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(54) **Floating and monitoring system for patients undergoing aquatic physical therapy**

(57) This invention deals with a system for use on patients undergoing aquatic physical therapy. More specifically, it is a monitoring, technical aid and diagnostic system for aquatic rehabilitation and hydrotherapy. It contains a set of floats at different points that are introduced during its manufacture, which enable a large number of users of limited mobility to have access to swimming pools and tanks. It also incorporates devices for measuring, reading and transmitting various physical, physiological and biomechanical parameters alongside audio and visual alarm devices to be actioned in the event of emergencies. There is also an external system for analysing, processing and storing the data produced and transmitted remotely.

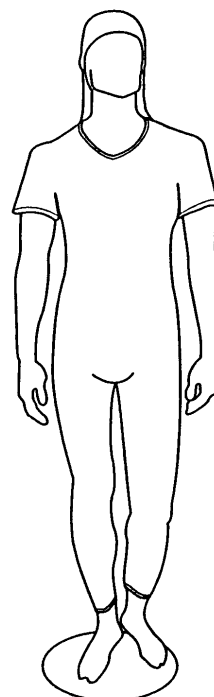


FIG. 1

Description

Scope of the Invention

[0001] This invention falls within the scope of technical sanitation support and rehabilitation control. More specifically, it lies within the scope of aquatic rehabilitation and hydrotherapy for infirmities and injuries that affect the locomotive system and mobility.

[0002] Hydrotherapy is a type of treatment that is based on the application of either hot or cold water, which is administered in different ways. Its mechanism can be summed up by the equation: stimulus - reaction - adaptation and it can be applied to a large number of infirmities and injuries. It substantially reduces the consumption of medicinal products and directly improves the performance of the cardiovascular and respiratory systems, as well as that of other systems, such as strengthening muscle mass, improving joint mobility, increasing blood flow and improving neuromotor coordination.

[0003] Equipment, ranging from diving-suit like garments to tanks and pools, to specialised hardware and software is necessary for enabling all the operations that are related to hydrotherapy to be carried out.

Prior Art

[0004] The applicant is aware of prior art, which deals only with devices and apparatuses of the bathtub or tank type for carrying out underwater exercises, such as those referred to in Patent ES 1 050 532 U. This refers to a medium and not to a technique that can be used therein. The drawbacks that are found with earlier patents such as the abovementioned Patent ES 1 050 532 U are: the need for the permanent presence of a person who can help to correct buoyancy and act in the event of an emergency, as well as the fact that many patients suffer from incontinence which makes it impossible for them to carry out aquatic exercises and hydrotherapy out of consideration for the other users of the facilities.

[0005] Amongst other related documents describing devices for monitoring patients are United States Patents 4815473 and 6047203.

[0006] United States Patent 4815473 describes a method and apparatus for monitoring respiration volumes by continuously measuring, while the patient breathes, variations in the patient's chest cross sectional area, or preferably, variations in both chest and abdomen areas.

[0007] United States Patent 6047203 concerns a non-invasive physiologic signs monitoring device which includes a garment with electrocardiogram electrodes and various inductive plethysmographic sensors sewn, embroidered, embedded, or otherwise attached to the garment with an adhesive. The garment is in the form of a suit. When the garment is fitted over the torso of the patient to be monitored, the electrodes and sensors generate signals in response to the physiologic signs of the

patient. The signals are transmitted to a recording/alarm device where they are monitored for adverse conditions and logged.

[0008] The applicants are therefore not aware of any complete systems for use on patients undergoing aquatic physical therapy.

[0009] These drawbacks and problems of prior art are remedied by this invention, which also improves the capacity for monitoring body and water temperature, heart rhythm, blood flow, blood and hydrostatic pressure and kinetic values, as well as goniometric evolution and muscular development. The system can also easily be transported from one facility to another, meaning that it does not, limit therapy and exercises to one place only.

Brief description of the figures

[0010] The description below is based on the annexed figures, which are not limiting and show:

- Figure 1 - a front view of the garment which forms a part of the system that is the object of this invention;
- Figure 2 - a back view of the garment shown in Figure 1;
- Figure 3 - a schematic view of the floats; and
- Figures 4 to 7 - detailed views of the floats. Figures 6 and 7 show the capsules that hold the positioning sensors.

Detailed description of the invention

[0011] An essential feature of the system that is the subject of this invention is that the garment, as shown in Figures 1 and 2, is similar to a diving suit. This is preferably a single item with an opening at the back and overlapping. This suit is fitted with a number of sensors, a transmission station and a remote data receiving and handling unit. It also contains:

- an inflatable floatation system;
 - a monitoring system; and
 - a replaceable item, which is impermeable to the external aqueous medium, for retaining and totally isolating urine or faeces;
- The suit must have certain characteristics to be able to perform its functions. Hence, it must not only meet all the static and shape needs, but must also comply with the following requirements:
- chlorine resistant;
 - a degree of elasticity and good recovery;
 - good fastness to washing;
 - water permeable;
 - a degree of consistency;
 - quick water evaporation.

[0012] To comply with these requirements, a prototype has been developed using a knitted fabric containing a high percentage of polypropylene together with some

elastane as a raw material. Other solutions that meet these requirements are also possible.

[0013] Another essential requirement is the ease with which the patient can put on and take off the garment, considering that it is intended for patients who, although they are capable of all movements, can only carry them out with a certain degree of difficulty (this includes the majority of spondylitis sufferers). In one of the possibilities studied, which is considered to be preferable, the suit consists of a single item with an opening at the back and overlapping. Other equally possible solutions include a suit made up of more than one garment with the upper part open at the front, with or without overlapping, etc.

[0014] Any solution will, however, have to meet all the requirements mentioned above whilst at the same time complying with the standards governing dimensional stability, resistance to tearing, abrasion and water penetration, elastic stretching and recovery, resistance to snagging, heat resistance, colour fastness to washing, and resistance to water, bleach and friction.

[0015] The suit also includes a replaceable item, which is impermeable to the external aqueous medium for retaining and totally isolating urine or faeces, i.e. basically a pair of shorts. These shorts are preferably made out of a multilayered fabric consisting of, for example: an outer impermeable layer, an impermeable membrane, an absorbent layer and a rapid extraction layer next to the body. Here there will also be several possibilities both in terms of structure and the materials used, as will be evident to those skilled in the art.

[0016] Another essential component of the suit is the module that contains the floats, which can be seen in Figure 3 and the subsequent figures. This component is of fundamental importance for enabling the patients to float and balance and for helping them to keep their bodies in different positions to allow them to perform different exercises. This consists of an inflatable system that is divided into two large zones: neck-spine-hips-shoulders and legs-arms. Figure 3 shows the position (schematically speaking) of the floats, whereas the subsequent figures show their possible configurations. Basically, the first zone, i.e. neck-spine-hips-shoulders, is fitted with floats that are inserted into the suit, whereas the second zone, i.e. legs-arms, is equipped with floats that are separate from the suit and are worn round the forearms and legs.

[0017] The flotation system consists of an inflatable flotation circuit that enables all or part of the garment to be filled or emptied, depending on the type of exercise to be performed or the amount of force required, by using containers of compressed air or gas and valves that can be opened and closed. Each of the different sectors of the flotation system has its own autonomously controlled inflation process.

[0018] As can be seen in Figures 4 to 7, the geometry of the float can be configured in several ways. Likewise, the materials used can also vary: examples include PVC lined with a knitted fabric, a lined knitted fabric and a

flexible membrane, or a three-dimensional knitted fabric into which a circuit of elastomer tubes is inserted. These, depending on the volume of air, can expand to increase their diameter.

[0019] The object of the system as a whole is to carry out three groups of functionalities: reading/capturing data, editing patient database records, and configuring and handling the data recorded and displayed.

[0020] To carry out these functionalities, the system also includes the hardware that is used together with the suit, the hardware that is external to the suit and the specific software used to manage the data.

[0021] The hardware used with this suit for prevention and control purposes consists of a base station, and a monitoring system, which is incorporated into the suit and allows all the wearer's physical, physiological and biomechanical variables to be recorded. These are transmitted to a receiver for analysis. Transmission of the collected data is guaranteed by a wireless communications device.

[0022] The monitoring system includes sensors that are attached to the garment. These are encapsulated, impermeable to the medium, and are used to record the wearer's different physical, physiological and biomechanical parameters. Parameters such as body temperature, heart rate, blood pressure, breathing rate, the movement capability and goniometric development of the shoulders, hips, spine, elbows and knees, and muscular development can be monitored.

[0023] The data obtained by the abovementioned sensors are handled by the transmission station, which consists of a microcontroller, a data collection module, a feeder system and a transmitter/receiver. This station is the unit that is responsible for collecting the data from the different sensors, for communicating with the base station, processing the data at the site, and actioning the alarm system if necessary. It includes replaceable transmitters which are attached to the suit, and are encapsulated and impermeable to water. The visual and audio alarms are also replaceable, encapsulated and attached to the suit. The system allows alarms to be triggered based on the data collected by the abovementioned sensors.

[0024] An energy supply or storage device, which is replaceable, encapsulated and impermeable to water, is attached to the suit. This feeds the abovementioned data capture sensors as well as the visual or audio alarms. Its status can be checked by consulting a data display device. The electric wiring connecting all these items is sealed into the suit.

[0025] The data display device is replaceable, encapsulated, impermeable, attached to the garment and enables several parameters such as the abovementioned energy storage status and the heart rate to be seen.

[0026] The hardware that is external to the suit consists basically of a base station made up of a microcontroller, a transmitter/receiver and a computer that enables data to be analysed either as they are received in real time,

or a posteriori. Data handling is based around the calculation of arithmetic averages, standard deviations, linear regressions, and maximum and minimum values. The data to be handled can also be grouped in accordance with a variable number, in order to divide the data into sub-groups, and to facilitate their analysis. The results of these analyses lead to the production of a number of displays. These displays can also be stored in suitably formatted files together with the numerical values that result from processing the data.

[0027] The complete set of data received from the patient is managed by software which sends control data to the garment.

[0028] The electrical circuits needed to operate the system that monitors the wearer's physical, physiological and biomechanical data are inserted into the floats. The hermetically sealed connecting capsules and the mechanisms for filling and emptying out the air are welded into place during the manufacturing process. This ensures that the air and electrical circuits are sealed off from the water. This type of suit, therefore, makes it possible for several sensors, transmitters, screens, energy sources, small compressed air supplying devices, and the valves that control the input and output of air to be attached and all to be encapsulated and hermetically sealed off from the water.

Claims

1. A system to be used by patients undergoing aquatic physical therapy consisting of a garment like a diving suit which is fitted with a number of sensors, a transmission station and a remote receiver unit with the following properties:

- the suit consists of:

- an inflatable floatation system;
- a monitoring system; and
- a replaceable item, which is impermeable to the external aqueous medium for retaining and totally isolating urine or faeces;

the system also includes:

- a wireless communications device;
- a visual and audio alarm device;
- the hardware used in conjunction with the abovementioned suit for prevention and control purposes, and which consists of sensors to measure heart rate and posture, a transmission station consisting of a microcontroller, a data collection module, an energy input system and a transmitter/receiver;
- external hardware consisting of a base station, which includes a microcontroller, a transmitter/receiver and a computer; and

- software for managing the data received from the patient and for sending control data to the suit.

2. A system to be used by patients undergoing aquatic physical therapy, as described in the claim above, with the feature that the suit itself consists of a single item with an opening at the back and an overlap.
3. A system to be used by patients undergoing aquatic physical therapy, as described in claim 1, featuring an inflatable floatation system, which helps keep the body in different positions and enables it to perform different exercises. This is divided into two large zones: neck-spine-hips-shoulders and legs-arms.
4. A system to be used by patients undergoing aquatic physical therapy, as described in claims 1 and 3, featuring a floatation system, consisting of an inflatable floatation circuit that uses containers of compressed air or gas and valves which can be opened and closed to enable all or part of the suit to be filled or emptied, depending on the type of exercise to be performed or the amount of force required.
5. A system to be used by patients undergoing aquatic physical therapy, as described in claims 1, 3, 4 and 5, where each of the different sectors of the floatation system has its own autonomously controlled inflation process.
6. A system to be used by patients undergoing aquatic physical therapy, as described in claim 1, featuring a monitoring system which is incorporated into the suit and which will allow all the wearer's physical, physiological and biomechanical variables to be recorded and transmitted to a receiver for analysis.
7. A system to be used by patients undergoing aquatic physical therapy, as described in claims 1 and 6, with a monitoring system featuring sensors that are attached to the suit. These are encapsulated, impermeable to the medium, and are used to record the wearer's different physical, physiological and biomechanical parameters.
8. A monitoring system for patients undergoing aquatic physical therapy, as described in claim 1, featuring a microcontroller, a data collection module and a transmitter/receiver, consisting of a unit that is responsible for collecting the data from the different sensors, for communicating with the base station, processing the data at the site, and actioning the alarm system if necessary. It includes replaceable transmitters which are attached to the suit, and are encapsulated and impermeable to water.
9. A system to be used by patients undergoing aquatic

physical therapy, as described in claim 1, featuring visual and audio alarms, which are encapsulated and attached to the suit. The system allows alarms to be triggered based on the data collected by the above-mentioned sensors.

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- 10.** A system to be used by patients undergoing aquatic physical therapy, as described in claim 1, featuring an energy storage device, which is replaceable, encapsulated, impermeable to water, and attached to the suit. This feeds the abovementioned data capture sensors as well as the visual or audio alarms.
- 11.** A system to be used by patients undergoing aquatic physical therapy, as described in claim 1, where the suit is made out of material with properties that include resistance to chlorine, elasticity and good recovery, good fastness to washing, water permeability, consistency and quick water evaporation.
- 12.** A system to be used by patients undergoing aquatic physical therapy, as described in claim 11, where the suit is made from a knitted fabric containing a high percentage of polypropylene and some elastane.
- 13.** A monitoring system for patients undergoing aquatic physical therapy, as described in claims 1 and 2, where the abovementioned suit is held onto the wearer's body using an overlap at the back. Hence the elasticity of the material forces it to adapt to the wearer's position.
- 14.** A monitoring system for patients undergoing aquatic physical therapy, as described in claim 1, where the electrical circuits needed to operate the system are inserted into the floats at the time that the suit is manufactured.

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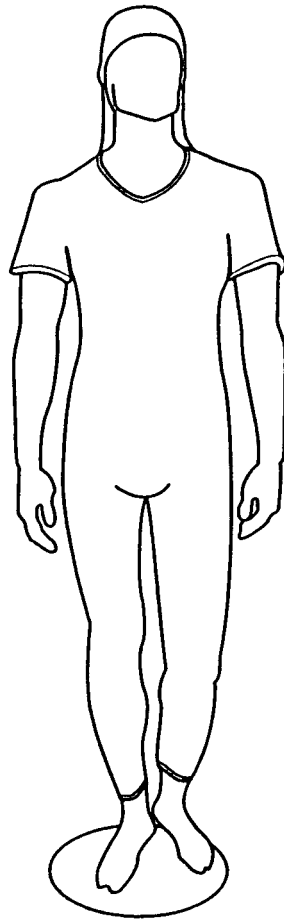


FIG. 1

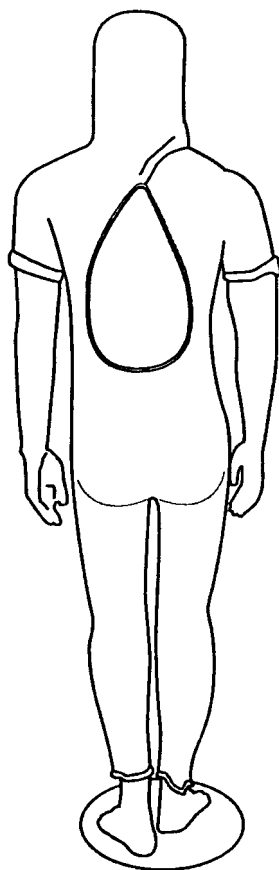


FIG. 2

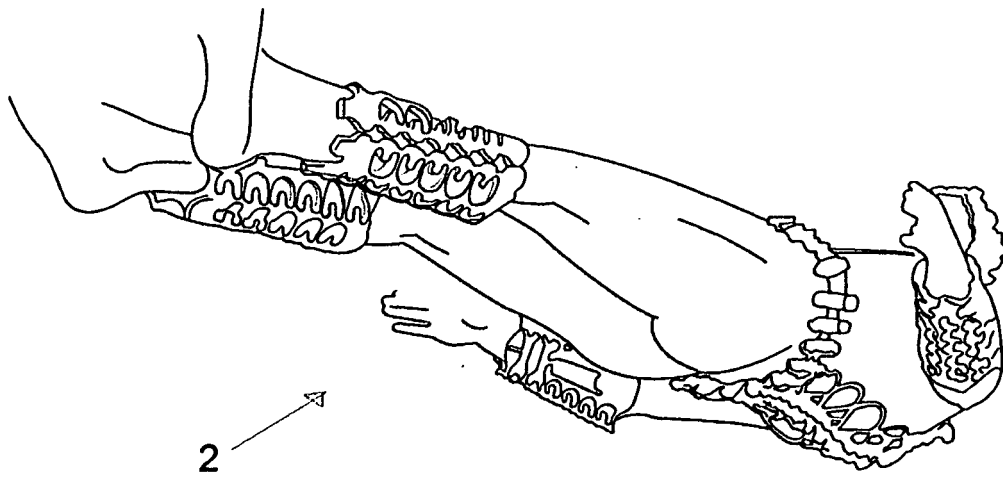


FIG. 3

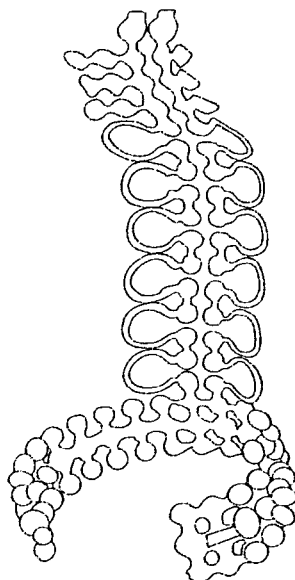


FIG. 4

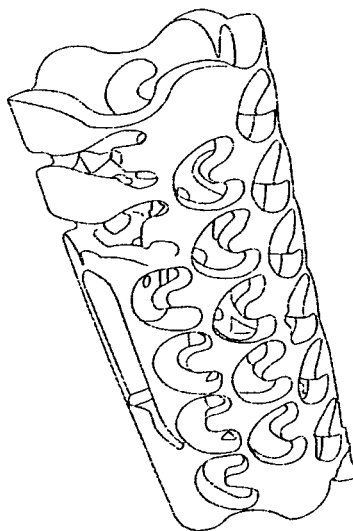


FIG. 5

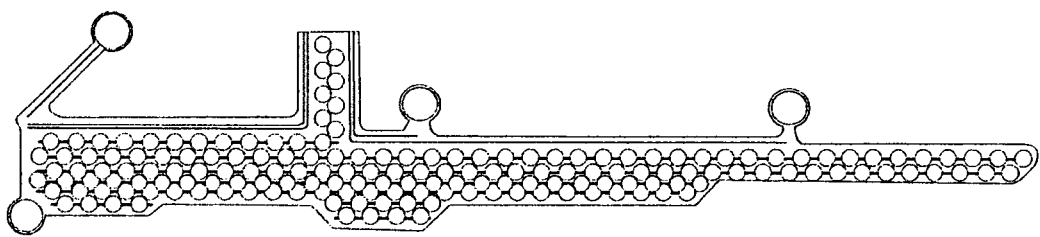


FIG. 6

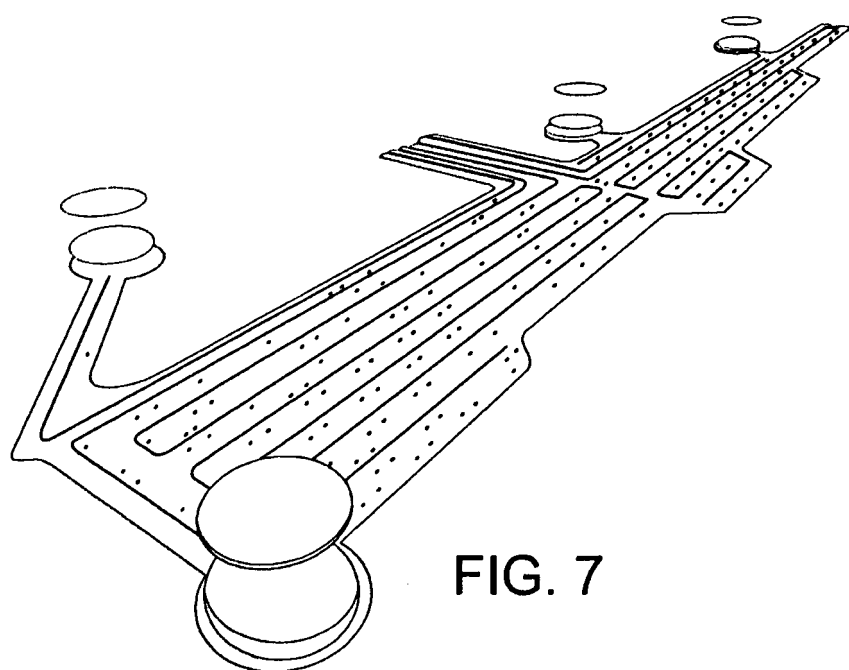


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 4815473 A [0005] [0006]
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