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 (54) Title: Linear actuator and a method for operating a linear actuator
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 (57) Abstract:

This invention relates to a linear actuator, comprising an electric motor (10), a worm gear (13, 14), a transmission (15, 16, 19), an outer tube (2) and a spindle (12), said spindle (12) being in connection with the transmission (15, 16, 19), a spindle nut (11) on the spindle (12), a thrust bearing (20) for supporting a shaft end (21) of the spindle (12), wherein the connection between the shaft end of the spindle (12) and the transmission (15, 16, 19) allows a mutual axial movement so that axial forces are only lead through the spindle (12) bypassing the transmission (15, 16, 19) and directly to the thrust bearing (20), wherein a support structure (17, 18, 24, 28) fixedly connects the outer tube (2) and a lower bracket (20, 22), wherein said worm gear (13, 14) drives a shaft (19) included in said transmission (15, 16, 19), which shaft (19) has a driving gear wheel (15) fixedly attached thereto, arranged to transmit torque to a driven gear wheel (16) fixedly attached to the spindle (12), wherein said transmission (15, 16, 19) is arranged to allow axial displacement of the driven gear wheel (16) in relation to the driving gear wheel (15).

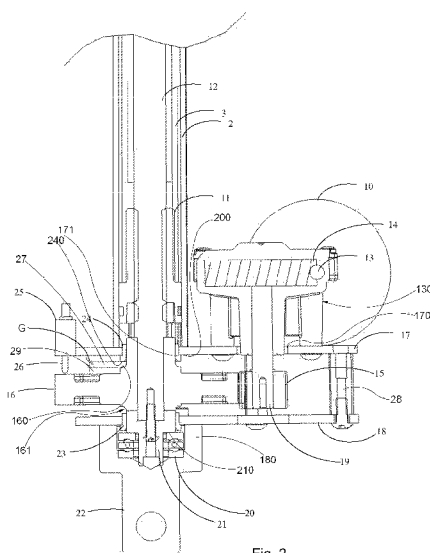


Fig. 2

ABSTRACT

This invention relates to a linear actuator, comprising an electric motor (10), a worm gear (13, 14), a transmission (15, 16, 19), an outer tube (2) and a spindle (12), said
5 spindle (12) being in connection with the transmission (15, 16, 19), a spindle nut (11) on the spindle (12), a thrust bearing (20) for supporting a shaft end (21) of the spindle (12), wherein the connection between the shaft end of the spindle (12) and the transmission (15, 16, 19) allows a mutual axial movement so that axial forces are only
10 lead through the spindle (12) bypassing the transmission (15, 16, 19) and directly to the thrust bearing (20), wherein a support structure (17, 18, 24, 28) fixedly connects the outer tube (2) and a lower bracket (20, 22), wherein said worm gear (13, 14) drives a shaft (19) included in said transmission (15, 16, 19), which shaft (19) has a driving gear wheel (15) fixedly attached thereto, arranged to transmit torque to a driven gear wheel (16) fixedly attached to the spindle (12), wherein said transmission (15, 16, 19) is
15 arranged to allow axial displacement of the driven gear wheel (16) in relation to the driving gear wheel (15).

LINEAR ACTUATOR AND A METHOD FOR OPERATING A LINEAR ACTUATOR

5 TECHNICAL FIELD

The present invention relates to a linear actuator device, comprising an electric motor, a worm gear a transmission, an outer tube and a spindle, said spindle being in connection with the transmission, a spindle nut on the spindle, a thrust bearing for supporting a shaft end of the spindle, wherein the connection between the shaft end of the spindle
10 and the transmission allows a mutual axial movement so that axial forces are only lead through the spindle bypassing the transmission and directly to the thrust bearing and wherein a support structure fixedly connects the outer tube and a lower bracket.

BACKGROUND ART

15 Linear actuators are well-known components for use in machines and control devices, not at least they are widely used within the hospital and care sectors, where they are used for adjustable furniture such as patient lifting devices, beds etc. In this kind of applications, the linear actuator transfers a force between the attachment points of the actuator.

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The construction of linear actuators, which can transfer the forces between the two attachment points without overloading the transmission and thus causing wearing, is difficult and often results in the construction being complicated and expensive. Further it mostly is more voluminous than desired. This is particularly the case where the linear
25 actuator is equipped with a transmission, which comprises a planetary gear, since the configuration of a worm gear driving the sun gear of the planetary gear, will always result in a motor orientation perpendicular to the actuator main axis.

WO 98/30816, US 8410731 and US 8308603 disclose linear actuators where the transmission comprises a planetary gear, e.g. implying many components. Many
30 components mean more expenses for material and production and that the linear actuator becomes voluminous.

The purpose of the invention is to provide a solution to the outlined problem, i.e. to achieve a linear actuator which is capable of leading the axial forces in the actuator
35 around the transmission and that is cost-efficient, and that may provide a more compact and/or simple construction.

SUMMARY OF THE INVENTION

The main object of the present invention is to provide a linear actuator which eliminates or at least minimizes any or some of the problems mentioned above, which is achieved in accordance with a device in accordance with claim 1.

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Thanks to the invention there is provided a more compact linear actuator, which moreover is simple in its construction and which is capable of leading the axial forces in the actuator through the transmission, bypassing the gear wheels, i.e. without any substantial axially reaction forces from the load acting upon the gear wheels.

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According to further aspects of the invention it may be preferred;

- that said gear wheels are spur gear wheels, which provides the advantage that the axial displacement may be achieved at minimal cost.
- 15 - that said driven gear wheel is fixedly attached to a hub, which hub is arranged with a displacement limiting member arranged to form a gap in relation to said support structure defining an upper stop limit for said displacement, which provides the advantage that an easy and cost efficient technical solution may be provided for a safe and secure device.
- 20 - that a lower stop limit of said gap is achieved by having said shaft end of the spindle abutting the thrust bearing, which also provides the advantage that an easy and cost efficient technical solution may be provided for a safe and secure device
- 25 - that a control sensor is arranged to sense an axial motion of said spindle and to stop the motor in connection with sensing a predetermined maximum allowed displacement that is equal to or less than said gap, which also provides the advantage that an easy and cost efficient technical solution may be provided for a safe and secure device.
- 30 - that said control sensor is arranged with a stop contact member arranged to contact the driven spur gear wheel in connection with reaching said predetermined maximum allowed displacement, which also provides the advantage that an easy and cost efficient technical solution may be provided for a safe and secure device.

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- that said support structure is arranged in a manner that also provides the advantage that an easy and cost efficient technical solution may be provided for a safe and secure device.

5 BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be described in more detail with reference to preferred embodiments and the appended drawings, where,

- Fig. 1 shows a perspective view of an embodiment according to the invention,
 10 Fig. 2 shows a cross sectional view of a part of a linear actuator device according to the invention, and,
 Fig. 3 shows a schematic view of an alternate embodiment of the invention.

15 DETAILED DESCRIPTION

In Fig 1 there is shown patient lifting equipment including a basic support structure 5, 9 and lifting members 4, 8 of a well-known kind. The patient lifting device includes a linear actuator 1, 2, 3 that via control equipment 6, 7 may assist in lifting a patient by means of the lifting members 4, 8. Fig. 1 demonstrates an example of use of the
 20 invention, wherein the invention may provide substantial advantages compared to the use of known linear actuators.

In Fig. 2 there is shown a cross sectional schematic view of a linear actuator according to a preferred embodiment of the invention. It is shown that the linear actuator is
 25 powered by an electric motor 10, which as shown in Fig. 1 normally is positioned within a housing 1. The electrical motor 10 powers a motor axis, having a worm 13 that in turn transmits torque to a worm gear wheel 14. The worm gear unit 130 is fixedly attached to a first support wall 17. In the support wall 17 there is a passage 170 through which a shaft 19 extends, which shaft 19 is powered by the worm gear wheel 14.

30 At the end of the worm gear shaft 19 there is attached a first spur gear wheel 15. This spur gear wheel 15 is arranged to directly transmit torque to a second spur gear wheel 16. The second spur gear wheel 16 is fixedly connected to a hub 161 (e.g. by means of being integrated or screw attached) that is fixedly attached to the end of a spindle 12.
 35 The fixation of the hub 161 is achieved by means of splines (or some other torque transferring arrangement, e.g. wedge) in combination with a spindle end cap 21. The

spindle end cap 21 has a rear abutment surface 210 that abuts a trust bearing 20. The trust bearing 20 is secured within a lower actuator mount 22.

The lower actuator mount 22 is fixedly attached to a second support wall 18. The
 5 second support wall 18 is fixedly connected at distance from the first support wall 17, by means of attachment members 28. The spur gear wheels 15, 16 will be positioned within the space delimited by the support walls 17, 18. The second support wall 18 has a passage 180 for the end part of the spindle 12, here in the form of an end cap 21 attached to the spindle 12. A bearing member 23 is arranged between the outer
 10 periphery of the end cap 21 and the passage 180 in the second wall 18.

On the spindle 12 there is arranged a spindle nut 11. On the spindle nut 11 there is arranged an inner tube 3. The inner tube 3 is moveable together with the spindle nut 11, within an outer tube 2.

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The outer tube 2 has its rear end 200 fixedly attached to the first wall member 17. The spindle 12, the hub 161 and the spindle end cap 21 are axially moveable arranged a predetermined limited distance, within a gap G. This is achieved by having the hub 161 arranged with a first displacement limiting member 160, here in the form an edge, that
 20 is positioned at a distance (corresponding to the gap G, when the spindle 12 is in its rear most position) from an upper stop limit 27, here in the form a lower end 240 of an upper spindle bearing 24. The upper spindle bearing 24 is fixedly attached to the first support wall 17 within a second passage 171, adapted for the bearing 24 and the spindle 12. The lower stop limit 29 of the play G is in this embodiment achieved by having a lower
 25 abutment surface 210 of the end cap in contact with the trust bearing 20. Accordingly, the spindle 12 may be moved within a gap G by applying a pulling force to the spindle 12, which will move the abutment surface 210 away from the trust bearing 20 and move the spindle, the hub 161 and end cap 21 until the edge 160 of the hub 161 is contacting the lower end 240 of the second spindle bearing 24. The outer way will be achieved
 30 automatically, i.e. once load is applied it will push the spindle 12 in contact with the trust bearing 20.

A control sensor 25, 26 is fixedly attached to the first support wall 17. This control sensor 25, 26 has in this embodiment a contact member 26 that at its front end may be
 35 in contact with the driven gear wheel 16. Accordingly, when the spindle 12 is moved to close the gap G the contact 26 will be pushed in by the driven gear wheel 16, thereby providing the ability to give signal at a predetermined position of displacement of the

contact member 26. This may for instance be used to arrange for a motor stop control signal when a predetermined displacement of the contact member 26 has been reached, facilitating a down-force limit safety arrangement

- 5 Accordingly, the invention presents a linear actuator device that comprises an electrical motor 10 which operates a worm gear 13, 14, which in turn transmits torque to a gear transmission 15, 16, 19, for rotation of the spindle 12, which in turn is transferred to linear movement of the spindle nut 11 that controls the position of the inner tube 3. The force that is exerted by a load applied to the upper end of the inner tube 3 will then be
- 10 transmitted directly via the spindle 12 to the trust bearing 20. Accordingly, no actual forces will be transferred to the transmission 15, 16 thanks to the use of axially displaceable gear wheels, which also facilitates axial displacement of the driven spur gear wheel 16 in relation to the driving gear wheel 15. Thanks to having the driven gear wheel 16 attached to a hub 161 having a displacement limiting member 160 there may
- 15 be provided a gap G, in relation to the support structure 17, 18, 24, 28 such that the spindle 12 together with the driven spur gear wheel 16 and the end cap 21 may be axially displaced, and further providing the advantage that the gear transmission facilitates a transfer of load directly on to the trust bearing 20.
- 20 All in all, this provides a simple and reliable structure in comparison with known prior art, which provides many advantages, such as ease of maintenance and relatively low cost.

- In Fig. 3 there is shown a schematic perspective view of a further embodiment
- 25 according to the invention, wherein the cross angle between driving and driven gears 15, 16 will allow for having the motor 10 mounted axially along the outer tube 2 thus reducing overall size. This kind of solution is not possible if using a design as suggested in the prior art, e.g. US 8308603. Most details are the same, i.e. fulfil the same functions, as has already been described in connection with Fig. 2 and therefore there is
- 30 a mere focus on different features. Here, the driving wheel 15 and the driven wheel 16 do not have straight cut teeth, but instead helical teeth. It is preferred to position the helical teeth such that a lifting reaction force will be transferred from the driving wheel 15, to the driven wheel 16, in connection with moving the aid device 4, 8 downwardly to thereby have that reaction force assisting in moving the driven wheel 16 against the
- 35 sensor 25, 26. Otherwise there is a risk that the reaction force eliminates actuation of the down-force limit safety arrangement. In the shown embodiment it means arranging the teeth such that a clockwise rotation of the driving wheel will rotate the driven wheel

anti-clockwise in connection with moving the inner tube 3 downwardly. It will be possible to move the spindle 12 axially in relation to the housing and the outer tube 2, whereby simultaneously with the axial movement the teeth will effect a small rotational movement of the spindle 12. However, this small rotation movement of the spindle 12

5 will not cause any substantial counterforce, thereby fulfilling in principle the same basic function as described in connection with Fig. 2. In some applications it may be needed to arrange a resilient counter force between the driven wheel 16 and the support structure, to eliminate undesired stops caused by the reaction force, e.g. if the weight/load acting on the spindle 12 is less than the reaction force. An advantage with

10 the embodiment shown in Fig. 3 is that the motor 12 can be positioned to extend in parallel with the spindle and the outer tube 2, which facilitates compact arrangement.

The invention is not limited by the embodiments presented above, but may be varied within a plurality of aspects without departing from the basic principles of the

15 invention. For instance, it is evident that the resilient force that may be desired, may be implemented in various forms, e.g. a helical spring, air cushions, resilient polymers, etc. Further it is evident that a variety of known per se devices/solutions may be used but still maintain the basic principles of the solution according to the invention. Moreover, it is foreseen that principles of the solution presented in connection with Fig. 3 may be

20 the subject for its own protection, without limitation to the use of the preferred kind of gear wheels as shown in Figs. 1 and 2, i.e. instead a focus on the novel arrangement of the motor and its attachment/connection to the rest of the actuator.

CLAIMS

1. A linear actuator, comprising an electric motor (10), a worm gear (13, 14), a transmission (15, 16, 19), an outer tube (2) and a spindle (12), said spindle (12) being in connection with the transmission (15, 16, 19), a spindle nut (11) on the spindle (12), a thrust bearing (20) for supporting a shaft end (21) of the spindle (12), wherein the connection between the shaft end of the spindle (12) and the transmission (15, 16, 19) allows a mutual axial movement so that axial forces are only lead through the spindle (12) bypassing the transmission (15, 16, 19) and directly to the thrust bearing (20), wherein a support structure (17, 18, 24, 28) fixedly connects the outer tube (2) and a lower bracket (20, 22), characterized in that said worm gear (13, 14) drives a shaft (19) included in said transmission (15, 16, 19), which shaft (19) has a driving gear wheel (15) fixedly attached thereto, arranged to transmit torque to a driven gear wheel (16) fixedly attached to the spindle (12), wherein said transmission (15, 16, 19) is arranged to allow axial displacement of the driven gear wheel (16) in relation to the driving gear wheel (15).
2. A linear actuator according to claim 1, characterized in that said gear wheels (15, 16) are spur gear wheels.
3. A linear actuator according to claim 1 or 2, characterized in that said driven gear wheel (16) is fixedly attached to a hub (161), which hub (161) is arranged with a displacement limiting member (160) arranged to form a gap (G) in relation to said support structure (17, 18, 24, 28) defining an upper stop limit (27) for said displacement.
4. A linear actuator according to claim 3, characterized in that a lower stop limit (29) of said gap (G) is achieved by having said shaft end (21) of the spindle (12) abutting the thrust bearing (20).
5. A linear actuator according to claim 2, 3 or 4, characterized in that a control sensor (25, 26) is arranged to sense an axial motion of said spindle (12) and to stop the motor (10) in connection with sensing a predetermined maximum allowed axial displacement that is equal to or less than said gap (G).
6. A linear actuator according to claim 5, characterized in that said control sensor (25, 26) is arranged with a stop contact member (26) arranged to contact the driven gear

wheel (16) in connection with reaching said predetermined maximum allowed displacement.

7. A linear actuator according to any preceding claim, characterized in that said support structure includes first and second wall members (17, 18) arranged to provide support for said worm gear unit (130) and to provide space between the wall members (17, 18) for said gear wheels (15, 16).

8. A linear actuator according to claim 7, characterized in that there is a first passage (171) in the first wall member (17) and a second coaxial passage (180) in the second wall member (18), wherein said first passage (171) is arranged to form a first centering support for the spindle (12) and the second passage (180) is arranged to form a second centering support for the spindle (12).

9. Method for operating a linear actuator, said linear actuator comprising a linear actuator, comprising an electric motor (10), a worm gear (13, 14), a transmission (15, 16, 19), an outer tube (2) and a spindle (12), said spindle (12) being in connection with the transmission (15, 16, 19), a spindle nut (11) on the spindle (12), a thrust bearing (20) for supporting a shaft end (21) of the spindle (12), wherein the connection between the shaft end of the spindle (12) and the transmission (15, 16, 19) allows a mutual axial movement so that axial forces are only lead through the spindle (12) bypassing the transmission (15, 16, 19) and directly to the thrust bearing (20), wherein a support structure (17, 18, 24, 28) fixedly connects the outer tube (2) and a lower bracket (20, 22) characterized by using said worm gear (13, 14) to drive a shaft (19) included in said transmission (15, 16, 19) and arranging said shaft (19) with a driving gear wheel (15) which transmits torque to a driven gear wheel (16) being fixedly attached to the spindle and wherein said transmission (15, 16, 19) facilitates axial displacement of the driven gear wheel (16) in relation to the driving gear wheel (15).

10. Method according to claim 9, characterized by the use of a displacement limiting member (160) arranged to enable the driven gear wheel (16) to be moved axially within a predetermined gap (G).

11. Method according to claim 10, characterized by having an upper stop limit (27) for said displacement when said displacement limiting member (106) contacts said support structure (17, 18, 24, 28).

12. Method according to claim 10 or 11, characterized by arranging a lower stop limit (29) for said axial displacement when a spindle shaft end (21) abuts the thrust bearing (20).

- 5 13. Method according to any of claims 9-12, characterized by arranging a control sensor (25, 26) to sense actual movement of said spindle (12) that stops the motor (10) in connection with sensing a predetermined maximum axial displacement.

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I följande bilaga finns en översättning av patentkraven till svenska. Observera att det är patentkravens lydelse på engelska som gäller.

A Swedish translation of the patent claims is enclosed. Please note that only the English claims have legal effect.

LINJÄRT MANÖVERDON OCH METOD FÖR ATT DRIVA ETT LINJÄRT MANÖVERDON

PATENTKRAV

- 5 1. Ett linjärt manöverdon, innefattande en elmotor (10), en snäckväxel (13, 14), en transmission (15, 16, 19), ett yttre rör (2) och en spindel (12), varvid nämnda spindel (12) är kopplad till nämnda transmission (15, 16, 19), en spindelmutter (11) på spindeln (12), ett axiallager (20) för uppbärning av en axelände (21) hos spindeln (12), varvid kopplingen mellan axeländan av spindeln (12) och transmissionen (15, 16, 19) möjliggör en ömsesidig axiell rörelse så att axiella
 - 10 krafter endast leder genom spindeln (12) som omger transmissionen (15, 16, 19) och direkt till trycklagret (20), varvid en stödkonstruktion (17, 18, 24, 28) förbinder det yttre röret (2) och en nedre konsol (20, 22), kännetecknat av att nämnda snäckväxel (13, 14) driver en axel (19) inkluderad i transmissionen (15, 16, 19), vilken axel (19) har ett drivhjul (15) fast fastsatt därtill,
 - 15 nämnda transmission (15, 16, 19) är anordnad att tillåta axiell förskjutning av det drivna kugghjulet (16) i förhållande till drivhjulet (15).
 2. Ett linjärt manöverdon enligt krav 1, kännetecknat av att nämnda kugghjul (15, 16) är spårkugghjul.
 - 20
 3. Linjärt manöverdon enligt krav 1 eller 2, kännetecknat av att det drivna kugghjulet (16) är fast fastsatt vid ett nav (161), vilket nav (161) är anordnat med ett förskjutningsbegränsningsorgan (160) anordnat att bilda ett mellanrum (G) i förhållande till stödstrukturen (17, 18, 24, 28) som definierar en övre stoppgräns (27) för nämnda förskjutning.
 - 25
 4. Linjärt manöverdon enligt krav 3, kännetecknat av att en nedre stoppgräns (29) hos spalten (G) uppnås genom att axeländan (21) hos spindeln (12) är anlagd mot trycklagret (20).
 5. Linjärt manöverdon enligt krav 2, 3 eller 4, kännetecknat av att en styrsensor (25, 26) är
 - 30 anordnad att känna av en axiell rörelse hos spindeln (12) och att stoppa motorn (10) i samband med avkänning av en förutbestämd maximalt tillåten axiell förskjutning som är lika med eller mindre än nämnda gap (G).
 6. Linjärt manöverdon enligt krav 5, kännetecknat av att styrsensorn (25, 26) är anordnad med en stoppkontakt (26) anordnad att komma i kontakt med det drivna kugghjulet (16) i samband
 - 35 med att den förutbestämda maximala tillåtna förskjutningen nås.

7. Linjärt manöverdon enligt något av föregående patentkrav, kännetecknat av att stödstrukturen innefattar första och andra väggelement (17, 18) anordnade att tillhandahålla stöd för snäckväxeln (130) och för att ge utrymme mellan väggelementen (17, 18) för nämnda kugghjul (15, 16).

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8. Linjärt manöverdon enligt patentkrav 7, kännetecknat av att det finns en första passage (171) i det första väggelementet (17) och en andra koaxialpassage (180) i det andra väggelementet (18), varvid nämnda första passage (171) är anordnad att bilda ett första centreringsstöd för spindeln (12) och den andra passagen (180) är anordnad att bilda ett andra centreringsstöd för spindeln (12).

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9. Metod för att driva ett linjärt manöverdon, varvid det linjära manöverdonet innefattar ett linjärt manöverdon, innefattande en elektrisk motor (10), en snäckväxel (13, 14), en transmission (15, 16, 19), ett yttre rör (2) och en spindel (12), varvid spindel (12) är i förbindelse med transmissionen (15, 16, 19), en spindelmutter (11) på spindeln (12), ett axiallager (20) för uppbärande av en axelände (21) hos spindeln (12), varvid förbindningen mellan axeländan av spindeln (12) och transmissionen (15, 16, 19) möjliggör en ömsesidig axiell rörelse så att axiella krafter endast leder genom spindeln (12)), som omger transmissionen (15, 16, 19) och direkt till axiallagret (20), varvid en stödkonstruktion (17, 18, 24, 28) förbinder det yttre röret (2) och en nedre konsol (20, 22)), kännetecknad av att man använder nämnda snäckväxel (13, 14) för att driva en axel (19) som ingår i transmissionen (15, 16, 19) och anordna axeln (19) med ett drivhjul (15) som överför vridmoment till ett drivet växelhjul (16), som är fast fastsatt vid spindeln och varvid transmissionen (15, 16, 19) möjliggör axiell förskjutning av det drivna kugghjulet (16) i förhållande till drivhjulet (15).

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10. Förfarande enligt krav 9, kännetecknat av användningen av ett förskjutningsbegränsningsorgan (160) anordnat att möjliggöra att det drivna kugghjulet (16) förflyttas axiellt inom ett förutbestämt mellanrum (G).

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11. Förfarande enligt patentkrav 10, kännetecknat av att ha en övre stoppgräns (27) för nämnda förskjutning när den förskjutningsbegränsande delen (106) kommer i kontakt med stödstrukturen (17, 18, 24, 28).

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12. Förfarande enligt krav 10 eller 11, kännetecknat av att ha en nedre stoppgräns (29) för axiell förskjutning, när en spindelaxelände (21) anliggar trycklagret (20).

13. Förfarande enligt något av kraven 9–12, kännetecknat av att en styrsensor (25, 26) anordnas för att känna verklig rörelse hos spindeln (12) och som stannar motorn (10) i samband med avkänning av en förutbestämd maximal axiell förskjutning.

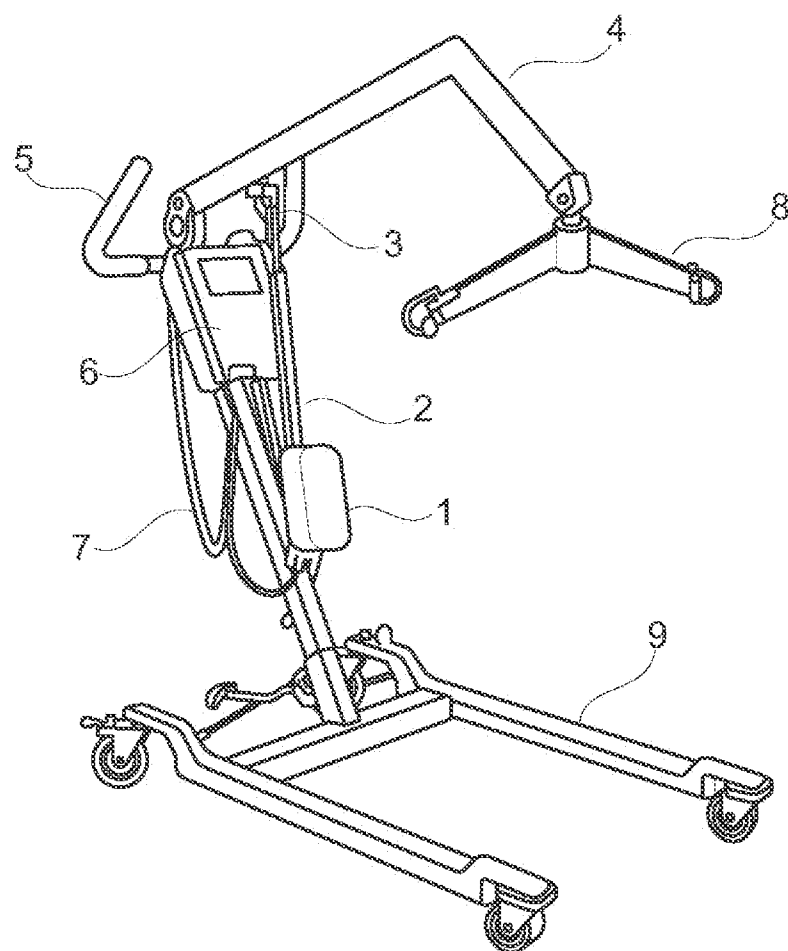


Fig. 1

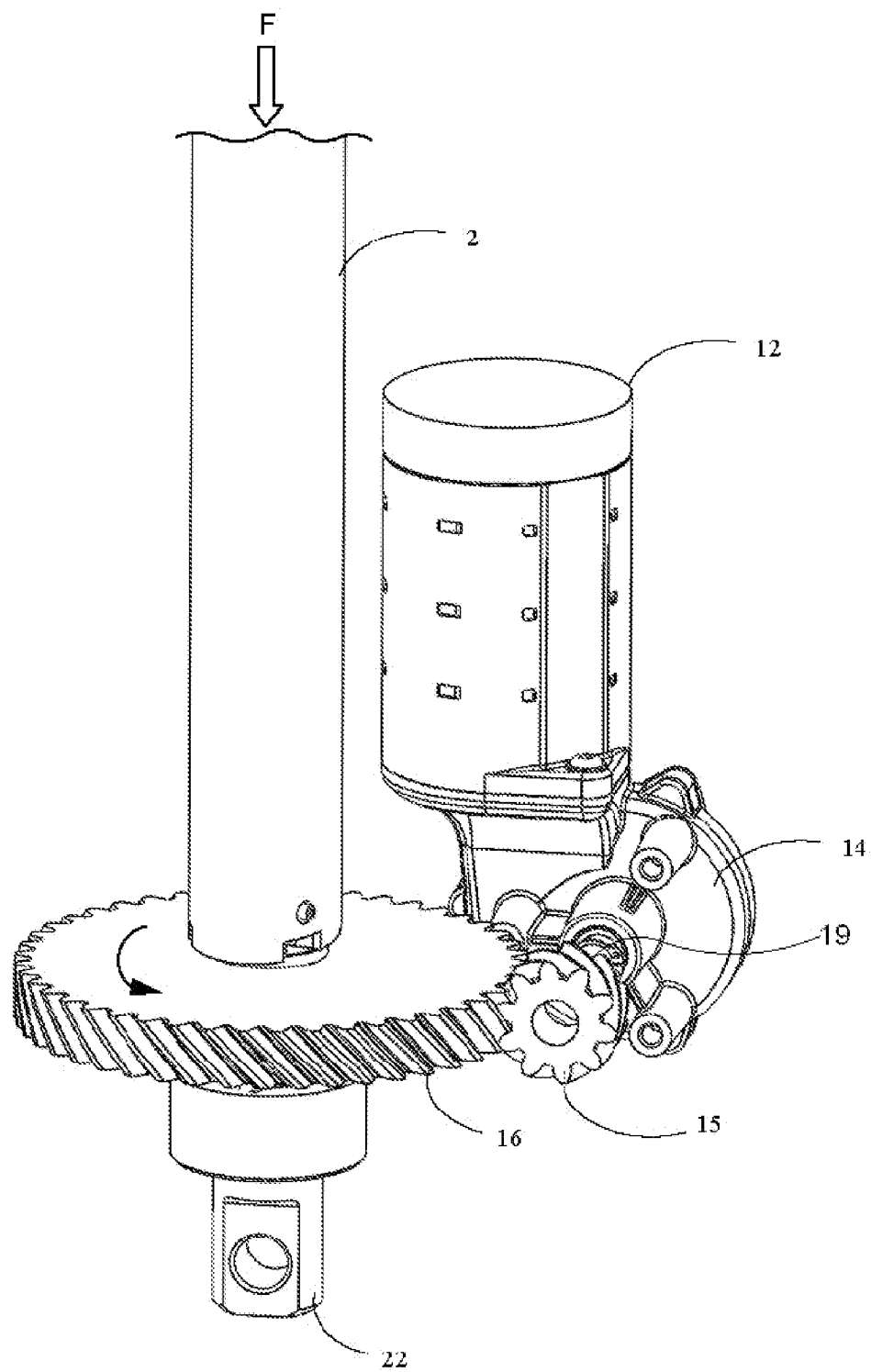


Fig. 3