(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 260 176 A1**

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.12.2017 Bulletin 2017/52

(51) Int Cl.:
A63B 21/005 *(2006.01)* ***A63B 23/08*** *(2006.01)*
A63B 21/00 *(2006.01)*

(21) Application number: **17176860.9**

(22) Date of filing: **20.06.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **20.06.2016 DK 201600359**

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(54) A LEG EXERCISING APPARATUS

(57) A leg exercising apparatus 10 for exercising a lower leg and/or foot of a patient, wherein a leg section 9 and a foot section 3, which are pivotable in relation to each other, are configured to be fastened to the lower leg 15 and foot 16 of the patient, respectively. The foot section 3 comprises a first fixation 4 and the leg section 9 comprises a second fixation 6 at an upper part. The leg exercising apparatus 10 further comprises an actuator 20 comprising an electromotor 5, wherein the actuator 20 is connected between the first 4 and the second fixation 6 to exert a force, when activated, to rotate the leg section 9 and the foot section 3 in relation to each other in respect to a pivot point 1. The leg exercising apparatus 10 further comprises a power limitation arrangement 17 for controlling the electromotor 5.

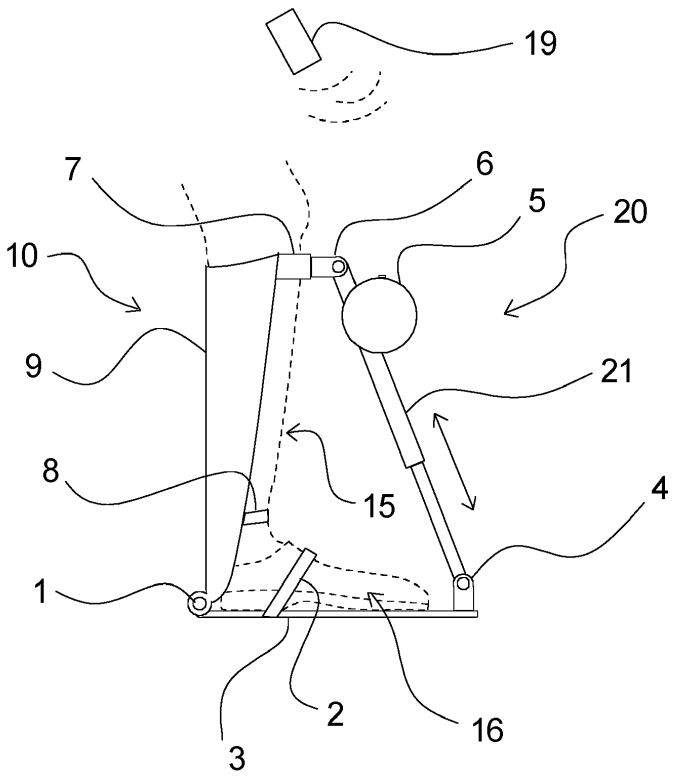

Fig. 7

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Description

Field of the invention

[0001] The invention relates to a leg exercising apparatus for exercising a lower leg and/or foot of a patient, wherein a leg section and a foot section, which are pivotable in relation to each other, are configured to be fastened to the lower leg and foot of the patient, respectively.

[0002] In particular, the invention relates to an apparatus for exercising a human lower leg, e.g. ankle movement, of a person, who in the following also will be referred to as a patient or a user, which person suffers from deficits such as drop foot (or "foot drop"), and where the exercising is required for example to stretch out a tense peroneus caused by drop foot.

[0003] The leg exercising apparatus may also be used in connection with other deficits of the human lower leg/foot movement, ankle movements, etc.

Background of the invention

[0004] Persons suffering from drop foot may relieve the condition and even return to a condition with normal leg/foot movement by exercise involving stretching of e.g. the muscles in the lower leg of the person, which muscles are involved in ankle movement such as dorsiflexion and/or plantar flexion. In particular the peroneus muscles may be tense in a drop foot condition and may be exercised by stretching to relieve or improve the condition.

[0005] For this purpose, it is known to perform a manual exercising, i.e. performed by the patient, and manual devices for facilitating a manual exercising of the leg/foot movement are known, where the user/patient has to exert pulling and/or pushing forces to lines, grips or similar means.

[0006] For example, US 6,206,807 B1 relates to an ankle exercise device, which includes a lower leg section and a foot section, wherein the lower leg section receives a calf portion of the lower leg of a user and wherein the foot section receives a foot of the user. The foot section is rotatably connected with the lower end of the lower leg section. Furthermore, a rigid control rod is connected at one end to the foot section and the user holds the opposite end. Thus, when the user successively pushes and pulls the control rod, the foot section is pivoted with respect to the lower leg section, whereby the ankle-foot complex is exercised.

[0007] This prior art device is thus relying on the manual power of the user to perform the exercising. When taking into consideration how strong/stiff a peroneus muscle can be, thus requiring a considerable force to be exerted by a user, further taking into account how often the exercising of the peroneus muscles must be performed, e.g. as much as 4-5 times per day to be effective, it is apparent that such a manually operated device for most users will be insufficient to provide an effective exercising and thereby relieve of a condition such a drop foot.

[0008] To this can be added that when stretching a peroneus muscle, a considerable force must as mentioned above be exerted, but furthermore, the pulling force must be maintained for a certain time in order to have a relaxing and/or stretching effect on the peroneus muscles, thus furthermore increasing the energy that is required by a person using such a prior art device to seek to remedy or relieve a drop foot condition.

[0009] Even further, the prior art device according to US 6,206,807 B1 is configured in such a manner that stability may be lacking, e.g. as regards support from the shin bone area and down to the foot, which may also add to the disadvantages when trying to manually exercise a tense peroneus muscle.

[0010] Also, it is noted that such a manually operated prior art device is difficult and even more exhausting to use, in case the person using it is lying in bed, e.g. bedbound at the time when exercising, and/or is in general lacking in arm muscle strength. Hence, a satisfactory effect can thus hardly be achieved.

[0011] A further example of a manually operated exercising apparatus is disclosed by WO 2005/089140 A2, which relates to an apparatus for exercising the plantar facia of the foot, i.e. a thick fibrous band of tissue running along the bottom of the human foot. However, it is mentioned in this prior art document that the calf and the hamstring muscles can be exercised as well. This prior art apparatus comprises a first member (strap) that is positioned under the ball of the foot, a second member that is positioned under the toes and a third member (strap) with an eye that is attached around the ankle. The first and the second members are each attached to a line and the two lines extend through the eye of the third member. The two lines are attached to a handle that can be gripped by the user. By pulling the handle, i.e. by the patient using the muscles in his arm, force is applied to the two lines, which force will cause the ankle and toes to move upwards, i.e. dorsiflex, and thereby stretch the plantar fascia.

[0012] The prior art apparatus as disclosed by WO 2005/089140 A2 is related with similar disadvantages as mentioned previously in connection with US 6,206,807 B1, including in particular that this prior art device is relying on the manual power of the user to perform the exercising. Thus, when taking into consideration how strong/stiff a peroneus muscle can be, thus requiring a considerable force to be exerted by a user, further taking into account how often the exercising of the peroneus muscles must be performed, e.g. as much as 4-5 times per day to be effective in drop foot exercising, it is apparent that such a manually operated device for most users will be insufficient to provide an effective exercising and thereby relieve of a condition such a drop foot.

[0013] Further can be added that when stretching a peroneus muscle, a considerable force must as mentioned above be exerted, but furthermore, the pulling force must be maintained for a certain time in order to

have a relaxing and/or stretching effect on the peroneus muscles, thus furthermore increasing the energy that is required by a person using such a prior art device to seek to remedy or relieve a drop foot condition.

[0014] Even further, the prior art device according to WO 2005/089140 A2 is also configured in such a manner that stability apparently will be lacking, which may also add to the disadvantages when trying to manually exercise for example a tense peroneus muscle.

[0015] Also, it is noted that such a manually operated prior art device is difficult and even more exhausting to use, in case the person using it is lying in bed, e.g. bedbound at the time when exercising, and/or is in general lacking in arm muscle strength. Hence, a satisfactory effect can thus hardly be achieved.

[0016] For both of the above-mentioned prior art devices it is apparent that since they are manually operated, it will be difficult for most patients to perform exercises that will have a desired effect, when e.g. dealing with drop foot conditions, peroneus muscles, etc., since the required amount of energy in order to achieve just a small effect is considerable. Thus, judged by experience, even healthy persons with strong muscles, e.g. arm muscles, will have problems with performing sustained effective exercises of the required periods, and the problems will be even larger for patients with weakened arm muscles, weakened conditions in general, etc.

[0017] Further, US 2013/0040782 A1 discloses exercise equipment intended for exercising legs of a person, i.e. by stretching or retraction. This prior art apparatus comprises a first frame and at least a first foot platform, which is rotatable fastened and arranged for exercising e.g. muscles at the back side of the leg, while the leg is supported by a leg support with support pads, which are arranged to support at the front side of the legs at or above knee level.

[0018] Thus, there is a need for improvements as regards such exercise devices which can be used by a patient to exercise a human lower leg, e.g. ankle movement, etc., for example a patient, who suffers from deficits such as drop foot (or "foot drop"), and where the exercising is required for example to stretch out a tense peroneus caused by drop foot.

[0019] Also, there is a need for improvements as regards such exercise devices which can be used by a patient in connection with other deficits of the human lower leg/foot movement, ankle movements, etc.

[0020] In particular, there is a need for such an exercising device or apparatus, by which the patient can stimulate, stretch, or the like a particular muscle such as a peroneus muscle with a necessary or required amount of force, e.g. in order to treat a drop foot condition, no matter whether the patient is strong or is more or less weakened, e.g. as regards arm muscles.

[0021] Further, there is a need for such an exercising device or apparatus, by which the patient can stimulate, stretch, or the like a particular muscle such as a peroneus muscle with a necessary or required amount of force for a required time, e.g. maintaining the force until the desired stretching effect has been achieved, e.g. in order to treat a drop foot condition, no matter whether the patient is strong or is more or less weakened, e.g. as regards arm muscles.

[0022] Even further, it is an object of the invention to provide such an exercising apparatus, which can be used in an uncomplicated manner by the patient, and whereby the exercises can be performed by the patient with the necessary exercising forces and for the necessary periods of time in order to achieve the desired effect.

[0023] Also, it is an object of the invention to provide such an apparatus, which can be used by the patient in a safe and secure manner, while still allowing a necessary maximum of force to be applied to the e.g. foot and/or leg muscles, tendons, etc. of the patient.

[0024] These and other objects are achievable by the invention as explained in further detail in the following

Summary of the invention

[0025] The invention relates to a leg exercising apparatus for exercising a lower leg and/or foot of a patient, wherein a leg section and a foot section, which are pivotable in relation to each other, are configured to be fastened to the lower leg and foot of the patient, respectively, characterized in that

- the foot section comprises a first fixation and the leg section comprises a second fixation at an upper part,
- the leg exercising apparatus further comprising an actuator comprising an electromotor, said actuator being connected between said first and said second fixation to exert a force, when activated, to rotate the leg section and the foot section in relation to each other in respect to a pivot point, and
- the leg exercising apparatus further comprising a power limitation arrangement for controlling the electromotor.

[0026] Hereby, it is achieved that a leg exercising apparatus is provided, by means of which a necessary exercising force can be applied to the lower leg/foot complex of the patient, e.g. for example a stretching force that can be applied to the peroneus muscle of the patient, which force is provided by the electromotor of the actuator arrangement. Thus, the exercise efficiency is not related to the actual muscle power of the patient and a required force can be applied in an easy and uncomplicated manner.

[0027] It is noted that the exercising that can be performed by the apparatus according to the invention, e.g. stretching involving rotation of the leg/ankle complex, may involve a variety of muscles, tendons, etc. in the leg/ankle complex. Herein, the peroneus muscle is mentioned as a particular example, but it will be understood that the exercising may apply to e.g. other muscles in the leg, calf portion, foot, etc.

[0028] Further, by having the power limitation arrangement for controlling the electromotor, the safety of the patient is ensured in that it can be prohibited that e.g. a peroneus muscle is stretched with an undesirable or even damaging high force, no matter whether this might be due to a faulty operation of the apparatus or because the patient may not be able to feel when a load on a muscle is too great. In such instances the power limitation arrangement will control the electromotor to reduce the applied force, e.g. to a limit that has been set, or to stop applying a force. Thus, this arrangement may also be used as an end stop. As regards the set limit (or limits), this may have been done in advance by e.g. a health service person or by the patient him- or herself. Also, it is noted that the limit (or limits) may be adjusted, e.g. in the course of an exercise sequence.

[0029] It is noted that the actuator comprising the electromotor is connected between the upper part of the leg section and the foot section and that thus the leg section and the foot section will be rotated towards each other, when the electromotor is controlled to move in one direction and that the leg section and the foot section will be rotated away from each other, when the electromotor is controlled to move in the opposite direction, thus applying corresponding forces on the respective parts of the leg and foot muscles, tendons and other parts. It is noted that it is a possibility that the electromotor may be controlled to move in one direction only, but preferably it can be moved in both directions.

[0030] According to an embodiment, the actuator may comprise an actuator link, rod or the like operably connected to the electromotor, said actuator link, rod or the like being connected to said first fixation and said electromotor being connected to said second fixation or vice versa.

[0031] Thus, it will be seen that the electromotor may exerts its effect via a rigid element such as a rod that may be telescopic or the like and that the electromotor may push as well as pull. Also, a flexible link may be used instead, e.g. a wire or line, whereby usually a pulling effect only can be applied. As regards the electromotor itself, this may preferably be located near the upper part of the leg section, i.e. connected to the second fixation, or it may alternatively be located near the foot section.

[0032] According to an embodiment, the leg section may comprise a bracket at an upper part, and wherein said second fixation may be arranged in connection with said bracket.

[0033] The bracket may advantageously serve for providing a stable connection and fixation point for the electromotor and whereby the electromotor may effect the leg section with a maximum of torque in respect to the pivot point.

[0034] According to an embodiment, the bracket may be loop-shaped and be configured to be releasable and/or adjustable.

[0035] Hereby, the bracket may serve to accommodate the leg of the user as the bracket is looping around the user's leg, when the apparatus is mounted on the user. The bracket is configured to be opened, when the user puts the apparatus on the leg, and subsequently closed and possibly adjusted to conform to the user's leg size. Similarly, the removal of the apparatus is facilitated.

[0036] According to an embodiment, the leg exercising apparatus may further comprise a mechanical foot plate being arranged in connection with the foot section.

[0037] As regards the mechanical foot plate being arranged in connection with the foot section, it is noted that by use of this a possible adjustment of the travel of the foot section is achievable, e.g. in case the travel of the actuator at some point in time during the exercises is insufficient. This can for example be the case, when e.g. the stretch of the peroneus muscle and/or the increased ankle movement allows the foot to be rotated more towards the leg, in which case the foot plate can be adjusted to an increased height above the foot section, e.g. at the toe area.

[0038] According to an embodiment, the leg section is configured to accommodate at least a part of a calf part of the lower leg of the patient, the leg section having a front part having an essentially concave sectional shape facing the lower leg and a corresponding essentially convex rear part.

[0039] Hereby, it is achieved that the leg section is made in a form that has inherent strength and which is user-friendly, e.g. since it conforms to the lower leg of the user. Also, it is hereby achieved that an increased stability and rigidity of the leg section as such and the apparatus in general is achieved. Further, a desirable optimal transfer of force between the leg section and the user's leg is achieved.

[0040] According to an embodiment, the second fixation may be arranged facing the front of the leg section, for example arranged on the bracket, and with the first fixation correspondingly arranged on a forward facing part of the foot section.

[0041] Hereby, a straightforward and efficient arrangement is achieved, whereby the force of the actuator is transferred to the leg section and the foot section to rotate the two parts relatively with respect to the pivot point, in a relatively simple manner.

[0042] According to an embodiment, the second fixation may be arranged to the rear of the leg section and wherein the first fixation correspondingly is arranged on a rearward facing part of the foot section to the rear of the pivot point.

[0043] According to this alternative embodiment, the bracket need not be a loop-shaped element, which the user has to open, when mounting or when removing the apparatus. Thus, when the electromotor is located at the rear, a more user-friendly embodiment may be achieved in this aspect. Further, since the first fixation according to this embodiment is located to the rear of the pivot point, e.g. on a small rearward facing extension of the foot section, it is achieved that a certain amount of travel of the actuator/electromotor will result in a relatively large rota-

tion of the foot section in relation to the leg section, e.g. a larger gearing as compared with the arrangement where the electromotor is arranged at the front part.

[0044] According to an embodiment, the foot section may comprise a foot fastener and said leg section may comprise a lower leg fastener.

[0045] Hereby, it is achieved that the two sections are fastened to the user in such a manner that the exerted force provided by the electromotor can be transferred to the leg and foot of the user in an efficient manner.

[0046] According to an embodiment, the foot fastener, for example in the form of a strap, may be located near the pivot point, and wherein said lower leg fastener, for example in the form of a strap, may be located at the shin area of the leg section.

[0047] Hereby, it is achieved that the two sections are fastened to the user in a particular efficient manner, e.g. whereby the exerted force provided by the electromotor can be transferred to the leg efficiently, since the leg and foot of the user will be in a preferred position with the lower leg fastener near the ankle rotation axis and with the foot fastener near the pivot point of the apparatus, whereby the foot is effectively secured from e.g. being lifted from the foot section, e.g. when the foot section and the leg section are forced to be rotated towards each other.

[0048] According to an embodiment, the leg section is provided in at least two different sizes.

[0049] Hereby, it is achieved that the exercising apparatus can be provided to a user in an optimal size, corresponding to the actual size, e.g. the height of the lower leg, of the user. This is of importance since the actuator and the electromotor will exert its force to an upper part of the leg section and the higher the leg section is, the larger the torque exerted on the leg section will be. However, it is also of importance that the leg section has a length so that it does not reach the height of the back of the knee, which otherwise could cause irritation to the user by the bracket and/or the second fixation.

[0050] The leg sections may for example be provided in three different lengths, e.g. small, medium and large. Further options may be available, also as regards the width of the leg sections.

[0051] According to an embodiment, the mechanical foot plate and/or said foot section may be provided with a support area and support length corresponding at least to the foot of the patient, e.g. including the whole length as well as the whole width of the foot.

[0052] Hereby, it is achieved that the force that is applied to the foot by the foot section, is transferred to the foot in total and not only to e.g. the toes or the ball of the foot as is the case with e.g. the prior art device according to WO 2005/089140 A2.

[0053] According to an embodiment, at least one of said

- leg section,
- foot section,
- mechanical foot plate,
- first fixation.
- second fixation and
- bracket

may be made partially or totally of a synthetic material such as hard plastic material,e.g. polyamide or other similar materials, carbon fiber material, etc.

[0054] Hereby, it is achieved that the apparatus may be fabricated in relatively light materials while still providing the necessary strength, durability, etc. Furthermore, the respective elements may hereby be formed to conform to the foot and leg of the user, thus improving comfort and user-friendliness. Even further, some of the elements may be padded, covered with soft material, etc. in order to further facilitate comfort.

[0055] According to an embodiment, the power limitation arrangement for controlling the electromotor is configured to limit the exerted force and/or to stop the electromotor.

[0056] Hereby, it is achieved that the safety of the patient or user is ensured in that it can be prohibited that e.g. a peroneus muscle is stretched with an undesirable or even damaging high force, no matter whether this might be due to a faulty operation of the apparatus or because the patient may not be able to feel when a load on a muscle is too great. In such instances the power limitation arrangement will control the electromotor to reduce the applied force, e.g. to a limit that has been set, or to stop applying a force. Thus, this arrangement may also be used as an end stop. As regards the set limit (or limits), this may have been done in advance by e.g. a health service person or by the patient him- or herself. Also, it is noted that the limit (or limits) may be adjusted, e.g. in the course of an exercise sequence.

[0057] According to an embodiment, the power limitation arrangement for controlling the electromotor is configured to limit the exerted force

- within an interval around 100 N to 3000 N,
- in an alternative form within an interval around 100 N to 1000 N, and
- in a further alternative form within an interval around 100 N to 700 N.

[0058] Hereby, it is achieved that suitable levels of limitation can be set, e.g. in view of the patient, in view of the abnormal condition, which it is intended to remedy by exercising, etc. However, other intervals, wherein the exerted force can be set and/or adjusted, are possible. Also, it is noted that other manners of controlling the load transferred to the patient via the power limitation arrangement are possible.

[0059] According to an embodiment, the leg exercising apparatus may be controllable via a control device, said control device being a wireless control device, e.g. using e.g. infrared, ultrasonic, radio frequency transmission means, etc., in particular a mobile communication device

such as a smartphone, comprising an application program (app) for facilitating control of the leg exercising apparatus.

[0060] Hereby, it is achieved that the leg exercising apparatus can be operated in a particular user-friendly manner, in particular in case a standard smartphone or the like is used for the control operations, which for example can be performed by downloading an application program, i.e. an app designed for the purpose, to the user's own smartphone. Hereby, the user can operate the leg exercising apparatus simply by using the input options of the smartphone, e.g. operating the actuator to pull or push, increasing or reducing the force exerted by the electromotor, etc. Further options will be available, e.g. the option that upper limit(s) for pulling or pushing forces exerted by the electromotor can be input in the smartphone app, thereby making it easy to adapt the leg exercising apparatus to the individual users and to personalize the control system to perform in an optimal manner.

[0061] Furthermore, it will be possible to have the smartphone app control and perform relatively complicated operations such as performing exercising actions, e.g. exerting a pulling force of a certain magnitude for a certain period and then releasing the force. Even further, it is possible to have the smartphone application perform predefined exercising sequences comprising a number of exercising actions, etc. which all may be adapted specifically to the actual user, e.g. based on input from a specialized health care person.

[0062] Hereby, the leg exercising apparatus can provide an even better effect on a patient over a relatively short time due to the consistent and precise exercises being performed in an optimal manner.

[0063] According to an embodiment, the leg exercising apparatus may comprise a battery power supply integrated with the actuator, e.g. the electromotor, which battery power supply may be rechargeable and may be in the form of a power bank.

The figures

[0064] The invention will be explained in further detail below with reference to the figures of which

Fig. 1 shows, seen from a side, an example of a leg exercising apparatus according to an embodiment of the invention with the leg exercising apparatus placed on a lower leg and foot of patient, where the leg exercising apparatus does not exert a force on the lower leg and foot of the patient,

Fig. 2 corresponds to fig. 1, but showing a scenario where the leg exercising apparatus exerts a force on the lower leg and foot of the patient, e.g. applying a pulling force between the foot and the lower leg in order to stretch a tense peroneus, which may be caused by drop foot,

Fig. 3 shows an example of a power supply and a control device for controlling the operation of a leg exercising apparatus according to an embodiment of the invention,

Fig. 4 is a block diagram illustrating an example of the power supply to the actuating means of the leg exercising apparatus according to an embodiment of the invention, which comprises a power limitation arrangement,

Fig. 5 is a block diagram corresponding to fig. 4, but illustrating an embodiment, wherein a remote control, mobile communication unit or the like is utilized,

Fig. 6 is a block diagram corresponding to fig. 5, i.e. illustrating an embodiment, wherein a remote control, mobile communication unit or the like is utilized, but wherein furthermore the power supply may be in the form of a battery,

Figs. 7-8 show a leg exercising apparatus essentially as disclosed in figs. 1 and 2, wherein further the actuator is controlled via a remote control, e.g. a smartphone or the like,

Figs. 9-10 show a similar leg exercising apparatus, wherein it is shown that the actuator can be located to the rear of the apparatus,

Figs. 11-12 show embodiments wherein the actuator may be placed in a position with the electromotor near the foot section,

Fig. 13 shows an embodiment indicating curvature of the leg section in the vertical direction in addition to being curved in the transverse direction, and

Fig. 14 shows an embodiment of an adjustable mechanical foot plate.

Detailed description

[0065] Fig. 1 shows, seen from a side, an example of a leg exercising apparatus, which generally is designated 10, according to an embodiment of the invention. The leg exercising apparatus 10 is positioned on a person (which will also be referred to as a user or a patient), i.e. with the leg exercising apparatus 10 placed on a lower leg 15 and a foot 16 of the patient. In the illustrated position, the leg exercising apparatus does not exert a force on the lower leg 15 and foot 16 of the patient.

[0066] The leg exercising apparatus 10 comprises a foot section 3 and a leg section 9, which are pivotably connected to each other at a pivot point 1. The pivot point 1 may be in the form of a hinge or the like, where a bolt defines the pivot point, e.g. an axle linking the two sections together. The leg section 9 nay also be referred to as a vertical section, due to its general position when the

patient is standing up, but it is apparent that the leg exercising apparatus may also be used with the leg in other positions, e.g. with the patient sitting down and the leg in an inclined position, with the patient lying down and the leg essentially horizontal, etc. Thus, preferably, the term leg section 9 will be used in the following.

[0067] As shown in fig. 1, the foot section 3 extends from the pivot point 1 forwards along the whole length of the foot 16 and to a position forward of the foot. Here, the foot section 3 comprises a first fixation 4, to which an actuator 20 can be connected as it will be explained further below. Further, the foot section 3 comprises a foot fastener 2, which as shown may be in the form of a releasable strap or the like, that can be applied around and possible tightened around the foot 16. The foot fastener 2 is preferably located near the pivot point 1 in order to hold the foot securely to the foot section 3 during exercises.

[0068] As further shown in fig. 1, the leg section 9 comprises a second fixation 6 that is located at an upper part of the leg section 9, e.g. near the knee of the patient. In the shown embodiment, the second fixation 6 is located in connection with a bracket 7, e.g. on a forward facing part of the bracket 7. This bracket 7 may thus serve to accommodate the leg 15 of the user as the bracket 7 is arranged around the user's leg 15, when the apparatus 10 is mounted on the user. The bracket 7 is configured to be opened, when the user puts the apparatus on the leg, and subsequently closed and possibly adjusted to conform to the user's leg size. Similarly, when the bracket 7 is opened, the leg exercising apparatus 10 can be removed. An actuator 20 can be connected to the second fixation 6 as it will be explained further below.

[0069] Further, the leg section 9 comprises a lower leg fastener 8, which as shown may be in the form of a releasable strap or the like, that can be applied around and tightened around the foot 15 of the user. The lower leg fastener 8 is preferably located at the shin area of the leg section 9, e.g. near the ankle rotation axis, whereby the leg can be effectively secured during exercises.

[0070] The leg exercising apparatus 10 also comprises an actuator that generally is designated 20, which actuator 20 comprises an electromotor 5 connected to an actuator link, rod or the like 21, which in fig. 1 is shown as an extendable rod, e.g. a telescopic rod, that extends, when the electromotor is rotated in one direction and retracts, when the electromotor 5 is reversed. The actuator 20 is connected between the first 4 and the second fixation 6, e.g. via bolt connections, links or the like, which allow rotational movement. As shown in fig. 1, the electromotor 5 is connected to the second fixation 6 and the end of the actuator link, rod or the like 21 is connected to the first fixation 4, but it will apparent that the reverse is possible and that other configurations are possible as well.

[0071] The actuator 20 is as shown arranged to exert a force, when it is activated, e.g. via a cable control or the like to the electromotor 5, whereby the leg section 9 and the foot section 3 will be rotated in relation to each other in respect to the pivot point 1. Thus, when the electromotor is driven in one direction, the leg section 9 and the foot section 3 will be rotated towards each other and when the electromotor 5 is driven in the opposite direction, the leg section 9 and the foot section 3 will be rotated away from each other. In this manner a desired or necessary exercising force can be applied to the lower leg/foot complex of the patient, e.g. for example a stretching force that can be applied to the peroneus muscle of the patient, which force can be applied in an controlled, easy and uncomplicated manner.

[0072] In fig. 1 the leg exercising apparatus 20 is shown in a relaxed/un-activated situation. i.e. where the leg exercising apparatus does not exert a force on the lower leg 15 and the foot 16 of the patient.

[0073] In fig. 2 the leg exercising apparatus 20 is shown in a similar manner as in fig. 1 and wherein the same reference numbers are used for the same elements, components and features. However, in fig. 2 a scenario is shown, where the leg exercising apparatus 20 exerts a pulling force between the leg section 9 and the foot section 3, thus applying a pulling force on the lower leg 15 and foot 16 of the patient, e.g. in order to stretch a tense peroneus, which may be caused by drop foot, or in order to perform exercising for other purposes. As shown, the actuator link, rod or the like 21 has been retracted, while the lower leg 15 and the foot 16 both are held stably fixed in the respective sections 9 and 3 so that the movement of the leg section 9 and the foot section 3 is fully transferred to the lower leg and the foot of the patient.

[0074] It is noted that in figs. 1 and 2, the patient is shown wearing shoes and clothes, but the leg exercising apparatus 20 may be configured for use for patients that are un-dressed, partially un-dressed as well as fully dressed. The various components may be adapted to conform specifically to such different uses, e.g. as regards size, padding, etc.

[0075] Furthermore, it is noted that a mechanical foot plate (not shown in figs. 1 and 2) may be arranged in connection with the foot section 3, e.g. between the foot section 3 and the foot 16 of the user. Hereby, an adjustment of the travel of the foot section can be achieved, e.g. in case the travel of the actuator 20 at some point in time during the exercises is insufficient. This can for example be the case, when e.g. the stretch of the peroneus muscle and/or the increased ankle movement allows the foot 16 to be rotated more towards the lower leg 15, in which case the foot plate can be adjusted to an increased height above the foot section 3, e.g. at the forward part, at the toe area, etc.

[0076] As regards the leg section 9, this is shown in figs. 1 and 2 having a form configured to accommodate at least a part of a calf part of the lower leg 15 of the patient. Further, it is indicated that the leg section 9 has a front part having an essentially concave sectional shape, which faces the lower leg 15, and a corresponding essentially convex rear part. Also, it will be apparent to

a skilled person that the leg section 9 may be curved in the vertical direction, e.g. to conform to the shape of the calf of the leg 15.

[0077] Thus, the leg section 9 has a stable, strong and user-friendly form, which serves to provide a desirable optimal transfer of force between the leg section 9 and the user's lower leg 15.

[0078] The length, e.g. the length from the heel to the upper end of the leg section 9 may depend on the actual user and for this purpose the leg section 9 may be provided in a number of sizes, e.g. at least two different sizes and possibly in three (or more) different lengths, e.g. small, medium and large. The importance of a correct length resides in e.g. that the actuator 20 and the electromotor 5 will exert its force to an upper part of the leg section 9 and the higher the leg section 9 is, the larger the torque exerted on the leg section. However, it is also of importance that the leg section has a length so that it does not reach the height of the back of the knee, which otherwise could cause irritation to the user e.g. due to the bracket 7, due to the upper edge of the leg section, due to the second fixation 6, etc.

[0079] Furthermore, it is noted that the various components and features of the leg exercising apparatus 20, such as e.g. the leg section 9, the foot section 3, the mechanical foot plate, the first fixation 4, the second fixation 6 and the bracket 7 may be made partially or totally of a suitable synthetic material such as hard plastic material, carbon fiber material, etc. A material such as polyamide can be used as well as other plastic materials having the necessary properties. However, it is noted that metal parts may be used as well, e.g. light alloys, aluminum, etc. Thus, the apparatus may be fabricated in relatively light materials while still providing the necessary strength, durability, etc. The respective elements may be formed to conform to the foot and leg of the user, thereby improving comfort and user-friendliness. Some of the elements may be padded, covered with soft material, etc. in order to further facilitate user comfort.

[0080] As it has been indicated in figs. 1 and 2, the electromotor 5 of the actuator 20 is controlled and supplied with electric power via an electrical cable or cord. However, it is noted that the electromotor 5 and the leg exercising apparatus 10 in general can be supplied with electric power from a battery, e.g. a rechargeable battery such as a power bank, which may be integrated with the actuator, e.g. with the electromotor 5.

[0081] Features of the control system will be further explained with reference to fig. 3, which shows an example of a power supply, e.g. a power supply converter 12, and a control device 13 for controlling the operation of a leg exercising apparatus 20 according to an embodiment of the invention.

[0082] Here, it is shown that the power supply is in the form of a power supply converter 12 of the type that plugs directly into a mains power supply, e.g. a 220 or 230 V AC mains power supply and converts the voltage to a suitable level, e.g. 12 V, which is led to the electromotor via further control arrangements, which e.g. includes a power limitation arrangement. As mentioned above, a battery supply may be used instead. Further, the control system comprises a control device 13, which as shown may be a handheld device having an actuating input device 14 for operating the electromotor 5. This actuating input device 14 may for example as shown be a two-way switch, a toggle switch, a joy-stick or the like, which, when moved in one direction (e.g. towards +) may actuate the electromotor 5 to exert a pulling force between the leg section 9 and the foot section 3 and when moved in the other direction (e.g. towards -) may actuate the electromotor 5 to release the pulling force between the leg section 9 and the foot section 3 and rotate these away from each other, e.g. by exerting a pushing force.

[0083] As shown, the control device 13 is in fig. 3 connected via electric cords to e.g. the power supply converter 12, the electromotor 5 and to further control arrangements, e.g. including a power limitation arrangement. It is noted, though, that the control may be performed wirelessly, e.g. using a remote control device, by means of which control signals can be transmitted from (and to) a handheld device to e.g. the actuator 20, e.g. via infrared, radio-frequency, ultrasonic, etc. signals as it will be obvious to a skilled person.

[0084] However, according to an embodiment of the invention, the actuator 20 may be controlled via an app that is stored to a smartphone, whereby the user can control the leg exercising apparatus 20 using his or her smartphone, e.g. via a Bluetooth link or the like. Hereby, it will also be possible to adapt the control system and the control parameters in an uncomplicated manner, i.e. by inputting such operation parameters via the smartphone app, e.g. by setting power limitation limits in the app. Furthermore, it will be possible to have the smartphone app control and perform relatively complicated operations such as performing exercising actions, e.g. exerting a pulling force of a certain magnitude for a certain period and then releasing the force. Even further, it is possible to have the smartphone application perform predefined exercising sequences comprising a number of exercising actions, etc. which all may be adapted specifically to the actual user, e.g. based on input from a specialized health care person.

[0085] Fig. 4 is a block diagram illustrating an example of the power supply to the actuating means of the leg exercising apparatus 10 according to an embodiment of the invention, which comprises a power limitation arrangement. Here, it is illustrated that the power supply 11, e.g. a mains 230 V power supply, may be coupled directly to a power supply converter 12, e.g. a 230/12 V AC transformer as mentioned in connection with fig. 3. The 12 V supply may be led to the electromotor 5 via the control device 13 as discussed above in connection with fig. 3, whereby the control device 13 may serve as a switch for controlling the electromotor to expand or retract the actuator rod 21 (or stop the electromotor in the middle position). It is apparent that more complex control devic-

es can be used, e.g. with the ability to control power supplied to the electromotor and thus also controlling the exerted force.

[0086] As shown in fig. 4, a power limitation arrangement 17 is arranged in connection with the control system, which comprises a force- and/or power measurement unit 18. This force- and/or power measurement unit 18 may for example comprise a wattmeter for measuring the electric power that is supplied to the electromotor 5 (as shown by the line leading from electromotor 5 to the unit 18), which may serve to indicate the force exerted by the electromotor 5. Thus, a comparison can be made with certain set limits and in case a limit is exceeded, the electromotor can be controlled to reduce the force exerted or even stop (as shown by the line leading from the unit 18 to the electromotor 5). Instead or in addition, the force- and/or power measurement unit 18 may measure directly on the actuator link, rod or the like 21, e.g. by measuring the force exerted, and the measurement may be led to the unit 18, where a comparison can be made with certain set limits as mentioned above. Again, in case a limit is exceeded, the electromotor 5 can be controlled to reduce the force exerted or even stop (as shown by the line leading from the unit 18 to the electromotor 5). The limit or limits may preferably be adjustable, e.g. in order to be set to suit the individual persons.

[0087] The above-mentioned power- and/or force limiting arrangement may also serve as end stop for the actuator, e.g. because the electric effect delivered to the electromotor 5 will change characteristically, when reaching the end of travel, which thus can effect that the power to the electromotor is switched off. Other arrangements, e.g. arrangements for achieving an end stop are possible, including arranging sensors, mechanical end stop switches, etc.

[0088] It is noted that the power limitation arrangement 17 including the force- and/or power measurement unit 18 can be integrated within a housing containing the electromotor 5, e.g. as illustrated in figs. 1 and 2.

[0089] The power limitation arrangement 17 for controlling the electromotor may for example be set or adjusted to limit the exerted force

- within an interval around 100 N to 3000 N (corresponding to app. 10 kg to 300 kg),
- in an alternative form within an interval around 100 N to 1000 N (corresponding to app. 10 kg to 100 kg), and
- in a further alternative form within an interval around 100 N to 700 N (corresponding to app. 10 kg to 70 kg).

[0090] Other intervals may be possible. Thus, suitable levels of limitation can be set, e.g. in view of the patient, in view of the abnormal condition, which it is intended to remedy by exercising, etc.

[0091] In fig. 5 a block diagram is shown corresponding to fig. 4, but illustrating an embodiment, wherein a remote control, mobile communication unit or the like 19 is utilized. Here, the control device 13 does not have any actuating input means, e.g. for being manually operated by the user, but the control device 13 here serves as receiver for wireless control signals transmitted from a remote control, mobile communication unit or the like 19. Subsequently, the control device 13 will control the actuator system accordingly. The control device 13 is here also included in the power limitation arrangement 17, since for example limit values for the exerted force may be input wirelessly, e.g. input by the remote control, mobile communication unit or the like 19 and set up via the control device 13.

[0092] As mentioned, such a wireless control device may use e.g. infrared, ultrasonic, radio frequency transmission means, etc., and in particular a mobile communication device such as a smartphone, comprising an application program (app) for facilitating control of the leg exercising apparatus, may be utilized in connection with fig. 5.

[0093] The such configured leg exercising apparatus can be operated in a particular user-friendly manner, in particular in case a standard smartphone or the like is used for the control operations, which for example can be performed by downloading an application program, i.e. an app designed for the purpose, to the user's own smartphone. Hereby, the user can operate the leg exercising apparatus simply by using the input options of the smartphone, e.g. operating the actuator to pull or push, increasing or reducing the force exerted by the electromotor, etc. Further options will be available, e.g. the option that upper limit(s) for pulling or pushing forces exerted by the electromotor can be input in the smartphone app, thereby making it easy to adapt the leg exercising apparatus to the individual users and to personalize the control system to perform in an optimal manner.

[0094] Furthermore, it will be possible to have the smartphone app control and perform relatively complicated operations such as performing exercising actions, e.g. exerting a pulling force of a certain magnitude for a certain period and then releasing the force. Even further, it is possible to have the smartphone application perform predefined exercising sequences comprising a number of exercising actions, etc. which all may be adapted specifically to the actual user, e.g. based on input from a specialized health care person.

[0095] In fig. 6 a block diagram is shown corresponding to fig. 5, i.e. illustrating an embodiment, wherein a remote control, mobile communication unit or the like 19 is utilized, but in fig. 6 it is furthermore illustrated that the power supply 11 need not be connected to a mains power supply, but may be in the form of a battery, e.g. a rechargeable battery such as a power bank or the like. Thus, power converter, plugs, wires, cables, etc. can be avoided and the power from the battery supply can be led directly to the control device 13. With this embodiment the power supply 13 in the form of a battery supply can be integrated with the electromotor 5, the control device 13, and e.g. the circuitry of the power limitation arrangement 17 in a

common housing, which will add to the user-friendliness of the leg exercising apparatus.

[0096] Further embodiments and details of the leg exercising apparatus will be explained in the following with reference to figs. 7-14, wherein a leg exercising apparatus is shown in a schematic manner in a side view. Also, the leg exercising apparatus is shown in connection with a lower leg 15 and a foot 16 of a person shown in a schematic manner in dotted lines, where it is indicated that the person is wearing a shoe. As mentioned previously, though, the leg exercising apparatus may be used without wearing shoes.

[0097] In figs. 7-14 the same reference numbers are used for the same elements, components and features as in the previous figures, in particular figs. 1 and 2. Thus, these will not be explained in further detail in connection with figs. 7-14.

[0098] In fig. 7 a leg exercising apparatus essentially as disclosed in figs. 1 and 2 is illustrated, but wherein the actuator 20 is controlled via a remote control 19, e.g. a smartphone or the like, which can communicate with receiving means (not shown) in e.g. the electromotor 5. In this manner the electromotor 5 can be controlled to retract or extend the actuator link, rod or the like 21 as shown with the double-arrow, e.g. in order to pull the leg section 9 and the foot section 3 towards each other as it has been explained above.

[0099] Such a scenario has been illustrated in fig. 8, where the leg section 9 and the foot section 3 have been rotated towards each other.

[0100] In figs. 9 and 10 a similar leg exercising apparatus is shown, but wherein it is shown that the actuator 20 can be located to the rear of the apparatus, e.g. behind the leg section 9. Here, the foot section 3 has been extended rearwards and the first fixation 4 has been moved to this location. Also, the second fixation 6 has been moved to the rear of the leg section 9 at the upper part of the leg section. Thus, it is a possibility that the bracket 7 can be avoided as shown with dotted lines. The actuator 20 is thus connected between the first 4 and the second fixation 6, whereby an extension of the actuator link, rod or the like 21 will result in a relative rotation of the foot section 3 towards the leg section 9, which is shown in fig. 10, and vice versa.

[0101] Further options as regards the configuration of the actuator 20 in relation to the leg exercising apparatus as such is illustrated in figs. 11 and 12, where fig. 11 essentially corresponds to fig. 7 and where fig. 12 essentially corresponds to fig. 9. In figs. 11 and 12 it is however shown that the actuator 20 may be placed in a position with the electromotor 5 near to the foot section 3, which may have advantages as regards e.g. a lower center of gravity, greater user comfort due to the weight of the electromotor 5 being placed in a lower position, etc.

[0102] In fig. 13, which essentially corresponds to fig. 7, it is indicated that the leg section 9 in addition to being curved in the transverse direction, e.g. by having a front part having an essentially concave sectional shape facing the lower leg and a corresponding essentially convex rear part, can be curved in the vertical direction to accommodate to the lower leg 15 of the user. Also, it will be seen from this figure as well as the previous that the leg section 9 has a curved form down to the pivot point 1, thereby also enclosing a portion of the heel of the user, which furthermore facilitates a stable and rigid configuration.

[0103] In fig. 14, which also essentially corresponds to fig. 7, it is indicated that the foot section 3 may comprise a mechanical foot plate 23, located above the foot section 3 in such a manner that the distance to the user's foot can be adjusted by e.g. a foot plate adjustment means 24 as indicated in fig. 14. Thus, an adjustment of the travel of the foot section 3 is achievable, e.g. in case the travel of the actuator 20 at some point in time during the exercises is insufficient. This can for example be the case, when e.g. the stretch of the peroneus muscle and/or the increased ankle movement allows the foot 16 to be rotated more towards the lower leg 15, in which case the mechanical foot plate 23 can be adjusted to an increased height above the foot section 3, e.g. at the toe area.

[0104] In the above description, various embodiments of the invention have been described with reference to the drawings, but it is apparent for a person skilled within the art that the invention can be carried out in an infinite number of ways, using e.g. the examples disclosed in the description in various combinations, and within a wide range of variations within the scope of the appended claims.

List of reference numbers

[0105]

1	Pivot point
2	Foot fastener
3	Foot section
4	First fixation
5	Electromotor
6	Second fixation
7	Bracket
8	Lower leg fastener
9	Leg section
10	Leg exercising apparatus
11	Power supply
12	Power supply converter
13	Control device
14	Actuating input device
15	Lower leg of patient
16	Foot of patient
17	Power limitation arrangement
18	Force and/or power measurement
19	Remote control, mobile communication unit or the like
20	Actuator
21	Actuator link, rod or the like

22 Leg section curvature
23 Mechanical foot plate
24 Foot plate adjustment means

Claims

1. A leg exercising apparatus (10) for exercising a lower leg and/or foot of a patient, wherein a leg section (9) and a foot section (3), which are pivotable in relation to each other, are configured to be fastened to the lower leg (15) and foot (16) of the patient, respectively,
characterized in that

- the foot section (3) comprises a first fixation (4) and the leg section (9) comprises a second fixation (6) at an upper part,
- the leg exercising apparatus (10) further comprising an actuator (20) comprising an electromotor (5), said actuator (20) being connected between said first (4) and said second fixation (6) to exert a force, when activated, to rotate the leg section (9) and the foot section (3) in relation to each other in respect to a pivot point (1), and
- the leg exercising apparatus (10) further comprising a power limitation arrangement (17) for controlling the electromotor (5).

2. The leg exercising apparatus according to claim 1, wherein said actuator (20) comprises an actuator link, rod or the like (21) operably connected to the electromotor (5), said actuator link, rod or the like (21) being connected to said first fixation (4) and said electromotor (5) being connected to said second fixation (6) or vice versa.

3. The leg exercising apparatus according to claim 1 or 2, wherein said leg section (9) comprises a bracket (7) at an upper part, and wherein said second fixation (6) is arranged in connection with said bracket (7), wherein said bracket (7) may be loop-shaped and may be configured to be releasable and/or adjustable.

4. The leg exercising apparatus according to any one of claims 1-3, further comprising a mechanical foot plate (23) being arranged in connection with the foot section (3).

5. The leg exercising apparatus according to any of claims 1-4, wherein said leg section (9) is configured to accommodate at least a part of a calf part of the lower leg (15) of the patient, the leg section having a front part having an essentially concave sectional shape facing the lower leg and a corresponding essentially convex rear part.

6. The leg exercising apparatus according to claim 5, wherein said second fixation (6) is arranged facing the front of the leg section (9), for example arranged on the bracket (7), and with the first fixation (4) correspondingly arranged on a forward facing part of the foot section (3).

7. The leg exercising apparatus according to claim 5, wherein said second fixation (6) is arranged to the rear of the leg section (9) and wherein the first fixation (4) correspondingly is arranged on a rearward facing part of the foot section (3) to the rear of the pivot point (1).

8. The leg exercising apparatus according to any one of claims 1-7, wherein said foot section (3) comprises a foot fastener (2) and wherein said leg section (9) comprises a lower leg fastener (8), wherein said foot fastener (2), for example in the form of a strap, preferably is located near the pivot point (1), and wherein said lower leg fastener (8), for example in the form of a strap, preferably is located at the shin area of the leg section (9).

9. The leg exercising apparatus according to any one of claims 1-8, wherein said leg section (9) is provided in at least two different sizes.

10. The leg exercising apparatus according to any one of claims 1-9, wherein said mechanical foot plate (23) and/or said foot section (3) is/are provided with a support area and support length corresponding at least to the foot of the patient.

11. The leg exercising apparatus according to any one of claims 1-10, wherein at least one of said

- leg section (9),
- foot section (3),
- mechanical foot plate (23),
- first fixation (4).
- second (6) fixation and
- bracket (7)

is made partially or totally of a synthetic material such as hard plastic material, e.g. polyamide or other similar materials, carbon fiber material, etc.

12. The leg exercising apparatus according to any one of claims 1-11, wherein said power limitation arrangement (17) for controlling the electromotor (5) is configured to limit the exerted force and/or to stop the electromotor.

13. The leg exercising apparatus according to claim 12, wherein said power limitation arrangement (17) for controlling the electromotor (5) is configured to limit the exerted force

- within an interval around 100 N to 3000 N,
- in an alternative form within an interval around 100 N to 1000 N, and
- in a further alternative form within an interval around 100 N to 700 N.

14. The leg exercising apparatus according to any one of claims 1-13, wherein the leg exercising apparatus (20) is controllable via a control device (13), said control device (13) being a wireless control device, e.g. using e.g. infrared, ultrasonic, radio frequency transmission means, etc., in particular a mobile communication device such as a smartphone, comprising an application program (app) for facilitating control of the leg exercising apparatus (20).

15. The leg exercising apparatus according to any one of claims 1-14, wherein the leg exercising apparatus (20) comprises a battery power supply integrated with the actuator (20), e.g. the electromotor, which battery power supply may be rechargeable.

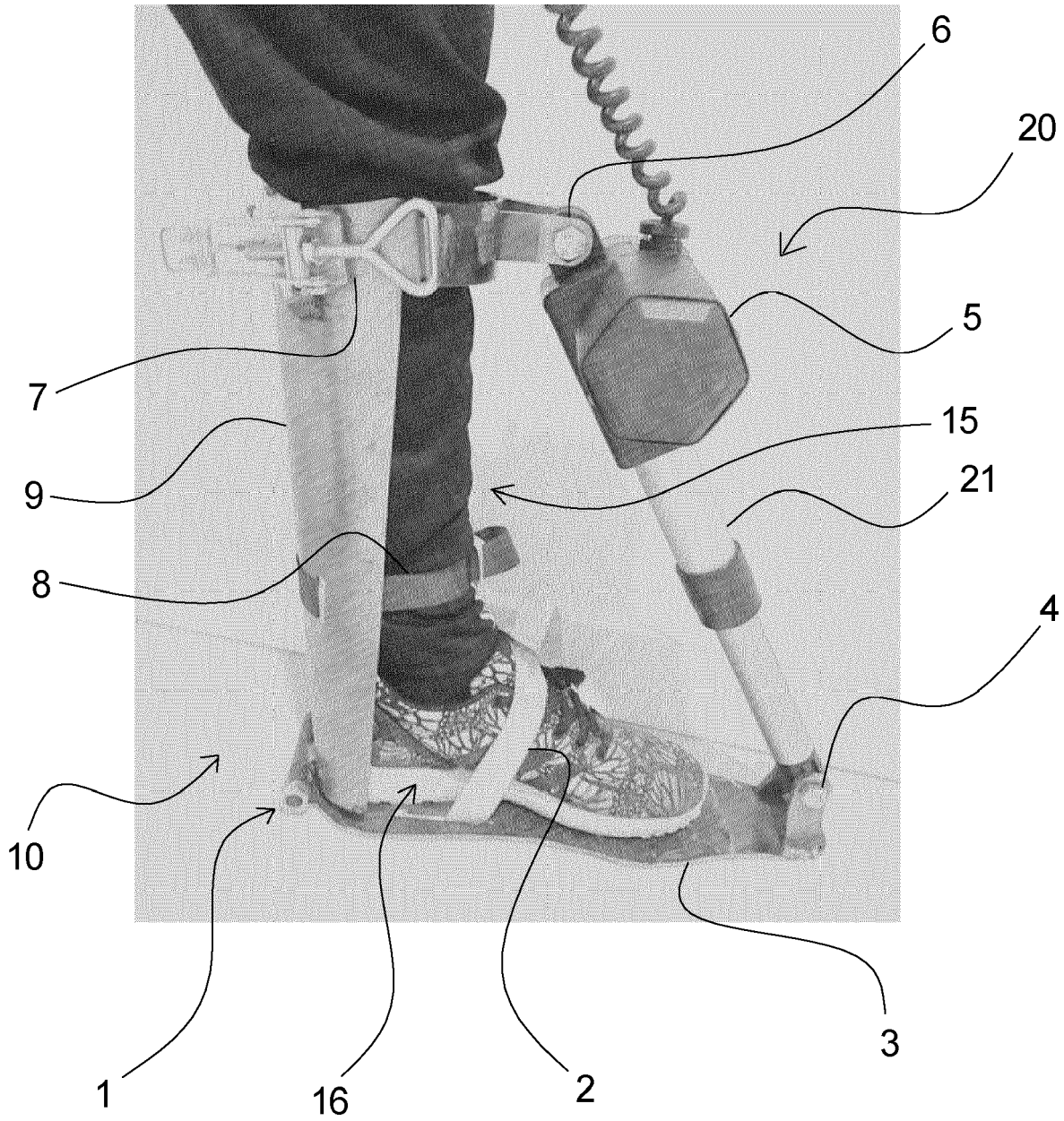

Fig. 1

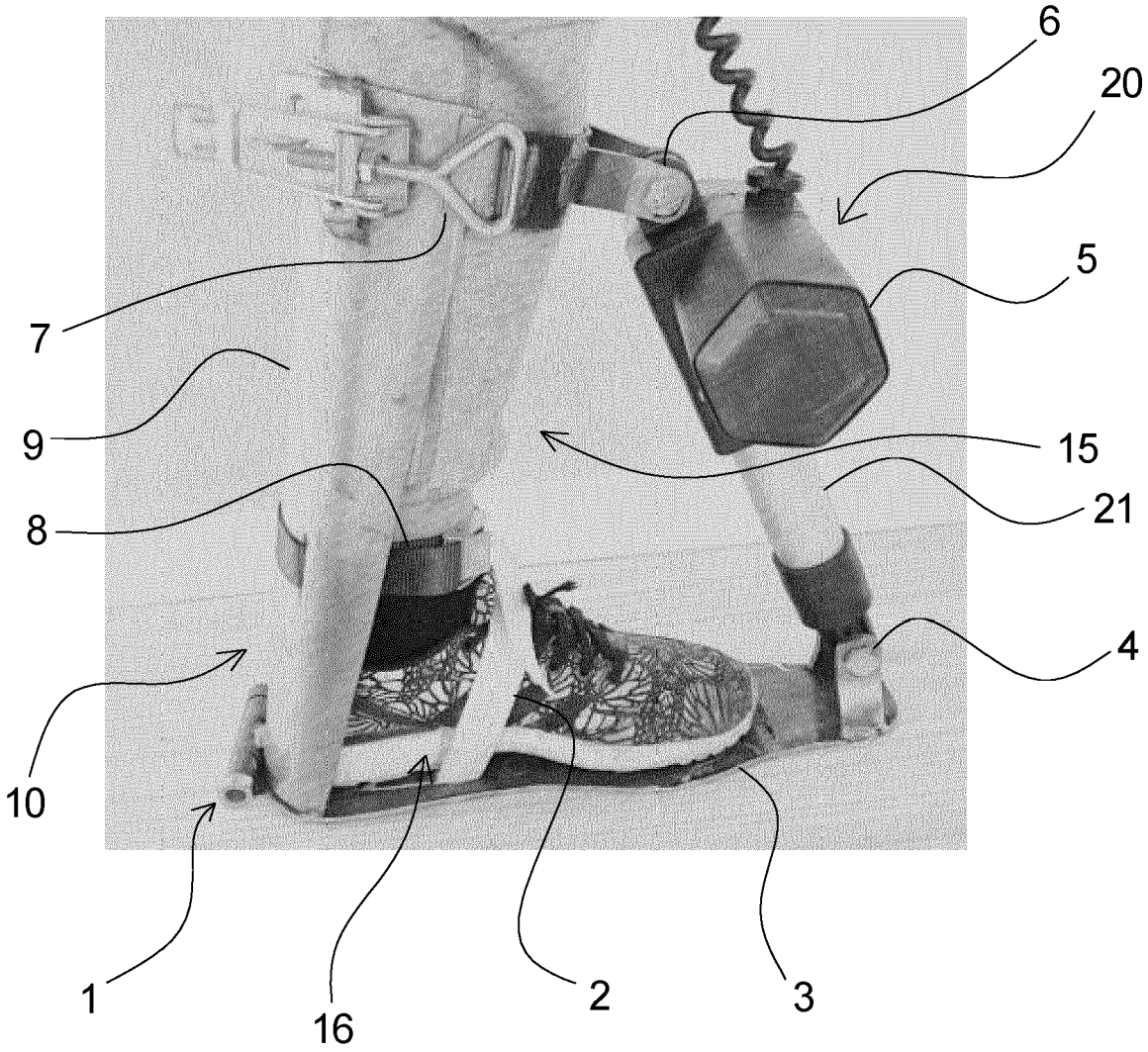

Fig. 2

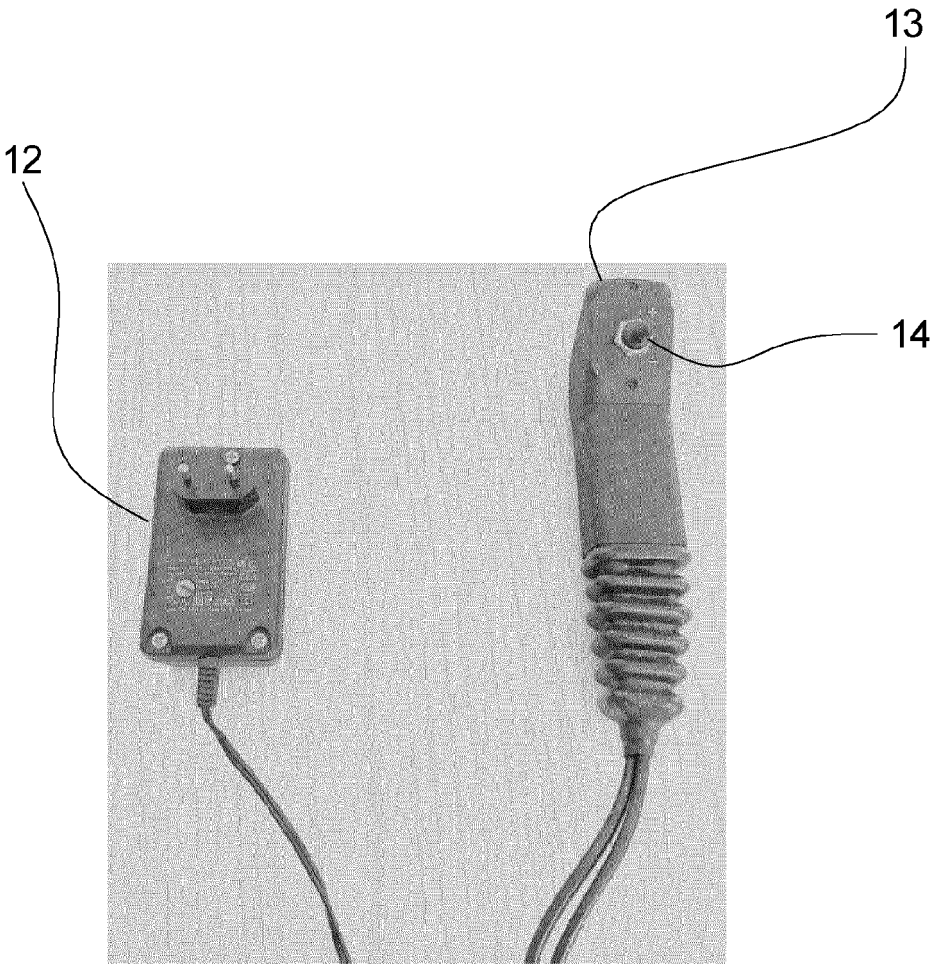

Fig. 3

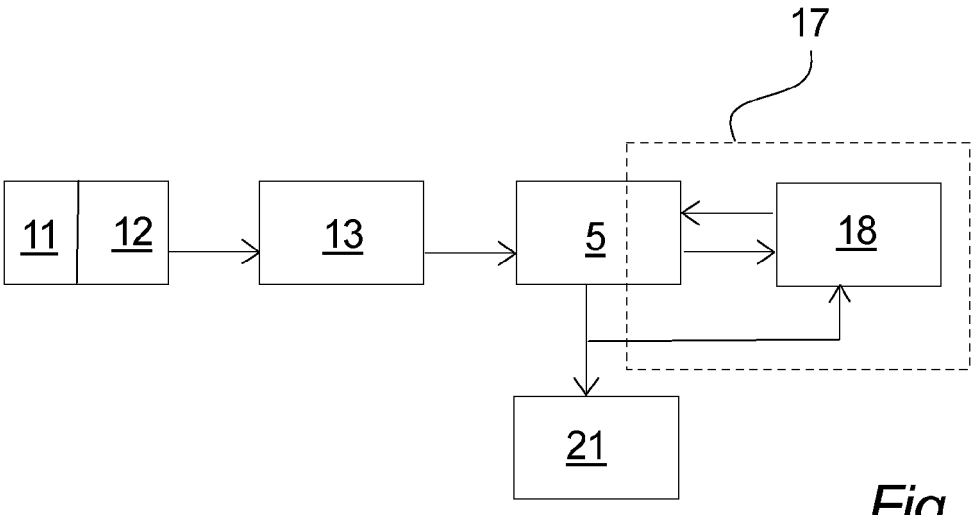

Fig. 4

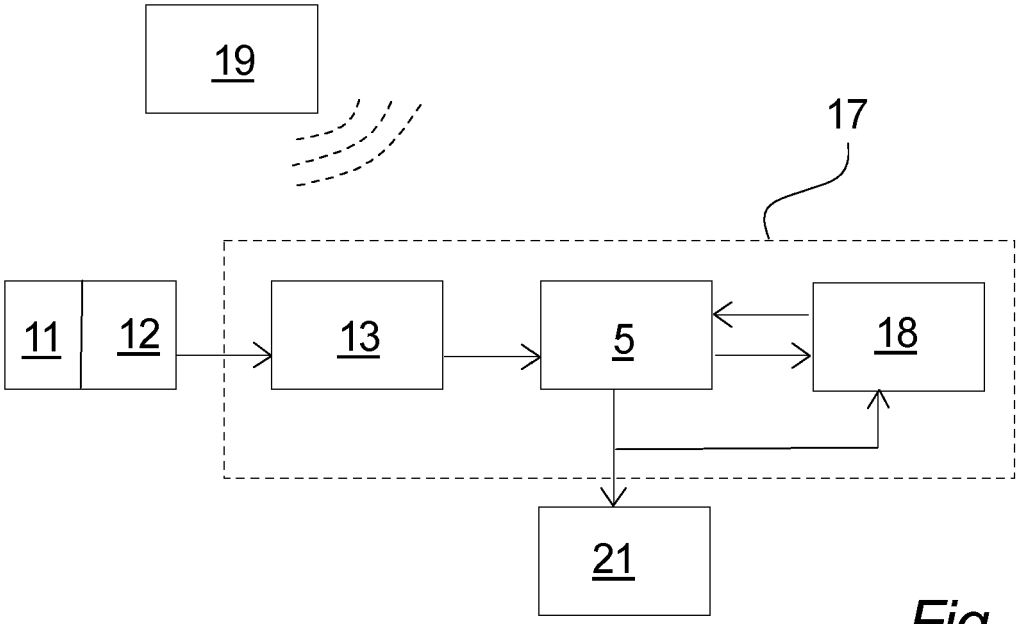

Fig. 5

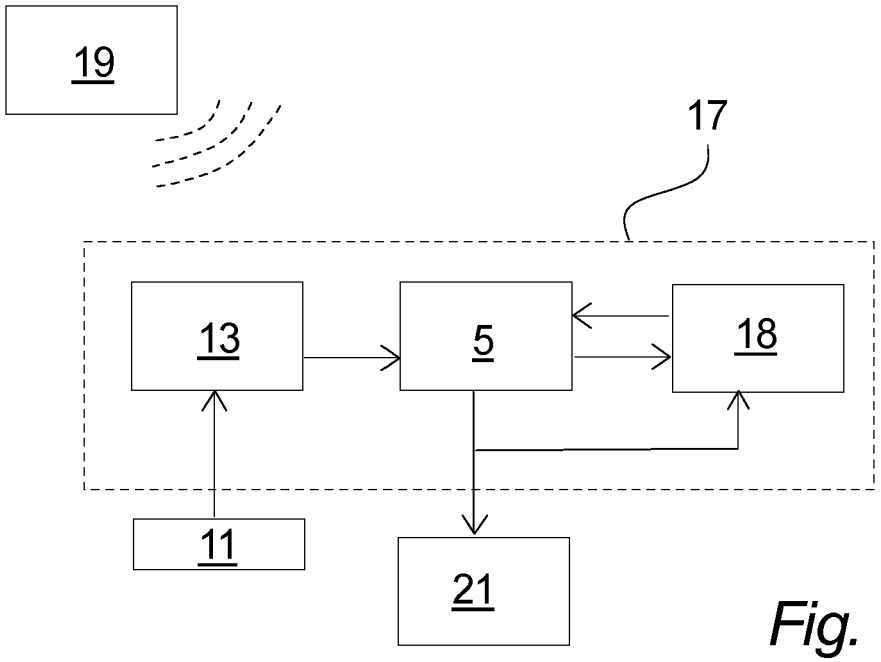

Fig. 6

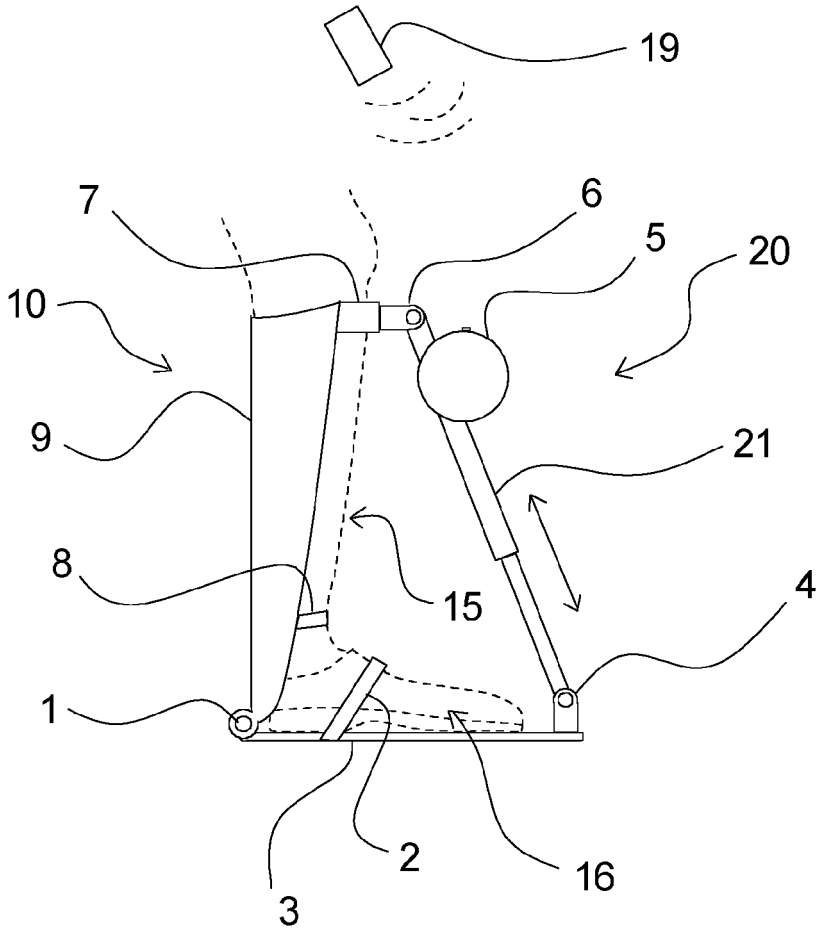

Fig. 7

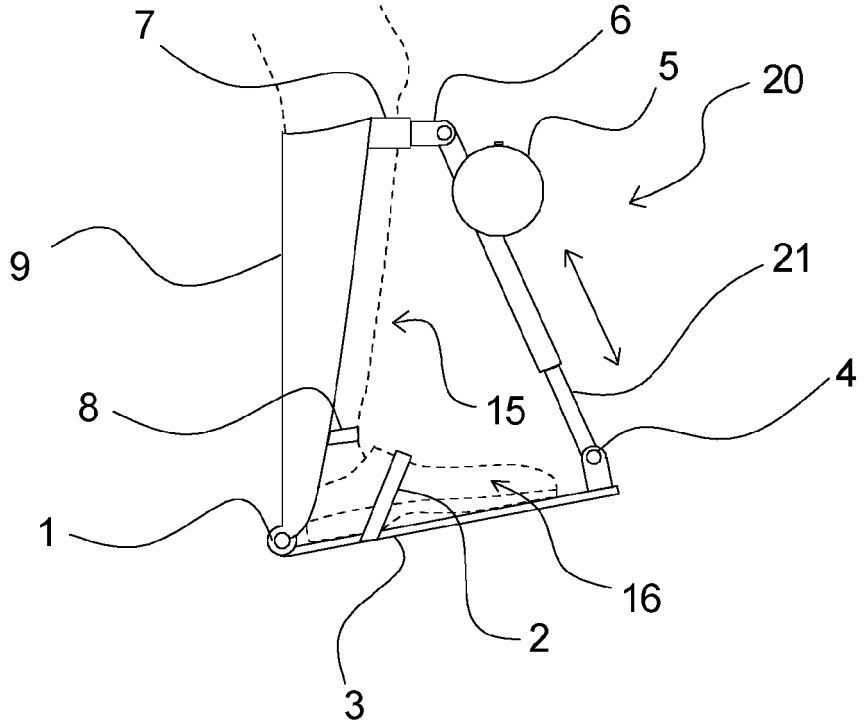

Fig. 8

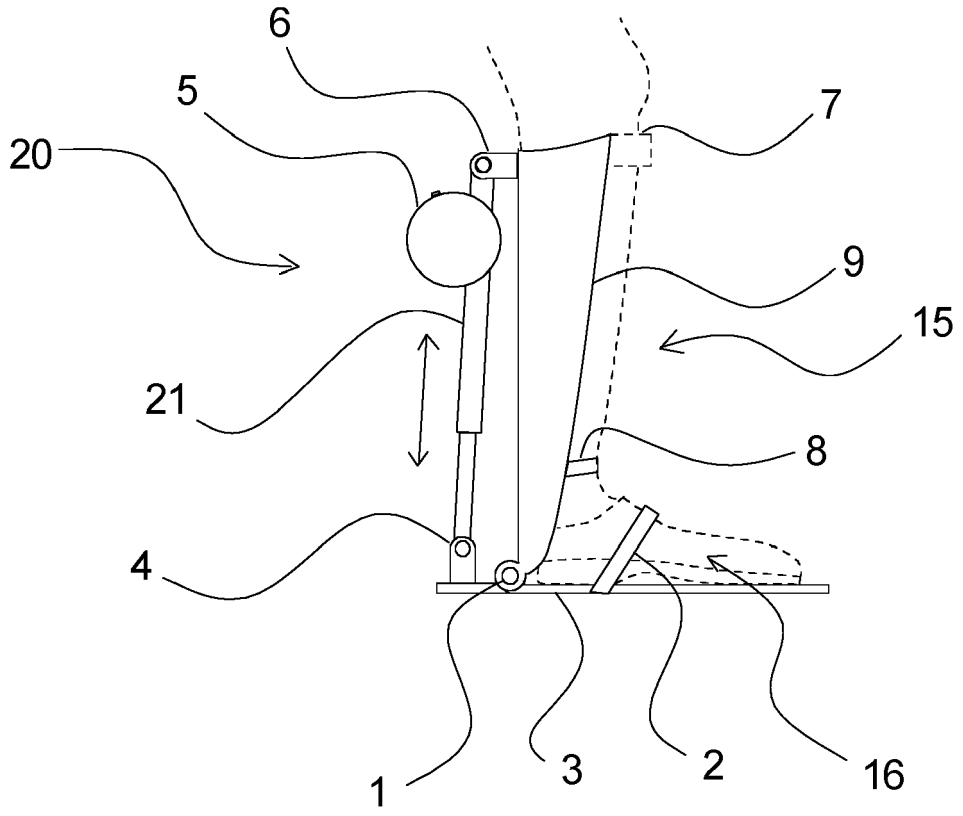

Fig. 9

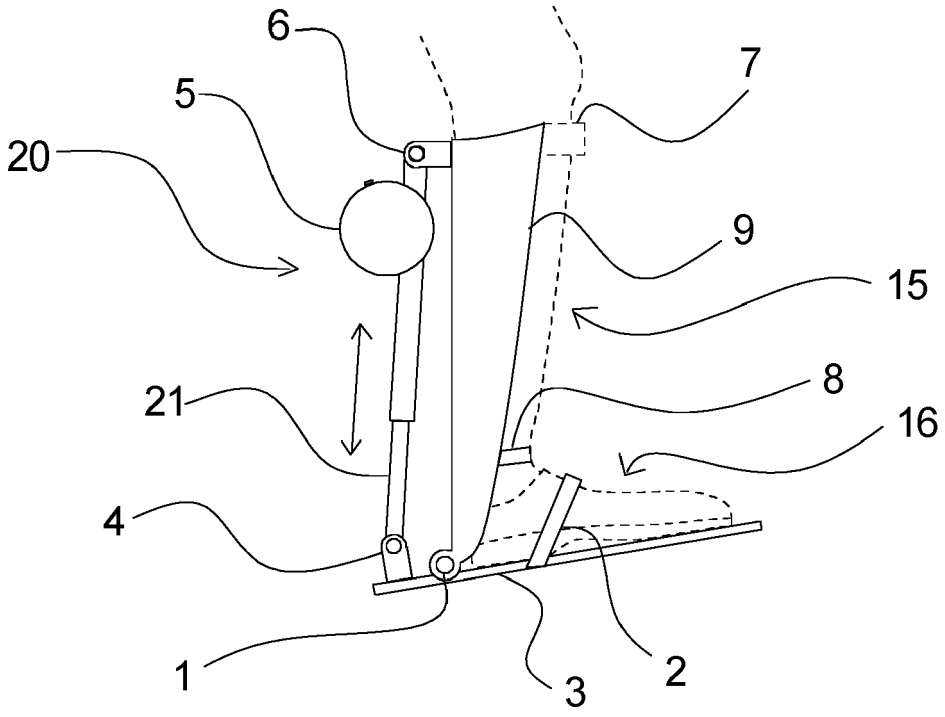

Fig. 10

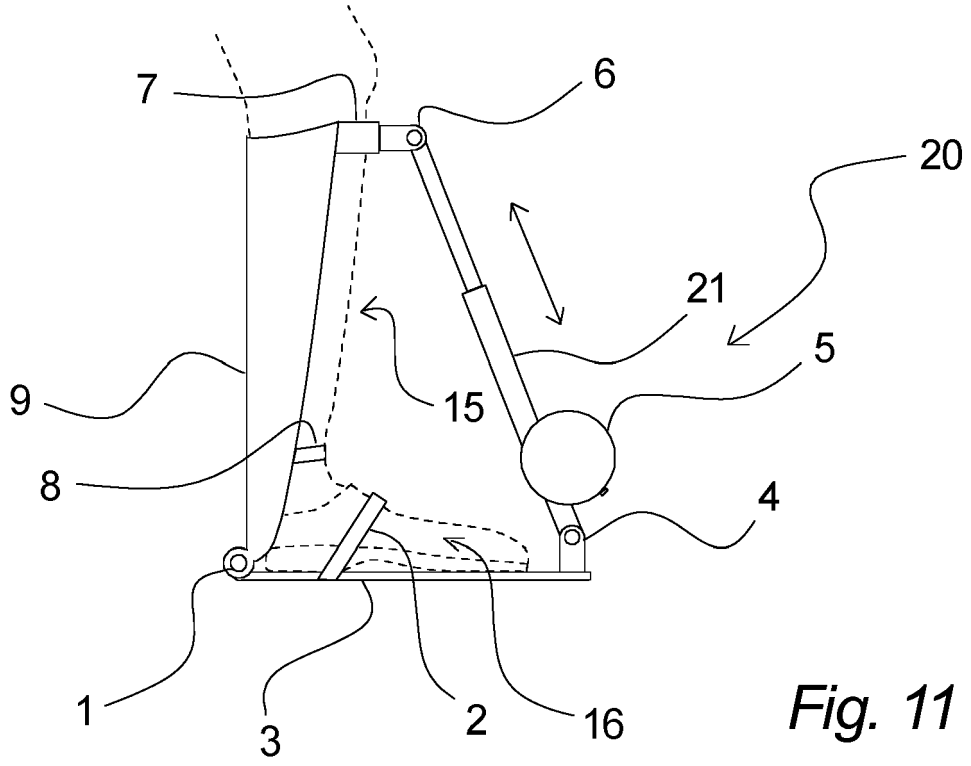

Fig. 11

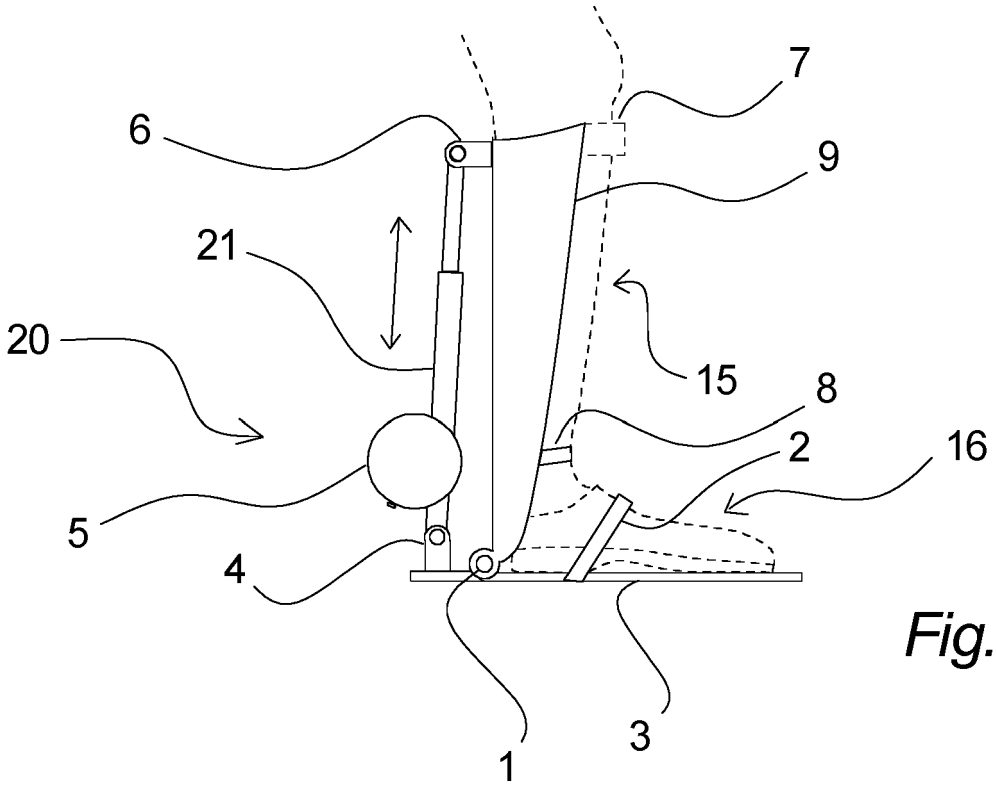

Fig. 12

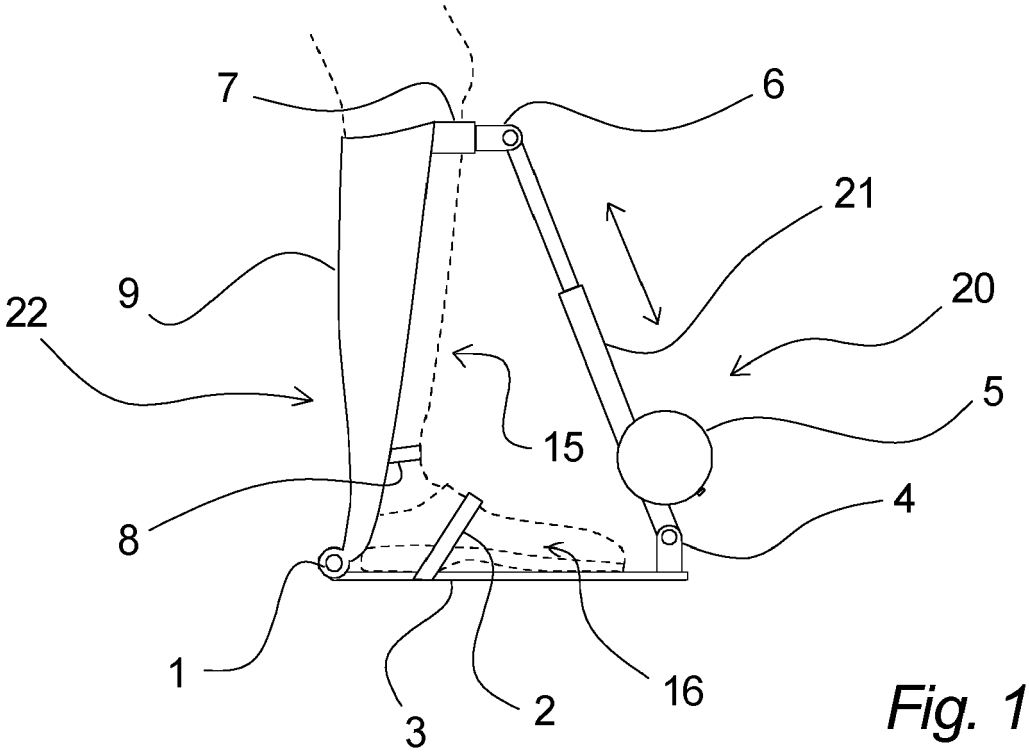

Fig. 13

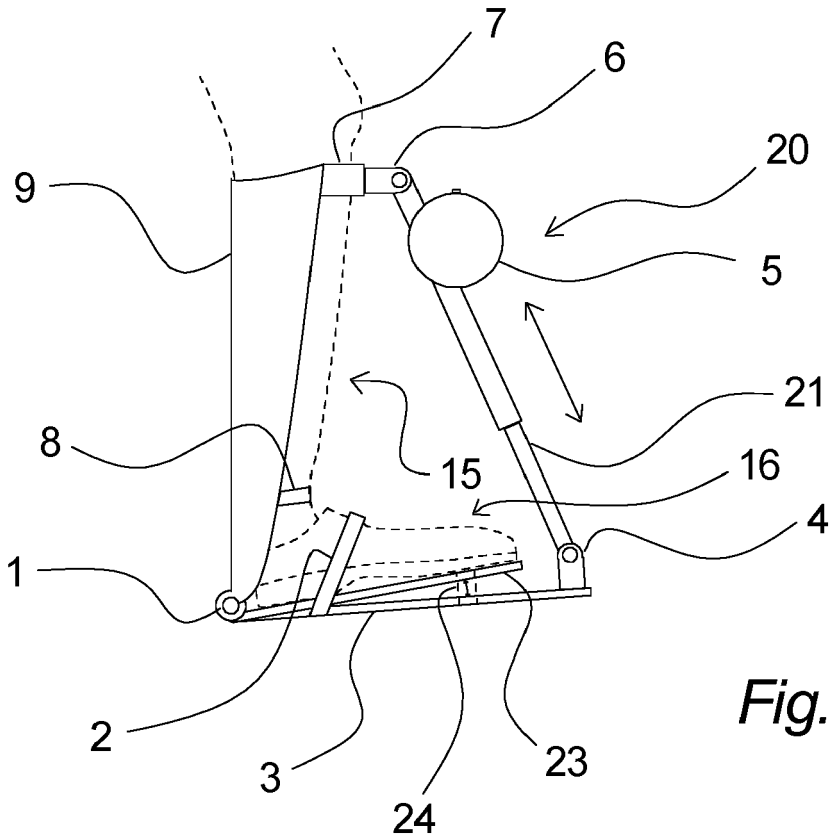

Fig. 14

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EUROPEAN SEARCH REPORT

Application Number
EP 17 17 6860

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 2010/198124 A1 (BHUGRA KERN [US]) 5 August 2010 (2010-08-05) * paragraphs [0006], [0012], [0013] - [0017]; figures *	1-15	INV. A63B21/005 A63B23/08 A63B21/00
X	US 2006/069336 A1 (KREBS HERMANO I [US] ET AL) 30 March 2006 (2006-03-30) * paragraphs [0004] - [0006], [0020], [0023], [0036] - [0038], [0052] - [0053], [0049]; figures 6,9,9A-9D *	1-11,13	
X	WO 2016/043973 A1 (SIMMONS GEORGE ROBERT [US]; MCDONNELL MICHAEL T [US]; GARRITY BRYN [US) 24 March 2016 (2016-03-24) * paragraphs [0018] - [0019], [0022] - [0024], [0026] - [0028], [0034] - [0036], [0039], [0042] - [0043], [0054], [0067], [0069] - [0070] *	1-12,15	
X	WO 2015/041621 A1 (CEYLAN MURAT [TR]) 26 March 2015 (2015-03-26) * claims 1,6; figure 12 *	1-11	TECHNICAL FIELDS SEARCHED (IPC)
A	EP 2 868 304 A1 (ABRAMOWICZ JOHN [CA]; KRISTJANSEN LARS [CA]) 6 May 2015 (2015-05-06) * figures *	1-15	A63B A61H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 November 2017	Vesin, Stéphane

CATEGORY OF CITED DOCUMENTS

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