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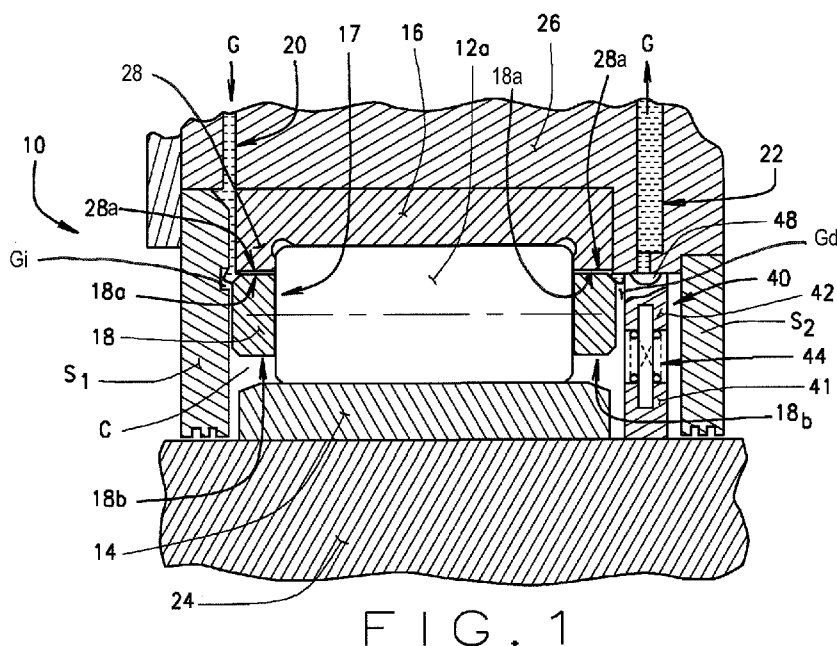
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[Continued on next page]

(54) Title: ROLLING ELEMENT BEARING WITH DIRECTIONAL GREASE FLOW



(57) Abstract: A rolling element bearing assembly (10) having at least one row of rolling elements (12) contained within a bearing cavity (C) between an inner race (14) and an outer race (16) by a retainer or cage (18), with a directional flow of grease (G) within the bearing cavity. Grease is delivered to selected grease delivery regions (G_i) within the bearing cavity through one or more inlets (20), and is transported through the bearing cavity by a directional pumping means employing a mechanical pumping action at an interface between components within the bearing cavity to a grease discharge region (G_d) and an associated discharge outlet (22), where quantities of used grease are mechanically removed from the bearing cavity.



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ROLLING ELEMENT BEARING WITH DIRECTIONAL GREASE FLOW

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is related to, and claims priority to, U.S. Provisional
5 Patent Application Serial No. 61/288,061 filed on December 18, 2009, which is
herein incorporated by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

Not Applicable.

BACKGROUND OF THE INVENTION

10 The present application is related generally to large antifriction bearings, and
in particular, to an apparatus for introducing fresh grease into, and for purging
precise quantities of used grease out from, a rolling element bearing assembly
without the need to excessively increase internal pressures within the bearing
assembly resulting from an injection of large quantities of new grease into bearing
15 internal cavities.

Grease disposed within the internal cavities of a roller bearing assembly, and
around the rolling elements contained within the rolling element bearing assembly,
has a natural tendency to flow or move which is imparted by the movement and
configuration of the various elements comprising the bearing assembly.

20 Within a rolling element bearing assembly having one or more rows of
cylindrical rollers disposed between inner and outer races, a mechanical movement
of the components and cylindrical rollers does not impart any axially-directed flow on
the introduced grease. Instead, rolling bearing assemblies employing cylindrical
rollers typically rely upon an increased pressure on the grease in the bearing cavity,
25 which is generated by the introduction of excess grease into the bearing cavities, to
provide a direction to a flow of the grease towards a discharge outlets.

In contrast, within a rolling element bearing assembly having one or more
rows of tapered rollers, there is a natural tendency to impart an axially-directed
pumping on the grease injected into the bearing cavity due to the conical shape of
30 the tapered rollers. In a two-row tapered roller bearing assembly wherein small ends

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of each row of tapered rollers are disposed towards each other, non-directed grease inlets are commonly provided to introduce grease into the common central bearing cavity between the rows of tapered rollers, and by an application of pressure, push the grease axially outward from the central bearing cavity the towards the adjacent rows of tapered rollers. However, the application of pressure and the non-directed introduction of the grease creates a likelihood for an unbalanced flow of grease through the two rows of tapered rollers, and the possibility of that one of the rows of rollers may suffer from grease starvation. In order to avoid grease starvation, it is a common practice to inject excess grease into the bearing cavity, with the hope that the excess grease will result in at least some grease reaching both rows of tapered rollers.

In large tapered roller bearing assemblies such as those which are used on wind power turbines, it is additionally desirable to remove the grease from the bearing assemblies after the grease has served as a grease for a period of time due, to the introduction of contaminants into the grease, as well as a possible breakdown of the lubricating characteristics. To assure a proper quantity and condition of grease in the large tapered roller bearing assembly, small quantities of grease are frequently introduced into the bearing cavity. However, it is often necessary to add a large amount of grease into the bearing cavity through one or more grease inlets both build sufficient pressure within the bearing assembly to force out the used grease, and to ensure that the introduced grease flows to all required surfaces. The processes of forcing out used grease, or providing flow directionality by utilizing excessive amount of new grease, each require generating high internal pressures within the bearing cavity, and can result in leakage of seals about the bearing axial faces as well as excessive wear of the seal components. Excess grease present in a bearing assembly is worked and carried by the tapered rollers, requiring additional energy which is transformed into heat.

Accordingly, it would be advantageous to provide a system and method by which fresh grease may be introduced into a rolling element bearing assembly in precise amounts, which does not exclusively require the use of increased internal

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grease pressures within the rolling element bearing assembly either to eject used grease, or to impart a desired flow directionality. It would be further advantageous to provide a directed pumping action to fresh grease introduced into a bearing cavity to maintain a uniform distribution without requiring the introduction of excessive quantities of grease.

BRIEF SUMMARY OF THE INVENTION

Briefly stated, the present disclosure provides a rolling element bearing assembly, having at least one row of rolling elements contained within a bearing cavity for rolling engagement between an inner race and an outer race by a retainer or cage, with a directional flow of grease within the bearing cavity. The grease is delivered to selected locations within the bearing cavity through one or more grease inlets, and is transported through the bearing cavity by mechanical pumping action to a grease discharge outlet or port, where quantities of used grease are mechanically removed from the bearing cavity.

In one embodiment of the present disclosure, the rolling element bearing assembly includes at least one row of rolling elements in rolling engagement with raceways on the inner and outer races, retained within pockets of the retainer. One or more grease inlets are provided in at least one of the bearing races or structures to which the races are fitted, adjacent a first axial end of the rolling elements, and are configured to introduce grease into the bearing cavity in proximity to an interface between the retainer and a supporting land on either the inner or outer race. Axially opposite the rolling elements from the inlets are one or more grease purge ports or discharge openings in at least one of the bearing races or structures to which the races are fitted. Surface grooves or channels on either the surface of the supporting land or the retainer, and/or on pocket sidewalls in the retainer, are configured to impart a directional pumping action on the introduced grease, moving the grease from the vicinity of the grease inlets towards and/or along the rolling elements, and eventually into the vicinity of the grease purge ports or discharge openings.

In another embodiment, to further facilitate removal of the grease moving through the bearing assembly of the present disclosure in a directed flow from the

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grease inlets, a purge port charging device is disposed to be rotationally carried past the grease purge ports or discharge openings during operation of the bearing assembly. The purge port charging device accumulates quantities of grease within an entrapment region adjacent to the grease purge ports or discharge opening during the rotational movement, and forces the accumulated quantities of grease into the grease purge ports or discharge openings for removal from the bearing cavity as it is carried past them.

In a further embodiment of the present disclosure, the rolling element bearing assembly includes two or more rows of tapered rollers retained for rolling engagement between an inner race and an outer race, within pockets of a retainer. Each tapered roller has a small end and a large end, and for each row of tapered rollers, one or more associated directed grease inlets are provided in at least one of the bearing races or structures to which the races are fitted. The inlets are disposed to deliver a "row" independent directed flow of grease at the small end of the tapered rolling elements. During the rolling engagement, the conical configuration of the tapered rolling elements imparts a directional flow to the delivered grease from the small end towards the large end of the tapered rollers, where it is discharged from the bearing cavity via one or more grease purge ports or discharge openings in at least one of the bearing races or structures to which the races are fitted.

In an alternate embodiment, removal of the used grease moving through the bearing assembly of the present invention in a directed flow from the grease inlets to the grease purge ports or discharge openings is facilitated by a suction purge device disposed to draw the grease through the grease purge ports or discharge openings via suction. The suction device removes the grease from the bearing interior cavity thoroughly enough that axial ends of the bearing may be enclosed by close-contact or labyrinth seals without preloaded lips, without resulting grease leakage through the seals.

The foregoing features, and advantages set forth in the present disclosure as well as presently preferred embodiments will become more apparent from the reading of the following description in connection with the accompanying drawings.

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BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

In the accompanying drawings which form part of the specification:

Figure 1 is a cross section of a single-row cylindrical roller bearing assembly for supporting a rotating shaft in a housing, configured with a grease delivery and discharge system of the present disclosure;

Figure 2 is a partial view of the outer circumferential surface of the retainer and a secured cylindrical roller of Fig 1, illustrating the position and orientation of surface features on the retainer for imparting a directional flow to delivered grease within the bearing cavity;

Figure 3 is an axial section view of a portion of the bearing assembly of Fig 1, illustrating the accumulation and movement of grease within the bearing cavity and on the retainer surfaces;

Figure 4 is an isometric view of a purge port charger component of the bearing assembly of Fig. 1;

Figure 5 is an isometric view of a portion of an alternate configuration for the retainer element of the bearing assembly of Fig 1, configured with surface features on the inner surfaces of the roller pockets for imparting a directional flow to delivered grease within the bearing cavity;

Figure 6 is a sectional view of double-row tapered roller bearing assembly with a stationary outer ring, configured with a grease delivery and discharge system of the present disclosure;

Figure 7 is a sectional view of one row of a multi-row tapered roller bearing assembly with a stationary inner ring, configured with a grease delivery and discharge system of the present disclosure;

Figure 8 is a cross section of a single-row spherical roller bearing assembly for mounted between a rotating shaft and a housing, configured with a grease delivery and discharge system of the present disclosure;

Corresponding reference numerals indicate corresponding parts throughout the several figures of the drawings. It is to be understood that the drawings are for illustrating the concepts set forth in the present disclosure and are not to scale.

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Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings.

5 DETAILED DESCRIPTION

The following detailed description illustrates the invention by way of example and not by way of limitation. The description enables one skilled in the art to make and use the present disclosure, and describes several embodiments, adaptations, variations, alternatives, and uses of the present disclosure, including what is
10 presently believed to be the best mode of carrying out the present disclosure.

In general, the present disclosure provides a row independent, directional flow of grease G to a rolling element bearing assembly 10, having at least an inner race 14 with an outwardly presented raceway, an outer race 16 with an inwardly presented raceway, and a set of rolling elements 12, such as cylindrical rollers,
15 tapered rollers, spherical rollers, or balls disposed within a bearing cavity C between the inner and outer races in rolling engagement with the inner and outer raceways. The rolling elements 12 are generally disposed within pockets 17 of a retainer or cage 18, and the axial ends of the bearing cavity C are enclosed by seals S1 and S2. The seals S1 and S2 may be supported directly by the bearing races, or may be
20 fitted to other structures in operative proximity to the bearing races, such as a housing or shaft onto which the bearing is disposed.

The grease G is delivered in precise quantities to selected grease delivery regions G_i within the bearing cavity C through one or more grease inlets 20 and associated grease passages provided in at least one of the bearing races or
25 associated structures such as a housing or shaft to which the races are fitted. The grease G is transported through the bearing cavity C by mechanical pumping action from a directional pumping means employing grooved surfaces to one or more grease discharge regions G_d having grease discharge outlets 22 provided in at least one of the bearing races or associated structures to which the races are fitted, where
30 quantities of used or contaminated grease G are mechanically removed from the

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bearing cavity C through grease discharge passages without requiring the addition of excess grease G into the bearing cavity C.

Referring to the figures, and to Figure 1 in particular, a rolling element bearing assembly 10 is shown configured with a single-row of cylindrical rollers 12a between
5 a rotating shaft 24 and a stationary housing 26. Within the bearing cavity C of the bearing assembly, the retainer or cage 18 is operatively supported about an outer circumferential surface 18a at opposite axial ends at an interface with a land support surface 28a on the support lands 28 carried by the stationary outer race 16. Those of ordinary skill in the art will recognize that the support lands 28 and supporting
10 surfaces 28a may alternatively be disposed on the inner race 14, and may be configured to operatively support the retainer or cage 18 on an inner circumferential surface 18b.

A precise or metered quantity of grease G is delivered into the bearing cavity C through one or more grease inlet ports 20, which discharge the grease into the
15 bearing cavity C at one axial end of the cylindrical rolling elements 12a, in the vicinity of the contact region or interface between the retainer 18 and the support land 28 supporting surface 28a, axially within the limits of the retainer 18. As shown in Figure 1, the grease inlet port 20 may be disposed in the housing 26 within which the outer race 16 is fitted, but those of ordinary skill in the art will recognize that the inlet port
20 20 may be disposed in one of the races 14 or 16, such as shown in Figure 8 illustrated with a single-row of spherical rollers 12c, and aligned with passages in the adjacent structures, without departing from the scope of the present disclosure,

The delivery of the grease G from the grease inlet port 20 to the bearing cavity C may be metered in discrete quantities, at discrete time intervals, or both, as
25 is required to provide adequate grease to the bearing assembly 10. Surface features 30 on the circumferential surface 18a of the retainer 18 or the supporting surface 28a of the support land 28, at the interface between the retainer and support land are configured to impart a directional flow to the delivered grease G, such that it is not necessary for the region of the bearing cavity C between the retainer 18 and the
30 seal S1, adjacent to the grease inlet ports 20, be fully filled with, or pressurized with,

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grease to ensure delivery of sufficient grease to the surfaces of the rolling element 12.

As seen in Figure 2, the surface features 30 on the retainer 18 are defined by multiple grooves in the circumferential surface 18a, 18b facing the supporting land 28. The grooves are generally aligned diagonally with respect to the axis of rotation of the bearing assembly, such that grease G delivered from the grease inlet ports 20 in the vicinity of the interface between the retainer circumferential surface 18a, 18b and the surface 28a of the support land 28 is imparted with a directional flow towards the rolling elements 12 by the rotational movement of the bearing assembly components within the bearing cavity C.

At the axially opposite end of the rolling element 12 from the grease inlet ports 20, the surface features 30 in the region of the support land 28 acquire accumulated grease G from the vicinity of the axial end of the rolling element 12, and impart it with a directional flow away from the rolling element 12 back into the bearing cavity C adjacent to the discharge port 22. As shown in Figure 1, the grease discharge port 22 may be disposed in the housing 26 within which the outer race 16 is fitted, but those of ordinary skill in the art will recognize that the grease discharge port 22 may be disposed in one of the races 14 or 16, such as shown in Figure 8 and aligned with passages in the adjacent structures without departing from the scope of the present disclosure.

As the grease G moves axially along the rolling elements 12, a quantity of grease G will become attached to the surfaces 18a and 18b of the retainer or cage 18 between adjacent rolling elements 12, as seen in Figure 3. This accumulation serves as a grease reservoir for lubricating the contact surfaces between the rolling elements 12 and the raceway surfaces of the inner race 14 and outer race 16.

Accumulations of grease G in the grease discharge region G_d of the bearing cavity C, adjacent to the grease discharge port or outlet 22, can be expelled from the bearing cavity C by a combination of mechanical action, suction, and/or bearing cavity pressure. For example, as seen in Figure 4, a purge port charging device 40 may be secured to a rotating component of the bearing assembly 10, such as the

inner race 14 (as shown in Fig. 8) or the rotating shaft 24 (as shown in Fig. 1), in operative relationship to an opposite adjacent stationary surface such as the outer race 16 (as shown in Fig. 8) or housing 26 (as shown in Fig. 1) in which the grease discharge ports or outlets 22 are located, in axial alignment with the grease discharge ports or outlets 22. The purge port charging device 40 could alternatively
5 be attached to the stationary component for facilitating a discharge of grease to an opposite surface of a rotating component containing the grease discharge ports or outlets in axial alignment with the purge port charging device.

The purge port charging device 40, as shown in Fig. 4, consists of an annular
10 member 41 coupled to the rotating component, and a shoe 42 which is biased towards the opposite surface by one or more springs 44. The shoe 42 includes an inclined surface 46 defining a grease entrapment region 48 adjacent to the opposite surface from the annular member 41. As the purge port charging device 40 is rotationally moved past the grease discharge ports or outlets 22 disposed in the
15 opposite surface, used grease G is swept up by, and accumulates within, the grease entrapment region 48 of the purge port device, against the opposite surface, and is mechanically forced into the grease discharge ports or outlets 22 by the inclined surface 42 as the ports or outlets are carried under the grease entrapment region 48. The grease G is then subsequent discharged from the bearing assembly 10
20 through the grease discharge ports or outlets 22 and associated grease passages. To facilitate the discharge of the grease G, a suction pressure may be externally applied to the grease discharge ports or outlets 22 by a suitable external pump or suction device, such as shown in Figure 6. When suction is used, the opening of the grease discharge ports or outlets 22 in operative proximity to the port charging
25 device 40 must have a suitably small opening to be fully closed by each delivered grease charge.

Preferably, the purge port charging device 40 and the grease discharge ports or outlets 22 are capable of removing more grease G from the bearing cavity C than what is intended to flow through the bearing assembly 10. The components of the
30 bearing assembly 10 will push out all but the minimum required amount of grease G

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required for the bearing assembly 10 to operate properly. The rate at which the grease G is delivered to the bearing cavity C through the grease inlet ports 20 determines the flow rate through the bearing assembly 10, and prevents an excess accumulation of grease adjacent to the seals S1 and S2 in the bearing cavity C.

5 Because there is very little accumulation of grease G in the grease delivery regions G_i or discharge regions G_d of the bearing assembly 10 when using an external suction device, the bearing assembly 10 does not require internal pressures to remove excess or used grease G from the bearing cavity C, and the bearing assembly 10 does not require the use of lip-force or rubbing-lip type seals to prevent

10 the escape of grease G. Rather, axial seals S1 and S2 may be close clearance seals with multiple chambers, typically known as a labyrinth seals, as shown in Figures 1 and 8.

The directional pumping means may employ additional features within the bearing assembly 10 in order to facilitate the directed flow of grease G within the bearing cavity C and past the rolling elements 12. For example, as shown in Figure

15 5, the retainer or cage 18 includes pockets or openings 17 into which the rolling elements 12 are disposed. The sidewall surfaces 17a of the pockets 17 may be configured with surface features or grooves 32 at the interface with the associated rolling elements, which function in the same manner as the surface features or

20 grooves 30 on the retainer support surfaces 18a (or 18b) or land support surface 28a as previously described. The surface features or grooves 32 on the sidewalls 17a of the pockets 17 impart a directional flow to grease as it is rotationally carried between the pocket sidewall and the exterior surface of the associated rolling element 12 contained within the pocket. The surface features or grooves 32 are

25 preferably aligned diagonally with respect to the bearing assembly radial direction, in an orientation selected to impart a directional flow to the grease G from the grease delivery region G_i of the bearing assembly 10 towards the grease discharge port or outlet side. These surface features or grooves 32 may be used alone, such as where the retainer 18 is not in close placement with a supporting land 28, or in

30 combination with the surface features or grooves 32 on the retainer support surface

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18a, 18b or supporting land 28, to impart the desired directional flow to the grease G within the bearing cavity C.

It will be recognized that the embodiments of the present disclosure for imparting a directional flow to grease G within a bearing assembly 10 are not limited to the specific configuration of a rolling element bearing assembly 10 and retainer 18 as shown in Figures 1 or 8, but rather, may be readily adapted for use with antifriction bearing assemblies having a variety of different configurations. For example, Figure 6 illustrates a double-row tapered roller bearing assembly 100 having two rows of tapered rollers 12b contained within a bearing cavity C. The bearing assembly 100 is configured to impart a directional flow to grease G within the bearing cavity C. The tapered rollers 12b are disposed in axially adjacent rows, with small ends of the tapered rollers 12b positioned axially outward from the large ends, arranged between a rotating inner race 114 and a stationary outer race 116, within pockets 117 of associated retainers or cages 118. Opposite axial ends of the bearing assembly 100 are enclosed by seals S3 and S4, which may be of a close clearance or labyrinth configuration.

During operation of the bearing assembly 100 shown in Figure 6, the grease G is delivered in precise quantities to selected grease delivery regions G_i within the bearing cavity C, adjacent to the axially outward small ends of the tapered rollers 12b, through one or more directed grease inlets 120 associated with each row of rolling elements, where it can enter the rolling element contact region without filling the bearing cavity C adjacent to the seals (S3, S4). The flow rate of the grease to each of the directed grease inlets 120 may be identical, or may be regulated and controlled individually, enabling control over the rate of directional flow of the grease G axially through the bearing cavity C at each row of rolling elements. The grease G is transported axially inward through the bearing cavity C by mechanical pumping action imparted from the conical configuration of the tapered rolling elements 12b, and/or surface features on the retainer or cage 118 or a supporting land surface, to one or more centrally disposed grease discharge outlets 122, where quantities of used or contaminated grease G are mechanically removed from the bearing cavity C

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without requiring the addition of excess grease G into the bearing cavity C. Accumulations of grease G in the central grease discharge region G_d of the bearing cavity C, between the rows of tapered rollers 12b and adjacent to the grease discharge ports 122 can be expelled from the bearing cavity C mechanically, by suction from a suction pump, or by a combination of mechanical action and suction. For example, as seen in Figure 6, a purge port charging device 140 may be secured to a rotating component of the bearing assembly 100, such as the inner race 114 or shaft, in operative relationship to an adjacent stationary surface such as the outer race 116 or housing, in which the grease discharge ports or outlets 122 are located.

Figure 7 illustrates a second example of an alternate configuration for a tapered roller bearing assembly embodying the features of the present disclosure, in which a rolling element bearing assembly 200 supports multiple rows of tapered rollers 12b, between a stationary inner race 214 and a rotating outer race 216. The tapered rollers 12b, only one row of which are shown in Figure 7, are disposed within pockets 217 of an associated retainer or cage 218. The rolling element bearing assembly 200 is configured to provide a row independent, directional flow of grease G through the bearing cavity C, by delivering the grease G in precise quantities to selected locations within the bearing cavity C adjacent to the small ends of the tapered rollers 12b, through one or more directed grease inlets 220 passing through the inner race 214. The delivered grease G can enter the roller contact region for each row of tapered rollers 12b without filling the bearing cavity C, and is transported axially through the bearing cavity C by a mechanical pumping action imparted from the conical configuration of the tapered rollers 12b, and/or surface features on the retainer or cage 218 or supporting land, and is discharged from the bearing cavity C adjacent to the large end of the tapered rollers 12b, such as through a grease purge port or outlet. Accumulations of grease G adjacent to the large end of the tapered rollers 12b can be expelled from the bearing cavity C mechanically, by suction, or by a combination of mechanical action and suction, as previously described.

As various changes could be made in the above constructions without departing from the scope of the disclosure, it is intended that all matter contained in

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the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense. For example, those of ordinary skill in the art will recognize that the features for imparting a directional flow to the lubricating grease within the bearing cavity C may be utilized for antifriction bearing assemblies

5 wherein the inner race is rotating with an associated shaft while the outer race remains stationary in an associated housing, or the converse, wherein the inner race remains stationary with an associated shaft, while the outer race rotates with an associated housing. Similarly, the specific placement of the grease inlet ports 20, 120 and discharge ports 22, 122 may be either through one or both of the bearing

10 races, or may be through one of both of the associated housing or shaft, provided that the supplied grease is deposited in a grease delivery region G_i in proximity to one axial end of the rolling elements in the bearing cavity C, and discharged from the grease discharge region G_d at an opposite axial end. The rolling elements themselves may be of any suitable configuration for the particular application in

15 which the bearing assembly 10 is to be employed, and may include cylindrical rollers, tapered rollers, spherical rollers, or balls. Finally, the placement of the seals at axial ends of the bearing assembly 10 to enclose the bearing cavity C need not be limited to close contact seals carried by the bearing outer race, but rather may include seals carried by the inner race, the shaft, the housing, or some other

20 adjacent support structure, provided that the seals perform the required functionality of retaining grease within the bearing cavity C and preventing contaminate ingress.

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CLAIMS:

1. A grease lubricated rolling element bearing assembly (10) for transferring loads between a shaft (24) and a housing (26), including an outer race (16) having an inwardly directed raceway, an inner race (14) having an outwardly directed raceway, and at least one set of rolling elements (12) disposed between the
5 inner and outer races for rolling engagement with the raceways within an interior bearing cavity (C) into which a grease (G) is delivered to a grease delivery region (G_i) through one or more grease inlet ports (20), comprising:

a retainer (18) associated with said rolling elements (12), said retainer
10 securing said rolling elements in a spaced arrangement within said interior bearing cavity (C);

a directional pumping means operatively associated with at least one surface (17a, 18a, 18b) of said retainer, said directional pumping means configured with grooves to mechanically impart a directional flow to the grease (G) from said grease
15 delivery region (G_i) towards a grease discharge region (G_d).

2. The bearing assembly of Claim 1 further including a land support (28) carried by one of said inner and outer races (14, 16), said land support having a land surface (28a) disposed towards a surface (18a, 18b) of said retainer (18); and

wherein said directional pumping means includes a plurality of directional
20 grooves (30) disposed on at least one of said surfaces (18a, 18b, 28a) at the retainer and support land interface, whereby grease disposed at an interface between said retainer surface and said land surface is mechanically imparted with a directional flow from said plurality of grooves.

3. The bearing assembly of Claim 1 wherein said rolling elements are
25 retained within pockets (17) of said retainer having sidewall surfaces (17a); and

wherein said directional pumping means is operatively associated with said sidewall surfaces, said directional pumping means including a plurality of directional grooves (32) disposed on said sidewall surfaces (17a) at an interface with said associated rolling elements, whereby grease disposed at said interface is
30 mechanically imparted with a directional flow from said plurality of grooves.

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4. The bearing assembly of Claim 1 wherein said rolling elements are cylindrical rollers.

5. The bearing assembly of Claim 4 further comprising at least one grease discharge port (22) in said grease discharge region (G_d) through which used grease (G) is discharged from the bearing cavity (C), wherein said grease discharge port (22) is disposed on one of said inner race (14) or said outer race (16);

further including a purge port charger (40) carried by the other of said inner race (14) or said outer race (16) in axial alignment with said grease discharge port; and

10 whereby said purge port charger is configured with a grease entrapment region to accumulate grease for mechanical discharge into said grease discharge port (22) as said grease discharge port (22) is rotationally carried past said grease entrapment region by the relative rotation of the inner race (14) and the outer race (16).

15 6. The bearing assembly of Claim 5 further including a suction device configured to draw grease through said grease discharge port (22).

7. The bearing assembly of Claim 1 further including a grease discharge port (22) in said grease discharge region (G_d), said grease discharge port configured to discharge a flow of used grease from said grease discharge region (G_d); and

20 wherein said grease inlet port (20) and said grease discharge port (22) are both carried by one of said housing, said shaft, said inner race, or said outer race.

8. A grease lubricated bearing assembly (10) for transferring loads between a shaft (24) and a housing (26), including an outer race (16) having an inwardly directed raceway, an inner race (14) having an outwardly directed raceway, and at least two rows of rolling elements (12) disposed between the inner and outer races for rolling engagement with the raceways, each row of rolling elements secured in a spaced arrangement by a retainer (18), the bearing assembly having an interior bearing cavity (C) into which a grease (G) is delivered to a grease delivery region (G_i) through one or more grease inlet ports (20), comprising:

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at least one grease inlet (20) for each row of said rolling elements, each of said grease inlets disposed within an axial limit of an associated retainer for said row of rolling elements; and

a means for imparting a directional flow towards said grease discharge region (G_d) for said grease (G) delivered to each row of rolling elements.

9. The bearing assembly of Claim 8 wherein said rolling elements are tapered rollers and at least one grease inlet port (20) is at a small diameter end of each of said rows of rolling elements.

10. The bearing assembly of Claim 9 further comprising at least one grease discharge port (22) in a grease discharge region (G_d) through which used grease (G) is discharged from the bearing cavity (C), wherein said grease discharge port (22) is disposed on one of said inner race (14) / shaft (24) or said outer race (16) / housing (26);

further including a purge port charger (40) carried by the other of said inner race (14) / shaft (24) or said outer race (16) / housing (26) in axial alignment with said grease discharge port; and

whereby said purge port charger is configured with a grease entrapment region to accumulate grease for mechanical discharge through said grease discharge port (22) as said grease discharge port (22) is rotationally carried past said grease entrapment region by the relative rotation of the inner race (14) / shaft (24) and the outer race (16) / housing (26).

11. The bearing assembly of Claim 8 further including a suction device configured to draw grease through said grease discharge port (22).

12. The bearing assembly of Claim 9 wherein said grease discharge region (G_d) for said grease (G) is axially between two rows of rolling elements, and wherein said imparted directional flow of said grease (G) is axially inward along each of said two rows of rolling elements.

13. A grease lubricated bearing assembly (10) for transferring forces between a shaft (24) and a housing (26), including an outer race (16) having an inwardly directed raceway, an inner race (14) having an outwardly directed raceway,

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and at least one two rows of rolling elements (12) disposed between the inner and outer races for rolling engagement with the raceways, each row of rolling elements, the bearing assembly having an interior bearing cavity (C) axially enclosed by seals (S1, S2) into which a grease (G) is delivered to a grease delivery region (G_i) through one or more grease inlet ports (20) disposed on one of said inner race (14) / shaft (24) or said outer race (16) / housing (26), and at least one grease discharge port (22) disposed on one of said inner race (14) / shaft (24) or said outer race (16) / housing (26) in a grease discharge region (G_d) through which used grease (G) is discharged from the bearing cavity (C), comprising:

a means for imparting a directional flow to said grease (G) from said grease delivery region (G_i) towards said grease discharge region (G_d);

a purge port charger (40) carried by the other of said inner race (14) / shaft (24) or said outer race (16) / housing (26) relative to, and in axial alignment with, said grease discharge port, said purge port charger configured with a grease entrapment region adjacent to an opposed surface to accumulate grease for mechanical discharge into said grease discharge port (22) as said grease discharge port (22) is rotationally carried past said grease entrapment region by the relative rotation of the inner race (14) / shaft (24) and the outer race (16) / housing (26);

an external suction device configured to draw said grease (G) through said grease discharge port (22) after said grease is mechanically discharged by said purge port charger (40); and

wherein said seals (S1, S2) at opposite axial ends of said bearing assembly are close-clearance seals.

14. The bearing assembly of Claim 13 wherein said rolling elements (12) are cylindrical rollers (12a) or spherical rollers (12c).

15. The bearing assembly of Claim 13 wherein said rolling elements (12) are tapered rollers (12b).

16. The bearing assembly of Claim 15 wherein said set of rolling elements (12) is arranged in at least two rows between said inner race (14) and said outer race (16).

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17. A method for grease lubrication of a rolling element bearing assembly (10), comprising:

delivering a quantity of grease (G) to a grease delivery region (G_i) within said bearing assembly through a grease delivery inlet (20, 120);

5 mechanically imparting an axially directed flow to said delivered quantity of grease during rotational operation of said rolling element bearing assembly;

receiving a portion of said quantity of grease at a grease discharge region (G_d) within said bearing assembly, said grease discharge region axially opposite a set of rolling elements (12) from said grease delivery region (G_i); and

10 mechanically expelling said portion of said grease from said grease discharge region through a grease discharge port (22, 122).

18. The method of Claim 17 wherein for a multi-row rolling element bearing assembly, a rate of said axially directed flow of grease (G) is independently controlled for each discrete row of rolling elements (12) by an inlet flow rate for said
15 grease at an associated directed grease inlet (120).

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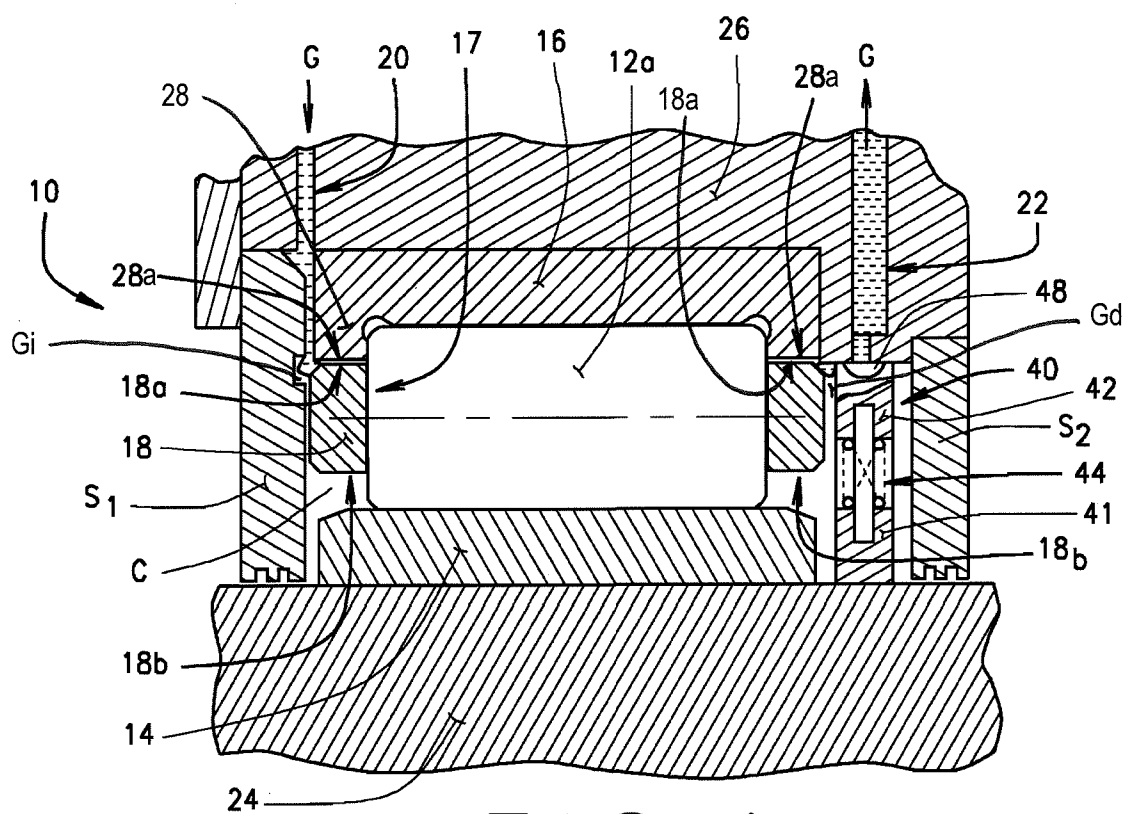


FIG. 1

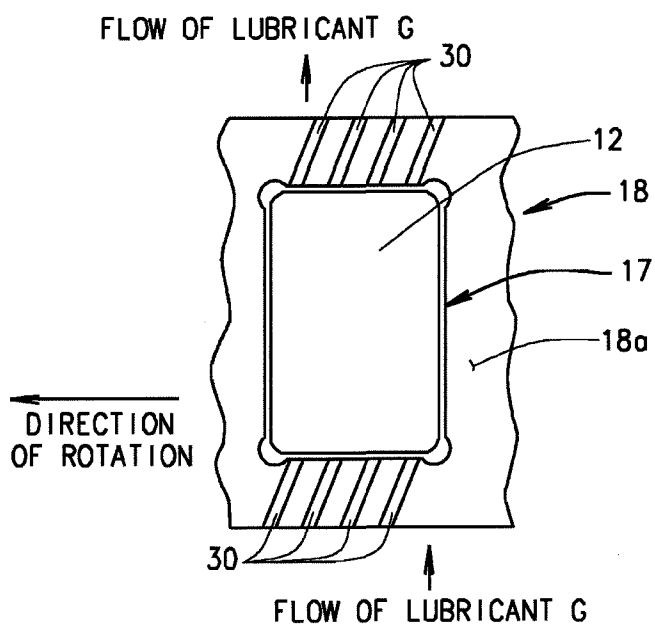


FIG. 2

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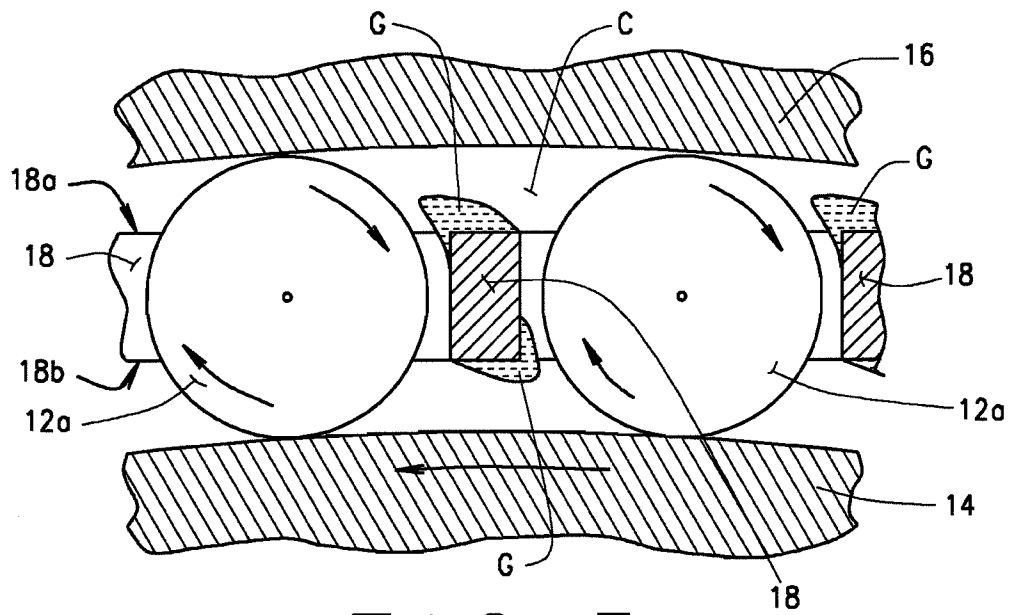


FIG. 3

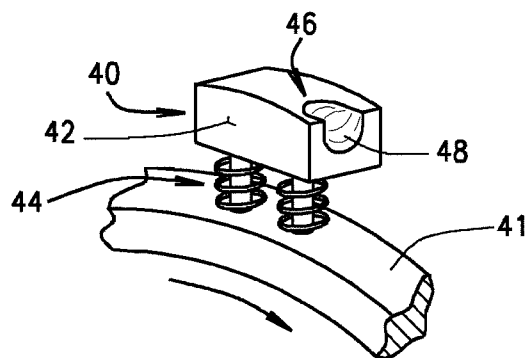


FIG. 4

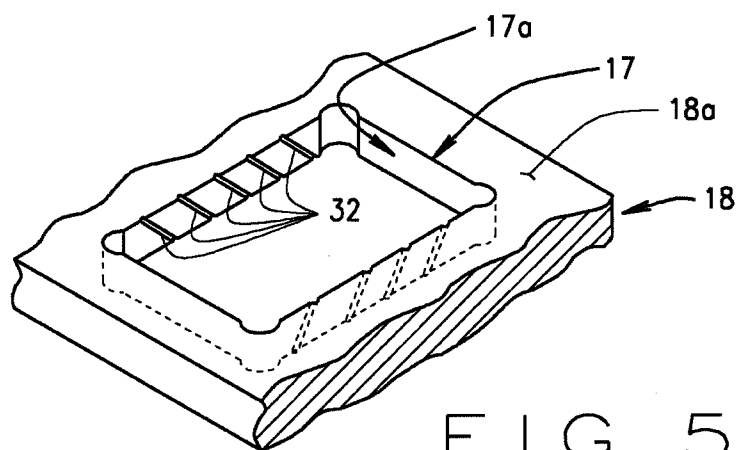


FIG. 5

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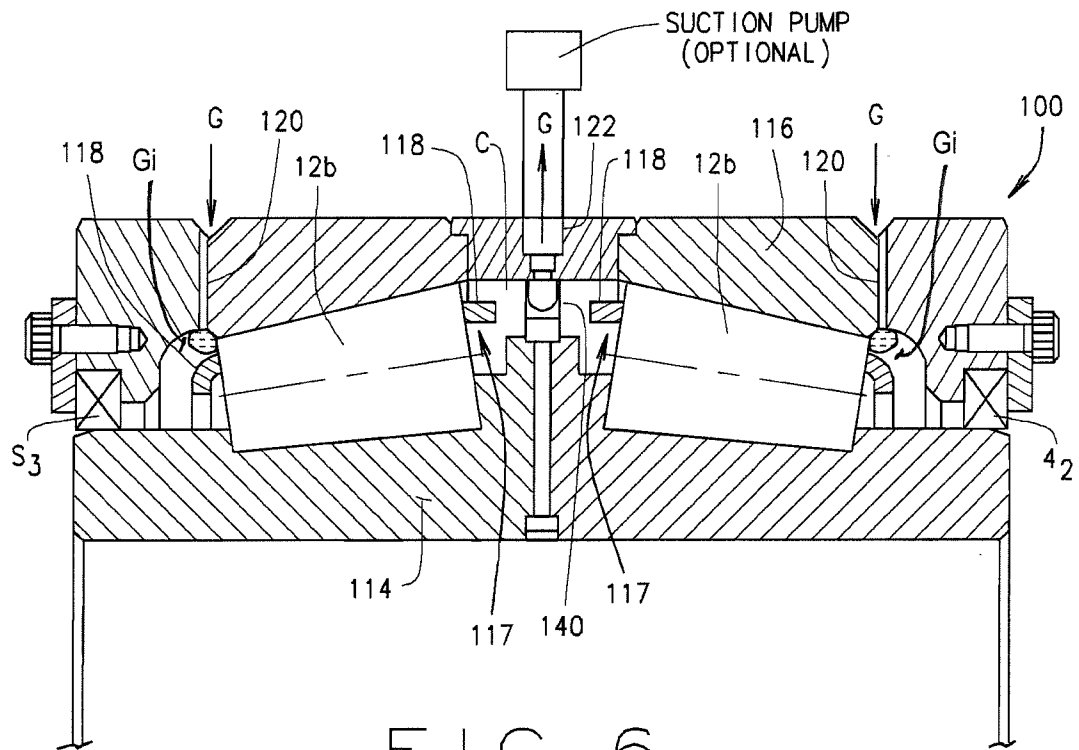


FIG. 6

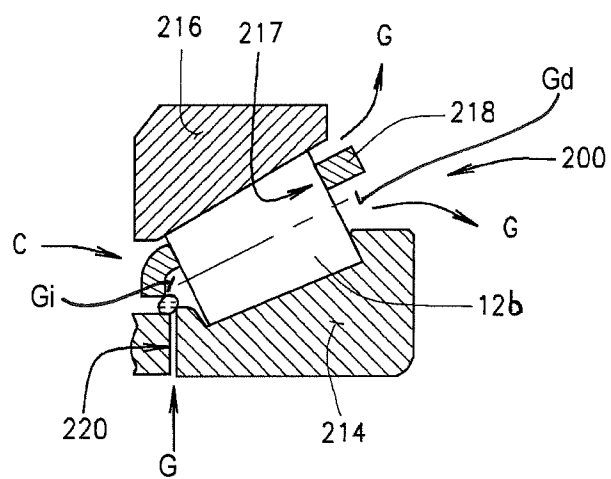


FIG. 7

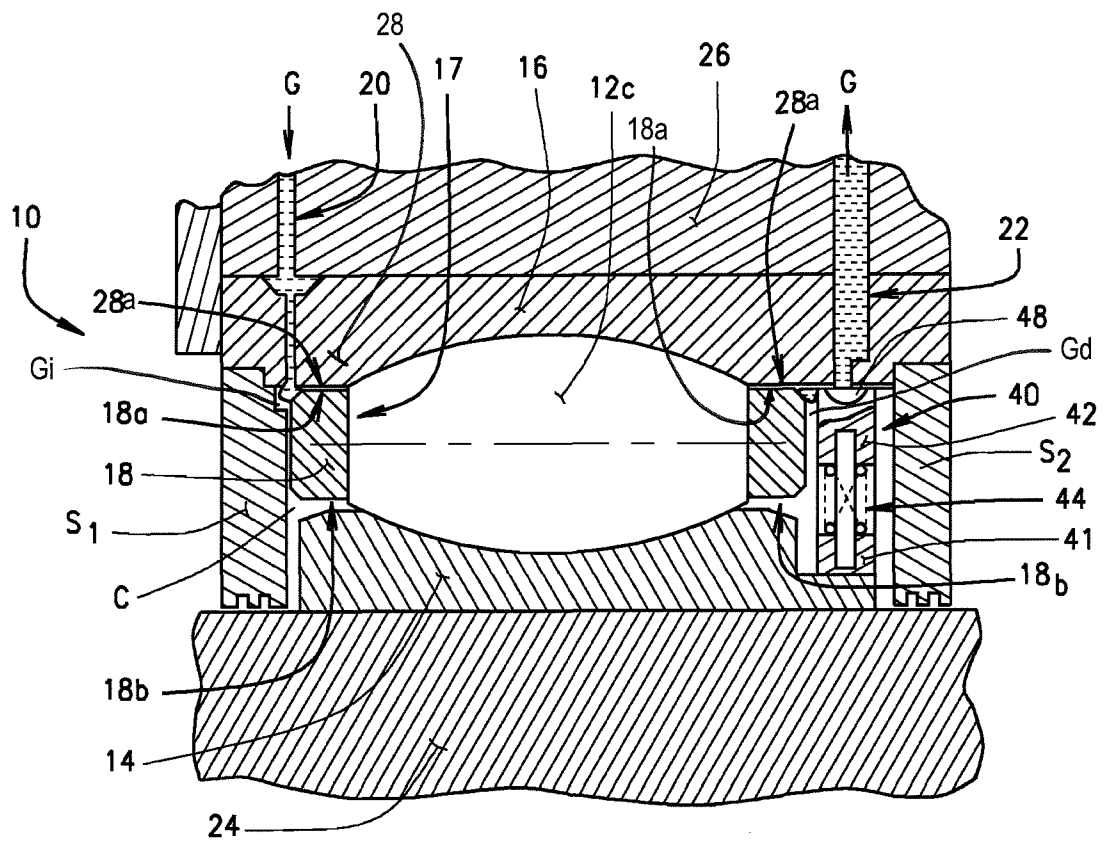


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/60962

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F16C 19/00 (2010.01)

USPC - 384/462

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

USPC: 384/462

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC: 384/456, 462, 465, 471, 445, 91

(keyword limited; terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWEST (PGPB, USPT, EPAB, JPAB); Google

Search terms: oil, grease, lubricate, purge, flush, bearing, pump, et al.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 2009/0103844 A1 (Kobayashi et al.) 23 April 2009 (23.04.2009), para [0030]-[0059], Fig 1-8	17 ----- 1-16, 18
Y	US 2009/0161997 A1 (Beauchamp et al.) 25 June 2009 (25.06.2009), para [0055]-[0057], Fig 3-7C	1-16
Y	US 2006/0239598 A1 (Matsuyama et al.) 26 October 2006 (26.10.2006), para [0411], [0412], [0736], Fig 16	5, 6, 10, 13-16, 18
Y	US 5,658,053 A (Vencill et al.) 19 August 1997 (19.08.1997), col 4, ln 66 to col 5, ln 31, Fig 2, 3	12
A	US 2007/0071382 A1 (Suzuki) 29 March 2007 (29.03.2007), entire document	1-18

☐ Further documents are listed in the continuation of Box C.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search

18 February 2011 (18.02.2011)

Date of mailing of the international search report

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