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(72) Inventors:
• **Beckers, Ralf**
88410 Bad Wurzach (DE)
• **Morent, Ulrich**
88299 Leutkirch (DE)
• **Dorn, Jürgen**
88260 Argenbühl (DE)

(71) Applicant: **elobau GmbH & Co. KG**
88299 Leutkirch im Allgäu (DE)

(74) Representative: **Knöner, Gregor et al**
Kahler Käck Mollekopf
Partnerschaft von Patentanwälten mbB
Vorderer Anger 239
86899 Landsberg am Lech (DE)

(54) **OPERATING ELEMENT WITH TORQUE APPLICATION ASSEMBLY**

(57) An operating element (100) comprising a lever (101) having a lever component (102) pivotable about a first rotational axis and a torque application assembly (110) coupled to the lever component (102) is provided. The torque application assembly (110) comprises a pivotable element (111) that is pivotable about a second rotational axis different from and spatially offset from the first rotational axis, and a coupling assembly (120) that mechanically couples the lever component (102) to the pivotable element (111) such that pivoting the lever component (102) about the first rotational axis results in a larger pivoting of the pivotable element (111) about the second rotational axis. The operating element (100) further comprises a guiding surface (130), wherein the pivotable element (111) is configured to interact with the guiding surface (130). The torque application assembly (110) is configured to transfer a torque generated by the interaction and acting on the pivotable element (111) via the coupling assembly (120) to the lever component (102).

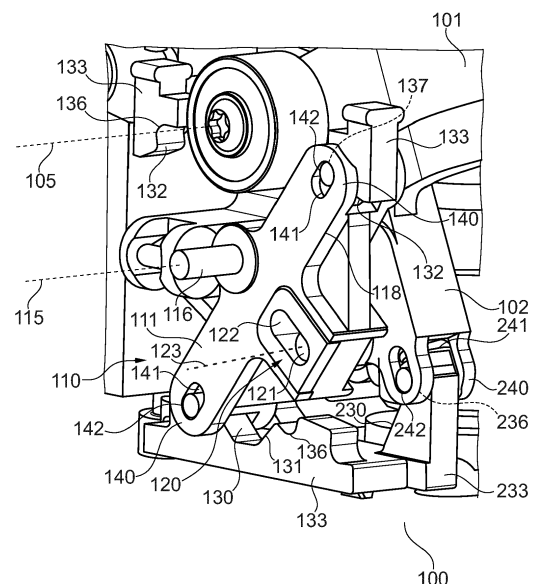


Fig. 3

EP 4 575 704 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to an operating element with a torque application assembly. It further relates to a corresponding method of operating an operating element.

BACKGROUND

[0002] Mobile machines, such as agricultural or construction vehicles, often comprise a plurality of different functionalities that need to be controlled. This may comprise controlling the movement of the vehicle itself and controlling different functions of the vehicle, such as an excavator arm or an agricultural tool. A respective mobile machine may accordingly comprise a plurality of different operating elements, such as levers (e.g. in the form of joysticks), switches, buttons, and the like. The space requirement of such large number of operating elements is excessive.

[0003] The installation space available for respective operating elements thus becomes smaller, resulting in the need for more compact operating elements. To be able to provide a more complex operating element, e.g. a joystick, within such small installation space, the operating elements are often provided with a simple configuration and reduced functionality. This may however make the operating elements less user-friendly and may result in a reduced strength or reduced lifetime. The lever of a conventional joystick may for example simply be coupled to a spring to provide a restoring force that restores the lever to a central position. Such simplified configuration may suffer from excessive play, e.g. when the joystick is in the central position, and may further have a quite limited functionality. Also, it will be difficult for a user to determine if a certain function has been activated or not.

[0004] Document PCT/EP2021/074407 discloses an operating lever with an associated sliding system. The sliding system includes a sliding part and restoring means which act on the sliding part to transfer it to a zero position. The operating lever is guided on the sliding system.

[0005] It is desirable to make existing control elements more compact without losing functionality and ease of use. In particular, it is desirable to also provide haptic feedback for users in compact operating elements, as operability and operational safety may thereby be improved.

SUMMARY

[0006] Accordingly, there is a need to mitigate at least some of the drawbacks mentioned above, in particular to enhance the haptic experience for a user when operating an operating element.

[0007] This need is met by the features of the indepen-

dent claims. The dependent claims describe embodiments of the invention.

[0008] According to an embodiment of the invention, an operating element comprising a lever having a lever component pivotable about a first rotational axis and a torque application assembly coupled to the lever component is provided. The torque application assembly comprises a pivotable element that is pivotable about a second rotational axis different from and spatially offset from the first rotational axis, and a coupling assembly that mechanically couples the lever component to the pivotable element such that pivoting of the lever component about the first rotational axis results in a larger pivoting of the pivoting element about the second rotational axis.

The operating element further comprises a guiding surface, wherein the pivotable element is configured to interact with the guiding surface to generate a torque acting on the pivotable element. The torque application assembly is configured to transfer the torque generated by the interaction via the coupling assembly to the lever component.

[0009] Such configuration of a torque application assembly may provide a torque increase that is transferred to the lever. In particular, as the pivoting of the lever component about an angle may result in a rotation of the pivotable element about a larger angle, a lever effect is achieved. The torque applied to the lever component may be increased by such lever effect. Further, as the distance over which the interaction with the guiding surface occurs is increased, an increased resolution may be obtained for haptic feedback and for operating positions provided by the operating element. With the same manufacturing tolerance, features on the guiding surface can be provided with a higher resolution. This may lead to a better control of a function controlled by the operating element. Furthermore, by providing such transmission from a smaller angle to a larger angle of rotation, the torque application assembly can be placed closer to the first rotational axis. This allows a compact design of the operating element.

[0010] The lever component may for example be a component that pivots with the lever when the lever is pivoted, e.g. by user actuation. The lever including the lever component may pivot together about the first rotational axis by the same angle when the lever is pivoted. The lever component may for example provide a support that supports a lever part (which may be or may carry a lever handle) pivotably about the first rotational axis. For example, the lever component may be a bracket, frame, mount or the like, for example of a gimbal mount or cardan suspension by which the lever is pivotably supported in a housing of the operating element. In other implementations, only the lever component may pivot about the first rotational axis; the lever component may form a main part of the lever (e.g. the only pivotable part, such as a part carrying a handle of the lever). For example, a handle may be mounted to the lever component so that it can directly be pivoted by a user, or the lever may consist of

the lever component (which may then provide a lever handle). It should be clear that the lever and the lever component may be implemented in many different ways and that the disclosed solution is applicable to any of these implementations.

[0011] According to a preferred embodiment of the invention, the second rotational axis is parallel to the first rotating axis.

[0012] According to an embodiment, the pivotable element comprises a contact member, wherein the contact member is configured to be in contact with and to be guided on the guiding surface.

[0013] The contact member may be configured to either slide or roll on the guiding surface. Alternatively, it may also be configured to slide and roll on the guiding surface.

[0014] According to an embodiment, the guiding surface extends over a range that corresponds to a pivoting range of the lever about the first rotational axis such that the contact member is (always) in contact with the guiding surface when the lever is pivoted within the pivoting range. According to another embodiment, the guiding surface extends over one or more sections, each section corresponding to a part of a pivoting range of the lever such that the contact member is in contact with the guiding surface when the lever is pivoted within the respective part of the pivoting range. The one or more sections of the guiding surface may not correspond to the full range of the pivoting range, but only to a fraction thereof. In other words, there may be one or more portions of the pivoting range of the lever in which the contact member is not in contact with the guiding surface. In such ranges, no torque may be applied to the lever component via the pivotable element (besides unavoidable friction). The guiding surface may for example have at least two sections and a gap between the sections. A pivoting range of the lever may correspond to a pivoting range of the lever component about the first rotational axis. A pivoting range of the lever may for example be limited by an end stop at each end of the range, against which the lever component or another part of the lever abuts when moved to the end of the range.

[0015] A guiding surface extending over a range corresponding to a pivoting range of the lever may allow an application of torque to the lever component over the whole range of movement of the lever.

[0016] When the guiding surface extends over one or more sections, positions of the lever can be defined in which no (additional) torque is applied to the lever component via the pivotable element, while at positions corresponding to the sections of the guiding surface, a desired torque profile may be generated, which may for example indicate certain operation conditions to the user. Also, by such sectioned guiding surface, the assembly may be more compact and placement may be facilitated.

[0017] According to an embodiment, the contact member comprises a force applying unit and a contact ele-

ment, wherein the force applying unit applies a force to the contact element to bring the contact element in contact with the guiding surface. As an example, the contact element may comprise a sliding element or a roller. It may also comprise a pin. Preferably, a needle roller is used as a contact element. Thus, the friction generated by the torque applying unit can be adapted according to the demands by using different contact elements interacting with the guiding surface.

[0018] Changes in force applied by the force applying unit may result in changes in torque when the contact element is moved over the guiding surface. The force applying unit may comprise a spring. It may for example comprise a coil spring, a pneumatic spring, or the like. Thereby, the forces of the interaction between the pivoting element and the guiding surface and thus the torque acting on the torque application assembly can be customized.

[0019] According to an embodiment, the guiding surface is shaped such that a force applied by the force applying unit of the contact member differs at different positions of the contact element on the guiding surface. By shaping the contact surface, different torques and thus different kinds of haptic feedback or control positions may thus be generated for the operating element.

[0020] According to an embodiment, the interaction between the pivoting element and the guiding surface is configured to generate a restoring torque that acts on the lever, in particular on the lever component. A restoring torque may be a torque that drives the lever towards a default (or initial) position, in particular an equilibrium position of the lever.

[0021] In some embodiments, the guiding surface is shaped such that the restoring torque is generated over the whole pivoting range of the lever. In other embodiments, the guiding surface is shaped such that the restoring torque is generated only over portions of the pivoting range of the lever. The guiding surface may for example be configured to generate one or more locked positions of the lever at which the lever is locked in place, which are different from the default position. The guiding surface may be shaped such that at the respective one or more locked positions, no restoring torque is generated. Thereby, the torque that has to be overcome by a user to bring the lever out of a locked position is not reduced by the restoring torque. Similarly, the torque that the user needs to apply to the lever for bringing the lever into the locked position is not increased by the restoring torque.

[0022] The guiding surface may be shaped such that by moving the lever from the default position, the pivotable member experiences a restoring torque by interaction with the guiding surface, wherein the rate of increasing restoring torque is determined by a rate at which the shape of the sliding surface causes an increase in force applied by the force applying unit to the contact element.

[0023] The guiding surface may for example have a linear section with a slope such that a deflection of the

lever leads to a monotonous torque increase. In another example, the guiding surface may have at least over a section a cycloidal, circular, or parabolical shape, so that the torque increases steeper when the lever is moved to more extreme positions. The shape of the guiding surface may be chosen such that the demands of torque increase may be fulfilled. It may in particular be possible to create a high-resolution restoring torque characteristic by using a particular shape of the guiding surface.

[0024] It should be clear that a default position of the lever may correspond to a default position of the lever component, and that a torque transfer to the lever may occur via the lever component.

[0025] In other implementations, a restoring torque generation assembly may be provided that applies a restoring torque to the lever, the restoring torque generation assembly being separate and distinct from the torque application assembly. In some implementations, the restoring torque may not be applied via the lever component, but may be applied to a different part of the lever. In other implementations, the restoring torque may be applied to the lever component, but not by the torque application assembly.

[0026] According to an embodiment, the guiding surface is shaped to define at least one of: a default position at which no torque is transferred via the pivotable element to the lever component; a pressure point at which the interaction between the pivotable element and the guiding surface generates a local or global maximum of the torque transferred to the lever component that has to be overcome when pivoting the lever; and a locked position different from a default position of the lever, wherein the torque generated by the interaction has a local or global maximum larger than a restoring torque applied to the lever, which has to be overcome for moving the lever out of the locked position.

[0027] By defining a default position, an initial position of the lever may be defined. For example, the guiding surface may have a recess at the default position which the contact member engages. Thus, a well-defined default position can be generated and a predefined torque has to be overcome to move the lever out of such default position.

[0028] To generate a pressure point, the guiding surface may for example have a shape that increases a force applied by the contact member to the guiding surface. For example, the guiding surface may have a protrusion that protrudes towards the contact member to generate such local or global maximum of torque. The user will have to overcome this torque when moving the lever, thus obtaining haptic feedback when crossing the pressure point. The user may thus reliably determine when a particular operating state of the operating element is reached.

[0029] Defining a locked position different from an initial position may allow easier usage of the operation element. For example, the one or more locked positions may be configured to correspond to a predefined operation condition of the machine, which is controlled by the

operating element. To generate a locked position, the guiding surface (e.g. a section thereof) may be shaped so as to generate a (local or global) maximum torque at an intermediate position that has to be overcome for reaching the locked position and for moving out of the locked position. For example, the guiding surface may have a protrusion to generate such maximum torque. Additionally or alternatively, the guiding surface may comprise a recess that corresponds to a locked position of the lever, which may allow easy incorporation into the guiding shape. The guiding surface may in particular be shaped such that a torque required to move the lever out of the locked position generated by the interaction is larger than a restoring torque acting on the lever at the locked position. By having to overcome a local or global maximum of torque larger than a restoring torque applied to the lever in the locked position, it may be possible to hold the lever safely in place in the locked position. Also, by having to overcome a local or global maximum to reach the locked position, it may be prevented that the locked position can be reached by mistake, thus increasing the safety of operation.

[0030] The force acting on the pivotable element and thus the resistance against the movement of the lever may increase until a maximum of the torque transferred to the lever is reached. Such maximum may be a local maximum, e.g. if the torque characteristic comprises plural pressure points, plural locked positions, or a combination of these. Such maximum may be overcome by the user applying more force to the lever. Also, a maximum may be reached at an end of the pivoting range of the lever where a restoring torque may be at a maximum.

[0031] Although the lever is preferably pivotable from a default position in two directions about the first rotational axis, it may only be pivotable in one direction (i.e. the default position may be at an end stop of the lever). Also, the torque profile defined by the shape of the guiding surface may be similar or may be different for different directions of actuation of the lever (e.g., a locked position in forward direction and a pressure point in backward direction). For each direction, one or more pressure points and/or one or more locked positions can be provided on the guiding surface. Optionally, the guiding surface may at least in some portions be shaped to provide a restoring torque.

[0032] According to an embodiment, a distance from the first rotational axis to the coupling assembly is larger than a distance from the second rotational axis to the coupling assembly so that a pivoting of the lever component about an angle results in the pivoting about a larger angle of the pivotable element. The distance to the coupling assembly may, e.g., correspond to the distance to a rotational axis of coupling assembly about which the coupling assembly is allowed to pivot (e.g. about which the pivotable element pivots with respect to the lever component). The distance may for example be measured to a central (cylinder) axis of a pin by which the coupling assembly provides coupling to the pivotable element. If

the distance of the pin to the first or second rotational axes is variable, the condition may apply for any positions of the pin relative to the first or second rotational axes.

[0033] The pivotable element being configured to pivot at a larger angle than the lever component results in an increased way that the pivotable element has to travel to correspond to the movement of the lever. This may lead to an increase in applied torque when the lever is displaced. It may further lead to an increased resolution, as the distance by which the contact member travels on the guiding surface may be increased. Manufacturing of the guiding surface may thereby be facilitated while the resolution with which features for haptic feedback can be provided may be increased.

[0034] According to an embodiment, the torque application assembly is configured to transmit a pivoting about the first rotational axis into a pivoting about the second rotational axis with a transmission ratio of at least 1:1.5. This means that the angle by which the pivoting element pivots about the second rotational axis is at least 1.5 times larger than the angle by which the lever component pivots about the first rotational axis. Preferably, the transmission ratio is at least 1:1.8, or at least 1:2. As a result, the torque applied by the pivoting element to the lever component is increased by the inverse ratio (i.e., at least 1.5:1), and the distance that over which the pivoting element interacts with the guiding surface is increased correspondingly. As mentioned above, this may allow a higher resolution of haptic features experienced during movement of the lever.

[0035] In an embodiment, the coupling assembly is a rotational coupling assembly allowing a relative movement between the lever component and the pivotable element at the coupling assembly. The coupling assembly preferably comprises a slit or recess at one of the lever component and the pivotable element, and a pin in engagement with the slit or recess at the other of the lever component and the pivotable element. Thus, a rotation about the first and second spatially offset rotational axes may be achieved while still providing a coupling that transfers torque between the lever component and the pivotable element.

[0036] According to an embodiment, the pivotable element comprises two arms extending in opposite directions, wherein each arm comprises a contact member having a contact element configured to contact a portion of the guiding surface. The arms may for example extend in a direction perpendicular to a connecting line between the second rotational axis and the coupling (e.g. pin central axis), wherein the connecting line is perpendicular to the second rotational axis.

[0037] By having two arms, each arm comprising a contact element interacting with the guiding surface, the torque applied to the lever component may be increased even further. The guiding surface may be configured to be in contact with the contact element of each arm at the same time (each contact element may contact a different portion or section of the guiding surface).

Preferably, the guiding surface is shaped such that the movement of the contact element of one arm on the guiding surface corresponds to the movement of the contact element of the other arm on the guiding surface.

In particular, both contact members may generate a corresponding (in particular the same) force profile when interacting with the guiding surface during pivoting. This may lead to a higher torque, especially when the contact elements reach a pressure point or a locked position of the lever. Also, the force that needs to be applied to the lever to put the contact elements into the locked position may be enhanced, so that operating error may be prevented and the locked position may be better defined.

[0038] Furthermore, the line connecting the contact elements may not intersect the second rotational axis, i.e., it may be offset. This may allow a generation of torque even when the lever is not moved, e.g., a restoring torque.

[0039] According to an embodiment, a distance between a contact point at which the pivotable element is in contact with the guiding surface and the second rotational axis is larger than a distance between the coupling assembly and the second rotational axis. The distance to the coupling assembly may e.g., comprise a distance to the rotational axis of the coupling assembly about which the coupling assembly is allowed to pivot, for example a distance to the center axis to the pin. It may in particular correspond to a position at which the pin has largest distance to the second rotational axis. Thereby, a further lever effect may be generated, as a movement of the coupling point about the second rotational axis by a certain circumferential distance will result in a movement by a larger circumferential distance of the contact point(s) on the guiding surface. This may allow increasing the torque applied to the pivotable element even more, and may further increase the distance that the contact point moves on the guiding surface, thereby further improving the resolution of the torque profile, e.g. of the haptic features.

[0040] According to an embodiment, the operating element comprises a shaft supported in a housing of the operating element, wherein the second rotational axis is provided by the shaft and wherein the pivotable element is supported on the shaft. In an example, the shaft may be configured to rotate. Alternatively, the pivotable element supported on the shaft is configured to rotate on the shaft. The shaft may be fixedly or stationarily supported in the housing. Forces acting due to the lever effect on the second rotational axis, in particular on the shaft, may thus efficiently be transferred to the housing. Correspondingly, a compact implementation of the operating element may be achieved.

[0041] According to an embodiment, the operating element comprises a further (second) guiding surface. The operating element may comprise a contact member mounted to or coupled to the lever component to pivot with the lever component about the first rotational axis. The (second) contact member may be configured to

interact with the (second) guiding surface to apply a torque to the lever component. Although the second contact member pivots by the same angle as the lever component about the first rotational axis (i.e. does not benefit from a transmission), a torque is generated that adds to the torque provided by the pivotable element so that the overall torque applied to the lever can be increased.

[0042] The (second) contact member may directly be mounted to or incorporated in the lever component that rotates about the first rotational axis. The movement of the lever may thus be directly translated into a torque acting on the lever component without transferring the generated torque via any intermediate coupling. By providing another guiding surface and contact member, the torque applied to the lever can further be increased. Further, the initially mentioned first guiding surface and the second guiding surface may be shaped differently, thus allowing an independent implementation of different haptic features. For example, it is possible that one guiding surface defines a pressure point while the other guiding surface defines a locked position. As another example, one guiding surface may implement a restoring torque applied to the lever while the other guiding surface may implement one or more haptic features (pressure point, locked position, or the like). As another example, both guiding surfaces may be shaped to cooperate for increasing a haptic effect, such as increasing the torque required to overcome a pressure point or increasing a torque required to leave a locked position.

[0043] According to an embodiment, the (second) contact member comprises a (second) force applying unit and a (second) contact element, wherein the (second) force applying unit applies a force to the (second) contact element to bring the (second) contact element in contact with the further (second) guiding surface. The (second) contact member may have a configuration corresponding to the configuration of the above-mentioned (first) contact member provided on the pivoting element; any features disclosed in relation to the first contact member may likewise be employed with the second contact member. By using the same components as for the torque application assembly, a simplified implementation may be realized.

[0044] In an embodiment, the features provided on the further (second) guiding surface may correspond to the features provided on the first mentioned guiding surface, such that when displacing the lever, a smooth movement with increased torque may be experienced. Furthermore, the default position on the first guiding surface (if provided) may correspond to a default position on the further (second) guiding surface, at which a minimum or no torque acts on the lever. The default position may thus better be defined. Additionally, one or more pressure points at which a local or global maximum of the torque is transferred to the lever, may be defined on the first guiding surface and may coincide with one or more pressure points defined on the further (second) guiding

surface, such that they are experienced by the contact elements at the same time. Similarly, on or more locked positions defined on the first guiding surface may coincide with one or more locked positions defined on the further (second) guiding surface.

[0045] According to an embodiment, the operating element may be configured to allow the control of a function of an off-highway vehicle. According to an embodiment, a mobile machine, in particular an off-highway vehicle, comprising an operating element having any of the configurations described herein is provided. The off-highway vehicle may comprise a vehicle for agricultural, earth/soil mining or construction site usage. It may also be an industrial vehicle, e.g. employed for logistics.

[0046] According to an embodiment, a method of operating an operating element comprising a lever having a lever component pivotable about a rotational axis and a torque application assembly coupled to the lever component is provided. The torque application assembly comprises a pivotable element that is pivotable about a second rotational axis different from and spatially offset from the first rotational axis, and a coupling assembly that mechanically couples the lever component to the pivotable element such that pivoting the lever component about the first rotational axis results in a larger pivoting of the pivoting element about the second rotational axis. The operating element further comprises a guiding surface, wherein the pivotable element is configured to interact with the guiding surface, wherein the torque application assembly is configured to transfer a torque generated by the interaction and acting on the pivotable element via the coupling to the lever component. The method comprises applying a force on the lever to pivot the lever component about the first rotational axis, whereby the pivotable element is pivoted by a larger angle about the second rotational axis; and generating a torque by the interaction between the pivotable element and the guiding surface and transferring the generated torque via the coupling assembly to the lever component. By such method, advantages similar to the ones outlined further above may be achieved. It should be clear that the torque may be generated while the lever is pivoted and thus has to be overcome by a user of the operating element when pivoting the lever.

[0047] In embodiments of the method, the method may comprise any of the operation steps described herein with respect to the operating element. The operating element may be configured to perform any of the methods described herein.

[0048] It is to be understood that the features mentioned above and those yet to be explained below can be used not only in the respective combinations indicated, but also in other combinations or in isolation, without leaving the scope of the present invention. In particular, the features of the different aspects and embodiments of the invention can be combined with each other unless noted to the contrary.

BRIEF DESCRIPTION OF THE DRAWINGS

[0049] The forgoing and other features and advantages of the invention will become further apparent from the following detailed description read in conjunction with the accompanying drawings. In the drawings, like reference numerals refer to like elements.

Fig. 1 is a schematic drawing showing of an operating element according to an embodiment of the invention.

Fig. 2 is a diagram illustrating a torque characteristic of torque acting on a lever of the operating element of Fig. 1.

Fig. 3 is a schematic drawing showing a perspective view of the operating element of Fig. 1.

Fig. 4 is a schematic drawing showing the operating principle of the torque application assembly according to an embodiment.

Fig. 5 is a schematic drawing showing the operating principle of the torque application assembly according to an embodiment.

Fig. 6 is a schematic drawing illustrating the generation of an overpressure point according to an embodiment.

Fig. 7 is a schematic drawing illustrating the generation of a locked position according to an embodiment.

DETAILED DESCRIPTION

[0050] In the following, embodiments of the invention will be described in detail with reference to the accompanying drawings. It is to be understood that the following description of the embodiments is given only for the purpose of illustration and is not to be taken in a limiting sense. It should be noted that the drawings are to be regarded as being schematic representations only, and elements in the drawings are not necessarily to scale with each other. Rather, the representation of the various elements is chosen such that their function and general purpose become apparent to a person skilled in the art. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprising," "having," "including," and "containing" are to be construed as openended terms (i.e., meaning "including, but not limited to,") unless otherwise noted.

[0051] Fig. 1 illustrates an embodiment of the operating element 100. The operating element 100 comprises a lever 101, which includes lever component 102 and further lever components 103 and 104. Lever component

102 is pivoted about a first rotational axis 105 when lever 101 is pivoted correspondingly. For example, lever 101 may comprise a handle mounted to lever component 103, and the user may pivot the handle and component 103 together with the lever component 102 about rotational axis 105. In the present example, the lever component 102 is shaped as a bracket and forms part of a cardan mount; it rotatably supports the lever against a housing of operating element 100. The further component 104 provides a similar rotational support about a orthogonal rotational axis (not indicated) so that the lever may be pivoted in two orthogonal directions. Although the solution is described herein below with respect to the lever component 102, a corresponding configuration can be provided for the lever component 104 and thus for the other pivoting direction of the lever 101. It should be clear that a respective cardan suspension can be implemented in many different ways, and that the present solution is applicably to any of these.

[0052] In other embodiments, the lever may only be pivotable about a single rotational axis. The lever component may in such case be the component 103 (i.e. no bracket 102 may thus be provided). The lever may thus only comprise the lever component pivotable about the first rotational axis, and a handle mounted to the lever component. The lever component that rotates about the first rotational axis 105 can thus be implemented in many different ways.

[0053] The operating element further comprises a torque application assembly 110 that includes a pivotable element 111 that is pivotable about the second rotational axis 115. As shown, rotational axes 105, 115 are parallel but spatially offset. The pivotable element 111 is coupled by means of a coupling assembly 120 to the lever element 102. The configuration is such that when lever component 102 rotates by a first angle about first rotational axis 105, the pivotable element 111 rotates by a larger second angle about the second rotational axis 115. The torque application assembly 110 thus implements a transmission mechanism that preferably provides a transmission ratio (i.e. ratio between the first and second rotation angles) of at least 1:1.5.

[0054] A first guiding element 133 that provides a guiding surface 130 is provided. Pivotable element 111 interacts with guiding surface 130 to generate a torque when lever component 102 is pivoted. Pivoting element may for this purpose comprise a contact member 140 that contacts the guiding surface. The generated torque is applied via coupling 120 to lever 101, i.e. to component 102 and component 103. The user thus has to overcome the generated torque when moving the lever, or the torque may drive the lever towards a particular position (e.g. default position).

[0055] Optionally, operating element 100 may comprise a second guiding element 233 providing a second guiding surface 230, which is explained in more detail further below. Further optionally, a restoring assembly 300 may be provided that applies a restoring torque to the

lever 101. The restoring torque acts on the lever to drive the lever back into a default position, in particular an equilibrium position, which is illustrated in Fig. 1.

[0056] In Fig. 3, which is a perspective view of the operating element 100 of Fig. 1, the lever 101 is shown in a pivoted position in which the pivotable element 111, in particular its contact member 140, interacts with the guiding surface 130. In the present example, guiding surface 130 (and thus guiding element 133) is split into three sections, wherein a first section 131 of the guiding surface 130 spans a larger range and two shorter further sections 132 are provided. As can be seen, there is a gap between the first section 131 and each of the further sections 132. A different number of sections or a continuous guiding surface may be provided alternatively.

[0057] The coupling assembly 120 comprises a pin 121 provided on the lever component 102 and a slit 122 in the pivotable element in which the pin 121 is engaged. A coupling is thus provided that allows relative rotation between pivotable element 111 and lever component 102 about the rotational axis 123 of the pin. Further, by the slit 122 (or elongated hole or recess), a relative movement is allowed. Such coupling allows the pivotable element 111 and the lever component 102 to rotate about the different rotational axes 105, 115 while transferring torque between them. The pivotable element is supported by a shaft 116 that supports the pivotable element in a housing of the operating element 100 so as to be rotatable about axis 115. As can be seen, the distance between the axis 123 of pin 121 of the coupling 120 and the first rotational axis 105 is larger than the distance between the pin axis 123 and the second rotational axis 115 (for all positions of the pin relative to the pivotable component 111), so that a transmission and lever effect is achieved. The coupling assembly 120 may of course be implemented in many different ways, the configuration may for example be reversed.

[0058] In the example of Fig. 3, the pivotable element 111 has two arms 118 extending in opposite directions and perpendicular to a line that connects the second rotational axis 115 and the central axis 123 of the pin. Each arm is provided with a contact member 140. The contact member 140 may comprise a contact element 142 and a force applying unit 141. Force applying unit 141 may be a spring, such as a coil spring, which pushes the contact element 142 into contact with the guiding surface 130. It may be possible to install springs with different spring stiffness on the contact member 140 so that the desired torque acting on the lever 101 may be set. The contact element 142 may be a needle roller, a ball or any other suitable element. The contact element is supported in an elongated hole in the pivotable element 111, thus allowing movement in a direction parallel to a direction of force application by the force applying unit 141. Accordingly, if the guiding surface 130 is structured to generate different torques, the contact element 142 can move over respective structures while being displaced and increasing (or decreasing) the force that it applies to the guiding

surface via the force application unit 141. Consequently, by changing the shape of the guiding surface 130, the applied force and thus the torque acting on pivotable element 111 can be modulated.

[0059] As can further be seen, the contact elements 142 at the arms 118 of the pivotable element have a distance from the rotational axis 115 that is larger than the distance of the coupling 120 (in particular of axis 123 of pin 121) from the rotational axis 115. Accordingly, there is a further lever effect and the contact elements 142 move a larger circumferential distance than the coupling 120 when the pivotable element is pivoted by a certain angle about the second rotational axis 115. As the distance travelled by control element 142 on guiding surface 130 is increased, the torque applied via coupling 120 to lever component 102 can be increased and the resolution of features on guiding surface 130 can be increased.

[0060] Guiding surface 130 may have a shape that implements different torque characteristics, as described in more detail further below. In the present example, it implements a second locked position 137 (the lever position shown in Fig. 3) and a first locked position 136 (a corresponding locked position for movement of the lever in the opposite direction). As both arms and corresponding contact members 140 engage the guiding surface 130, the guiding surface may comprise corresponding features for each of the contact members 140. As can be seen for the first locked position 136, the section 132 has a recess for engagement by contact element 142 of one arm, and the section 131 has a corresponding recess for engagement of the contact element 142 of the other arm. Thus, the torque required to move out of the locked position can be doubled, and a precise and secure locking of the lever in the respective position is achieved. A locked position in particular refers to a position at which the restoring torque is smaller than the torque required to leave the locked position, so that the lever remains in the locked position.

[0061] In other embodiments, the pivotable element 111 may comprise only a single contact member 140, or may comprise further contact members 140 (optionally with a respective number of arms).

[0062] Fig. 3 further shows that an optional second guiding element 233 providing a second guiding surface 230 is provided. A second contact member 240 is mounted to the lever component 102 and pivots with the lever component 102 about the first rotational axis 105, when the lever 101 is pivoted. In a similar manner, the second contact member 240 comprises a second force applying unit 241 that acts on a second contact element 242 and pushes the second contact element 242 in contact with the second guiding surface 230. By such interaction, further torque that acts on the lever element 102 can be generated, which adds to the torque provided via the pivotable element 111. The difference is that there is no transmission or lever effect for the interaction with the second guiding surface 230. The second guiding surface can be shaped to implement similar features

as the first guiding surface. In the present example, a locked position 236 is provided that corresponds to the locked position 137 of the first guiding surface. Accordingly, both assemblies act together to retain the lever 101 in the respective locked position. The second guiding surface 230 can be shaped to provide any desirable torque characteristic, such as defining a default position, a pressure point, a locked position or applying/contributing to a restoring torque. Guiding surface 230 may be shaped to apply a similar type of torque as guiding surface 130 (same torque profile), or may have a shape that results in a different torque profile that is applied to lever 101.

[0063] Fig. 2 illustrates the increase of torque acting on the lever 101 by using the torque application assembly 110 according to an embodiment. The horizontal axis corresponds to the angle of deflection α (in degrees) of the lever 101 from its initial position, which may correspond to a default (zero) position of the lever 101. The vertical axis corresponds to the torque M applied to the lever 101. An angle of 0° corresponds to the default (equilibrium) position of the lever. The diagram illustrates a torque profile 10 that results from the application of torque to lever 101 by the torque application assembly 110, the second contact member interacting with the second guiding surface 230, and the restoring assembly 300. Curve section 11 illustrates a steep increase in torque that has to be overcome for moving the lever out of the default position. This may be generated by the restoring assembly 300 alone or in combination with one of the two assemblies (i.e. by the shape of the first and/or second guiding surface 130, 230). In the second section 12 of the torque characteristic, the torque increases as the lever is moved further out of the default position. Such increase in torque may be generated by the restoring assembly 300. During this range of lever movement, the contact members 140 of the pivotable element 111 may move between the sections 131, 132 of the guiding surface 130, i.e. they may move over the gap and thus not apply any torque. Similarly, no torque may be applied via the second guiding surface 230.

[0064] In section 13 of the torque characteristic, the lever is moved to a position at which the contact elements 142, 242 start to engage the respective locked positions 137, 236 on the respective guiding surfaces. The torques that are generated by this interaction sum up, thus creating a large torque peak in the characteristic that has to be overcome by the user in order to move the lever into the locked position. The peak may be present at an intermediate position 15, which may correspond to a maximum protrusion of the respective feature on the respective guiding surface (and thus to a maximum compression of the respective spring). After passing the maximum, the torque drops again and in particular drops to or below a zero torque. If the lever is now released by the user, the torque generated by the locking position by means of the first and second guiding surfaces is larger than the restoring torque, so that the lever will stay at the

locked position and not move back to the default position. For moving back to the default position, the maximum torque at the intermediate position 15 has to be again overcome by user actuation. If the lever is released by the user thereafter, it will return to the default position by means of the restoring torque applied by restoring assembly 300.

[0065] It should be noted that in such configuration, the torque characteristic looks different when the lever moves away from the default position, wherein the restoring torque is added to the torque generated by assembly 110, and when the lever moves towards the default position, wherein the restoring torque is subtracted from the torque generated by assembly 110. The torque that needs to be applied by the user to enter the locked position is thus higher than the torque required to leave the locked position. In other implementations described below, no restoring assembly 300 is provided.

[0066] In other implementations, the guiding surface 130 may be shaped to generate one or more pressure points in the torque characteristic, which correspond to a local or global maximum of the torque, which has to be overcome by the user, but which is smaller than the restoring torque. The user thus obtains haptic feedback when passing such pressure point, but the lever will nevertheless return to its default position when released. The guiding surface may have a protrusion that protrudes towards the second rotational axis for generating a pressure point.

[0067] Turning back to Fig. 3, the contact elements 142, 242 may be configured to either slide and/or roll on the guiding surface.

[0068] Fig. 4 schematically illustrates the operation of the torque application assembly 110 of the embodiment of Fig. 1. The pivotable element 111 with its two arms 118 and the respective contact members 140 is shown. Each contact member comprises the force applying unit 141 and the contact element 142. The left hand side of Fig. 4 shows the default position of the lever 101. The guiding surface is sectioned into sections 131, 132 separated by a gap. In the illustrated default position and when the lever is moved (slightly) out of the default position, the contact elements 142 are located within the gap so that no torque is applied to lever component 102 by pivotable element 111. The right hand side of Fig. 4 illustrates a situation in which the lever has been moved out of the default position and far enough so that the contact elements 142 engage the sections 132 of the guiding surface 130. Accordingly, the springs 141 are compressed and the pivotable element 111 will apply a torque to lever component 102. The guiding surface sections 131, 132 may in the example of Fig. 4 generate a pressure point that needs to be overcome when moving the lever further.

[0069] Due to the offset between the rotational axes 105, 115, the pivoting angle of lever component 102 about rotation axis 105 translates into a significantly larger pivoting angle of pivotable element 111 about rotation axis 115. The transmission ratio is preferably

larger than 1:1.5, preferably larger than 1:1.8 or even larger than 1:2. A corresponding torque increase may accordingly be achieved. In other words, the user needs to apply a significantly higher torque to lever 101 in order to overcome the torque generated by assembly 110 than it would be the case without such transmission. The same compressive force of the springs 141 can thus generate a higher torque. At the same time, a larger angular displacement is available for generating the torque characteristic, thus resulting in an increased resolution. As indicated above, the sections 131, 132 of the guiding surface 130 may be shaped to create a pressure point, a locked position or any other desirable torque characteristic.

[0070] Fig. 5 shows an embodiment that is a modification of the above-described embodiments. All above explanations are thus equally applicable. In the present embodiment, the guiding surface 130 is continuous over the pivoting range of the lever 101. In other words, the contact elements 142 are always in contact with the guiding surface 130 over the whole pivoting range. This does naturally not exclude that a separate guiding surface 130 is provided for each contact member 140 of pivotable element 111.

[0071] The shape of the guiding surface 130 of Fig. 5 is such that a restoring torque is generated that acts on the lever when the lever is moved out of the default position shown in the left part of Fig. 5. The default position may be an equilibrium position in which no torque is applied to lever 101, or the applied torques compensate each other (e.g. of the two arms 118). The guiding surface is shaped such that the compression of spring 141 is increased if the lever is pivoted in one or the other direction. Accordingly, a torque is applied to pivotable element 111 about the rotation axis 115 which is transferred via the coupling 120 to a torque acting on the lever component about rotational axis 105, with the respective transmission ratio. A relatively high restoring torque may thus be generated in a compact assembly. Such configuration may avoid the need for the restoring assembly 300. For this purpose, the guiding surface 113 may be shaped cycloidal, or may have another shape, such as circular (with a higher radius of curvature) or parabolic, or it may have linear slopes. A cycloidal shape may result in a constant force increase generated by the force applying unit 311 and thus a constant torque increase transferred to the lever 101.

[0072] Further, also in the embodiment of Fig. 5, the guiding surface 130 may be shaped to include further features that may generate a pressure point, a locked position, and/or the like in the torque characteristic. In the right hand part of Fig. 5, the lever is pivoted to a respective position in which the guiding surface 130 transitions into a pressure point feature at which the springs 141 are compressed at a higher rate. An increased torque thus has to be overcome by the user when moving the lever past such pressure point.

[0073] Fig. 6 illustrates in more detail the shape of a guiding surface 130 that may implement a pressure point

135 in any of the embodiments disclosed herein. As can be seen, the guiding surface 130 has a flat section at pressure point 135. If the contact element 142 passes the flat section, the force applying unit 141 is further compressed, thus generating a higher force and accordingly a higher torque applied via pivotable element 111 to the lever 101. Consequently, the user obtains haptic feedback that the pressure point is being passed. This may indicate to the user an activation of a particular function or the like.

[0074] Fig. 7 illustrates in more detail the shape of a guiding surface 130 that may implement a locked position 136 in any of the embodiments disclosed herein. As can be seen the surface 130 curves towards the rotation axis 115, resulting in an increasing compression of the force applying unit 141, until the maximum compression (and thus maximum torque) is reached at the intermediate position 15. After the user has applied sufficient torque to the lever to pass the intermediate position 15, the guiding surface 130 comprises a recess or indent that allows the force applying unit 141 to expand again, thereby reducing the torque applied to the lever. Accordingly, the pivotable element 111 and thus the lever 101 becomes locked in the respective position, since an increase in torque is required to move the lever out of the locked position 136.

[0075] If the guiding surface 130 is also shaped to generate the restoring torque (as in Fig. 5), then the recess may be shaped such that no restoring torque is applied at the locked position. The restoring torque does therefore not lower the torque required to move the lever out of such locked position 136.

[0076] It should be clear that plural different shapes of the guiding surface are conceivable to generate the desired torque characteristic, either with or without generation of a restoring torque. As mentioned above, the guiding surface 130 can be sectioned, thus allowing a great versatility and variety of shapes. Further, the torque acting on the lever can be increased in several ways, foremost by the transmission mechanism of the torque application assembly. Further torque increases become possible by using one or a combination of providing two contact members on the pivotable element that are in contact with the guiding surface, by the spacing of the contact element(s) from the second rotational axis, and the additional torque provided by the interaction with the second guiding surface. Even in a small and compact operating element, a high torque and useful tactile feedback can thereby be generated. The precision of the tactile features in the torque characteristic is further improved by the increase in resolution achieved by the torque application assembly, in particular its transmission mechanism.

[0077] List of reference signs

10	torque characteristic
11-14	torque curve sections
15	intermediate position
100	operating element
101	lever
102	lever component
103	further lever component
104	further lever component
105	first rotational axis
110	torque application assembly
111	pivotable element
115	second rotational axis
116	shaft
118	arm of pivotable element
120	coupling assembly
121	pin
122	slit or recess
123	rotation axis of coupling
130	first guiding surface
131	first section of first guiding surface
132	sections of first guiding surface
133	first guiding element
135	pressure point
136	first locked position
137	second locked position
140	contact member
141	force applying unit
142	contact element
230	second guiding surface
233	second guiding element
235	second pressure point
236	second locked position
240	second contact member
241	second force applying unit
242	second contact element
300	restoring assembly

Claims

1. An operating element (100) comprising a lever (101) having a lever component (102) pivotable about a first rotational axis (105) and a torque application assembly (110) coupled to the lever component (102), wherein the torque application assembly (110) comprises:
 - a pivotable element (111) that is pivotable about a second rotational axis (105) different from and spatially offset from the first rotational axis (105);
 - a coupling assembly (120) that mechanically couples the lever component (102) to the pivotable element (111) such that pivoting the lever component (102) about the first rotational axis (105) results in a larger pivoting of the pivotable element (111) about the second rotational axis (115),

wherein the operating element (100) further comprises a guiding surface (130), wherein the pivotable element (111) is configured to interact with the guiding surface (130), wherein the torque application assembly (110) is configured to transfer a torque generated by the interaction and acting on the pivotable element (111) via the coupling assembly (120) to the lever component (102).

2. The operating element according to claim 1, wherein the pivotable element (111) comprises a contact member (140), wherein the contact member (140) is configured to be in contact with and to be guided on the guiding surface (130).
3. The operating element of claim 2, wherein the guiding surface (130) extends over a range that corresponds to a pivoting range of the lever (101) about the first rotational axis (105) such that the contact member (140) is in contact with the guiding surface (130) when the lever (101) is pivoted within the pivoting range, or wherein the guiding surface (130) extends over one or more sections (131, 132), each section corresponding to a part of a pivoting range of the lever (101) such that the contact member (140) is in contact with the guiding surface (130) when the lever (101) is pivoted within the respective part of the pivoting range.
4. The operating element of any preceding claim, wherein the contact member (140) comprises a force applying unit (141) and a contact element (142), wherein the force applying unit (141) applies a force to the contact element (142) to bring the contact element (142) in contact with the guiding surface (130).
5. The operating element of any preceding claim, wherein the guiding surface (130) is shaped such that a force applied by the force applying unit (141) of the contact member (140) differs at different positions of the contact element (142) on the guiding surface (130).
6. The operating element according to any of the preceding claims, wherein the interaction between the pivotable element (111) and the guiding surface (130) is configured to generate a restoring torque that acts on the lever component (102).
7. The operating element of any preceding claim, wherein the guiding surface (130) is shaped to define at least one of
 - a default position at which no torque is transferred via the pivotable element (111) to the lever component (102),

- a pressure point (135) at which the interaction between the pivotable element (111) and the guiding surface (130) generates a local or global maximum of the torque transferred to the lever component (102) that has to be overcome when pivoting the lever (101), and
- a locked position (136, 137) different from a default position of the lever (101), wherein the torque generated by the interaction has a local or global maximum larger than a restoring torque applied to the lever (101) which has to be overcome for moving the lever (101) out of the locked position (136, 137).
8. The operating element according to any of the preceding claims, wherein a distance from the first rotational axis (105) to the coupling assembly (120) is larger than a distance from the second rotational axis (115) to the coupling assembly (120) so that a pivoting of the lever component (102) about an angle results in the pivoting of the pivotable element (111) about a larger angle.
 9. The operating element according to any of the preceding claims, wherein the torque application assembly (110) is configured to transmit a pivoting about the first rotational axis (105) into a pivoting about the second rotational axis (115) with a transmission ratio of at least 1:1.5.
 10. The operating element according to any of the preceding claims, wherein the pivotable element (111) comprises two arms (118) extending in opposite directions, wherein each arm (118) comprises a contact member (140) having a contact element (142) configured to contact a portion of the guiding surface (130).
 11. The operating element according to any of the preceding claims, wherein a distance between a contact point at which the pivotable element (111) is in contact with the guiding surface (130) and the second rotational axis (115) is larger than a distance between the coupling assembly (120) and the second rotational axis (115).
 12. The operating element according to any of the preceding claims, wherein the operating element (100) comprises a shaft (116) supported in a housing of the operating element (100), wherein the second rotational axis (115) is provided by the shaft (116) and wherein the pivotable element (111) is supported on the shaft (116).
 13. The operating element according to any of the preceding claims, wherein the operating element (100) comprises a further guiding surface (230), and wherein the operating element (100) comprises a contact member (240) mounted to or coupled to the lever component (102) to pivot with the lever component (102) about the first rotational axis (105), wherein the contact member (240) is configured to interact with the further guiding surface (230) to apply a torque to the lever component (102).
 14. The operating element according to any of the preceding claims, wherein the contact member (240) comprises a force applying unit (241) and a contact element (242), wherein the force applying unit (241) applies a force to the contact element (242) to bring the contact element (241) in contact with the further guiding surface (230).
 15. A method of operating an operating element comprising a lever (101) having a lever component (102) pivotable about a first rotational axis (105) and a torque application assembly (110) coupled to the lever component (102), wherein the torque application assembly (110) comprises a pivotable element (111) that is pivotable about a second rotational axis (115) different from and spatially offset from the first rotational axis (105), and a coupling assembly (120) that mechanically couples the lever component (102) to the pivotable element (111) such that pivoting the lever component (102) about the first rotational axis (105) results in a larger pivoting of the pivotable element (111) about the second rotational axis (115), the operating element further comprising a guiding surface (130), wherein the pivotable element (111) is configured to interact with the guiding surface (130), wherein the torque application assembly (110) is configured to transfer a torque generated by the interaction and acting on the pivotable element (111) via the coupling assembly (120) to the lever component (102), wherein the method comprises:
 - applying a force on the lever (101) to pivot the lever component (102) about the first rotational axis (105), whereby the pivotable element (111) is pivoted by a larger angle about the second rotational axis (115); and
 - generating a torque by the interaction between the pivotable element (111) and the guiding surface (130) and transferring the generated torque via the coupling assembly (120) to the lever component (102).

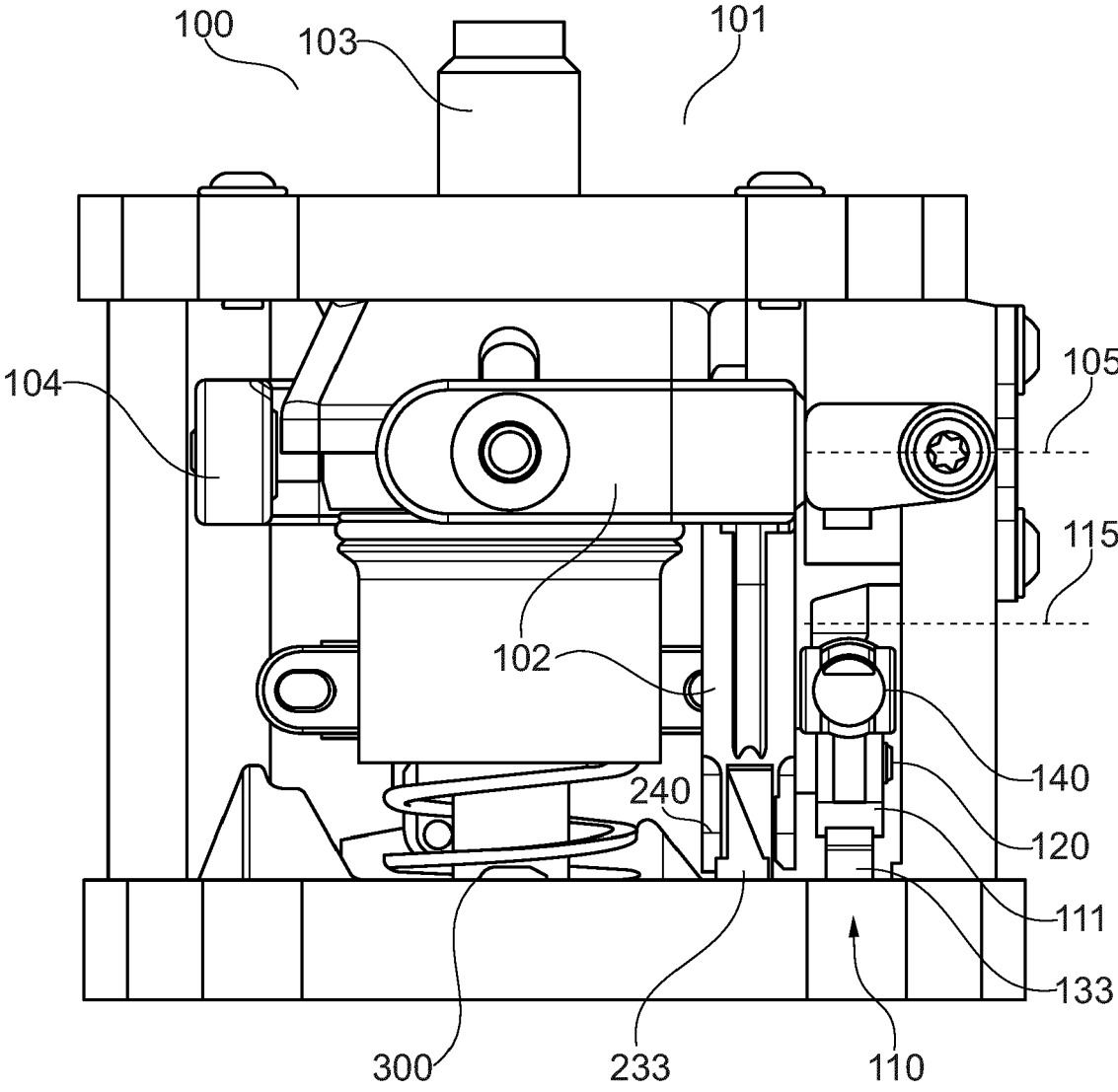


Fig. 1

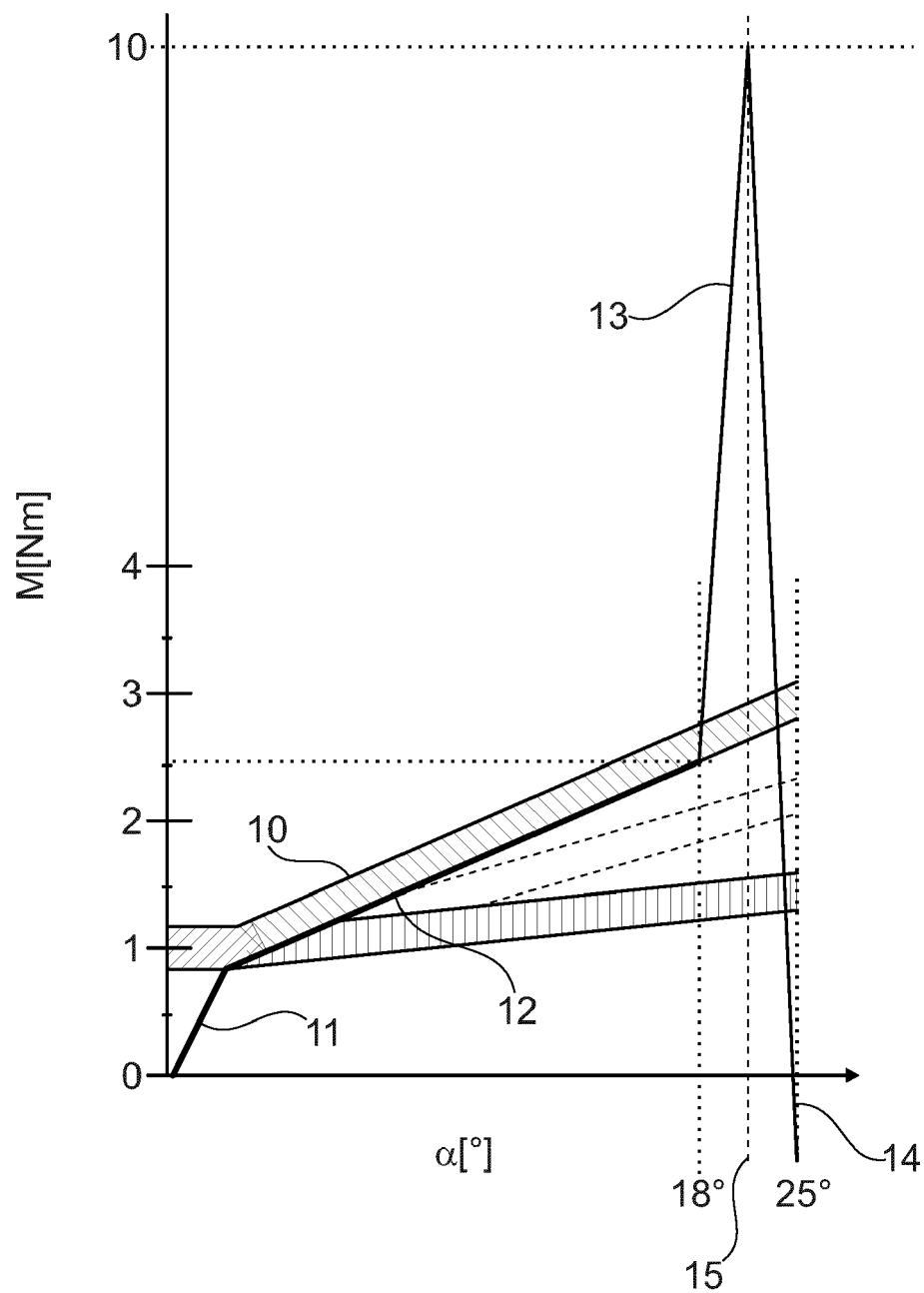


Fig. 2

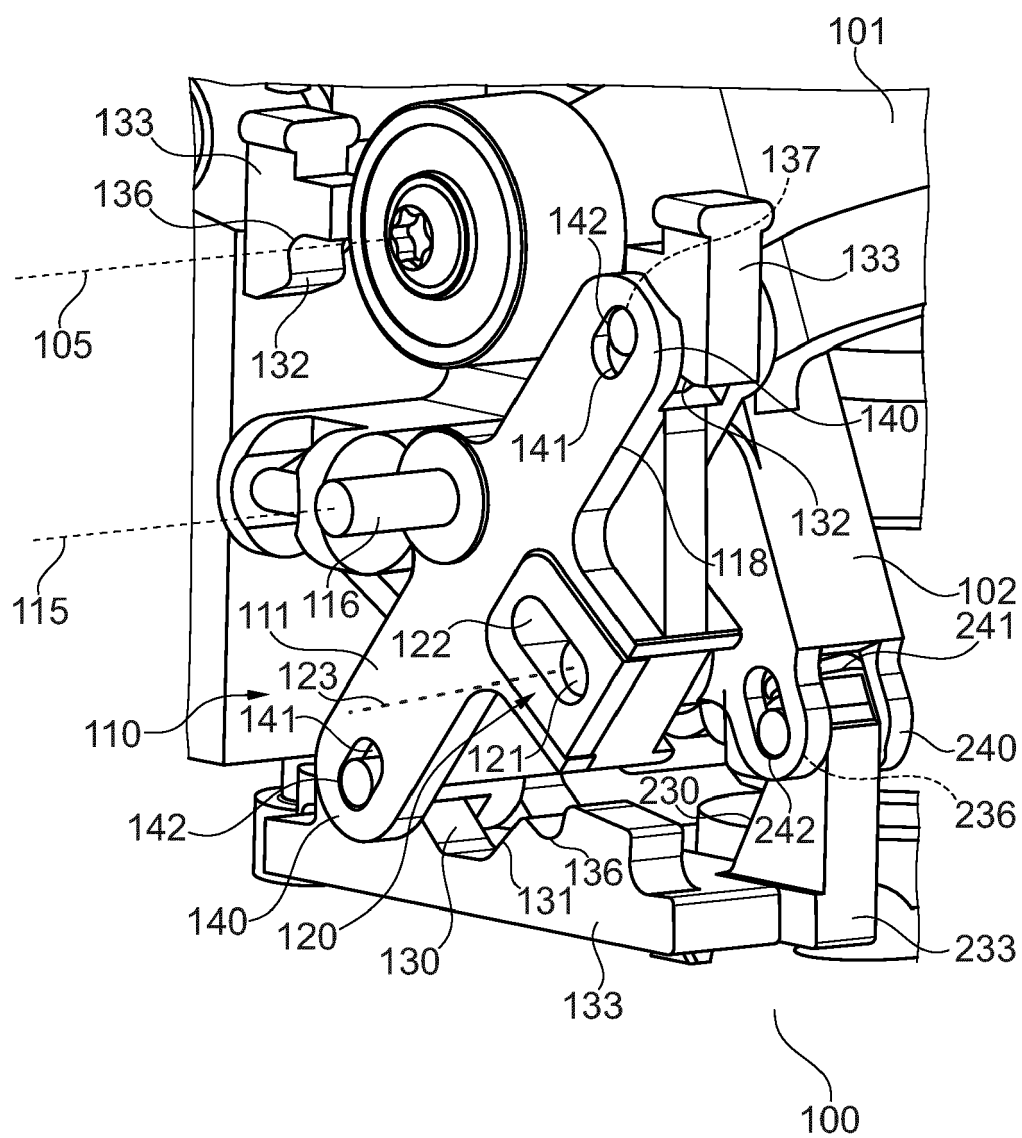


Fig. 3

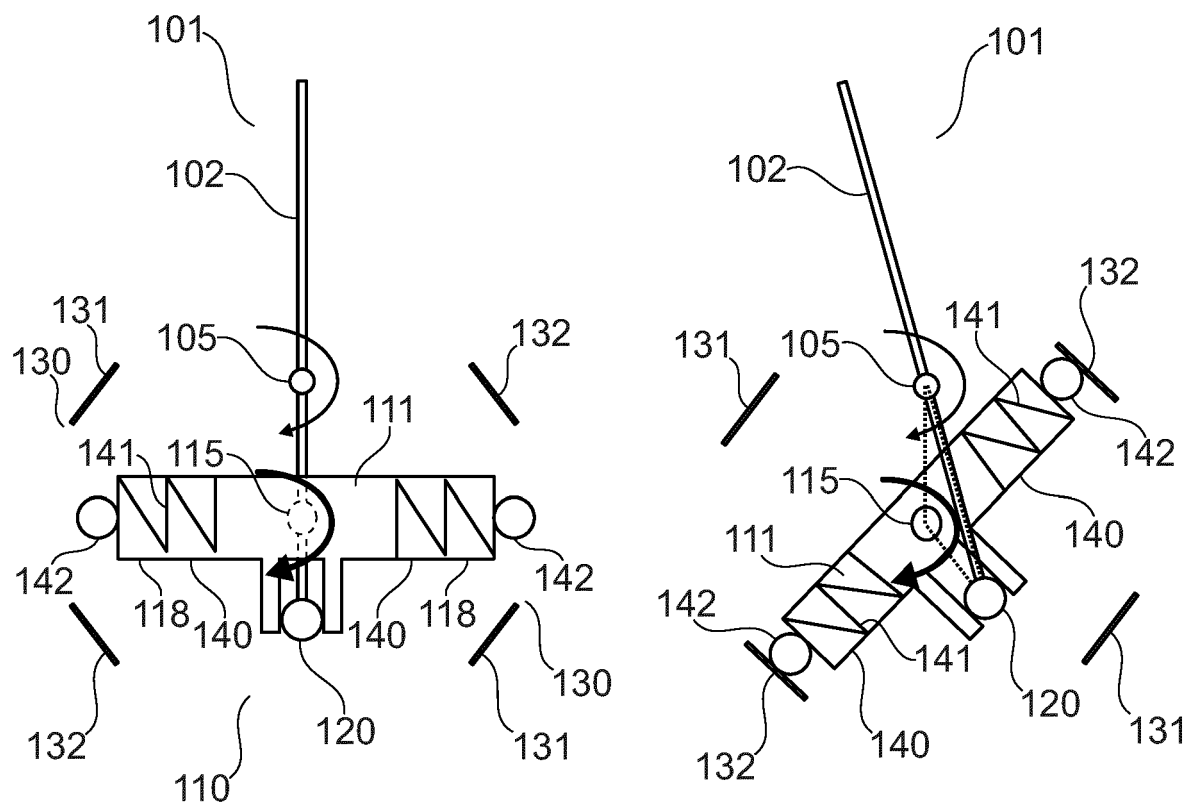


Fig. 4

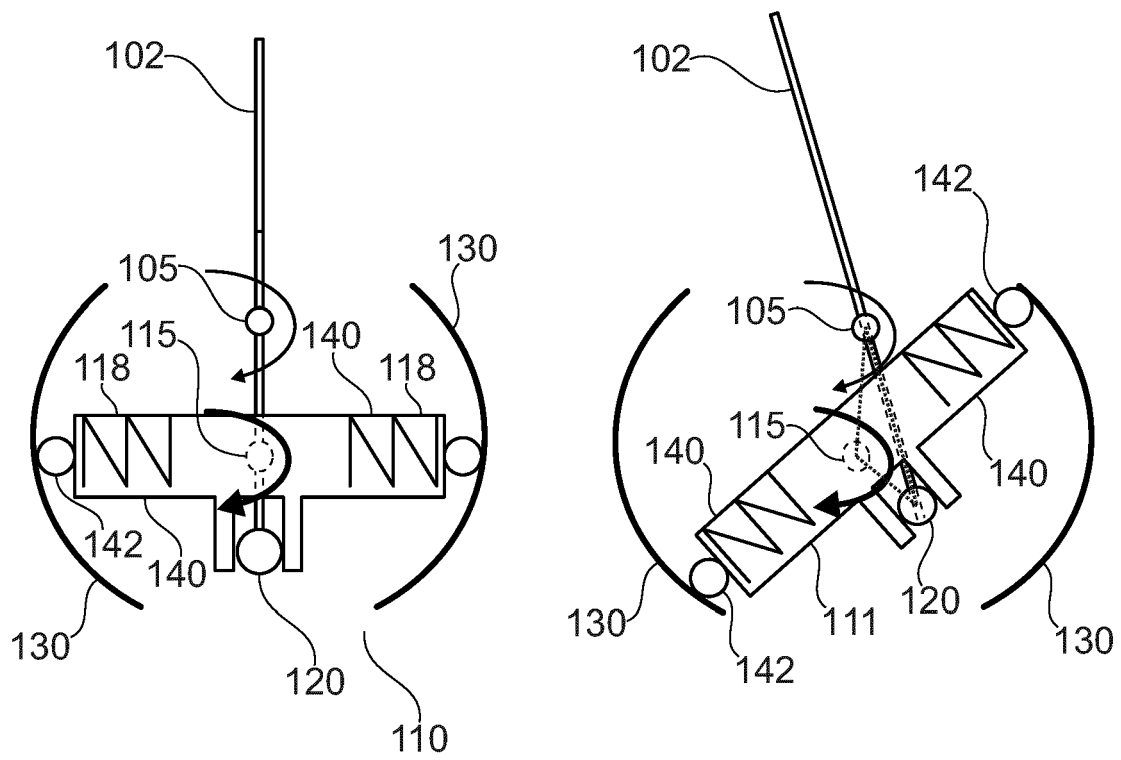


Fig. 5

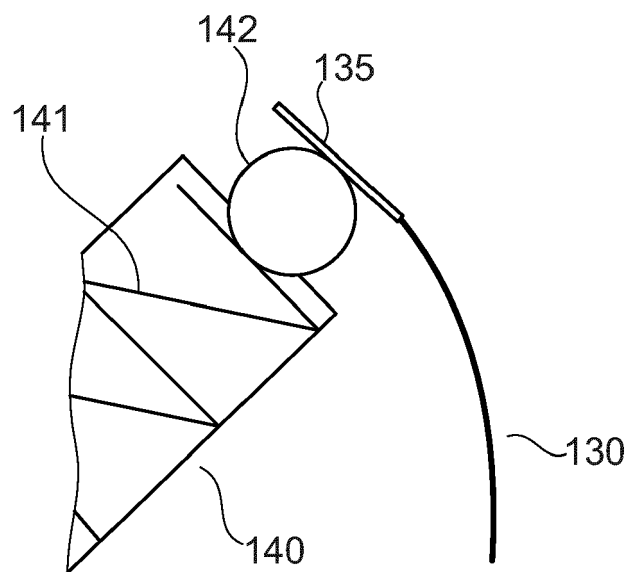


Fig. 6

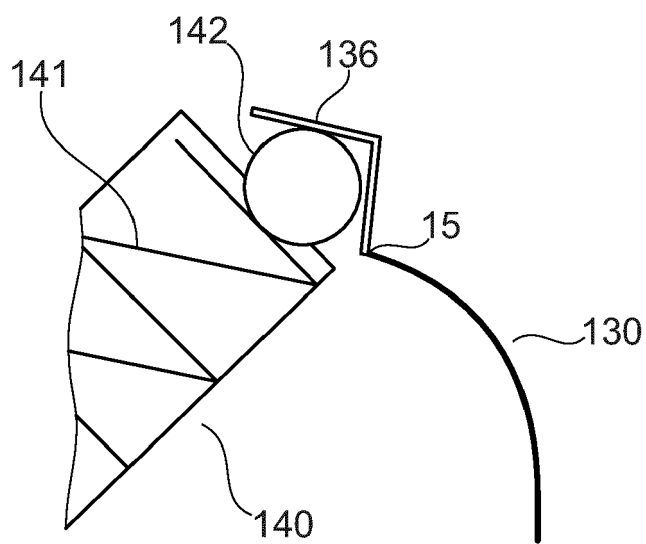


Fig. 7



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Application Number

EP 23 21 7681

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Date of completion of the search			
3 June 2024			
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