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(72) Inventors:
• **Gelmetti, Nicola**
37017 Lazise (VR) (IT)
• **Martinelli, Fabio**
37029 San Pietro in Cariano (VR) (IT)

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(74) Representative: **Fisauli, Beatrice A. M.**
Con Lor S.p.A
Via Renato Fucini, 5
20133 Milano (IT)

(71) Applicant: **MKS Innovatech S.r.l.**
20135 Milano (IT)

(54) **Apparatus with inflatable mattress and method for supporting a patient with said apparatus**

(57) Method of operation of a system (110) for supporting a patient, that comprises: - an inflatable mattress (10) comprising a first series of cells (21) and a second series of cells (25); - detecting means to detect the air pressure in the inside of the first series of cells (21) and the air pressure in the inside of the second series of cells (25); - a compressor (60) to inflate said inflatable mattress (10); - a valve (64) having a discharge connection (70) for the discharge in the outer ambient, said valve (64) being connected through a first conduit (72) to the first series of cells (21) of the inflatable mattress (10), through a second conduit (74) to the second series of cells (25), and through a feed conduit (62) to the compressor (60);

- a controller (100), connected to the valve (64), to the pressure detecting means and to the compressor (60); characterized by the fact that the system comprises further: - at least one control chamber (30, 38, 48, 66, 94, 96, 120), placed under the patient and connected to a pressure sensor (98), to the compressor (60) in order to be inflated, and to a discharge (70) in order to be deflated; said pressure sensor (98) being connected to the controller (100).

The method is adapted to calculate the supporting pressure of a patient on an inflatable bedsores mattress (10) on the base of parameters such as, for instance, weight and position.

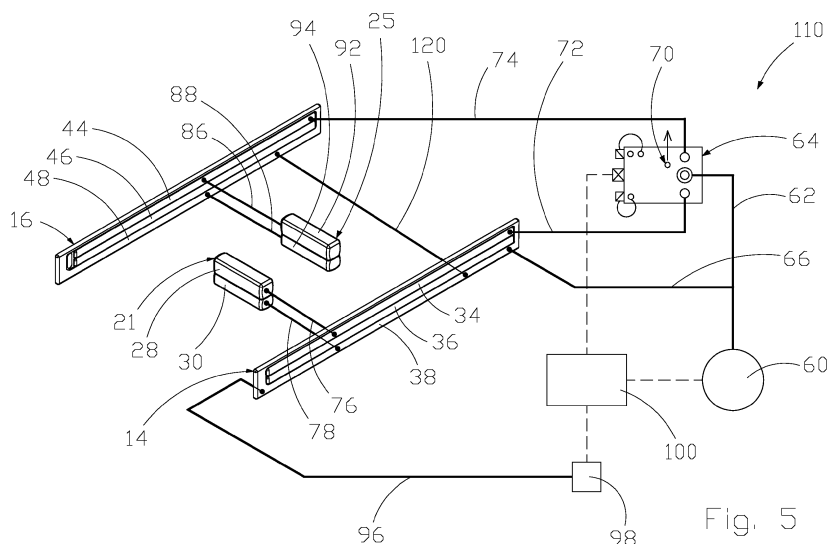


Fig. 5

Description

[0001] The present invention refers, in general, to a system with an inflatable mattress and a method of operation for said system.

[0002] More particularly, the present invention refers to a system comprising an inflatable bedsores mattress and a method of operation for said system.

[0003] As is known, there exist several typologies of anti-decubitus mattresses which usually have at least two series of cells which are inflated and deflated alternately according to predefined time cycles in order to vary over time the position of the patient who lies on the mattress by varying the zones of support of the patient on the mattress.

[0004] Thus, the bedsores mattresses are inflated by one or more compressors whose operation has to be controlled by a suitable management and control system which adjusts the inflation and deflation of each of the two series of cells in the mattress.

[0005] In particular, these management and control systems have to ensure the maintenance of a correct pressure of the mattress on the body of the patient. A typology of inflating systems according to prior art provides that air flowing out of the mattress, or rather flowing out of the two series of cells, flows into a sensor mat placed under the mattress so that the sensor mat detects the pressure that the user or patient puts on the mattress.

[0006] However, a system like this does not allow to obtain an efficient control of the pressure applied on the mattress. Besides, the mattress has to be continuously fed because the air, even if in a variable quantity, flows from the mattress to the sensor mat and from the sensor mat to the outside.

[0007] Another typology of inflating systems according to prior art, visible in figure 1, provides that an inflatable mattress B comprising a first series of cells C and a second series of cells D is fed through a valve F by a compressor E. The compressed air flows from the compressor E through a conduit G to the valve F.

[0008] The valve F allows to convoy the compressed air through the conduit H to the first series of cells C or, alternately, through a conduit I to the second series of cells D.

[0009] The valve F communicates also with an exhaust L from which the air flows out in the outside, as indicated with reference M. The pressure of the air M flowing out of the exhaust L is measured by a pressure sensor N, positioned near the exhaust L.

[0010] The system according to prior art inflates and deflates the cells by means of the valve F, according to preset times. For instance, for a certain interval of time, the first series of cells C remains inflated at a first pressure while the second series of cells D is at a second pressure which is lower than the first pressure.

[0011] Then, the system may change the distribution of the pressures inside the inflatable mattress B by deflating the first series of cells C and inflating the second

series of cells D.

[0012] The air discharged from the first series of cells C flows, therefore, out of the exhaust L while its pressure is measured by the pressure sensor N.

5 **[0013]** In this way, the system tries to evaluate the weight and posture of the patient without using a sensor mat and measures an air pressure drop in a preset time.

[0014] Then, the system compares the value of the detected air pressure drop with experimental values contained in a database in order to ascertain the optimal pressure for the inflation of the cells in the next cycle. In this way, it is possible to guarantee an evaluation of the weight and posture of the patient which varies over time and a consequent adaptation is possible.

10 **[0015]** The known systems may evaluate the weight and posture of the patient also during the inflation phase of the cells. This measurement takes place by discharging some cells while the cells are inflated. Thus, it is estimated a ratio between a preset time and the interval of pressure measured near the exhaust L during the inflation of the cells.

[0016] An example of such systems is disclosed in US 6,789,284.

15 **[0017]** However, these systems do not allow a precise, reliable evaluation of the optimal pressure for the inflation of the cells of the controlled anti-decubitus mattress.

20 **[0018]** The pressure sensor N is not capable of measuring a comparable, repeatable pressure value because the measured pressures are variable for the sensor is affected by the air flowing out of the exhaust L.

25 **[0019]** Another problem of the so-described system is caused by the method of measuring the pressure drop which can be evaluated by initial pressures, even very different from each other, owing to the different pressure of the cells when the cells start to be deflated by the system, instant in which the measurement of the pressure drop begins.

30 **[0020]** Another problem of the system is due to the variability of the measurements according to the posture of the patient. In fact, when the patient rests on a number of cells of the first series of cells C different from the number of cells of the second series of cells D, the system will supply two different evaluations according to the cells that the system deflates or inflates each time. For instance, a patient sitting, who distributes his/her weight on four cells of the first series of cells C and on two cells of the second series of cells D, will be evaluated in two different ways according to the cells that will be deflated or inflated.

35 **[0021]** With reference to figure 2, two measurements are described according to the so-described method.

40 **[0022]** The graph shows the evolution O of the pressure inside a cell as a function of time when this cell is connected to a determined exhaust of the system. However, the evolution O is not linear and is difficult to evaluate. In a first situation, the pressure of the cell is high owing to the presence of a very heavy patient or owing to a patient disposed in a position such as to cause said

high pressure or owing to the fact that the monitored cell is one of the cells having a higher pressure in the alternating cycle.

[0023] When the system deflates the cell and measures its pressure drop P1 in a predetermined time T, the evolution of the pressure over time involves a measurement of a pressure range of a high entity.

[0024] A second situation refers to a cell that is deflated starting from an inner pressure lower than that of the first situation.

[0025] This second situation may be due to a patient less heavy than the previous patient or to a patient disposed according to a different posture, or to the fact that the monitored cell is one of the cells having a lower pressure in the alternating cycle.

[0026] In this second situation, in the predetermined time T, the system measures a pressure drop P2 different and lower than the previous pressure drop P1. The system must, therefore, be equipped of a complex database containing a large amount of experimental data in order to ascertain all the pressure drops that the system detects in the predetermined time T.

[0027] In addition, the system is not capable to ensure a repeatability owing to the difficulty in evaluating a non-linear behavior of deflation.

[0028] Accordingly, the prior art systems are not capable to determine with precision and reliability the combination of weight and posture of the patient resting on the inflatable mattress in order to try to adjust the pressure at which the cells will be inflated in the next cycle.

[0029] Besides, said prior art systems do not ensure safety to the supported patient because the cells could be discharged completely on causing the patient to touch the ground with unwished effects and an inefficiency of the function of the anti-decubitus mattress.

[0030] An aim of the invention is to carry out a mattress inflating system overcoming the problems of the prior art.

[0031] Another aim of the invention is to supply a mattress inflating system of low consumption and simple operation.

[0032] Another aim of the invention is that the evaluation of the optimal pressure at which the cells of the mattress are inflated is more precise and reliable without being affected by the problems described above.

[0033] All the so-described aims and others are achieved according to the invention by a method of operating a system for supporting a patient, adapted to calculate the supporting pressure of a patient on an inflatable mattress on the base of parameters such as, for instance, weight, position. The system comprises:

- a first series of cells and a second series of cells included in the inflatable mattress;
- detecting means to detect the air pressure in the inside of the first series of cells and the air pressure in the inside of the second series of cells;
- a compressor to inflate said inflatable mattress;
- a valve having a discharge connection for the dis-

charge in the outer ambient, said valve being connected through a first conduit to the first series of cells of the inflatable mattress, through a second conduit to the second series of cells, and through a feed conduit to the compressor;

- a controller connected to the valve, to the pressure detecting means and to the compressor.

[0034] The method comprises the steps of:

- inflating the first series of cells or the second series of cells at a supporting pressure;
- deflating the first series of cells at a pressure lower than the supporting pressure if the second series of cells has been inflated at the supporting pressure, or deflating the second series of cells at a lower pressure than the supporting pressure if the first series of cells has been inflated at the supporting pressure.

[0035] The method is characterized by the fact that the system comprises further:

- one or more control chambers placed under the patient and connected to a pressure sensor, to the compressor in order to be inflated, and to a discharge in order to be deflated;
- said pressure sensor being connected to the controller;

[0036] In addition, the method is characterized by the fact of comprising the steps of:

- choosing initially a first pressure and a second pressure so as to have a first predetermined pressure and a second predetermined pressure;
- inflating or deflating the one or more control chambers;
- measuring an indicative time to be spent by the one or more control chambers to pass from a first pressure to a second pressure, both pressures being detected by the pressure sensor;

calculating the supporting pressure on the base of the indicative time as measured in the previous phase.

[0037] The so-described method allows to determine the supporting pressure on the base of the indicative time, with a measurement of the time spent by the one or more control chambers to pass from a first pressure to a second pressure, on obtaining a precise estimation of the weight and posture of the patient, both during the inflation and during the deflation of the inflatable mattress. The first pressure and/or the second pressure are predetermined so as to compare the indicative time measured to pass from the first pressure to the second pressure with experimental data having the same first pressure and/or the same second pressure.

[0038] In this way, it is possible to make the determination of the supporting pressure independent from the

course of the pressure so as to obtain measurements that may be easily compared with experimental data.

[0039] Besides, the discharge connection of the valve may comprise a calibrated hole.

[0040] The presence of the calibrated hole allows air to go out of the mattress through one or more holes whose dimensions and features have been determined previously. The measurements effected with said calibrated hole allow a comparison with experimental data obtained with other exhausts or discharges having calibrated holes.

[0041] Advantageously, the controller may control the start of the inflation and/or deflation of the control chamber from a reset pressure that is higher than the first pressure in case of a deflation, or lower than the first pressure in case of an inflation, the indicative time being measured in any case as time spent by the control chamber to pass from the first pressure to the second pressure.

[0042] In any case, the start from a reset pressure allows the controller to measure the indicative time from the moment that the control chamber passes from the first pressure to the second pressure, there being the additional advantage of obtaining a more accurate, precise measurement because the variable transitional phenomena occurring at the beginning of the inflation or deflation are excluded.

[0043] This advantage is important in case of a deflation because the time required to pass from the first pressure to the second pressure is usually shorter than the passage time required in case of an inflation.

[0044] More advantageously, the first series of cells and/or the second series of cells may comprise a dynamic portion and a static portion, which are separated from each other. The static portions may communicate with each other through connecting means. The static portions may be connected to the compressor and to the pressure sensor. The control chamber may comprise said static portions.

[0045] The so-described construction allows the static portions to form, at least partially, the control chamber. The static portions of the cells communicate with each other and therefore, are always at the same pressure and behave as an only element so that an only control chamber is obtained.

[0046] In addition, the static portion may be connected at a first point with the pressure sensor and at a second point with the compressor and valve, said first point being disposed at an end of the inflatable mattress and said second point being disposed at the opposite end so as to space them and to deflate the static portion by means of the discharge of the valve.

[0047] The so-described construction allows to obtain as much distance as possible between the exhaust or discharge of the valve, where air goes out of the static portion and/or the control chamber, and the pressure sensor. In this way, a large amount of air is interposed between the pressure sensor and the exhaust and this air has to flow through the elements forming the control

chamber in order to go out of the discharge of the valve. Thus, the pressure sensor measures a pressure under conditions of static fluids. The pressure measurement does not undergo the measurement errors of the prior art, due to a leakage of air in the vicinity of the pressure sensor.

[0048] Advantageously, the controller may start said measurement of indicative time on starting the system and when the controller detects a pressure variation in the at least one control chamber, said pressure variation being evaluated as a pressure jump occurred in a predetermined time, said pressure variation is intended by the controller as a variation of weight and/or posture of the patient supported by the inflatable mattress.

[0049] In this way, abrupt changes are filtered because the system detects small movements of the patient but the system does not consider them while the system considers the pressure variations that are maintained for a predetermined time that is not an impulsive time.

[0050] More advantageously, said pressure jump exceeds a predetermined threshold level.

[0051] Since the pressure jump has to overcome a predetermined threshold level, it is possible to filter the small movements of the patient or the small changes in weight and/or posture that cause pressure variations in the control chamber. In this way, it is possible to have the start of the measurement of indicative time only in those cases in which the variation of weight and/or posture of the patient are such as to impose a variation in the support pressure.

[0052] Besides, there may be only one control chamber which extends for the whole length of the inflatable mattress. In this way, the problems of the prior art are overcome. In fact, the prior art measures the patient in a different way according to the series of cells that are charged or discharged while in the method and system according to the invention, the determination of the supporting pressure of the patient is always based on a measurement of the variation of weight and/or posture over the entire length of the mattress.

[0053] The aims are also achieved according to the invention by a system, adapted to support a patient. The system comprises:

- an inflatable mattress, placed under the patient and comprising a first series of cells and a second series of cells;
- detecting means to detect the air pressure in the inside of the first series of cells and the air pressure in the inside of the second series of cells;
- a compressor to inflate said inflatable mattress;
- a valve having a discharge connection for the discharge in the outer ambient, said valve being connected through a first conduit to the first series of cells of the inflatable mattress, through a second conduit to the second series of cells, and through a feed conduit to the compressor;
- a controller, connected to the valve, to the pressure

detecting means and to the compressor.

[0054] The system is characterized by the fact of comprising further:

- one or more control chambers, placed under the patient and connected to a pressure sensor, to the compressor in order to be inflated, and to a discharge in order to be deflated.

[0055] The pressure sensor is connected to the controller.

[0056] The so-described construction allows the patient to be supported by the first series of cells and second series of cells while the measurement of the support pressure is effected by inflating and/or deflating the control chamber. Advantageously, the first series of cells and/or the second series of cells comprises a dynamic portion and a static portion which are separated from each other, said static portions being communicating with each other through means of connection, said static portions being connected to the compressor and to the pressure sensor and acting as a control chamber.

[0057] In this way, the cells are divided according to their function into two distinct portions. Since the static chambers communicate with each other, they may form an only control chamber.

[0058] More advantageously, the static portion may be connected at a first point with the pressure sensor and at a second point with the compressor and valve, said first point being placed at an end of the inflatable mattress and said second point being placed at the opposite end so as to space them and to deflate the static portion through the discharge of the valve.

[0059] With such a construction it is possible to obtain as much distance as possible between the valve discharge, where air goes out of the static portion and/or out of the control chamber, and the pressure sensor so as to obtain the advantages outlined above and below.

[0060] Advantageously, the discharge connection of the valve may comprise a calibrated hole.

[0061] The presence of the calibrated hole allows air to go out of the mattress through one or more holes whose dimensions and features have been predetermined. The measurements made by using said calibrated hole allow a comparison with experimental data obtained by using other discharges or exhausts having calibrated holes.

[0062] Further features and details of the invention will be better understood from the following description supplied as a non-limiting example as well as from the accompanying drawings wherein:

Fig. 1 is a diagram of an apparatus equipped with an inflatable mattress according to prior art;

Fig. 2 is an evaluation of the course of pressure in relation to time of a cell in its deflation phase;

Fig. 3 shows an inflatable mattress of a system equipped with an inflatable mattress, according to

the invention;

Fig. 4 is a detail of the inflatable mattress in Fig. 3, according to the invention;

Fig. 5 shows a system equipped with an inflatable mattress, according to the invention.

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[0063] With reference to the accompanying figures, in particular Figure 3, reference number 10 denotes an inflatable mattress comprising a top sheet 11 and a conduit for feeding air from the outside (not visible in the figure).

[0064] The top sheet 11 is joined to a bottom sheet 15, for instance by means of a zipper. A first series of cells 21 and a second series of cells 25 are arranged between the upper sheet 11 and the bottom sheet 25 so as to obtain an alternate configuration of each cell of the first series of cells 21 with the corresponding cells of the second series of cells 25.

[0065] The first series of cells 21 and the second series of cells 25 are maintained in position by a pair of bands 23 that surround each cell from a right manifold 14 and a left manifold 16, the latter being visible in Figure 4.

[0066] As visible in Figure 4, each cell of the first series 21 comprises a first chamber 28 and a second chamber 30, which are separated by means of a diaphragm 32.

[0067] The right manifold 14 comprises a first right track 34, a second right track 36 and a third right track 38. The third right track 38 surrounds the first right track 34 and the second right track 36.

[0068] Similarly, the left manifold 16 comprises a first left track 44, a second left track 46 and a third left track 48. The third left track 48 surrounds the first left track 44 and the second left track 46.

[0069] Conveniently, a safety mat 40 is placed between the second chamber 30 and the lower sheet 15 for the safety of the patient.

[0070] With reference to Figure 5, reference number 110 denotes a system comprising an inflatable mattress 10, as described above, and a compressor 60. The compressor 60 communicates through a first feed conduit 62 with a valve 64 and communicates through a second feed conduit 66 with the third right track 38 of the right manifold 14 of the inflatable mattress.

[0071] The valve 64 comprises four connections with the outside, namely, one connection being connected with the first feed conduit 62, two delivery conduits comprising a respective pressure-gauge and a last discharge connection 70.

[0072] The discharge connection 70 is conveniently obtained with a calibrated hole so as to have a controlled, predetermined discharge flow, useful to a correct operation of the system 110 as described below.

[0073] Besides, the valve 64 comprises an inner mechanism that puts two or more of the four connections to the outside in communication with each other in order to allow a continuous adjustment of the valve 64 and passage of the air inside the valve 64.

[0074] The first series of cells 21 of the inflatable mattress 10 is fed by the right manifold 14 and the second

series of cells is fed by the left manifold 16. Inside the inflatable mattress, each cell of the first series of cells 21 is alternated with a cell of the second series of cells 25.

[0075] A first delivery conduit 72 of the valve 64 communicates with the first right track 34 of the right manifold 14 while a second delivery conduit 74 of the valve 64 communicates with the first left track 44 of the left manifold 16.

[0076] The first right track 34 sends compressed air through a first connection 76 to the first series of cells 21 while the first left track 44 sends compressed air through a second connection 86 to the second series of cells 25. The first series of cells 21 and the second series of cells 25 are visible in the figure in a lower number in order to make the invention more evident. As a matter of fact, the cells are present in a higher number and are alternated to each other consecutively, as visible in Figure 3.

[0077] The third right track 38 and the third left track 48 communicate by means of a bridge 12 that allows to make the air pressure uniform.

[0078] The first chambers 28 correspond to the dynamic portion of the first series of cells 21, this dynamic portion being fed by the first connection 76 directly, while the second chambers 30 correspond to the static portion communicating through a static connection 78 with the right track 38 of the right manifold 14. Below, the reference number 28 is utilized to denote the dynamic portion and the reference number 30 is utilized to denote the static portion.

[0079] Similarly, the second series of cells 25 comprises a dynamic portion 92, fed by the second connection 86 directly, and a static portion 94 communicating through a static connection 88 with the third left track 48 of the left manifold 16.

[0080] The second right track 36 and the second left track 46 may be utilized to inflate and deflate two further possible series of cells supporting body parts different from those subjected to the action of the first series of cells 21 and second series of cells 25, for instance in order to supply pressure to a sector supporting the feet.

[0081] At an end of the right manifold 14, opposite the end to which the second feed conduit 66 is connected, a sensor conduit 96 is connected and communicates with a pressure sensor 98.

[0082] A controller 100 controls and monitors the operation of the compressor 60, the valve 64 and the pressure sensor 98.

[0083] Below, the operation of the system equipped with an inflatable mattress according to the invention is described.

[0084] With reference to Figure 5, the operation of the system 110 is actuated by the controller 100 that orders the compressor to supply compressed air to the first feed conduit 62 and to the second feed conduit 66 so as to supply compressed air to the valve 64 and to the third right track 38 of the right manifold 14 and to inflate, consequently, the static portion 30 of the first series of cells 21 and the static portion 94 of the second series of cells

25 which reach, therefore, the same pressure since they are in communication with each other.

[0085] In addition, the controller 100 controls the valve 64 so that the valve 64 puts the first feed conduit 62 in communication with the first delivery conduit 72 and/or with the second delivery conduit 74 on inflating the dynamic portion 30 of the first series of cells 21 and/or the dynamic portion 92 of the second series of cells 25, respectively.

[0086] Besides, the controller 100 may deflate, through the control of the inner mechanism of the valve 64, the dynamic portion 28 of the first series of cells 21 on putting the first delivery conduit 72 in communication with the discharge 70 of the valve 64. Similarly, the dynamic portion 92 of the second series of cells 25 may be deflated on putting the second delivery conduit 74 in communication with the discharge 70 of the valve 64. The deflation of the respective dynamic portions may take place whether the compressor 60 is operating or the compressor 60 is not operating and therefore, it does not supply compressed air to the first feed conduit 62.

[0087] When the compressor 60 is off, it is possible to discharge air through the discharge 70 of the valve 64 also from the second feed conduit 66, through the first feed conduit 62. Thus, it is possible to obtain the deflation of the static portion 30 of the first series of cells 21 and the static portion 94 of the second series of cells 25 through their respective connections with the third right track 38 and with the third left track 48.

[0088] The controller 100 controls the pressure of the air contained in the relative dynamic portions of the first series of cells 21 and second series of cells 25 by means of the two pressure-gauges contained in the valve 64 for the first delivery conduit 72 and the second delivery conduit 74.

[0089] The pressure of the air contained in the static portions is controlled by the pressure sensor 98.

[0090] The operation of the system 110 according to an alternate mode is described below. Here, the system 110 performs an operating cycle in which the body of the patient is supported alternately by the first series of cells 21 and second series of cells 25 of the inflatable mattress by changing the air pressure in each point of the inflatable mattress over time.

[0091] The system 110 brings alternately the first series of cells 21 and the second series of cells 25 to the so-called support pressure that is the optimal pressure for the support of the patient depending mainly on the weight and posture of the patient resting on the inflatable mattress.

[0092] The support pressure for supporting the patient may vary over time depending, for instance, on the presence or absence of the patient on the inflatable mattress, the presence of a patient of different weight, each change of posture or position of the patient and other factors or events affecting the patient or the system 110.

[0093] Conveniently, during the operation in the alternate mode, the system 110 always maintains the static

portions of the inflatable mattress at a pressure higher than the atmospheric pressure so as to ensure a safe support for the patient. The system 110 allows, therefore, to obtain an alternation of the supporting points of the patient by alternating the inflation and/or deflation of the dynamic portions of the inflatable mattress.

[0094] Below, a method is described to determine the support pressure, (called evaluation cycle hereinafter) which allows an evaluation of the support pressure when the system 110 is started, as well as an evaluation of its variation over time, due to the factors listed above.

[0095] When the system 110 is started and a patient is supported by the inflatable mattress, the controller 100 actuates the compressor 60 and arranges the valve 64 in such a way that the first feed conduit 62 is in communication with the first delivery conduit 72 and with the second delivery conduit 74 in order to inflate the dynamic downstream portions. The compressed air supplied by the compressor 60 inflates also all the static portions of the inflatable mattress through the second feed conduit 66.

[0096] Through both pressure-gauges included in the valve 64 and through the pressure sensor 98, the controller 100 allows the dynamic portions of the inflatable mattress to be inflated so as to reach an initial pressure, for instance a support pressure evaluated or preset that corresponds, for instance, to 25 mm of mercury. When this condition has been reached, the controller 100 orders the valve 64 to separate the first delivery conduit 72 and the second delivery conduit 74 from the first feed conduit 62 so as not to further inflate the dynamic portions of the inflatable mattress.

[0097] The controller 100 keeps the compressor 60 alight on allowing a further inflation of the static portions of the inflatable mattress so as to reach a reset pressure that will be, therefore, higher than the initial pressure at which the dynamic portions of the inflatable mattress are inflated. For instance, the reset pressure may be 32 mm of mercury.

[0098] When the pressure sensor 98 detects the reaching of the reset pressure in the static portions of the inflatable mattress, the controller 100 may, conveniently, orders the turning off of the compressor 60 so as to obtain a remarkable energy saving in comparison with the known systems in which the compressor remains always alight. Of course, the compressor 60 may be turned on again and utilized in the various operation phases of the system 110, for instance after a predetermined time has elapsed, for instance a time of 5 or 10 minutes, after which it is necessary to alternate the pressures of the air contained in the respective dynamic portions of the first series of cells 21 and second series of cells 25.

[0099] While the support of the patient is ensured by maintaining the dynamic portions of the inflatable mattress at the initial pressure, the controller 100 orders the valve 64 to put the first feed conduit 62 in communication with its discharge 70 so as to deflate the static portions or the inflatable mattress through the calibrated hole of

the discharge 70.

[0100] When the pressure sensor 98 detects a pressure corresponding to a start pressure, for instance of 30 mm of mercury, the controller 100 starts measuring an indicative time, spent to reach a stop pressure, for instance of 20 mm of mercury, detected by the pressure sensor 98, the stop pressure being lower than the start pressure. When the stop pressure has been reached, the controller 100 orders the valve 64 to stop the communication between the first feed conduit 62 and the discharge 70 so as not to further deflate the static portions of the inflatable mattress.

[0101] The indicative time, spent to reach the stop pressure beginning from the start pressure, is evaluated by the controller 100 to obtain an estimation of the support pressure that will be applied in a subsequent time, the evaluated pressure being indicative of the weight and posture of the patient supported by the inflatable mattress.

[0102] The controller 100 evaluates the support pressure by taking advantage of a database of experimental data that correlate the measured indicative time with corresponding times obtained in the experiments, to which a determined support pressure has been correlated.

[0103] Conveniently, the database may supply time intervals for which a determined optimal support pressure is provided in order to simplify the collection of the experimental data and the processing thereof in view of a correct operation of the system 110.

[0104] Besides, a correlation table may be drafted to bind the measured time intervals with the respective suggested support pressures.

[0105] The controller 100 monitors the pressure sensor 98 and the pressure-gauge of the valve 64 continuously to detect any abrupt pressure changes due to a change of patient or to a change of posture in order to proceed with a new estimation of the optimal support pressure for the new condition by utilizing the so-described evaluation cycle.

[0106] In this way, it is possible to obtain an estimation of the support pressure easy to be obtained automatically, safe and reliable.

[0107] The reliability of the estimation is ensured by the distance between the discharge 70 of the valve 64 and the pressure sensor 98, which distance allows the pressure sensor 98 to continuously detect a pressure that is not affected by the air flow going out of the discharge 70 of the valve 64 while the pressure sensors in the known systems are placed near the discharge. Indeed, in the system according to the invention, the pressure sensor 98 is connected to the third right track 38 at the end opposite the second feed conduit 66 so that any pressure variations due to the air flow going out of the discharge 70 are absorbed by all the static portions connected to the third right track 38 and to the third left track 48.

[0108] The safety of the patient is ensured by the continuous support given by the dynamic portions of the in-

flatable mattress, whose pressure is not modified during the evaluation cycle that affects only the static portions of the inflatable mattress.

[0109] According to a variant of the invention, the determination of another indicative time may be obtained by measuring the interval of time spent to inflate the static portions of the inflatable mattress from a start pressure to a final pressure higher than the start pressure.

[0110] If a pressure interval is fixed between the start pressure and the final pressure, the time spent to reach the final pressure will vary depending on the above mentioned factors, for instance variations of weight or posture of the patient.

[0111] Even in this case, the controller 100 may evaluate the support pressure by taking advantage of a database of experimental data correlating the new measured indicative time with corresponding times obtained experimentally, to which a determined pressure of optimal support has been correlated. Conveniently, the database may comprise time intervals for which a determined support pressure is provided so that the collection of the experimental data and the processing thereof is simplified in view of a simpler operation of the system 110.

[0112] Accordingly, it is possible to obtain another correlation table in order to bind the measured time intervals with the respective suggested support pressures. In addition, this further method for the estimation of the support pressure of the patient does not need the use of the discharge 70 of the valve 64 because the presence of a discharge could make the pressure values measured by the pressure sensor 98 unstable and false, as occurs in the known systems.

[0113] The evaluation cycle according to the invention always utilizes the same pressure interval for the evaluation of the time spent and evaluates a support pressure on the base of said time so that the evaluation cycle according to the invention offers the advantages of greatly simplifying the collection of experimental data and avoiding the possibility of causing a too fast and uncontrolled deflation, which could make the patient touch the ground.

[0114] The estimation according to the known systems, which takes place by effecting the deflation for a predetermined time and evaluating then the consequent pressure drop, is subjected to all the problems mentioned above. The subdivision of each cell of the inflatable mattress according to the invention into a dynamic portion and a static portion allows to subdivide two functions of the system in the space.

[0115] In fact, a first function, that is the support of the patient on ensuring an alternation of pressures between the first series of cells and the second series of cells so as to avoid the formation of bedsores and other problems is effected by the whole of the dynamic portions of the cells.

[0116] On the contrary, a second function, that is the evaluation of the weight and posture of the patient for the estimation of a correct support pressure is effected by

the whole of the static portions.

[0117] In the known systems, the two functions carried out in a different way were performed by each cell inside a single chamber.

[0118] In addition, the system according to the invention improves the patient safety because the patient is supported by two layers that may be considered independent to each other so that in case a layer should be defective, the other layer, formed by the whole of the static portions, would continue ensuring the patient support on avoiding that the patient touches the ground unintentionally.

[0119] Finally, further variants and constructive systems are possible which are to be considered as included in the scope of protection as defined by the following claims.

Claims

1. Method of operating a system (110) for supporting a patient, adapted to calculate the supporting pressure of a patient on an inflatable mattress (10) on the base of parameters such as, for instance, weight, position, said system (110) comprising:

- a first series of cells (21) and a second series of cells (25) included in the inflatable mattress (10);
 - detecting means to detect the air pressure in the inside of the first series of cells (21) and the air pressure in the inside of the second series of cells (25);
 - a compressor (60) to inflate said inflatable mattress (10);
 - a valve (64) having a discharge connection (70) for the discharge in the outer ambient, said valve (64) being connected through a first conduit (72) to the first series of cells (21) of the inflatable mattress (10), through a second conduit (74) to the second series of cells (25), and through a feed conduit (62) to the compressor (60);
 - a controller (100) connected to the valve (64), to the pressure detecting means and to the compressor (60);
- said method comprising the steps of:
- inflating the first series of cells (21) or the second series of cells (25) at a supporting pressure;
 - deflating the first series of cells (21) at a pressure lower than the supporting pressure if the second series of cells (25) has been inflated at the supporting pressure, or deflating the second series of cells (25) at a lower pressure than the supporting pressure if the first series of cells (21) has been inflated at the supporting pressure, said method being **characterized by** the fact that the system comprises further:
 - at least one control chamber (30, 38, 48, 66,

- 94, 96, 120) placed under the patient and connected to a pressure sensor (98), to the compressor (60) in order to be inflated, and to a discharge (70) in order to be deflated;
- said pressure sensor (98) being connected to the controller (100);
 - and by the fact of comprising the steps of:
 - choosing initially a first pressure and a second pressure so as to have a first predetermined pressure and a second predetermined pressure;
 - inflating or deflating the at least one control chamber (30, 38, 48, 66, 94, 96, 120);
 - measuring an indicative time to be spent by the at least one control chamber (30, 38, 48, 66, 94, 96, 120) to pass from a first pressure to a second pressure, both pressures being detected by the pressure sensor (98);
 - calculating the supporting pressure on the base of the indicative time as measured in the previous phase.
2. Method according to one of the preceding claims, wherein the discharge connection (70) of the valve (64) comprises a calibrated hole.
 3. Method according to one of the preceding claims, wherein the controller (100) controls the start of the inflation and/or deflation of the control chamber (30, 38, 48, 66, 94, 96, 120) from a reset pressure that is higher than the first pressure in case of a deflation, or lower than the first pressure in case of an inflation, the indicative time being measured in any case as the time spent by the control chamber (30, 38, 48, 66, 94, 96, 120) to pass from the first pressure to the second pressure.
 4. Method according to one of the preceding claims, wherein the first series of cells (21) and/or the second series of cells (25) comprises a dynamic portion (28, 92) and a static portion (30, 94), which are separated from each other, said static portions (30, 94) being communicating with each other through connecting means (38, 48, 78, 88, 120), said static portions being connected to the compressor (60) and to the pressure sensor (98) and wherein the control chamber comprises said static portions (30, 94).
 5. Method according to the preceding claim, wherein the static portion (30, 94) is connected at a first point (96) with the pressure sensor (98) and at a second point (66) with the compressor and valve (64), said first point (96) being disposed at an end of the inflatable mattress (10) and said second point (66) being disposed at the opposite end so as to space them and to deflate the static portion (30, 94) by means of the discharge (70) of the valve (64).
 6. Method according to one of the preceding claims, wherein the controller (100) starts said measurement of indicative time on starting the system (110) and when the controller detects a pressure variation in the at least one control chamber, said pressure variation being evaluated as a pressure jump occurred in a predetermined time, said pressure variation is intended by the controller (100) as a variation of weight and/or posture of the patient supported by the inflatable mattress (10).
 7. Method according to the preceding claim, wherein said pressure jump exceeds a predetermined threshold level.
 8. Method according to one of the preceding claims, wherein there is only one control chamber which extends for the whole length of the inflatable mattress (10).
 9. System (110), adapted to support a patient, said system (110) comprising:
 - an inflatable mattress (10), placed under the patient and comprising a first series of cells (21) and a second series of cells (25);
 - detecting means to detect the air pressure in the inside of the first series of cells (21) and the air pressure in the inside of the second series of cells (25);
 - a compressor (60) to inflate said inflatable mattress (10);
 - a valve (64) having a discharge connection (70) for the discharge in the outer ambient, said valve (64) being connected through a first conduit (72) to the first series of cells (21) of the inflatable mattress (10), through a second conduit (74) to the second series of cells (25), and through a feed conduit (62) to the compressor (60);
 - a controller (100), connected to the valve (64), to the pressure detecting means and to the compressor (60);
 - characterized by the fact that** the system comprises further:
 - at least one control chamber (30, 38, 48, 66, 94, 96, 120), placed under the patient and connected to a pressure sensor (98), to the compressor (60) in order to be inflated, and to a discharge (70) in order to be deflated;
 - said pressure sensor (98) being connected to the controller (100).
 10. System (110) according to the preceding claim, wherein the first series of cells (21) and/or the second series of cells (25) comprises a dynamic portion (28, 92) and a static portion (30, 94) which are separated from each other, said static portions (30, 94) being communicating with each other through means of connection (38, 48, 78, 88, 120), said static portions

being connected to the compressor (60) and to the pressure sensor (98) and acting as a control chamber.

11. System (110) according to the preceding claim, 5
wherein the static portion (30, 94) is connected at a first point (96) with the pressure sensor (98) and at a second point (66) with the compressor and valve (64), said first point (96) being placed at an end of the inflatable mattress (10) and said second point (66) being placed at the opposite end so as to space 10
them and to deflate the static portion (30, 94) through the discharge (70) of the valve (64).
12. System (110) according to one of claims 9 to 11, 15
wherein the discharge connection (70) of the valve (64) comprises a calibrated hole.

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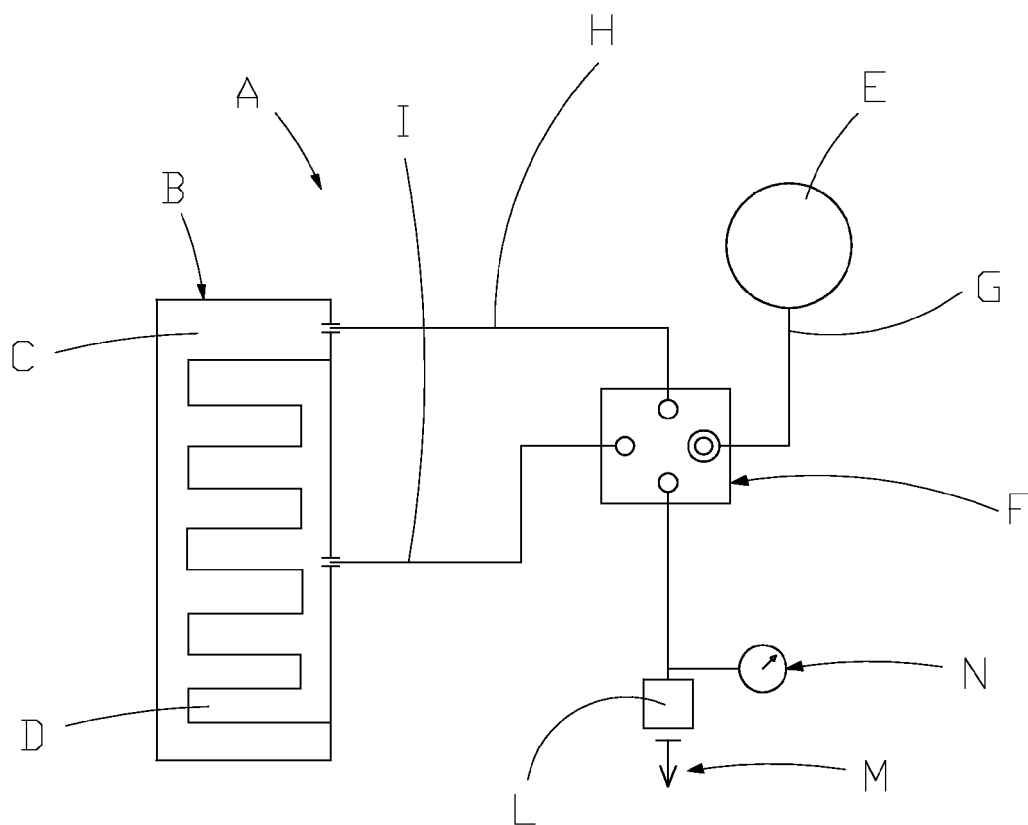


Fig. 1

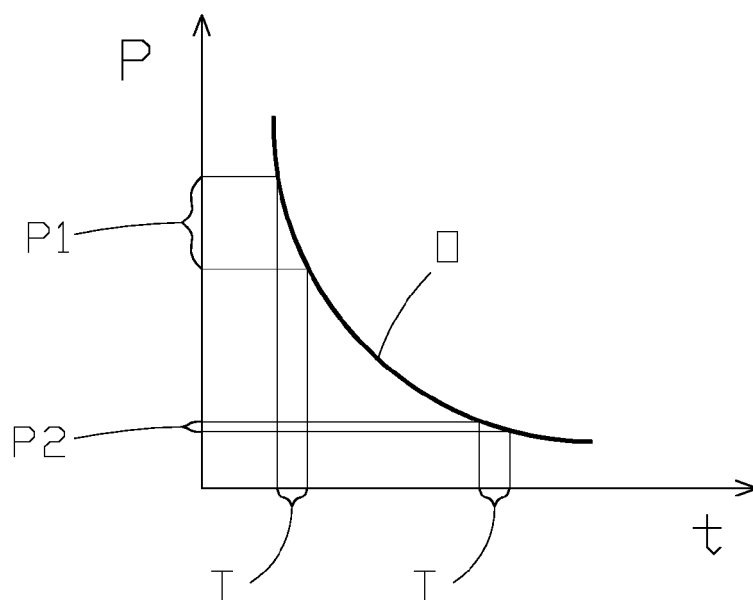


Fig. 2

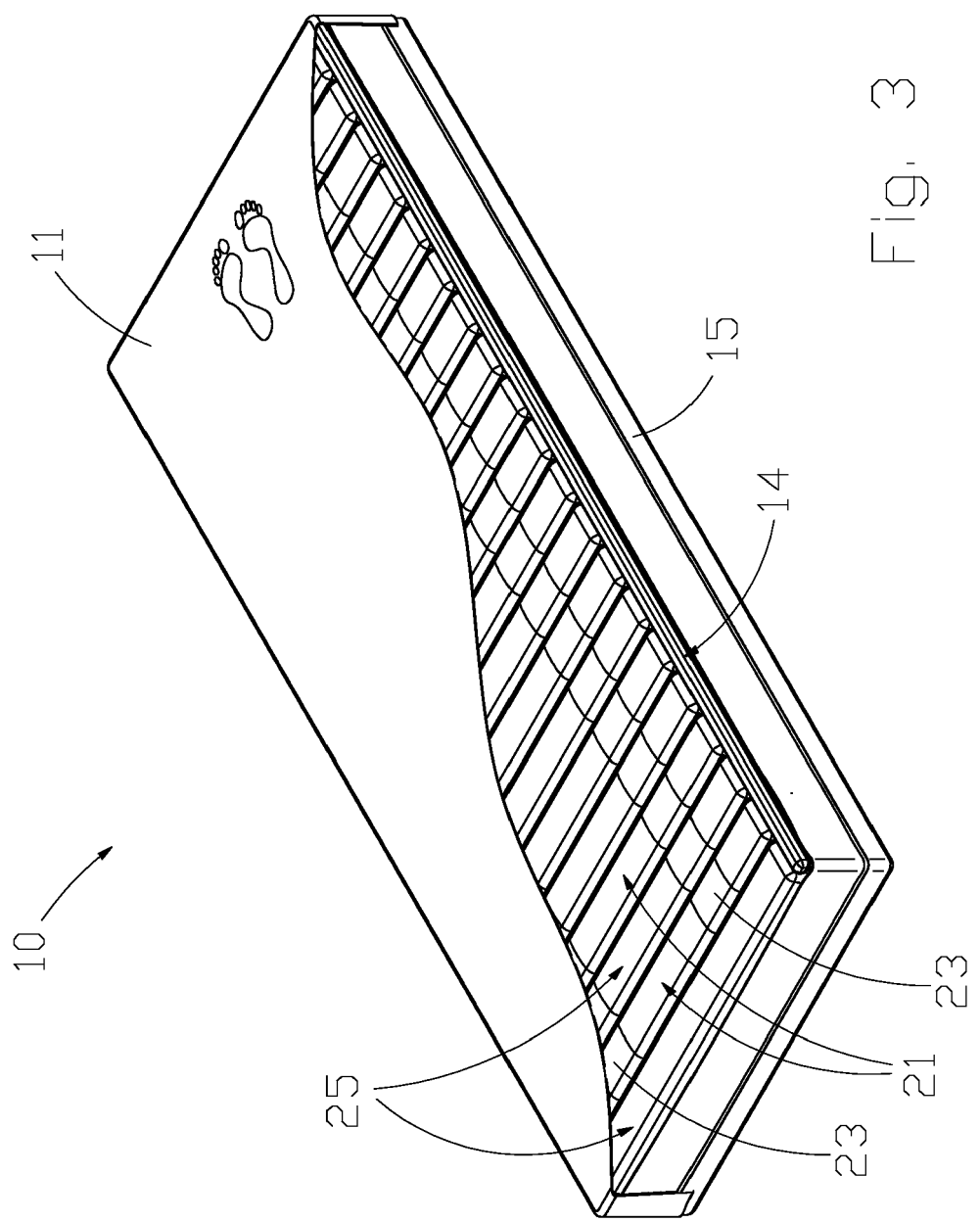


Fig. 3

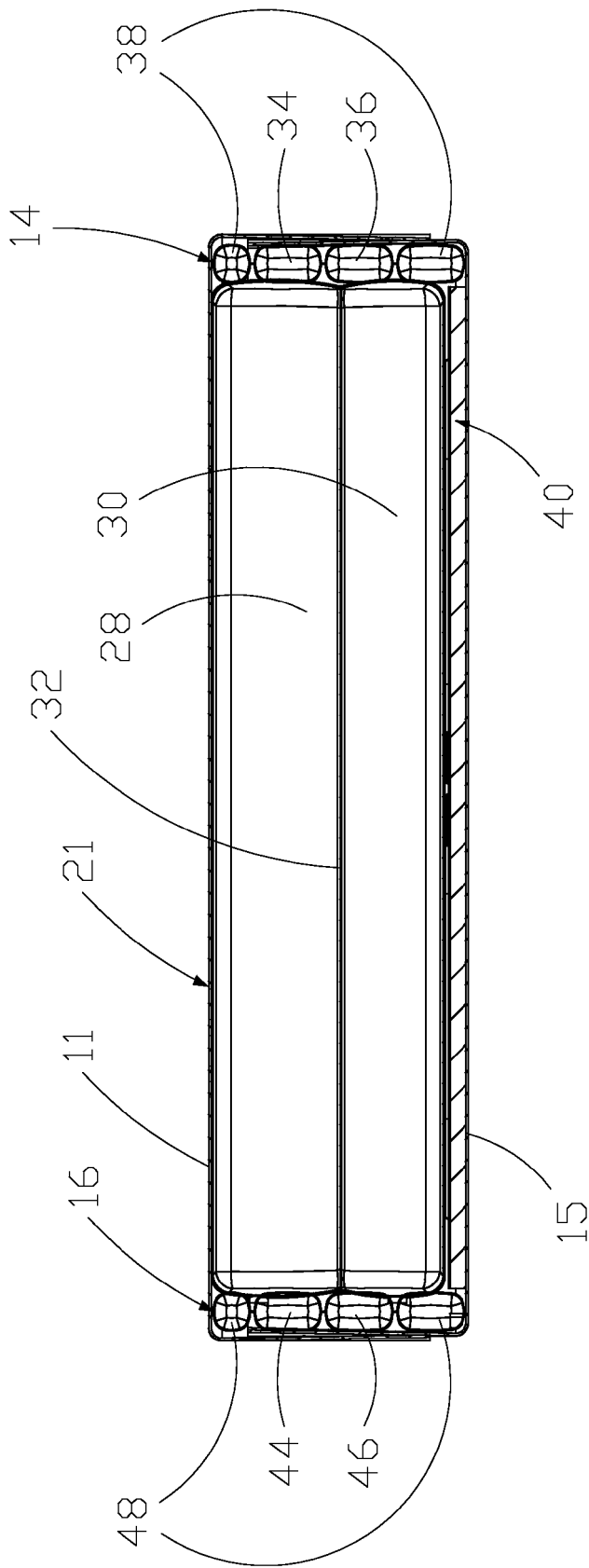
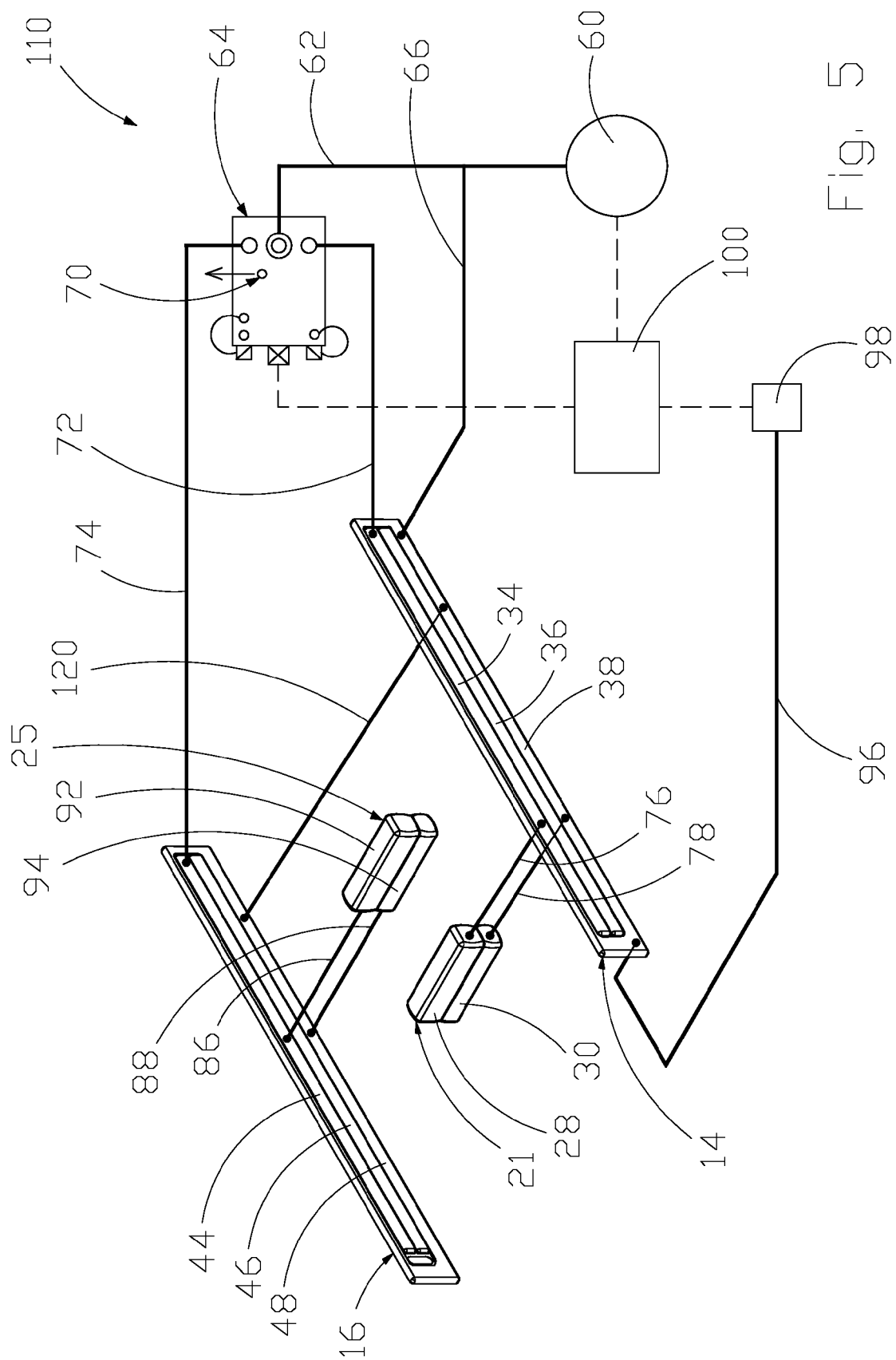


Fig. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 4552

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Y	* column 2, line 54 - column 3, line 2 * * column 3, line 52 - column 4, line 19; figure 1 *	4,5,8,10,11	
X	----- US 2009/007341 A1 (ROFF SIMON MICHAEL [GB] ET AL) 8 January 2009 (2009-01-08)	9,12	
Y	* paragraph [0014] - paragraph [0017]; claims 1-18; figure 1 *	5,8,11	
X	----- US 6 058 537 A (LARSON LYNN D [US]) 9 May 2000 (2000-05-09)	9	
	* column 1, line 56 - column 2, line 56; claim 1; figure 1 *		
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 3 March 2014	Examiner Sommer, Jean
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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