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(54) **SENSOR UNIT, BED FOR A PATIENT AND METHOD OF MODIFYING A PATIENT'S BED**

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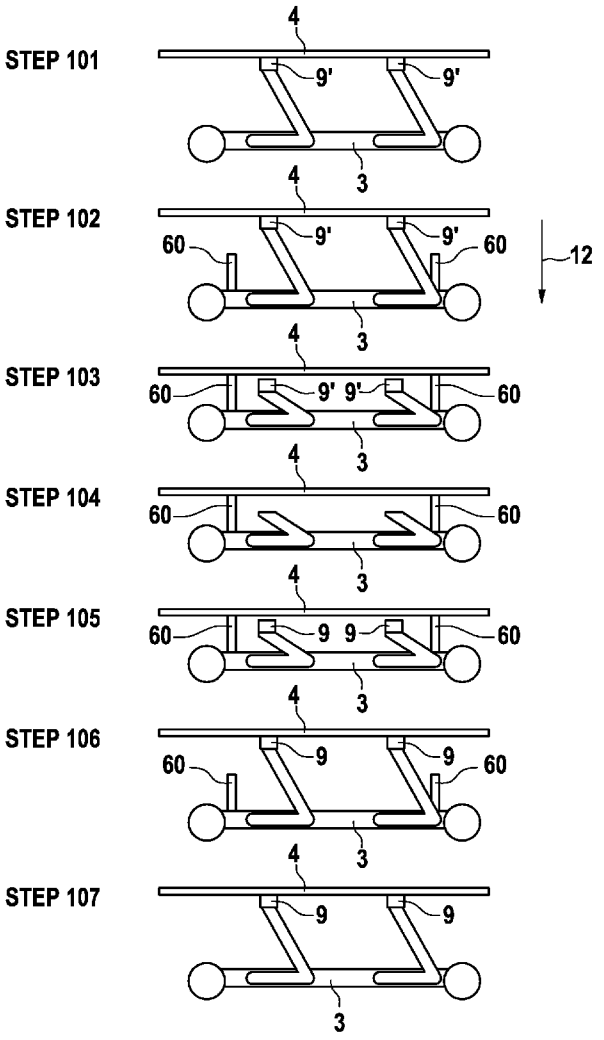
(57) **ABSTRACT**

The present invention allows on demand retrofit of a bed (**2**) with the sensing units (**9**) of a new monitoring system, which allows mechanical sensing of the presence of patients, movements of patients, breathing and heart rate.



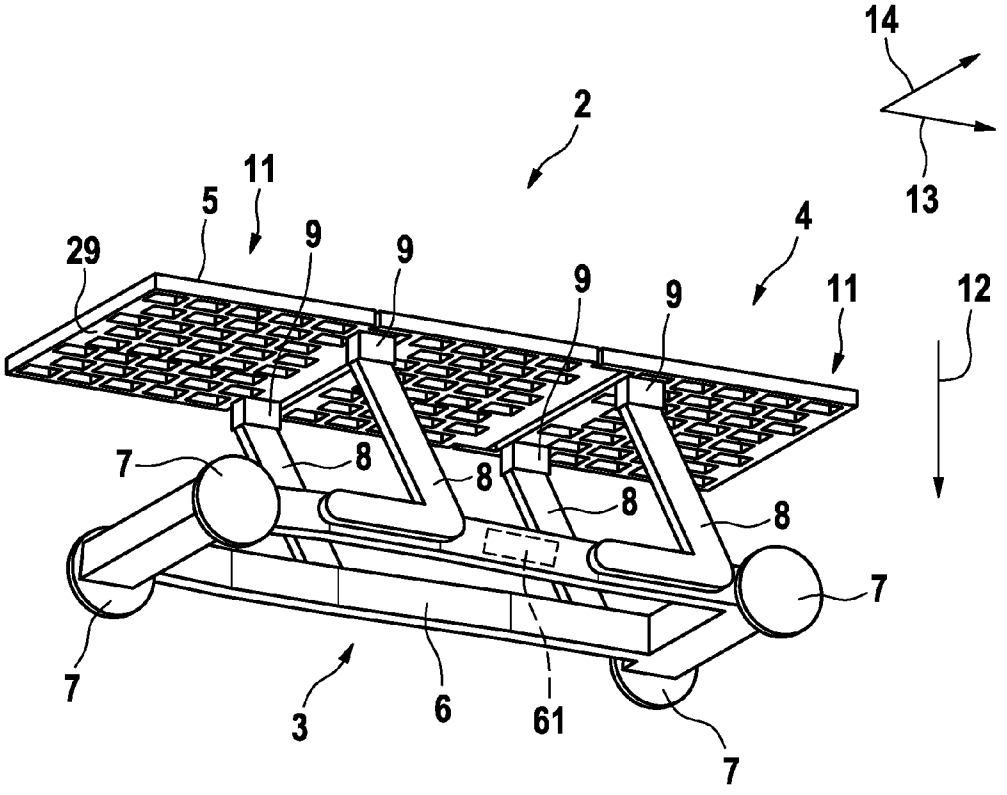


FIG. 1

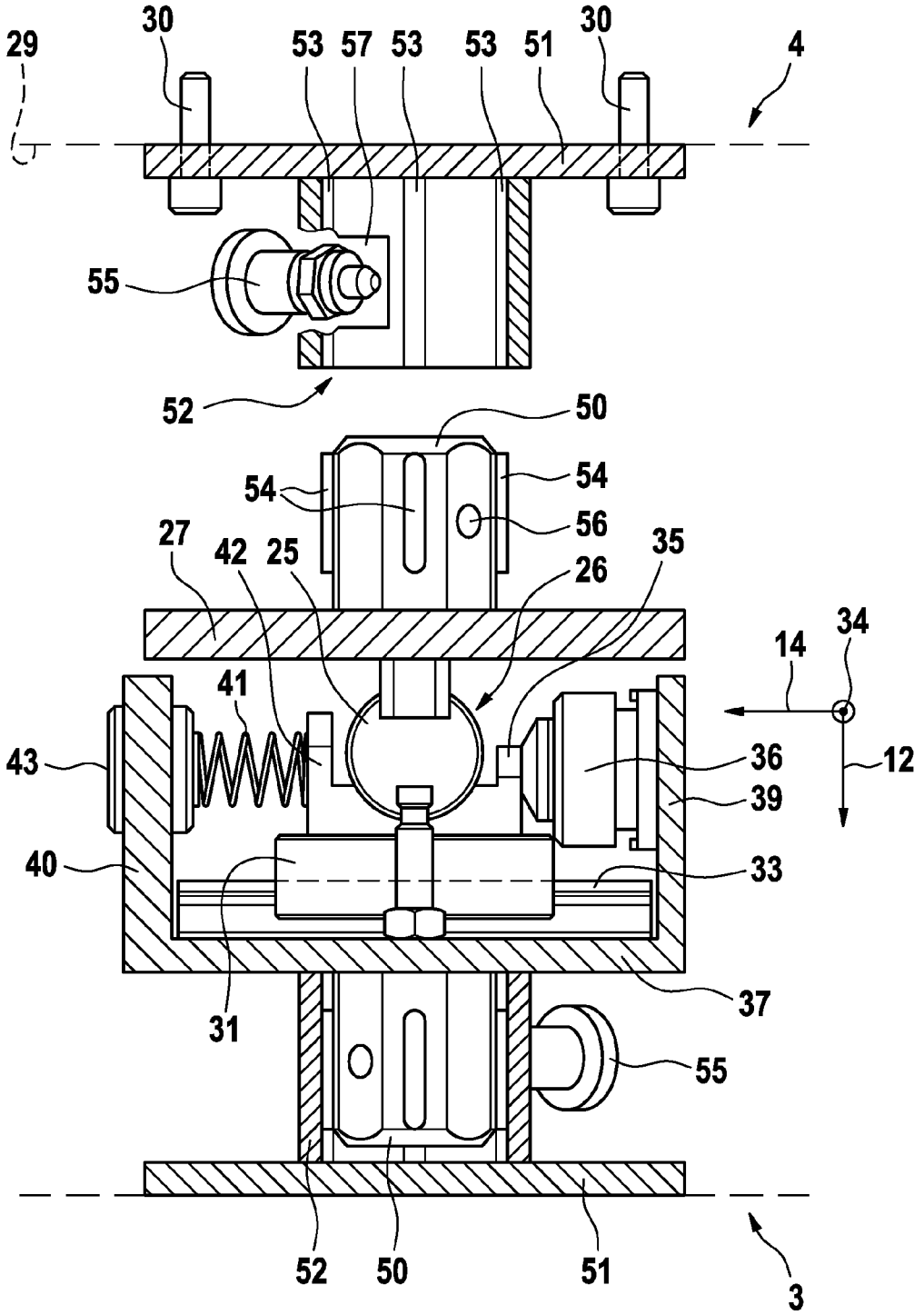

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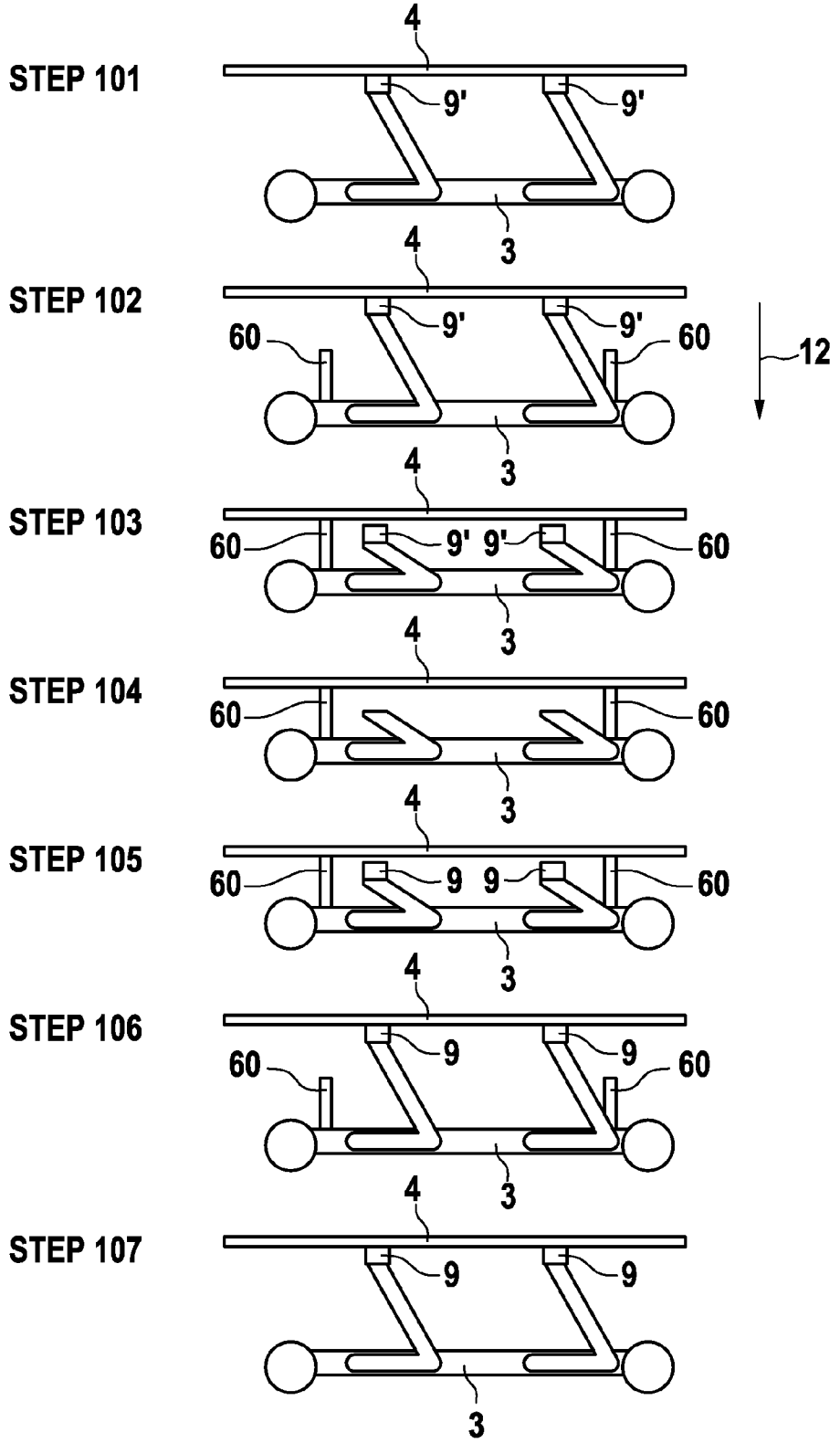
FIG. 2


STEP 101
STEP 102
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9'
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12
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FIG. 3

SENSOR UNIT, BED FOR A PATIENT AND METHOD OF MODIFYING A PATIENT'S BED

[0001] The present invention relates to a sensor unit and a bed for a patient. Furthermore, the present invention relates to a method of modifying a patient's bed.

[0002] Monitoring of patients during sleep is a standard tool in different situations, mostly in hospital settings. Depending on the diagnosis, different parameters are monitored. Parameters that are needed often are weight, heart rate, breathing rate and breathing abnormalities, as well as special movement patterns during sleep. It requires a significant technical effort and different techniques to measure these quantities.

[0003] In patent application EP 05109419.1 (Philips ID 298116), a new technique of bedside monitoring has recently been described, including a monitoring system, the sensor units of which are integrated into a hospital bed. This new system allows mechanical sensing of the presence of patients, movements of patients, breathing and heart rate. However, in practical use, such a type of patient monitoring will only apply to a certain part of all patients. For monetary and workflow considerations, it would be much more attractive to equip the bed with the sensor units only if required.

[0004] It is an object of the present invention to provide a technique, which allows a retrofit of the bed with the sensing units on demand.

[0005] The object of the present invention is achieved by a sensor unit for measuring at least one force component acting in a first direction, comprising a number of mechanical fasteners, said fasteners being adapted for establishing a mechanical connection to a bed in a way that the sensor unit is in a clearly defined position relative to the bed, said fasteners being detachable in said first direction.

[0006] This object is achieved according to the invention by a bed for a patient, comprising a system for manipulating the position of the patient in a first direction, and further comprising a number of mechanical fasteners, wherein said number of fasteners attach a number of sensor units to the bed in such a manner that each sensor unit is in a clearly defined position relative to the bed, said number of fasteners are adapted in such a way that each sensor unit is replaceable by another sensor unit, and said fasteners being detachable in the first direction, and said replacing being achievable using the manipulating system of the bed.

[0007] This object is achieved according to the invention by a method of modifying a patient's bed, the bed comprising a system for manipulating the position of the patient in a first direction, and further comprising a number of mechanical fasteners, said fasteners being detachable in the first direction, said method comprising the steps of operating the manipulating system in such a manner that the patient moves from a first position to a second position, replacing a number of first sensor units, which are attached to the bed by means of the fasteners in such a manner that each sensor unit is in a clearly defined position relative to the bed, by second sensor units, and operating the manipulating system in such a manner that the patient moves from the second position to the first position.

[0008] The present invention describes a design of a bed and a sensor unit. Furthermore, the present invention describes a method of handling said sensor unit with said bed.

[0009] A bed according to the present invention is defined as a surface or any other device to rest on or to sit on etc., e.g. a conventional bed, a hospital bed, a couch, a conventional chair, a dentist's chair, a wheelchair, an (operating) table, etc. However, the present invention is preferably applicable in hospital settings. Accordingly, the bed is preferably a hospital bed.

[0010] A working sensor unit according to the present invention is preferably a sensor unit as described in patent application EP 05109419.1 (Philips ID 298116), the disclosure of which is incorporated herein by reference.

[0011] A core idea of the invention is to provide a technique which allows for a retrofit of the bed with the sensing units on demand. Thus, not every hospital bed has to comprise these integrated sensor units, but can be equipped with the sensor units when relevant. This significantly reduces the cost of hospital beds. The retrofit can be done easily by care personnel, no technician is required. This is achieved according to the invention by using detachable mechanical fasteners, which attach the sensor unit dummies or the working sensor units to the bed in such a manner that they are in a clearly defined position relative to the bed. The main advantage of the present invention is the easy replaceability of one type of sensor unit by another type. This is achieved by using the existing manipulating system of the bed. In other words, the manipulating system of the bed, which is already available, can be utilized for retrofitting. Furthermore, the present invention may as well be used for a simple replacing of working sensor units, e.g. in case of repair or maintenance. Because of the fact that the fasteners are detachable in the same direction into which the manipulating system is operating, which also corresponds to the direction in which a force to be measured by the sensor unit is acting, an easy retrofit is possible and at the same time a secure mechanical connection between the sensor unit and the bed can be guaranteed.

[0012] These and other aspects of the invention will be further elaborated on the basis of the following embodiments, which are defined in the dependent claims.

[0013] According to a preferred embodiment of the invention, the sensor unit dummies and the working sensor units comprise a number of spline shafts and the bed comprises a number of receptacles for said spline shafts or vice versa. In this manner a very simple and effective attaching system is provided. The use of spline shaft elements eliminates the risk of confusion during the replacement of the sensor units. To achieve easy handling during sensor unit exchange or retrofit, the spline shafts and receptacles run in the operating direction of the manipulating system. The retrofit can easily be performed by care personnel or even back staff. Where applicable other attaching elements can be used.

[0014] According to another preferred embodiment of the invention, a number of fasteners comprise a quick opening device. The use of quick opening devices makes the replacing procedure even easier and ensures a fast retrofit during short periods of bed manipulations.

[0015] Preferably, the bed comprises a base frame and a patient support, the patient support being connected to the base frame. Since the patient support in a hospital bed is usually connected to the base frame in an adjustable way (e.g. for providing height adjustment), integration of the sensor unit into the patient support requires a greater effort in terms of measuring and/or data processing, because the directions of the force components may vary depending on the variable position of the patient support. Thus, for unobtrusive moni-

toring of said parameters, integration into the base frame is preferred. Thus, according to yet another preferred embodiment of the invention, a number of fasteners are attached to or part of the base frame and the patient support, and a number of sensor unit dummies or a number of working sensor units are attached by means of the fasteners between the patient support and the base frame. This position allows for the measurement of forces of the patient support relative to the base frame of the bed. This will allow optimal characterization of patient movements and ensure optimal extraction of heart rate, breathing rate and weight, and it will also allow monitoring of these data over a period of time.

[0016] According to another preferred embodiment of the invention, the manipulating system is adapted to lower the patient support into a displacement position, in which the sensor units can be partly detached from the bed and the replacement of the sensor units can be carried out, while the patient support is supported from below by a number of displacement rods. For the time of the retrofit said displacement rods serve as a replacement for the base frame of the bed. The use of displacement rods ensures safe positioning of the patient support during the replacement procedure.

[0017] According to another preferred embodiment of the invention, a hydraulic manipulating system is provided for easy manipulation of the patient support, thus assuring an easy retrofit.

[0018] The present invention allows for the first time an on demand retrofit of a bed with the sensing units of a new monitoring system, allowing mechanical sensing of the presence of patients, movements of patients, breathing and heart rate.

[0019] These and other aspects of the invention will be described in detail hereinafter, by way of example, with reference to the following embodiments and the accompanying drawings; in which:

[0020] FIG. **1** shows a schematic illustration of a hospital bed with four sensor units,

[0021] FIG. **2** shows an illustration of a working sensor unit with spline shafts and receptacles for said spline shafts, said receptacles being attached to the bed frame (not shown) and the patient support (not shown), and

[0022] FIG. **3** shows a scheme of how to replace a sensor unit dummy by a working sensor unit or vice versa in seven steps.

[0023] FIG. **1** shows a typical mobile hospital bed **2**. The bed **2** comprises a base frame **3** and a moveable patient support **4**. A patient's mattress (not shown) is positioned on the upside **5** of the patient support **4**. The base frame **3** comprises a wheel frame **6** with four wheels **7** and further comprises four bedposts **8** extending upward from the wheel frame **6** to bear the patient support **4**. At the upper end of each bedpost **8**, identical working sensor units **9** are provided. In other words, the patient support **4** is connected to the upper ends of the four bedposts **8** via said sensor units **9**. The bed **2** is configurable by means of hydraulics (not shown) in terms of height of the patient and positioning of different areas **11** of the patient support **4** relative to each other.

[0024] The sensor units **9** connect the base frame **3** with the patient support **4** in a movable manner. This means that, if a patient is located on the mattress, the patient support **4** can be moved downward in the direction of arrow **12**. If the patient moves, the patient support **4** is moveable sideward in an arbitrary lateral direction, for example in the direction of arrow **13** or in the direction of arrow **14**. Those lateral movements are caused by "large scale" movements, e.g. when the patient turns, or by "small scale" movements, e.g. by the patient's beating heart or by the patient's breathing.

[0025] Each working sensor unit **9** comprises two force sensor devices for sensing force components in different directions **12**, **13**, **14**, as explained in more detail in EP 05109419.1 (Philips ID 298116). Each sensor unit **9** comprises a sender for sending measurement data to a data device using a wired or wireless data communication link. The specific position of the sensor units **9** allows for the measurement of forces of the mattress and patient support **4** on which the patient is lying relative to the base frame **3** of the bed **2**. The weight of the patient as well as the patient's movements can be characterized and heart rate and breathing rate of the patient can be extracted by the data device, which for this purpose comprises a computer executing a dedicated computer program for extracting said information from the measuring data.

[0026] In FIG. **2**, a single working sensor unit **9** is shown. In this embodiment, a strain gauge sensor **25**, acting as first sensor device, is attached to the patient support **4**. For this purpose, a spline shaft **50** is attached to the upper connecting plate **27** of the sensor unit **9**. The upper connecting plate **27** is mounted to the bottom side **29** of the patient support **4** by means of three connecting members **30**.

[0027] The spline shaft **50** extends orthogonally from the upper connecting plate **27** of the sensor unit **9** towards the patient support **4** in the direction of arrow **12**. The patient support **4** comprises a connecting plate **51** comprising a cylinder with a receptacle **52** for said spline shaft. Said receptacle **52** extends orthogonally from the connecting plate **51** of the patient support **4** towards the sensor unit **9** in the same direction. The receptacle **52** comprises a plurality of axially extending recessed spaces **53** (grooves). The spline shaft **50** is provided with a plurality of ribs **54** extending in the axial direction thereof, said ribs **54** being shaped to conform with said plurality of recessed spaces **53** of the receptacle **52** for engaging the spline shaft **50** with the receptacle **52**. In this manner, anti-rotation of the shaft's axis is provided. As a result, the sensor unit **9** is in a clearly defined position relative to the patient support **4**. The spline shaft **50** is retained in the receptacle **52** by means of a quick opening device in form of a securing screw **55**. Said securing screw **55** is adapted for securing the spline shaft **50** in the receptacle **52** by entering a bore **56** in the spline shaft **50** after the spline shaft **50** has taken up its end position. For this purpose, the securing screw **55** is provided in an opening **57** in the receptacle's cylinder. The securing screw **55** ensures a stable construction even during movements of the patient support **4** and/or the bed **2**. For reason of clarity, the cylinder in FIG. **2** is shown with parts of the cylinder's wall being omitted.

[0028] The strain gauge sensor **25** is adapted to measure a force component in a vertical direction **12** in order to provide the patient's weight. The strain gauge sensor **25** is mounted horizontally in a protecting box **26** having a cylindrical shape. One end of the strain gauge sensor **25** is linked with the free end of an upper T-shaped connecting plate **27** by means of a vertical intermediate piece (not shown).

[0029] The other end of the strain gauge sensor **25** is linked with a slide **31** by means of a connecting member. The slide **31** allows for relative movements of the base frame **3** and the patient support **4**. The slide **31** is mounted on a rail element **33**. The rail element **33** extends horizontally and perpendicular to the longitudinal axis **34** of the strain gauge sensor **25**.

One front end **35** of the slide **31** rests again a piezo sensor **36**. The piezo sensor **36** acts as second sensor device and is rigidly attached to a mainly U-shaped lower connecting plate **37**. The lower connecting plate **37** comprises another spline shaft **50**, extending orthogonally from the lower connecting plate **37** towards the base frame **3**. The base frame again comprises a connecting plate **51**, which comprises a receptacle **52** for said spline shaft **50**. The functionality of fastener elements **50**, **52**, . . . is identical to the functionality of the fastener elements **50**, **52**, . . . described above. As a result the sensor unit **9** takes a clearly defined position relative to the base frame **3**.

[0030] The rail element **33** guiding the slide **31** is provided in between the two U-legs **39**, **40** of the lower connecting plate **37** and the piezo sensor **36** is mounted on the inside of the first U-leg **39**. The piezo sensor **36** is adapted to measure a force component in a horizontal direction, e.g. in direction **13** or **14**, in order to provide information about the movements of the patient. In other words, every additional horizontal force component will yield a signal in the piezo sensor **36**. The slide **31** is connected with the piezo sensor **36** via a pre-stressed spiral spring **41**. The spiral spring **41**, which exerts a certain defined tension force on the piezo sensor **36**, is mounted on the inside of the opposite second U-leg **40**, and is connected with the other front end **42** of the slide **31**. The initial tension of the spiral spring **41** can be adjusted by means of an adjusting screw **43** on the outside of the second U-leg **40**. Instead of a spiral spring **41**, other types of resilient elements may be used.

[0031] The functionality of the mechanical fasteners **50**, **52**, . . . has been discussed with reference to a working sensor unit **9**. A sensor unit dummy (not shown) according to the present invention exhibits the same attaching functionality. However, the sensor unit dummy is a mechanical component that replaces the working sensor unit **9**, but is not carrying sensors **25**, **26** and therefore is of lower cost. In other words, the sensor unit dummy mainly comprises the upper and lower connecting plates, which are connected to each other, and the spline shafts **50**. When patient monitoring is required, each dummy sensor unit can be replaced by a working sensor unit **9**, as explained below.

[0032] With reference to FIG. **3**, a replacing procedure is explained. In order to replace sensor unit dummies **9'** with working sensor units **9**, in a first step **101**, the securing screws **55** of the spline shafts **50** between the sensor unit dummies **9'** and the patient support **4** are opened. In the next step **102**, displacement rods **60** are made available. Said displacement rods **60** are preferably part of the base frame **3** of the bed **2** and can be provided on demand by means of joints. The bed **2** comprises a hydraulic manipulating system **61** (only illustrated schematically in FIG. **1**). By means of said manipulating system, the patient support **4** is lowered (direction **12**) into a displacement position in step **103**. In this position, the patient support **4** is supported from below by a number of displacement rods **60**, while the bedposts **8** are in a position that is so low that the sensor unit dummies **9'** do not contact the patient support **4**. The sensor unit dummies **9'** can be detached from the bed **2**, step **104**, and the replacement can be carried out, step **105**. In step **106**, the base frame **4**, now equipped with working sensor units **9**, is lifted up again and the securing screws **55** can be fastened. Finally, the displacement rods **60** are folded in step **107**.

[0033] It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments, and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein. It will furthermore be evident that the word "comprising" does not exclude other elements or steps, that the words "a" or "an" do not exclude a plurality, and that a single element, such as a computer system or another unit, may fulfil the functions of several means recited in the claims. Any reference signs in the claims shall not be construed as limiting the claim concerned.

REFERENCE NUMERALS:

[0034] **1** (free)
[0035] **2** bed
[0036] **3** base frame
[0037] **4** patient support
[0038] **5** upside
[0039] **6** wheel frame
[0040] **7** wheel
[0041] **8** bedpost
[0042] **9** sensor unit
[0043] **10** (free)
[0044] **11** moveable area
[0045] **12** downward direction
[0046] **13** lateral direction
[0047] **14** lateral direction
[0048] **15** (free)
[0049] **16** (free)
[0050] **17** (free)
[0051] **18** (free)
[0052] **19** (free)
[0053] **20** (free)
[0054] **21** (free)
[0055] **22** (free)
[0056] **23** (free)
[0057] **24** (free)
[0058] **25** strain gauge sensor
[0059] **26** protecting box
[0060] **27** upper connecting plate
[0061] **28** (free)
[0062] **29** bottom side
[0063] **30** connecting member
[0064] **31** slide
[0065] **32** (free)
[0066] **33** rail element
[0067] **34** longitudinal axis
[0068] **35** front end
[0069] **36** piezo sensor
[0070] **37** lower connecting plate
[0071] **38** (free)
[0072] **39** U-leg
[0073] **40** U-leg
[0074] **41** spiral spring
[0075] **42** front end
[0076] **43** adjusting screw
[0077] **44** (free)
[0078] **45** (free)
[0079] **46** (free)
[0080] **47** (free)

[0081] **48** (free)
[0082] **49** (free)
[0083] **50** spline shaft
[0084] **51** connecting plate
[0085] **52** receptacle
[0086] **53** groove
[0087] **54** rib
[0088] **55** securing screw
[0089] **56** bore
[0090] **57** opening
[0091] **58** (free)
[0092] **59** (free)
[0093] **60** displacement rod
[0094] **61** hydraulic system

1. A sensor unit (**9**) for measuring at least one force component acting in a first direction (**12**), comprising a number of mechanical fasteners (**50**, . . .), said fasteners (**50**, . . .) being adapted for establishing a mechanical connection to a bed (**2**) in a way that the sensor unit (**9**) is in a clearly defined position relative to the bed (**2**), said fasteners (**50**, . . .) being detachable in said first direction (**12**).

2. A bed (**2**) for a patient, comprising a system (**61**) for manipulating the position of the patient in a first direction (**12**), and further comprising a number of mechanical fasteners (**50**, **52**, . . .), wherein

said number of fasteners (**50**, **52**, . . .) attach a number of sensor units (**9**, **9'**) to the bed (**2**) in such a manner that each sensor unit (**9**, **9'**) is in a clearly defined position relative to the bed (**2**),

said number of fasteners (**50**, **52**, . . .) are adapted in such a way that each sensor unit (**9**, **9'**) is replaceable by another sensor unit (**9**, **9'**), and said fasteners (**50**, **52**, . . .) being detachable in the first direction (**12**), and

said replacing being achievable using the manipulating system (**61**) of the bed (**2**).

3. The bed (**2**) as claimed in claim **2**, wherein the sensor unit is a working sensor unit (**9**) or a sensor unit dummy (**9'**).

4. The bed (**2**) as claimed in claim **2**, wherein the working sensor unit (**9**) is adapted to measure a first force component acting in the first direction (**12**), and a second force component acting in a second direction (**13**, **14**), said second direction (**13**, **14**) being different from said first direction (**12**), said first force component corresponding to a number of first parameters of the patient, e.g. the patient's weight, and said second force component corresponding to a number of second parameters of the patient, e.g. the patient's movements.

5. The bed (**2**) as claimed in claim **2**, wherein the sensor units (**9**, **9'**) comprise a number of spline shafts (**50**) and the bed (**2**) comprises a number of receptacles (**52**) for said spline shafts (**50**) or vice versa.

6. The bed (**2**) as claimed in claim **2**, characterized in that the manipulating system (**61**) is adapted to lower the patient support (**4**) in the first direction (**12**) into a displacement position, in which the sensor units (**9**, **9'**) can be partly detached from the bed (**2**) and the replacement of the sensor units (**9**. **9'**) can be carried out, while the patient support (**4**) is supported from below by a number of displacement rods (**60**).

7. The bed (**2**) as claimed in claim **2**, wherein a number of fasteners (**50**, **52**, . . .) are attached to or part of the base frame (**3**) and the patient support (**4**), and a number of sensor units (**9**, **9'**) are attached by means of the fasteners (**50**, **52**, . . .) between the base frame (**3**) and the patient support (**4**).

8. The bed (**2**) as claimed in claim **2**, wherein a number of fasteners (**50**, **52**, . . .) comprises a quick opening device (**55**).

9. The bed (**2**) as claimed in claim **2**, characterized by a hydraulic manipulating system (**61**).

10. A method of modifying a patient's bed (**2**), the bed (**2**) comprising a system (**61**) for manipulating the position of the patient in a first direction (**12**), and further comprising a number of mechanical fasteners (**50**, **52**, . . .), said fasteners (**50**, **52**, . . .) being detachable in the first direction (**12**), said method comprising the steps of

operating the manipulating system (**61**) in such a manner that the patient moves from a first position to a second position,

replacing a number of first sensor units (**9**, **9'**), which are attached to the bed (**2**) by means of the fasteners (**50**, **52**, . . .) in such a manner that each sensor unit (**9**, **9'**) is in a clearly defined position relative to the bed (**2**), by second sensor units (**9**, **9'**), and

operating the manipulating system (**61**) in such a manner that the patient moves from the second position to the first position.

* * * * *