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(54) OPERATING ELEMENT FOR A MACHINE

(57) An operating element for a machine is provided. The operating element comprises a lever (11) that is pivotable about a rotation axis (12). It further includes a restoring device (30) configured to apply a restoring torque to the lever (11) and a braking device (20) configured to apply a braking torque to the lever (11). The braking torque provides a resistance to a pivoting of the lever (11) about the rotation axis (12). The braking device (20) and/or the restoring device (30) is an active device that is configured to be controllable to actively change the applied braking torque and/or the applied restoring torque, respectively.

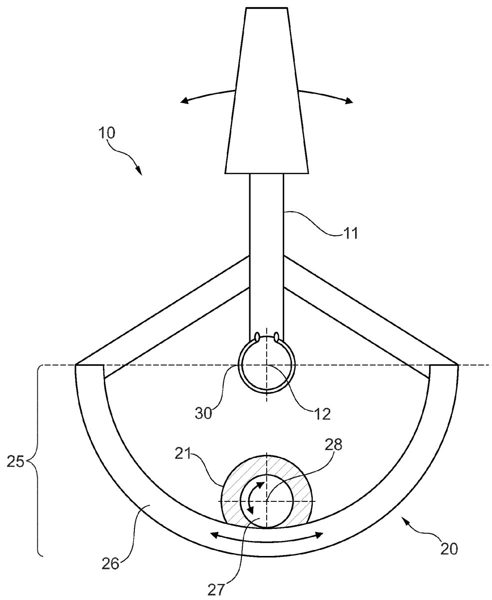

Fig. 2

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an operating element for a machine, such as a vehicle, in particular for off-highway applications. It further relates to a method of controlling a respective operating element.

BACKGROUND

[0002] Machines, in particular 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 such 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 requirements of such a large number of operating elements is excessive and a large number of different operating elements may further confuse the operator.

[0003] Providing plural functions in the same operating element may not be desirable, since a compromise between different haptic requirements has to be found so that the operating element may not be the preferred choice for either one of the functions to be controlled. This may make the control for the operator more difficult and may result in a less precise control.

[0004] It is therefore desirable to provide an accurate control of such machine and to make the control more intuitive. It is further desirable to reduce the space required by the operating elements of such machine.

SUMMARY

[0005] Accordingly, there is a need to mitigate at least some of the drawbacks mentioned above and to improve the control of such machine. It is in particular desirable to enable an accurate control of the machine without the large space requirements of plural operating elements as in a conventional operating panel.

[0006] This need is met by the features of the independent claims. The dependent claims describe preferred embodiments of the invention.

[0007] According to an embodiment of the invention, an operating element for a machine, in particular for a mobile machine, is provided, which comprises a lever that is pivotable about a rotation axis. It further comprises a restoring device configured to apply a restoring torque to the lever and a braking device configured to apply a braking torque to the lever. The braking torque provides a resistance to a pivoting of the lever about the rotation axis. The braking device and/or the restoring device is an active device that is configured to be controllable to actively change the applied braking torque and/or restoring torque, respectively.

[0008] Such operating element may allow the control of two or more different functions while ensuring an accurate and intuitive control by the operator. By providing such active device, it becomes possible to adapt the operating characteristic of the operating element in accordance with the function to be controlled. By adjusting the braking torque and/or the restoring torque, the operating characteristic can be controlled to include pressure points, latching or locking points, and the like. The operating characteristic of the operating element may thus be adapted specifically for the respective function which is to be controlled. Two or more functions of the machine can thus be controlled by the same operating element, which reduces space requirements of a user interface of the machine while still ensuring a tailored and accurate control. Besides using the same operating element for controlling different functions, the disclosed solution also allows the manufacturing and deployment of the same type of operating element for controlling plural different functions. Each operating element may then be configured with an operating characteristic corresponding to the respective function. Manufacturing of the operating element may thus be facilitated and may be more cost-efficient.

[0009] The restoring torque may for example restore the lever to an initial position, such as an equilibrium position or a default position. The active device may be configured to change the braking torque relative to the restoring torque, either by changing one of them or by changing both. The operating element may in particular be configured to control a function of a vehicle, e.g. an off-highway vehicle, such as an agricultural vehicle, a construction vehicle, or an industrial vehicle (e.g. handling equipment, such as a fork lift).

[0010] In an embodiment, the active device is configured to cause the actively applied torque to change during pivoting of the lever. The force that the user needs to apply to the lever may thus be changed during operation of the lever. Changing the torque may for example occur in accordance with a torque characteristic. Such characteristic may define a respective torque for different pivoting positions, e.g. different angular positions of the lever about the rotation axis (pivoting angle). The active device may thus control the applied torque as a function of lever position.

[0011] Such torque characteristic may also be provided in form of an impedance characteristic that may define a mechanical impedance of the lever in dependence on lever position. The characteristic may define a mechanical target impedance, and a torque generation by the active device may be controlled in accordance with such target impedance. For example, feedback control may be employed (e.g., position-based active impedance control). Controlling the torque generated by the active device in accordance with a torque characteristic may thus occur directly (e.g. by defining a target torque) or indirectly (e.g. by defining a target mechanical impedance or any other suitable quantity, such as using admittance control).

[0012] The lever may be configured to be actuated by a user, it may for example comprise a respective handle. The lever may in particular be a tilting lever, which may be pivoted with respect to a housing of the operating element. The operating element may for example be a joystick.

[0013] In an embodiment, the operating element further comprises a controller coupled to the active device, wherein the controller is configured to operate the operating element in one, two, or more operating modes. In each operating mode, the controller actively controls the active device to apply the respective torque in accordance with a respective torque characteristic. The controller may in particular operate the operating element in at least two operating modes, wherein the torque characteristics of the two or more operating modes are different. For example, at least a first mode with a first characteristic that is different from a second characteristic of a second mode may be provided. By operating the operating element in accordance with different torque characteristics, the operating characteristic can be adapted to the respective function that the operating element controls in the respective operating mode.

[0014] The torque characteristics of different operating modes may in particular differ by the torque applied by the active device at one or more of the same pivotal positions of the lever. For example, in one operating mode, the torque characteristic may define a higher torque at the same pivotal position than the torque defined in another torque characteristic of a different operating mode. This may allow an individual adjustment of the applied torque for each respective operating mode.

[0015] The one, two or more operating modes may include an operating mode having a torque characteristic that includes a locked position of the lever (i.e. at a respective pivotal position) and an intermediate position of the lever located between an initial (e.g. equilibrium) position of the lever and a locked position of the lever. At the intermediate position, the braking torque may exceed the restoring torque. With such torque characteristic, if the lever is pushed beyond the intermediate position, it will not return to the initial position and will thus be locked. Such characteristic may thus allow retaining the lever at a predefined position after actuation by the user. At the locked position, the braking torque may be smaller than the restoring torque. This may provide a better definition of the position in which the lever is locked. The locked position may be close to an end stop of the lever. A respective torque characteristic may include one or more locked position on one or on each side of the lever motion. Respective intermediate positions may be provided in which the braking torque exceeds the restoring torque, so that the lever remains at the locked position into which the user has moved the lever.

[0016] In another example, the one, two or more operating modes may include an operating mode having a torque characteristic that includes a pressure point at a pivotal position of the lever at which the braking torque is below the restoring torque and at which the braking torque has a local or global maximum. When the active device is controlled in accordance with such torque characteristic, the user will experience a resistance that needs to be overcome when the lever is being pushed in the respective direction. The user may thus obtain haptic feedback, for example for the activation of a particular function that may require pushing the lever beyond such pressure point. An example is a floating position of a hydraulic system. The user may feel a respective resistance when moving the lever towards the end stop. In particular, the combination of the braking torque and the restoring torque (combined torque) at the pivotal position of the pressure point may have a local or global maximum with respect to the deflection of the lever in the direction of the end stop. When the lever is returned to the initial position, the combined torque may be lower since the restoring torque acts towards the initial position. However, the torque characteristic of the braking torque may still provide haptic feedback when crossing the respective pressure point.

[0017] The operating modes may for example include an operating mode having a torque characteristic that includes one pressure point between an initial position of the lever and an end stop position of the lever. If the lever is movable in two directions from the initial position, one pressure point may be provided between the initial position and each end stop position of the lever. Such characteristic may for example be useful if the operating mode corresponds to a function of the operating element that controls a moving direction of the mobile machine, such as entering into a forward drive mode or a reverse drive mode when the lever passes the pressure point in the respective direction.

[0018] As another example, the operating modes may include an operating mode having a torque characteristic that comprises two or more pressure points between an initial position of the lever and an end stop position of the lever. If the lever is movable in two directions, two or more pressure points may be provided between the initial position and each end stop position of the lever. When moving the lever in the respective direction, the user may thus feel several points of resistance. An operating mode having such characteristic may for example be useful when adjusting an operating parameter, wherein the crossing of each pressure point corresponds to a certain increase or decrease in the parameter value. Such parameter may for example correspond to a position of a tool of the machine that is adjusted when moving the lever.

[0019] It should be clear that these are examples only, and that the torque characteristic can be adapted in accordance with the function of the machine that is controlled in the respective operating mode of the operating element. If the lever is movable in two directions, the torque characteristic for each direction may be the same or may be different (e.g., a locked position may be provided in one direction and plural pressure points may be provided in the other direction). Also, it should be clear that the torque characteristic may depend on the direction of movement of the lever, for example whether it is moved towards the end stop or towards the initial position. As an example, after the user has moved the lever across one or more pressure points and releases the lever, a torque characteristic that applies no braking torque may be used so that the lever can quickly move to its initial position after release. The disclosed operating element thus allows adaptation of its operation to a plurality of different functions which it is supposed to control.

[0020] In an embodiment, the active device is configured to be controllable to actively move the lever. For example, the braking device may apply a torque that moves the lever against the restoring torque to a controllable position. This may correspond to the application of a negative braking torque by the braking device. The lever may for example be moved from an initial position to a new position at which the braking torque is again applied to cause the lever to remain at this position. The angular position of a initial or equilibrium position of the lever may thereby be controlled. As another example the machine may be remote controlled and the lever may be moved to a position corresponding to the currently performed function.

[0021] The torque characteristic of an operating mode may define a respective torque (for a respective pivotal position) that actively moves the lever. The torque characteristic may thus define the application of a positive and/or a negative braking torque, and/or of a restoring torque by the respective active device, e.g. by the braking device and/or the restoring device.

[0022] The active device, in particular the braking device, may comprise a transmission mechanism configured to convert a smaller torque or force into a larger torque that is applied by the active device to the lever. The element of the active device that generates the force or torque may thus be made more compact and may only need to generate a relatively small torque or force. The transmission may then increase this generated torque or force to a larger torque that is applied to the lever, for example as a braking torque, as a restoring torque, or as an actively moving torque. The dimensions of the operating element may thus be kept small while sufficiently large torques can be generated.

[0023] In an embodiment, the transmission mechanism is configured to transmit a pivoting of the lever to a rotation of a transmission wheel, wherein an active element of the active device is controllable to apply a force or torque to the transmission wheel, for example to brake the transmission wheel and/or to actively rotate the transmission wheel. Such transmission mechanism may allow controlling the torque characteristic of the operating element in a simple and efficient way.

[0024] The transmission wheel may be stationary and rotate about a stationary rotation axis, or the transmission wheel may be coupled to the lever and move with the lever. The former configuration is preferred, as it allows the active element to remain stationary as well.

[0025] A geared transmission mechanism may for example be used. The transmission mechanism may comprise an internal ring gear section coupled or mounted to the lever and meshing with the transmission wheel. 'Internal' refers to the gear teeth being located on an inner annular surface of the ring section. The ring gear section may thus pivot/rotate with the lever and may cause the stationary transmission wheel to rotate. As the outer diameter of the transmission wheel may be (significantly) smaller than the inner diameter of the ring gear section, a pivoting of the lever is transmitted into a relatively fast rotation of the transmission wheel. Such arrangement thus allows the generation of a high torque acting on the lever from a smaller torque applied to the transmission wheel. The transmission wheel may be a spur gear or helical gear.

[0026] A center of rotation of the ring gear section preferably coincides with the rotational axis of the lever (i.e., they may be arranged concentrically). The position of the transmission wheel may be chosen such that a pivoting range of the lever is symmetrical (similar range in each pivoting direction) or is asymmetrical (a larger pivoting range in one direction compared to the other). Respective end stops may be provided at which the pivoting range of the lever ends.

[0027] In some implementations, the lever and the ring gear section may be formed integrally. This may facilitate manufacturing of the lever and ring gear section.

[0028] A geared transmission mechanism is only an example. Other transmission mechanisms may be used as well. For example, a lever mechanism may be employed that translates a small torque or force applied to an end of a lever arm towards a larger torque or force applied to an end of the lever of the operating element. Further, such transmission mechanism is optional, and a respective force or torque may directly be applied to the lever of the operating element.

[0029] The active device may include at least one of a magnetic braking element, a magnetorheological fluid (MRF) braking element, an electric motor, and a hydraulic braking element. Respective active elements may require only little space and may thus allow the operating element to remain compact. An MRF braking element or an electric motor are preferred, as they allow a fast control of the applied torque or force.

[0030] The operating element may further comprise a position sensor configured to detect a pivotal position (in particular a pivoting angle) of the lever. The operating element may be configured to control the active device in dependence on a detected pivotal position of the lever. It may in particular control the torque applied by the active device in dependence on the pivotal position, e.g. in accordance with a respective torque characteristic. A rotary sensor may for example be employed, e.g. a magnetic sensor, a rotary encoder, or the like. The pivotal position may also be detected by deriving the position by means of an observer from a measurement using a force and/or torque sensor.

[0031] The restoring device may comprise one or more springs. For example, one or more torsion springs, such as leg springs, may be employed. The restoring device may be a passive device. When the restoring device is implemented as an active device, it preferably comprises an electric motor. Implementing the restoring device as active device may allow moving the lever into an predefined default or equilibrium position.

[0032] In some embodiments, the restoring device and the braking device are physically separate devices. In particular, one may be an active device and the other may be a passive device, i.e. a device that cannot be actively controlled. In other embodiments, the active device may implement both, the restoring device and the braking device, i.e. a single physical device may implement both of these functional devices. For example, an electric motor may be coupled directly or indirectly (i.e. via a respective transmission mechanism) to the lever and may both act as a restoring device by applying a restoring torque to the lever and act as a braking device by applying a braking torque to the lever. Using one active device to implement both, the restoring device and the braking device, may further reduce complexity of the operating element and may improve compactness. The implementation as two separate physical devices is however preferred.

[0033] It is preferred that the braking device is the active device, and that the restoring device is a passive device.

[0034] In some embodiments, the lever of the operating element may be pivotable only about the (single) rotational axis. In other embodiments, the lever may be pivotable about two (orthogonal) rotational axes. For the pivoting about the second rotational axis, a corresponding configuration for applying the braking torque and for applying the restoring torque may be provided. A gimbal mount may be used to mount the lever to provide two rotation axes, and the respective restoring device and braking device may be mounted, e.g., to a shaft section of the gimbal mount that rotates with the lever about the respective axis.

[0035] The controller may be configured to operate the operating element in two or more operating modes, wherein in each of the at least two operating modes, the operating element controls a different function of the machine. In each of the at least two operating modes, the controller may control the active element in accordance with a different torque characteristic. Each function of the operating element may thus be associated with a torque characteristic specific to that function. Control of the different functions by the user may thus be facilitated and made more intuitive.

[0036] According to a further embodiment of the invention, a mobile machine comprising a control element having any of the configurations described herein is provided. The control element may be configured to control one, tow, or more functions of the mobile machine, e.g. by operating the control element in different operating modes.

[0037] According to a further embodiment of the invention, a method of controlling an operating element of a vehicle is provided. The operating element comprises a lever that is pivotable about a rotation axis, a restoring device for applying a restoring torque to the lever; and a braking device for applying a braking torque to the lever. The braking torque provides a resistance to a pivoting of the lever about the rotation axis. The braking device and/or the restoring device is an active device. The method may comprise controlling the active device to actively change the braking torque and/or the restoring torque applied by the braking device and/or by the restoring device, respectively. By such method, advantages similar to the ones outlined further above may be achieved.

[0038] The method may further comprise operating the operating element in one, two, or more operating modes, wherein operating in the respective operating mode comprises actively controlling the torque applied by the active device in accordance with a respective torque characteristic that defines the torque to be applied as a function of lever position. Preferably, the torque characteristics of different operating modes are different.

[0039] According to a further embodiment of the invention, a computer program for controlling an operating element having any of the configurations disclosed herein is provided. The computer program comprises control instructions which, when executed on a processing unit of a controller that controls the operating element, causes the controller to perform any of the methods disclosed herein. Such computer program may be provided on a volatile or non-volatile data carrier or storage medium. It may also be provided as an electronic signal, e.g. via a data communication connection, e.g. via a network connection. Such computer program may for example be used to operate the operating element in accordance with a particular torque characteristic.

[0040] 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. In particular, the method may be carried out by an operating element having any of the configurations described herein. Further, the operating element may be configured to carry out any of the method steps described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] 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 a perspective view of an operating element according to an embodiment.

Fig. 2 is a schematic drawing showing a side view of an operating element according to a further embodiment.

Fig. 3 is a diagram schematically illustrating different torque characteristics in accordance with which the operating element of figure 1 or figure 2 may be operated.

Fig. 4 is a flow diagram illustrating a method of controlling an operating element according to an embodiment.

DETAILED DESCRIPTION

[0042] 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.

[0043] Fig. 1 schematically illustrates an operating element 10 according to an embodiment, which comprises a lever 11 that is pivotable about a rotation axis 12. Lever 11 may comprise a handle 15 by which a user can grip and operate the lever 11. It should be clear that Fig. 1 shows a simplified schematic representation, and that the operating element 10 may be provided in form of a joystick for vehicle control.

[0044] Operating element 10 comprises a restoring device 30 that applies a restoring torque to lever 11, so that the lever 11 is restored to an initial position or equilibrium position upon being released by the user. Such initial position may be a default position that is determined by the mechanical configuration of operating element 10 or that may be configurable. Restoring device 30 is preferably implemented as a passive device, such as one or more springs, in particular torsion springs, that apply a torque to lever 11 when moved out of its initial position. In other implementations, restoring device 30 can be implemented as an active device that actively applies a restoring torque to lever 11, for example in form of an electric motor, a hydraulic actuator or the like.

[0045] Operating element 10 further comprises a braking device 20 that applies a braking torque to lever 11 when lever 11 is pivoted about the rotation axis 12. Braking device 20 may be implemented as a passive device, such as a friction element that provides a braking torque due to friction, or as an active device that actively controls a braking torque applied to lever 11. Braking device 20 may for example comprise a braking element in form of a magnetic braking element, a mechanical braking element, a hydraulic element, or the like. Preferably, it includes a magneto-rheological fluid (MRF) braking element or an electric motor.

[0046] A magneto-rheological fluid is a fluid that changes its viscosity upon application of a magnetic field. Accordingly, when such fluid is for example provided between two disks, one rotating against the other, the torque required for rotating one disk against the other can be adjusted by applying a magnetic field (e.g., by means of an electromagnet) that changes the viscosity of the MRF. A very fast and precise control of the braking torque may thereby be achieved.

[0047] Similarly, using an electric motor, the application of a braking torque can be controlled in a fast and precise manner.

[0048] The braking device 20, the restoring device 30, or both are provided as active device so that the application of the respective torque can be actively controlled, e.g. by a respective control signal. Braking device 20 and restoring device 30 may be provided as physically separate devices. In other implementations, a single active device may implement both, the restoring device 30 and the braking device 20. For example, an electric motor may apply both the restoring torque and the braking torque in a controlled manner.

[0049] Operating element 10 further comprises a sensor 40 configured to measure the position of lever 11, for example the pivoting angle. Sensor 40 can include a rotary sensor, in particular a magnetic rotary sensor, a rotary encoder, or the like.

[0050] Operating element 10 may comprise a controller 50 that is configured to control the active device. Controller 50 may form part of a larger control system or may be a dedicated controller for operating element 10. Controller 50 controls the torque applied by the active device in dependence on the pivotal position of lever 11. It may for example change the braking torque when lever 11 is moved in one or the other direction, and/or may change the restoring torque applied by the restoring device 30. Controller 50 may generate and supply a respective control signal to the respective active device. In the example shown in Fig. 1, controller 50 is coupled to the braking device 20 which is an active device in order to control the braking torque. Further, controller 50 is coupled to the position sensor 40 and receives a position signal so that it can monitor the pivotal position of lever 11.

[0051] Controller 50 operates the respective active device in accordance with a torque characteristic. Such torque characteristic defines the torque to be applied by the respective active device as a function of position of lever 11. Controller 50 detects the position of the lever 11 by the sensor 40 and controls the active device to apply the respective torque prescribed by the torque characteristic. Accordingly, as the user operates the lever 11, the braking torque and/or the restoring torque is changed in an actively controlled manner, so that different operating characteristics of the operating element 10 can be implemented.

[0052] Controller 50 comprises a processing unit 51 and a memory 52. Processing unit 51 may be a digital signal processor, an application specific integrated circuit, a field programmable gate array, a microprocessor or the like. Memory 52 may be a RAM, ROM, Flash-Memory, or the like. Memory 52 may for example store a torque characteristic, and may further store control instructions to be executed by the processing unit 51. Processing unit 51 may retrieve the torque characteristic from memory 52 and may operate the active device in accordance therewith.

[0053] Controller 50 is preferably configured to operate the operating element 10 in two or more different operating modes. In each operating mode, the operating element 10 may control a different function of the (mobile) machine, for example of an agricultural vehicle, a construction vehicle, an industrial vehicle, or the like. In each of two or more different operating modes, the controller 50 operates the operating element 10 in accordance with a different torque characteristic. The torque characteristic may be specific to the function of the machine to be controlled. The operating element 10 can thereby implement different operating characteristics for different functions. A highly flexible and intuitive control of the machine can thereby be enabled.

[0054] Fig. 2 illustrates a particular implementation of the operating element 10 of Fig. 1, so that the above explanations apply equally to the embodiment of Fig. 2. In the example of Fig. 2, the restoring device 30 is implemented as a passive element and in particular as one or more springs that apply the restoring torque to the lever 11. Lever 11 is again pivoted about the rotation axis 12, as shown. In such configuration, the restoring device 30 defines an equilibrium position of lever 11; pivoting of lever 11 from the equilibrium position in either direction results in the generation of a respective restoring torque by the spring.

[0055] Braking device 20 is implemented as an active device that applies a controllable braking force. Braking device 20 comprises a transmission mechanism 25 that converts a small torque applied by the braking element 21 of braking device 20 into a larger torque applied to the lever 11. The force that a user needs to apply to lever 11 to overcome the braking torque may thus be increased. The braking element 21 may again be a MRF braking element, an electric motor, or the like. By such transmission mechanism 25, the size of the braking element can be kept small and a compact configuration of operating element 10 is achieved.

[0056] In the present example, the transmission mechanism 25 is implemented as a geared transmission mechanism. A ring gear section 26 with internal teeth (not shown) is mounted (directly or indirectly) to the lever 11. The center of the ring gear section 26 coincides with the rotation axis 12 so that when the lever 11 is pivoted, the ring gear section rotates about the rotation axis 12. A transmission wheel or gear 27 meshes with the internal teeth of the ring gear section 26 and is thus rotated about the second rotational axis 28. Second rotational axis 28 is stationary, so that the transmission wheel 27 rotates as indicated by the arrow in Fig. 2. Braking element 21 acts on the transmission wheel 27 to apply a braking torque to the transmission wheel 27. The skilled person will readily appreciate that such braking torque applied to the transmission wheel 27 is translated into a larger torque applied to the lever 11 by the transmission mechanism 25.

[0057] In the example of Fig. 2, the transmission wheel 27 is set so that the range of movement of lever 11 is symmetric in either direction. The transmission wheel 27 may also be arranged at a different position (i.e., an angular offset about rotation axis 12) so that an asymmetric operating range of lever 11 is obtained.

[0058] Transmission mechanism 25 is optional, and the active device may directly apply the required torque to lever 11. Further, transmission mechanism 25 may be implemented in different ways, such as by providing a linkage on lever 11 which actuates a lever arm to which a braking force is applied (which the transmission mechanism translates into the required braking torque). The skilled person will appreciate that a plurality of possibilities of implementing a respective transmission mechanism exist. The example of Fig. 2 achieves a improved compactness of the operating element 10 while being mechanically simple.

[0059] Although not shown, the controller 50 and the sensor 40 may also be present in the embodiment of Fig. 2 in order to actively control the braking torque applied by the active braking device 20. The above explanations apply correspondingly. The controller may in particular provide a control signal to the braking element 21 in order to control the braking torque (or force) applied by the braking element 21.

[0060] Fig. 3 is a diagram that schematically illustrates examples of restoring torque and braking torque that may be applied by the restoring device 30 and the braking device 20. In the example of Fig. 3, the braking device 20 is the active device, and respective torque characteristics may be implemented in the embodiments of Figs. 1 and 2 and any variations thereof. The horizontal axis of the diagram of Fig. 3 illustrates the pivoting angle of lever 11 in degrees and the vertical axis illustrates the torque (either restoring or braking torque) in arbitrary units. It should be clear that the actual torque values will be adapted in accordance with the particular application, such as lever size and mechanical configuration of the restoring/braking devices.

[0061] Curve 65 illustrates an exemplary torque characteristic of a restoring torque of a passive restoring device, for example of one or two springs (torsion springs) in the example of Fig. 2. The restoring torque acts in the direction towards the equilibrium position (at 0 degrees in the present example) and needs to be overcome when moving the lever out of the equilibrium position. Although it might have been drawn as a positive torque in one direction of actuation and a negative torque in the other direction of actuation, as they act in opposite directions, the restoring torque is only shown as positive values in Fig. 3 for the sake of simplicity.

[0062] Curves 61, 62, and 63 illustrate three different torque characteristics for the braking torque. Each corresponds to a different mode of operation of the operating element 10. Controller 50 may implement one, two, or all three of these torque characteristics, i.e. may implement the respective operating modes.

[0063] Torque characteristic 61 has a locked position 72 (or latched position). When the lever 11 is moved into this position, it will remain in this position until the user moves the lever back. To implement such locked position, the braking torque characteristic 61 comprises an intermediate position 71 at which the braking torque 61 exceeds the restoring torque 65. Consequently, if the lever is moved beyond the intermediate position 71, the restoring torque is not sufficiently large to overcome the braking torque, so that the lever remains at the locked position 72. In the present example, the lever 11 is movable between an end stop at -30 degrees and an end stop at +30 degrees. The locked position 72 is thus between the intermediate position 71 and the respective end stop. At the locked position 72, the brake torque is similar to the restoring torque, which defines the locked position (at the position where the curve 61 intersects curve 65). This is however optional and the braking torque 61 may as well remain above the restoring torque 65 at the locked position. Further, curve 61 comprises a respective locked position towards either side of the lever movement. It should be clear that the torque characteristic may not be symmetric and that such locked position may only be provided on one side. In other implementations, the lever may be movable only in one direction. An operating mode of operating element 10 using the braking torque characteristic 61 may for example control a hydraulic function of the mobile machine, for which purpose it may be useful to lock the lever at such locking position.

[0064] A torque characteristic of the braking torque may also comprise plural respective locking positions (and thus corresponding plural intermediate positions 71 at which the braking torque is above the restoring torque). When operating in an operating mode comprising such torque characteristic, the user may accordingly bring the lever 11 into different locked positions, wherein each locked position may correspond to a different setting of an operating parameter, a different position of an actuator of the mobile machine, or the like.

[0065] The braking torque characteristic 62 comprises a global maximum 81 of the braking torque that lies below the restoring torque 65 at the respective lever position. Accordingly, when the user pivots the lever 11, the user will experience a resistance at the maximum 81 of the braking torque (pressure point) which needs to be overcome. The user thus obtains tactile feedback when a particular position of the lever has been reached. Such position may correspond to the activation of a function of the mobile machine. An application is for example the change of a driving direction of the mobile machine. Upon releasing the lever, the lever will return to the equilibrium position at 0 degrees, since the restoring torque is larger than the braking torque. Pushing the lever in one direction and overcoming the pressure point 81 may set the mobile machine into a forward driving mode and pushing the lever in the other direction and overcoming the pressure point 81 may set the mobile machine into a rearward driving mode.

[0066] The torque characteristic 63 includes plural respective pressure points 91 that are local maxima of the braking torque and that are smaller than the restoring torque 65 at the respective lever positions. When moving the lever, the user thus repeatedly needs to overcome respective resistances. Feedback may thus be provided to the user on the lever position. Such operating mode may be useful for controlling a parameter, which may be incremented by a predetermined amount each time that a respective pressure point is overcome. Functional values of the mobile machine may thereby be adjusted, the position of an actuator may be controlled accurately, or the like.

[0067] The above are only examples of respective torque characteristics, and the torque characteristics may be varied in any desired way in accordance with the respective application and the desired functionality. The torque characteristic may provide a different torque for the different directions in which the lever can be moved from the equilibrium position. Also, a torque characteristic may be different in dependence on the direction of movement of the lever. For example, if the lever is released by the user after passing one or more pressure points, the braking torque may be removed so that the lever quickly returns to the equilibrium position.

[0068] Furthermore, the active device (braking device 20 or restoring device 30) may apply a torque to move lever 11 to a desired position. Braking element 21 may be implemented as an electric motor, and the motor may be controlled to apply a "negative" braking torque to move the lever to a desired position. An initial position may thus be adjusted, or the lever may take a position that corresponds to a function setting controlled by remote control.

[0069] Fig. 4 shows a flow diagram of a method of controlling the operating element 10. In step S10, an operating mode is selected for the operating element

10. By such selection, a function of the mobile machine may be assigned to the operating element and may be controlled by the operating element. Further, a torque characteristic associated with the operating mode may be obtained, e.g. from memory 52. In step S11, the user actuates the operating element, for example by pivoting lever 11. In step S12, the application of torque to the lever 11 by the respective active device (in particular the braking device 20) is controlled in accordance with the torque characteristic that corresponds to the selected operating mode. For the braking device 20, such torque characteristic may for example correspond to one of the torque characteristics 61, 62, 63 of Fig. 3, or any modification thereof. An intuitive and accurate control of the function of the mobile machine is thereby achieved.

[0070] While specific embodiments are disclosed herein, various changes and modifications can be made without departing from the scope of the invention. The present embodiments are to be considered in all respects as illustrative and non-restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

List of reference signs

[0071]

10	operating element
11	lever
12	rotation axis
15	handle
20	braking device
21	braking element
25	transmission mechanism
26	ring gear section
27	transmission wheel
28	second rotation axis
30	restoring device
40	position sensor
50	controller
51	processing unit
52	memory
60	torque characteristics
61-63	braking torque characteristic
65	restoring torque characteristic
71	intermediate position
72	locked position
81	pressure point
91	pressure point
S10-S12	method steps

Claims

1. An operating element for a machine, comprising:

   - a lever (11), wherein the lever (11) is pivotable about a rotation axis (12);
   - a restoring device (30) configured to apply a restoring torque to the lever (11); and
   - a braking device (20) configured to apply a braking torque to the lever (11), the braking torque providing a resistance to a pivoting of the lever (11) about the rotation axis (12),

   wherein the braking device (20) and/or the restoring device (30) is an active device that is configured to be controllable to actively change the applied braking torque and/or the applied restoring torque, respectively.

2. The operating element according to claim 1, wherein the active device is configured to cause the actively applied torque to change during pivoting of the lever (11).

3. The operating element according to claim 1 or 2, further comprising a controller (50) coupled to the active device (20; 30), wherein the controller (50) is configured to operate the operating element (10) in one, two, or more operating modes, wherein in each operating mode, the controller (50) actively controls the active device (20; 30) to apply the respective torque in accordance with a respective torque characteristic (60).

4. The operating element according to claim 3, wherein the torque characteristics (60) of different operating modes differ by the torque applied by the active device (20; 30) at one or more of the same pivotal positions of the lever (11).

5. The operating element according to claim 3 or 4, wherein the one, two or more operating modes include an operating mode having a torque characteristic (61) that includes a locked position (72) of the lever (11) and an intermediate position (71) of the lever (11) located between an initial position of the lever and the locked position (72) of the lever (11), wherein at the intermediate position (71), the braking torque exceeds the restoring torque.

6. The operating element according to any of claims 3-5, wherein the one, two or more operating modes include an operating mode having a torque characteristic (62, 63) that includes a pressure point (81, 91) at a pivotal position of the lever (11) at which the braking torque is below the restoring torque and at which the braking torque has a local or global maximum.

7. The operating element according to claim 6, wherein the one, two or more operating modes include an operating mode having a torque characteristic (62) that includes one pressure point (81) between an initial position of the lever (11) and an end stop position of the lever (11), preferably one pressure

point (81) between the initial position and each end stop position of the lever (11).

8. The operating element according to claim 6 or 7, wherein the one, two or more operating modes include an operating mode having a torque characteristic (63) that comprises two or more pressure points (91) between an initial position of the lever (11) and an end stop position of the lever (11), preferably two or more pressure points (91) between the initial position and each end stop position of the lever (11).

9. The operating element according to any of the preceding claims, wherein the active device (20; 30) is configured to be controllable to actively move the lever (11).

10. The operating element according to any of the preceding claims, wherein the active device (20; 30) comprises a transmission mechanism (25) that converts a smaller torque or force into a larger torque applied by the active device (20; 30) to the lever (11).

11. The operating element according to claim 10, wherein the transmission mechanism (25) is configured to transmit a pivoting of the lever (11) to a rotation of a transmission wheel (27), wherein an active element (21) of the active device (20) is controllable to apply a force or torque to the transmission wheel (27) to brake or drive the transmission wheel (27).

12. The operating element according to claim 11, wherein the transmission mechanism (25) comprises an internal ring gear section (26) mounted to the lever (11) and meshing with the transmission wheel (27).

13. The operating element according to any of the preceding claims, wherein the active device (20; 30) includes an active element (21), the active element being at least one of a magnetic braking element, a magnetorheological fluid, MRF, braking element, an electric motor, a mechanical braking element, and a hydraulic active element.

14. The operating element according to any of the preceding claims, further comprising a position sensor (40) configured to detect a pivotal position of the lever (11), the operating element (10) being configured to control the active device (20; 30) in dependence on a detected pivotal position of the lever (11).

15. A method of controlling an operating element (10) of a machine, wherein the operating element (10) comprises a lever (11) that is pivotable about a rotation axis (12), a restoring device (30) for applying a restoring torque to the lever (11), and a braking device (20) for applying a braking torque to the lever (11), the braking torque providing a resistance to a pivoting of the lever (11) about the rotation axis (12), wherein the braking device (20) and/or the restoring device (30) is an active device, wherein the method comprises:

- controlling the active device to actively change the braking torque and/or the restoring torque applied by the braking device (20) and/or by the restoring device (30), respectively.

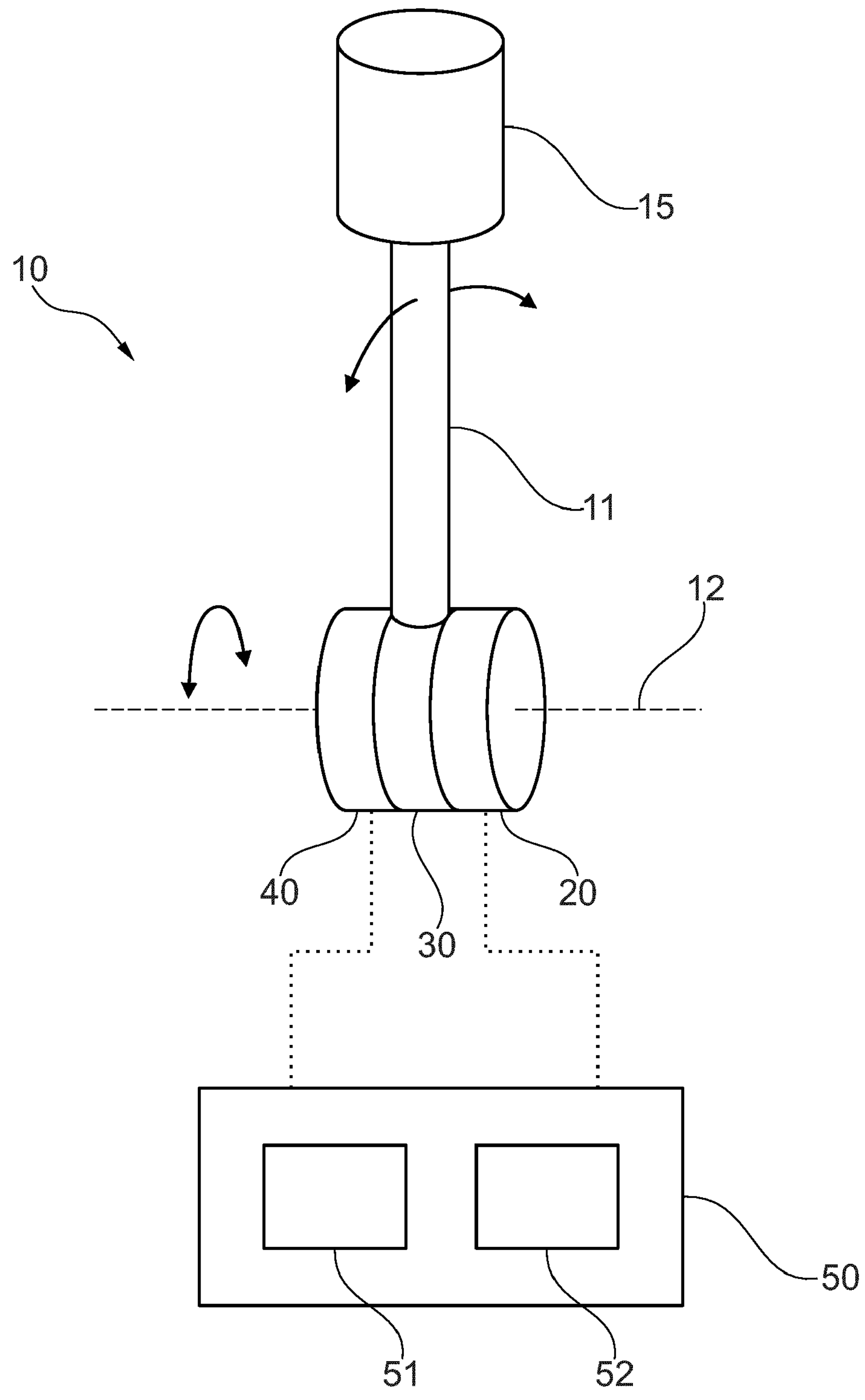

Fig. 1

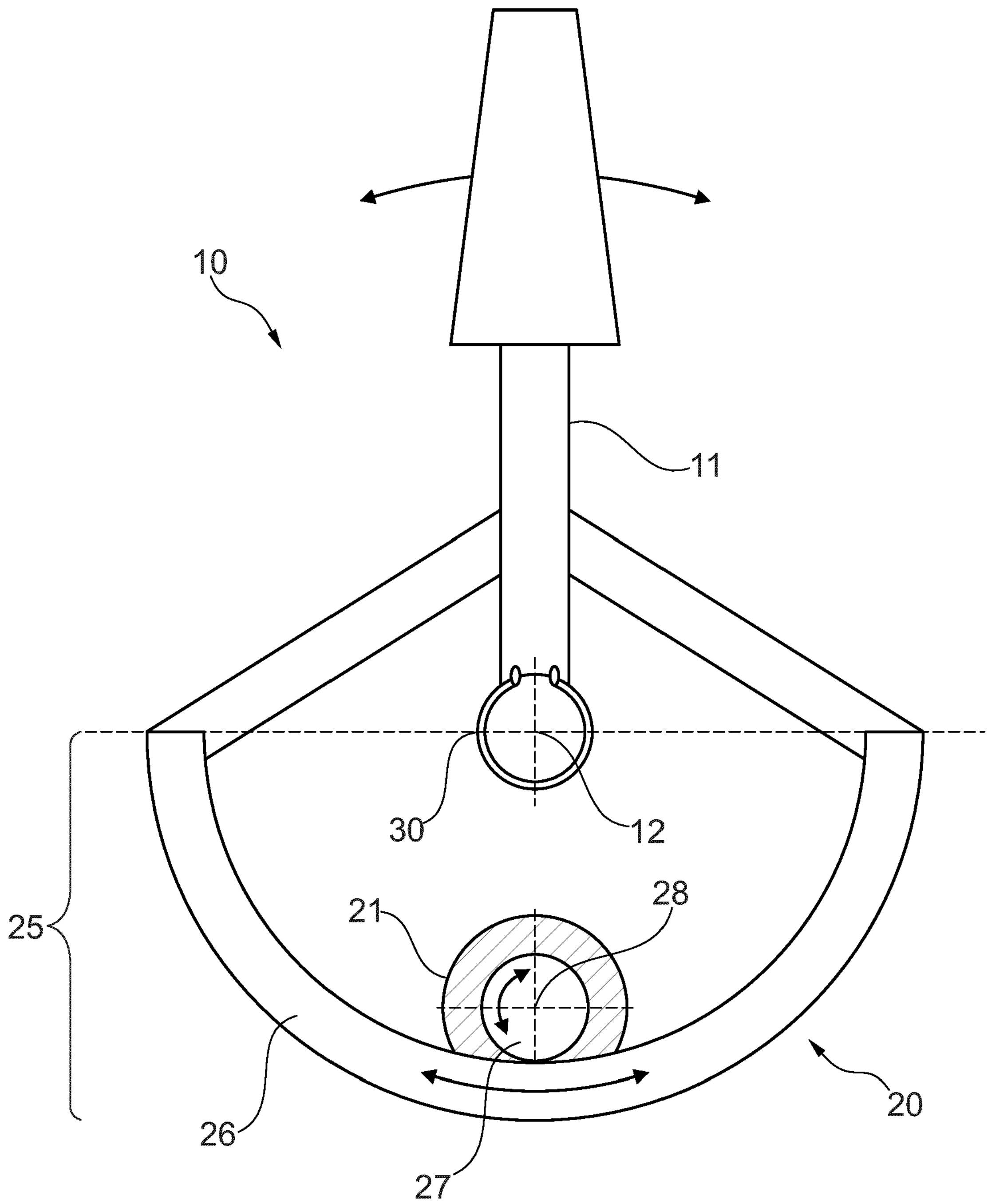

Fig. 2

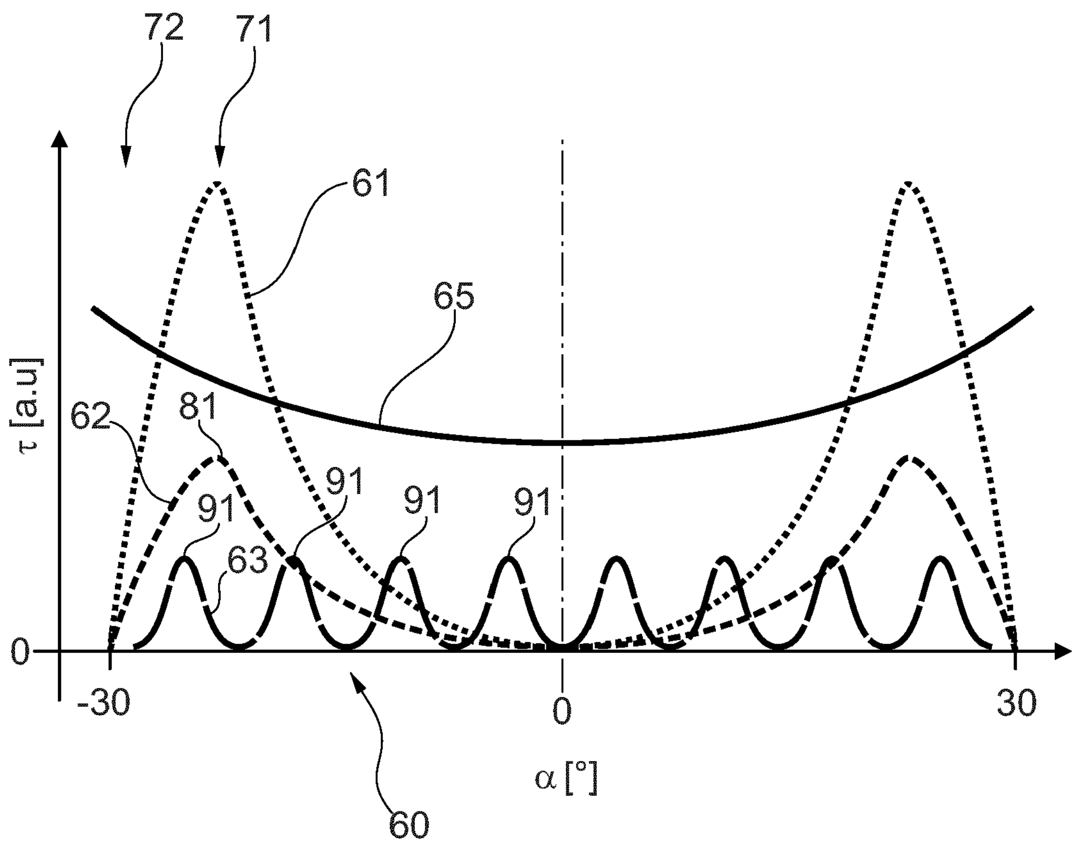

Fig. 3

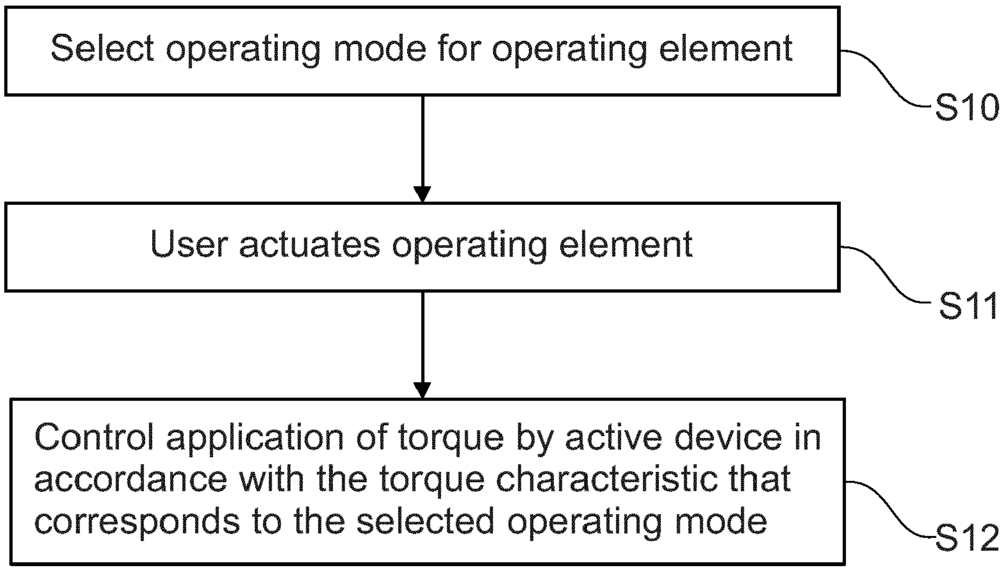
Select operating mode for operating element
S10
User actuates operating element
S11
Control application of torque by active device in accordance with the torque characteristic that corresponds to the selected operating mode
S12

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 8520

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			G05G

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	22 April 2024	Huyge, Kevin

CATEGORY OF CITED DOCUMENTS

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