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(71) Applicant(s)
SEW Eurodrive GmbH & Co KG

(72) Inventor(s)
BANASIK, Lech

(74) Agent / Attorney
Griffith Hack, Level 15, 376-390 Collins Street, Melbourne, VIC, 3000, AU

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(71) **Anmelder: SEW-EURODRIVE GMBH & CO. KG** [DE/DE]; Ernst-Blickle-Str. 42, 76646 Bruchsal (DE).

(72) **Erfinder: BANASIK, Lech**; 54 Eilizabeth Street, 3187 Brighton East (AU).

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(54) **Title:** DRIVE AND METHOD FOR OPERATING A DRIVE

(54) **Bezeichnung:** ANTRIEB UND VERFAHREN ZUM BETREIBEN EINES ANTRIEBS

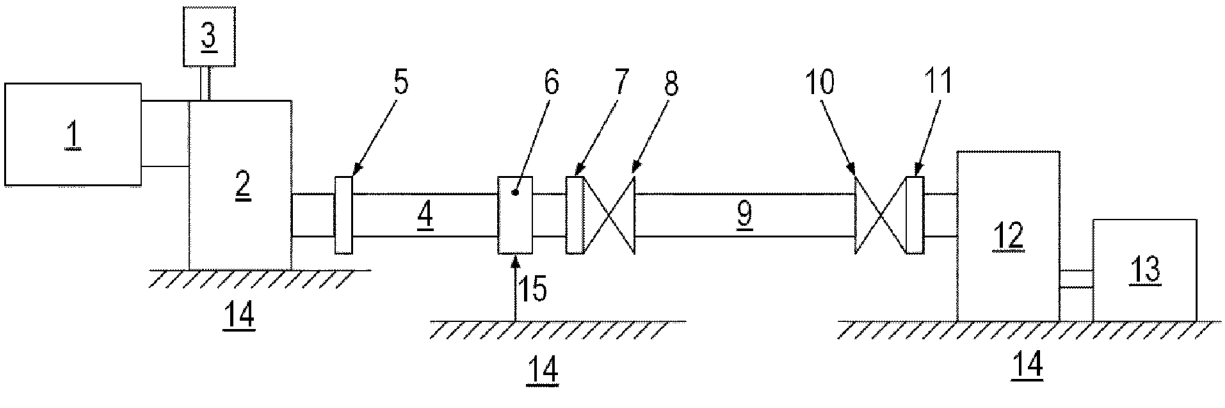

Fig. 1

(57) **Abstract:** The invention relates to a drive and a method for operating a drive, comprising an electric motor and a first gearbox that can be driven by the electric motor, wherein an output shaft of the first gearbox is connected to a first shaft in a rotationally fixed manner by means of a coupling, in particular a rigid shaft coupling, wherein the first shaft is supported by an, in particular single axial bearing that can be loaded with a force by at least one controllable first linear actuator.

(57) **Zusammenfassung:** Antrieb und Verfahren zum Betreiben eines Antriebs, aufweisend einen Elektromotor und ein erstes Getriebe, das von dem Elektromotor antreibbar ist, wobei eine abtreibende Welle des ersten Getriebes mittels einer Kupplung, insbesondere starren Wellenkupplung, mit einer ersten Welle drehfest verbunden ist, wobei die erste Welle mittels eines, insbesondere einzigen, Axiallagers gelagert ist, welches von zumindest einem steuerbaren ersten Linearaktor mit einer Kraft beaufschlagbar ist.

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Drive and Method for Operating a Drive

Technical Field

The invention relates to a drive and to a method for operating a drive.

Background Art

It is generally known that a gearbox can be driven by an electric motor.

A loading device known from DE 10 2010 017 456 A1.

A drive device for an extruder is known from US 2005 / 0 063 245 A1.

A mixer is known from DE 10 03 541 U.

A bearing and lubricant tester is known from US 2 623 384 A.

A device for testing a gearbox for lubricant loss is known from CN 107 687 946 A.

There is a need to increase safety in a drive.

It is to be understood that, if any prior art is referred to herein, such reference does not constitute an admission that the prior art forms a part of the common general knowledge in the art, in Australia or any other country.

Summary

In a first aspect, the invention provides a drive comprising an electric motor and a first gearbox, the first gear box configured to be driven by the electric motor, and an output shaft of the first gearbox rotatably connected to a first shaft by a coupling, the first shaft mounted on an axial bearing, and configured to be subjected to a force by at least one linear actuator, the first gearbox having an interior filled with oil and connected to an expansion tank, the expansion tank comprising an inner space formed from two subregions, the two subregions separated from one another by a membrane, a first of the two subregions connected to the interior of the first gearbox via an oil line, the second of

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the two subregions of the expansion tank connected to the environment, wherein thermally caused expansion of the oil in the interior of the first gearbox is received in the expansion tank.

The drive may increase safety.

In some embodiments, the axial bearing may be a single axial bearing.

It can be advantageous here that an axial bearing is provided for the first shaft. Thus, an axial force can be assumed by the axial bearing. The first linear actuator can thus be arranged such that it is supported on the base of an industrial plant, on which base the first gearbox is set up. Alternatively, a different indirect support of the first linear actuator on the housing of the first gearbox may be enabled or direct support of the linear actuator on the housing of the first gearbox may be enabled. The first gearbox may also be embodied with a further axial bearing that rotationally mounts the output shaft and is received in the housing of the first gearbox.

The output shaft can be subjected to a force by means of the linear actuator, so that the gearbox can be used as a test specimen, wherein the oil-tightness of the first gearbox can be checked under load, that is by applying transverse force. The first gearbox can be filled with oil, wherein the output shaft can be oriented horizontally. If the test is successful, that is once the test has been passed, the first gearbox can be removed and arranged rotated by 90˚, where it is driven by a further electric motor. This also does not require complete filling with oil, but rather only partial filling, wherein then, no expansion tank is present, either.

In the present disclosure, it is significant that the output shaft is rotatably connected to a first shaft, that is, a shaft mounted outside of the first gearbox. Thus it is made possible for the bearing, that is, in particular the outer ring of the axial bearing, to be subjected to a force that is thus then supplied to the first shaft via this axial bearing. In this way the first gearbox may be loaded with a force similar to that which may also be provided in a later application for which the first gearbox is provided.

If the testing of the gearbox is passed, that is, if the gearbox has withstood the load undamaged and with no oil leak, the gearbox may be removed and employed in the application. In doing so, the spatial orientation of the gearbox can be rotated 90°. For example, where the first gearbox is employed in a mixer application, in particular in a stirrer, wherein the output shaft is oriented vertically. It is preferable that oil does not exit from the gearbox. To reduce the mass of the first gearbox, the first

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gearbox may be filled only partially with oil in some embodiments. In such embodiments, the oil level may only be high enough for the bearing and the toothed parts engaged with one another to be at least partially lubricated, that is, in particular the engagement region is below the oil level.

In some embodiments, the first shaft may be connected, in particular connected rotation-fast, to a generator unit via a cardan shaft, in particular by means of cardan joints. in some embodiments the generator unit is a generator or a generator that can be driven via a second gear box. It may be advantageous here that the amount of energy introduced by the electric motor when driving the first gearbox is largely recoverable. In addition, the recovered power can be controlled in broad limits with the generator unit.

In some embodiments, the first shaft may be connected, in particular rotation-fast, at an end region facing away from the first gearbox, using a coupling, in particular a rigid coupling, to a first cardan joint that at a side of the first cardan joint facing away from the first shaft is connected, in particular rotation-fast, to a or the cardan shaft. The cardan shaft may be connected, in particular rotation-fast, at a side facing away from the first shaft, to a second cardan joint, such that at a side of the second cardan joint facing away from the cardan shaft is connected rotation-fast by means of a coupling, in particular a rigid coupling, to the drive shaft of the generator unit, via a second gearbox of the generator unit. It may be advantageous here that the transverse deflections of the first shaft caused by the force can be compensated via the cardan joint, so that the generator unit can be driven unchanged.

In some embodiments, the expansion tank may be filled, in particular completely, with oil. Thermally caused expansion of the oil in the interior of the first gearbox can be received in the expansion tank. It may be advantageous here that the gearbox is completely filled with oil, but no change in pressure relative to the surroundings (i.e. the environment) can be effected when there is a change in temperature. Thus, any shaft seals of the first gearbox may be protected against overpressure.

Regarding the expansion tank, in some embodiments, in particular wherein the first subregion together with the inner space of the first gearbox is completely filled with oil, the inner space of the expansion tank, in particular the membrane, may be arranged in use higher in the direction of gravity than the inner space of the first gearbox. It may be advantageous here that the embodied membrane is flexible and thus the expansion of the oil through a modified surface can be effected without a significant increase in pressure. The membrane may be positioned, at least in part, against the modified surfaces.

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In some embodiments, a further axial bearing, in particular a thrust bearing, may be received in the housing of the first gearbox and the output shaft of the first gearbox may be rotationally mounted by means of the further axial bearing. The rotational axis of the output shaft may be oriented horizontally, that is, in particular perpendicular to the direction of gravity. It may be advantageous here that a force introduced into the gearbox via the output shaft can be compensated. Thus, the smooth functioning of the first gearbox can be checked by means of the force introduced via the first axial bearing.

In some embodiments, the output shaft of the first gearbox may be further rotationally mounted via two further bearings received in the housing of the first gearbox (i.e. not only via the further axial bearing, but also via the two further bearings received in the housing of the first gearbox). In particular wherein each of the two further bearings received in the housing of the first gearbox may be embodied as a twin row bearing. It may be advantageous here that the output shaft is rotationally mounted via the two further bearings and a high force load can be received via the further axial bearing. Thus it may be possible to provide reliable and robust functioning.

In some embodiments, the drive may be set up on a flat base surface of an industrial plant.

The rotational axis of the output shaft may be oriented perpendicular to the normal of a plane of the base surface. It may be advantageous here that the first gearbox is provided with a vertically oriented output shaft for some applications, in particular for a stirrer or in a mixer, but is oriented horizontally for testing the output shaft.

In some embodiments, the axial bearing can be subjected to a force, in particular a force oriented perpendicular to the force effected by the first linear actuator, by at least one controllable second linear actuator. It may be advantageous here that, as an overlaying of the two forces generated by the two linear actuators, a resulting force can be introduced into the first shaft, wherein the direction of the resulting force includes a non-vanishing angle to the horizontal direction and also to the vertical direction.

In some embodiments, the axial bearing can be subjected to a force by at least one controllable third linear actuator, in particular a force oriented perpendicular to the force effected by the first linear actuator and oriented perpendicular to the force effected by the second linear actuator. It may be advantageous here that even an axial component can be overlayed on the radial component

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generated by the first two linear actuators. Thus a load as similar as possible to the real load in the application can be applied.

In some embodiments, the first linear actuator may be controlled by a control with a time-variable first control signal, in particular a periodically variable first control signal, and the second linear actuator can be controlled by a control with a time-variable second control signal, in particular a periodically variable second control signal, in particular wherein the first and second control signals have the same frequency and have a 90° phase offset relative to one another. It may be advantageous here that a radially oriented force that occurs during stirring can be simulated. The direction of the force vector may be circumferential. Preferably the rotational speed of the output shaft may selected for the frequency. This is because a circumferential load that later occurs in the stirrer in the application when the frictional forces are as small as possible can be simulated at exactly this frequency. However, in order to also simulate the load when stirring with non-negligible frictional forces, a slip, that is, a deviation between the frequency and the rotational speed of the output shaft of the first gearbox, can be selected. In this case the frequency and the rotational speed of the output shaft may differ by a maximum of 40%. In this way the tilt of the electric motor driving the first gearbox, in particular a three-phase asynchronous motor, may also be adequately taken into account.

The drive comprises an electric motor and a first gearbox that can be driven by the electric motor.

The drive further comprises an output shaft of the first gearbox connected rotation-fast to a first shaft by means of a coupling, in particular a rigid shaft coupling.

The first shaft is mounted by means of an axial bearing, in particular a single axial bearing, that can be subjected to a force by at least one controllable first linear actuator.

The axial bearing may be subjected to a further force by at least one controllable second linear actuator. The output shaft defines a direction of a rotational axis.

The first gearbox is connected to an expansion tank comprising an inner space formed from two subregions, separated from one another by a membrane, a first of the subregions connected to the inner space of the first gearbox with an oil line, the second of the subregions connected to the environment, such that when an inner space of the first gearbox is filled with oil, thermally caused expansions of the oil in the inner space can be received in the expansion tank.

In a second aspect, the invention provides method for operating a drive, the drive comprising an electric motor and a first gearbox that can be driven by the electric motor and an output shaft of the first gearbox rotatably connected to a first shaft by means of a rigid shaft coupling, the first shaft mounted by means of a single axial bearing that can be subjected to a force by at least one controllable first linear actuator, the axial bearing can be subjected to a further force by at least one controllable second linear actuator, the output shaft defining a direction of a rotational axis, wherein the first gearbox is connected to an expansion tank comprising an inner space formed from two subregions, separated from one another by a membrane, a first of the subregions connected to an interior the first gearbox with an oil line, the second of the subregions connected to the environment, such that when the interior of the first gearbox is filled with oil, thermally caused expansion of the oil in the interior is received in the expansion tank, the method comprising a first method step wherein: the first linear actuator is controlled by a control with a periodically time-variable first control signal; and the second linear actuator is controlled by the control with a second periodically time-variable second control signal.

The method may comprise a first method step, wherein the first linear actuator is controlled by a control with a time-variable first control signal, in particular a periodically variable first control signal, and wherein the second linear actuator is controlled by the control with a time-variable second control signal, in particular a periodically variable second control signal.

In some embodiments, the first and second control signals may have the same frequency and have a 90° phase offset relative to one another, in particular wherein the rotational speed of the output shaft equals the frequency. It may be advantageous here that the load when employing the first gearbox in a stirrer can be simulated.

In some embodiments, the first and second control signals may have the same frequency, but the rotational speed of the output shaft differs from the frequency, in particular by up to 40%. In this way stirring with friction can be simulated and the testing can be carried out accordingly.

In some embodiments, in a second method step the first gearbox of the drive may be removed and then connected to a further electric motor.

In the second method step the direction of the rotational axis of the output shaft may be oriented perpendicular to the direction of the rotational axis of the output shaft in the first method step, in particular wherein in the second method step the output shaft of the first gearbox may be rotated 90˚, in particular in the vertical direction, that is, in particular parallel to the direction of gravity. It may be advantageous here that the testing of the first gearbox occurs rotated by 90˚ and thus the first gearbox provided for a mixer or stirrer application can be tested with an arrangement that can be constructed rapidly and simply.

In some embodiments, in the first method step the inner space of the first gearbox may be completely filled with oil and in the second method step the inner space of the first gearbox may only be partially filled with oil, (i.e. in particular not completely filled with oil), in particular wherein the further axial bearing and the two further bearings received in the housing of the first gearbox are arranged at least in part below the oil level. It may be advantageous here that during the testing, which is executed rotated by 90˚, the regions to be wetted with oil in the application are nevertheless wetted with oil. However, for this purpose the first gearbox is completely filled with oil during the testing and an expansion tank, which is not required in the application, is connected.

The drive employed by the method may be as otherwise described for the first aspect.

Further advantages may result from the subclaims. The invention is not limited to the combination of features of the claims. Further sensible potential combinations of claims and/or individual claim features and/or features of the description and/or of the figures are clear to the person skilled in the art, particularly from the object of the invention and/or the object presented by comparing with the prior art.

Brief Description of the Drawings

The invention shall now be explained in greater detail using schematic figures:

Figure 1 provides a schematic depiction of a test stand for introducing transverse force into the output shaft of a gearbox, in accordance with an embodiment of the invention.

Detailed Description

An electric motor 1 of the test stand drives a test specimen 2, in particular a gearbox. To this end the rotor shaft of the electric motor 1 is connected to the drive shaft of the test specimen 2 embodied as a gearbox.

The housing of the test specimen 2 and the housing of the electric motor 1 are connected to the base 14 of the industrial plant in which the test stand is set up.

Toothed parts having rotationally mounted shafts are arranged in the inner space surrounded by the housing of the test specimen 2 and are surrounded by oil, in particular lubricating oil. Since the gearbox used as test specimen 2 is provided for applications in which the output shaft is oriented vertically, that is, in particular for example when provided as a mixer gearbox, and in that application, at least partial filling of the inner space with oil is provided, the gearbox 2 is completely filled with oil for the testing on the test stand. This ensures that all regions to be wetted with oil in the application are also wetted with oil on the test stand during the testing. An expansion tank 3 is connected to the gearbox 2 so that, in the event of thermal expansion of the oil, the latter can flow into a volume preferably limited by a diaphragm. Or can flow out. To this end, the inner space of the gearbox 2 is connected to the inner space of the expansion tank 3 and the part of the inner space of the expansion tank 3 not filled with oil is connected to the surroundings. The expansion tank 3 is arranged higher than the gearbox, at least in part.

The output shaft of the gearbox 2 is connected by means of a first coupling 5, in particular a rigid shaft coupling, to a first shaft 4 arranged rotationally mounted via at least one axial bearing 6.

The axial bearing 6 has an inner ring, rolling elements, and an outer ring. The inner ring is placed over the first shaft 4. The inner ring is preferably connected to the first shaft 4 in a non-positive fit, in particular by means of a snug fit.

The outer ring is movable by a first linear actuator 15, in particular by a hydraulic actuator, transverse to the rotational axis of the first shaft 4, that is, also transverse to the rotational axis of the output shaft of the gearbox 2. The first linear actuator 15 is supported on the base 14.

Thus, by means of the first linear actuator 15, the first shaft 4 and therefore also the output shaft of the gearbox 2 can be subjected to a transverse force that is oriented perpendicular to the direction of the rotational axis of the first shaft 4 and of the output shaft of the gearbox 2.

By modulated operation of the linear actuator 15, a corresponding time-dependent transverse force can be generated. In this way a periodic load can preferably be introduced during the rotational movement of the output shaft.

A second coupling 7, in particular a rigid shaft coupling, is arranged at the end region of the first shaft 4 facing away from the gearbox 2, to which coupling a cardan joint 8 is connected, so that the torque supplied by the output shaft of the gearbox 2 is fed to a cardan shaft 9, which is connected to a generator 13 connected via a gearbox 12, via a further cardan joint 10 arranged on its side facing away from the gearbox 12, with a further coupling 11, in particular with a further rigid shaft coupling.

Thus, transverse deflections of the first shaft 4 can also be compensated by means of the cardan joints (8, 10).

In further inventive exemplary embodiments, a second linear actuator 15’ is arranged, supported on the base 14 and also pressing on the outer ring of the axial bearing 6, wherein the direction of the transverse force is applied preferably perpendicular, or at least produces an angle of more than 50° to the effective direction of the first linear actuator 15.

Thus, with suitable modulation, in particular 90° phase-shifted periodic modulation, of the two linear actuators 15, 15’, circularly circumferential transverse forces can also be generated.

Thus, the first linear actuator 15 is preferably subjected to a sinusoidal time-dependent control signal, and the second linear actuator 15’ to a co-sinusoidal time-dependent control signal.

Such a periodically circulating load is suitable for simulating a load during stirring operation of a mixer.

In further inventive exemplary embodiments, alternatively or in addition a third linear actuator is provided that loads the outer ring in the axial direction, that is, parallel to the direction of the rotational axis of the output shaft. Thus an axial force, in particular a modulated axial force, can also be simulated.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the

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presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

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List of reference numbers

1 Electric motor

2 Test specimen, in particular gearbox

3 Expansion tank, in particular for oil

4 First shaft

5 First coupling

6 Axial bearing

7 Second coupling

8 Cardan joint

9 Second shaft, in particular cardan shaft

10 Cardan joint

11 Third coupling

12 Gearbox

13 Generator

14 Base

15 Linear actuator, in particular hydraulic actuator

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Claims

The claims defining the invention are as follows:

1. A drive, comprising an electric motor and a first gearbox, the first gear box configured to be driven by the electric motor, and an output shaft of the first gearbox rotatably connected to a first shaft by a coupling, the first shaft mounted on an axial bearing, and configured to be subjected to a force by at least one linear actuator,

   the first gearbox having an interior filled with oil and connected to an expansion tank, the expansion tank comprising an inner space formed from two subregions, the two subregions separated from one another by a membrane, a first of the two subregions connected to the interior of the first gearbox via an oil line, the second of the two subregions of the expansion tank connected to the environment,

   wherein thermally caused expansion of the oil in the interior of the first gearbox is received in the expansion tank.

2. The drive according to claim 1, wherein the coupling is a rigid coupling.

3. The drive according to claim 1 or claim 2, wherein the axial bearing is a single axial bearing.

4. The drive according to any one of the preceding claims, wherein the first shaft is rotatably connected to a generator unit via a cardan shaft, by means of a plurality of cardan joints.

5. The drive according to claim 4, wherein the generator unit is a generator or a generator driven via a second gearbox.

6. The drive according to claim 5, wherein the first shaft is rotatably connected at an end region facing away from the first gearbox, using a first rigid coupling to a first cardan joint and a side of the first cardan joint facing away from the first shaft is rotatably connected to a cardan shaft, and

   wherein the cardan shaft is rotatably connected at a side facing away from the first shaft, to a second cardan joint, and a side of the second cardan joint facing away from the cardan shaft is rotatably connected by means of a second rigid coupling to a drive shaft of the generator unit via a second gearbox.

7. The drive according to any one of the preceding claims, wherein the expansion tank is filled with oil.

8. The drive according to any one of the preceding claims, wherein the inner space of the expansion tank and the membrane are arranged above the interior of the first gear box, in the direction of gravity.

9. The drive according to any one of the preceding claims, wherein an axial thrust bearing is received in a housing of the first gearbox and the output shaft of the first gearbox is rotationally mounted by means of the axial thrust bearing,

wherein a rotational axis of the output shaft is oriented, in use, horizontally, perpendicular to the direction of gravity.

10. The drive according to claim 9, wherein the output shaft of the first gearbox is further rotationally mounted via two further bearings received in the housing of the first gearbox,

wherein each of the two further bearings received in the housing of the first gearbox is embodied as a twin row bearing.

11. The drive according to claim 9 or claim 10, wherein the drive is arranged on a flat surface of an industrial plant defining a plane, and

wherein the rotational axis of the output shaft is oriented, in use, perpendicular to the normal of the plane.

12. The drive according to any one of the preceding claims, wherein the axial bearing is subjected to a force by at least one controllable second linear actuator, which force is oriented perpendicular to the force effected by the first linear actuator.

13. The drive according to claim 12, wherein the axial bearing can be subjected to an axially oriented force by at least one controllable further linear actuator.

14. The drive according to claim 13, wherein the at least one controllable further linear actuator is a third linear actuator and the axial bearing is subjected to a force, oriented perpendicular to the force effected by the first linear actuator and perpendicular to the force effected by the second linear actuator, being a force oriented in the axial direction, by the at least one controllable third linear actuator.

15. The drive according to any one of claims 12 to 14, wherein the first linear actuator can be controlled by a control with a periodically time-variable first control signal, and wherein the second linear actuator can be controlled by a control with a periodically time-variable second control signal, wherein the first and second control signals have the same frequency and have a 90° phase offset relative to one another.

16. A method for operating a drive, the drive comprising an electric motor and a first gearbox that can be driven by the electric motor and an output shaft of the first gearbox rotatably connected to a first shaft by means of a rigid shaft coupling, the first shaft mounted by means of a single axial bearing that can be subjected to a force by at least one controllable first linear actuator, the axial bearing can be subjected to a further force by at least one controllable second linear actuator, the output shaft defining a direction of a rotational axis,

wherein the first gearbox is connected to an expansion tank comprising an inner space formed from two subregions, separated from one another by a membrane, a first of the subregions connected to an interior the first gearbox with an oil line, the second of the subregions connected to the environment, such that when the interior of the first gearbox is filled with oil, thermally caused expansion of the oil in the interior is received in the expansion tank,

the method comprising a first method step wherein:

the first linear actuator is controlled by a control with a periodically time-variable first control signal; and

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the second linear actuator is controlled by the control with a second periodically time-variable second control signal.

17. The method according to claim 16, wherein the first and second control signals have the same frequency, and

wherein the first control signal has a 90˚ phase offset relative to the second control signal, and/or

wherein the rotational speed of the output shaft equals the frequency.

18. The method according to claim 16, wherein the first and second control signals have the same frequency, and

wherein the rotational speed of the output shaft differs from the frequency by less than 40%, and

wherein the first control signal has a 90˚ phase offset relative to the second control signal.

19. The method according to any one of claims 16 to 18, wherein in a second method step, the first gearbox of the drive is removed and then connected to a further electric motor, and

a direction of a rotational axis of the output shaft is oriented perpendicular to the direction of the rotational axis of the output shaft in the first method step, and

the output shaft of the first gearbox is rotated 90˚ in the vertical direction, parallel to the direction of gravity.

20. The method according to claim 19, wherein in the first method step, the interior of the first gearbox is completely filled with oil; and

in the second method step the interior of the first gearbox is partially filled with oil, wherein a further axial bearing and two further bearings received in the housing of the first gearbox are arranged at least in part below a level of the oil in the interior.

21. The method according to any one of claims 16 to 20, wherein the drive is as defined according to any one of claims 1 to 15.

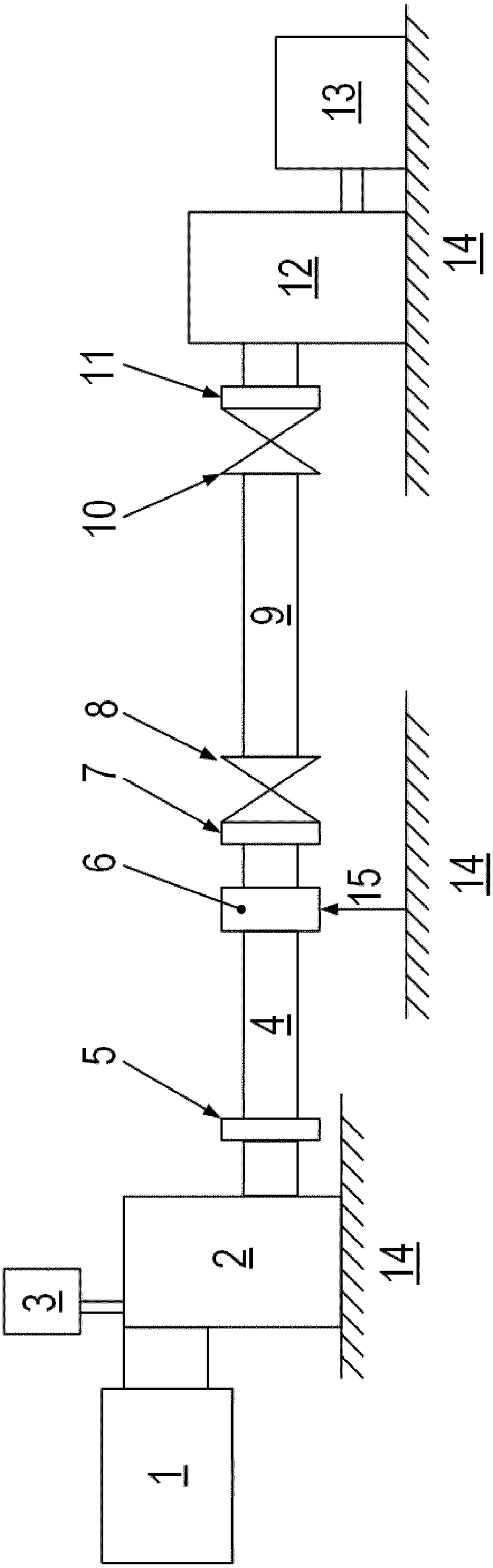

Fig. 1