(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
02 August 2018 (02.08.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/140254 A1

(51) International Patent Classification:
F02M 37/22 (2006.01) *B01D 29/58* (2006.01)
F02M 61/16 (2006.01)

(21) International Application Number:
PCT/US2018/013816

(22) International Filing Date:
16 January 2018 (16.01.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
15/413,951 24 January 2017 (24.01.2017) US

(71) Applicant: **CATERPILLAR INC.** [US/US]; 100 N.E. Adams Street, Peoria, IL 61629-9510 (US).

(72) Inventor: **CACERES, Diego**; 11217 N. Northtrail Drive, Dunlap, IL 61525 (US).

(74) Agent: **RUFENER, A., Bryce** et al.; Caterpillar Inc., 100 N.E. Adams Street, Peoria, IL 61629-9510 (US).

(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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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.

(54) Title: FILTER FOR A FUEL INJECTOR

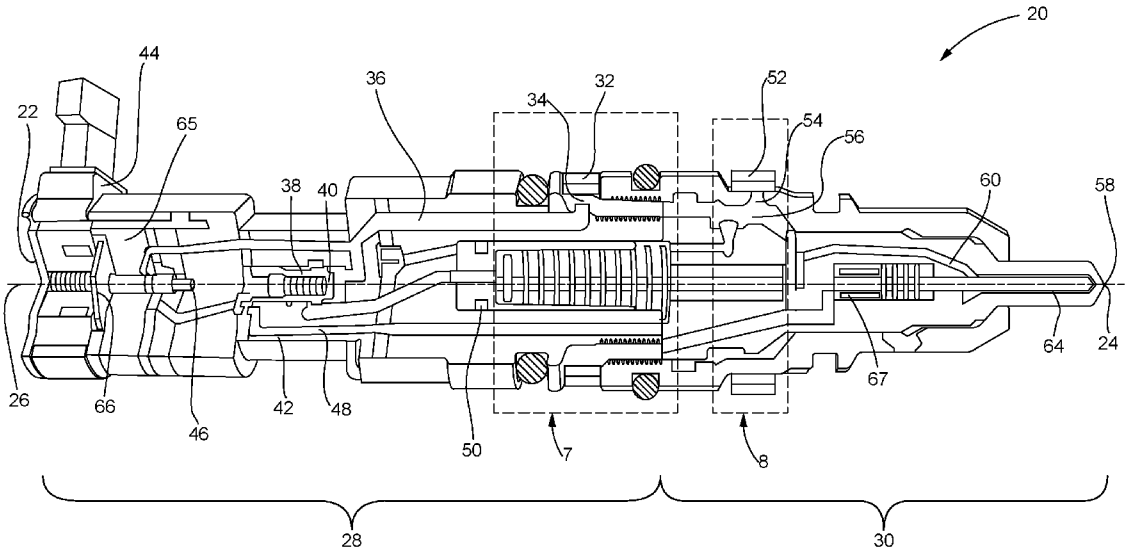


FIG. 2

(57) Abstract: A fuel injector filter (32, 52) is disclosed. The filter (32, 52) may include an inner ring (66) concentrically surrounded by an outer ring (74). The inner ring (66) may radially extend between an inner ring inner perimeter (68) and an inner ring outer perimeter (70), and comprise a first port (72) radially extending between the inner ring inner perimeter (68) and the inner ring outer perimeter (70). The outer ring (74) may radially extend between an outer ring inner perimeter (76) and an outer ring outer perimeter (78), and comprise a first aperture (80) radially extending between the outer ring inner perimeter (76) and the outer ring inner perimeter (78). The first aperture (80) may be circumferentially offset from the first port (72). A filtration channel (82) may radially extend between the inner ring outer perimeter (70) and the outer ring inner perimeter (76) and be configured to impede movement of a particle toward the first port (72).

WO 2018/140254 A1

[Continued on next page]

(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, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Description

FILTER FOR A FUEL INJECTOR

Technical Field

This disclosure generally relates to a fuel injector and, more particularly, to a filter for a fuel injector.

Background

Generally speaking, fuel injectors include a first end and a second end opposite the first end, and a longitudinal axis extending therethrough. A control section may be located adjacent to the first end and an injection section may be positioned adjacent to the second end. The injection section may be configured to deliver metered amounts of fuel into a cylinder with which the fuel injector is associated. The control section, on the other hand, may regulate operation of the injection section through mechanical, electrical, electromechanical, hydraulic means, piezoelectric, or other means.

The injection section may include a fuel injection needle in tight tolerance with an injector outlet. Fuel from a fuel feed stream may pass between the injection needle and injector outlet during operation, and particles suspended in the fuel feed stream may rub or scuff the injector outlet or injection needle during operation, thereby leading to decreased fuel injector efficiency. Likewise, the control section may include a valve in tight tolerance with a valve body. When the valve is open, oil from an oil feed stream may pass by the valve from a first oil passageway to a second oil passageway. The oil feed stream may also include suspended particles that may rub or scuff the valve or valve body, also leading to decreased fuel injector efficiency.

Ordinarily, screen-based filters may be utilized with the fuel injector to remove particles in both the fuel feed stream and the oil feed stream. For example, German Patent Application DE102013201802 (‘802) discloses a

screen-based filter to remove suspended particles in a fuel feed stream. This filter includes an inner screen and an outer screen and a flow channel positioned between the inner screen and the outer screen. While certainly effective for its intended purpose, it has certain drawbacks. For example, when particles begin building on the screen, pressure on screen builds until the screen buckles. With enough pressure, the screen ruptures and particles flow through the filter causing rubbing and scuffing on injector parts, thereby causing decreased fuel injector efficiency.

The present disclosure is directed to overcoming one or more problems set forth above and/or other problems associated with the prior art.

Summary

In accordance with one aspect of the present disclosure, a fuel injector filter is disclosed. The fuel injector filter may include an inner ring concentrically surrounded by an outer ring. The inner ring may radially extend between an inner ring inner perimeter and an inner ring outer perimeter, and comprise a first port radially extending between the inner ring inner perimeter and the inner ring outer perimeter. The outer ring may radially extend between an outer ring inner perimeter and an outer ring outer perimeter, and comprise a first aperture radially extending between the outer ring inner perimeter and the outer ring inner perimeter. The first aperture may be circumferentially offset from the first port. A filtration channel may radially extend between the inner ring outer perimeter and the outer ring inner perimeter and be configured to impede movement of a particle toward the first port.

In accordance with another aspect of the present disclosure, a fuel injector is disclosed. The fuel injector may include a first end, a second end opposite the first end, and a longitudinal axis extending through the first end and the second end. The fuel injector may also include a fuel inlet, and a fuel injector filter may concentrically surround the fuel inlet. The fuel injector filter may include an inner ring concentrically surrounded by an outer ring. The inner ring

may radially extend between an inner ring inner perimeter and an inner ring outer perimeter, and comprise a first port radially extending between the inner ring inner perimeter and the inner ring outer perimeter. The outer ring may radially extend between an outer ring inner perimeter and an outer ring outer perimeter, and comprise a first aperture radially extending between the outer ring inner perimeter and the outer ring inner perimeter. The first aperture may be circumferentially offset from the first port. A filtration channel may radially extend between the inner ring outer perimeter and the outer ring inner perimeter and be configured to impede movement of a particle toward the first port.

In accordance with another embodiment of the present disclosure, a method of purifying a feed stream for a fuel injector with a fuel filter, the feed stream including fuel and a suspended particle, is disclosed. The method may include entering by the feed stream into an inlet side of an aperture of an outer ring, and exiting by the feed stream out of an outlet side of the aperture of the outer ring. The method may also include entering by the fuel into a filtration channel, the filtration channel radially extending between an inner ring outer perimeter and an outer ring inner perimeter. Further, the method may include stopping the suspended particle at a junction between the outlet side of the aperture, the inner ring outer perimeter, and the filtration channel, thereby preventing movement of the suspended particle into the filtration channel, passing the fuel through a port in an inner ring and into the fuel injector.

These and other aspects and features of the present disclosure will be more readily understood when read in conjunction with the accompanying drawings.

Brief Description

FIG. 1 is side view of a fuel injector in accordance with the present disclosure.

FIG. 2 is a cross-sectional view of the fuel injector according to FIG. 1.

FIG. 3 is a perspective view of a fuel injector filter in accordance with the present disclosure.

FIG. 4 is a cross-sectional view of the fuel injector along line 4-4 of FIG. 3.

FIG. 5 is an enlarged view of portion 5 of FIG. 4.

FIG. 6 is an enlarged in-phantom view of a portion of 6 of FIG. 3.

FIG. 7 is an enlarged cross-sectional view of portion 7 of FIG. 2.

FIG. 8 is an enlarged cross-sectional view of portion 8 of FIG. 2.

FIG. 9 is a perspective view of an inner ring in accordance with the present disclosure.

FIG. 10 is a perspective view of an outer ring in accordance with the present disclosure.

FIG. 11 is a perspective view of an outer ring in accordance with the present disclosure.

FIG. 12 is a perspective view of an inner ring in accordance with the present disclosure.

FIG. 13 is a perspective view of an inner ring in accordance with the present disclosure.

FIG. 14 is a perspective view of an outer ring in accordance with the present disclosure.

FIG. 15 is a flowchart depicting a sample sequence of steps for a purifying a feed stream for a fuel injector with a fuel filter, when the feed stream includes fuel and a suspended particle.

Detailed Description of the Disclosure

Various aspects of the disclosure will now be described with reference to the drawings, wherein like reference numbers refer to like elements, unless specified otherwise. Referring now to the drawings and with specific reference to FIG. 1, a fuel injector is disclosed and generally referred to by reference numeral 20. The fuel injector 20 may include a first end 22, a second

end 24 opposite the first end 22, and a longitudinal axis 26 extending through the first end 22 and the second end 24. A control section 28 may be located adjacent the first end 22 and an injection section 30 may be positioned adjacent the second end 24.

Turning to FIG. 2, the control section 28 may include an oil filter 32 surrounding an oil inlet 34. A first oil passageway 36 may fluidly connect the oil inlet 34 with a first valve 46 slidingly engaged in tight tolerance with a first bore 46 of a valve body 65. The first valve 46 may be operably coupled to an actuator 44, such as a solenoid, via a connecting element armature 66. A second oil passageway 48 may fluidly connect the oil inlet 34 to an injector actuator 67 via the first oil passageway 36 and the first bore 46. The actuator 44 may slidingly reciprocate the first valve 46 in the first bore 65 between an open position and a closed position. In the open position oil may flow through the oil inlet 34, the first oil passageway 36, the first bore 65, valve seat of valve 46 and the second oil passageway 48 toward the injector actuator 38 and bore 40, thereby placing oil pressure on the injector actuator 50 and pushing fuel through passage 60 to get a needle valve 64 lift for fuel injection to start. In the closed position, oil may be redirected to flow past the first bore 65 and through the second oil passageway 48 toward the injector actuator 67 in order to force the closing of the needle valve 64, thereby the oil used to actuate actuator 50 may return and drain oil pressure on the injector actuator 50.

The injector section 30 may include a fuel filter 52 surrounding a fuel inlet 54. A fuel chamber 56 may be positioned adjacent to the fuel inlet 54 and my fluidly connect the fuel inlet to an injector outlet 58 via a fuel passageway 60 and a needle bore 64. An injection needle 64 may slidingly reciprocate in within and in tight tolerance with the needle bore 60 between an injection position and a non-injection position. In the injection position, the needle may slidingly move away from the injector outlet 58 thereby allowing fuel to pass through the fuel inlet 54, the fuel chamber 56, the fuel passageway 60, the

needle bore 64, and out the injector outlet 58 and into a cylinder with which the fuel injector 20 is associated. In the non-injection position, the injection needle 64 may be in tight tolerance with and be seated in the injector outlet 58, thereby preventing the flow of fuel between the fuel inlet 54 and into the cylinder with which the fuel injector 20 is associated.

Both the oil and the fuel passing into the fuel injector 20 may include suspended particles. Particles suspended in the oil may rub or scuff the first valve 46 or the first bore 65, thereby allowing oil to pass into the oil passageway 48 while the first valve 46 is in the closed position. The particles can also sieze actuator 40, not letting enough oil to feed actuator 50 and also actuator 67 could sieze and not allowing the injector needle 64 to open. Likewise, the particles suspended in the fuel may rub or scuff the injection needle 64 and the injector outlet 58, thus allowing fuel to pass into the cylinder when the needle 64 is in the non-injection position.

The present disclosure is directed toward an oil filter 32 and a fuel filter 52 constructed in accordance with FIGS. 3-14. As illustrated in FIGS. 3-4, the filter 32, 52 may include an inner ring 66 radially extending between an inner ring inner perimeter 68 and an inner ring outer perimeter 70. The inner ring 66 may include a plurality of ports 72 radially extending between the inner ring inner perimeter 68 and the inner ring outer perimeter 70. The filter 32, 52 may also include an outer ring 74 concentrically surrounding the inner ring 66. The outer ring 74 may radially extend between an outer ring inner perimeter 76 and an outer ring outer perimeter 78, and include a plurality of apertures 80 radially extending between the outer ring inner perimeter 76 and the outer ring outer perimeter 78. Turning to FIG. 5, a filtration channel 82 may radially extend between the inner ring outer perimeter 70 and the outer ring inner perimeter 76. The filtration channel 82 may be configured to impede movement of a particle toward the plurality of ports 72.

As illustrated in each of FIGS. 3-5, each aperture of the plurality of apertures 80 may be circumferentially offset set from each other with respect to the outer ring outer perimeter 78, with an upright 84 extending between each adjacent aperture of the plurality of apertures 80. Each aperture of the plurality of apertures 80 may include an inlet side 81 positioned at the outer ring outer perimeter 78, and an outlet side 83 positioned at the outer ring inner perimeter 76. Further, each port of the plurality of ports 72 may be circumferentially offset from each other with respect to the outer ring perimeter 78, and include a wall 86 extending between each adjacent port of the plurality of ports 72.

Each port of the plurality of ports 72 may also be circumferentially offset from each adjacent aperture of the plurality of apertures 80 with respect to the outer ring outer perimeter78. Thus, each port of the plurality of ports 80 may be circumferentially positioned between adjacent apertures of the plurality of apertures 80. In other words, each port of the plurality of ports 72 may be circumferentially aligned with an upright 84 extending between adjacent apertures of the plurality of apertures 80 with respect to the outer ring outer perimeter 78. As such, each wall of extending between adjacent ports of the plurality of ports 72 may be circumferentially aligned with an upright 84 extending between adjacent apertures of the plurality of apertures 80 with respect to the outer ring outer perimeter 78.

Referring now to FIGS. 5-6, the filtration channel 82 may be further defined by a channel width 88, which may be the distance between the inner ring outer perimeter 70 and the outer ring inner perimeter 76. The channel width 88 may be less than or equal to a predetermined width defined by a particle diameter of the particle suspended in an oil or fuel feed stream. For example, in the instance the filter 32, 52 is utilized as an oil filter 32, the channel width 84 may be less than or equal to 300 μm. In a more preferred embodiment, when the filter 32, 52 is utilized as an oil filter, the channel width may be less than or equal to 200 μm and greater than or equal to 100 μm. In the instance the filter 32, 52 is

utilized as a fuel filter 52, the channel width 84 may be less than or equal to 200 μm. In a more preferred embodiment, when the filter 32, 52 is utilized as a fuel filter 52, the channel width 84 may be less than or equal to 200 μm and greater than or equal to 50 μm.

Now referring specifically to FIG. 6, each aperture of the plurality of apertures 80 may comprise an aperture height 90 and an aperture width 92, and at least one of the aperture height 90 and the aperture width is greater than or equal to the predetermined width. For example, when the filter 32, 52 is utilized as an oil filter 32, at least one of the aperture height 90 and the aperture width 92 may be greater or equal to 100 μm. In another embodiment, when the filter 32, 52 is utilized as an oil filter, at least one of the aperture height 90 and the aperture width 92 is greater than or equal to 200 μm. In an additional embodiment, when the filter 32, 52 is utilized as an oil filter, at least one of the aperture height 90 and the aperture width 92 may be greater or equal to 300 μm. In the instance the filter 32, 52 is used as a fuel filter 52, at least one of the aperture height 90 and the aperture width 92 is greater than or equal to 50 μm and less than or equal to 100 μm. In another embodiment, when the filter 32, 52 is used as a fuel filter 52, at least one of the aperture height 90 and the aperture width 92 is greater than or equal to 200 μm.

Each port of the plurality of ports 72 may comprise a port height 94 and a port width 96, and at least one of the port height 94 and the port width 96 may be less than or equal to the predetermined width. For example, when the filter 32, 52 is utilized as an oil filter 32, at least one of the port height 94 and the port width 95 may be less than or equal to 100 μm. In another embodiment, when the filter 32, 52 is utilized as an oil filter, at least one of the port height 94 and the port width 96 may be less than or equal to 200 μm. In an additional embodiment, when the filter 32, 52 is utilized as an oil filter, at least one of the port height 94 and the port width 96 may be less or equal to 300 μm. However, in the instance the filter 32, 52 is used as a fuel filter 52, at least one of the port

height 94 and the aperture width 96 may be less than or equal to 50 μm and less than or equal to 100 μm. In another embodiment, when the filter 32, 52 is used as a fuel filter 52, at least one of the port height 94 and the port width 96 may be less than or equal to 200 μm.

Referring to FIG. 7, an enlarged cross-sectional view of the oil inlet of FIG. 2 is depicted. As is illustrated therein, the oil inlet 34 may include an oil inlet width 98 and an oil inlet circumference 100. The product of the oil inlet width 98 and oil inlet circumference 100 may define an oil inlet surface area. In one embodiment, when the filter 32, 52 is used as an oil filter 32, the sum of the surface area of each aperture of the plurality of apertures 80, wherein the surface area of each aperture is defined as the product of the aperture height 90 and the aperture width 92, is greater than or equal to the oil inlet surface area. In another embodiment, when the filter 32, 52 is used as an oil filter 32, the sum of the surface area of each port of the plurality of ports 72, wherein the surface are of each port is defined as the product of the port height 94 and the port width 96, is greater than or equal to the oil inlet surface area. Otherwise, the oil filter 32 would starve the flow of oil into the oil inlet 34.

Turning to FIG. 8, an enlarged cross-sectional view of the fuel inlet 54 is depicted. As seen there, the fuel inlet 54 may be a port defining a fuel inlet surface area 102. In one embodiment, when the filter 32, 52 is used as a fuel filter 52, the sum of the surface area of each aperture of the plurality of apertures 80, wherein the surface area of each aperture is defined as the product of the aperture height 90 and the aperture width 92, is greater than or equal to the fuel inlet surface area 102. In another embodiment, when the filter 32, 52 is used as a fuel filter 52, the sum of the surface area of each port of the plurality of ports 72, wherein the surface are of each port is defined as the product of the port height 94 and the port width 96, is greater than or equal to the fuel inlet surface area 102. Otherwise, the fuel filter 52 would starve the flow of fuel into the fuel inlet 54.

Turning to FIGS. 9-11, one embodiment of locking the rotation of the inner ring 66 relative to the outer ring 74 is illustrated. As depicted in FIG.9, the inner ring 66 may include an inner rib 104 extending radially outward from the inner ring outer perimeter 70. The inner rib 104 may be circumferentially positioned at least one wall 86 of the inner ring 66. Turning to FIG. 10, the outer ring 74 may include an outer groove 106 extending partially radially outward from the outer ring inner perimeter 76 that may be configured to receive the inner rib 104, thereby locking the rotation of the inner ring 66 relative to the outer ring 74. The outer groove 106 may be circumferentially positioned at least one upright 84 of the outer ring 74. Alternatively, and turning to FIG. 11, the outer ring 74 may include and outer slot 108 radially extending between the outer ring inner perimeter 76 and the outer ring outer perimeter 78, that may be configured to receive the inner rib 104 and thereby locking the rotation of the inner ring 66 relative to the outer ring 74. The outer slot 108 may be circumferentially positioned at least one upright 84 of the outer ring 74.

Referring to FIGS. 12-14, another embodiment of locking the rotation of the inner ring 66 relative to the outer ring 74 is depicted. As is seen in FIG. 12, the inner ring 66 may include an inner groove 110 extending partially radially inward from the inner ring outer perimeter 70 toward the inner ring inner perimeter 68. Circumferentially, the inner groove 110 may be positioned at the wall 86 of the inner ring 66. Instead, and turning to FIG. 13, the inner ring 66 may include an inner slot 112 radially extending between the inner ring inner perimeter 68 the inner ring outer perimeter 70. Turning to FIG. 14, the outer ring 74 may also include an outer rib 114 extending partially radially outward from the outer ring inner perimeter 76 toward the outer ring outer perimeter 78. Circumferentially, the outer rib 114 may be positioned at an upright 84. The outer rib 114 may be configured to receive either the inner groove 110 or the inner slot 112 of the inner ring 66, thereby locking the rotation of the inner ring 66 relative to the outer ring 74.

Industrial Applicability

The disclosed filter finds potential in any fluid system requiring removal of a suspended particle from a feed stream. The disclosed filter finds particular applicability in fuel and oil filtration applications, for example, with fuel injectors configured to deliver liquid fuel or gaseous based fuel to a combustion cylinder, or with fuel injectors utilizing oil as a hydraulic means to regulate operation of the injection section. One skilled in the art will recognize, however, that the filter may be utilized in other functions that may or may not be associated with requiring removal of suspended particle from a feed stream, and other applications besides fuel injectors. Operation of the filter will now be described in more detail.

A feed stream, such as fuel for a fuel injector 20, may include a suspended particle that may rub or scuff the injection needle 64 or the injector outlet 58, thereby allowing fuel to pass into a cylinder with which the fuel injector 20 is associated when the needle 64 is in the non-injection position. Accordingly, as is depicted in FIG. 14, at step 116, the feed stream may enter into an inlet side 81 of an aperture of the plurality of apertures 80 of an outer ring 74. In an additional step 118, the feed stream may exit an outlet side 83 of the aperture of the plurality of apertures 80 of the outer ring 74. Subsequently, and as is depicted in step 120, the fuel may enter into a filtration channel 82, while as is depicted in step 122 the suspended particle may be stopped at a junction between the outlet side 83 of the aperture of the plurality of apertures 80, an inner ring outer perimeter 70, and the filtration channel 82, thereby stopping movement of the particle into the filtration channel 82. The filtration channel 82 may radially extend between the inner ring outer perimeter 70 and an outer ring inner perimeter 76. Next, as seen at step 124, the fuel may pass move through the filtration channel 82 and pass through a port of a plurality of ports 72 of an inner ring 66 and into the fuel injector 20. When the filter 32, 52 is utilized as an oil

filter 52, the same process applies except that the feed stream contains oil and a suspended particle.

The above description is meant to be representative only, and thus modifications may be made to the embodiments described herein without departing from the scope of the disclosure. Thus, these modifications fall within the scope of present disclosure and are intended to fall within the appended claims.

Claims

1. A fuel injector filter (32, 52), comprising:

an inner ring (66) radially extending between an inner ring inner perimeter (68) and an inner ring outer perimeter (70), and comprising a first port (72) radially extending between the inner ring inner perimeter (68) and the inner ring outer perimeter (70);

an outer ring (74) concentrically surrounding the inner ring (66) and radially extending between an outer ring inner perimeter (76) and an outer ring outer perimeter (78), comprising a first aperture (80) radially extending between the outer ring inner perimeter (76) and the outer ring inner perimeter (78), and the first aperture (80) is circumferentially offset from the first port (72); and

a filtration channel (82) radially extending between the inner ring outer perimeter (70) and the outer ring inner perimeter (76) configured to impede movement of a particle toward the first port (72).

2. The fuel injector filter (32,52) according to claim 1, the outer ring (74) further comprising a second aperture (80) radially extending between the outer ring inner perimeter (76) and the outer ring outer perimeter (78), wherein the second aperture (80) is circumferentially offset from the first aperture (80), and wherein the first port (72) is circumferentially positioned between the first aperture (80) and the second aperture (80).

3. The fuel injector filter (32, 52) according to claim 2, the outer ring (74) further comprising an upright (84) radially extending between the outer ring inner perimeter (76) and the outer ring outer perimeter (78) and circumferentially extending between the first aperture (80) and the second aperture (80).

4. The fuel injector filter (32, 52) according to claim 1, the outer ring (74) further comprising a second aperture (80) radially extending between the outer ring inner perimeter (76) and the outer ring outer perimeter (78), wherein the second aperture (80) is circumferentially offset from the first aperture (80), the outer ring (74) further comprising an upright (84) radially extending between the outer ring inner perimeter (76) and the outer ring outer perimeter (78) and circumferentially extending between the first aperture (80) and the second aperture (80), and wherein the first port (72) is circumferentially aligned with the upright (84).

5. The fuel injector filter (32, 52) according to claim 1, the filtration channel (82) further comprising a channel width (88) defined by the distance between the inner ring outer perimeter (70) and the inner ring inner perimeter (76), wherein the channel width (88) is less than or equal to a predetermined width, and wherein the predetermined width is defined by a diameter of the particle.

6. The fuel injector filter (32, 52) according to claim 5, the first aperture (80) further comprising an aperture height (90) and an aperture width (92), and wherein at least one of the aperture height (90) and the aperture width (92) is greater than or equal to the predetermined width.

7. The fuel injector filter (32, 52) according to claim 6, wherein the predetermined width is 300 μm.

8. The fuel injector filter (32, 52) according to claim 6, wherein the predetermined with is 200 μm.

9. The fuel injector filter (32, 52) according to claim 5, the first port (72) further comprising a port height (94) and a port width (96), and wherein at least one of the port height (94) and the port width (96) is less than or equal to the predetermined width.

10. A fuel injector (20), comprising:

a first end (22);

a second end (24) opposite the first end (22);

a longitudinal axis (26) extending through the first end (22) and the second end (24);

a fluid inlet (34, 54);

a fuel injector filter (32, 52) concentrically surrounding the fluid inlet (34, 54), the fuel injector filter (32, 52) comprising an inner ring (66) radially extending between an inner ring inner perimeter (68) and an inner ring outer perimeter (70), the inner ring (66) comprising a first port (70) radially extending between the inner ring inner perimeter (68) and the inner ring outer perimeter (70), the fuel injector filter (32, 52) further comprising an outer ring (74) concentrically surrounding the inner ring (66), the outer ring (74) radially extending between an outer ring inner perimeter (76) and an outer ring outer perimeter (78), the outer ring (74) further comprising a plurality of apertures (80) radially extending between the outer ring inner perimeter (76) and the outer ring outer perimeter (78), wherein the first port (72) is circumferentially positioned between adjacent apertures (80) of the plurality of apertures (80), the fuel injector filter (32, 52) further comprising a filtration channel (82) radially extending between the inner ring outer perimeter (70) and the outer ring inner perimeter (76) configured to impede movement of a particle toward the first port (72).

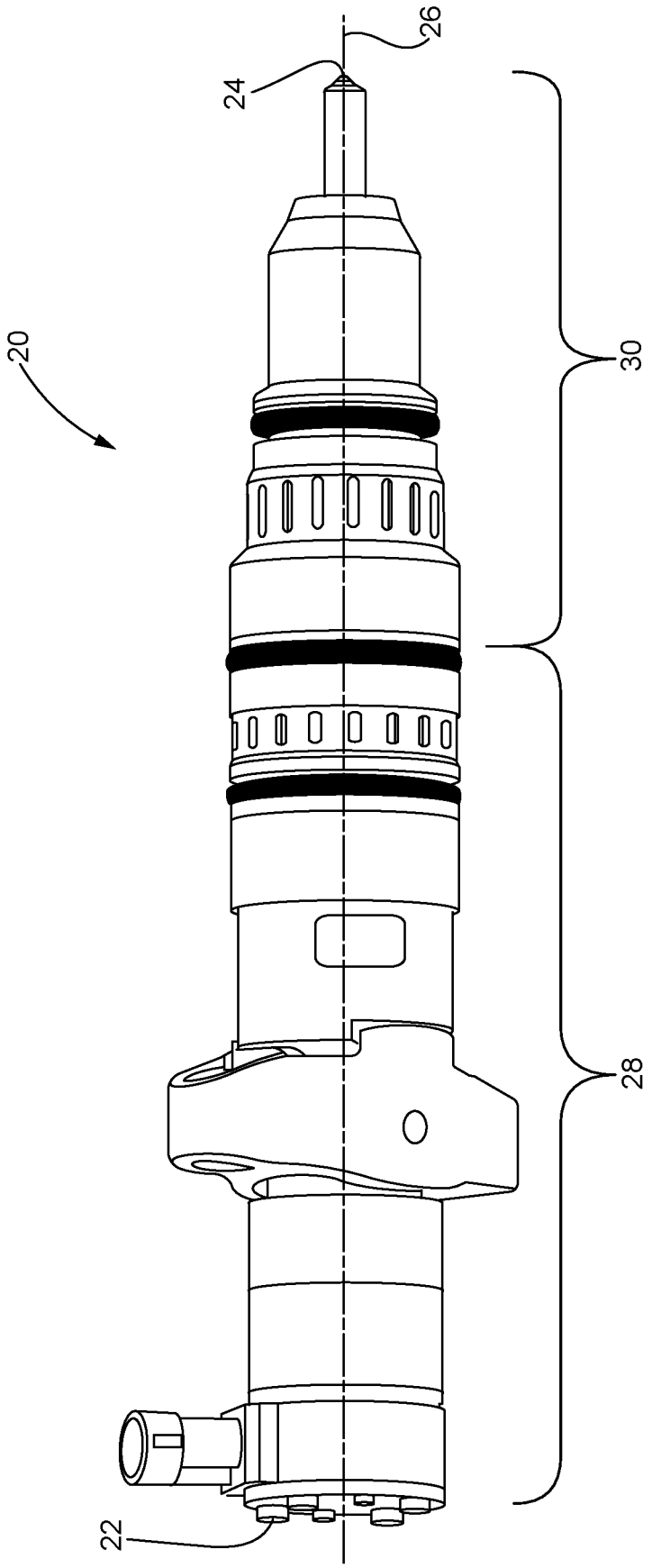


FIG. 1

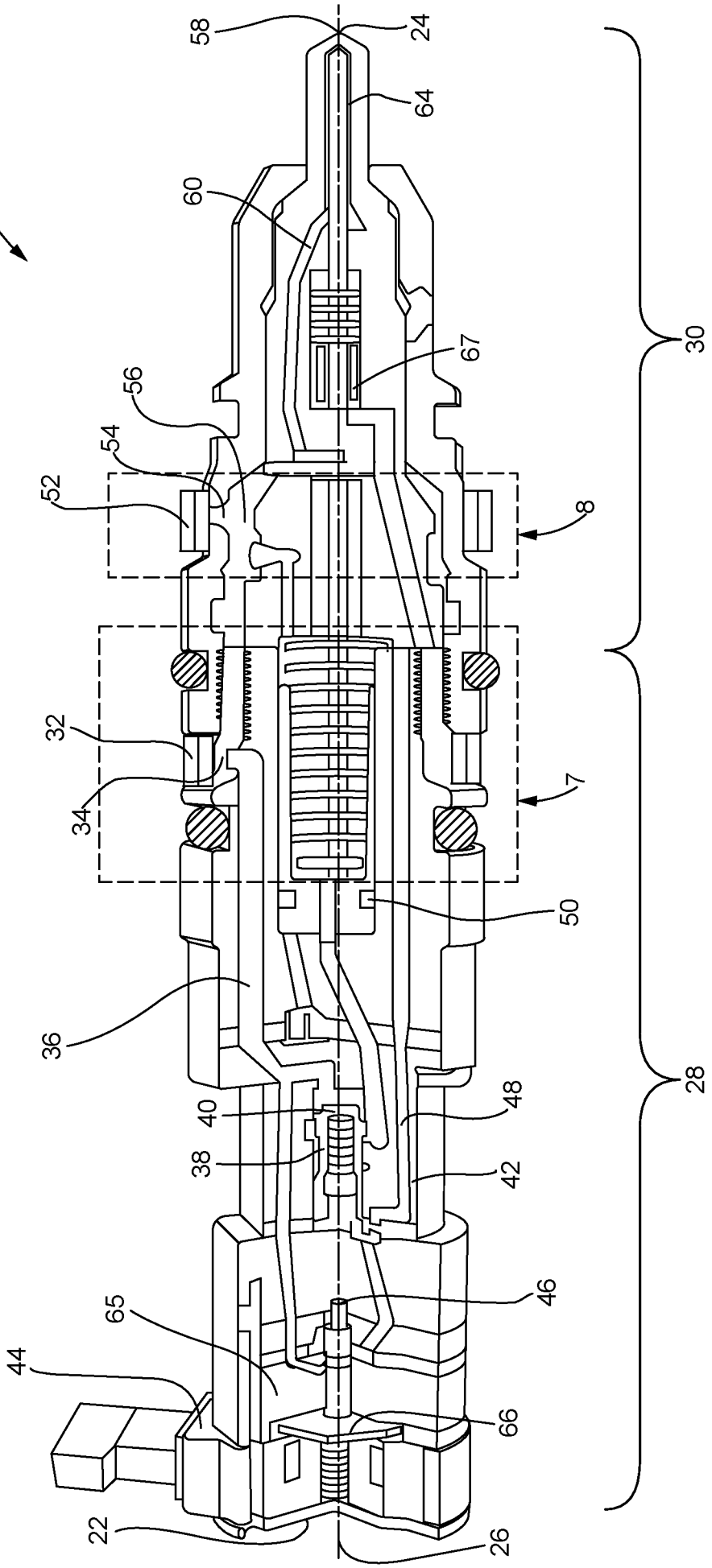

20
58
24
64
60
67
56
54
52
8
30
32
34
7
50
36
28
40
48
38
42
46
65
44
66
22
26

FIG. 2

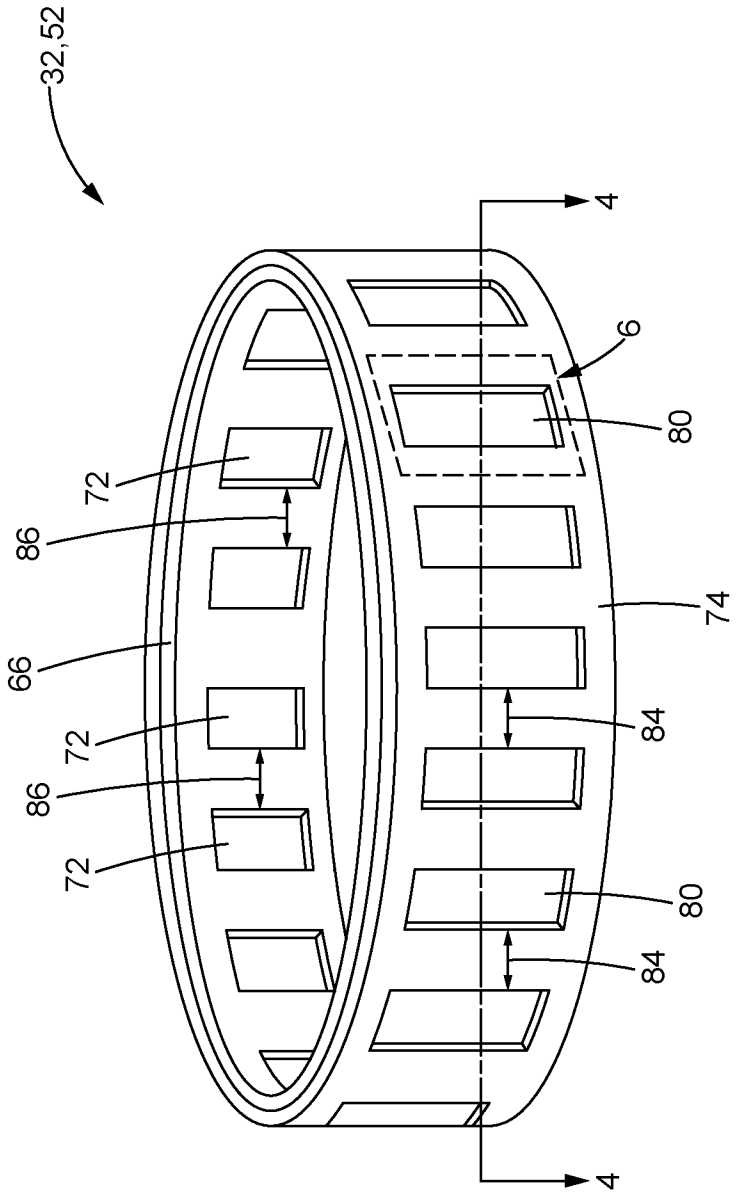


FIG. 3

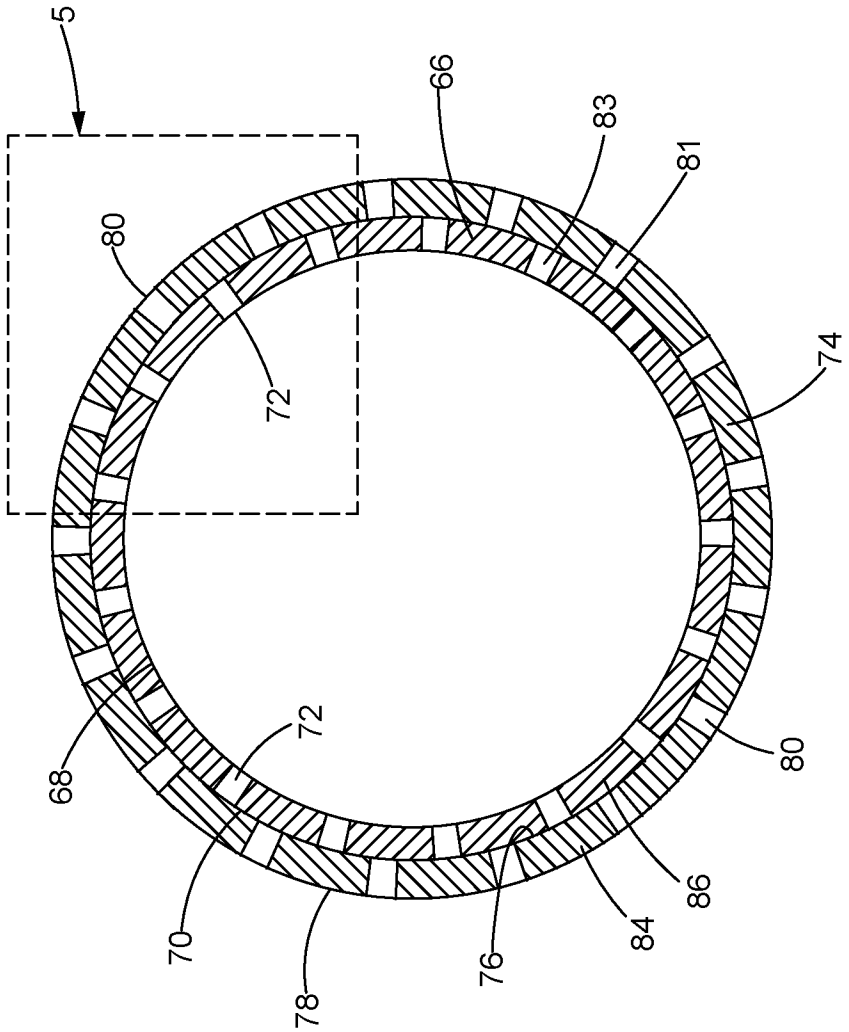


FIG. 4

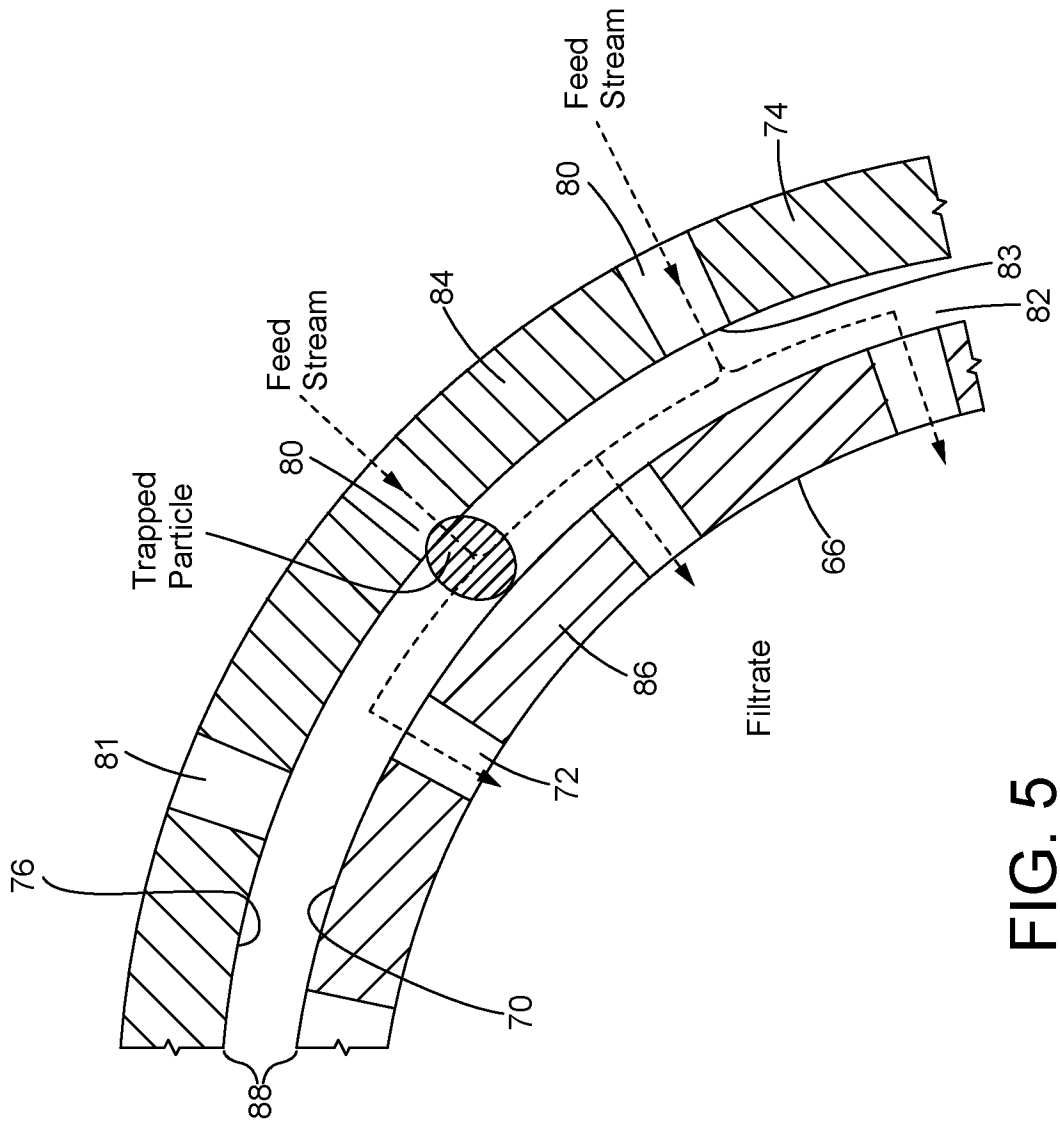

Feed Stream
74
80
83
82
84
Feed Stream
80
Trapped Particle
66
86
Filtrate
81
72
76
70
88

FIG. 5

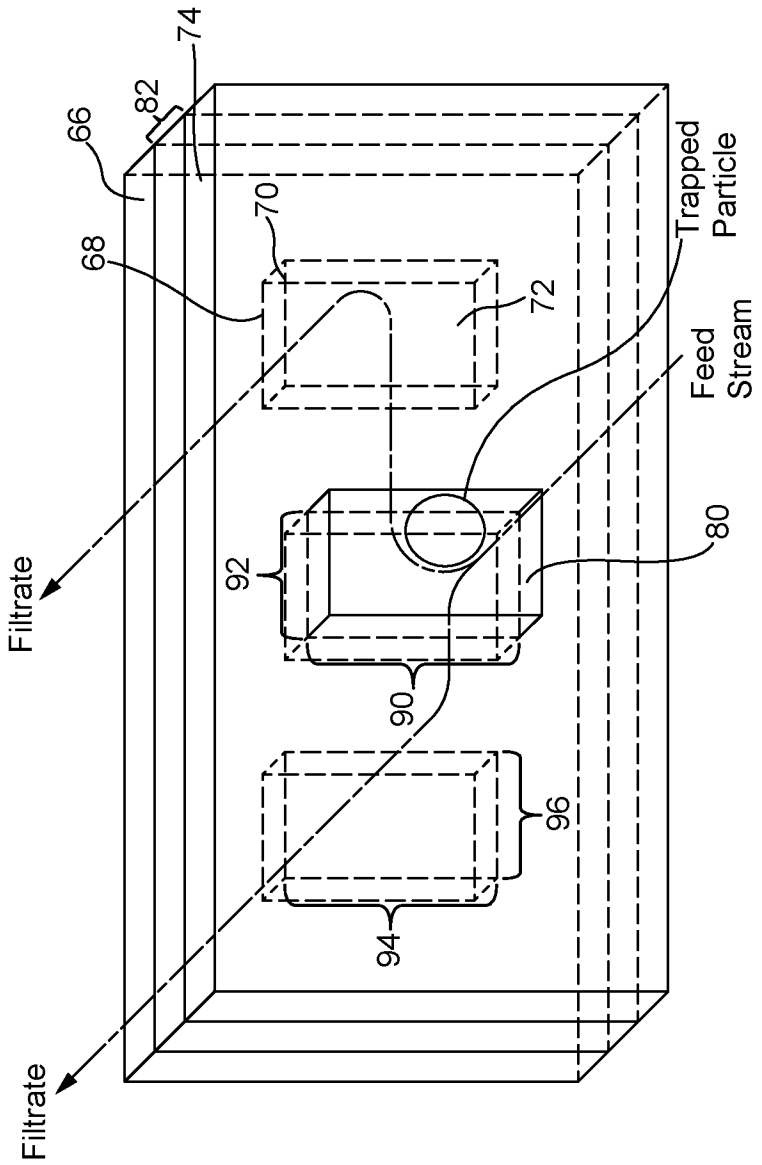

74
82
66
70
68
72
Trapped Particle
Feed Stream
80
92
Filtrate
90
96
94
Filtrate

FIG. 6

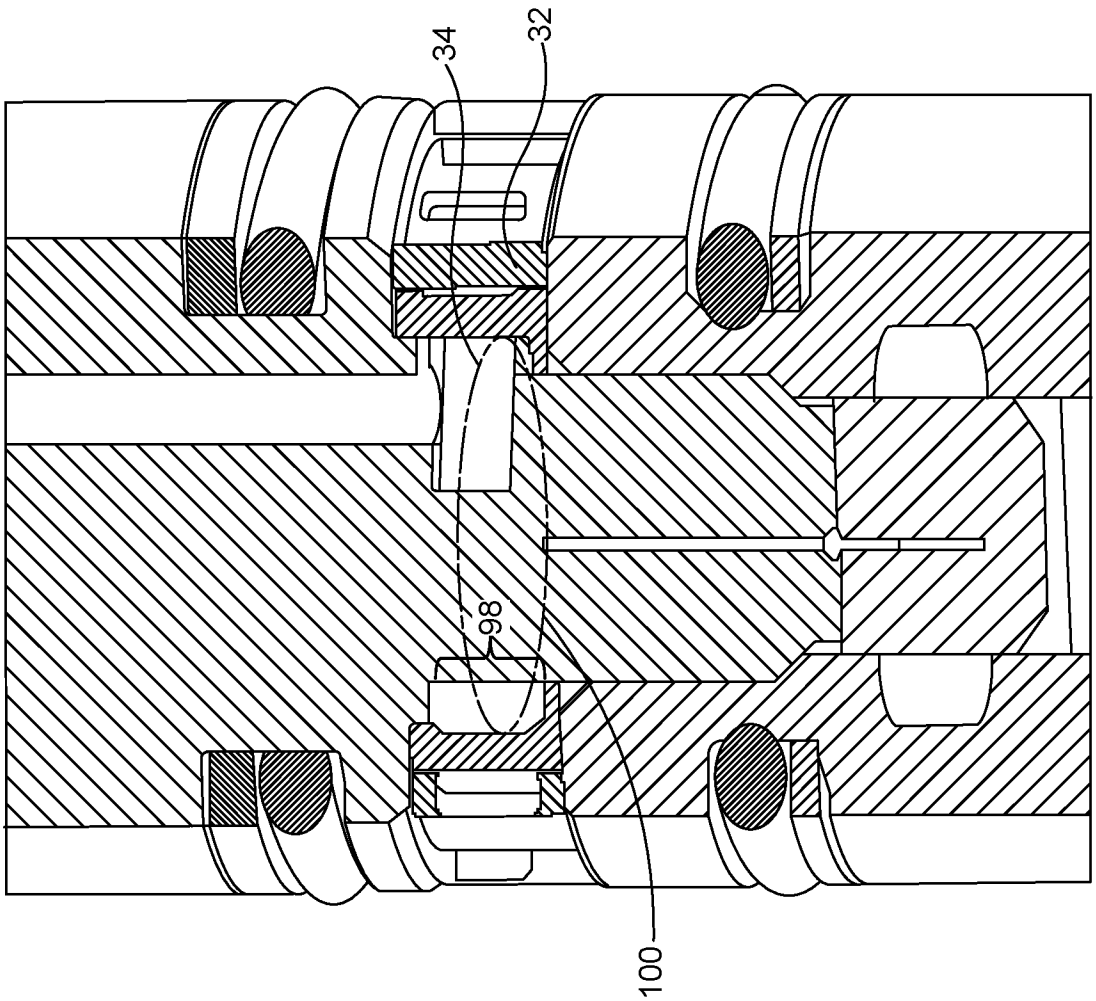


FIG. 7

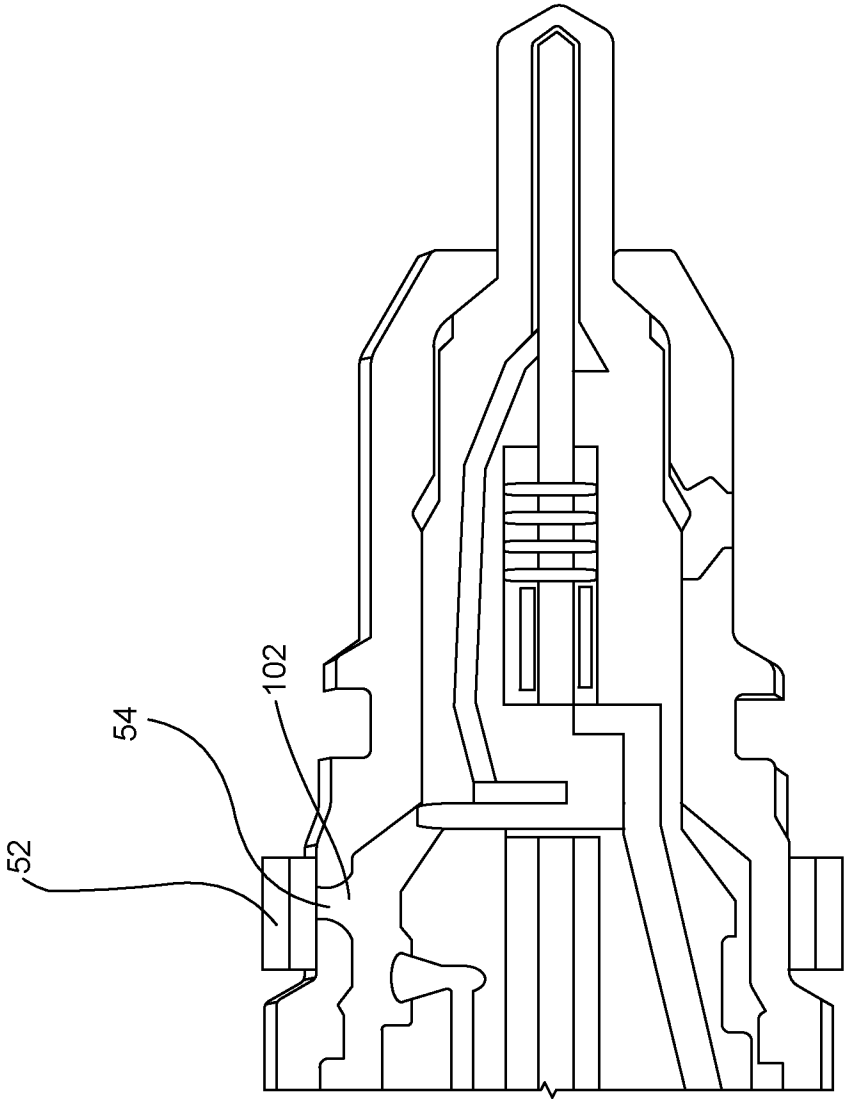


FIG. 8

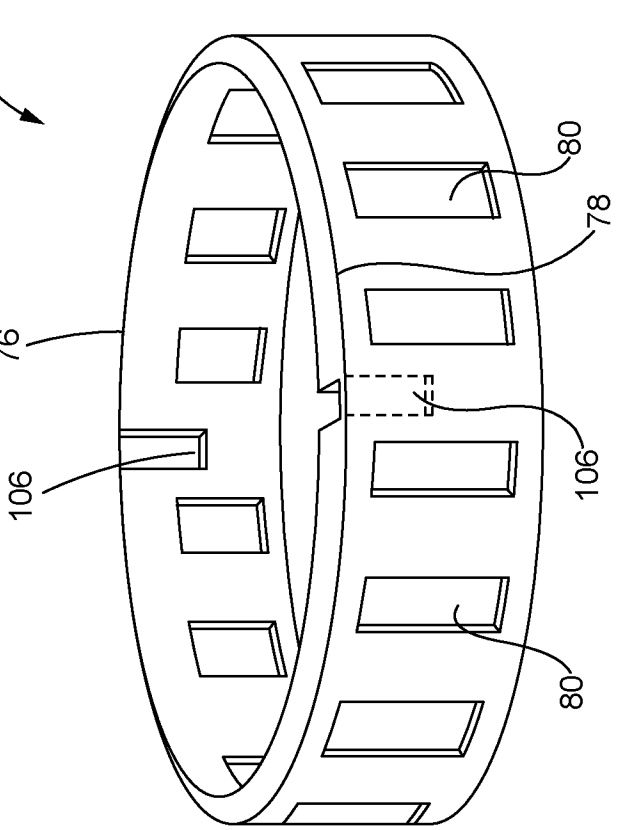


FIG. 10

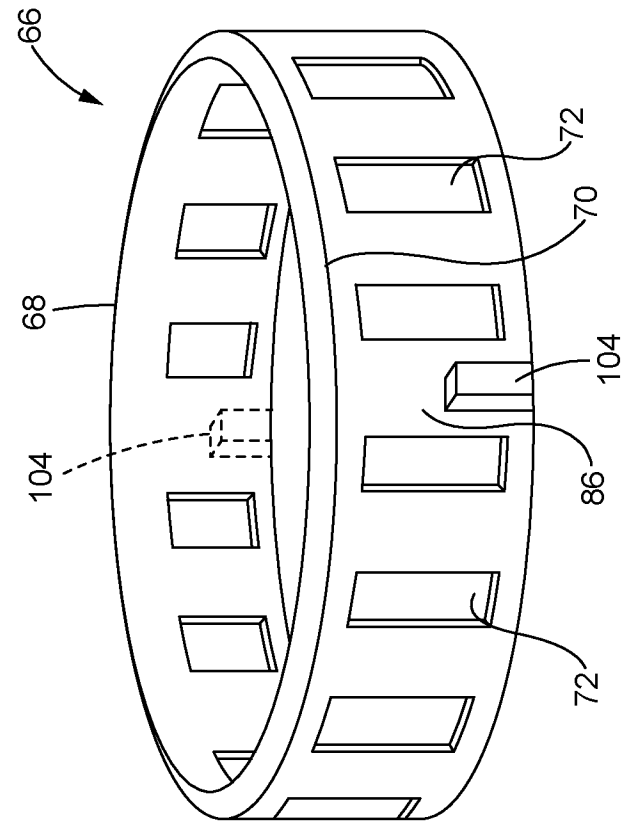


FIG. 9

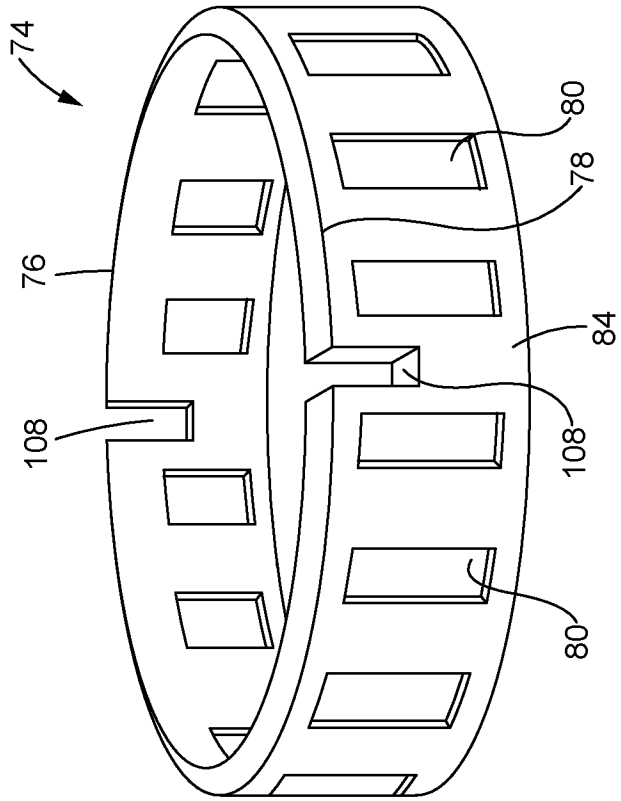


FIG. 11

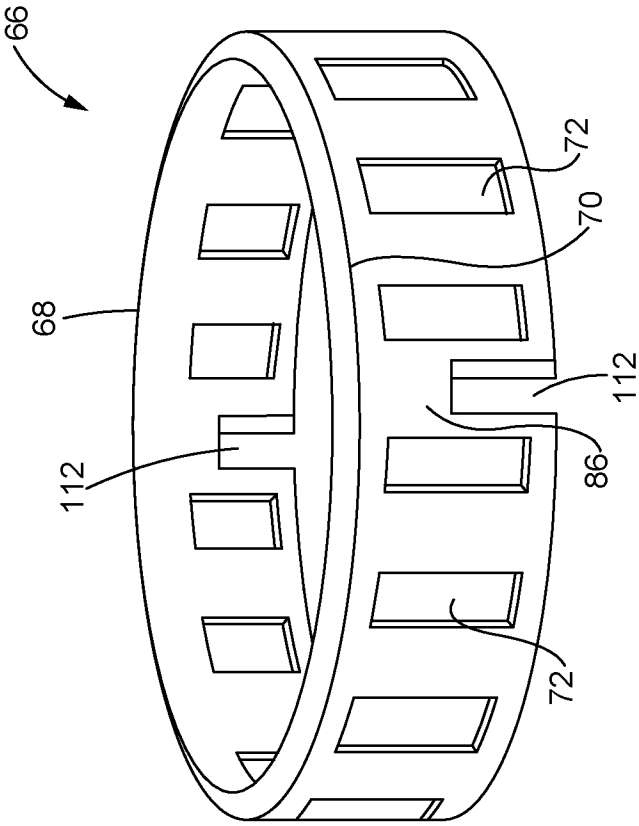


FIG. 13

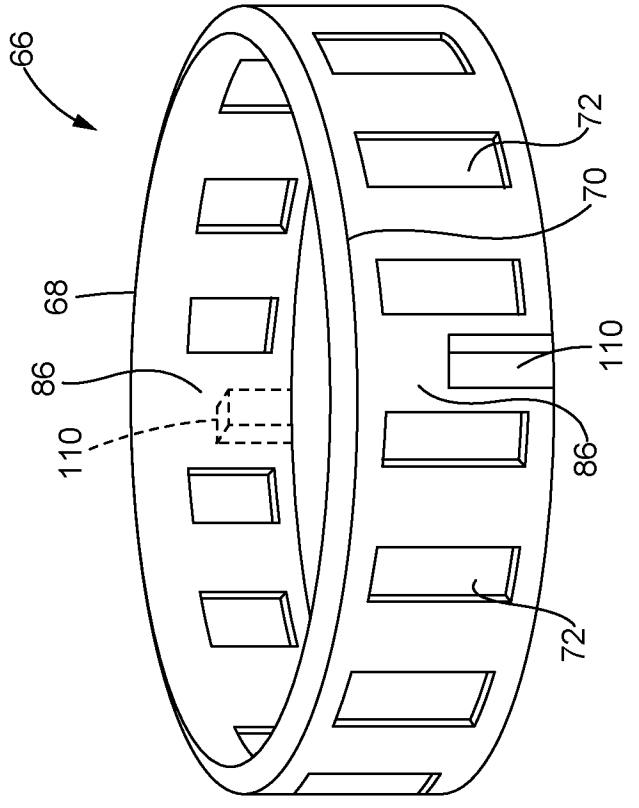


FIG. 12

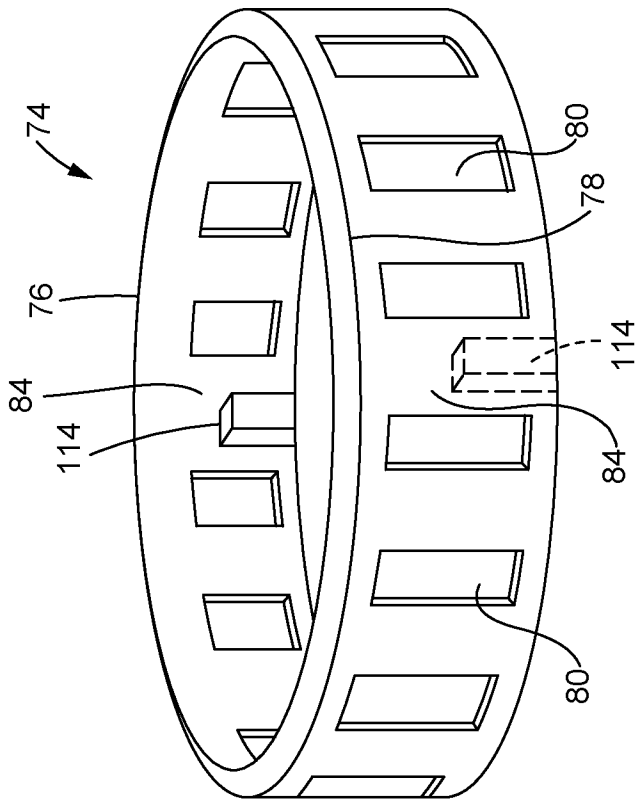


FIG. 14

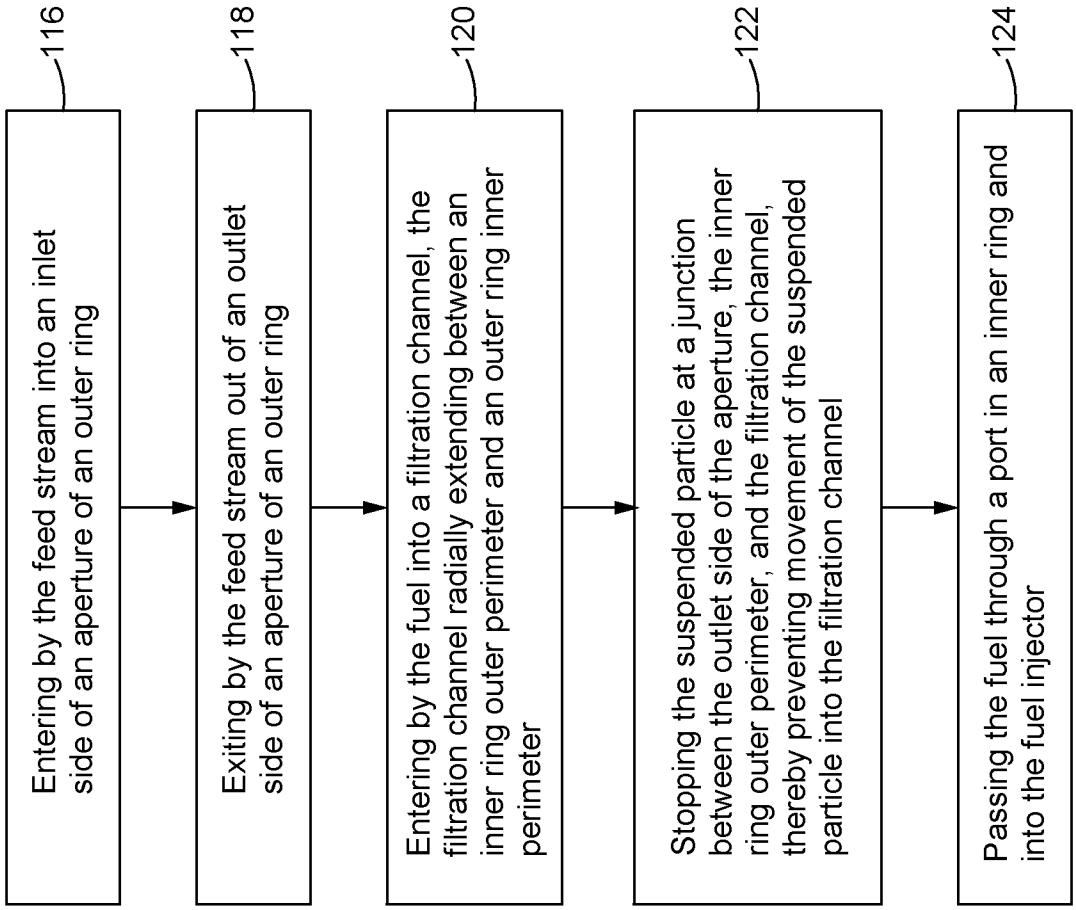

116
Entering by the feed stream into an inlet side of an aperture of an outer ring
118
Exiting by the feed stream out of an outlet side of an aperture of an outer ring
120
Entering by the fuel into a filtration channel, the filtration channel radially extending between an inner ring outer perimeter and an outer ring inner perimeter
122
Stopping the suspended particle at a junction between the outlet side of the aperture, the inner ring outer perimeter, and the filtration channel, thereby preventing movement of the suspended particle into the filtration channel
124
Passing the fuel through a port in an inner ring and into the fuel injector

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/013816

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02M37/22 F02M61/16 B01D29/58
ADD.

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)
F02M B01D F01L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/174704 A1 (YAMADA KATSUHISA [JP] ET AL) 21 July 2011 (2011-07-21) paragraph [0070]; figures 27, 28 paragraph [0132] - paragraph [0137] paragraph [0152] - paragraph [0153]	1-6,9,10
X	DE 10 2006 047557 A1 (DAIMLER AG [DE]) 10 April 2008 (2008-04-10) paragraph [0014] - paragraph [0019]; claim 1; figure 1	1-6,9,10
X	WO 2016/122829 A1 (CATERPILLAR INC [US]) 4 August 2016 (2016-08-04) page 5, line 15 - line 28; figures 1, 7, 8 page 9, line 16 - line 33	1-3,5-10

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

"P" document published prior to the international filing date but later than the priority date claimed

"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
22 May 2018	28/05/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Tortosa Masiá, A

3

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 338 797 B1 (NURSE JR HARRY L [US] ET AL) 15 January 2002 (2002-01-15) column 3, line 14 - column 3, line 53; figure 1	1-7,9,10
X	GB 293 668 A (OVE PETERSEN) 12 July 1928 (1928-07-12) page 1, line 78 - page 2, line 40; figure 1	1-6,9,10
X	DE 10 2007 050447 A1 (HYDRAULIK RING GMBH [DE]) 23 April 2009 (2009-04-23)	1,10
A	paragraph [0055]; figure 13	2-9
A	EP 0 880 985 A2 (KOTESKEY GARY L [US]) 2 December 1998 (1998-12-02) column 6, line 56 - column 8, line 31; figure 1	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2018/013816

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011174704 A1	21-07-2011	JP 5126321 B2	23-01-2013
		JP 2011169310 A	01-09-2011
		US 2011174704 A1	21-07-2011
DE 102006047557 A1	10-04-2008	NONE	
WO 2016122829 A1	04-08-2016	US 2016220926 A1	04-08-2016
		WO 2016122829 A1	04-08-2016
US 6338797 B1	15-01-2002	NONE	
GB 293668 A	12-07-1928	NONE	
DE 102007050447 A1	23-04-2009	NONE	
EP 0880985 A2	02-12-1998	CA 2237751 A1	28-11-1998
		EP 0880985 A2	02-12-1998
		US 5885452 A	23-03-1999