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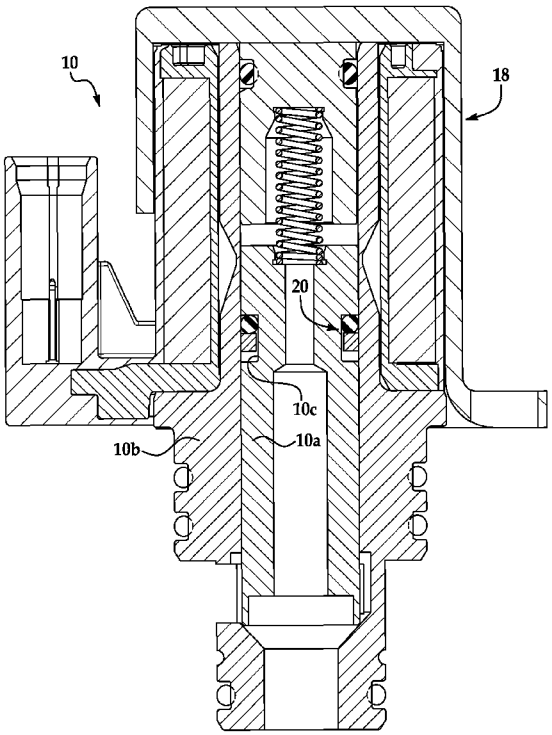
(54) Title: ONE-WAY PRESSURE ACTIVATED PISTON SEAL



(57) Abstract: A solenoid actuated valve (10) holds pressure and volume of an accumulator with low leakage and provides low actuation drag during a release stroke for dumping fluid contents of the accumulator at very low current draw. Two elongate valve members (10a, 10b) are assembled to be movable axially relative to one another with a gland or groove (10c) formed in one of the two valve members (10a). An o-ring (12) located within the groove (10c) is in a non-contacting relationship to the other valve member (10b) when in a non-energized state. An energizer ring (14) located within the groove (10c) can reciprocate axially with respect to the o-ring (12). The energizer ring (14) moves axially toward the o-ring (12) in response to fluid pressure against a surface (14a) of the energizer ring (14) opposite from the o-ring (12) to axially compresses the o-ring (12), causing the o-ring (12) to expand radially outwardly into sealing contact with the other valve member (10b).

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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

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ONE-WAY PRESSURE ACTIVATED PISTON SEAL

FIELD OF THE INVENTION

[0001] The invention relates to a one-way pressure activated piston seal and method that provides low drag when not activated by pressure and low leakage when activated by pressure.

BACKGROUND

[0002] The industry has many variations on piston seals using o-rings and polytetrafluoroethylene (PTFE) rings, sometimes referred to using the brand name TEFLON™. For example, various types and configurations of piston seals are disclosed in U.S. Patent No. 7,815,195, U.S. Patent No. 6,502,826, U.S. Patent No. 6,129,358, U.S. Patent No. 5,140,904, U.S. Patent No. 5,082,295, U.S. Patent No. 4,291,890, U.S. Patent No. 4,109,921, and U.S. Patent No. 3,592,164. While these piston seals appear to be appropriate for their intended purposes, none of these configurations provide a pressure activated low-leak seal with low actuation drag.

[0003] As best seen in Figure 6, a prior known solenoid actuated hydraulic fluid valve 30 includes first and second valve members 30a, 30b, which are movable with respect to one another. One of the valve members 30a includes a groove 30c formed therein. A standard o-ring 32 is located within the groove 30c and biases a PTFE ring 34 into sealing engagement with the other valve member 30b. This sealing system uses the o-ring 32 to load a PTFE-based seal ring 34 against the inside diameter (ID) of the piston bore 36 defined by the second valve member 30b.

SUMMARY

[0004] While the prior known system created a good seal, it also produced higher drag than is desired. A solution was required that only needed to seal in one direction and that would release the seal during actuation to minimize or eliminate the amount of actuation drag. It would be desirable to provide a solenoid actuated hydraulic fluid valve with low leakage when sealed in one direction. It would be desirable to provide a solenoid actuated hydraulic fluid valve with low actuation drag in an opposite direction. It would be desirable to provide a solenoid actuated hydraulic fluid valve with a low leakage seal in response to fluid pressure, and a low actuation drag in the absence of fluid pressure.

[0005] In order to hold the pressure and volume of an accumulator, a hydraulic solenoid valve has very demanding leakage requirements. Additionally, the hydraulic solenoid valve needs to be able to stroke and dump the accumulator at very low current draw requiring low actuation drag. A one-way pressure activated piston seal can achieve the dual goals of low-leakage and low actuation drag for the hydraulic solenoid valve by sealing the valve in response to fluid pressure and by releasing the seal in response to initial solenoid actuator movement providing low actuation drag. It would be desirable to provide a high-flow, two-way, on/off hydraulic solenoid valve to close and hold a pressurized hydraulic accumulator with low leakage and then release and dump the accumulator with low actuation drag when requested.

[0006] A one-way pressure activated piston seal can include two members movable axially relative to one another with a gland or groove formed in one of two members. An o-ring can be located within the groove in a non-contacting relationship to the other of the two members when in a non-energized state. An energizer ring can be located within the groove for reciprocation axially with respect to the o-ring, where the energizer ring moves axially toward the o-ring in response to fluid pressure against a surface opposite from the o-ring and compresses the o-ring, causing the o-ring to expand radially outwardly into sealing contact with the other of the two members.

[0007] A method for sealing between two members movable axially with respect to one another in a one direction with low-leakage, while providing low drag in an opposite direction can include providing a gland or groove in one of the two members, positioning an o-ring in the groove in a non-contacting relationship with the other of the two members when in a non-energized state, and axially moving an energizer ring within the groove between first and second positions relative to the o-ring, where the energizer ring moves axially toward the o-ring in response to fluid pressure against a surface opposite from the o-ring and compresses the o-ring thereby causing axial compression of the o-ring and radial expansion of the o-ring into sealing contact with the other of the two members.

[0008] A solenoid actuated valve for holding pressure and volume of an accumulator with low leakage and for providing low actuation drag during release stroke of the solenoid actuated valve for dumping fluid contents of the accumulator at very low current draw can include two valve members movable axially relative to one another with a gland or groove formed in one of two valve members, an o-ring located within the

groove in non-contacting relationship to the other of the two valve members when in a non-energized state, and an energizer ring located within the groove for reciprocation axially with respect to the o-ring, where the energizer ring moves axially toward the o-ring in response to fluid pressure against a surface opposite from the o-ring and compresses the o-ring causing the o-ring to expand radially outwardly into sealing contact with the other of the two valve members.

[0009] Other applications of the present invention will become apparent to those skilled in the art when the following description of the best mode contemplated for practicing the invention is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0011] Figure 1 illustrates a cross sectional view of a one-way pressure activated piston seal for a solenoid actuated valve having a solenoid armature (acting as a piston) with a gland on the outside diameter (OD) that accommodates an o-ring and an energizing ring, where without fluid pressure, the o-ring sits in the gland and is located clear of the piston bore;

[0012] Figure 2 illustrates a detailed cross sectional view of the o-ring and energizer ring of the one-way pressure activated piston seal for a solenoid actuated valve according to Figure 1, where the o-ring and energizer ring are in a relaxed, non-energized state with the o-ring located clear of the piston bore;

[0013] Figure 3 illustrates a detailed cross sectional view of the o-ring and energizer ring of the one-way pressure activated piston seal for a solenoid actuated valve according to Figure 1, where the o-ring and energizer ring are in an energized state with the o-ring compressed axially and expanded radially to seal the piston bore;

[0014] Figure 4 illustrates a detailed cross sectional view of the o-ring and energizer ring of the one-way pressure activated piston seal for a solenoid actuated valve according to Figure 1, where the solenoid actuated valve moves in the direction of the arrow relieving compression of the o-ring and returning the o-ring and energizer ring to the relaxed, non-energized state of Figure 2;

[0015] Figures 5A-5B illustrate alternative cross sections for the energizer ring; and

[0016] Figure 6 illustrates a prior art solenoid valve having a standard o-ring energized PTFE piston seal ring, where the o-ring is used to load a PTFE-based seal ring against the inside diameter (ID) of a piston bore.

DETAILED DESCRIPTION

[0017] Referring now to Figures 1-4, a solenoid actuated, fluid valve 10 is depicted for holding pressure and volume of an accumulator with low leakage and for providing low actuation drag during a release stroke of the solenoid actuated valve for dumping fluid contents of the accumulator at very low current draw. The fluid valve 10 can include two elongate valve members 10a, 10b capable of reciprocal movement axially relative to one another with a gland or groove 10c formed in one of two valve members 10a.

[0018] As best seen in Figure 2, an o-ring 12 is located within the groove 10c in non-contacting relationship to the other of the two valve members 10b when in a non-energized state. An energizer ring 14 is located within the gland or groove 10c for reciprocation axially with respect to the o-ring 12. The energizer ring 14 is illustrated as having a rectangular cross section, or square cross section, with a surface 14a on a side opposite from the o-ring 12. However, it should be recognized that the energizer ring 14 can have any desired cross section. By way of example and not limitation, the energizer ring 14 can have an L-shaped cross section 14b as illustrated in Figure 5A, or L-shaped cross section with an angled o-ring engaging surface 14c as illustrated in Figure 5B, or L-shaped cross section with a curved o-ring engaging surface, or a triangular shaped cross section, or any combination thereof. In any case, the energized ring 14 includes a surface 14a on a side opposite from the o-ring 12 allowing fluid pressure to act on surface 14a of the energizer ring 14 to drive the energizer ring 14 axially into compressive engagement with the o-ring.

[0019] As best seen in Figure 3, in response to fluid pressure, the energizer ring 14 moves axially toward the o-ring 12 against a surface 14a opposite from the o-ring 12. While in the fluid pressure energized state, the energizer ring 14 compresses the o-ring 12 causing the o-ring 12 to expand radially outwardly into sealing contact with the other of the two valve members 10b. The o-ring 12 is held in a radially outwardly expanded

energized state by the energizer ring 14 in response to the fluid pressure acting on surface 14a.

[0020] As best seen in Figure 4, when the solenoid 18 energizes to initiate movement of the valve member 10a in the direction of arrow 16, the movement of the valve member 10a releases or unloads compressive pressure on the o-ring 12 by the energizer ring 14 allowing the o-ring 12 to retract or transition from the radially expanded condition illustrated in Figure 3 to return to the non-energized state illustrated in Figure 2.

[0021] The one-way pressure activated piston seal assembly 20 was developed to resolve a sealing challenge related to a low-leak, high-flow, two-way, on/off, solenoid operated, hydraulic fluid valve. The solenoid operated fluid valve 10 is used to close and hold a pressurized hydraulic accumulator and then release and dump the accumulator when requested. In order hold the pressure and volume of the accumulator, the solenoid operated fluid valve 10 has very demanding leakage requirements. Additionally, the solenoid operated fluid valve 10 needs to be able to stroke and dump the accumulator at very low current draw and therefore needs to have low actuation drag.

[0022] Referring again to Figure 1, the solenoid operated fluid valve 10 is illustrated with the solenoid armature 10a acting as a piston and with a gland 10c on the outside diameter (OD) that accommodates an o-ring 12 and an energizing ring 14. Without pressure, the o-ring 12 sits in the gland 10c and is clear of the piston bore 26 defined by the inside diameter (ID) of the valve body 10b. The energizing ring 14 is designed as a clearance fit to the bore 26 as well, so there is little to no seal drag. When there is a pressure differential (higher pressure on the energizing ring side), the energizer ring 14 compresses the o-ring 12 forcing the outside diameter (OD) of the o-ring 12 out and into contact with the piston ring 10b and seals the piston bore 26. When the solenoid 18 is commanded to actuate and dump the accumulator, the piston 10a moves up and unloads the o-ring 12 allowing the o-ring 12 to retract from the piston bore 26 and eliminate the drag.

[0023] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiments but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, which scope is to be accorded the broadest

interpretation so as to encompass all such modifications and equivalent structures as is permitted under the law.

What is claimed is:

1. A one-way pressure activated piston seal comprising:

two elongate members (10a, 10b) movable axially relative to one another with a groove (10c) formed in one of two members (10a);

an o-ring (12) located within the groove (10c) in non-contacting relationship to the other of the two members (10b) when in a non-energized state; and

an energizer ring (14) located within the groove (10c) for axially reciprocal movement with respect to the o-ring (12), where the energizer ring (14) moves axially toward the o-ring (12) in response to fluid pressure against a surface (14a) opposite from the o-ring (12) and compresses the o-ring (12) to expand radially outwardly into sealing contact with the other of the two members (10b) movable relative to one another.

2. The seal of claim 1, wherein the energizer ring (14) has a rectangular cross section.

3. The seal of claim 1, wherein the energizer ring (14) has an L-shaped cross section (14b).

4. The seal of claim 1, wherein the energizer ring (14) has an L-shaped cross section (14b) with an angled o-ring engaging surface (14c).

5. A method for sealing between two elongate members (10a, 10b) movable axially with respect to one another in a one direction with low-leakage, while providing low drag in an opposite direction comprising:

providing a groove (10c) in one of the two elongate members (10a);

positioning an o-ring (12) in the groove (10c) in a non-contacting relationship with the other of the two members (10b) when in a non-energized state; and

assembling an energizer ring (14) within the groove (10c) for axially reciprocal movement with respect to the o-ring (12), where the energizer ring (14) moves axially toward the o-ring (12) in response to fluid pressure against a surface (14a) opposite from the o-ring (12) and compresses the o-ring (12) thereby causing radial expansion of the o-ring (12) into sealing contact with the other of the two members (10b).

6. The method of claim 5 further comprising:

providing the energizer ring (14) with a rectangular cross section.

7. The method of claim 5 further comprising:

providing the energizer ring (14) with an L-shaped cross section (14b).

8. The method of claim 5 further comprising:

providing the energizer ring (14) with an L-shaped cross section (14b) having an angled o-ring engaging surface (14c).

9. A solenoid actuated valve (10) for holding pressure and volume of an accumulator with low leakage and for providing low actuation drag during release stroke of the solenoid actuated valve (10) for dumping fluid contents of the accumulator at very low current draw comprising:

two elongate valve members (10a, 10b) movable axially relative to one another with a groove (10c) formed in one of two valve members (10a);

an o-ring (12) located within the groove (10c) in non-contacting relationship to the other of the two valve members (10b) when in a non-energized state; and

an energizer ring (14) located within the groove (10c) for axial movement with respect to the o-ring (12), where the energizer ring (14) moves axially toward the o-ring (12) in response to fluid pressure against a surface (14a) opposite from the o-ring (12) and compresses the o-ring (12) causing the o-ring (12) to expand radially outwardly into sealing contact with the other of the two valve members (10b).

10. The valve (10) of claim 9, wherein actuation of the solenoid actuated valve (10) unloads compressive pressure on the o-ring (12) allowing retraction from the radially outwardly expanded energized state to the non-energized state.

11. The valve (10) of claim 9, wherein the energizer ring (14) has a rectangular cross section.

12. The valve (10) of claim 9, wherein the energizer ring (14) has an L-shaped cross section (14b).

13. The valve (10) of claim 9, wherein the energizer ring (14) has an L-shaped cross section (14b) with an angled o-ring engaging surface (14c).

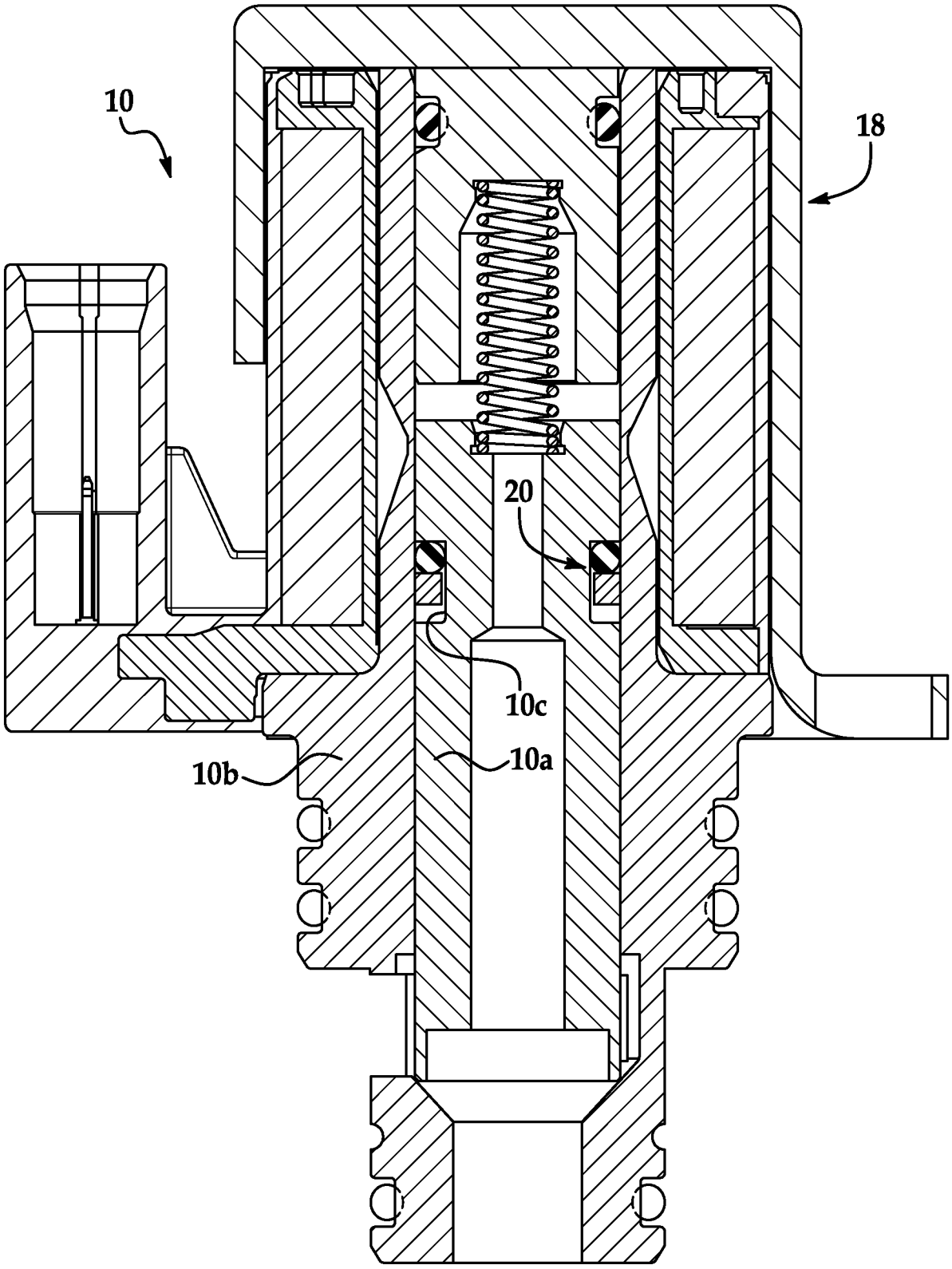

FIG. 1

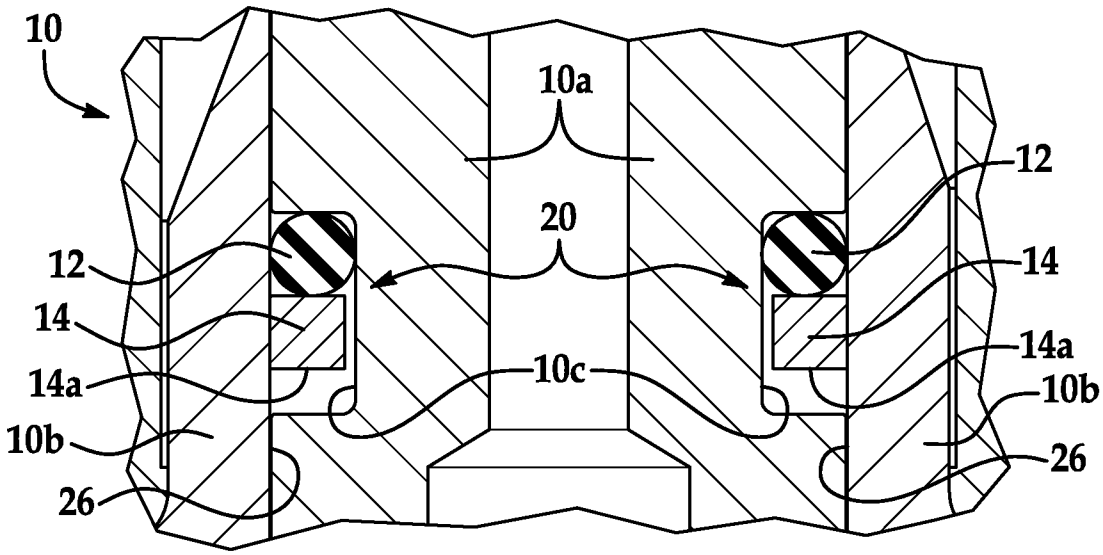

FIG. 2

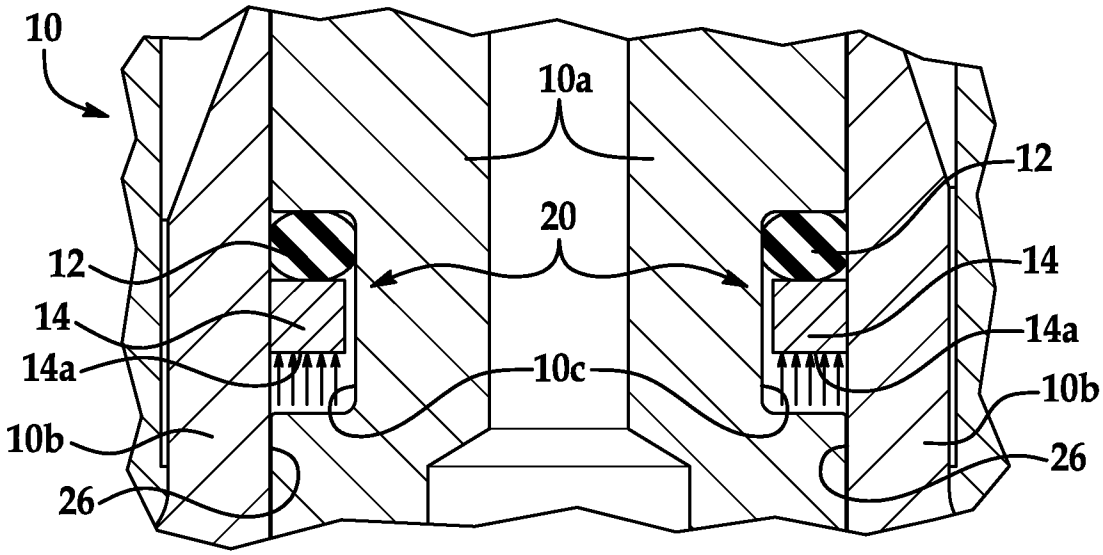

FIG. 3

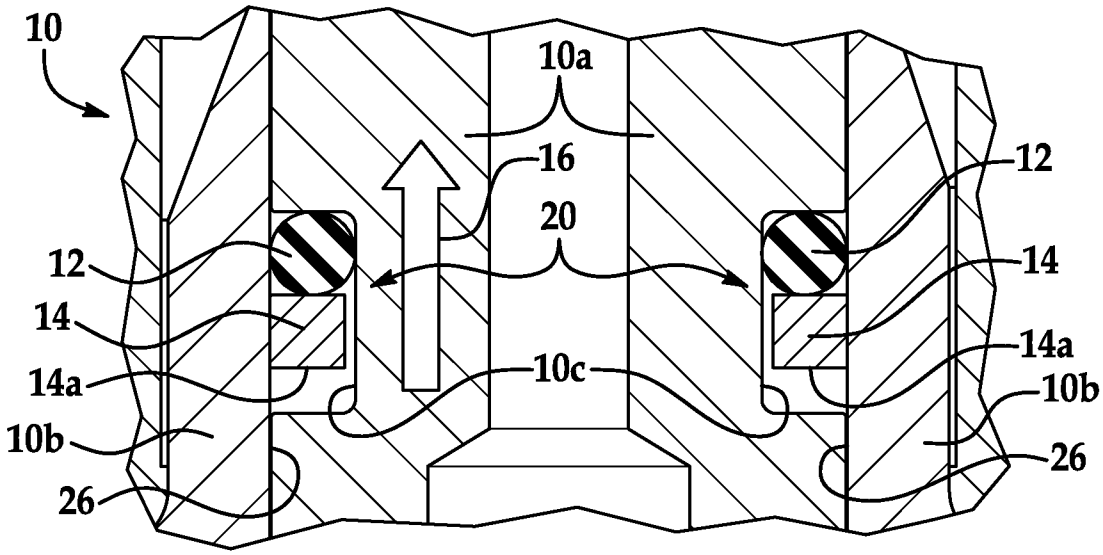

FIG. 4

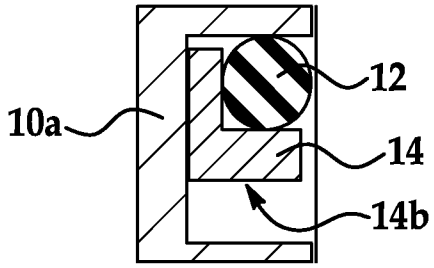

FIG. 5A

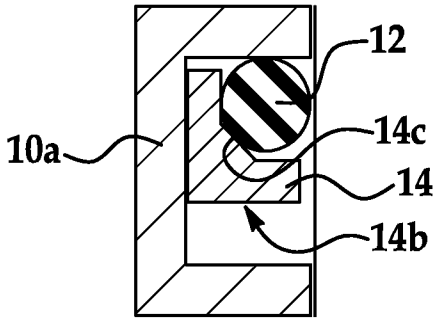

FIG. 5B

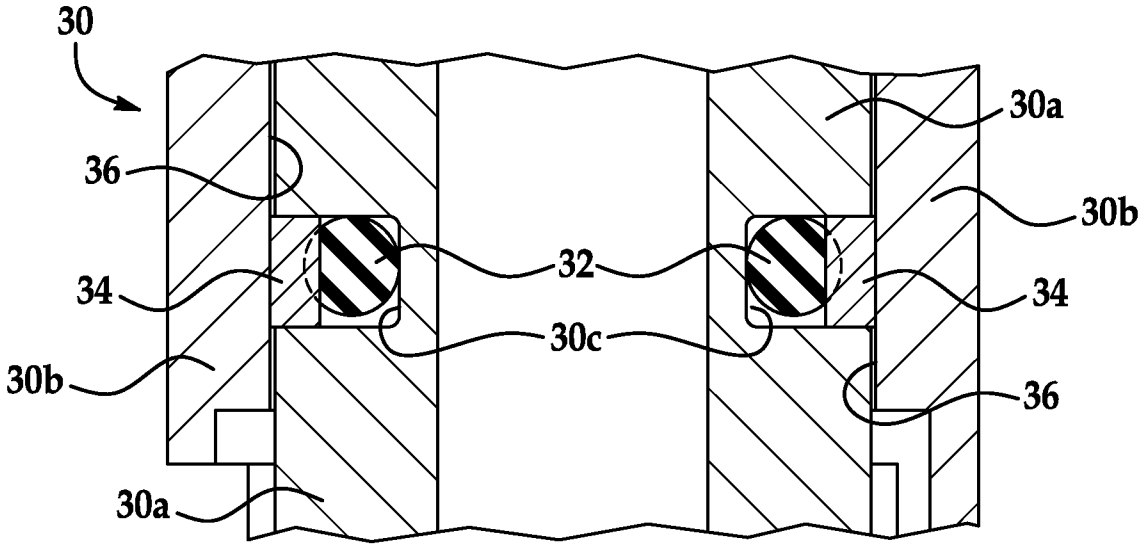

FIG. 6
PRIOR ART

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/029492

A. CLASSIFICATION OF SUBJECT MATTER

F16J 15/16(2006.01)i, F16J 9/14(2006.01)i

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)
F16J 15/16; F16J 15/54; F16K 31/02; F15B 13/043; F16J 15/48

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: sealing, O-ring, energizer, drag, solenoid, and radial

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y		9-13
Y	US 2009-0120521 A1 (CLARK et al.) 14 May 2009 See abstract; paragraph [0022]; and figure 6A.	9-13
A	US 6648337 B1 (BAEHL et al.) 18 November 2003 See abstract; column 4, line 45 - column 5, line 51; and figures 1, 2.	1-13
A	US 5143382 A (MARINGER, MARTIN M.) 01 September 1992 See abstract and column 5, lines 6-45.	1-13
A	US 2003-0057658 A1 (HOPE et al.) 27 March 2003 See abstract; paragraphs [0065]-[0067]; and figures 9-11.	1-13

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

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 June 2013 (24.06.2013)	**27 June 2013 (27.06.2013)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer SONG, Ho Keun Telephone No. 82-42-481-5580

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/029492

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