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(54) **PELVIS INTERFACE DEVICE FOR AN EXOSKELETON**

(57) A pelvic interface device for an exoskeleton, comprising a brace (1) adapted to at least partially encircle the patient's body as well as means for connecting to an exoskeleton (2).

The brace (1) comprises a central portion (11) and two side extensions (12) configured to encircle the patient's body in the abdominal region. The extensions (12) are provided with removable mutual fastening means.

The central portion (11) comprises a central lumbar support element (10), and said connection means comprise a coupling element (5) to said exoskeleton (2), which coupling element (5) is fixed to said lumbar support element (10).

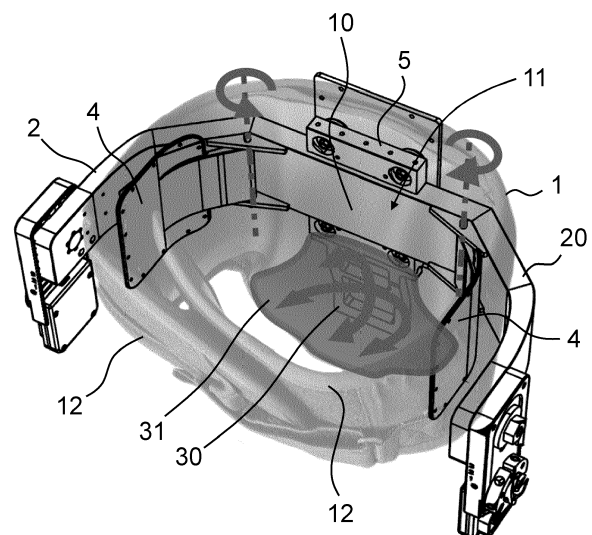


Fig. 1

Description

[0001] The present invention relates to a pelvic interface device for an exoskeleton, comprising a brace adapted to at least partially wrap the patient's body, as well as means for connecting it to an exoskeleton.

[0002] The benefit derived from the use of exoskeletons for paraplegic patients with spinal injuries and/or strokes is confirmed by the relevant scientific literature: the need to provide for a correct stimulation of the musculoskeletal system has led, over time, to the development of numerous active or passive robotic systems - exoskeletons - which can be worn on the lower limbs and which allow the patient both to stand in an upright position and have the possibility of performing specific tasks such as walking, getting up and sitting down, and climbing and descending stairs. These devices aim to mimic the human joints of the lower limb (hip, knee, ankle) with as many mechanical joints that replicate their behaviour on one or more anatomical planes. Generally, the hip and knee joints are motorised, while it is common to identify a passive joint that mimics the behaviour of the ankle in the sagittal plane, whether it is a real joint or an ankle-foot orthosis equipped with elastic properties that provide the equivalent to the required range of motion (ROM). As the devices are wearable, the interface between patient and machine is a primary criticality, especially when dealing with patients with reduced proprioceptive capabilities or sensitivity with levels of disability that depend on the degree and severity of the spinal injury. In this sense, the connection is represented by interfaces that bind the patient's body segments to the corresponding segments of the exoskeleton.

[0003] The pelvic interface of the exoskeleton represents a fundamental and critical element in that it mechanically connects the device to the patient's hip and torso, areas proximal to the regions of residual sensitivity of the subject and strongly involved in the mechanisms of balance and movement.

[0004] Depending on the type of lesions reported by the patient, the latter's trunk behaves differently and this affects the correct use of the exoskeleton, in particular the correct transmission of loads between the patient and the exoskeleton.

[0005] Indeed, actuation of an active exoskeleton typically occurs with a predetermined imbalance of the trunk that displaces the centre of mass of the patient-skeleton system. This movement trigger can be of different types, but generally involves a frontal-lateral imbalance.

[0006] The structure of the exoskeleton therefore provides a predetermined posture to be adopted correctly, precisely to be able to exercise the trigger, and this posture in many ways does not reflect the physiological position.

[0007] A first criticality is due to a rotation of the patient's pelvis until it causes hyperlordosis, called anteversion of the pelvis. To counteract this movement, the patient should lean backwards to obtain a passive balance

of posture relying on their own ligaments; however, this contrasts with the use of the exoskeleton, which does not work properly with the patient fully extended. If, on the other hand, the patient is flexed, there is a high risk of the pelvis undergoing an overly accentuated anteversion, with possible damage and vertebral compression.

[0008] There is also a second criticality, which concerns patients with very high lesions in the vertebral column, for example at vertebrae T6 - T7, whose control and tone of the abdominal muscles is lost and who therefore tend to assume incorrect postures in the exoskeleton. Such patients tend to collapse, as if slipping inside the exoskeleton.

[0009] In known systems of the type mentioned at the beginning, i.e., comprising a brace, it is only possible to act on the tightening condition of the brace on the patient. However, there are maximum compression limits of the abdominal area of the patient beyond which even serious damage can occur, and these insurmountable limits are often insufficient, quite the contrary, to ensure sufficient structural retention. Moreover, since paraplegic patients typically have no sensitivity in the lower regions of the body, it is basically impossible to find a brace that is truly functional to chest support without at the same time causing damage to the patient.

[0010] Document US20130245512A1 describes an exoskeleton comprising interface devices for connection with the patient's pelvis, trunk and legs. The connection uses containment braces, but no system is indicated to support and monitor the patient's movements within the exoskeleton.

[0011] Document US10537488 discloses a self-aligning system for coupling an exoskeleton to a patient, but does not disclose a support system with a postural control function.

[0012] Document US20160235616A1 describes a locomotion assisting exoskeleton, which includes a plurality of braces, including a trunk support for attachment to a torso portion of a patient and braces for leg segments. The braces have a restraining function only, and provide no stabilisation or support. The exoskeleton also necessarily includes a backpack anchored to the pelvis, which constitutes an additional restraint and can be uncomfortable for some patients.

[0013] The devices known in the art do not therefore give the patient the possibility of tilting the trunk simultaneously with the pelvic part of the exoskeleton. However, this is necessary to track the movements of the exoskeleton accurately and to improve posture.

[0014] There is therefore an unmet need in the prior art for a pelvic interface device for an exoskeleton capable of:

- complying with patient's anthropometric needs, which may vary from anatomical standards following prolonged maintenance of a seated posture, without imposing harmful compression and shear stresses on the patient's body, which can result in injuries

from which it is difficult to recover, especially in patients suffering from myelosis;

- stabilising the patient's torso in the abdominal region in order to contain possible collapses in muscularly incapacitated subjects;
- accommodating and controlling the movements of the patient's torso during the tasks performed;
- compensating for erroneous postural tendencies that lead to lumbar spine overload as a result of laxity and lack of muscle balance on the part of the patient;
- enabling the patient to have proper control over the exoskeleton.

[0015] The present invention aims to achieve the aforementioned purposes with a device as described at the beginning and which also includes a brace comprising a central portion and two side extensions configured to encircle the patient's body in the abdominal region, which extensions are provided with removable mutual fastening means, which central portion comprises a central lumbar support element, and wherein said connecting means comprise a coupling element to said exoskeleton, which coupling element is fixed to said lumbar support element.

[0016] In an exemplary embodiment, the brace is made of fabric.

[0017] During the design and manufacturing phase of the brace, the fabric makes it possible to adjust the stiffness of the material and, therefore, in a worn condition, to enjoy a predetermined freedom of relative movement between the patient and the exoskeleton.

[0018] In one embodiment, said brace is provided with internal pockets for housing thickening elements.

[0019] This makes it possible to compensate for any gaps between the patient and the exoskeleton, improving the connection between the two.

[0020] According to an exemplary embodiment, the lumbar support element is provided with one or more shock-absorbing elements to support the patient's back, which shock absorbing elements are arranged to form at least two side bands with respect to the vertebral column independent of each other or connected to each other in a U-shaped configuration.

[0021] The entire lumbar anatomical region, and also the lumbosacral area, is critical due to friction with the exoskeleton, particularly its pelvic element. Paraplegic patients typically do not sense contact with the exoskeleton and therefore cannot adjust their movements so as to limit friction against the more rigid parts of the device. This can quickly lead to friction burns and even injury and is particularly critical in the central area, at the vertebral column.

[0022] The shock-absorbing elements act as a cushion lateral to the vertebral column and therefore rest on an area rich in adipose tissue, thereby keeping the bony region located more closely to the skin away from the exoskeleton.

[0023] In one embodiment, controlled stiffness means for mediolateral stabilisation of the patient's torso are pro-

vided.

[0024] According to a preferred exemplary embodiment, aid stabilisation means comprise at least two arcuate wings, each having one end constrained to the lumbar support element or the exoskeleton and a free end that is oriented towards a respective said extension.

[0025] With the presence of the wings, every movement of the patient is controlled, that is, is accompanied at all times, and is never left up to the patient.

[0026] In one embodiment, said brace comprises housing pockets of at least the free end of each said wing.

[0027] In this way, the wings are coupled to the brace and become integral with it, causing a controlled response, in terms of deformation, to the movements of the patient.

[0028] According to one embodiment, each said wing is hinged to the exoskeleton or lumbar support element in such a way that it is oscillating around a vertical axis.

[0029] In one embodiment, each said wing has stretchers out in the direction of the respective said extension such that it does not exceed the median frontal plane.

[0030] In one embodiment, each said wing is free hinged and has a greater thickness in the vicinity of the constrained end and a lesser thickness in the vicinity of the free end.

[0031] This makes it possible to adjust the elasticity of the wings in the design and production phase thanks to the geometry of the same, together with the choice of the material that can be of any type known to those skilled in the art for the required elastic support purposes.

[0032] In a further embodiment, alternatively or in combination, each of said wings is provided with elastic means of stress in the direction of the patient. Such elastic means may for example be springs, torsional springs, elastic tie rods or other systems known to those skilled in the art, which may be placed between the patient and the exoskeleton, preferably in the hinge housing of each wing.

[0033] In an exemplary embodiment, a lumbosacral support element is connected to the lumbar support element.

[0034] This makes it possible to limit the degree of anteversion of the patient's pelvis. The lumbosacral support element provides feedback for the patient's lumbosacral area and also supports and assists in load transmission, thus helping the patient to maintain correct posture and orientation of the vertebral column.

[0035] According to one improvement, the lumbosacral support element is hinged to the lumbar support element or to the exoskeleton and is inserted into a special pocket provided in the central portion of the brace.

[0036] This allows the lumbosacral support element to be coupled to a specific area of the brace which, thanks to its mechanical characteristics, forms a relatively mobile support cushion that can support the patient's lumbosacral area without completely preventing it from moving.

[0037] According to a further embodiment, a thoracic

support system comprising at least one rigid upright connected to the brace and/or exoskeleton as well as means for restraining the patient's thorax to said upright is provided.

[0038] This system promotes the maintenance of upright posture, especially for patients with severe spinal injuries. Thanks to this support the patient tends not to fall and can keep his or her gaze forward, in this way allowing the exoskeleton to be used correctly. The interface device is thus expanded to the thoracic area and can be attached at the top, in an area where the patient has sensitivity, and is made integral with the whole structure.

[0039] These and other features and advantages of the present invention will become clearer from the following description of some embodiments illustrated, by way of example only, in the attached drawings, wherein:

Figure 1 shows an overall view of an exemplary embodiment of the device according to the present invention;

Figure 2 illustrates front view;

Figure 3 illustrates a top view;

Figures 4 and 5 illustrate respectively external and internal views of an embodiment of the brace in deployed condition;

Figures 6, 7 and 8 illustrate different views of an exemplary embodiment of the wing;

Figures 9, 10 and 11 illustrate different views of a pelvic portion of an exoskeleton;

Figure 12 illustrates an exemplary embodiment of a thoracic support.

[0040] Figure 1 illustrates an exemplary embodiment of a pelvic interface device for an exoskeleton of the present invention. The interface device comprises a fabric brace 1 that appears as an extended band of predominant length over height in the frontal plane, which resembles a C shape in the transverse plane and is substantially symmetrical with respect to the sagittal plane.

[0041] The brace 1 is composed of a central portion 11 in contact with the patient's vertebral column and two symmetrical side extensions 12 capable of wrapping around each other and around the abdominal region of the patient's body.

[0042] The central portion 11 comprises a central lumbar support element 10. This element is interposed between the patient and the exoskeleton 2 and forms a support for the lower back of the patient. The lumbar support element 10 can consist only of the central portion 11 of the fabric brace 1, or it can consist of an additional member, of appropriate rigidity, fixed to the brace 1 or inserted into its thickness.

[0043] Said extensions 12 are provided with removable mutual fastening means and are therefore adapted to encircle the patient's body. The removable reciprocal fastening means illustrated in the Figures provide that the right extension 12 has a hook-and-loop fastening re-

gion on its inner portion, while on the contralateral extension 12 the hook-and-loop fastening system is on the outside and covers a larger portion in order to be able to encompass more sizes and allow for a more or less tight clamping. Preferably, the fastening means include an additional belt. The fastening means may be of any other suitable type and may include, for example, straps, buoys, or other locking systems.

[0044] The geometry of the brace 1 is visible in Figures 2, 4 and 5, wherein the element is shown in a deployed condition. This geometry makes it possible to adapt to the size of the patient's trunk and at the same time provide a system for stabilising the torso in the abdominal area, since the patient has a very limited possibility of flexing the thorax over the pelvis by voluntary movement or involuntary collapse of the rectus abdominis. The level of impediment obstruction is determined by the intensity of the tightening of the locking system. The fabric can be chosen according to the use purposes, such as jeans for resistance to tear. The seams are such as to prevent them from coming undone during use.

[0045] The brace 1 is constrained to the exoskeleton by a coupling element 5 to the exoskeleton 2, which coupling element 5 is attached to the lumbar support element 10. The interface device is connected in the example in the Figures to a pelvic 20 portion of the exoskeleton 2, in particular a C-shaped structure at opposite ends of which coupling units 6 of leg modules are provided. This is the best configuration for a pelvis part of an exoskeleton 2, because it is the one that most conforms to this anatomical zone. However, it is possible to use different exoskeleton configurations. The coupling element 5 can, for example, be a plate which can be coupled to a special housing provided on the pelvic 20 portion of the exoskeleton, in a central area thereof, by means of threaded coupling.

[0046] This connection allows the pelvis 20 to transmit the motion of the exoskeleton 2 to the patient's body and guarantees optimal adhesion during hip flexion-extension movements, since the patient's perception must be that of feeling firmly anchored to the structure so as to be able to perform all the tasks without compromising his or her health.

[0047] The internal walls of the brace 1 in contact with the patient, visible in Figure 5, are provided with portions of soft material and fabric (for example, elastam) suitable for contact with the skin, in order both to avoid biocompatibility problems due to prolonged use, and to cushion and mitigate contact between the rigid component of the pelvic 20 portion of the exoskeleton 2 and the patient's body. This makes it possible not to have anatomical regions rigidly in contact with a metal body, i.e., the pelvic 20 portion, which would lead to normal and shear stresses harmful to the patient.

[0048] The addition of thickening elements 13 to compensate for any gaps between the tissue and part of the pelvis 20 due to particular anthropometric dimensions of the patient is made possible by means of several pockets

positioned in the central region of the brace 1. Similar pockets can also be provided in one or both of the side extensions 12, in such a way that a lordosis correction action can also be achieved when placed frontally.

[0049] Furthermore, in order to prevent the part of the skin in the area of the vertebral column from receiving excessive contact pressure from the lumbar support element, generating very large areas of irritation on the patient and/or even sores, one or more shock-absorbing elements 14 can be provided. These shock-absorbing elements 14, or cushions, are arranged to form at least two side bands with respect to the vertebral column that are independent of each other or connected to each other in a U-shaped configuration by inserting laterals, as shown for example in Figure 5. The shock-absorbing elements 14 are therefore positioned in such a way as to interpose themselves between the brace 1 and the patient, so as to keep the most stressed area, i.e., the area at the vertebral column, raised and free of contact. In this way, excessive friction burns on the area of the patient's vertebral column, which can appear even after a few minutes of use, are prevented. Alternatively, in a similar way, it is possible to replicate this operation within the thickness of the brace 1, by inserting two symmetrical L-shaped braces, which perform the same function but remain hidden from view. This system greatly increases the comfort in the lumbosacral area, thus favouring a prolonged use of the device in a continuous and non-intermittent manner.

[0050] A lumbosacral support element 3, formed of a rigid element extending in the longitudinal direction to cover said body region completely, is positioned in the central portion 11 of the brace 1.

[0051] The lumbosacral support element 3 is hinged to the pelvic 20 portion and can therefore tilt around a substantially horizontal axis. The lumbosacral support element 3 is stressed in the direction of the patient by elastic means, for example a spring provided in the hinge housing. This allows it to act as a support for the patient by reacting on the pelvis 20. The free end of the lumbosacral support element 3 is inserted into a special pocket 30 provided in the central portion of the brace 1. The pocket 30 makes it possible to house the lumbosacral support element 3 and bind it to the rest of the interface device. In an alternative embodiment, the lumbosacral support element 3 is rigidly constrained to the pelvis portion and is oriented towards the patient.

[0052] The central portion 11 is specially shaped with an appendage 15 protruding downwards so as to extend to cover the sacral part. This appendix 15 has a rigidity such that it is slightly flexible, so that at the lumbosacral support element 3 it can move both around said horizontal axis and around a substantially vertical axis, as indicated in Figure 1. In this way, the lumbosacral support element 3 is connected to the lumbar element 10 only through the brace 1.

[0053] Alternatively, the lumbosacral support member 3 is hinged directly to the lumbar support element 10. In

this way, the two members 10 and 3 are connected to each other directly by the hinge itself.

[0054] The lumbosacral support element 30 can tilt in the sagittal plane and in the transverse plane integrally with the patient's pelvis, in particular the sacrococcygeal region, with respect to the pelvic 20 portion, following the anatomy and movements of the patient. In fact, this structure makes it possible to compensate for a natural imbalance of the pelvis due to the muscular structure of the subject at the level of the hip flexors (naturally more contracted due to the prolonged sitting position assumed by the patient during the day) and the buttocks (naturally more relaxed for the same reason). This imbalance leads to a tendency to excessive lumbar lordosis in the standing position, which, under load, leads to a harmful strain on the vertebral column (lumbosacral area). The presence of a support with controlled elasticity therefore makes it possible to impede this movement by exerting normal resistance in the lumbar region, keeping the patient in a correct position during the various tasks carried out with the exoskeleton without ulceration of the skin.

[0055] In this regard, it is also possible to insert thicknesses of different degrees of stiffness in such a way as to adapt to the patient's measurements and increase his or her comfort. In particular, in the thickness of the appendix 15 it is possible to provide an element 31 with a different level of stiffness from the rest of the brace 1, which is adapted to cooperate with the lumbosacral support element 3 to aid the patient.

[0056] The brace 1 thus operates on both sides, which constitute two working macro-regions.

[0057] In addition, in order to maximise the perception of solid anchorage between patient and orthosis, controlled stiffness means of mediolateral stabilisation of the patient's torso are provided. In particular, there is a system of wings 4, as illustrated in the Figures, which extend from the ends of the patient's lumbar region and are forged to accommodate his or her anatomical shape (in particular arched), remaining at all times posterior to the frontal plane and not acting on the iliac crests. The wings 4 are inserted inside pockets 40 in the brace 1, in particular located in the side extensions 12, symmetrically with respect to the central region 11, which may contain an additional elastic material to convey the elastic behaviour of the assembly.

[0058] At least two arcuate wings 4 are provided, each having an end connected to the pelvic 20 portion to the exoskeleton 2 and a free end oriented towards a respective extension 12. The wings 4 are preferably connected directly to the pelvic 20 portion by means of a hinge system provided, illustrated in Figures 6, 7 and 8. The wing 4, inserted in situ, is provided at its restraint end 41 with a through hole that can accommodate a cylinder 42, properly sized, at the ends of which are inserted Seeger rings 43 or other appropriate locking systems.

[0059] More than two wings 4 are possible, for example four. It is also possible to provide for coupling of the wings 4 to the lumbar support element 10 instead of to the ex-

oskeleton 2.

[0060] The wings 4 can be designed in various ways: the hinge can be left free to rotate, allowing complete tilting to the wings 4, which do not hinder the closure of the device and the mid-lateral oscillation of the patient; the system can then be provided with controlled elasticity, either by means of a hinge with an elastic element, such as a torsional spring, or other appropriate systems, in the region of restraint, or by means of the intrinsic elasticity due to the manufacture and geometry of the wings 4 themselves: the region proximal to the restraint 41 is thicker and has a reduced extension, in order to ensure mechanical safety, while a more pronounced tapering continues to the opposite end, i.e. the free end 44, where in parallel the longitudinal extension is increased in order to cover a larger region of the body.

[0061] The wings 4 can therefore deform under load and thus guarantee both a limit to the relative movement between the patient and the pelvis 20 and an elastic recovery that favours repositioning the patient in the position of equilibrium following an imbalance due to the task carried out by the exoskeleton 2. This configuration makes it possible to limit movement to the transverse plane only, guaranteeing maximum flexion rigidity in the sagittal plane at all times: this is necessary to ensure that any type of frontal trigger is not subject to alteration by the interface device, preserving maximum responsiveness to input.

[0062] The device can include a thoracic support system 21, which acts as a stabiliser of the patient's thorax: this system consists of a rigid element 22 located in the central posterior area which functions as a support for the vertebral column and, by acting through restraints 23, allows the torso to be kept in position during tasks.

[0063] Restraints 23 are preferably elastic and may include alternatively or in combination braces, laces or chest straps.

[0064] The thoracic support system 21 is anchored directly to the lumbar support element 10 or to the pelvic 20 portion of the exoskeleton 2, preferably by a threaded connection 24. This mechanism allows to avoid a collapse of patients with medium-high chest lesions that are unable to control the flexion of the thorax by means of the abdominal muscles. This system can be tightened at different levels, to avoid unwanted upper limb impediments and pain in the cervical area for the patient. The introduction of this component also allows the patient to maintain an upright position with their gaze upwards, hence no longer focused on the tips of their toes, making the resulting gait much more natural.

[0065] If necessary, it is possible to provide a further connection between the thoracic support system and the brace 1, carried out by means of elastic elements 25 such as straps, tapes, or the like, with the anterior portion 26 of the brace 1, that is, with the extensions 12 superimposed on each other in a closed configuration on the patient. This front connection of the thoracic support increases the effectiveness of the system, while also keep-

ing the straps in the correct position. The front connection can also help limit excessive leaning backward by the patient.

[0066] The present invention therefore offers the patient the possibility of tilting his or her trunk in a manner that is integral with the pelvic part of the exoskeleton and, at the same time, the possibility of inserting elements with controlled elasticity, specifically the side wings 4, for the recovery of balance in the frontal plane.

[0067] On the basis of the technical features described above and claimed below, the present invention achieves the following technical advantages:

- controlled stiffness of the lumbar supports achieved through the elasticity of the internal component of the support;
- controlled stiffness of the thoracic support system achieved by elastic connection, in particular braces;
- possible controlled stiffness of the side wings 4, as an alternative to free tilting, achieved by means of external torsional springs or the elastic bending of the wings 4;
- decoupling of movements in the sagittal and transverse planes;
- tilting of the lumbosacral support element, for movement of the sacrum-coccyx integrally with the brace 1, and for maintenance of the standing position;
- side wings 4 for controlled containment of torso sway in the frontal plane and rigid in sagittal flexion for transmission of motion;
- anthropometric adaptability, made possible by the many technical choices tailored to the human body;
- high ergonomics by means of biocompatible yielding systems for anchoring or connecting the patient to the orthotic device.

Claims

1. A pelvic interface device for an exoskeleton, comprising a brace (1) adapted to at least partially encircle the patient's body as well as means for connecting to an exoskeleton (2),
characterized in that
the brace (1) comprises a central portion (11) and two side extensions (12) configured to encircle the patient's body in the abdominal region, which extensions (12) are provided with removable mutual fastening means, which central portion (11) comprises a central lumbar support element (10), wherein said connection means comprise a coupling element (5) to said exoskeleton (2), which coupling element (5) is fixed to said lumbar support element (10).
2. Device according to claim 1, wherein the lumbar support element (10) is provided with one or more shock-absorbing elements (15) for resting on the patient's back, which shock-absorbing elements (15) are ar-

ranged to form at least two side bands with respect to the vertebral column independent of each other or connected to each other in a U-shaped configuration.

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3. Device according to one or more of the preceding claims, wherein controlled stiffness means for mediolateral stabilisation of the patient's torso are provided, said stabilisation means comprising at least two arcuate wings (4) each having one end (41) constrained to the lumbar support element (10) or to the exoskeleton (2) and a free end (44) oriented towards a respective said extension (12). 10
4. Device according to claim 3, wherein said brace (1) comprises housing pockets of at least the free end (44) of each said wing (4). 15
5. Device according to claim 3 or 4, wherein each said wing (4) is hinged to the exoskeleton (2) or to the lumbar support element (10) in such a way that it is oscillating around a respective vertical axis. 20
6. Device according to one or more of claims 3 to 5, wherein each said wing (4) is hinged free and has a greater thickness near the constrained end (41) and a lesser thickness at the free end (44). 25
7. Device according to one or more of claims 3 to 6, wherein each said wing (4) is provided with elastic stress means in the direction of the patient. 30
8. Device according to one or more of the preceding claims, wherein a lumbosacral support element (3) is provided connected to the lumbar support element (10). 35
9. Device according to one or more of the preceding claims, wherein the lumbosacral support element (3) is hinged to the lumbar support element (10) or to the exoskeleton (2) and is inserted into a special pocket (30) provided in the central portion (11) of the brace (1). 40
10. Device according to one or more of the preceding claims, wherein a thoracic support system (21) is provided comprising at least one rigid upright (22) connected to the brace (1) and/or to the exoskeleton (2) and means (23) for retaining the patient's thorax to said upright (22). 45 50

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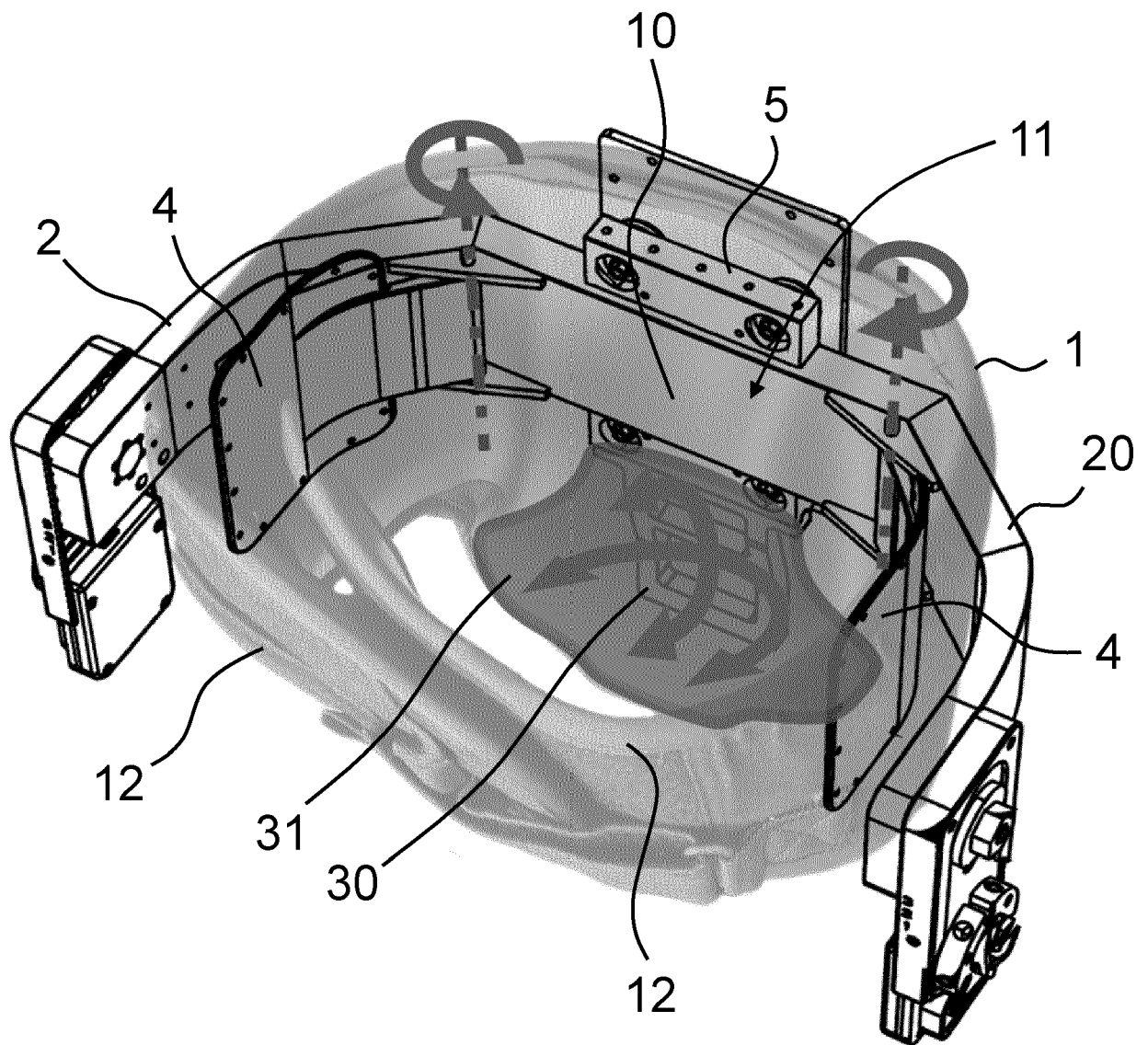


Fig. 1

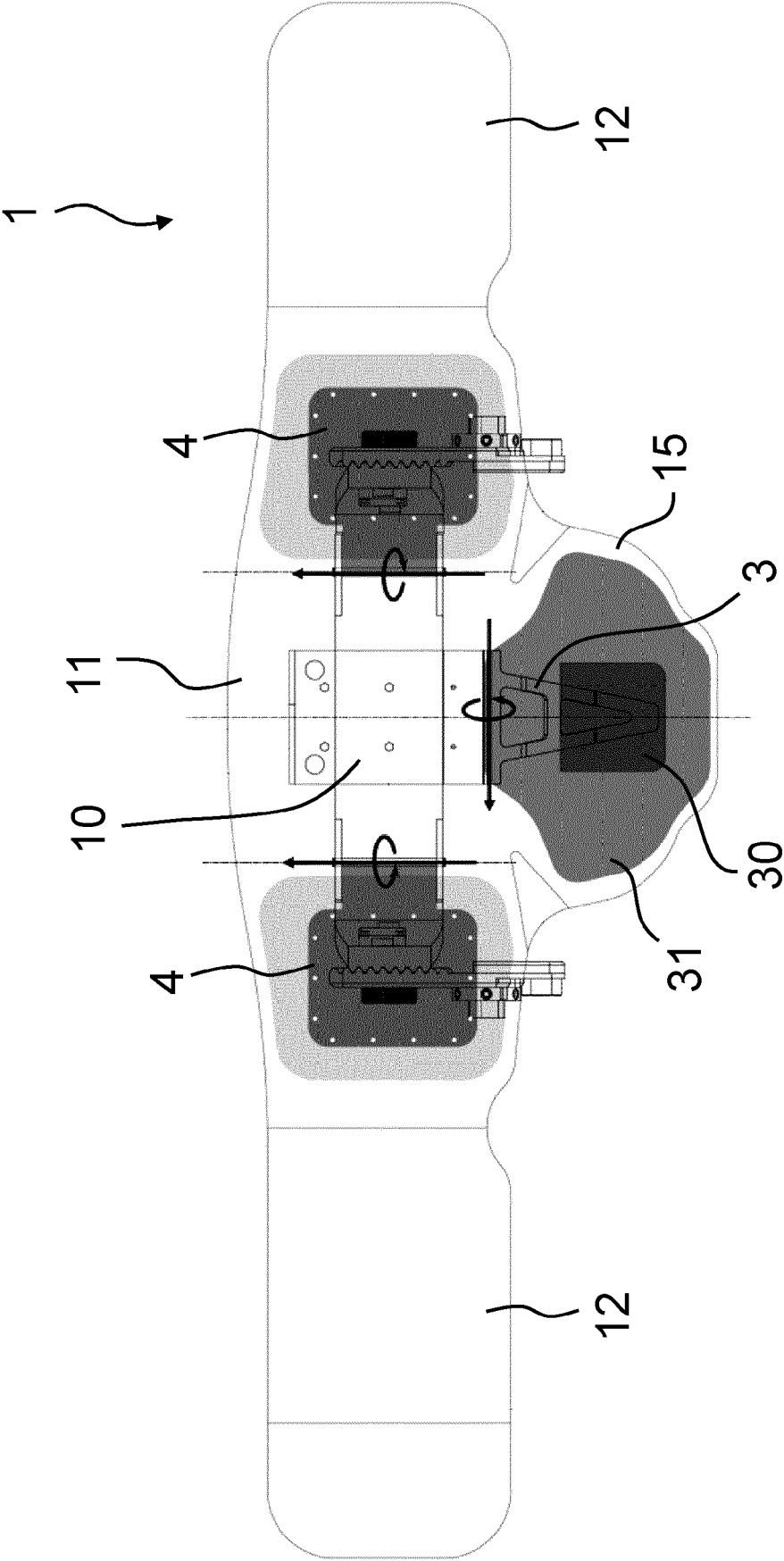


Fig.2

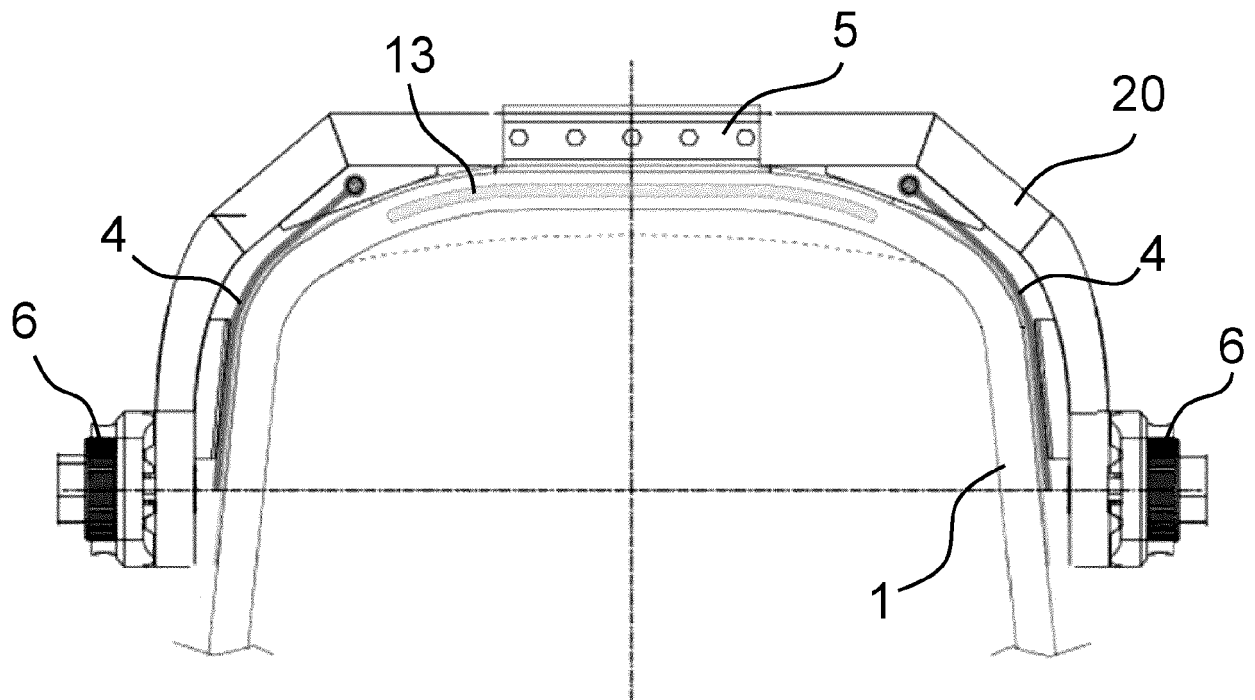


Fig. 3

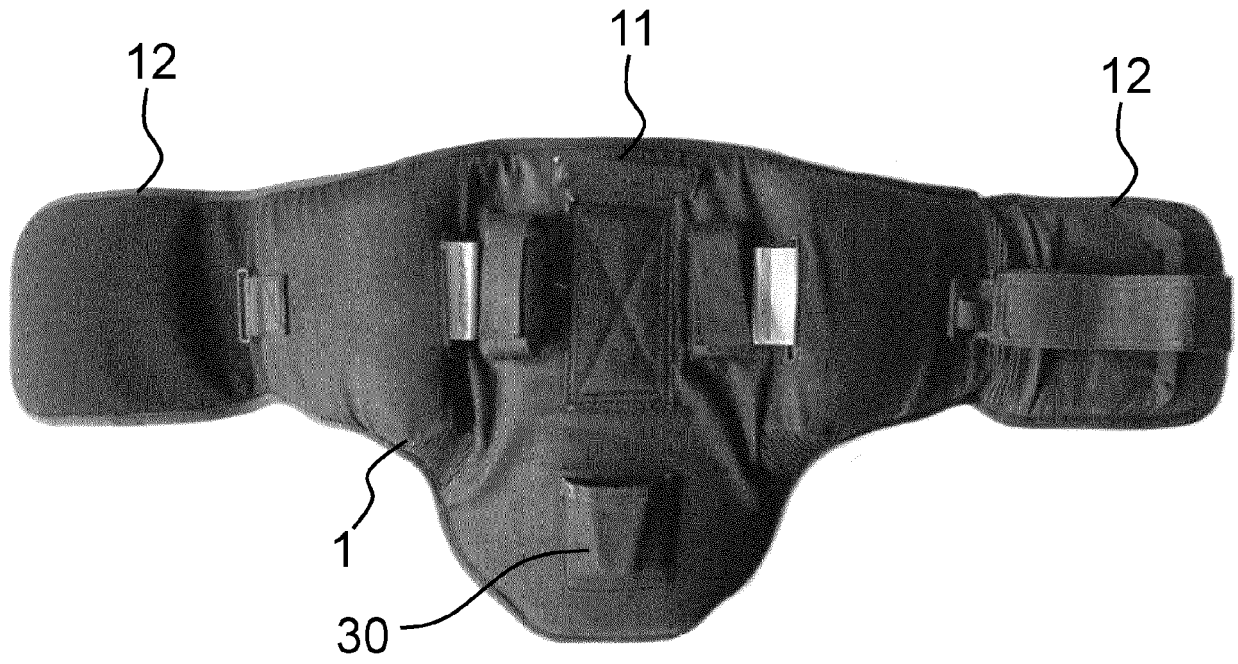


Fig. 4

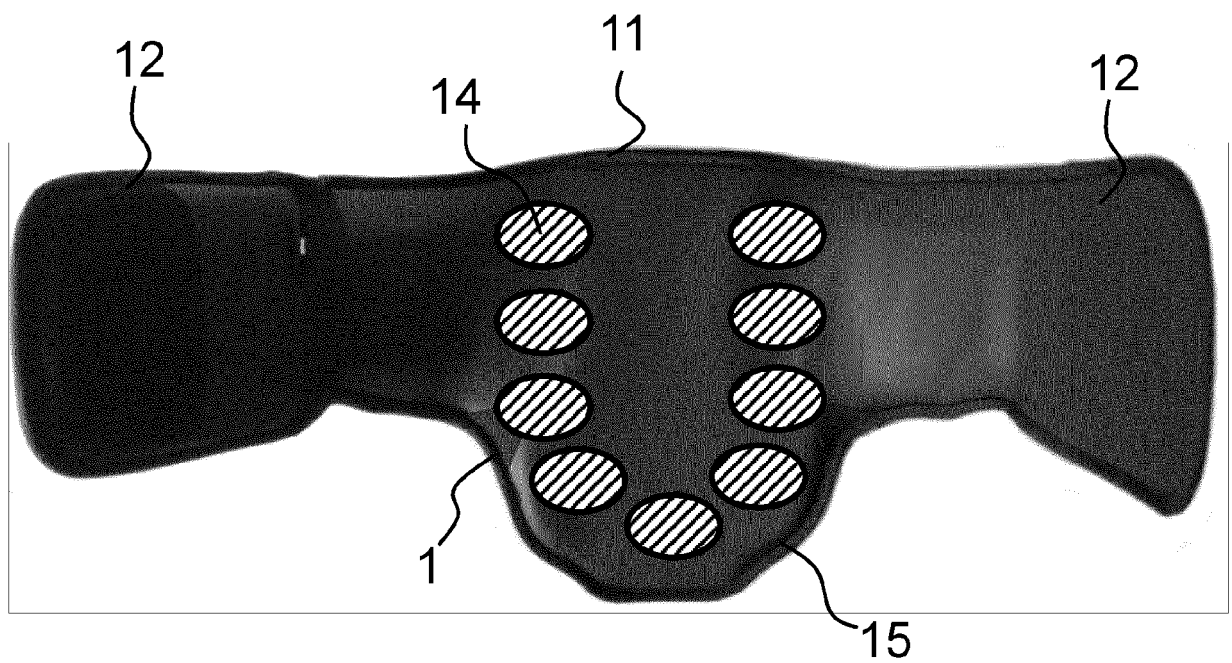


Fig. 5

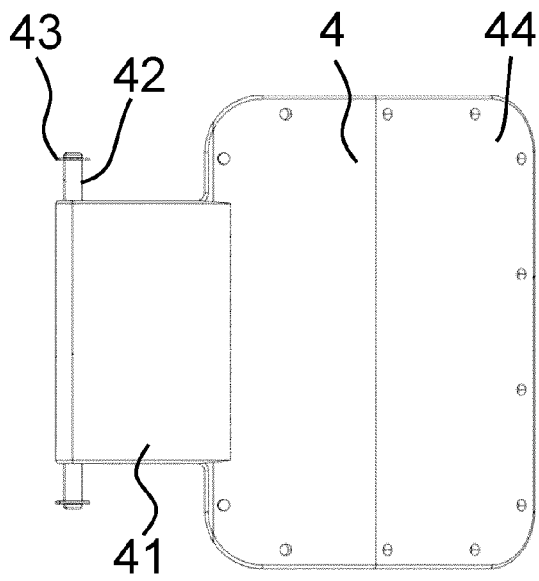


Fig. 6

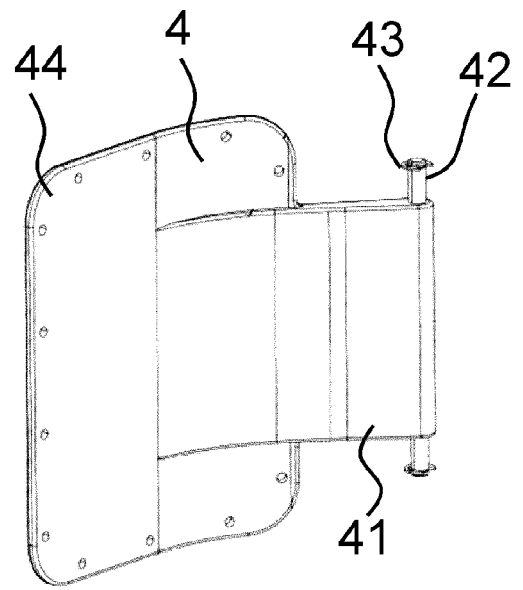


Fig. 7

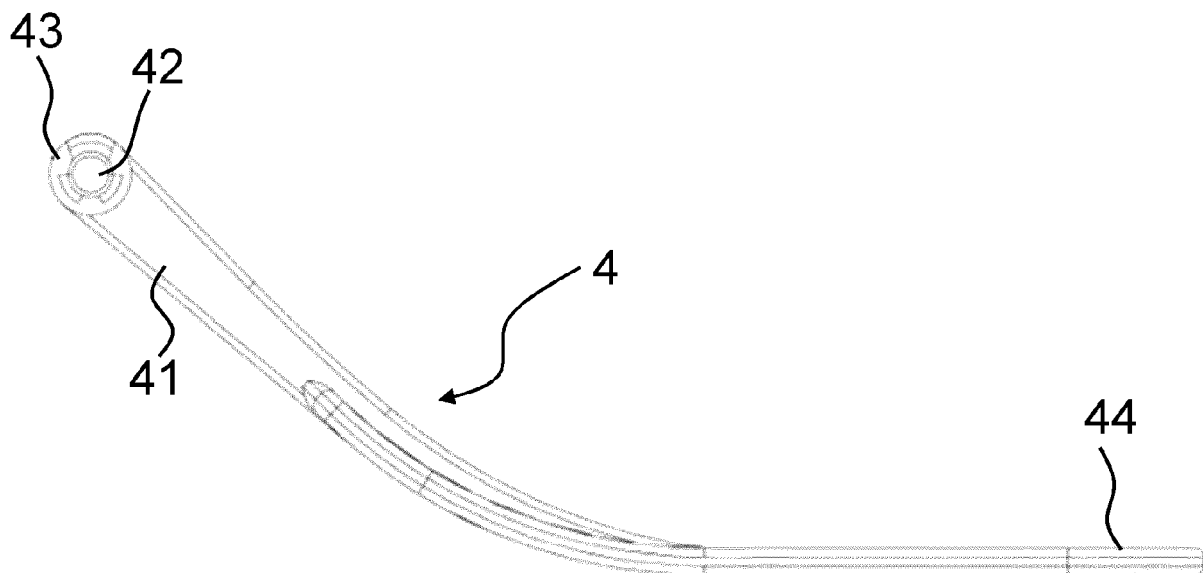


Fig. 8

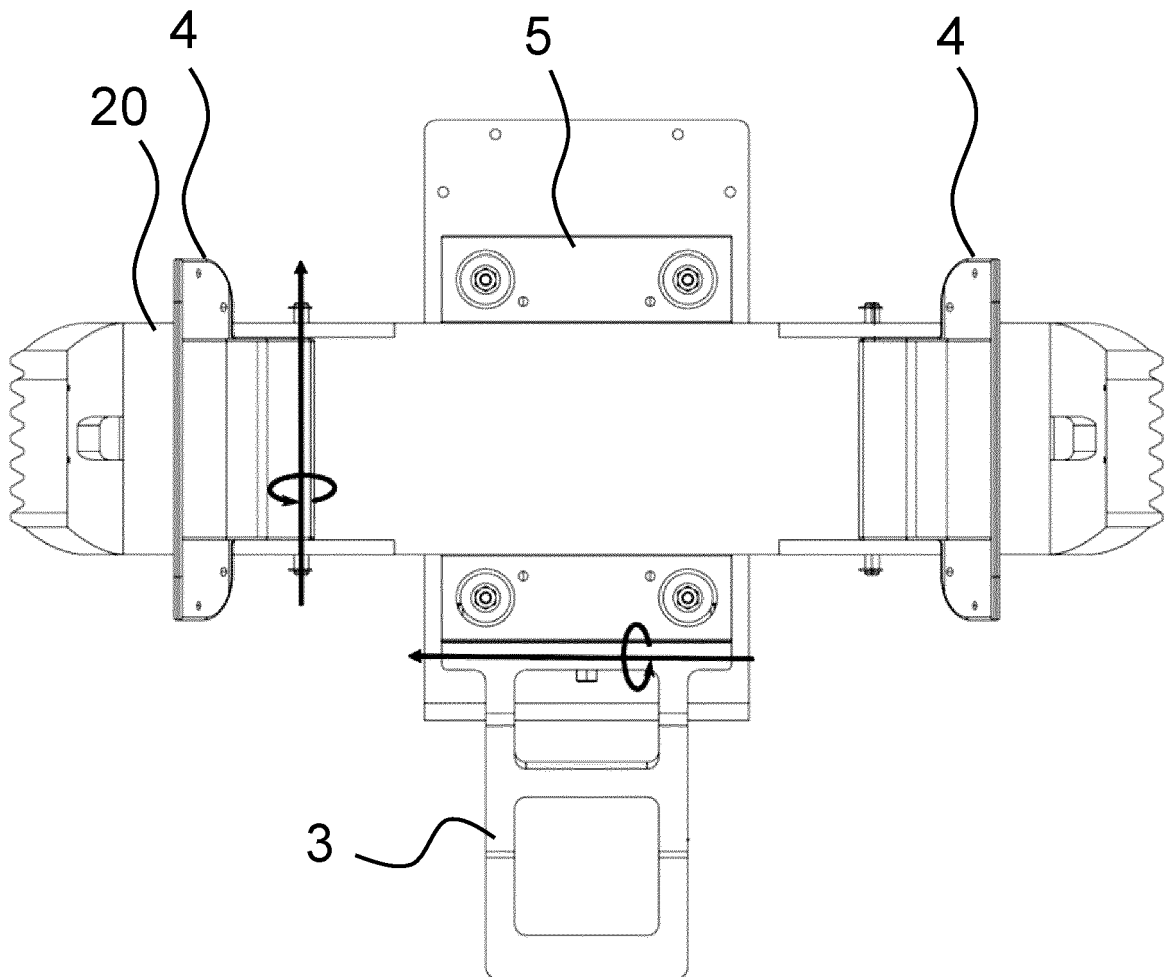


Fig. 9

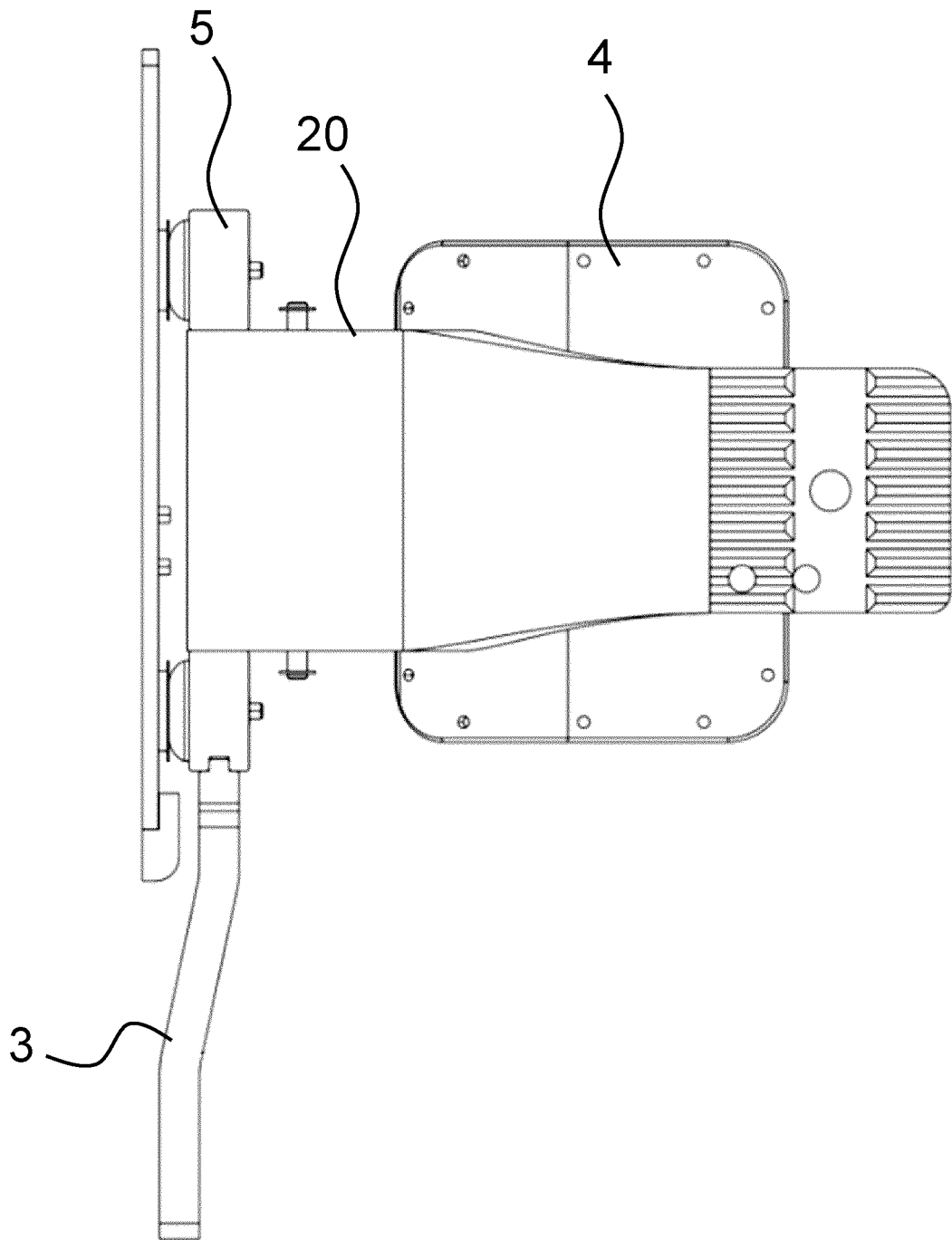


Fig. 10

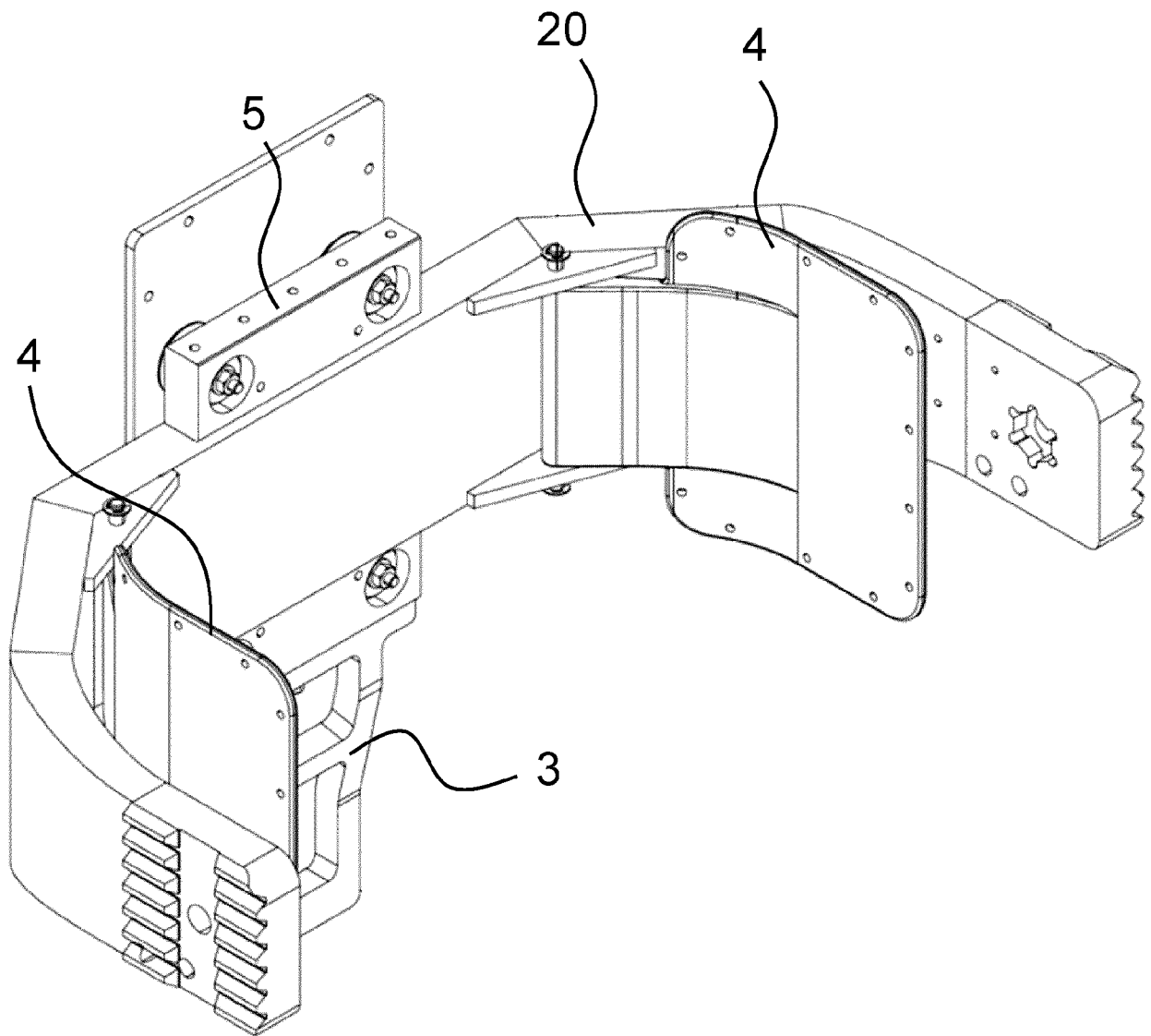


Fig. 11

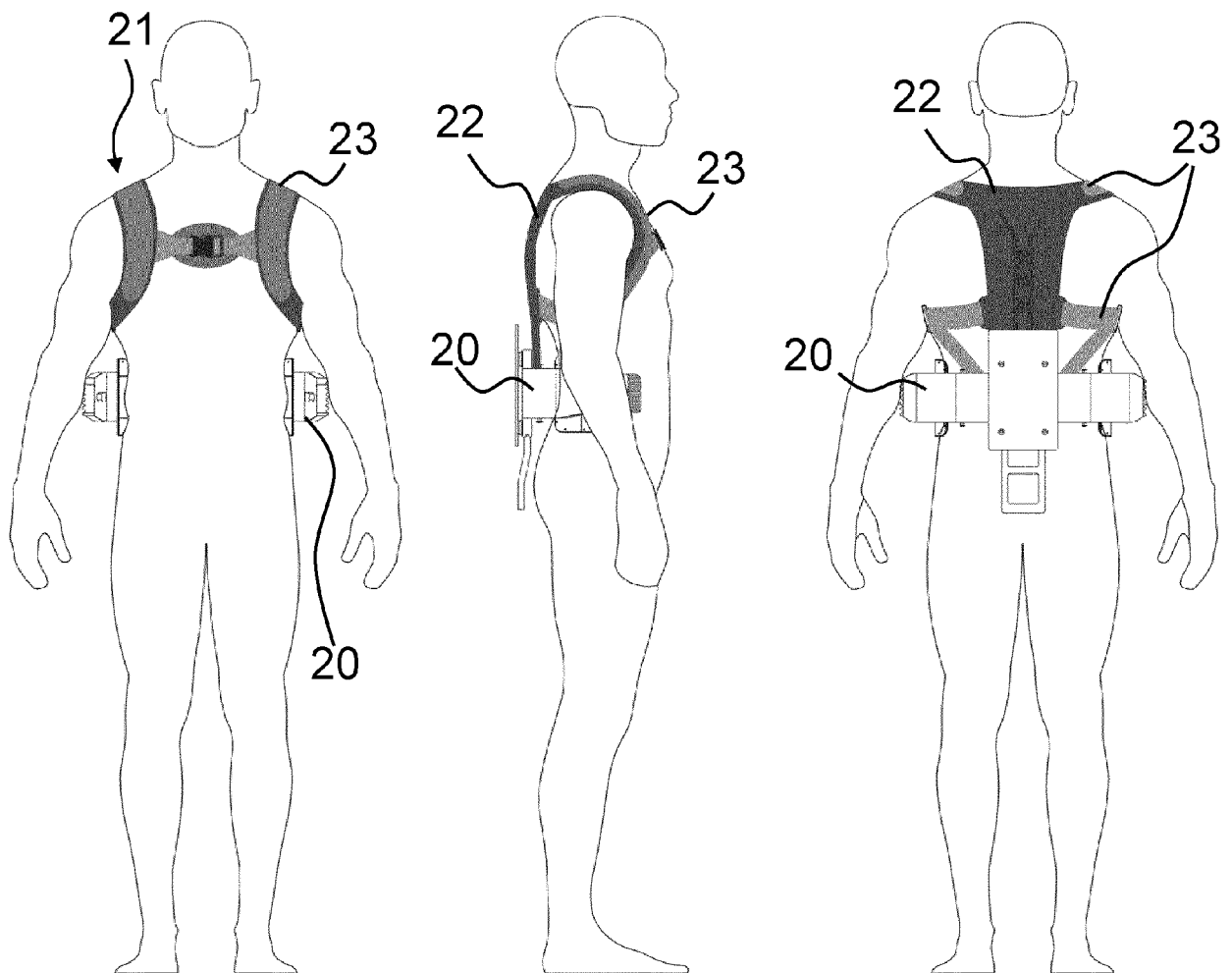


Fig. 12



EUROPEAN SEARCH REPORT

Application Number

EP 22 15 6130

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2018/071129 A1 (OZSECEN MUZAFFER Y [US] ET AL) 15 March 2018 (2018-03-15) * paragraph [0020] - paragraph [0029]; figures * * paragraph [0040] * * paragraph [0046] - paragraph [0048] * -----	1-10	INV. A61H3/00
X	WO 2018/200436 A1 (OSSUR ICELAND EHF [IS]; OSSUR AMERICAS INC [US]) 1 November 2018 (2018-11-01) * figures * -----	1-10	
X	US 2019/274912 A1 (NAM BOHYUN [KR] ET AL) 12 September 2019 (2019-09-12) * paragraph [0033]; figures * * paragraph [0046] - paragraph [0047] * -----	1-10	
X	MEYER JAN T ET AL: "User-centered Design and Evaluation of Physical Interfaces for an Exoskeleton for Paraplegic Users", 2019 IEEE 16TH INTERNATIONAL CONFERENCE ON REHABILITATION ROBOTICS (ICORR), IEEE, 24 June 2019 (2019-06-24), pages 1159-1166, XP033583325, DOI: 10.1109/ICORR.2019.8779527 * the whole document * -----	1,10	TECHNICAL FIELDS SEARCHED (IPC) A61H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 31 May 2022	Examiner Squeri, Michele
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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ON EUROPEAN PATENT APPLICATION NO.**

EP 22 15 6130

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

31-05-2022

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2018071129 A1	15-03-2018	NONE	
WO 2018200436 A1	01-11-2018	CN 110678156 A	10-01-2020
		EP 3614989 A1	04-03-2020
		US 2018303699 A1	25-10-2018
		US 2021154084 A1	27-05-2021
		WO 2018200436 A1	01-11-2018
US 2019274912 A1	12-09-2019	NONE	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20130245512 A1 [0010]
- US 10537488 B [0011]
- US 20160235616 A1 [0012]