is caused by air escaping from the interior of the cells and back through the pump into the surrounding atmosphere.

The inflatable mattress is typically located on a plurality of pressure sensor filaments, which lie directly underneath the mattress and communicate pressure information to a pressure gauge connected thereto. The sensor filaments activate the pump when contact is made between the mattress and the sensor filaments. The pressure gauge is set manually by an operator according to the weight of the patient on the bed and if the detected pressure is below the pre-set level, the pump increases the air pressure in the cells.

Problems encountered with these conventional inflatable mattresses are that the sensor filaments are fragile and the contacts of the same frequently break, thus providing inaccurate pressure readings in the mattress cells. As a result, the pump inflates the cells to an incorrect pressure, thus resulting in discomfort to the patient. The sensors under the mattress need to be placed on a flat surface to function properly and this can be difficult to achieve and not always possible. In addition, if the pressure gauge is not reset for each new bed user, the inflation pressure will be incorrect for the weight of the new user. This is likely to result in the mattress being too hard or too soft and causing discomfort to the user, which is undesirable.

If the patient moves to a sitting position on the mattress or moves such that the pressure on one part of the mattress increases, the mattress cells contact the pressure sensors, which indicates to the

pressure gauge that a heavier patient is now on the bed and this signals to the pump to change the inflation pressure of the entire mattress accordingly. A similar problem occurs if a visitor sits on the bed, the mattress cells touch the pressure sensors and the pressure gauge interprets this as a heavier person being in the bed and again changes the pressure accordingly. This is likely to result in over-inflation of the mattress cells, which can result in discomfort to the bed user and may increase the problems of bed sores rather than reduce the problem. Furthermore, different parts of the user's body are likely to require different levels of support and thus the pressure typically needs to be changed in different regions of the mattress. This is not possible with conventional mattresses which provide even pressure throughout the odd/even cells and, as a result, the support provided by a part of the mattress, such as where the user's torso is typically located, may be adequate but in a different region, such as where the user's head is located, the mattress may be too hard or too soft.

It is therefore an object of the present invention to provide an inflatable mattress and a method of using the same, which overcomes the abovementioned problems.

According to a first aspect of the present invention there is provided an inflatable mattress system, said inflatable mattress system including a plurality of inflatable cells, a pump for adjusting the fluid pressure in said cells by allowing inflation and/or deflation thereof, and pressure detection means for measuring the pressure in said cells, and characterised in that said system includes processing means for controlling the inflation and/or deflation of one or more of said cells in a pre-determined configuration, via the pump, by adjusting and/or setting the pressure in said one or more cells in response to variations in the pressure measured by the pressure detection means relative to expected or pre-defined pressure

readings, and between pre-defined pressure ranges, over one or more pre-determined time intervals.

The pre-defined pressure ranges can be input and stored in the processing means by the manufacturer and/or the operator of the mattress.

Preferably the processing means is provided in or in communication with a housing having a plurality of user-actuated buttons/dials thereon.

In one embodiment the user-actuated buttons/dials enable an operator to set a predicted pressure start point for the system and actuation of each button adjusts the pressure in the mattress cells between pre-defined pressure ranges. For example, actuation of the dials/buttons, can set the pressure of the cells to be "light", "medium" or "heavy". Thus, if the operator considers the mattress user is of light body weight, they can depress the light button and if the operator considers the mattress user is of heavy body weight, they can depress the heavy button. The pre-programmed threshold levels in the processing means and the pressure feedback from the pressure detection means ensure that if an incorrect starting point is given by the operator, the processing means signals to the pump to adjust the pressure level accordingly. The pressure feedback data received by the processing means via the solenoid valve, and signalling between the processing means and the pump, typically takes less than a few seconds such that the correct pressure in the cells is rapidly reached. However, it is also noted that the operator can override the system if required and in this case the cell pressure remains at the operator set level.

The pre-defined pressure ranges provided by the processing means prevent over-inflation and/or under-inflation of the mattress. This

is an important feature of the present invention as if the pressure detection means detects increased pressure feedback caused by a visitor sitting on the mattress, the processing means is informed of a requirement for a change in pressure but does not exceed pre-defined levels, so there is no risk to the mattress user that the mattress will become too hard or too soft. This provides a significant advantage over conventional mattresses, which do have means to adjust the pressure in the mattress between upper and lower threshold limits, and therefore do not have means to prevent operator error and/or account for visitors sitting on the bed.

Preferably the pressure detection means includes one or more valves which determine the pressure feedback from the cells caused by the user moving onto and/or on the mattress. This enables the pressure detection means to measure the pressure in the cells and to allow processing means and/or the pump to determine an appropriate degree of cell inflation and/or cell deflation required by a particular mattress user.

Further preferably the one or more valves are solenoid valves. The diameter of the solenoid valves can be varied for different mattress types.

Thus the present system detects fluid flow and pressure changes within the interior of the cells, rather than relying on sensor filaments to detect changes in pressure underneath the mattress as with conventional mattresses.

Preferably the processing means processes the pressure feedback information from the solenoid valves and activates the pump to adjust the pressure of the cells within pre-determined upper and lower limits. The processing means is typically pre-programmed

with values of appropriate cell pressures corresponding to pressure feedback data and these values provide the expected readings.

Preferably the processing means assesses the pressure feedback from the cells at pre-determined time intervals, such that transient pressure changes do not result in the pump being activated, but reoccurring pressure feedback data measured over one or more cycles results in the pump being activated. For example, if a visitor sits on an area of cells and increases the pressure feedback recorded in that area, the processing means and/or pump does not initially respond to the change in pressure detected until a similar pressure is detected over one or more repeated cycles. The upper and lower threshold values determined by the processing means will prevent the pressure in the mattress from being over-inflated or under-inflated, thereby preventing discomfort to the mattress user. As such the system acts to "fine tune" the pressure in the cells, thus providing the user with improved comfort to that of a conventional mattress.

The processing means can form part of a network via use of one or more modems, with a number of mattress systems controlled via a central processor, thereby allowing an operator to determine the status of all the mattress systems at any one time. Conventional mattresses cannot be networked in this manner. In the present invention, if a fault is detected in the network of beds, the central processor can inform the operator which bed has the fault and where the bed is located in the hospital or premises. The ability to monitor the beds from a central unit also allows indication of bed use to be monitored, such that for example, an operator can immediately determine whether a bed is free on a ward.

Typically the pump can adjust the pressure in the plurality of cells by inflating the same using a fluid such as air. Fluid moving back

through the solenoid valves is typically exhausted to the atmosphere.

Preferably hoses, pipes and/or the like connect the cells with the pump.

Preferably the mattress cells are divided into two or more distinct areas and each distinct cell area can have different internal pressures therein. The cells in each area can be made of the same and/or different materials.

In a preferred embodiment, the mattress cells are split into three distinct cell areas; a head region, a central body region and a lower limb region, the pressure in each area being separately controlled. For example, the central part of the bed typically requires a greater cell pressure than the lower limb region or the head region, since this is where a large proportion of the user's body weight is located.

Preferably the rows of cells within each area have different inflation cycles. For example, 1 in 2 cell rows can alternately inflate, 1 in 3 cell rows can alternately inflate and/or the like. In addition, the cells between areas and/or in areas of cells can be inflated for different periods of time.

Preferably each cell is divided into two compartments; an upper compartment and a lower compartment.

In one embodiment the compartments are divided into a "figure of 8" formation of approximately 8 inches deep, the top and bottom compartments each being approximately 4 inches deep.

In an alternative embodiment each cell is approximately 9 inches deep, the top and bottom compartment being 6 inches and 3 inches

respectively. Further combinations of depths of the top and bottom compartments can be provided.

Further preferably the lower compartment of each cell is provided with a one way valve such that if there is a power cut or if the upper compartment is punctured i.e., by a needle puncture, the lower compartment remains inflated and prevents the entire mattress from deflating. This ensures that a degree of inflation is maintained in the mattress cells for the comfort of the user.

Cardiopulmonary resuscitation (CPR) cannot be adequately performed with the mattress inflated and in one embodiment of the present invention a quick release valve is provided on the mattress, which communicates with one or more cell areas, such that if the mattress user requires CPR, the mattress can be deflated immediately and CPR can be given.

In a further embodiment a quick release valve is provided which operates the head portion of the mattress only, to enable procedures such as intubation and the like to be performed.

In one embodiment, the cells of the lower limb area are provided at an acute angle, typically inclined away from the cells of the other mattress areas. This prevents shearing of the heel area of the mattress user's foot if the user's foot falls between inflated and deflated cells.

Preferably the mattress is provided with a suitable protective cover. The cover can be easily removed and/or accessed for repair and maintenance, typically via a zip or sealing strip.

In one embodiment a static switch is provided in the system, such that when the switch is actuated the pressure in all the mattress cells can be equalised. This is advantageous if a procedure is to be performed on the mattress user which requires the user to be still, for example, if an injection is to be given. The static switch can be provided with a timer such that if the operator forgets to turn the static switch off after completing the procedure, the static switch reverts to the off position after a pre-determined time interval, thus ensuring the mattress user is not left in discomfort for a prolonged period of time.

Preferably the mattress system is provided with an alarm to notify an operator in the event of a problem, for example, notifying the operator that the mattress has a puncture. The alarm can be provided to signal on one or more of the timed cycles.

According to a second aspect of the present invention there is provided a method of using an inflatable mattress system, said inflatable mattress system including a plurality of inflatable cells and pump means, and characterised in that said method includes the steps of obtaining one or more pressure readings from said cells continuously or periodically using pressure detection means, comparing said pressure reading(s) with expected or pre-defined pressure readings using processing means and, at pre-determined time intervals, adjusting or setting the pressure in said cells, via said pump means, in response to variations detected between said pressure reading(s) and said expected/predefined readings, and said processing means limiting the adjustment or setting of the pressure in said cells between pre-defined pressure ranges.

Due to the cell arrangement in the conventional inflatable mattresses, the cells typically require cell pressure to be approximately 130 mmHg to provide sufficient support for the user

and to provide a sufficient pressure difference between the inflated cells and the deflated cells. The cell arrangement in the mattress according to the present invention typically requires a cell pressure of between 30-80mmHg.

An embodiment of the present invention will now be described with reference to the accompanying Figures wherein:

Figure 1 is a schematic representation of the mattress system according to the present invention;

Figure 2 is a side view of the cell areas of the mattress system;

Figure 3 is an enlarged cross sectional view taken through a cell;

Figures 4a-4c illustrate examples of different combinations of inflation/deflation of the mattress cells.

Referring to the figures, there is illustrated an inflatable mattress system 2 according to the present invention, said mattress system 2 including a plurality of rows of cells; even row cells 4, and odd row cells 8.

The cell rows 4 and 8 are divided into three distinct areas, a head region 50, a central body region 52 and a lower limb region 54. The pressure in the three areas 50, 52 and 54 can be controlled separately and each area has different upper and lower threshold pressure values, as set by processing means 18. Each cell is divided into upper and lower compartments (as shown by dotted lines 7) and each compartment has a connection with a hose, which in turn communicates with a pump 12.

There are typically six cells provided within each region but it is noted that any combination of cells can be provided in accordance with the present invention. In addition, fewer cells are shown in figure 1 for the purposes of clarity.

Hoses 6 and 10 communicate with head region 50 and lower limb region 53. Hoses 9 and 11 communicate with central body region 52.

The pump 12 inflates the different cells and cell regions via the hoses to the required pressure as set by the processing means. Pressure detection means in the form of solenoid valves 14 are located at the ends of the hoses and monitor the pressure feedback from the cells caused by a person lying on the mattress and/or moving on the mattress. A timer 16 is provided to vary the pressure in the cell rows 4, 8 and regions cyclically over pre-determined time intervals and the processing means 18 determines an appropriate degree of cell inflation required by the particular mattress user.

Processing means 18 processes the feedback information from the solenoid valves 14 and activates the pump 12 to adjust the pressure of the cells accordingly. The processing means 18 is pre-programmed with upper and lower threshold limits and values of appropriate cell pressures corresponding to known pressure feedback data.

The processing means 18 assesses the pressure feedback at pre-determined time intervals such that transient pressure changes do not result in the pump being activated. However reoccurring pressure feedback data measured over one or more cycles result in the pump means being activated within the pre-defined upper and lower threshold limits. These threshold limits prevent the mattress from being over-inflated or under-inflated, an advantage which is not provided for by conventional mattresses.

Further control means 22 are provided having a "light" button 23, a "medium" button 25 and a "heavy" button 27. These buttons enable an operator to set a predicted pressure start point for the system 2. Thus if the operator considers the patient is of light body weight, they can depress the "light" button 23. If the actuated button corresponds to a pressure which is different from the feedback information received by the processing means and pressure detection means, the processing means signals to the pump to inflate and/or deflate the cells accordingly within the pre-determined thresholds set for each button. The operator can override the system if required.

The cells of the lower limb region 54 are provided at an acute angle to the cells in regions 50, 52 to prevent shearing of the heel area of the mattress user's foot, which can be caused by the foot falling between inflated and deflated cells. The cells of the central and head regions 50 and 52 are substantially vertical.

Referring to Figure 3, there is illustrated a cross sectional view through a cell. The cell is divided into two compartments, an upper compartment 56 and a lower compartment 58, which form a "figure of eight" type of formation. Hoses 60 and 62 connect with compartments 56, 58 respectively. The hoses 60 and 62 join with the hoses 6, 9, 10 and 11 depending on which region the cell is in. The hose 62 contains a one way valve (not shown) such that if there is a power cut or if the upper compartment is punctured, the lower compartment does not deflate, thus ensuring a degree of inflation is maintained in the mattress cells for the comfort of the user.

A quick release valve 20 is provided on the mattress system 2 which communicates with all the cells, and when actuated rapidly deflates the entire mattress. This enables CPR to be performed if required.

A quick release valve can be provided to deflate the head region 50 only of the mattress to enable procedures such as intubation to be performed.

The processing means 18 can form part of a network so that an operator can control a number of mattresses via a central processor and determine the status of any particular mattress at any one time. Thus for example, a number of inflatable mattress/beds in an intensive care ward of a hospital can be controlled via a central processor, such that if a fault develops in any bed, the operator is informed immediately of which bed the fault has occurred in and where that bed is in the network.

The processing means typically includes a programmable logic control system.

The timer can be programmed to inflate the cells on any predetermined cycle and the combination of the cells that are inflated at any one time can also be varied. Figures 4a-4c illustrate examples of different combinations of cell inflation/deflation that are possible with the system of the present invention. The size of the cells in these figures illustrate the degree of inflation/deflation at a particular time. For example, large upper compartment cells 56' have higher air pressure than smaller lower compartment cells 58'. Shaded cells are being inflated and non-shaded cells are being deflated.

A static switch can be provided (not shown) which allows the pressure in all the mattress cells to be equalised. This is typically used if a procedure needs to be performed which requires the mattress and/or mattress user to be still.

An audible alarm can be provided with the system to inform an operator if cell pressure becomes too low or too high.

Thus it can be seen from the above description that the present invention provides a mattress system which resets the cell pressure in the mattress according to the pressure feedback data detected over one or more cycles from one or more different cell areas and according to the upper and lower limits controlled by the processing means. The upper and lower threshold values ensure that if the patient moves on the bed or if a visitor sits on the bed, the cell pressure does not vary beyond these threshold limits, thereby preventing the patient from being left in discomfort for any extended period of time.

Claims:-

1. An inflatable mattress system, said inflatable mattress system including a plurality of inflatable cells, a pump for adjusting the fluid pressure in said cells by allowing inflation and/or deflation thereof, and pressure detection means for measuring the pressure in said cells, characterised in that said system includes processing means for controlling the inflation and/or deflation of one or more of said cells in a pre-determined configuration, via the pump, by adjusting and/or setting the pressure in said one or more cells in response to variations in the pressure measured by the pressure detection means relative to expected or pre-defined pressure readings, and between pre-defined pressure ranges, over one or more pre-determined time intervals.

2. An inflatable mattress system according to claim 1 characterised in that one or more valves are provided in communication with the cells to detect changes in pressure in said cells.

3. An inflatable mattress system according to claim 2 characterised in that the one or more valves detect feedback pressure from the cells.

4. An inflatable mattress system according to claim 2 characterised in that said one or more valves are solenoid valves.

5. An inflatable mattress system according to claim 4 characterised in that the solenoid valves are provided in the pump.

6. An inflatable mattress system according to claim 4 characterised in that the fluid is a gas, and gas moving from the cells through the solenoid valve(s) is exhausted to the atmosphere.

7. An inflatable mattress system according to claim 1 characterised in that hoses or pipes connect the cells with the solenoid valve(s) and/or pump.

8. An inflatable mattress system according to claim 1 characterised in that the plurality of cells are divided into two or more distinct areas.

9. An inflatable mattress system according to claim 8 characterised in that the pressure in each area is separately controlled by the processing means, such that each area has one or more pre-defined pressures or pressure ranges and/or inflate/deflate at or over different time intervals.

10. An inflatable mattress system according to claim 8 characterised in that three distinct areas are provided; a head region, a central body region and a lower limb region.

11. An inflatable mattress system according to claim 1 characterised in that each cell is divided into at least an upper compartment and a lower compartment.

12. An inflatable mattress system according to claim 11 characterised in that the upper and lower compartment are provided in a "figure of eight" formation.

13. An inflatable mattress system according to claim 11 characterised in that the fluid pressure in the lower and upper

compartments are separately controlled by the processing means.

14. An inflatable mattress system according to claim 11 characterised in the lower compartment(s) of one or more cells is/are provided with one or more one way valves.

15. An inflatable mattress system according to claim 1 characterised in that a quick release valve is provided in connection with the cells to allow rapid deflation of said cells.

16. An inflatable mattress system according to claim 15 characterised in that the quick release valve is connected to cells corresponding to a head region of the mattress.

17. An inflatable mattress system according to claim 1 characterised in that a switch or valve is provided to allow equalisation of the pressure in the cells for a pre-determined time period.

18. An inflatable mattress system according to claim 1 characterised in that the cells corresponding to a lower leg region of the mattress are provided at an acute angle to the remaining cells.

19. An inflatable mattress system according to claim 1 characterised in that the cells are provided in a removable outer cover.

20. An inflatable mattress system according to claim 1 characterised in that an alarm is provided if the pressure readings in one or more of said cells fall below and/or rise above pre-determined pressure readings.

21. An inflatable mattress system according to claim 1 characterised in that the fluid pressure in said cells is between 30-80mmHg.

22. An inflatable mattress system according to claim 1 characterised in that the processing means forms part of a network including a number of mattress systems controlled by a central processor.

23. An inflatable mattress system according to claim 1 characterised in that the processing means has one or more user-input controls.

24. A method of using an inflatable mattress system, said inflatable mattress system including a plurality of inflatable cells and pump means, characterised in that said method includes the steps of obtaining one or more pressure readings from in said cells continuously or periodically using pressure detection means, comparing said pressure reading(s) with expected or pre-defined pressure readings using processing means, and at pre-determined time intervals adjusting or setting the pressure in said cells, via said pump means, in response to variations detected between said pressure reading(s) and said expected/predefined readings, and said processing means limiting the adjustment or setting of the pressure in said cells between pre-defined pressure ranges.

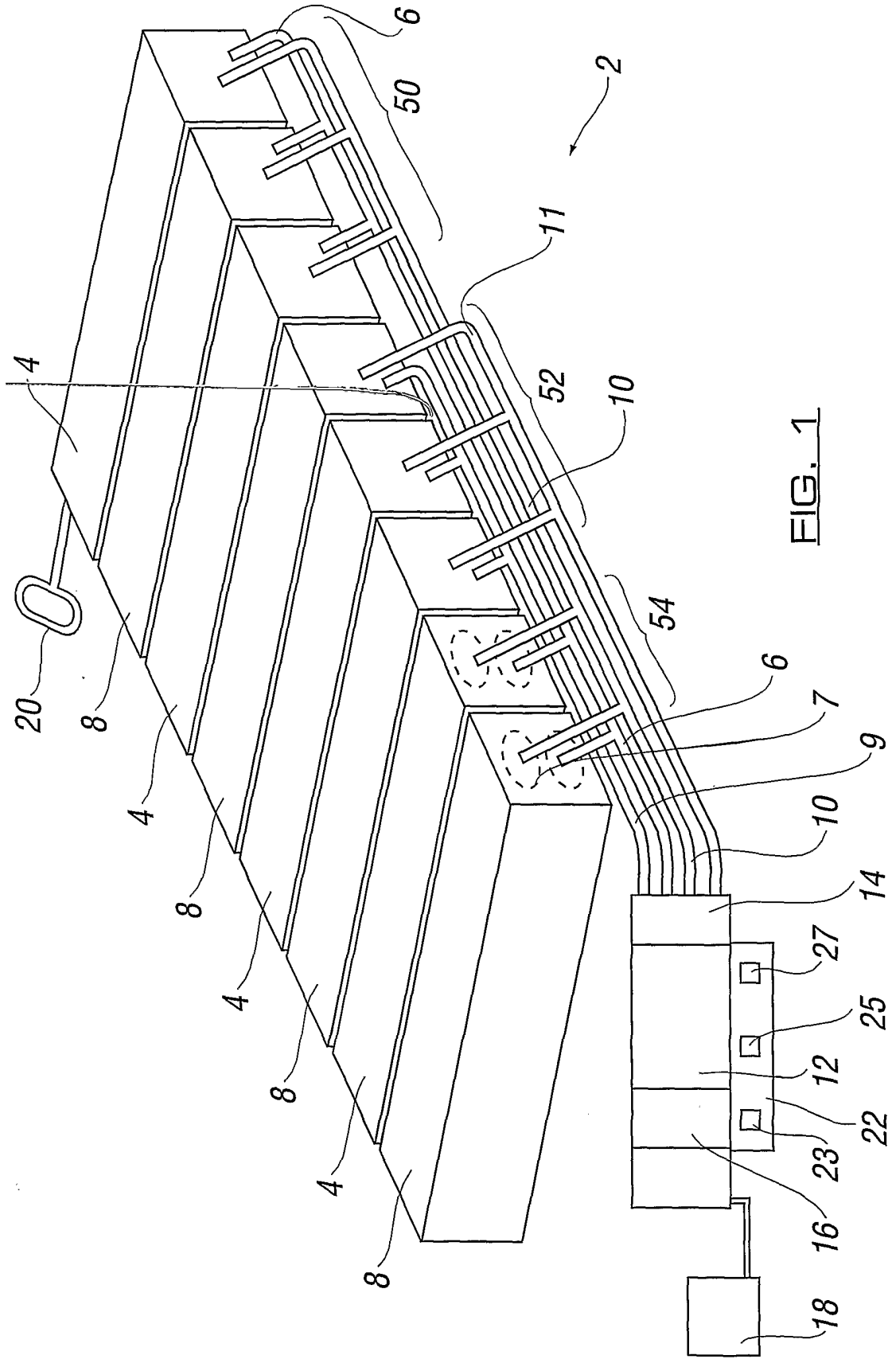

FIG. 1

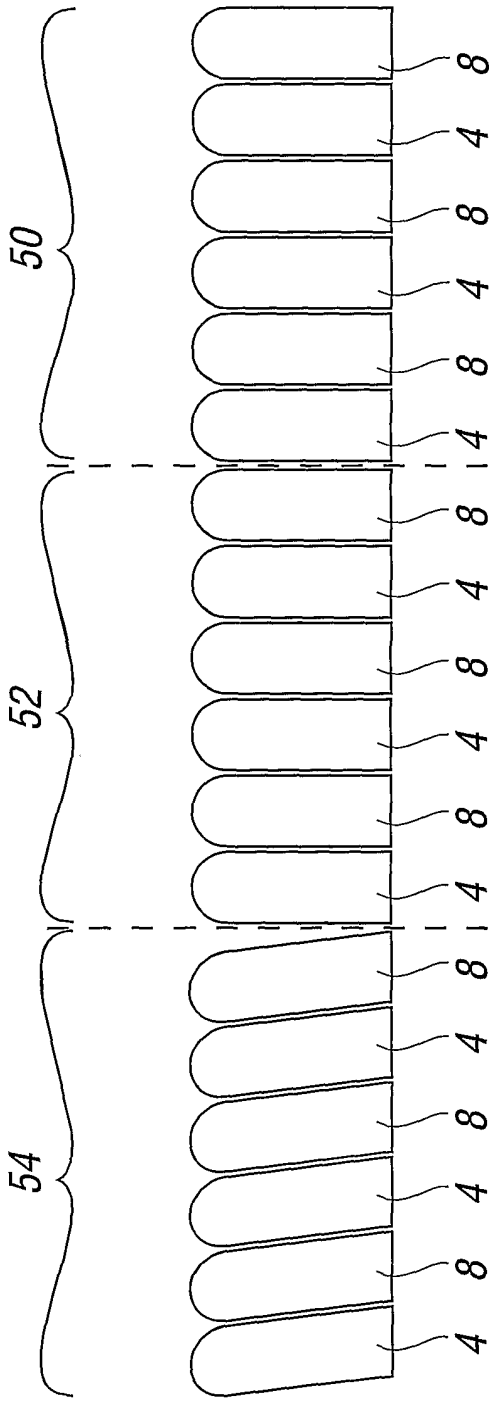

FIG. 2

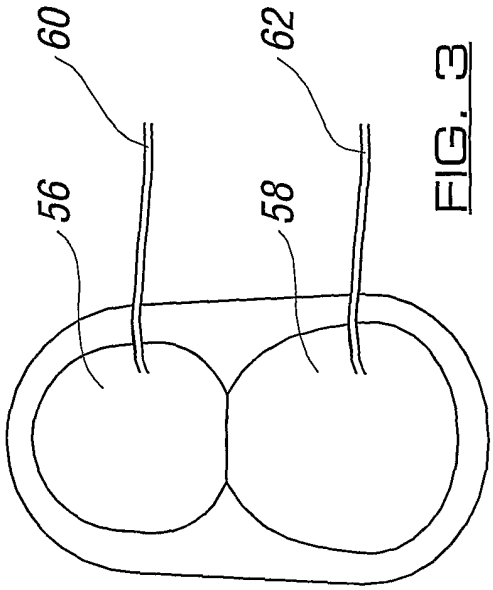

FIG. 3

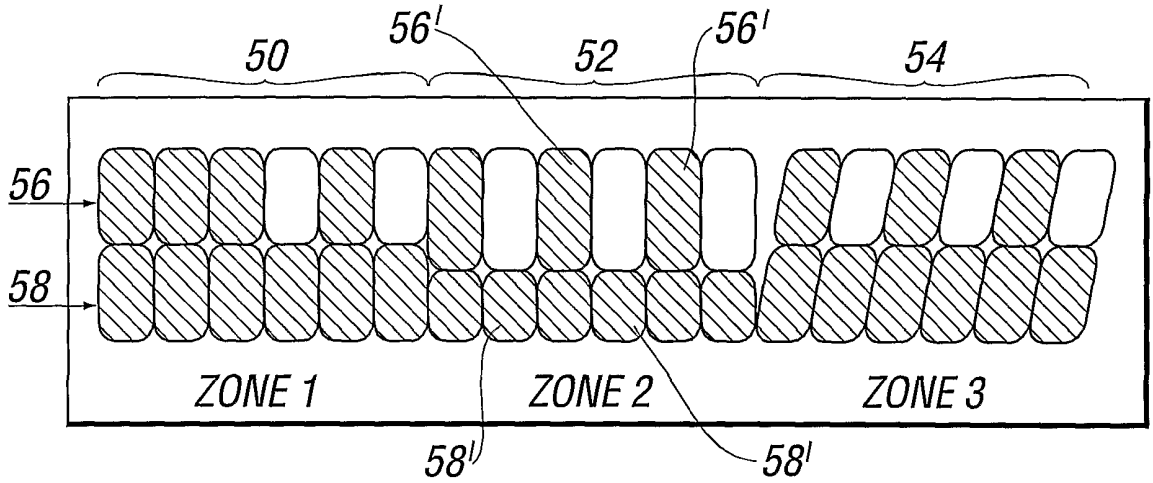

FIG. 4A

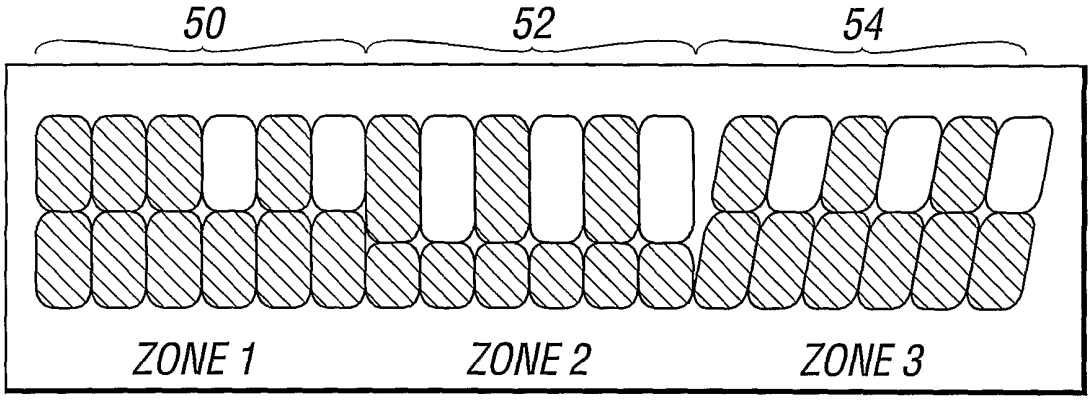

FIG. 4B

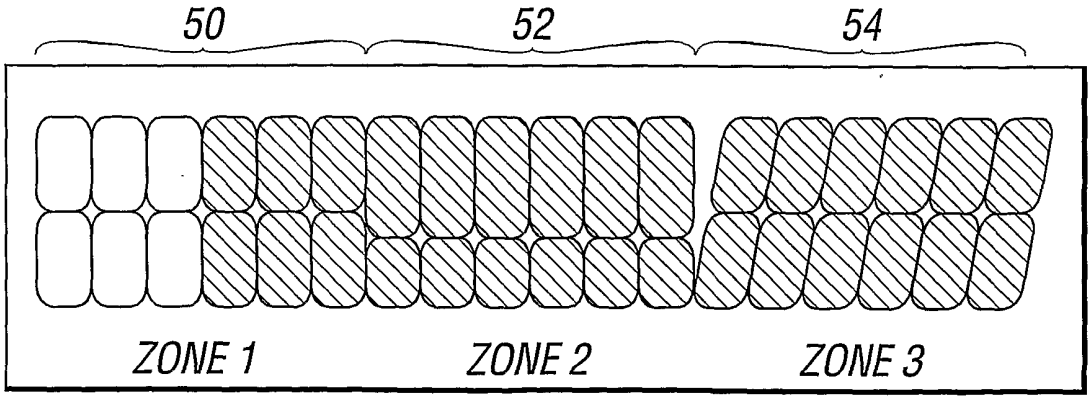

FIG. 4C

INTERNATIONAL SEARCH REPORT

Int nal Application No
PCT/GB 01/03819

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61G7/057

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61G

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 168 213 A (TALLEY MEDICAL EQUIPMENT LTD) 15 January 1986 (1986-01-15)	1,2, 4-10,21, 24
A	page 11, line 6 - line 17	3,15-20, 22,23
	page 15, line 5 - line 14; figures	

X	US 5 103 519 A (HASTY CHARLES E) 14 April 1992 (1992-04-14) column 9, line 62 -column 10, line 15	1-4,6-9, 15,23,24
A	column 11, line 11 - line 14 column 11, line 44 - line 49; figures	5,16-22

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
18 December 2001	27/12/2001

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INTERNATIONAL SEARCH REPORT

Int[illegible]ial Application No
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