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(54) ROTARY ACTUATOR ASSEMBLY

(57) A rotary actuator assembly comprises a knob and an electric motor for providing a haptic effect at the knob and/or for driving the knob. The electric motor comprises a shaft, a gear assembly rotationally coupling the knob to the shaft of the electric motor, the gear assembly including a rotary oil damper damping the rotation of the knob. The rotary actuator assembly further comprises an optical rotation detection device for detecting direction, speed and/or angle of rotation of the knob and/or of the electric motor, wherein the optical rotation detection device is detecting the rotation of an element on the shaft.

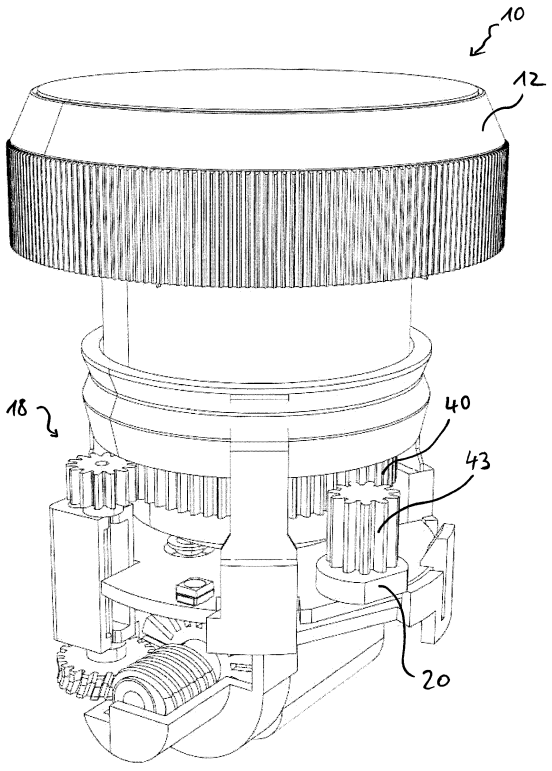

Fig. 2

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Description

[0001] The present invention refers to a rotary actuator assembly comprising a knob and an electric motor for providing a haptic effect at the knob and/or for driving the knob.

[0002] Such a rotary actuator assembly is, for example, used in cars for control of an infotainment system, such as a navigation/radio-combination.

[0003] A possible method for providing a haptic effect at a knob of a rotary actuator assembly includes the use of an electromagnetic brake, which allows only for creating a force in a direction opposite to an activation force. This resembles a small and simple solution.

[0004] Another possibility is to provide the haptic effect by an electric motor, such as a DC motor. This solution allows for providing a force in both rotational directions. However, it generally requires a relatively large and heavy motor to create enough torque to achieve the desired feel.

[0005] Both solutions require information about direction, speed and/or angel of rotation. This information can be obtained, for example, by means of an incremental encoder. Control of the haptics of the actuator can be based on the information from the encoder and a software defining a desired haptic characteristic.

[0006] It is an object of the invention to provide an improved rotary actuator assembly, in particular as regards the feel at the knob.

[0007] This object is achieved by a rotary actuator assembly in accordance with claim 1. The rotary actuator assembly comprises a knob and an electric motor for providing a haptic effect at the knob and/or for driving the knob The electric motor comprises a shaft, and a gear assembly rotationally coupling the knob to the shaft of the electric motor. The gear assembly includes a rotary oil damper damping the rotation of the knob and an optical rotation detection device for detecting direction, speed and/or angle of rotation of the knob and/or of the electric motor. The optical rotation detection device is detecting the rotation of an element on the shaft.

[0008] The desired feel at the knob is implemented by means of the electric motor which can be controlled by software. Signals from the rotation detection device can be transmitted to a control unit, such as a microcontroller, and used by a software of the control unit to generate a characteristic, in particular DC, power supply for the electric motor in order to generate the desired haptics at the knob. The haptics can be described as a torque as function of displacement. Other possible sensors for detecting rotation may include magnetic sensors or other types of incremental rotational sensors.

[0009] In particular, the shaft of the electric motor may be linked to the knob by the gear assembly. Other possibilities for driving the knob include e.g. a timing belt, a rope drive or rubber rolls.

[0010] The gear assembly allows for a speed reduction from the electric motor to the knob. Thereby, the applicable torque at the knob can be increased such that a relatively small motor can be used. This leads to an advantageous packaging of the assembly and, thus, only a smaller available space for the assembly is necessary. The gear ratio can be adjusted to modify the haptics at the knob.

[0011] The rotary oil damper reduces free play feeling at the knob and improves the feel by smoothing the haptic characteristics at the knob. Further, the rotary oil damper keeps vibrations from the environment, such as from a car engine, away from the knob. This is especially useful when the electric motor is inactive, for example when it is not powered. Also, vibrations from the electric motor can be reduced at the knob.

[0012] Because the optical rotation detection device is detecting the rotation of an element on the shaft, the possibility of oscillation of the knob and/or the electric motor within the free play range is reduced. In the prior art, such oscillation is noticed by the user as vibration feel at the knob and additional noise. Particularly, the element on the shaft can be connected to the shaft such that the connection is free of play. Control of the electric motor can be improved if the control loop between the optical rotation detection device and a control unit is free of play.

[0013] The rotary actuator assembly of the invention generally provides for a reduction of free play in the gear box assembly and at the knob, thus facilitating motor control and improving the feel at the knob.

[0014] According to a further advantageous embodiment, the shaft is perpendicular to a rotational axis of the knob. This further facilitates accommodating of the electric motor within the rotary actuator assembly, in particular below the knob and/or intersecting the rotational axis of the knob.

[0015] A particularly simple optical rotation detection device comprises a light gate and a plurality of light barriers.

[0016] Advantageously, the light barriers are defined by the element on the shaft. Therefore, no wiring needs to be connected to the rotating element on the shaft. In particular, the light gate may be fixed to a housing of the electric motor, of the gear assembly or of the rotary actuator assembly. The light barriers are preferably implemented as teeth of the element on the shaft that extend radially outwardly.

[0017] According to a further embodiment, the gear assembly comprises a worm gear assembly that includes a worm gear and a worm. The worm gear assembly implements a high gear ratio and reduces free play within the gear assembly. Furthermore, an arrangement of the electric motor is allowed which is perpendicular to the rotational axis. Thus, a high flexibility in the arrangement of the electric motor within the rotary actuator assembly is achieved, in particular without the need for additional mechanical components.

[0018] Preferably, the element on the shaft is the worm in order to provide a reduced speed at the knob relative to the electric motor. In particular, the worm can be inte-

grally formed with an element of which the optical rotation device is detecting the rotation, such as an element defining light barriers.

[0019] According to a further embodiment, the gear assembly comprises a spur gear assembly that includes a first spur gear and a second spur gear. The spur gear assembly can further facilitate packaging, e.g. by coupling the knob to a worm gear assembly.

[0020] The first spur gear can advantageously be fixed to the knob. In particular, the first spur gear can be defined by a ring element at least partly encompassing an element of the knob, such as a knob shaft.

[0021] The second spur gear can be connected to the worm gear by means of a gear shaft. Thereby, the rotational movement can advantageously be transferred and such shaft generally requires only limited space within the assembly. The gear shaft is preferably arranged parallel to the rotational axis of the knob in order to keep the transverse dimensions of the rotary actuator assembly small.

[0022] According to a further embodiment, the rotary oil damper comprises a plurality of rotor paddles and an oil reservoir, wherein the plurality of rotor blades is connected to the gear shaft. This resembles a simple arrangement effectively damping the knob such that play at the knob is greatly reduced. The rotary oil damper can preferably be arranged at least partly within the second spur gear such that the space therein is advantageously utilized.

[0023] In the following, the invention is exemplarily further described with reference to the Figures.

Fig. 1 shows a rotary actuator assembly in accordance with the invention in a sectional view.

Fig. 2 shows the rotary actuator assembly of Fig. 1 in a complete isometric view.

Fig. 3 shows an exemplary torque curve at a knob of a rotary actuator assembly.

[0024] In Fig. 1 a rotary actuator assembly 10 is shown that includes a knob 12 and an electric motor 14 for providing a haptic effect at the knob and for driving the knob. The knob 12 is coupled to the electric motor 14 by means of a gear assembly 18.

[0025] The electric motor 14, which preferably is a DC motor, comprises a shaft 16. On the shaft 16 a worm 36 of a worm gear assembly 32 is positioned. The worm 36 is integrally formed with a chopper wheel 24 that is positioned on the shaft 16 together with the worm 36. The chopper wheel 24 defines sprockets 30 that function as light barriers for an optical rotation detection device 22 and that are shaped as teeth of the chopper wheel 24 extending radially outwardly. The sprockets 30 rotate together with the element 24 and the shaft 16 such that they alternatingly break a light path of a light gate 28 of the optical rotation detection device 22. Thereby, an optical incremental sensor is implemented. The information from the optical rotation detection device 22 is used in the control of the electric motor 14.

[0026] The element 24 on the shaft 16 comprises a worm 36 of a worm gear assembly 32, the worm 36 engaging with a worm gear 34 to transmit torque from the electric motor. The light barriers 30 and the worm 36 are formed integrally with the element 24 on the shaft 16.

[0027] Beside the worm gear assembly 32 the gear assembly 28 comprises a spur gear assembly 38 including a first spur gear 40 and a second spur gear 42. The second spur gear 42 is connected to the worm gear 34 of the worm gear assembly 32 by means of a gear shaft 44. The first spur gear 40 is connected to the knob 12 and rotates together with the knob 12.

[0028] The knob 12 is able to rotate around a rotational axis 26 that is a vertical axis in Fig. 1. The second spur gear 42, the gear shaft 44 and the worm gear 34 rotate together around a gear shaft axis that is parallel to the rotational axis 26 of the knob 12. The worm gear assembly 32 translates the rotational movement of the gear shaft 44 into a rotation around an axis of the shaft 16 of the electric motor 14, the axis of the shaft 16 being perpendicular to the rotational axis 26 of the knob 12. As can be seen from Fig. 1, this arrangement provides for an advantageous packaging and the electric motor 14 can be located under the knob 12 in a compact manner.

[0029] In Fig. 2 the rotary actuator assembly 10 of Fig. 1 is shown, which comprises a rotary oil damper 20. The rotary oil damper 20 includes a plurality of rotor paddles rotating in an oil reservoir (both not shown), wherein the paddles are connected to a third spur gear 43 that engages with the first spur gear 40 in order to damp the rotation of the knob 12.The rotary oil damper 20 reduces free play of the gear assembly 18 and, therefore, improves the feel at the knob 12.

[0030] In Fig. 3 an exemplary characteristic of torque 50, e.g. of knob 12 of the rotary actuator assembly 10 of Fig. 1 is qualitatively shown as a function of rotational displacement of shaft 16. The torque 50 resembles the feel at the knob 12. Peaks of the torque 50 can be adjusted in a range 56 between a maximum peak torque 52 and a minimum peak torque 54. The exemplary characteristic of torque 50 also includes a negative peak of the torque 50, which comprises a negative torque value, i.e. the torque acts in the same direction as a user. Thereby, the knob can be actively moved into a predefined resting position. The negative peak of the torque 50 can be adjusted for example within ranges 58 (torque) and 60 (rotational displacement). These adjustments are to a large extent freely programmable in a control unit (not shown) for an electric motor of a rotary actuator assembly.

List of References

[0031]

10 rotary knob assembly
12 knob
14 electric motor
16 shaft
18 gear assembly
20 rotary oil damper
22 optical rotation detection device
24 chopper wheel
26 rotational axis of the knob
28 light gate
30 light barrier
32 worm gear assembly
34 worm gear
36 worm
38 spur gear assembly
40 first spur gear
42 second spur gear
43 third spur gear
44 gear shaft
50 torque
52 maximum peak torque
54 minimum peak torque
56 range
58 range
60 range

Claims

1. A rotary actuator assembly (10) comprising:

a knob (12);
an electric motor (14) for providing a haptic effect at the knob (12) and/or for driving the knob (12), the electric motor (14) comprising a shaft (16);
a gear assembly (18) rotationally coupling the knob (12) to the shaft (16) of the electric motor (14), the gear assembly (18) including a rotary oil damper (20) damping the rotation of the knob (12);
an optical rotation detection device (22) for detecting direction, speed and/or angle of rotation of the knob (12) and/or of the electric motor (14);
wherein the optical rotation detection device (22) is detecting the rotation of an element (24, 36) on the shaft (16).

2. A rotary actuator assembly (10) in accordance with claim 1,
wherein the shaft (16) is perpendicular to a rotational axis (26) of the knob (12).

3. A rotary actuator assembly (10) in accordance with claim 1 or 2,
wherein the optical rotation detection device (22) comprises a light gate (28) and a plurality of light barriers (30).

4. A rotary actuator assembly (10) in accordance with claim 3,
wherein the light barriers (30) are defined by the element (24) on the shaft (16).

5. A rotary actuator assembly (10) in accordance with any of the preceding claims,
wherein the gear assembly (18) comprises a worm gear assembly (32) that includes a worm gear (34) and a worm (36).

6. A rotary actuator assembly (10) in accordance with claim 5,
wherein the element on the shaft (16) is the worm (36) of the worm gear assembly (32), in particular wherein the worm (36) is integrally formed with an element (24) defining the light barriers (30).

7. A rotary actuator assembly (10) in accordance with any of the preceding claims,
wherein the gear assembly (18) comprises a spur gear assembly (38) that includes a first spur gear (40) and a second spur gear (42).

8. A rotary actuator assembly (10) in accordance with claim 7,
wherein the first spur gear (40) is fixed to the knob (12).

9. A rotary actuator assembly (10) in accordance with claim 7 or 8,
wherein the second spur gear (40) is connected to the worm gear (34) by means of a gear shaft (44).

10. A rotary actuator assembly (10) in accordance with any of the preceding claims,
wherein the rotary oil damper (20) comprises a plurality of rotor paddles and an oil reservoir.

11. A rotary actuator assembly (10) in accordance with claim 10,
wherein the plurality of rotor paddles is connected to a third spur gear (43) which engages with a first spur gear (40) connected to the knob (12).

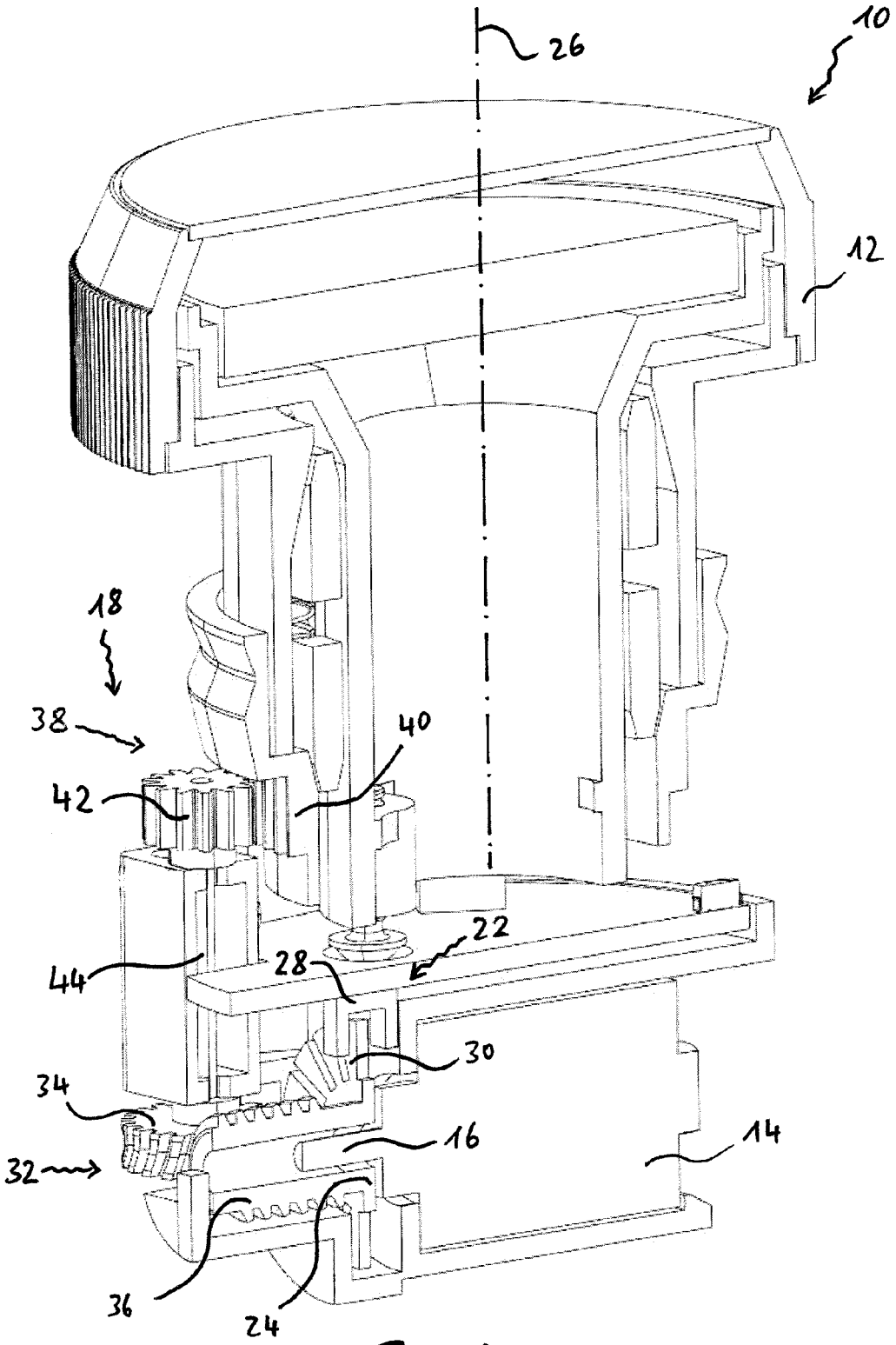

Fig. 1

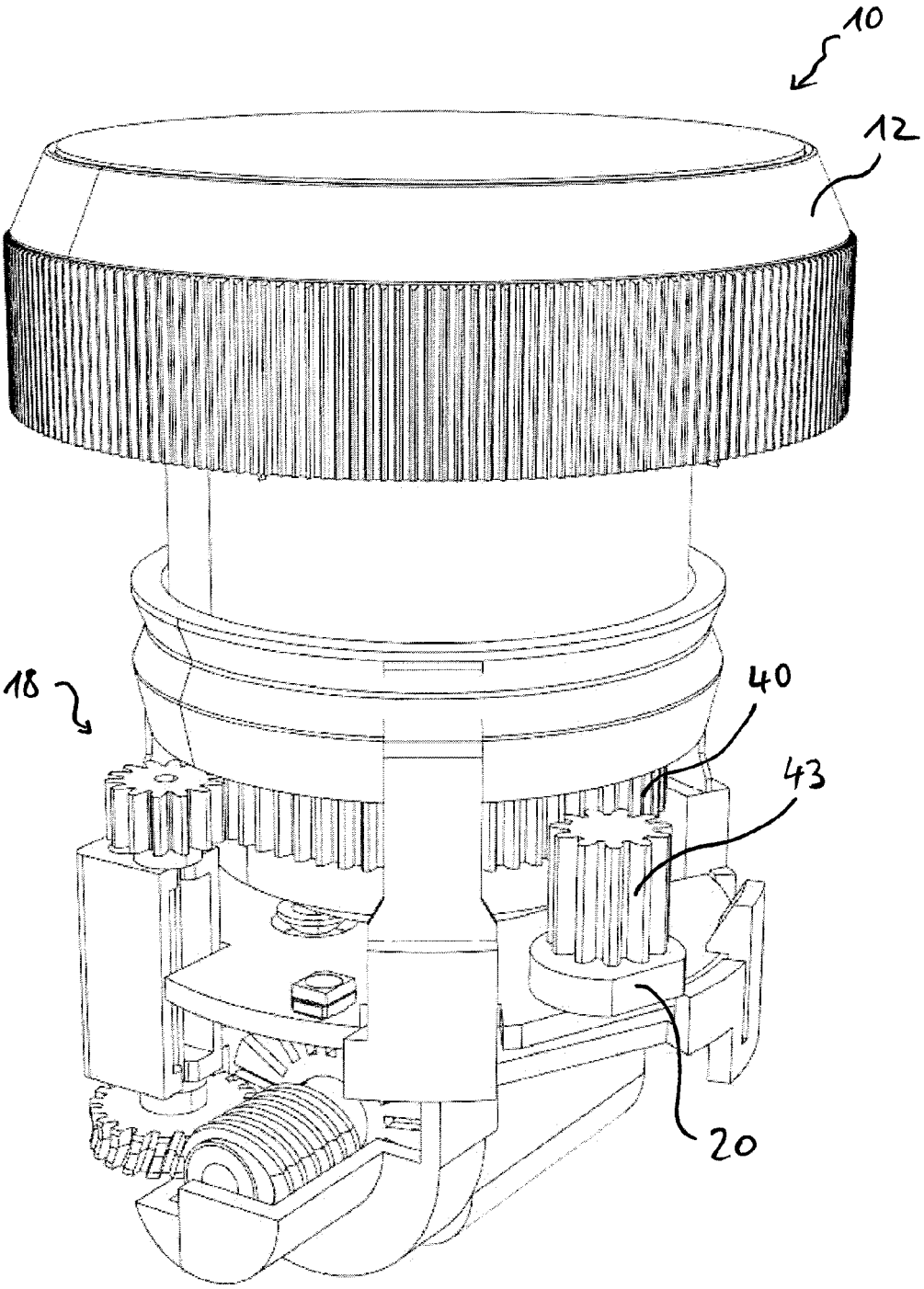

Fig. 2

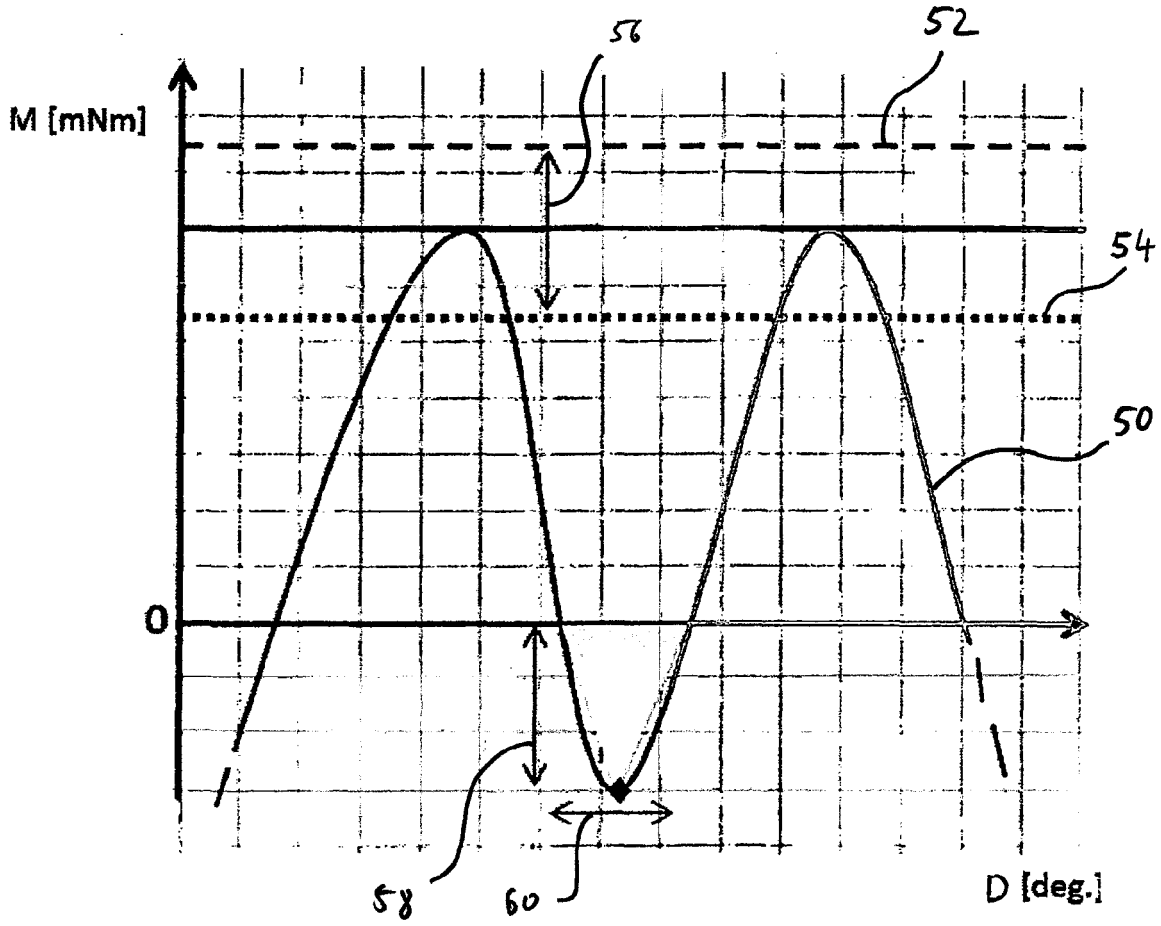

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 15 18 5537

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 May 2016	de Beurs, Marco

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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