Patient simulator

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[Continued on next page]

(54) Title: PATIENT SIMULATOR

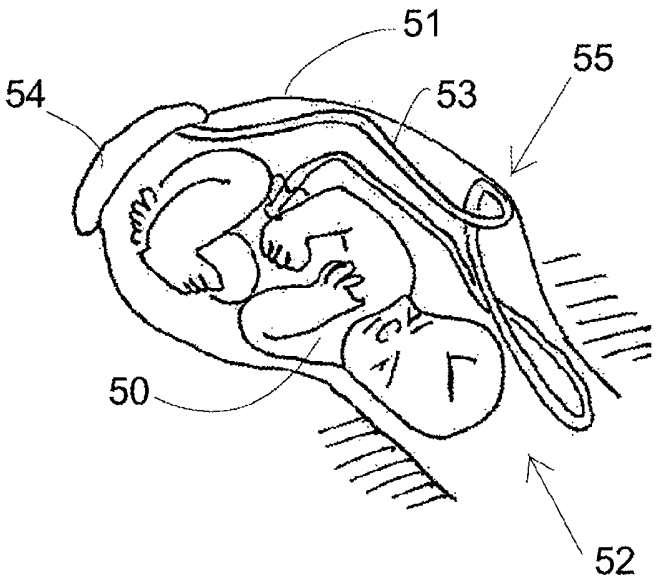

Fig. 2

(57) Abstract: The present invention relates to a patient simulator comprising an elongated flexible conduit for simulating a human or animal fluid conduit. The patient simulator to that end comprises detection means for detecting local deformation of the cross-section of the conduit. The present invention further relates to a method for simulating constriction of a human or animal fluid conduit in a patient simulator.

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Patient simulator

DESCRIPTION

The present invention, according to a first aspect thereof, relates to a patient simulator comprising an elongated flexible conduit for simulating a human or animal fluid conduit.

Patient simulators are used in training medical staff. Said simulators simulate (part of) a patient's body and can be used for training a variety of medical actions.

Within the framework of the present invention, the term "patient simulator" is understood to mean the whole of both the physical object representing a patient's body or a part of a patient's body and the apparatus present therein and operatively connected thereto, including embedded software for simulating body characteristics and functions and medical complications related thereto.

Patient simulators are also used for training purposes in the specific field of obstetrics, in this case said patient simulators are more specifically childbirth simulators, being a combination of a mother simulator and a baby simulator. These simulators can be used for training childbirth situations and complications that may occur during childbirth. The present invention in particular relates to childbirth simulators, without excluding the use of the present invention in other types of patient simulators.

A complication that occurs with some frequency during childbirth is the constriction of the umbilical cord caused by local compression of the umbilical cord. Compression of the umbilical cord can for example occur when the umbilical cord becomes positioned between the baby's body (frequently the baby's head) and the pelvic floor during childbirth or when the umbilical cord is twisted round the baby's neck. In the latter case there is even a risk of an airway and/or an artery or a vein in the baby's neck being pinched off as well. The above compression and pinching can be life-threatening both for the baby and for the mother.

US 3,822,486 discloses a patient simulator as described in the first paragraph. More specifically, said known patient simulator is a childbirth simulator, in which the baby simulator comprises a loudspeaker for simulating sound produced by the heart (heartbeat). The baby simulator further comprises a (simulated) umbilical cord. Via said umbilical cord, the baby simulator is connected to the

placenta. An electrical conductor extends through the umbilical cord and through the placenta, via which the loudspeaker in the baby simulator can be connected to the mother simulator.

A drawback of the above-described patient simulator is its limited functionality. Constrictions in blood vessels and/or airways by random and in many cases unexpected causes, for example compression, whether or not resulting from actions by medical staff themselves, are not simulated. The medical staff does not get any feedback regarding the aforesaid complications from the patient simulator, and consequently it is not possible, or at least only to a very limited degree, to train the action to be taken in response thereto. Since the aforesaid constriction is often life-threatening in practice, it is essential to train the actions to be taken in response thereto. Accordingly it is an object of the present invention to provide, whether or not in preferred embodiments thereof, a patient simulator having a greater functionality. The aforesaid object is accomplished with the patient simulator according to the invention, which is characterised by detection means for detecting local deformation of the cross-section of the conduit. A major advantage of the patient simulator according to the invention is that it makes it possible to detect a local constriction in a simulated fluid conduit, such as a blood vessel or an airway, due to random and in many cases unexpected causes, for example local compression, and in particular to train medical staff in recognising, preventing and remedying the aforesaid compression.

As an aside it is noted that US 5,890,908 discloses a patient simulator by means of which various (complications in) lung functions can be simulated. The simulator inter alia are comprises a construction by means of which a constriction in an airway can be effected. In said known simulator, this is a situation which can be set in the simulator itself, the response to which situation can subsequently be trained or, in other words, the degree of constriction is a given. Constriction due to random and in many cases unexpected causes, for example due to compression, whether or not caused by action taken by medical staff themselves, is not simulated.

In order to be able to detect deformation of the fluid conduit along the entire length thereof, the detection means preferably comprise a transmitter unit for generating a physical signal in the conduit and a receiver unit for detecting the physical signal generated in the conduit by the transmitter unit.

Furthermore preferably, the detection means of the patient simulator according to the present invention comprise processing means for determining local deformation of the cross-section of the conduit by comparing the physical signal detected by the receiver unit with the physical signal generated by the transmitter unit. It has been found that this comparison, more specifically the ratio between the detected signal and the generated signal, can be a suitable measure of the local deformation of the cross-section of the fluid conduit.

In order to optimally utilise the functionality, the detection means are preferably arranged for emitting a signal which is related to the degree of local deformation of the cross-section of the conduit. The signal emitted by the detection means can for example be converted into a visible or audible signal by a higher-level control system and/or be processed by said higher-level control system into (mathematical) models of, for example, control functions and body functions of the patient simulator. On the basis of this it can be pointed out to the user of the patient simulator that he/she must perform a specific action.

Furthermore preferably, the conduit comprises a channel extending in the longitudinal direction of the conduit for passing the physical signal through the conduit. Since fluid conduits in the human body likewise comprise a channel, or, in other words, are hollow, the characteristics, among which stiffness, resistance against bending and torsion of the simulated fluid conduits in question are simulated with a higher degree of accuracy by providing a conduit provided with a channel.

It is advantageous if the transmitter unit is arranged for generating the physical signal near a first end of the conduit. In this way a physical signal can be generated in the entire conduit in a simple manner.

The receiver unit is preferably arranged for receiving the physical signal near a second end of the conduit. In this way a physical signal generated in the conduit by the transmitter unit can pass through the entire conduit before being received by the receiver unit.

The receiver unit furthermore preferably comprises a signal filter for filtering the signal received by the receiver unit. Objectionable effects, for example from ambient noise, can be reduced by means of said signal filter.

In an advantageous preferred embodiment, the physical signal comprises an acoustic signal and the transmitter unit comprises an actuator for generating the acoustic signal in the conduit. The major advantage of the use of an

acoustic signal is the simplicity with which said signal can be transported and be generated, for example by means of the aforesaid actuator.

The receiver unit preferably comprises an acoustic sensor for receiving the acoustic signal generated in the conduit by the actuator. The generated acoustic signal can be detected in a simple and inexpensive manner by means of an acoustic sensor and be converted into, for example, an electrical signal.

In another advantageous preferred embodiment, the physical signal comprises an electrical signal and the transmitter unit is arranged for generating the electrical signal in the conduit. An advantageous alternative to the use of the above-described acoustic signal is the use of an electrical signal. An electrical signal can likewise be generated in a simple manner in the conduit.

To enable an efficient detection of deformation of the cross-section of the conduit, the conduit preferably comprises electrical conductor elements which are operatively connected to the transmitter unit, wherein the degree of conductivity of the conductor elements is related to the degree of deformation of the cross-section of the conductor. Think in this connection of the use of conductive plastics.

Preferably, the detection means are to that end arranged for detecting a change in the conductivity of the conductor elements. In this way the deformation of the cross-section can thus be detected in a relatively simple manner by the detection means.

In an advantageous embodiment the conduit simulates an umbilical cord, or at least a blood vessel thereof. The aforesaid detection means are highly suitable for use in a simulated umbilical cord, making it possible to simulate complications such as constriction of the umbilical cord, for example caused by compression, during childbirth simulations.

In order to be able to simulate the actual situation more closely, a number of conduits, for example three conduits, simulate an identical number of blood vessels of the umbilical cord.

With a view to simulating the actual situation with a high degree of likeness, it is furthermore advantageous if the patient simulator further comprises a simulated torso part and a simulated placenta, in which case the transmitter unit and the receiver unit are located in the placenta and in the torso part, respectively, or vice versa.

The present invention, according to a second aspect thereof, relates to a method for simulating constriction of a human or animal fluid conduit in a patient simulator, comprising the steps of

a) providing an elongated, flexible conduit in the patient simulator for simulating the fluid conduit; and

b) detecting the local deformation of the cross-section of the conduit, using detection means.

The advantages of the method as described in the foregoing and of preferred embodiments thereof are analogous to the advantages of the patient simulator according to the first aspect of the invention, likewise as described in the foregoing.

The present invention will now be explained in more detail by means of a description of a preferred embodiment of a device according to the invention, in which reference is made to the following figures:

Figure 1 is a schematic view of part of a patient simulator according to the present invention;

Figure 2 is a schematic view of a baby in a situation that may occur during childbirth;

Figure 3 is a schematic view of a baby in another situation that may occur during childbirth;

Figure 4a is a longitudinal sectional view of a locally constricted conduit used in a patient simulator according to the present invention;

Figures 4b and 4c are cross-sectional views along the lines IVb-IVb and IVc-IVc, respectively, in figure 4a.

In figure 1 a schematic view is shown of part of a patient simulator according to the present invention, more specifically the device 1 forming part of the patient simulator for detecting constrictions in a simulated fluid conduit of the human body, such as a blood vessel or an airway. The device 1 essentially consists of a transmitter unit 2, a conduit, in the form of a hollow hose 4 in this embodiment, a receiver unit 3 and a processing unit 6.

The transmitter unit 2 comprises a signal source 21 which generates a sinusoidal input signal of 1700 Hz. It should be noted in this regard that in fact any sufficiently high frequency can be used, including frequencies at ultrasonic level. In principle frequency higher than 1 Hz would already suffice. If a

frequency lower than 1 Hz is chosen, constrictions that last less than 1 second will not be detected. The input signal is converted into a sound wave, in this case likewise of 1700 Hz, by a loudspeaker 22. The loudspeaker 22 is built into a plastic housing 23, which is provided with a small aperture 24, to which the hose 4 is connected. The loudspeaker 22 thus generates sound waves that pass through the channel 41 in the hose 4.

The hose 4, which is made of a flexible plastic material, simulates the fluid conduit. The material of the wall 42 of the hose 4 has been selected so that the stiffness, the bending strength and the torsional strength and the external surface and structure correspond as much as possible to the simulated conduit in question. Since sound waves are used, the hose 4 need not contain a liquid. The presence of air in the channel 41 in the hose 4 in principle suffices for the correct functioning of the device. If desired, the hose 4 can thus be disconnected and connected in a simple manner when training.

Located at the other end of the hose 4 is the receiver unit 3, which comprises a microphone 31. The hose 4 is connected to the aperture 32 in the housing 33 of the microphone 31, and the microphone 31 thus registers the sound waves being generated by the loudspeaker 22 and passing through the hose 4. Like the housing 23, the housing 33 is provided with a sound-deadening material so as to minimise the occurrence of standing (sound) waves in the hose 4 as much as possible. It is noted in this regard that the presence of such sound-deadening material is desirable, but not necessary. The receiver unit 3 further comprises a bandpass filter 34, a rectifier 35 and a low-pass filter 36. The sound waves converted into an electrical signal by the microphone 31 are passed through the bandpass filter 34, which bandpass filter 34 amplifies frequencies of (and around) 1700 Hz but attenuates other frequencies. As a result, the influence of any external disturbances, such as ambient noise, is minimised. Noise on a particular frequency could of course also be effectively attenuated by means of a so-called notch filter set at the frequency in question. The electrical signal is then passed through a rectifier 35 and a low-pass filter 36, respectively, whereupon the envelope of the amplitude of the signal registered by the microphone 31 is obtained as the output signal. Since the input signal is a sinus having a fixed amplitude, the determination of the aforesaid envelope as the output signal will in principle suffice. The output signal is then led to a processing unit 6. In said unit, the output signal is compared to the

input signal.

If the flexible wall of the hose 4 is locally deformed as a result of being compressed, to such an extent that it leads to constriction of the hose 4, partial or complete attenuation of the acoustic signal received by the microphone 31 will occur as a consequence of the decrease of the cross-sectional area of the channel 41 of the hose 4, and thus also a corresponding attenuation of the output signal. The degree of attenuation of the output signal in relation to the input signal, or the change in the ratio between the output signal and the input signal, is thus a measure of the degree of constriction of the hose 4.

The information regarding the degree of constriction of the hose 4 is then sent to a higher-level control system (not shown). The higher-level control system comprises mathematical models of the mother simulator and/or the baby simulator for simulating body characteristics, such as the blood flow, the heartbeat and the skin colour. On the basis of a constriction in the fluid conduit, the higher-level control system can for example render a weakening simulated heartbeat by means of a loudspeaker operatively connected to the control system, or the baby simulator can for example be pale or have a weak heartbeat upon being "born". The constriction in the fluid conduit can be rendered audible or visible inter alia in this way. The person who carries out the simulated medical action must then act in response to this complication.

Figure 2 schematically shows a baby 50 in a situation that may occur during childbirth. The baby 50 is present in a womb 51. The head of the baby 50 is already partially present in the pelvic floor (pelvic cavity ??) 52. The umbilical cord 53, via which the baby 50 is connected to the placenta 55, has become positioned between the baby's head and the wall of the pelvic floor 52. During the further course of the childbirth this may result in compression of the umbilical cord. If the above-described device 1 is built into a childbirth simulator, with the transmitter unit 2 being built into the simulated placenta, for example, and the receiver unit 3 being built into the baby simulator, and the hose 4 functioning as a simulated umbilical cord, personnel can be trained in preventing and remedying such a situation. Possible compression and the resulting constriction of the umbilical cord can be detected by means of the device during the simulated childbirth.

Figure 3 shows (in one and the same illustration) two further medical complications that may occur. In the first case, the umbilical cord 62 is

compressed as a result of being twisted round the neck of the baby 60. In the second case, the baby's trachea 61 is compressed, for example as a result of the baby's umbilical cord 62 being twisted around the neck. Training for such situations can also be done by means of a childbirth simulator provided with a baby simulator, in an analogous manner as described above.

Figure 4a shows a longitudinal sectional view of part of the hose 4. The hose 4 is partially constricted at the location of the cross-sectional line IVb-IVb. The cross-sectional line IVb-IVb is shown in figure 4b. A cross-section IVc-IVc of a non-constricted part of the hose 4 is shown in figure 4c.

An advantage of the use of an acoustic signal for detecting constriction of the hose 4 is that attenuation of the acoustic signal is highly sensitive to changes in the cross-sectional area of the channel 41 of the hose 4, and only to a limited degree to the length of the constricted part of the channel 41 of the hose 4. If the hose 4 were to become constricted to a small degree over a significant part of its length, the volume of the channel 41 of the hose 4 will nevertheless decrease considerably. If, for example, as an alternative to the use of an acoustic signal, the air or liquid pressure in a completely sealed hollow space in the hose 4 were to be measured for the purpose of detecting a local constriction, the measured pressure will depend on the volume of the hollow space. Thus it is not possible to distinguish a very local but strong constriction from a long but limited constriction. A strong constriction is of course much more dangerous in practice than a very small but long constriction. The use of an acoustic signal for detecting a constriction in a fluid conduit is thus considerably more suitable for use in a patient simulator than the use of the aforesaid (air) pressure measurement.

It is further noted that it is possible without any problems to have a few data and/or power cables extend through the hose 4, for example for communication between a baby simulator and the mother simulator in the case of a childbirth simulator. The presence of a few cables does not have any significant adverse effect on the acoustic waves passing through the hose 4, although care should of course be taken in that case that a sufficient amount of cross-sectional area of the channel 41 will remain clear.

If the device 1 is incorporated in a patient simulator, which patient simulator is not limited to a baby simulator, also other forms of compression of fluid conduits can be simulated, of course. Think in this connection of simulating

constriction of an airway due to strangulation, something which is not limited to baby simulators, of course. In this connection simulation of a carotid artery and/or the trachea, for example, by means of the above-described device 1 may be considered. In several cases the material of the wall 42 of the hose 4 can be selected so that it simulates the (mechanical) characteristics of the fluid conduit in question sufficiently closely.

CLAIMS

1. A patient simulator comprising an elongated flexible conduit (4) for simulating a human or animal fluid conduit, characterised in that the patient simulator comprises detection means (1) for detecting local deformation of the cross-section of the conduit.

2. A patient simulator according to claim 1, characterised in that the detection means comprise a transmitter unit (2) for generating a physical signal in the conduit and a receiver unit (3) for receiving the physical signal generated in the conduit by the transmitter unit.

3. A patient simulator according to claim 2, characterised in that the detection means comprise processing means (6) for determining local deformation of the cross-section of the conduit by comparing the physical signal detected by the receiver unit with the physical signal generated by the transmitter unit.

4. A patient simulator according to claim 1, 2 or 3, characterised in that the detection means are arranged for emitting a signal which is related to the degree of local deformation of the cross-section of the conduit.

5. A patient simulator according to any one of claims 2-4, characterised in that the conduit comprises a channel (41) extending in the longitudinal direction of the conduit for passing the physical signal through the conduit.

6. A patient simulator according to any one of claims 2-5, characterised in that the transmitter unit is arranged for generating the physical signal near a first end of the conduit.

7. A patient simulator according to any one of claims 2-6, characterised in that the receiver unit is arranged for receiving the physical signal near a second end of the conduit.

8. A patient simulator according to any one of claims 2-7, characterised in that the receiver unit comprises a signal filter (34, 36) for filtering the signal received by the receiver unit.

9. A patient simulator according to any one of claims 2-8, characterised in that the physical signal comprises an acoustic signal and the transmitter unit comprises an actuator (22) for generating the acoustic signal in the conduit.

10. A patient simulator according to claim 9, characterised in that the receiver unit comprises an acoustic sensor for receiving the acoustic signal generated in the conduit by the actuator.

11. A patient simulator according to any one of claims 2-8, characterised in that the physical signal comprises an electrical signal and the transmitter unit is arranged for generating the electrical signal in the conduit.

12. A patient simulator according to claim 11, characterised in that the conduit comprises electrical conductor elements which are operatively connected to the transmitter unit, wherein the degree of conductivity of the conductor elements is related to the degree of deformation of the cross-section of the conductor.

13. A patient simulator according to claim 12, characterised in that the detection means are arranged for detecting a change in the conductivity of the conductor elements.

14. A patient simulator according to any one of the preceding claims, characterised in that said conduit simulates an umbilical cord or at least a blood vessel thereof.

15. A patient simulator according to claim 14, wherein a number of conduits simulate an identical number of blood vessels of the umbilical cord.

16. A patient simulator according to claim 14 or 15, further comprising a simulated torso part (50) and a simulated placenta (54), wherein the transmitter unit and the receiver unit are located in the placenta and in the torso part, respectively, or vice versa.

17. A method for simulating constriction of a human or animal fluid conduit in a patient simulator, comprising the steps of

a) providing an elongated, flexible conduit (4) in the patient simulator for simulating the fluid conduit; and

b) detecting the local deformation of the cross-section of the conduit, using detection means (1).

18. A method according to claim 17, wherein the detection means comprise a transmitter unit (2) and a receiver unit (3), and wherein step b comprises

- the generation of a physical signal by means of the transmitter unit; and

- the detection by means of the receiver unit of the physical signal generated in the conduit by the transmitter unit.

1/2

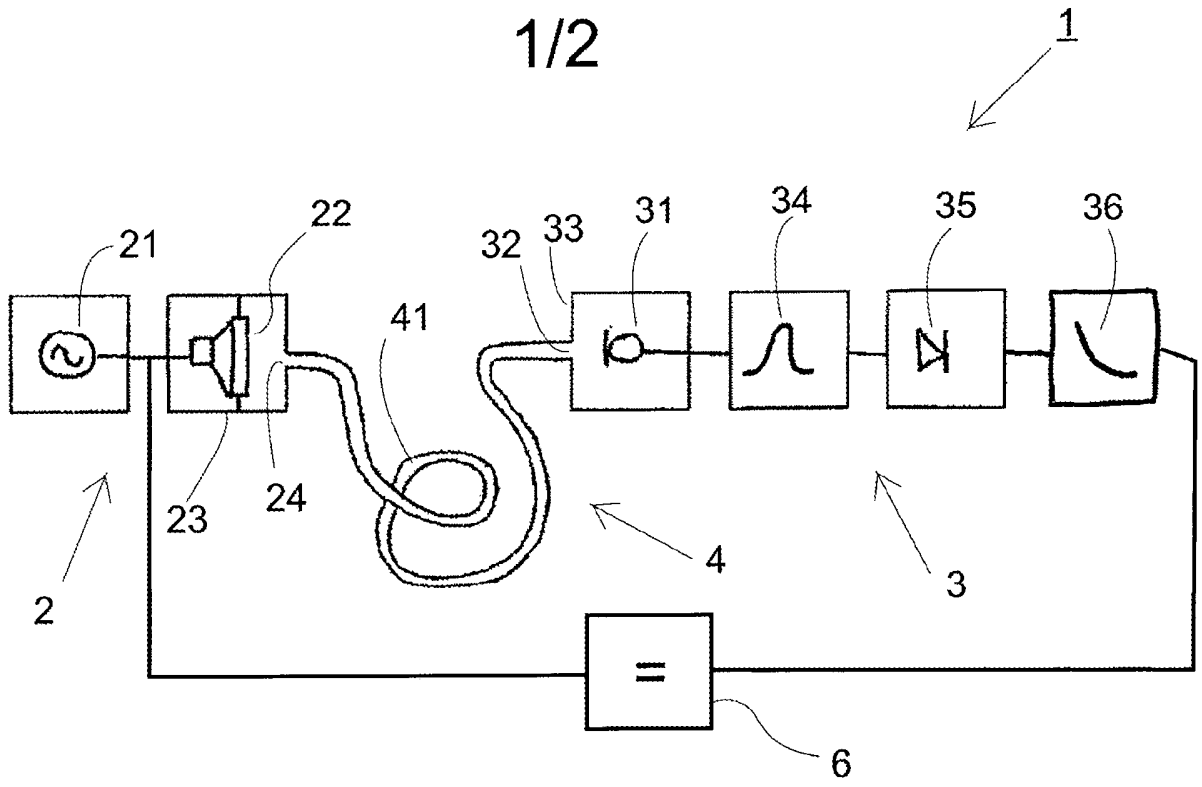

Fig. 1

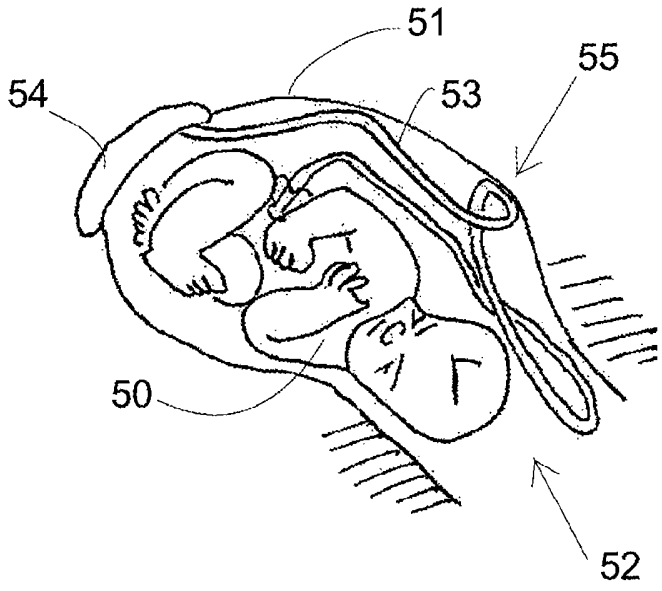

Fig. 2

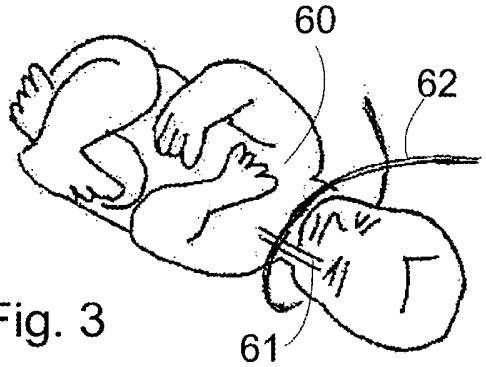

Fig. 3

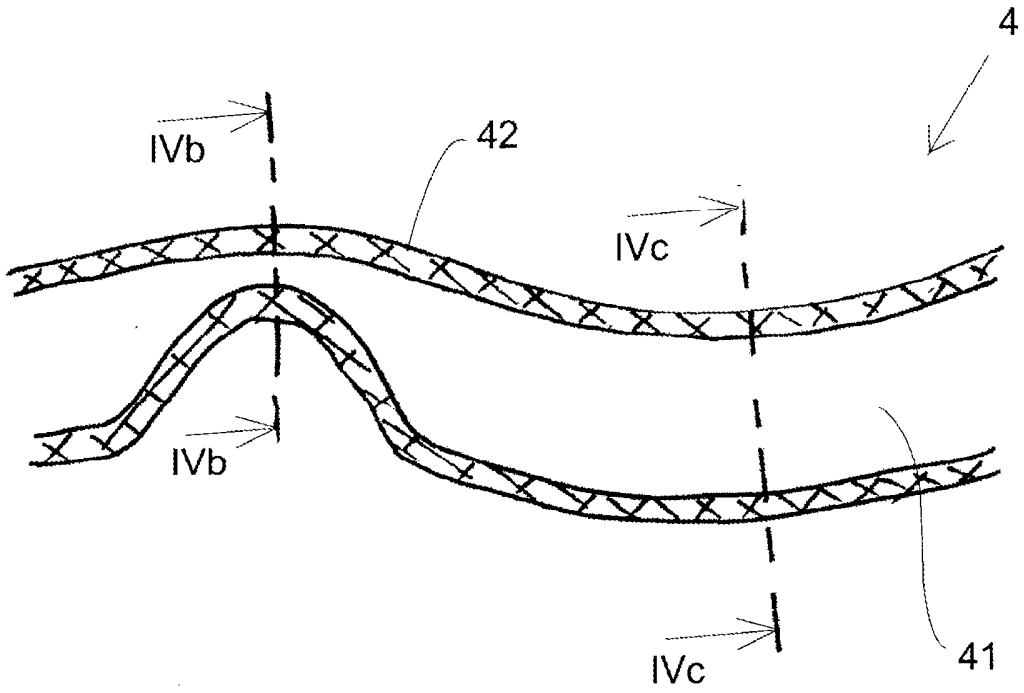

Fig. 4a

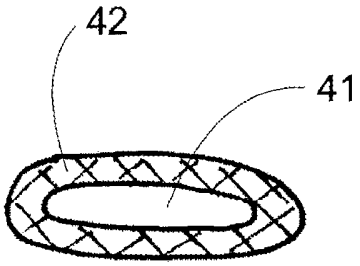

Fig. 4b

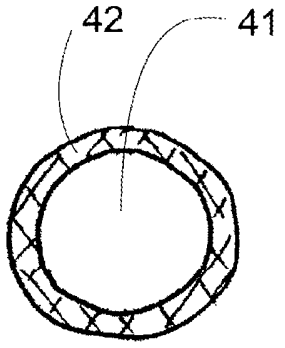

Fig. 4c

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2009/050567

A. CLASSIFICATION OF SUBJECT MATTER
INV. G09B23/28

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)
G09B

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	WO 2004/095398 A (LIMBS AND THINGS LTD [GB]; KITCHING MILES [GB]; GEROLEMOU NICK [GB]) 4 November 2004 (2004-11-04)	1,4,17
Y	page 9, paragraph 8 - page 10, paragraph 2	14-16
Y	US 2007/122785 A1 (EGGERT JOHN S [US] ET AL) 31 May 2007 (2007-05-31)	14-16
A	paragraphs [0060], [0065], [0077]	1-12,17, 18
A	US 3 822 486 A (KNAPP C ET AL) 9 July 1974 (1974-07-09) cited in the application column 1, lines 46-56 column 7, lines 3-31 column 9, lines 35-40 column 10, lines 61-67	1-18

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

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
15 December 2009	22/12/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Gabriel, Christiaan

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2009/050567

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 890 908 A (LAMPOTANG SAMSUN [US] ET AL) 6 April 1999 (1999-04-06) cited in the application figure 8 column 29, line 19 - column 20, line 14	1-18

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