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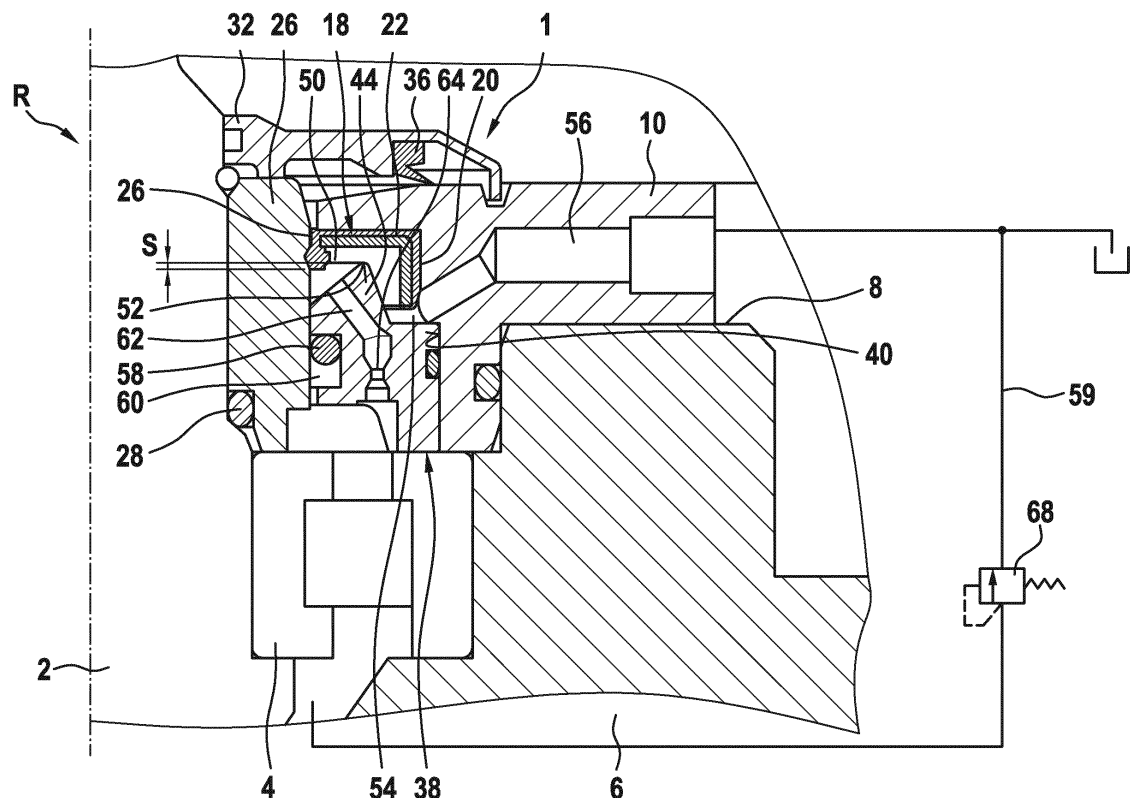
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(54) **SHAFT SEAL ARRANGEMENT AND RADIAL PISTON MACHINE**

(57) The invention discloses a shaft seal arrangement and a hydraulic machine comprising the latter, especially a radial piston machine, in which flushing of a seal ring is ensured even in the case of vertical shaft

assembly. Furthermore it discloses a shaft seal arrangement that will also decrease the strain on the seal ring when higher shaft speeds and case pressures must be used.

Fig. 2



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Description

[0001] The invention relates to a shaft seal arrangement according to the preamble of claim 1 and to a hydraulic machine, especially a radial piston machine, designed to include such shaft seal arrangement.

[0002] Radial piston machines of this type, for example radial piston motors, usually include pistons disposed in the radial direction relative to a shaft and accommodated in star shape in a cylinder block. Depending on the constructional design, oil may be applied from inside or from outside to said pistons, when viewed in the radial direction. The basic set-up of a radial piston motor to which pressure fluid is applied from inside is disclosed, for example, in the document EP 0 102 915 B1. In this concept, a drive shaft is supported in a case accommodating the cylinder block, with the shaft being sealed relative to the case via a shaft seal arrangement. An end portion of the shaft is guided out of the case and is connected to a unit to be driven via an appropriate coupling.

[0003] The shaft seal arrangement comprises, inter alia, in the area where the shaft exits the case adjacent to a shaft bearing a seal ring which is in sealing contact with the outer periphery of the shaft and is supported on the case side. For avoiding excessive wear of the seal ring, the latter is lubricated with oil. Consequently, in this area frequently a drain channel is formed through which the oil is drained to a leak line opening into a tank or an oil reservoir, for example, so that the oil surrounding the seal ring is exchanged to decrease the temperature generated by the friction between the seal lip and the counter surface, often a wear ring.

[0004] In the case of vertical assembly of the radial piston machine orientated in the direction of gravity, the seal ring is located at the top in the direction of gravity and may even be disposed above the drain channel, depending on the design concept. In such relative arrangement of the seal ring, the lubrication possibly may not be ensured in the area of contact with the shaft so that the seal ring is subjected to premature wear and needs to be replaced. Such a lack of lubrication inter alia results from the fact that, in the case of vertical assembly of the radial piston machine, in the area delimited by the seal ring, air is trapped which prevents oil from flushing the seal ring.

[0005] As compared to this, the object underlying the invention is to provide a shaft seal arrangement and a hydraulic machine configured to include such shaft seal arrangement, especially a radial piston machine, in which lubrication of the shaft seal arrangement is improved.

[0006] This object is achieved with respect to the shaft seal arrangement by the features of claim 1 and with respect to the hydraulic machine by the features of the independent claim 11.

[0007] Advantageous developments of the invention constitute the subject matter of the subclaims.

[0008] The shaft seal arrangement according to the invention comprises a seal ring including a sealing lip to

be arranged in sealing contact with a shaft and being retained by a retainer flange. The shaft seal arrangement furthermore includes a drain channel for draining leak oil. In accordance with the invention, the shaft seal arrangement is configured to include a retention ring which is disposed in an oil flow path upstream to the drain channel or in the area of the seal ring and through which oil is guided toward the seal ring.

[0009] Hence draining fluid is accumulated via said retention ring so that sufficient lubrication of the seal ring is guaranteed.

[0010] In an especially preferred embodiment of the invention, the retention ring is configured to include a retention rib extending toward the seal ring and accumulating the oil up into the area of the sealing lip. Such accumulation constantly ensures, even in the case of vertical assembly, i.e. with a seal ring located at the top in the direction of gravity, that sufficient oil is present in the contact area of the seal ring with the shaft.

[0011] According to an advantageous development of the invention, the retention rib is configured so as to delimit an oil reservoir which is in fluid communication with the drain channel.

[0012] The seal ring may take an U-shaped profile, with the retention rib then extending into the space spanned by the two legs in the U.

[0013] In such configuration of the seal ring, an area distant from the sealing lip together with a rear side of the retention rib may form an oil outlet reduced in cross-section which opens into the drain channel.

[0014] It is usually advantageous to the function of the shaft seal arrangement when the pressure prevailing in the case to be sealed is relatively low. In several applications, for example in heavy-duty hydraulic machines, an elevated case pressure may be advantageous. For improving the sealing in the event of those high internal case pressures, another embodiment provides to design a radial seal in an area between the shaft and the retention ring so that basically the sealing is carried out by two seal elements, viz. the seal ring and the radial seal. In this way, reliable sealing is ensured even with high internal case pressures.

[0015] In such solution, oil may be supplied to the contact area of the seal ring by means of a flush channel passing through the retention ring and opening, on the one hand, in the area of the retention rib and, on the other hand, on the case side. The oil outlet from the retention rib is chosen so that the oil is guided toward the seal ring.

[0016] Excessive pressurization of the seal ring can be prevented by arranging an orifice inside the flush channel.

[0017] The afore-described higher pressure prevailing in the case may be obtained by providing a pressure relieve valve in the case drain channel into which the seal drain channel opens downstream, with the pressure being adjustable via the pressure relief valve in the case drain channel and thus also in the contact area of the seal ring. The flow rates through the seal drain channel

may be controlled by either an orifice or a flow control valve, either applied upstream or downstream of the seal. In an especially compact design, the seal drain channel is configured in the seal retainer flange.

[0018] The radial piston machine according to the invention comprises, as afore explained, a shaft which is supported in a case by means of a shaft bearing, wherein the sealing between the case and the shaft is realized by a shaft seal arrangement configured in accordance with the afore-mentioned designs.

[0019] In the following, a preferred embodiment of the invention shall be illustrated in detail by way of schematic drawings, wherein:

Figure 1 shows a sectional view of a shaft seal arrangement according to the invention as applied in a radial piston machine,

Figure 2 shows another embodiment of a shaft seal arrangement as applied in a radial piston machine, and

Figure 3a, 3b show symbolic drawings of hydraulic machines provided with a shaft seal arrangement according to the embodiments shown in Figures 1 and 2.

[0020] Figure 1 illustrates a partial representation of a shaft seal arrangement 1, for example of a radial piston motor R. As explained in the beginning, such radial piston motor R comprises a shaft 2 being supported via a bearing arrangement, for example including an anti-friction bearing 4, in a case 6 which in turn accommodates a cylinder block (not shown) including pistons radially disposed relative to the shaft 2. Said pistons may be pressurized by pressure fluid in the radial direction from inside or from outside. Since the basic set-up of such radial piston motors is known, further explanations regarding the set-up of such radial piston motors may be dispensed with.

[0021] In the embodiment shown in Figure 1, a seal retainer flange 10 immersing by an annular collar 12 into a stepped mount 14 of the case 6 is fastened to a front face 8 of the case 6. In the contact area of the annular collar 12 with the mount 14 an O-ring 16 is provided. In the axial direction the mount 14 also bears against an outer ring of the anti-friction bearing 4.

[0022] The seal retainer flange 10 includes a recess 17 which opens toward the shaft 2 and into which a seal ring 18 is inserted. The latter includes an annular wall 20 orientated in the vertical direction in the representation of Figure 1 which annular wall 20 bears against the angular recess 17 in the radial direction. The annular wall 20 merges into an annular front wall 22 extending in the radial direction at the inner peripheral portion of which facing the shaft 2 a sealing lip 24 is formed which is in sealing contact with a wear ring 26 being fastened to the shaft 2. The front wall 22 bears against the portion of the

recess 17 extending in the horizontal direction in Figure 1. The wear ring 26, in turn, is sealed relative to the shaft 2 via an O-ring 28. As illustrated in Figure 1, the wear ring 26 is adjacent to the inner bearing ring of the anti-friction bearing 4.

[0023] For the purpose of improving the dimensional stability of the seal ring 18, the latter is reinforced by means of a dimensionally stable support ring 30 made from metal, for example, whereas the front wall 22 and the annular wall 20 are made from polymer material optimized regarding the sliding characteristics and the sealing. The contour of said support ring 30 is adapted to that of the annular wall 20 and of the front wall 22, and together with the sealing lip 24 and the wear ring 26 it approximates an up-side-down U-shaped set-up, resulting in the representation according to Figure 1.

[0024] The front-side transition zone between the shaft 2 and the seal retainer flange 10 is covered by means of a cover 32 which is connected to co-rotate with the shaft 2 and in the axial direction is adjacent to the wear ring 26. A radially outer rim portion 34 of the cover 32 immerses into a front groove of the seal retainer flange 10. In this area, between the front side of the seal retainer flange 10 and the inner surface of the rim portion 34 a wiper 36 is provided for preventing ingress of foreign matter from occurring on the front side. However, such a cover 32 is not an indispensable feature of the hydraulic machine.

[0025] In the zone between the wear ring 26 and the seal retainer flange 10, in the embodiment shown in Figure 1, a retention ring 38 is provided which in the axial direction bears against the outer bearing ring of the anti-friction bearing 4 and in the radial direction bears against the annular collar 12 of the seal retainer flange 10. For this purpose, the inner peripheral surface of the annular collar 12 is extended below the recess 17 in the radial direction so as to form a retaining mount 40 into which an outer peripheral portion of the retention ring 38 immerses in an accurately fitting manner so that the latter is upwardly retained also in the axial direction (view according to Figure 1). In the contact area between the retention ring 38 and the annular collar 12 again a seal 42 is provided.

[0026] A retention rib 44 is formed in the area of the retention ring 38 projecting from the retaining mount 40, with the retention rib 44 extending inclined relative to the shaft axis into the area encompassed by the annular wall 20 of the seal ring 18. Said retention rib 44 extends in the axial direction towards the front wall 22 beyond the contact area of the sealing lip 24 with the wear ring 26. A guide surface 46 of the retention rib 44 is orientated so that it points approximately toward the sealing lip 24. Surface 46 and a peripheral surface 48 of the wear ring 26 help delimit an oil reservoir 50 into which oil may enter from the case 6, through the interstice between roller elements in the anti-friction bearing 4, or through a, for that purpose, designated flush inlet channel, not shown here. The oil provided in the oil reservoir 50 accumulates due to the axial extension of the retention rib 44 up to a

level lying above the contact area of the sealing lip 24 with the wear ring 26 so as to ensure that at least the contact areas of the seal ring 18 are sufficiently supplied with oil for lubrication so that dry running is reliably prevented. When the oil accumulates beyond an apex 52 of the retention rib 44, the oil drains on the rear side between the annular wall 20 and the retention rib 44 and via a passage 54 enters into a drain channel 56 extending approximately in the radial direction through the seal retainer flange 10. Said drain channel 56 may be connected, as shown in Figure 1, to a drain line 59 through which the oil is returned to a tank. On principle, it is also possible to guide the drain channel 56 through the motor to a valve or the like.

[0027] In the area of the leakage oil flow path containing the drain channel 56 an orifice 66 may be provided which helps determine the flow in the drain channel 56. Said drain line 59 can be provided with a pressure relief valve 68 in order to limit the pressure in case 6.

[0028] According to one embodiment of the invention, said drain channel 56 is connected to the drain line 59 downstream of the pressure relief valve 68.

[0029] Figure 2 illustrates a variant of the shaft seal arrangement 1 which is especially suited for hydraulic machines of elevated internal case pressure. The variant shown in Figure 2 corresponds to the afore-described embodiment as regards the configuration of the seal retainer flange 10, the wear ring 26, the seal ring 18 and the front-side cover 32 so that, to simplify matters, regarding the set-up of said components the foregoing explanations are referred to.

[0030] In the embodiment shown in Figure 2, the retention ring 38 has a more complex design than in the embodiment according to Figure 1. As in the afore-described embodiment, the retention ring 38 immerses into a retaining mount 40 of the seal retainer flange 10 so that in the axial direction the retention ring 38 is adjacent, on the one hand, to the shoulder of the retaining mount 40 and, on the other hand, to the anti-friction bearing 4. The retention ring 38 includes - just as the afore-described embodiment - a retention rib 44 which extends inclined approximately toward the sealing lip 24 of the seal ring 18, wherein the apex 52 of the retention rib 44 in turn projects upwards from the contact area of the sealing lip 24 with the wear ring 26 (or the shaft 2) in the axial direction. The measure s is shown in Figure 2. As afore-explained, in this way the fluid accumulates in the oil reservoir 50 so as to ensure lubrication of the seal ring 18.

[0031] In contrast to the afore-described embodiment, the retention rib does not freely project into the oil reservoir 50 but extends below the apex 52 in the radial direction to the wear ring 26. In the peripheral surface of the retention ring 38 facing the wear ring 26, an annular groove 58 is formed into which a radial seal 60 located at the bottom with respect to the seal ring 18 is inserted, the radial seal 60 sealing the contact area between the wear ring 26 and the retention ring 38 so that no oil is allowed to penetrate said area. For guiding the oil into

the oil reservoir 50, a flush channel 62 opening, on the one hand, into the space encompassed by the case 6 and, on the other hand, into the oil reservoir 50 is formed in the retention ring 38. The latter opening area is oriented approximately in such manner that the oil exits toward the sealing lip 24 so as to flush the latter. In the shown solution, an orifice 64 is formed in the flush channel 62. The pressure drop occurring at said orifice 64 prevents the sealing lip 24 from being excessively pressurized.

[0032] As illustrated at the beginning, the oil passing over the apex 52 flows off through passage 54 into the drain channel 56 so that the sealing lip 24 is constantly flushed with oil.

[0033] The inner seal 58 is supposed to be a pressure reducing seal, whereas the outer seal 18 is supposed to be fluid tight at low pressure, even if the pressure in case 6 is higher than allowed for the seal 18. Thus the inner seal 58 can be both slightly leaking and fluid tight, but the orifice 64 still provides a sufficient flow of oil through the channel 62 to the oil reservoir/basin 50.

[0034] As described in the foregoing, the concept according to the invention which reliably ensures flushing of the seal ring 18 with oil reliably prevents the seal ring 18 from running dry or from premature wear in the case of vertical assembly of the radial piston machine/hydraulic machine. In the case of horizontal assembly, the problems stated in the beginning do not exist or only exist to a smaller extent, as in that case no air trap obstructing lubrication can form, but in the case of higher pressures in the case 6 and higher annular speeds of the shaft 2 and subsequently the wear ring 26, the inner seal ring 58 protects the outer seal ring 18 from excessive pressure while still supplying sufficient oil flow through orifice 64 and channel 62 to reduce the temperature in the contact between the surface 48 of wear ring 26 and the sealing lip 24 of seal ring 18, thus also in the case of horizontal assembly.

[0035] Figures 3a and 3b show symbolic drawings of hydraulic machines, for example, a radial piston machine R, provided with a shaft seal arrangement 1 as shown in Figures 1 and 2, respectively. As already mentioned above, the object of the invention is to retain an oil sump around the seal ring 18 even in vertical shaft 2 alignment.

[0036] The embodiment according to Figures 1 and 3a is preferably used at lower pressures p in the case 6 and at moderate shaft rotary speed n . The pressure relief valve 68 renders a pressure difference to drive fluid past the seal ring 18. The flowrate $Q_{\text{Drain(OUT)}}$ is governed by the orifice 66.

[0037] At higher case pressures p and higher shaft 2 rotary speed n the embodiment according to Figures 2 and 3b may be used. The pressure relief valve 68 renders a pressure difference to drive fluid past the seal ring 18, whereby the flow is governed by orifice 64. The drain line 59 is "open" downstream from the seal ring 18, thus lowering the pressure and hence decreasing the strain exerted by the increased shaft speed n . In Figures 3a, 3b

the flush-flowrate is indicated with $Q_{\text{Flush(IN)}}$.

[0038] The invention discloses a shaft seal arrangement and a hydraulic machine configured with the same, especially a radial piston machine in which flushing of a seal ring is ensured even in the case of vertical shaft assembly. Furthermore it discloses a shaft seal arrangement that will also decrease the strain on the seal ring when higher shaft speeds and case pressures must be used. The flow of oil through the seal cavity is ensured by a specific placement of the case pressure relief valve.

Claims

1. A shaft seal arrangement comprising a seal ring (18) which includes a sealing lip (24) to be directly or indirectly brought into sealing contact with a shaft (2) and which is supported by a seal retainer flange (10), and comprising a drain channel (56) for draining leak oil, **characterized by** a retention ring (38) which is arranged within an oil flow path toward the drain channel (56) downstream or in the area of a seal ring (18) and via which oil is passed toward the seal ring (18). 5
2. The shaft seal arrangement according to claim 1, wherein the retention ring (38) includes a retention rib (44) extending in the direction of the seal ring (18) and accumulating the oil up to the area of the sealing lip (24). 20
3. The shaft seal arrangement according to claim 2, wherein the retention rib (44) delimits an oil reservoir (50) which is in fluid communication with the drain channel (56). 25
4. The shaft seal arrangement according to any one of the preceding claims, wherein the seal ring (18) takes an approximately U-shaped or L-shaped profile, with the retention rib (44) extending into the space spanned by the profile. 30
5. The shaft seal arrangement according to any one of the preceding claims, wherein a secondary radial seal (60) is formed between the shaft (2) and the retention ring (38). 35
6. The shaft seal arrangement according to claim 5, wherein the retention ring (38) includes a flush channel (62) which opens, on the one hand, into the area of the sealing lip (24) or of an oil reservoir (50) and, on the other hand, into the case side. 40
7. The shaft seal arrangement according to claim 6, wherein an orifice (64) is formed in the flush channel (62). 45
8. The shaft seal arrangement according to any one of

the preceding claims, wherein a pressure relief valve (68) is disposed in a drain line (59) from the case (6) and wherein, preferably, the seal drain channel (56) is connected downstream thereof.

9. The shaft seal arrangement according to any one of the preceding claims, wherein the drain channel (56) is configured in the seal retainer flange (10). 5
10. The shaft seal arrangement according to claim 8 or 9, wherein a pressure difference rendered by the pressure relief valve (68) renders a driving force for the oil to flush the seal ring (18). 10
11. A hydraulic machine, especially a radial piston machine, whose shaft (2) is supported in a case (6) by means of a shaft bearing, **characterized by** a shaft seal arrangement (1) according to any one of the preceding claims. 15
12. The hydraulic machine according to claim 11, wherein the shaft (2) is arranged upright, i.e. with its axis being arranged in the direction of gravity, also known as "vertical shaft". 20

Fig. 1

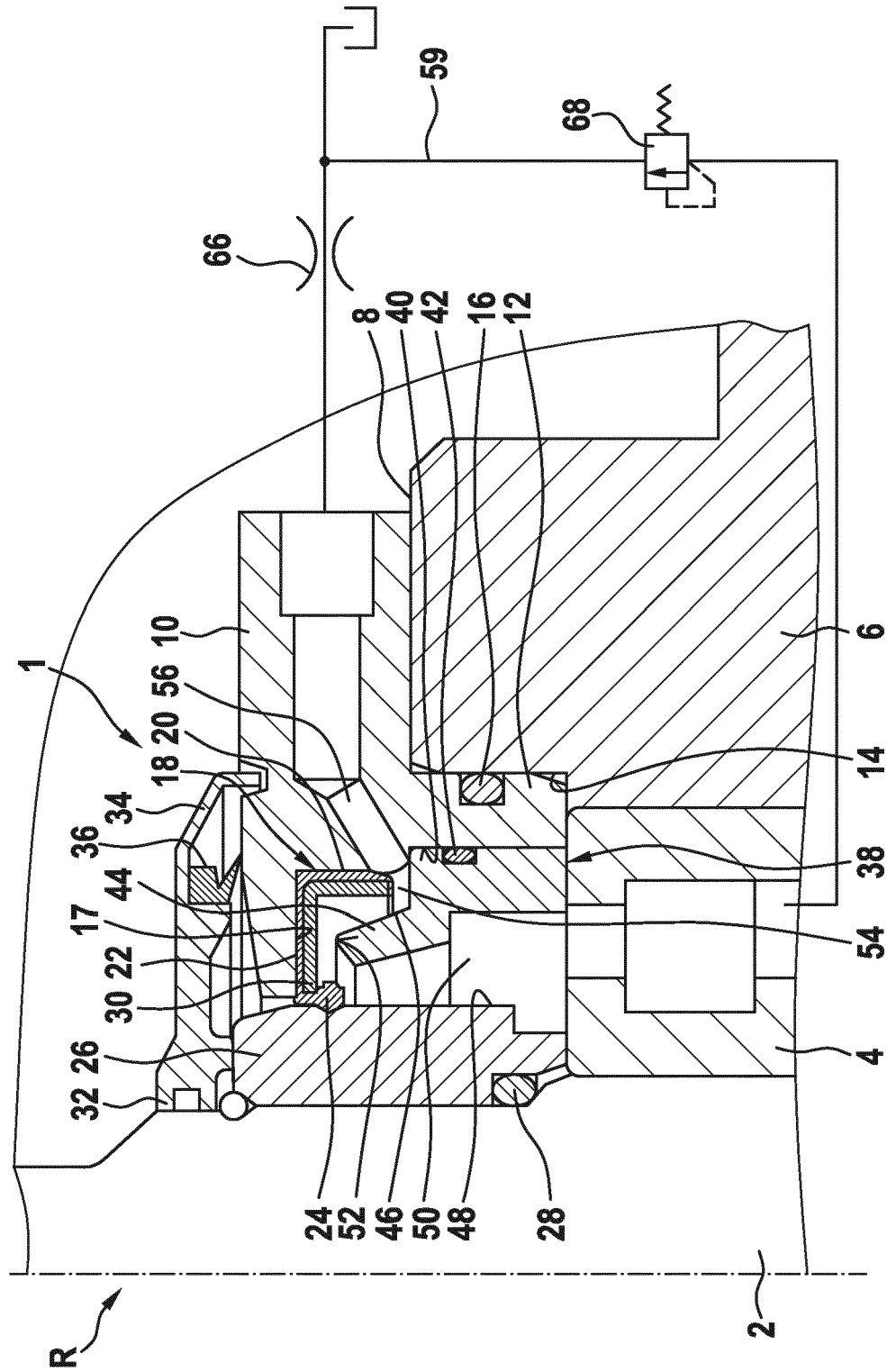


Fig. 2

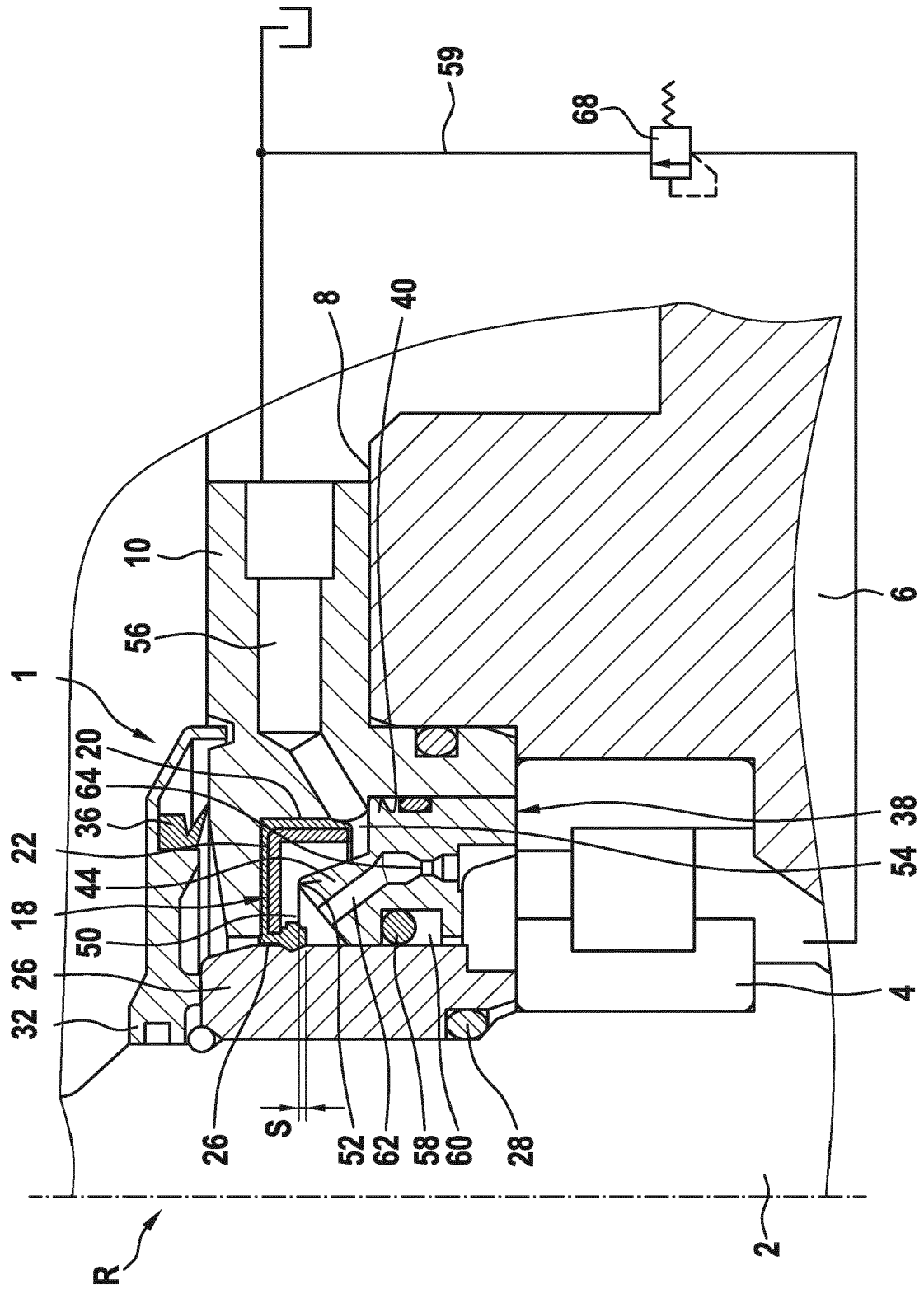


Fig. 3a

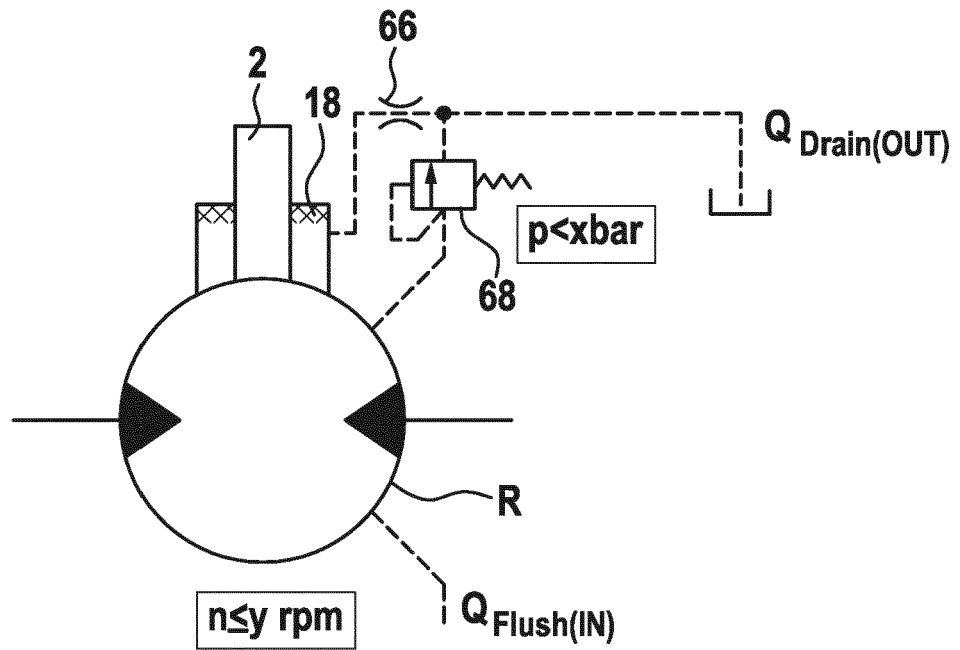
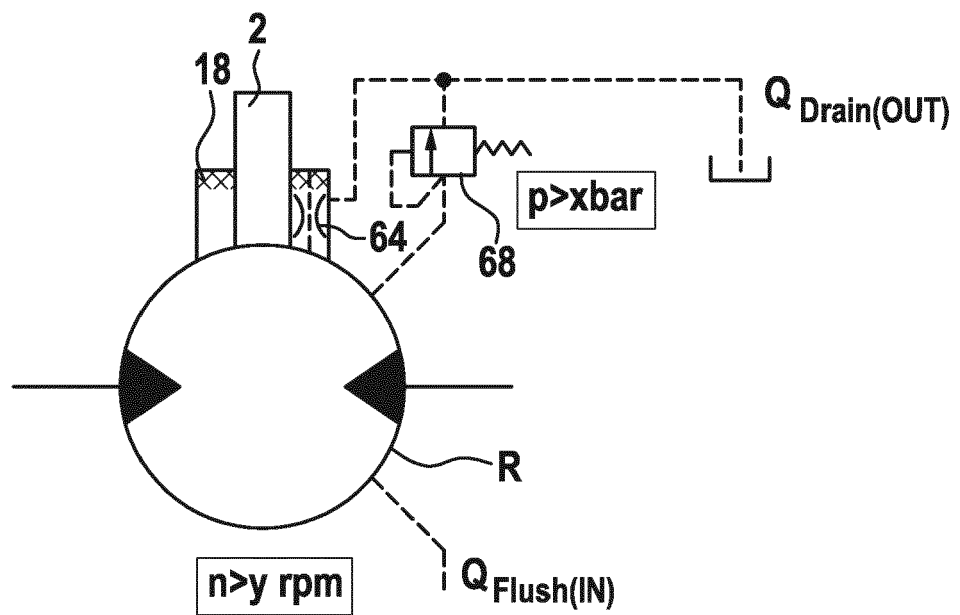


Fig. 3b





EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2014/106247 A1 (THERMO KING CORP [US]) 3 July 2014 (2014-07-03) * abstract *; claims; figure 2b * -----	1-12	INV. F04B1/04 F04B1/12 F04B53/00 F04B53/08 F04B53/18 F03C1/04 F04B27/10
X	EP 1 426 618 A2 (CARRIER CORP [US]) 9 June 2004 (2004-06-09) * abstract *; figures 3,4 * -----	1-12	
X	WO 2009/128228 A1 (VALEO THERMAL SYS JAPAN CO [JP]; DEGUCHI HIRONOBU [JP]; ISHIDA HIROYUK) 22 October 2009 (2009-10-22) * abstract *; figures * -----	1-12	
X	US 2007/169998 A1 (THIEL ALFRED [DE]) 26 July 2007 (2007-07-26) * abstract *; figure 2 * -----	1	
A		2-12	
X	US 5 899 460 A (ALTIERI KEITH L [US]) 4 May 1999 (1999-05-04) * abstract *; figure 1 * -----	1	
X	WO 2009/150986 A1 (NOK CORP [JP]; NAKAGAWA TAKEHIRO [JP]) 17 December 2009 (2009-12-17) * abstract *; figure 1 * -----	1	TECHNICAL FIELDS SEARCHED (IPC) F04B F03C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 5 June 2018	Examiner Pinna, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014106247 A1	03-07-2014	CN 105026761 A	04-11-2015
		EP 2941566 A1	11-11-2015
		US 2015337964 A1	26-11-2015
		WO 2014106247 A1	03-07-2014
EP 1426618 A2	09-06-2004	CN 1514135 A	21-07-2004
		EP 1426618 A2	09-06-2004
		JP 2004183655 A	02-07-2004
		KR 20040048301 A	07-06-2004
		US 2008169157 A1	17-07-2008
WO 2009128228 A1	22-10-2009	JP 2009257131 A	05-11-2009
		WO 2009128228 A1	22-10-2009
US 2007169998 A1	26-07-2007	AT 399737 T	15-07-2008
		CN 1902123 A	24-01-2007
		DE 102004002836 A1	11-08-2005
		EP 1708951 A1	11-10-2006
		ES 2308283 T3	01-12-2008
		US 2007169998 A1	26-07-2007
		WO 2005068339 A1	28-07-2005
US 5899460 A	04-05-1999	NONE	
WO 2009150986 A1	17-12-2009	CN 102027273 A	20-04-2011
		JP 5158357 B2	06-03-2013
		JP 2009293752 A	17-12-2009
		US 2011068542 A1	24-03-2011
		WO 2009150986 A1	17-12-2009

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0102915 B1 [0002]