



- (51) **International Patent Classification:** Not classified
- (21) **International Application Number:**
PCT/GB2011/001442
- (22) **International Filing Date:**
5 October 2011 (05.10.2011)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
1016759.1 6 October 2010 (06.10.2010) GB
- (71) **Applicant (for all designated States except US):** **NATIONAL OILWELL VARCO L.P.** [US/US]; 7909 Parkwood Circle Drive, Houston, Texas 77036 (US).
- (72) **Inventor; and**
- (75) **Inventor/Applicant (for US only):** **GARETH, Thomas** [GB/GB]; 38 Green Lane, Holingworth, Rochdale SK14 8JG (GB).
- (74) **Agent:** **BAILEY, Richard;** Marks & Clerk LLP, 27 Imperial Square, Cheltenham GL50 1RQ (GB).
- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States (unless otherwise indicated, for every kind of regional protection available):** ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- without international search report and to be republished upon receipt of that report (Rule 48.2(g))

(54) **Title:** SEAL LEAKAGE DETECTION

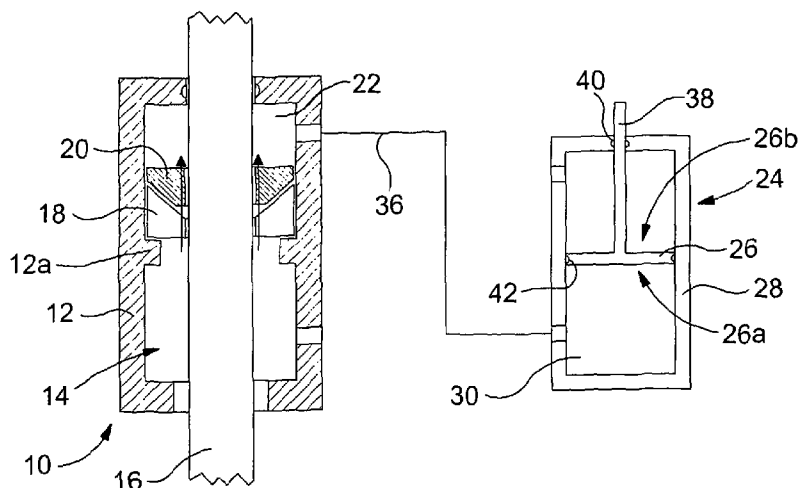


Figure 5

(57) **Abstract:** A seal leakage detection arrangement for use with a seal arrangement of the type in which an annular seal is compressed, in use, by a fluid under pressure, the seal leakage detection arrangement comprising a pressurising piston slidable within a housing and forming with the housing a first chamber and a second chamber, the pressurising piston having a first effective area exposed to a first fluid pressure within the first chamber which is related to a flowline or wellbore pressure, in use, the pressurising piston further having a second effective area exposed to the fluid pressure within the second chamber, the second chamber communicating, in use, with a chamber of the seal arrangement to which the seal is exposed, the second effective area being smaller than the first effective area, and an indicator indicative of the position of the pressurising piston. within the housing.

Seal Leakage Detection

This invention relates to a seal leakage detection arrangement, for example for use in detecting leakage past the seals of a stuffing-box type seal arrangement. Although one
5 specific application of the seal leakage detection arrangement is described herein, it will be appreciated that the invention is not restricted to such use and may be applied in a range of other applications in which a rotary seal is provided.

It is well known to provide a stuffing-box type sealing arrangement to prevent or contain
10 leaks of wellbore or other fluids where a rotating seal is required. Typically, a stuffing-box arrangement comprises an annular seal which can be compressed, axially, by means of a piston. Compression of the seal in this manner results in the inner diameter thereof reducing in size, the seal being compressed against the outer surface
15 against a wall of a housing of the stuffing-box, thus it will be appreciated that adjustment of the position of the piston to compress the seal results in a substantially fluid tight seal being formed between the rod and the housing. As, in normal use, the rod will rotate, it will be appreciated that the degree of compression of the seal is chosen to allow such rotation to take place whilst preventing leakage, or reducing it to
20 an acceptably small level.

Stuffing-box type sealing arrangements of this general type are described in US3967678 and US2002/0179300.

25 As the rod rotates, in use, it will be appreciated that wear occurs between the rod and the seal with the result that, over time, leakage of fluid past the seal is likely to occur. It

is desirable to maintain such leakage at a low level. Indeed, regulations in some countries require that such leakage be avoided altogether, and hence require a well to be shut down in the event that even a very small leak occurs. Obviously this is undesirable. In the arrangement described in US3967678, fluid leaking past the seal is collected in a collection vessel, and sensing means are provided to output a signal indicative of the depth of the collected fluid and thereby provide an indication of the status of the seal. US2002/0179300 likewise describes a containment arrangement whereby fluids escaping past a seal are collected.

10 It is an object of the invention to provide a seal leakage detection arrangement suitable for use in such an application and which is of simple and convenient form.

According to the present invention there is provided a seal leakage detection arrangement for use with a seal arrangement of the type in which an annular seal is provided, the seal leakage detection arrangement comprising a piston slidable within a housing and forming with the housing a first chamber and a second chamber, the first chamber communicating with a part of the seal arrangement such that leakage of fluid past the seal thereof results in movement of the piston.

20 In such an arrangement, movement of the piston will provide an indication that leakage of fluid past the seal is occurring.

In one embodiment, the seal arrangement includes a chamber into which fluid leaking past the seal will flow, the said chamber communicating with the first chamber of the seal detection arrangement.

In an alternative arrangement, the piston may have a first effective area exposed to a first fluid pressure within the first chamber which is related to a flowline or wellbore pressure, in use, the piston further having a second effective area exposed to the fluid pressure within the second chamber, the second chamber communicating, in use, with a chamber of the seal arrangement to which the seal is exposed, the second effective area being smaller than the first effective area, and an indicator indicative of the position of the pressurising piston within the housing. In such an arrangement, the piston serves as a pressurising piston, maintaining the second chamber at a higher pressure than the first chamber.

Conveniently, the fluid in the second chamber is a clean, barrier fluid. For example, it may comprise a clean oil.

In such an arrangement, the pressure applied to the pressurising piston by the flowline or wellbore pressure results in the application of an elevated pressure to the seal, compressing the seal to a degree sufficient to avoid leakage under normal circumstances. In the event that there is leakage past the seal, the leakage direction will be such that the pressurising piston will move to reduce the volume of the second chamber in trying to maintain the pressure differential, and by sensing the movement of the pressurising piston, an indication of the status of the seal can be gained.

The difference in effective area may arise from the presence of a piston rod extending from the pressurising piston and out of the second chamber. The piston rod may protrude from the housing.

In either arrangement, the indicator may be a visible indicator. For example, where a rod is connected to the piston and protrudes from the housing, movement of the rod or

a change in the position of the rod can provide an indication that the seal is leaking. Alternatively, a movement or position sensor may detect movement of the piston and/or rod and output a signal indicative of such movement. A range of sensors could be used to provide this functionality.

5

The invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic view illustrating a seal leakage detection arrangement in accordance with an embodiment of the invention, in use;

10

Figures 2 and 3 are diagrammatic views illustrating parts of the seal leakage detection arrangement in greater detail,

Figure 4 illustrates a modification to the arrangement illustrated in Figures 1 to 3;

15

Figure 5 illustrates an alternative arrangement; and

Figures 6 and 7 are views illustrating an arrangement similar to that shown in Figure 5.

20

Referring firstly to Figure 1, a stuffing-box type sealing arrangement 10 is illustrated, diagrammatically, and comprises an outer housing 12 defining a passageway 14 along which a rod 16 extends. The rod 16 rotates, in use, under the control of a motor or other drive arrangement (not shown). An annular seal ring 18 is provided between the outer surface of the rod 16 and the inner surface of the housing 12, the seal serving to limit or prevent the flow of wellbore fluid along the passageway 14. As outlined hereinbefore, a seal piston 20 bears against one end of the seal ring 18 to apply a

25

compressive load thereto, compressing the seal ring 18 against a step 12a, the compression of the seal ring 18 serving to force the seal ring 18 into engagement with the rod 16 and the inner surface of the housing 12. The position of the seal piston 20 is dependent, at least in part, upon the fluid pressure within a seal control chamber 22, an
5 end face of the seal piston 20 being exposed to the fluid pressure within the seal control chamber 22.

The seal leakage detection arrangement 24 illustrated in the accompanying drawings is intended for use in monitoring for the leakage of fluid past the seal ring 18. The
10 arrangement 24 comprises a pressurising piston 26 located within a piston housing 28 and defining, with the housing 28, a first chamber 30 and a second chamber 32. The first chamber 30 is connected via a line 34 with part of the passageway 14 beneath the seal ring 18 so that the first chamber 30 is pressurised to a level related to the pressure of the wellbore fluid. The second chamber 32 communicates via a line 36 with the seal
15 control chamber 22. The seal control chamber 22, second chamber 32 and line 36 are filled with a clean barrier fluid. For example, the clean barrier fluid may comprise a clean oil.

As illustrated, the pressurising piston 26 includes an integrally formed piston rod 38
20 which extends through the second chamber 32, and protrudes through the housing 28 so that an end part thereof is visible from the exterior of the housing 28. A suitable sliding seal 40 is provided between the rod 38 and the housing 28 so as to minimise the escape of fluid from the second chamber 32, and the pressurising piston 26 is provided with a seal 42 to minimise the passage of fluids between the first and second
25 chamber 30, 32. As the rod 38 extends through the second chamber 32, it will be appreciated that a first effective area 26a of the pressurising piston 26 exposed to the fluid pressure within the first chamber 30 is larger than a second effective area 26b of

the pressurising piston 26 exposed to the fluid pressure within the second chamber 32. Consequently, it will be appreciated that the fluid pressure within the second chamber 32 will be higher than the fluid pressure within the first chamber 30.

5 In use, the fluid pressure within the first chamber 30 will be at substantially the wellbore fluid pressure. By virtue of the nature of the pressurising piston 26, the fluid pressure within the second chamber 32 will be higher than the wellbore fluid pressure, and it is envisaged that a differential of approximately 10% in the fluid pressures will typically be maintained, although arrangements may be possible in which different pressure
10 differentials are maintained. As a consequence, the fluid pressure applied to the seal piston 20 is higher than the wellbore fluid pressure and is sufficient to compress the seal ring 18 to a degree to maintain a good seal between the rod 16 and the housing 12 without impeding rotation of the rod 16. Provided that no fluid leaks past the seal, the pressure differential will be maintained with substantially no movement of the
15 pressurising piston 26 occurring during use.

In the event that fluid starts to leak past the seal ring 18, for example as a result of wear causing damage thereto, the direction in which fluid leaks past the seal ring 18 will be from the seal control chamber 22 towards the wellbore as a result of the fluid
20 within the seal control chamber 22 being held at an elevated pressure by virtue of the nature and operation of the pressurising piston 26. As the leakage occurs in this direction, it will be appreciated that the risk of contamination is very low. Furthermore, by providing a clean barrier fluid in the seal control chamber 22, the risk of contamination can further be reduced.

25

In order to maintain the required pressure differential despite the leakage of fluid past the seal ring 18, the pressurising piston 26 will move relative to its housing 28 resulting

in an increased length of the rod 38 protruding from the housing 28. The increase in the length of the part of the rod 38 protruding from the housing 28 provides a visual indication that fluid is leaking past the seal ring 18, alerting an operator to the presence of the leak, and hence allowing appropriate remedial action to be taken before the leak
5 has reached a point at which significant contamination or damage has occurred.

If desired, for safety reasons, a pressure relief valve could be incorporated into the housing 28 to allow, for example, gases to escape from the first chamber 30 in the event that the pressure therein becomes excessive. Rather than venting to the
10 atmosphere, any fluid escaping from the first chamber 30 by the operation of such a pressure relief valve would conveniently flow to a suitable container via a suitable line so as to minimise the risk of contamination.

Although in the arrangement described hereinbefore the movement of the rod 38
15 provides a visible indication that a leak is occurring past the seal ring 18, it will be appreciated that the leak detection arrangement could be automated in that, as shown in Figure 4, a position sensor 44 may be provided and arranged to monitor the position of a target 46 provided on the rod 38. If the position sensor 44 detects that the rod 38 has moved, then an output signal indicating that fluid is leaking past the seal ring 18
20 will be output. The position sensor 44 could take a wide range of forms. For example, it could comprise a Hall sensor operable to monitor the position of a magnet secured to the rod 38. Alternatively, it could comprise a microswitch which changes state in the event that the rod 38 moves beyond a predetermined position. Rather than monitor the position of, or movement of, the rod, the position of the piston 26, or movement thereof,
25 could be sensed directly using a suitable sensor.

In the arrangement described hereinbefore, the first and second chambers 30, 32 of the leak detection arrangement are connected, respectively, to parts of the sealing arrangement on opposing sides of the seal, the leak detection arrangement operating by monitoring for variations in the relative pressures. This need not always be the case, and Figure 5 illustrates an alternative, simpler, arrangement in which the leak detection arrangement monitors directly for the presence of fluid leaking past the seal.

The arrangement of Figure 5 is very similar to that of Figures 1 to 4, but differs therefrom primarily in the manner in which the leak detection arrangement is connected to the sealing arrangement. In the arrangement of Figure 5, the sealing arrangement includes a seal control chamber 22 which contains a suitable barrier fluid. Unlike the arrangement of Figures 1 to 4, the control chamber 22 is connected to the first chamber 30 of the leak detection arrangement, the control chamber 30 thus also containing the barrier fluid, and the second chamber 32 of the leak detection arrangement is vented to the atmosphere.

In normal operation, the seal ring 18 and piston 20 serve to form the required seal and so substantially no fluid flows past the seal so formed. In these circumstances, the volume of fluid within the control chamber 22 and first chamber 30 remains substantially fixed, and so the piston 26 remains stationary, providing an indication that the seal arrangement is functioning adequately. However, if the seal ring 18 becomes worn or otherwise starts to leak, then fluid will flow past the seal ring 18 and into the control chamber 22. Fluid from the control chamber 22 is displaced along the line 36 into the first chamber 30 of the leak detection arrangement. In order to accommodate the increased volume of fluid, the piston 26 moves upwardly, in the orientation illustrated, displacing air from the second chamber 32. The upward movement of the piston 26 will be apparent as the length of the part of the rod 38 protruding from the

housing 28 will increase. The upward movement of the piston 26 thus provides a visible indication that fluid is leaking past the seal ring 18.

As with the embodiment described hereinbefore, means may be provided to permit sensing of the movement of the piston and thereby provide an automated warning, for example in the form of an alarm or illumination of warning lamps, to show that leakage is occurring.

Figures 6 and 7 illustrate an implementation or embodiment which, operationally, is very similar to that illustrated diagrammatically in Figure 5. In Figures 6 and 7, some of the detail of the seal arrangement 10 is omitted as it is not of relevance to the nature of the seal leakage detection arrangement or of the operation thereof. As shown in Figures 6 and 7, and as with the arrangement of Figure 5, the control chamber 22 of the sealing arrangement 10, together with the first chamber 30 of the leakage detection arrangement and the line 36 connecting these chambers to one another, is filled with a barrier fluid. The housing 28 of the leakage detection arrangement is conveniently provided with a removable filler plug 50 to permit the introduction of the barrier fluid into these locations.

The second chamber 32, which is vented to the atmosphere via a breather opening 52, contains a spring 54 that engages part of the piston 26, urging the piston 26 in a direction that raises the pressure of the barrier fluid in normal operation.

As with the arrangement of Figure 5, in the event of fluid leakage past the seal arrangement 10, for example flowing into the chamber 22 thereof, the leakage of fluid will result in an increase in the volume of the fluid located within the first chamber 30. In order to accommodate this increased volume without significantly increasing the

pressure thereof, the piston 26 will move. The movement of the piston 26 results in corresponding movement of the rod 38 which, as described hereinbefore, provides an indication that leakage of fluid past the seal is occurring. By providing a spring urging the piston 26 to pressurize the fluid within the first chamber 30, it will be appreciated
5 that the responsiveness of the arrangement is enhanced.

It will be appreciated that a wide range of modifications or alterations may be made to the arrangements described hereinbefore without departing from the scope of the invention. For example, although the invention is described in the context of a stuffing-
10 box seal arrangement, the invention may be suitable for use with a number of other seal arrangements in which it is desirable to be able to monitor for the leakage of fluids past the seal.

CLAIMS:

1. A seal leakage detection arrangement for use with a seal arrangement of the type in which an annular seal is provided, the seal leakage detection arrangement comprising a piston slidable within a housing and forming with the housing a first chamber and a second chamber, the first chamber communicating with a part of the seal arrangement such that leakage of fluid past the seal thereof results in movement of the piston.
2. An arrangement according to Claim 1, wherein the seal arrangement includes a chamber into which fluid leaking past the seal will flow, the said chamber communicating with the first chamber of the seal detection arrangement.
3. An arrangement according to Claim 2, wherein the said chamber contains a clean barrier fluid.
4. An arrangement according to any of the preceding claims, wherein a spring is provided within the second chamber to apply a biasing load to the piston.
5. An arrangement according to any of the preceding claims, further comprising an indicator indicative of the position of the piston within the housing.
6. An arrangement according to Claim 5, wherein the indicator comprises a piston rod connected to the piston and protruding from the housing.

7. An arrangement according to Claim 5 or Claim 6, wherein the indicator is a visible indicator.

8. An arrangement according to any of Claims 5 to 7, further comprising a sensor operable to detect movement or a change in the position of the piston and output a signal indicative of such movement.

9. An arrangement according to Claim 8, wherein where the piston includes a rod, and the sensor is operable to detect movement of a change in the position of the rod.

10. An arrangement according to Claim 1, wherein the annular seal is compressed, in use, by a fluid under pressure, and wherein the piston has a first effective area exposed to a first fluid pressure within the first chamber which is related to a flowline or wellbore pressure, in use, the piston further has a second effective area exposed to the fluid pressure within the second chamber, the second chamber communicating, in use, with the chamber of the seal arrangement to which the seal is exposed, the second effective area being smaller than the first effective area.

11. An arrangement according to Claim 10, wherein the piston is a pressurising piston.

12. An arrangement according to Claim 10 or Claim 11, wherein the difference in effective area arises from the presence of a piston rod extending from the pressurising piston and out of the second chamber.

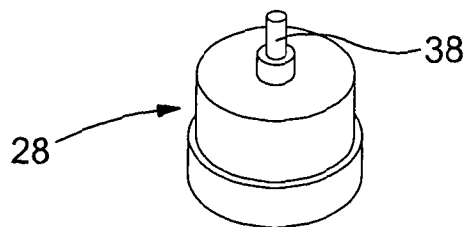
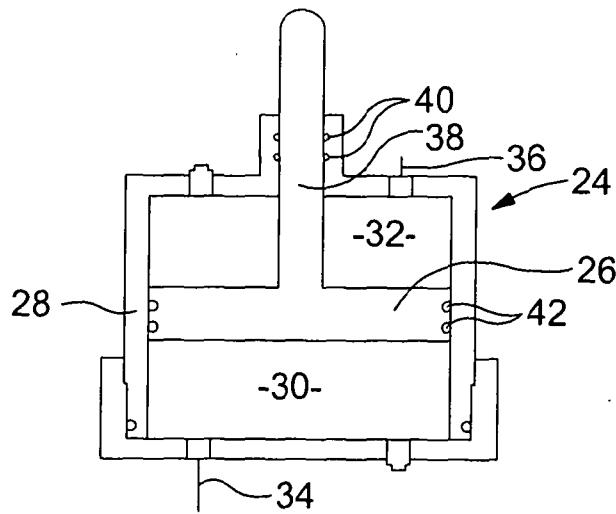
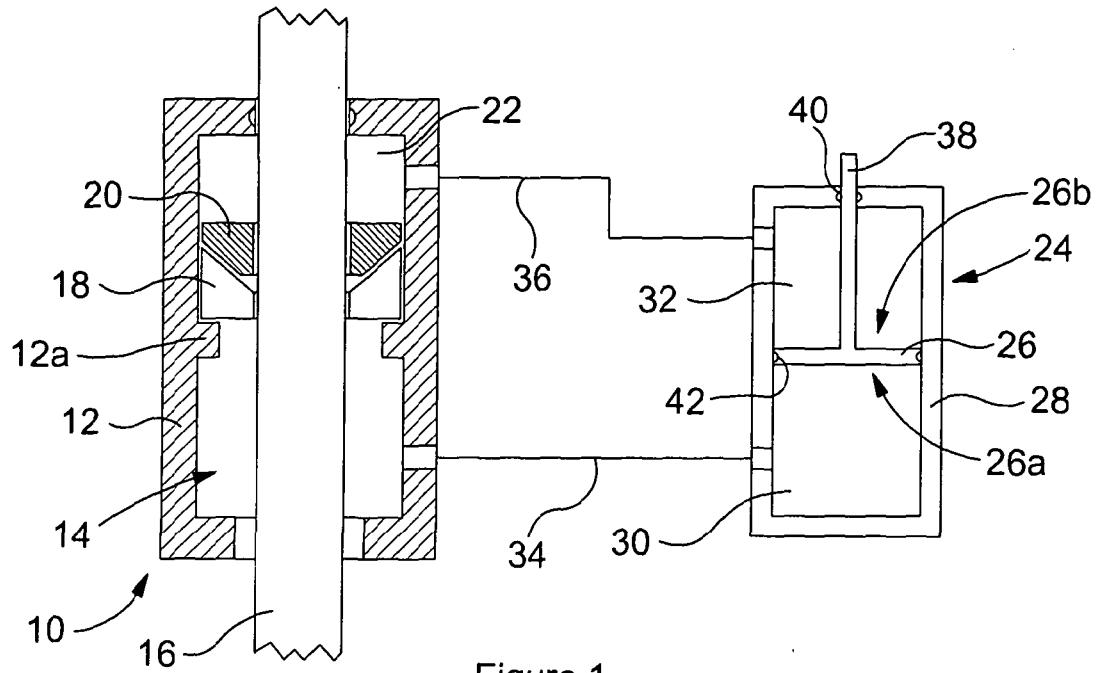
13. An arrangement according to any of the preceding claims, wherein the fluid in the second chamber is a clean, barrier fluid.

14. An arrangement according to any of the preceding claims, wherein the fluid in the first chamber is a clean, barrier fluid.

5 15. A seal arrangement comprising an annular seal compressed, in use, by a fluid under pressure, and a seal leakage detection arrangement comprising a pressurising piston slidable within a housing and forming with the housing a first chamber and a second chamber, the pressurising piston having a first effective area exposed to a first fluid pressure within the first chamber which is related to a flowline or wellbore pressure, in use, the pressurising piston further having a second effective area exposed to the fluid pressure within the second chamber, the second chamber communicating, in use, with a chamber of the seal arrangement to which the seal is exposed, the second effective area being smaller than the first effective area, and an indicator indicative of the position of the pressurising piston within the housing.

15 16. An arrangement according to Claim 15, further comprising a seal piston exposed to the fluid pressure within a control chamber and moveable to compress the seal.

20 17. An arrangement according to Claim 16, wherein the control chamber and the second chamber are in fluid communication with one another.



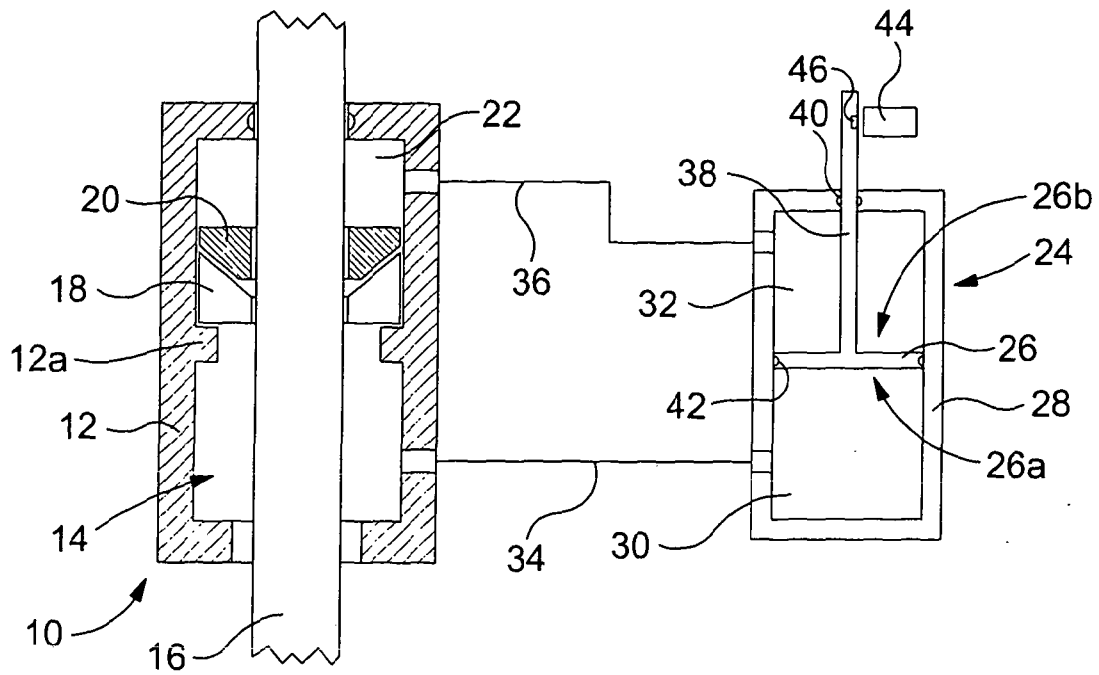


Figure 4

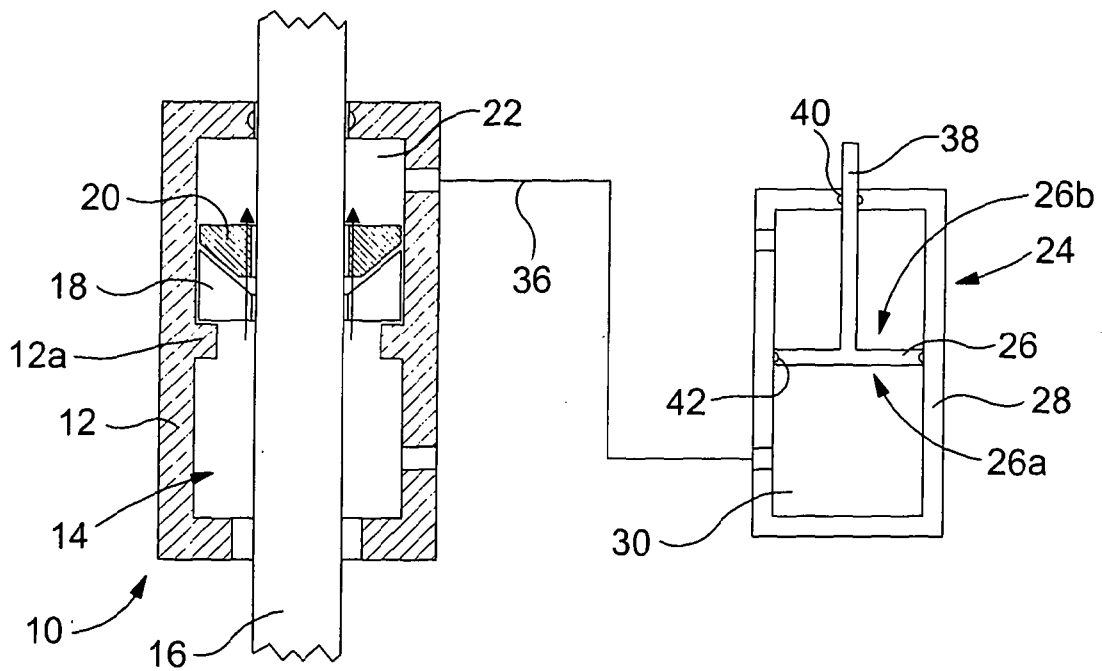


Figure 5

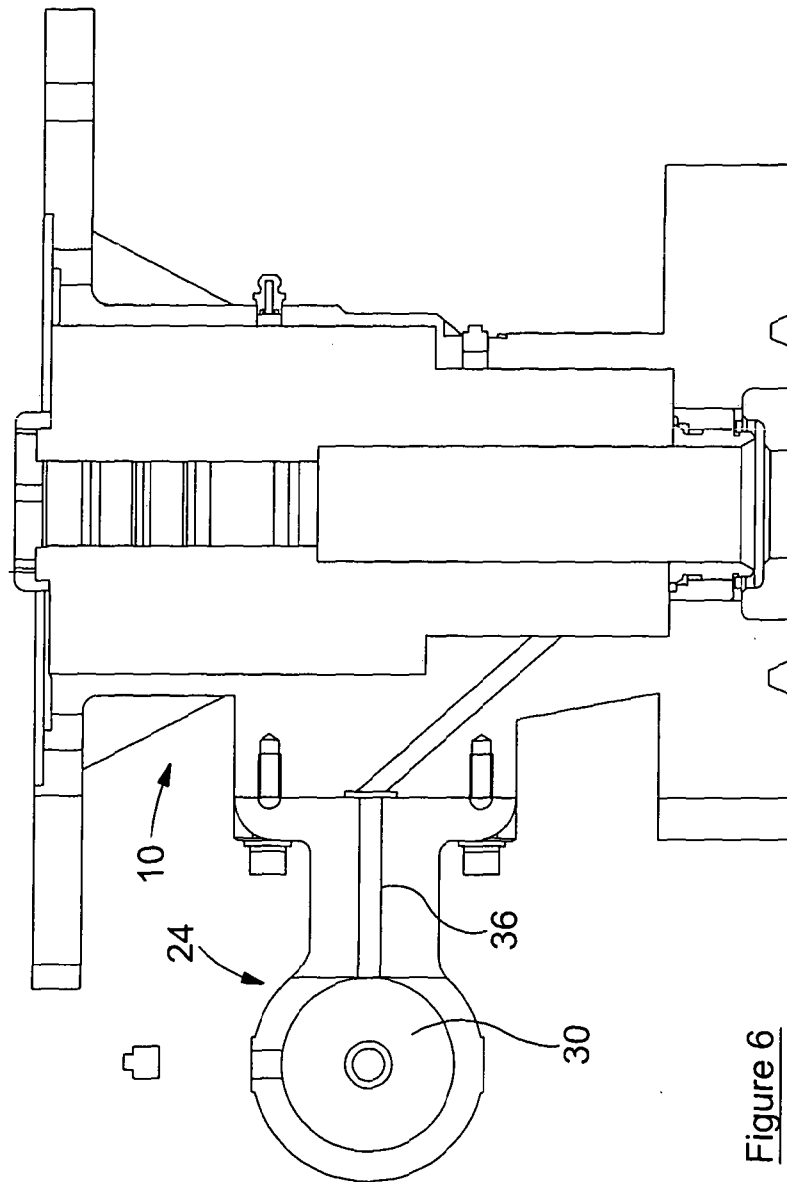


Figure 6

Figure 7

