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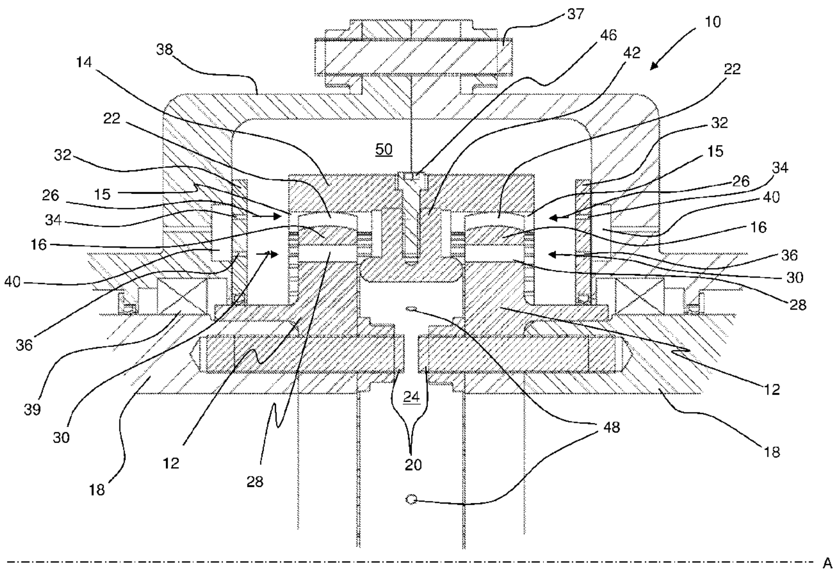

FIG. 1

(57) **Abstract**: A coupling comprising a first end connected to a second end via a geared sleeve. The first end comprises a geared hub having teeth that mesh with teeth of the geared sleeve, and the first geared hub has an outer axial side for connection to a component and an inner axial side nearest to the second end of the coupling. Two oil supplies are provided; one oil supply is arranged to supply oil to the meshing teeth of the geared hub and sleeve at the outer axial side of the geared hub, and the other oil supply is arranged to supply oil to the meshing teeth of the geared hub and sleeve at the inner axial side of the geared hub.

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Coupling

FIELD OF THE INVENTION

The present invention relates to a coupling, in particular, but not exclusively, a low speed geared coupling, and/or a method of lubricating and cooling a coupling.

BACKGROUND OF THE INVENTION

Geared couplings are commonly used to connect two shafts together. For example, one or more geared couplings may be used in a drive train of a wind turbine, e.g. between a rotor shaft and a gearbox shaft, or between a gearbox shaft and a generator shaft. A geared coupling generally includes two geared hubs and a sleeve. The sleeve includes teeth protruding from an inner or outer radial surface. The teeth of the sleeve mesh with teeth protruding from an inner or outer radial surface of each of the two geared hubs. The sleeve and two geared hubs rotate with the connected shafts. Gear couplings are beneficial because they can account for a degree of angular and axial misalignment between two connected shafts under dynamic operating conditions, offer high specific torque capacity and good reliability in view of the simplicity of their construction. Geared couplings may also be provided with one geared hub at one end of the coupling and a static connection at the other end of the coupling. Such couplings can generally account for angular misalignment but the axes of the connected shafts must intersect.

The teeth of the geared hubs and sleeve need to be lubricated to reduce friction, wear and to extend the life of the gear coupling. Current methods of lubricating the teeth include applying grease or oil to the interface between the teeth of the geared hub and sleeve. Seals are used to substantially retain the grease or oil within the coupling. However, with this current method of lubrication, wear of the coupling can be higher than desirable. This is partly because debris produced as a result of wear remains within the coupling and interacts with surfaces of the coupling to accelerate wear. Leakage of grease and oil from the coupling can also be a problem. Further, periodic maintenance of a conventional gear coupling is required to regularly change the grease or oil and replace worn seals.

Gear coupling wear is particularly problematic for low speed couplings, for example a gear coupling between a rotor shaft and a gearbox of a wind turbine, because the centrifugal force due to rotation of the gear and sleeve of the coupling is not sufficient to distribute the grease or oil across the interface of the meshing teeth. In a wind turbine application, this issue is exacerbated by the high and unsteady component loading arising from the stochastic nature of the wind resource and the difficulty of access and downtime required for coupling maintenance.

SUMMARY OF THE INVENTION

The present invention seeks to alleviate one or more of the problems associated with couplings of the prior art.

A first aspect of the invention provides a coupling comprising: a first end connected to a second end via a geared sleeve, the first end comprising a geared hub having teeth that mesh with teeth of the geared sleeve, and the geared hub having an outer axial side for connection to a component and an inner axial side nearest to the second end of the coupling; and two oil supplies, wherein one oil supply is arranged to supply oil to the meshing teeth of the geared hub and geared sleeve at an outer axial side of the geared hub, and the other oil supply is arranged to supply oil to the meshing teeth of the geared hub and geared sleeve at the inner axial side of the geared hub.

The provision of two oil supplies supplying oil (e.g. oil, a lubricant with an oil base, a synthetic oil, or a lubricant with a synthetic oil base) to each axial side of the meshing teeth improves lubrication of the meshing teeth of the geared hub and the sleeve. Improved lubrication reduces friction at the interface of the meshing teeth, cools the interface between the meshing teeth, and removes wear debris, all of which contribute to reduced coupling wear rate and therefore extended life of the coupling.

The coupling may be configured such that the sleeve and geared hub rotate during use. The coupling may be intended for use at low speeds. For example, speeds where the centrifugal force is not sufficient to distribute oil effectively across the teeth of the geared hub and sleeve. The present invention ensures that oil is distributed to the meshing teeth of the geared hub and sleeve even at low speeds, and even when the coupling is a large scale coupling such as necessary in power generation and other heavy industrial processes.

Further, the present invention removes the need for seals to retain grease within the coupling, as is required for couplings of the prior art lubricated using grease. Yet further, provision of an oil flow through the coupling means that coupling maintenance is reduced compared to couplings of the prior art, because there is no need to regularly clean out the coupling and reapply lubricant at the interface between the teeth of the geared hub(s) and sleeve.

The geared hub may have radially outwardly protruding teeth and the geared sleeve may have radially inwardly protruding teeth. Alternatively, the geared hub may have radially inwardly protruding teeth and the geared sleeve may have radially outwardly protruding teeth.

One of the oil supplies may comprise one or more through holes in the hub for directing oil from one axial side of the geared hub to the other axial side of the geared hub. For example, the one or more through holes in the hub may direct oil from the outer axial side of the geared hub to the inner axial side of the geared hub.

At least one of the two oil supplies may be configured to intermittently supply oil to the meshing teeth of the geared hub. In exemplary embodiments, both of the oil supplies may be configured to intermittently supply oil to the meshing teeth of the geared hub. The time between each application of oil to the meshing teeth provides an opportunity for debris to be washed away. It would be generally thought in the art that oil should be applied to only one side of the coupling to improve removal of debris. The present inventor has gone against this prejudice and provided two oil supplies on both axial sides of the geared hub. However, to further improve debris removal the oil supply may be intermittent.

The coupling may comprise a weir to control oil flow from one or both of the two oil supplies to the inner axial side of the meshed teeth of the geared hub and sleeve. The weir may be provided on the inner axial side of the geared hub. The weir may be configured to act as an axial stop for the geared hub. The weir may be secured to the geared sleeve via at least one fastener, e.g. a bolt and/or may be substantially T-shaped in cross section.

The coupling may comprise one or more jet arrangements for supplying oil to the meshing teeth of the geared hub and sleeve. The jet arrangements may be configured to intermittently supply oil to the meshing teeth of the geared hub and sleeve. The one or more jet arrangements may be provided on the outer axial side of the geared hub. One or more of the jet arrangements may be substantially radially aligned with an interface between the meshing teeth of the geared hub and sleeve, e.g. at the meshing zone of the teeth of the geared hub or sleeve. When the geared hub includes one or more through holes, one or more of the jet arrangements may be substantially aligned with one or more of the through holes.

The coupling may comprise a manifold having one or more channels through which oil is directed to the meshing teeth of the geared hub and sleeve. The manifold may be arranged adjacent a chamber or other supply system (e.g. a pressurised oil feed system), such that oil from the chamber can be directed through the channels of the manifold.

The geared hub and sleeve may be configured to be rotatable about a central longitudinal axis extending therethrough. The manifold may be configured to be static, e.g. the manifold may be configured not to rotate with the geared hub and sleeve. Provision of a static oil supply (e.g. a static manifold), simplifies manufacture, improves reliability and reduces wear because there is a reduced number of components and contacting parts moving relative to each other. Alternatively, the manifold may rotate, for example the manifold may rotate synchronously or otherwise with the geared hub and sleeve.

The manifold may be axially spaced from the geared hub.

The manifold may comprise one or more channels substantially radially aligned with an interface between the meshing teeth of first gear and sleeve, e.g. at the meshing zone of the teeth of the geared hub or sleeve. When the hub includes one or more through holes, one or more of the channels of the manifold may be substantially radially aligned with one or more of the through holes.

The coupling may comprise a flow controller for metering oil flow to the oil supplies. The coupling may comprise a pump system for supplying oil to the oil supplies. The pump system may be configured to pump oil from an associated or adjacent gearbox or other machinery. The coupling may comprise a flow controller and a pump system, and the flow controller may be configured to alter the flow rate of oil from the pump system to the meshing teeth of the geared hub and sleeve.

The flow controller may be configured to detect torque transmission across the coupling and meter the oil flow to the oil supplies dependent on the level of torque transmission. For example, the flow rate of oil through the coupling may be increased during periods of high duty and reduced during periods of low duty, or machinery standstill conditions, which can further minimise corrosion risk and localised wear under the effects of vibration or dynamic circumferential loading.

The coupling may comprise an overflow chamber to which oil can drain. The overflow chamber may extend circumferentially around the coupling, e.g. adjacent an outer surface of the sleeve. The overflow chamber may be defined by a casing that surrounds the sleeve and the geared hub. The casing may be arranged to be static during use of the coupling.

The coupling may comprise a weir on the inner axial side of the hub. The sleeve may comprise a drain channel through which oil can drain to the overflow chamber. The weir may be formed integrally with a stop that prevents axial disengagement of the teeth of the geared hub and the sleeve.

The second end of the coupling may comprise a geared hub. Teeth of the geared hub may be meshed with teeth of the sleeve (e.g. the sleeve may have a series of teeth at one axial end and a series of teeth at an opposite axial end). The geared hub of the second end may have an outer axial side for connection to a component and an inner axial side nearest to the first end of the coupling. The inner axial side of the geared hub of the second end may be arranged in opposition to the inner axial side of the geared hub of the first end.

The coupling may comprise two further oil supplies configured to supply oil to the meshing teeth of the geared hub of the second end and the sleeve. One of the further oil supplies may be on the outer axial side of the geared hub of the second end, and the other further oil supply may be on the inner axial side of the geared hub of the second end. Alternatively, only two oil supplies may be provided, and said two oil supplies may lubricate both the geared hubs of the first and second ends. In such embodiments, one of the geared hubs may comprise one or more through holes.

One of the oil supplies may comprise one or more through holes in the geared hub of the first end and one of the further oil supplies may comprise one or more through holes in the geared hub of the second end. The through holes in the hub of the first end may be misaligned with the through holes in the hub of the second end. For example, the through holes in the hub of the first end may be spaced circumferentially around the geared hub of the first end and be out of phase with the through holes spaced circumferentially around the geared hub of the second end.

The coupling may comprise a stop positioned between the geared hubs of the first and second ends. The stop may be arranged to restrict relative axial movement between the geared hubs of the first and second ends and the sleeve. The stop may be integrally formed with the weir (e.g. the stop is shaped to provide the function of both a weir and a stop). Advantageously, the oil supplies also lubricate an interface between the stop and the geared hubs.

The coupling may comprise two stop plates, one positioned on an outer axial side of the geared hub of the first end and the other positioned on the outer axial side of the geared hub of the second end. The stop plates may be connected to the sleeve and arranged to restrict relative axial movement between the geared hubs of the first and second ends and the sleeve. The stop plates may comprise a hole through which oil is directed to the meshing teeth of the geared hubs of the first and second ends and the sleeve. Advantageously, the oil supplies also lubricate an interface between the stop plates and the geared hubs.

The gear coupling may be for use in a wind turbine drive train, e.g. the gear coupling may be a wind turbine gear coupling. Alternatively, the gear coupling may be used in a tidal turbine drive train, or any other type of renewable power generation application.

In a second aspect the invention provides a gear coupling comprising: a first geared hub and a second geared hub connected via a geared sleeve, wherein teeth of the geared sleeve are meshed with teeth of the first and second geared hubs; and two oil supplies, one oil supply being arranged to supply oil to the meshing teeth of the first and/or second geared hub and the geared sleeve at the outer axial side of the first and/or second geared hub, and the other oil supply being arranged to supply oil to the meshing teeth of the first and/or second geared hub and sleeve at the inner axial side of the first and/or second geared hub.

The gear coupling of the second aspect may have one or more of the optional features of the gear coupling of the first aspect.

In a third aspect the invention provides a method of lubricating a coupling of the type having a first end connected to a second end via a geared sleeve, the first end comprising a geared hub, wherein teeth of the geared hub are meshed with teeth of the geared sleeve, and the geared hub having an outer axial side for connection to a component and an inner axial side nearest to the second end of the coupling; the method comprising: supplying oil directly to an interface of the meshing teeth of the geared hub and the sleeve on both the outer axial side and the inner axial side of the geared hub.

Oil may be intermittently supplied to the interface of the meshing teeth of the geared hub and the sleeve. The time between each application of oil to the meshing teeth provides an opportunity for debris to be washed away. It would be generally thought in the art that oil should be applied to only one side of the coupling to improve removal of debris. The present inventor has gone against this prejudice and provided two oil supplies on both axial sides of the geared hub. However, to further improve debris removal the oil supply may be intermittent.

The method may comprise changing the flow rate of oil to the meshing teeth of the gear and the sleeve depending on torque transmission across the coupling.

The method may comprise circulating clean oil through the coupling during operation of the coupling.

The method may comprise extracting a sample of oil from the coupling during coupling operation and using the sample of oil to characterise coupling wear.

In a fourth aspect, the present invention provides a wind turbine or a tidal turbine comprising a rotor, a gearbox, a generator, and two or more shafts extending between the rotor and gearbox and/or the gearbox and the generator, wherein at least two of the two or more shafts are connected using a gear coupling of the first or second aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a cross section through one radial half of a gear coupling;

Figure 2 shows a side view of a manifold of the gear coupling of Figure 1;

Figure 3 shows schematically a pump and control system for supplying oil to and from the gear coupling of Figure 1; and

Figure 4 shows a cross section through one radial half of an alternative gear coupling.

DETAILED DESCRIPTION OF EMBODIMENT(S)

Referring to Figure 1, a coupling is indicated generally at 10. The coupling 10 includes two geared hubs 12 having teeth 16 protruding from an outer radial surface thereof. A sleeve 14 surrounds the two geared hubs 12 and has gear teeth 15 protruding from an inner radial surface, at an axial position aligned with the teeth 16 of the geared hubs 12. The gear teeth 16 of the two geared hubs mesh with the teeth 15 of the sleeve.

The coupling 10 connects two shafts 18 together by connecting one hub 12 to one shaft and connecting the other hub 12 to the other shaft 18. The two hubs 12 are connected to the respective shafts 18 using a plurality of fasteners 20 spaced circumferentially around the hub and shaft. In alternative embodiments, the two hubs may be connected to the respective shafts using splines, keys, etc, or alternatively the hub and shaft may be integrally formed. The coupling 10 is capable of transmitting torque from one shaft to the other shaft. During torque transmission, the sleeve 14 and hubs 12 rotate about an axis A extending centrally through the coupling 10 and shafts 18 in a longitudinal direction.

A casing 38 surrounds the sleeve 14 and hubs 12. The casing 38 is provided in two-parts that are connected by a plurality of fasteners 37 spaced circumferentially around the coupling 10. The casing 38 is mounted to the geared hubs 12 via a bearing 39, such that the casing 38 is substantially stationary during use, i.e. the casing 38 does not rotate with the sleeve 14 and the geared hubs 12.

In the present embodiment the coupling 10 is used in a drive train of a wind turbine, and as such the sleeve 14 and geared hubs 12 rotate at very low speeds. Typical geared couplings would be considered to be low speed below around 1500 RPM, medium speed around 1500 RPM to around 3000 RPM and high speed above 3000 RPM. Centrifugal oil distribution depends upon the coupling size and the coupling rotational speed, with the speed being the dominant feature. In the present embodiment, the coupling 10 is intended for use a very low speeds of below 100 RPM and even down to below 10 RPM with large coupling sizes (approx. 0.5 m tooth pitch diameter and above). At these very low speeds the centrifugal force due to rotation of the sleeve 14 and geared hubs 12 is not sufficient to adequately distribute oil across an interface between the teeth 16 of the geared hubs 12 and the teeth 15 of the sleeve 14.

The two geared hubs 12 have an outer axial side which is axially nearest the respective connected shaft 18 and an inner axial side that is axially nearest the opposing geared hub 12. The inner axial sides of the two geared hubs 12 together with the sleeve 16 define an inner chamber 24 of the coupling. An interface 22 between the teeth 16 of the geared hub 12 and the teeth 15 of the sleeve 14 extends from the outer axial side to the inner axial side of the geared hub 12.

A lubrication system is provided to lubricate the interface 22 between the teeth 16 of the geared hub 12 and the teeth 15 of the sleeve 14, as will now be described.

An oil supply, in this embodiment a series of jets 26 are provided to directly deliver oil to the interface 22 between the teeth of the geared hubs 12 and the sleeve 14. The jets 26 are arranged to deliver oil to the interface 22 at the outer side of the geared hubs 12.

A series of axially extending through holes 28 extend through the hubs 12, and an oil supply, in this embodiment a series of jets 30, are provided to directly deliver oil to the through holes, which in turn permits oil to be directed to the interface 22 on the inner axial side of the geared hubs 12.

In the present embodiment, the jets 28, 30 are formed using a jet arrangement that includes an annular manifold 32. Referring to Figure 2, the annular manifold 32 includes an outer series of holes 34 and an inner series of holes 36. The holes 34 and 36 are spaced circumferentially around the manifold 32. The outer series of holes 34 is spaced more radially outwardly than the inner series of holes 36, such that the outer series of holes 34 is substantially radially aligned with the interface 22 of the gear teeth of the geared hubs 12 and the sleeve 14, and the inner series of holes 36 is substantially radially aligned with the axial through holes 28 formed in the hubs 12.

Two manifolds 32 are mounted on opposing sides of the coupling and axially spaced from the geared hubs 12. The manifolds 32 are mounted to the casing 38 of the coupling 10. Since the casing 38 is static during use, so is the manifold 32. However, in alternative embodiments the manifold may rotate synchronously or otherwise with the sleeve 14 and geared hubs 12.

An annular chamber 40 is formed in the outer casing 38 behind the manifold 32. A pump, not shown, but of the type known in the art, pumps oil to the chamber 40. In use, oil is directed from the chamber 40 through the holes 34, 36 in the manifold 32.

Advantageously, transfer of oil to the meshing teeth of the geared hubs 12 and sleeve 14 from a static position (i.e. from the static holes 34, 36 of the static manifold 32) simplifies operation and manufacture of the coupling 10.

The axial through holes 28 formed in the hubs 12 are positioned circumferentially around the hubs 12. The axial through holes 28 are spaced radially inwardly from the teeth 16, but radially outwardly from a position of connection to the respective shaft 18. The number of through holes 28 provided depends on a number of factors, including frictional losses, rotational speed of the coupling, and coupling diameter.

In the present embodiment, a weir 42 is provided in the inner chamber 24 of the coupling. In use, oil from the holes 36 in the manifold 32 is directed through the through holes 28 to the weir 42, and from the weir 42 to the interface 22 between the teeth of the geared hubs 12 and sleeve 14.

In the present embodiment, the weir 42 is formed to also provide the function of an annular stop in the inner chamber 24 of the coupling to prevent axial disengagement of the teeth 16 of the geared hubs 12 and the teeth 15 of the sleeve 14.

The weir 42 has a T-shaped cross-section. The weir 42 is fastened to an inner radial surface of the sleeve 14, in this embodiment via a bolt 46. The weir 42 is arranged so that the wider portion of the T-shaped cross-section is radially inwards and the narrower portion of the T-shaped cross-section is radially outwards.

The through holes 28 of the hub 12 are positioned such that oil supplied to the weir 42 also lubricates an interface between the weir 42 and the geared hubs 12. In alternative embodiments, a bleed hole may be provided in the weir so as to direct oil to lubricate an interface between the weir and the geared hubs.

An overflow channel 48 extends through the weir 42 and the sleeve 14 from the inner chamber 24 of the coupling to an overflow chamber 50. The overflow chamber 50 is defined by the casing 38 and extends radially around the sleeve 14. A drain is connected to the overflow chamber to drain oil from the overflow chamber 50. In exemplary embodiments, the oil is drained to a recirculation system and pumped back to be supplied to the jets 26, 30. The recirculation system may include a filtering mechanism to filter drained oil.

In use, oil is pumped to the chambers 40 of the casing 38. The oil may be supplied from an associated gearbox or machinery. The person skilled in the art is familiar with selecting a suitable oil. Oil exits the chambers 40 through the holes 34, 36 in the manifold 32. Oil from the holes 34 directly impinges on the interface 22 of a tooth 16 of the geared hub 12 and teeth 15 of the sleeve 14. As the geared hubs 12 and sleeve 14 rotate, oil is supplied to the interface 22.

As the coupling rotates the through holes 28 in the hubs 12 are presented in substantial alignment with the holes 36. When the through holes 28 and the holes 36 overlap, oil is supplied from the holes 36 to the through holes 28. In this way, oil is intermittently supplied to the interface 22 between the teeth 16 of the geared hubs 12 and the teeth 15 of the sleeve 14.

Oil from the through holes 28 enters the inner chamber 24. The weir 42 directs the oil from the through holes 28 to the inner axial side of the interface 22 between the teeth 16 of the gear 13 and the teeth 15 of the sleeve 14.

An excess of oil from the weir 42 is drained through the channel 48 in the weir 42 and the sleeve 14 and into the overflow chamber 50, from which the oil may be drained and/or re-circulated.

Referring to Figure 3, in one example of operation, a control system 62 may be used to monitor the torque transmission across the coupling 10. The control system 62 may also be configured to alter the rate at which oil is pumped to the coupling 10 from a pump 60, and drained from the coupling via the overflow chamber 50 depending on the torque transmitted across the coupling. For example, the flow rate may be increased to suit a high duty and reduced for a lower duty or for standstill conditions. Altering the amount of oil pumped to/from the coupling so that the pump is not constantly operating at full power can help to reduce energy consumption. The type of oil circulated in the coupling could also be adjusted to suit the duty cycle of the coupling. Further, during periods of inactivity, the oil may be drained from the system and fresh oil circulated through the system, which can help to prevent corrosion and reduce the risk of fretting.

Advantageously, the lubrication system of the coupling 10 provides lubrication of the meshing teeth of the sleeve and geared hubs, without the reliance on centrifugal force. This is particularly advantageous when the coupling is used in a drive train of a wind turbine or tidal turbine because the coupling is rotating at low speed so the centrifugal force is not sufficient to adequately distribute the oil.

The lubrication system permits a continuous supply of oil to the coupling and drainage of oil from the coupling, both of which provide cooling and “wash away” any debris from the coupling to reduce friction and wear. The lubrication system is arranged to intermittently supply oil to the interface 22 of the teeth of the geared hubs 12 and the sleeve 14, which improves debris removal from the interference 22 of the teeth of the geared hubs 12 and the sleeve 14.

A further advantage of the presently described embodiment is that no seals are required. Oil is moving in a continuous flow, so there is no need for seals to hold grease or oil in a region of the meshing teeth, as with couplings of the prior art that are lubricated with grease. Removing the need for seals simplifies the design and manufacture of the coupling. Seals also generally wear at a high rate compared to other components of the coupling, so maintenance of the coupling 10 is simplified compared to couplings of the prior art that are lubricated with grease.

The lubrication system also lubricates the stop provided by the weir 42 to reduce wear of the stop and geared hubs 12.

Components of the coupling 10 may be seeded or otherwise chosen to have distinct compositional identity. This means that oil can be sampled from the coupling and tested with any particulates found in the oil; identification of the particulates can be used to identify which components of the coupling that are starting to wear, and the quantity of particulates found in the oil can be used to determine the level of wear of a given component. The testing methods are those used in other types of seeding systems. The ease of access to oil circulating through the coupling 10 permits this testing method to be implemented.

An alternative coupling 110 is shown in Figure 4. The coupling 110 is similar to the coupling 10 and similar features are given similar reference numerals but with a prefix “1”. Only the differences between the coupling 110 and the previously described coupling 10 will be described here.

In the coupling 110 of Figure 4, no stop is provided in the inner chamber 124 of the coupling. Instead, an annular stop plate 152 is mounted to the outer side of the sleeve 114 via bolts 156. The annular stop plate 152 overlaps the hub 112 and the interface 122 between the teeth 116 of the geared hubs 112 and the teeth 115 of the sleeve 114. The plate 152 has a plurality of holes 154 arranged circumferentially around the plate 152 that are radially aligned with the interface 122 of the teeth of the geared hubs 112 and the sleeve 114. Oil from the jets 126 is delivered to the interface 122 between the teeth of the geared hubs 112 and sleeve 114 via the holes 154. Oil directed to the interface 122 also provides lubrication between the stop plate 152 and the geared hub 112.

The through holes 128 formed in one of the hubs 112 are misaligned with the through holes 128 formed in the other of the hubs 112 so as to prevent oil entering the inner chamber 124 of the coupling 110 through one through hole 128 and exiting the coupling through the through hole 128 in the opposite hub 112 instead of circulating to the interface 122 of the teeth of the geared hub 112 and sleeve 114.

Although the invention has been described above with reference to one or more preferred embodiments, it will be appreciated that various changes or modifications may be made without departing from the scope of the invention as defined in the appended claims.

For example, an oil supply may only be provided on an outer side of only one of the geared hubs. For example, only one manifold and chamber may be provided. In such an embodiment, only one of the hubs may include through holes. In a further embodiment, an oil supply may be provided on the outer axial side of both geared hubs to direct oil to the interface between the meshed teeth of the geared hubs and sleeve, but only one of the hubs may include through holes. In such an embodiment, oil may be supplied through the through hole and directed to the interface between the teeth of both geared hubs and the sleeve from an inner axial side of the geared hubs.

In the described embodiments oil is supplied to an inner axial side of the geared hubs via through holes in the hub, but in alternative embodiments no through holes may be provide. For example a supply of oil may be provided through e.g. the sleeve.

In a further alternative embodiment, an overflow chamber may not be defined by the casing, and instead oil may be drained directly from the inner chamber to an external drain.

The size of the holes in the manifold may be variable to vary the flow of oil from the jets. Alternatively, a device may be provided to modulate flow to the interface or through holes of the hubs, so as to selectively alter the flow rate of oil to the interface or through holes.

In the present embodiment a manifold is used to form the jets of oil, but in alternative embodiments the jets may be formed using one or more nozzles. The supply of oil has been described as being intermittent, but in alternative embodiments the supply may be continuous (e.g. the oil can be pumped to the jets at substantially constant pressure and the manifold can rotate at the same speed as the geared hubs). In the present embodiment the relative motion between the geared hubs and the manifold has been used to intermittently supply oil to the meshing teeth, but in alternative embodiments the oil may be pumped at varying pressure (e.g. a pulsed or oscillating supply).

The teeth of the geared hubs have been described as being arranged to protrude radially outwardly and the teeth of the sleeve have been described as being arranged to protrude radially inwardly, but in alternative embodiments the teeth of the geared hubs may protrude radially inwardly and the teeth of the sleeve may protrude radially outwardly.

The couplings in the described embodiments have a geared hub at both axial ends of the coupling, but in alternative embodiments only one end of the coupling may have a geared hub.

In the present embodiment the weir also performs the function of the stop, but in alternative embodiments the weir may be a separate component to the stop.

The invention has been described with reference to use in a wind turbine, but in alternative embodiments the coupling may be used in any other low speed applications (e.g. tidal turbine), as would be understood by the person skilled in the art. In yet further alternative embodiments, the coupling could also be used in high speed applications.

Claims

1. A coupling comprising:

    a first end connected to a second end via a geared sleeve, the first end comprising a geared hub having teeth that mesh with teeth of the geared sleeve, and the first geared hub having an outer axial side for connection to a component and an inner axial side nearest to the second end of the coupling; and

    two oil supplies, wherein one oil supply is arranged to supply oil to the meshing teeth of the geared hub and the geared sleeve at the outer axial side of the geared hub, and the other oil supply is arranged to supply oil to the meshing teeth of the geared hub and the geared sleeve at the inner axial side of the geared hub.

2. The coupling according to claim 1, wherein one of the oil supplies comprises one or more through holes in the geared hub for directing oil from one axial side of the geared hub to the other axial side of the geared hub.

3. The coupling according to claim 1 or 2, wherein at least one of the two oil supplies is configured to intermittently supply oil to the meshing teeth of the geared hub.

4. The coupling according to any one of the previous claims, further comprising a weir adjacent the meshing teeth of the geared hub and the geared sleeve, and wherein the weir is arranged to control oil flow from at least one oil supply to the inner axial side of the meshed teeth.

5. The coupling according to claim 4, wherein the weir is provided on the inner axial side of the geared hub.

6. The coupling according to claim 4 or claim 5, wherein the weir is configured to act as an axial stop for the geared hub.

7. The coupling according to any one of claims 4 to 6, wherein the weir is secured to the geared sleeve via at least one fastener, e.g. a bolt.

8. The coupling according to any one of claims 4 to 7, wherein the weir is substantially T-shaped in cross section.

9. The coupling according to any one of the previous claims, wherein at least one of the two oil supplies comprises one or more jet arrangements for supplying oil to the meshing teeth of the geared hub and the geared sleeve.

10. The coupling according to claim 9, wherein the jet arrangements are configured for intermittently supplying oil to the meshing teeth of the geared hub and the geared sleeve.

11. The coupling according to claim 9 or claim 10, wherein the one or more jet arrangements are provided on the outer axial side of the geared hub.

12. The coupling according to any one of claims 9 to 11, further comprising a manifold having one or more channels through which oil is directed to the meshing teeth of the geared hub and geared sleeve.

13. The coupling according to claim 12, wherein the geared hub and the geared sleeve are configured to be rotatable about a central longitudinal axis extending therethrough, and the manifold is configured to be static.

14. The coupling according to any one of the previous claims, further comprising a flow controller for metering oil flow to the two oil supplies.

15. The coupling according to claim 14, further comprising a pump system for supplying oil to the two oil supplies, and wherein the flow controller is configured to alter the flow rate of oil from the pump to the two oil supplies.

16. The coupling according to claim 14 or 15, wherein the flow controller is configured to detect torque transmission across the coupling and meter the oil flow to the oil supplies dependent on the level of torque transmission.

17. The coupling according to any one of the previous claims, further comprising an overflow chamber to which oil can drain.

18. The coupling according to any one of the previous claims, wherein the second end comprises a geared hub and wherein teeth of the geared hub are meshed with the teeth of the geared sleeve, and the geared hub of the second end having an outer axial side for connection to a component and an inner axial side nearest to the first end of the coupling; the inner axial side of the geared hub of the second end being arranged in opposition to the inner axial side of the geared hub of the first end, and wherein the coupling comprises two further oil supplies configured to supply oil to the meshing teeth of the geared hub of the second end and the geared sleeve, one of the further oil supplies being on the outer axial side of the geared hub of the second end and the other further oil supply being on the inner axial side of the geared hub of the second end.

19. The coupling according to claim 18, wherein one of the oil supplies comprises one or more through holes in the geared hub of the first end and one of the further oil supplies comprises one or more through holes in the geared hub of the second end.

20. The coupling according to claim 19, wherein the through holes in the geared hub of the first end are misaligned with the through holes in the geared hub of the second end.

21. The coupling according to claim 19 or claim 20, further comprising a weir positioned between the geared hubs of the first and second ends to direct oil flow from the through holes to the meshing teeth of the geared hubs of the first and second ends and the geared sleeve.

22. A method of lubricating a coupling of the type including a first end connected to a second end via a geared sleeve, the first end comprising a geared hub having teeth that mesh with teeth of the geared sleeve, and the geared hub having an outer axial side for connection to a component and an inner axial side nearest to the second end of the coupling; the method comprising:

supplying oil directly to an interface of the meshing teeth of the geared hub and the geared sleeve on both the outer axial side and the inner axial side of the geared hub.

23. The method according to claim 22, wherein oil is intermittently supplied to the interface of the meshing teeth of the geared hub and the geared sleeve.

24. The method according to claim 22 or 23, further comprising changing the flow rate of oil to the meshing teeth of the geared hub and the geared sleeve depending on torque transmission across the coupling.

25. The method according to any one of claims 22 to 24, further comprising circulating clean oil through the coupling during operation of the coupling.

26. The method according to any one of claims 22 to 25, further comprising extracting a sample of oil from the coupling whilst the coupling is in operation and using the sample of oil to characterise coupling wear.

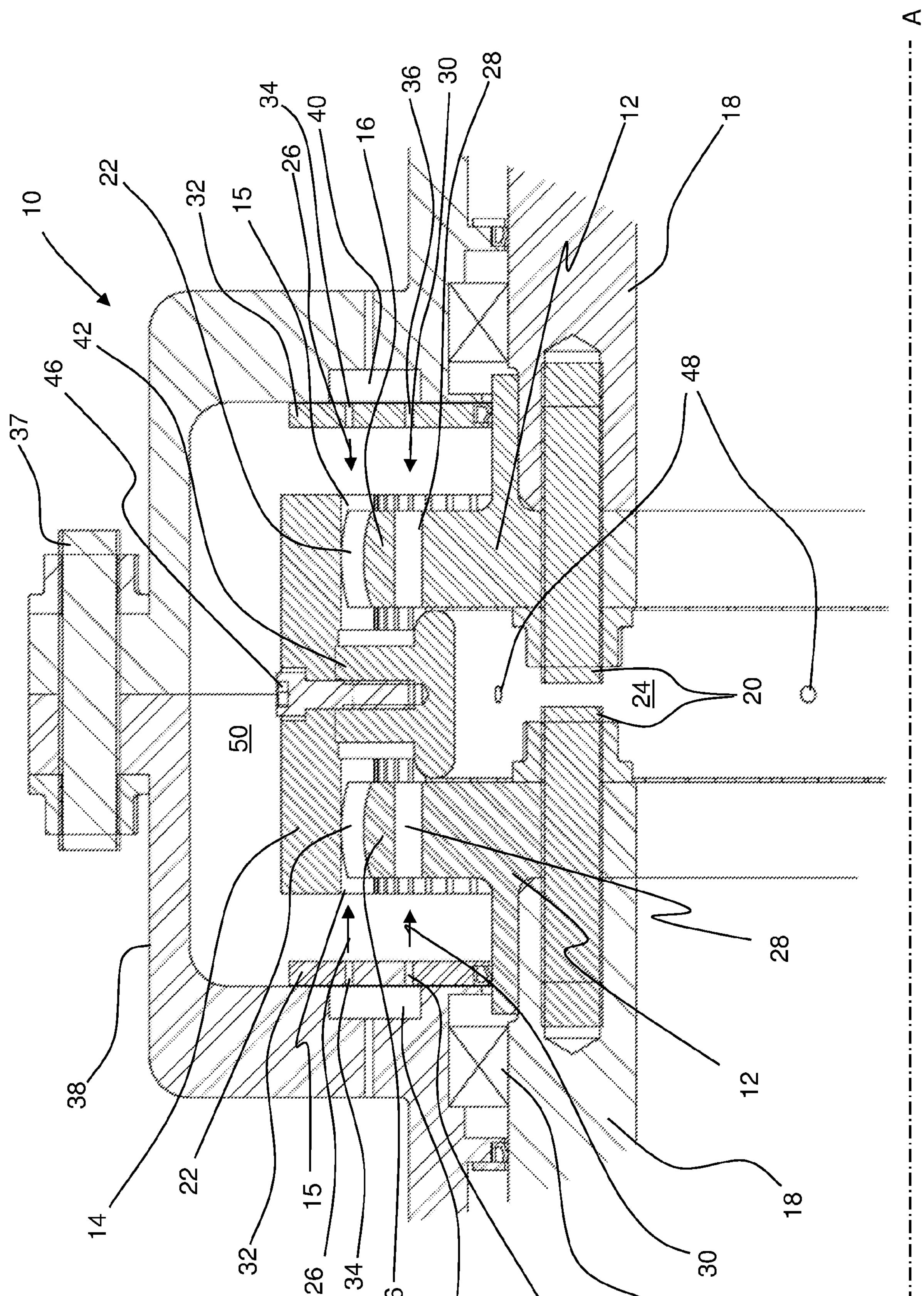

FIG. 1

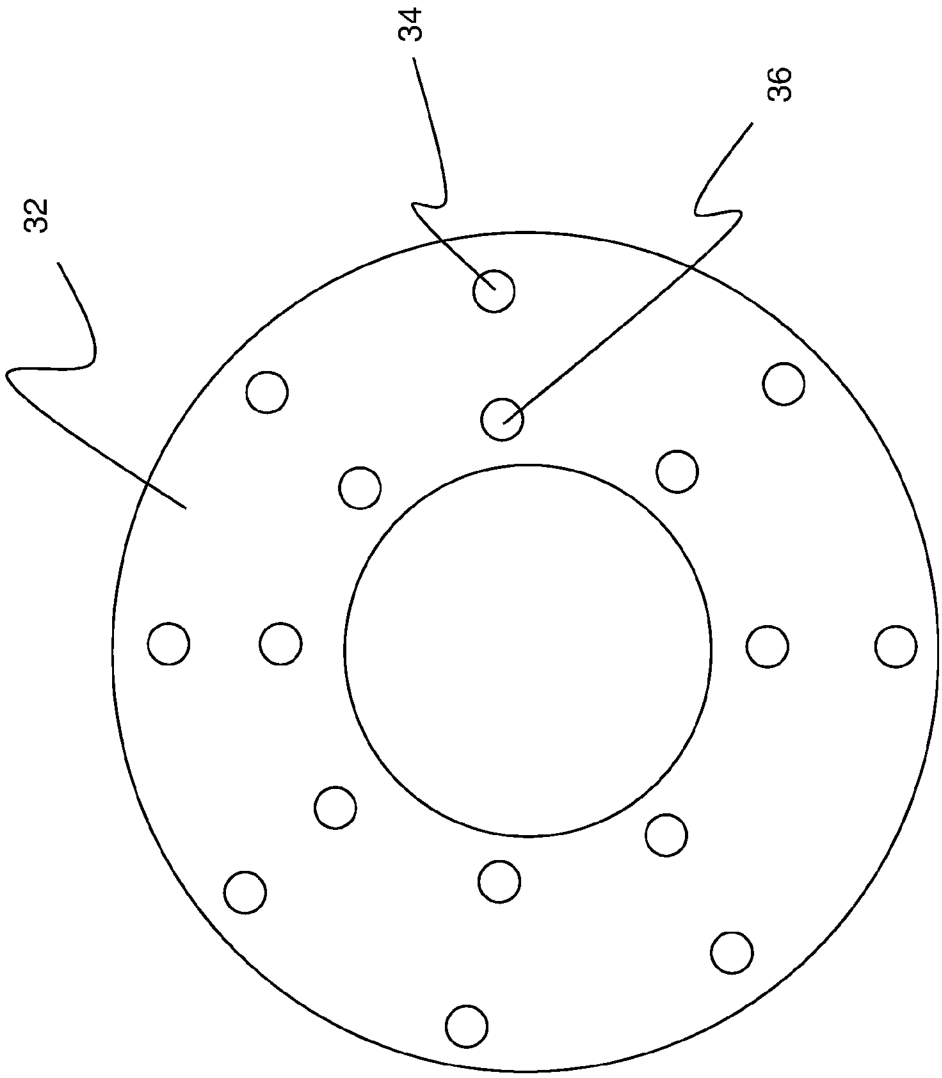

FIG. 2

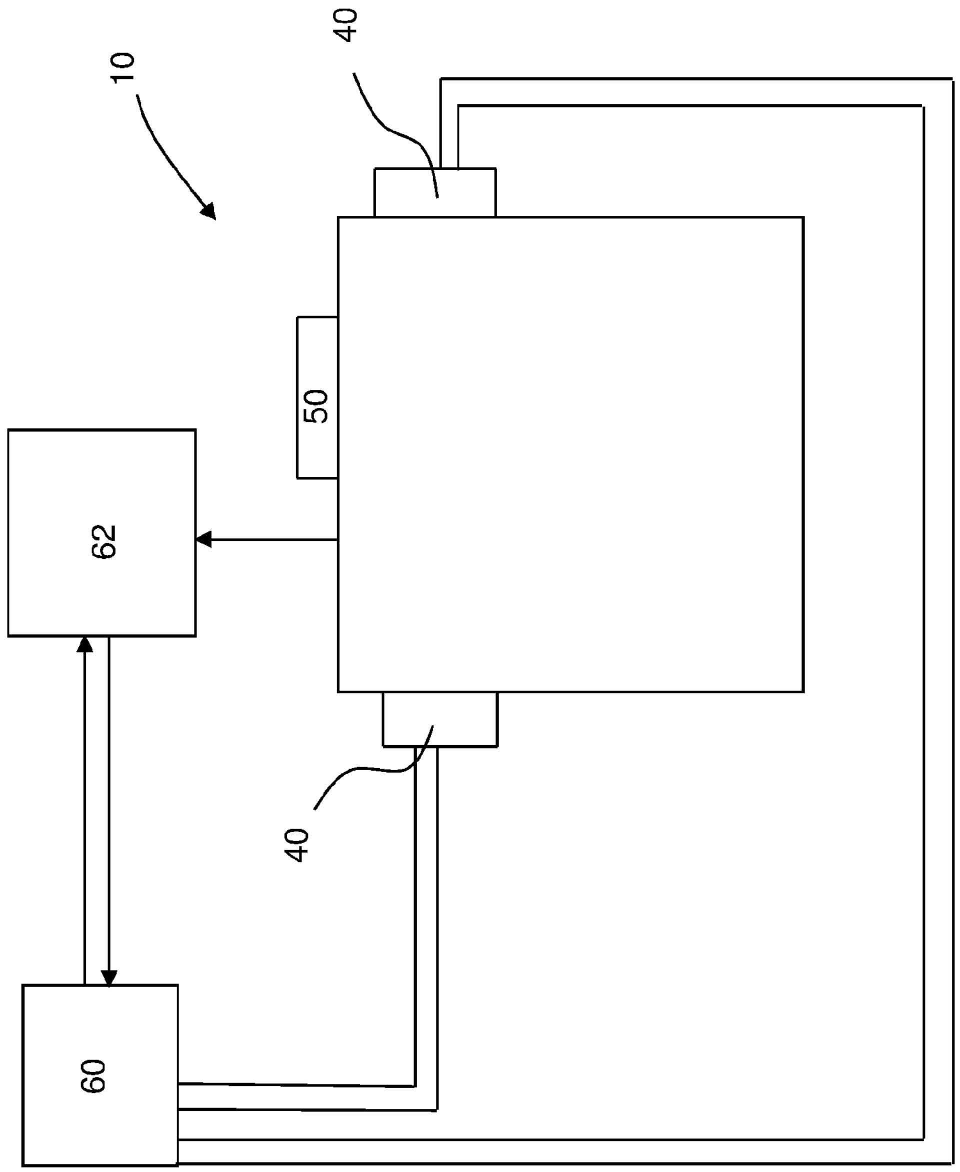

FIG. 3

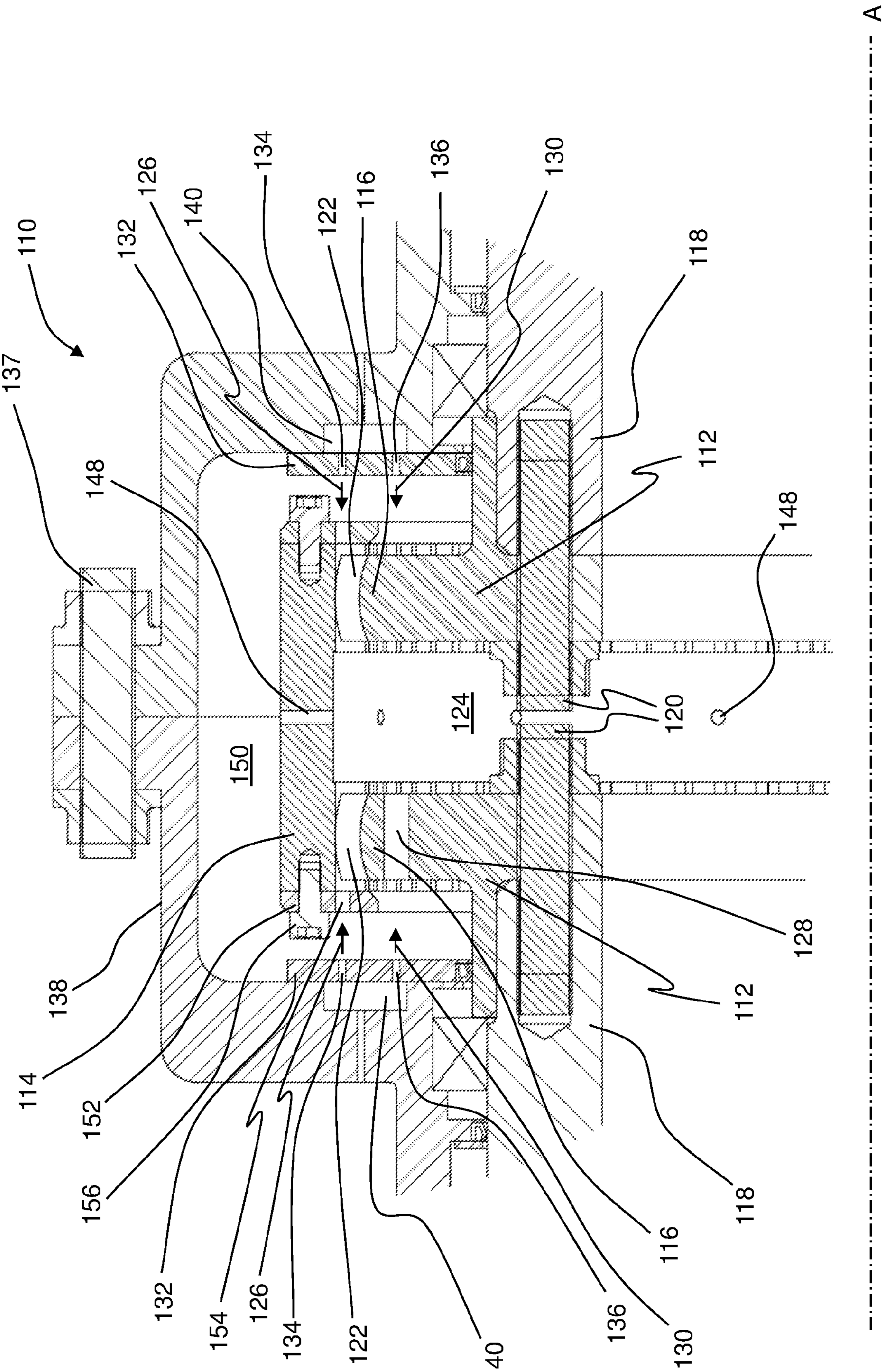
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FIG. 4