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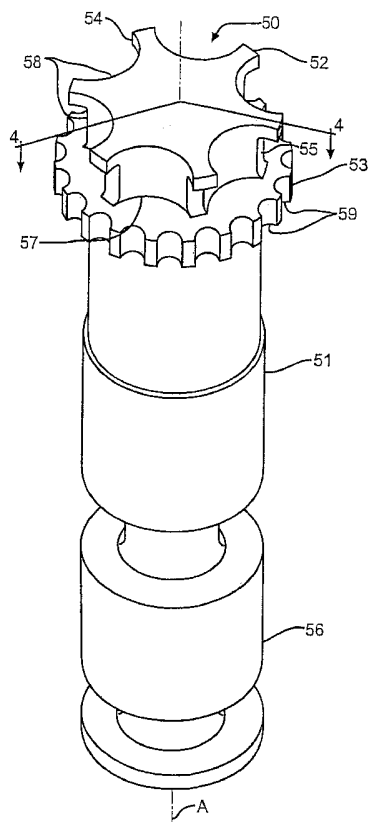
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(54) Title: PUMP WITH RECIPROCATING HIGH PRESSURE SEAL AND VALVE FOR VEHICLE BRAKING SYSTEMS



(57) Abstract: A pump assembly with a combination reciprocating high-pressure seal (63, 163, 257, 357) and fluid inlet check valve(70, 270, 370) comprises a housing(61, 260, 360) having a bore (62, 261, 361) formed therethrough and a piston (50, 250, 350) disposed within the bore for reciprocal movement therein. An annular seal is disposed around the piston for reciprocal movement thereon. At least one passageway(57, 180, 258) is formed in the piston and/or by a cooperation of the piston with the annular seal, and an inlet flange portion (53, 153, 253, 353) of the piston has at least one passageway (59, 159, 263, 363) formed therein. The passageway, the piston, and the annular seal and cooperate to form a check valve assembly (70, 270, 370). The annular seal is moveable to a first position relative to the piston in which the check valve assembly is in a flow-through position to fill the pump chamber (77, 177, 277, 377) during a fluid inlet stroke. The annular seal is moveable to a second position relative to the piston in which the check valve assembly is closed. Further a non-metallic annular seal for a pump is claimed with featureless end faces and a groove formed in the inner wall.

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[0001] Pump with Reciprocating High Pressure Seal and Valve for Vehicle Braking Systems

BACKGROUND OF THE INVENTION

[0002] This invention relates in general to brake systems for vehicles and in particular to a pump assembly with a combination reciprocating high-pressure seal and fluid inlet check valve for use within brake systems.

[0003] In conventional vehicular brake systems having anti-lock brake, traction control and/or vehicle stability control, a supply of hydraulic fluid for the vehicle brakes is modulated by a hydraulic control unit. Various hydraulic pumps may be employed to selectively supply hydraulic fluid to the vehicle brakes. Several hydraulic pump designs are known.

[0004] U.S. Patent No. 4,556,261 to Farr, discloses a prior art pump and skid sensing assembly for a vehicle hydraulic anti-skid braking system, as shown in Figs. 1 and 2. The assembly comprises a housing 1 incorporating a hydraulic pump 2, and a solenoid-operated valve assembly 3. Only the operation of the pump 2 will be described herein, as the operation of the rest of the anti-skid braking system is not relevant to the present invention. The pump 2 includes a plunger 10, which reciprocates within a stepped bore 11 in the housing 1. The plunger 10 is engageable with a drive mechanism comprising a ring 12 rotatable on a shaft 4. The plunger 10 carries an 'O' ring seal 18 and a lip seal 19. The seals 18 and 19 are disposed on opposite sides of a passage 20 leading to the valve 3. The seals 18 and 19, the plunger 10, and the bore 11 define a chamber 22. A reservoir 35 supplies the chamber 22 with fluid.

[0005] The seal 19, which is illustrated in detail in FIG. 2, comprises an annular ring of elastomeric material, which is received in an annular groove 25 in the plunger 10. The groove 25 is parallel sided and is of an axial length greater than the thickness of the seal 19. Opposite faces 26 and 27 of the seal

being provided with at least one diametrical slot 28 which communicates with one or more passages 29 in the inner peripheral edge of the seal 19. The planar face 26 is adapted to seal against the adjacent, inner, face 25a of the groove 25 to prevent flow from the secondary chamber 22 into the reservoir 35 when the seal 19 is in a first position relative to the plunger 10. The face 25a is formed by an inlet flange 40 of the plunger 10. Thus, the face 26 of the seal 19 and the inlet flange 40 form a check valve assembly for separating the secondary chamber 22 and the reservoir 35. The seal 19 is rather complex in that it contains at least one radial slot 28 and at least one longitudinal passage 29 formed therethrough to permit fluid flow past the check valve assembly when the face 22 of the seal 19 abuts the adjacent side wall of the groove 25.

[0006] An inlet passageway 41 is formed by the inlet flange 40 and the housing 1. A retaining flange 42 and the housing 1 form an outlet passageway 43 of the check valve assembly. As the plunger 10 is moved towards the ring 12, the seal 19 moves to a second position relative to the plunger 10 so that the face 26 is spaced apart from the adjacent side wall of the groove 25 and the inlet flange 40. In the second position, the seal 19 may abut the retaining flange 41. This allows fluid from the reservoir 35 to be drawn into the increasing volume of the chamber 22 past the seal 19. When the seal 19 is in the second position, the longitudinal passageway 29 is not in direct communication with the outlet passageway 43. When the seal 19 is in the second position, the longitudinal passage 29 is in fluid communication with the inlet passageway 41, and the longitudinal passage 29 is in fluid communication with the radial slot 28. The radial slot 28 is in fluid communication with the outlet passageway 43, such that the check valve assembly is in an open position and the chamber 22 and the reservoir 35 are communicably connected. Therefore, the radial slot 28 allows the longitudinal passageway 29 to be in indirect fluid communication with the outlet passageway 43. The radial slot 28 has an outer radius that extends beyond the outer radius of the longitudinal passage 29 taken about a longitudinal axis of the plunger 10.

the seal 19 seals against the adjacent face of the groove 25 so that fluid cannot flow between the plunger 10 and the seal 19 or through the slot 28 and the at least one passage 29 within the seal 19. The seal 19 in this condition thus provides a seal between the plunger 10 and the wall of the bore 11, closing the check valve assembly, and allowing the plunger 10 to pump fluid from the secondary chamber 22 into the primary chamber 23.

[0008] Although prior hydraulic pumps, such as the one described above, have been effective, it would be desirable to provide a low cost pump assembly having more easily manufactured and more durable components.

SUMMARY OF THE INVENTION

[0009] The present invention is a pump assembly with a combination reciprocating high-pressure seal and fluid inlet check valve for use within brake systems. The pump assembly comprises a piston for reciprocal movement within a bore in a housing.

[0010] The pump assembly includes a housing having a bore formed therethrough and a piston disposed within the bore for reciprocal movement along a longitudinal axis therein. The piston has an inlet flange extending outwardly substantially perpendicular to the longitudinal axis. An annular seal, is disposed around the piston for reciprocal movement thereon. In one embodiment, the annular seal cooperates with at least one of the piston and the housing to form at least one longitudinally extending passageway. In another embodiment, the piston has at least one passageway formed therein. The passageway, the piston, and the annular seal cooperate to form a check valve assembly. The retaining flange and the housing cooperate to form an outlet passageway of the check valve assembly. The annular seal is moveable to a first position relative to one of the inlet flange and the piston in which the at least one longitudinally extending passageway communicates directly with the outlet passageway to the pumping chamber and said check valve assembly is in

a flow-through position to fill the pumping chamber with fluid from the inlet chamber during a fluid inlet stroke. The annular seal is moveable to a second position relative to the one of the inlet flange and the piston in which the check valve assembly is closed, for example, to pressurize the fluid within the pumping chamber during a pumping stroke.

[0011] In a first embodiment, the piston includes a retaining flange, an inlet flange, and an intermediate portion disposed therebetween. Both the retaining flange and the inlet flange extend substantially perpendicular from the piston. The inlet flange and the housing cooperate to form at least one inlet passageway through the bore, and/or the intermediate portion of the piston has at least one longitudinally extending passageway formed therethrough. The retaining flange may also have at least one passageway formed therethrough. The at least one passageway of the intermediate portion and the at least one passageway of the retaining flange are communicably connected. The retaining flange and the housing cooperate to form at least one outlet passageway through the bore. For example, the retaining flange may be comprised of a cir-clip disposed around the piston. Alternatively, the inlet flange may have at least one passageway formed therethrough.

[0012] A high-pressure seal is disposed around the intermediate portion of the piston. The seal is not as thick as the intermediate portion is long, and, therefore, the seal can reciprocate between the retaining flange and inlet flange. The seal and the inlet flange cooperate to form a first check valve assembly, as will be described below.

[0013] The piston, housing, the first check valve assembly, and a second check valve assembly define a pumping chamber. The piston, housing, and the first check valve assembly define an inlet chamber. A fluid inlet supplies fluid to the inlet chamber.

[0014] On a fluid inlet stroke, the piston withdraws from the bore and the volume of the pumping chamber increases. As the piston withdraws, the seal is moved into a first position relative to the inlet flange, in which the seal is not

valve assembly is opened, and fluid from the inlet chamber is allowed to flow into the pumping chamber.

[0015] On a pumping stroke, the piston moves toward the second check valve assembly, and the seal is moved into a second position relative to the inlet flange, in which the seal is seated against the inlet flange. When the seal is in the second position, the inlet flange and seal cooperate to prevent fluid from exiting the pumping chamber, such that the first check valve assembly is closed. The fluid pressure builds within the pumping chamber until the pressure overcomes the force required to unseat the ball of the second check valve assembly. The second check valve assembly then opens, allowing the pressurized fluid to exit the pumping chamber through a fluid outlet to be delivered to the vehicle brake system.

[0016] In an alternate embodiment of the invention, the at least one passageway in the retaining flange is communicably connected to at least one passageway in the seal. The seal and the inlet flange form a check valve assembly. When the seal is in the first position, fluid is allowed to flow through the at least one passageway in the inlet flange, below the seal, through the passageway in the seal, through the at least one passageway in the retaining flange, and into the pumping chamber. Thus, the check valve assembly is in a flow-through position. When the seal is in a second position, seated against the sealing surface of the inlet flange, the at least one passageway in the seal is prevented from communicating with the at least one passageway in the inlet flange. Thus, the check valve assembly is in a closed position.

[0017] Various objects and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiment, when read in light of the accompanying drawings.

- [0018] Fig. 1 is a cross sectional view of a prior art hydraulic pump assembly.
- [0019] Fig. 2 is a cross sectional view of the seal of the prior art hydraulic pump assembly illustrated in Fig. 1.
- [0020] Fig. 3 is a perspective view of a first embodiment of a piston in accordance with the present invention.
- [0021] Fig. 4 is a cross sectional view of the piston shown in Fig. 3, taken along line 4-4, with the piston disposed within a first embodiment of a pump assembly, in accordance with the present invention.
- [0022] Fig. 5 is a cross sectional view of the pump assembly of Fig. 4.
- [0023] Fig. 6 is an enlarged cross sectional view of a portion of a second embodiment of a pump assembly in accordance with the present invention.
- [0024] Fig. 7 is a perspective view of a third embodiment of a piston in accordance with the present invention.
- [0025] Fig. 8 is a perspective view of a portion of the piston shown in Fig. 7 and a third embodiment of a seal in accordance with the present invention.
- [0026] Fig. 9 is a cross sectional view of the piston and seal shown in Figs. 7 and 8, taken along line 9-9, with the piston disposed within a third embodiment of a pump assembly, in accordance with the present invention.
- [0027] Fig. 10 is a cross sectional view of the pump assembly of Fig. 9.
- [0028] Fig. 11 is a perspective view of a fourth embodiment of a piston in accordance with the present invention.
- [0029] Fig. 12 is a top view of a portion of the piston shown in Fig. 11 and a fourth embodiment of a seal in accordance with the present invention.

11 and 12, taken along line 13-13, with the piston disposed within a fourth embodiment of a pump assembly, in accordance with the present invention.

[0031] Fig. 14 is a cross sectional view of the pump assembly of Fig. 13.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] Referring to the drawings, there is illustrated in Fig. 3, a first embodiment of a piston, indicated generally at 50, in accordance with this invention. The piston 50 comprises a shaft 51, a retaining flange 52, and an inlet flange 53. The retaining flange 52 extends substantially perpendicular from the shaft 51 at a first end portion 54 of the shaft 51. The inlet flange 53 extends substantially perpendicular from the shaft 51 below and spaced apart from the retaining flange 52. The retaining flange 52 and the inlet flange 53 cooperate to define an intermediate portion 55 of the shaft 51 disposed between retaining flange 52 and the inlet flange 53.

[0033] The shaft 51 is generally elongated along a longitudinal axis A. The shaft 51 includes a second end portion 56, opposite the first end portion 54. The intermediate portion 55, described above is disposed between the first end portion 54 and the second end portion 56. The second end portion 56 is engaged by a driving mechanism (not shown) for reciprocatingly driving the piston 50. The intermediate portion 55 of the shaft 51 may have a generally circular cross section. The intermediate portion 55 extends outwardly from the axis A to a radius R_1 , as is shown in Figs. 4 and 5, and as will be described further below. The intermediate portion 55 has at least one passageway 57 formed therethrough. In a preferred embodiment, the at least one passageway 57 comprises a plurality of longitudinally extending grooves, with preferably semi-circular cross-section, that have been machined through the intermediate portion 55 of the shaft 51 around the periphery of the intermediate portion 55. In a more preferred embodiment, the at least one passageway 57 comprises a plurality of longitudinally extending notches molded in the intermediate

portion 55, with preferably rectangular or diamond-shaped cross-section. However, it will be appreciated that the at least one passageway 57 may be formed in the intermediate portion 55 in any manner, and may have any suitable cross-section. As used throughout the application, semi-circular encompasses any portion of a circle, which includes but is not limited to half of a circle. The at least one passageway 57 is formed through the intermediate portion 55 such that no part of the at least one passageway 57 extends further into the intermediate portion 55 than a radius R_2 from the axis A.

[0034] The retaining flange 52 may have a generally circular cross section, and has a radius taken from the axis A that is larger than the radius R_1 of the intermediate portion 55, the purpose of which will be described below. The retaining flange 52 has at least one passageway 58 formed therethrough. In a preferred embodiment, the at least one passageway 58 comprises a plurality of longitudinally extending grooves, preferably with semi-circular cross-section, that have been machined through the retaining flange 52 around the periphery of the retaining flange 52. In a more preferred embodiment, the at least one passageway 58 comprises a plurality of longitudinally extending notches molded in the retaining flange 52, with preferably rectangular or diamond-shaped cross-section. However, it will be appreciated that the at least one passageway 58 may be formed in the retaining flange 52 in any manner, and may have any suitable cross-section. It will also be appreciated that the retaining flange 52 may be any one of a plurality of nubs or tangs extending outwardly from said piston 50, the purpose of which will be described below. The at least one passageway 58 is formed through the retaining flange 52 such that the at least one passageway 58 does not extend into the retaining flange 52 any closer than a radius R_3 from the axis A as seen in Fig. 4. The radius R_3 is smaller than the radius R_1 of the intermediate portion, the such that the at least one passageway 58 is aligned to radially overlap the at least one passageway 57, and the at least one passageway 58 and the at least one passageway 57 are connected in fluid communication.

[0035] The inlet flange 53 may have a circular cross section, and has at least one passageway 59 formed therethrough. In a preferred embodiment, the at least one passageway 59 comprises a plurality of longitudinally extending grooves, preferably with semi-circular cross-section, that have been machined through the inlet flange 53 around the periphery of the inlet flange 53. In a more preferred embodiment, the at least one passageway 59 comprises a plurality of longitudinally extending notches molded in the inlet flange 53, with preferably rectangular or diamond-shaped cross-section. However, it will be appreciated that the at least one passageway 59 may be formed in the inlet flange 53 in any manner, and may have any suitable cross-section. The at least one passageway 59 is formed through the inlet flange 53 such that the at least one passageway 59 does not extend further into the inlet flange 53 any closer than a radius R_4 from the axis A, as seen in Fig. 4. The radius R_4 is greater than the radius R_1 , the outer radius of the at least one passageway 57, such that even though the at least one passageway 57 and the passageway 59 may be aligned to overlap radially, the at least one passageway 57 and the at least one passageway 59 are not directly communicably connected with one another.

[0036] The piston 50 is suitable for use in a pump assembly, such as the first embodiment of a pump assembly, indicated generally at 60, in Figs. 4 and 5. The pump assembly 60 comprises a housing 61 having a bore 62 formed therethrough. The piston 50 is mounted for reciprocal movement within the bore 62 of the housing 61. Preferably, the piston 50 is formed of a material that is sufficient to sustain operation of the pump assembly 60 under operating conditions within the pump assembly 60 as described herein, such as the relatively high operating pressures of a pump assembly within a vehicle brake system. Additionally, in a preferred embodiment, the piston 50 is comprised of materials that are compatible with hydraulic brake fluid.

[0037] An annular high-pressure seal 63 is disposed around the intermediate portion 55 of the piston 50. In a preferred embodiment, the high-pressure seal 63 has a generally rectangular radial cross section as illustrated for each portion

of the seal 63 shown on either side of the axis A in Fig. 4. However, it will be appreciated that the seal may have any radial cross-section. In a preferred embodiment, the seal 63 is not as thick as the intermediate portion 55 is long, such that the seal 63 can reciprocate between the retaining flange 52 and the inlet flange 53 of the piston 50, as will be described below. The seal 63 is preferably elastomeric. In a preferred embodiment, the seal 63 includes a base material, such as Polytetrafluoroethylene (PTFE) sold under the tradename Teflon® and manufactured by DuPont, and a filler material, such as carbon. In a more preferred embodiment, the seal 63 includes carbon fiber, or other high tensile strength fibers suitable for use in composite materials. Preferably, the seal 63 is formed of a material that is sufficient to sustain operation of the pump assembly 60 under operating conditions within the pump assembly 60 as described herein, such as the relatively high operating pressures of a pump assembly within a vehicle brake system. In a preferred embodiment, the seal 63 is formed of a material that is sufficient to sustain operation of the pump assembly 60 with an operating pressure range of about 0 to about 250 bars absolute pressure within the pump assembly 60, as will be described in more detail below. However, it will be appreciated that operating pressure within the pump assembly 60 may vary, and may be a negative pressure under some operating conditions, as will be described below. In a preferred embodiment, the seal 63 is formed of a material that is sufficient to sustain operation of the pump assembly 60 in a temperature range of about -40 degrees Celsius to about 120 degrees Celsius. Additionally, in a preferred embodiment, the seal 63 is comprised of materials that are compatible with hydraulic brake fluid.

[0038] The seal 63 has a first surface 64 that slidingly engages the walls of the housing 61 that form the bore 62 to form a dynamic seal therebetween. The seal 63 also has a second surface 65 that slidingly engages the outer periphery of the intermediate portion 55 of the piston 50, although such is not required. The seal 63 is able to move relative to the intermediate portion 55 between a first position, in which the seal 63 contacts the retaining flange 52 and a second position, in which the seal 63 contacts the inlet flange 53 as will be described

below. The second surface 65 may seal against only the outer periphery of the intermediate portion 55, and does not contact the inner periphery of the at least one passageway 57, such that the seal 63 does not enter the at least one passageway 57. Thus, no seal is formed between the seal 63 and the intermediate portion 55.

[0039] The seal 63 further includes a third surface 66 that engages a surface 68 of the retaining flange 52 when the seal 63 is in the first position thereof. As indicated above, in a preferred embodiment, the at least one passageway 58 is a plurality of similar passageways in the form of grooves that are symmetrically positioned around the retaining flange 52, so that the seal 63 is evenly axially supported by the retaining flange 52 when seated in the first position.

[0040] The seal 63 has a fourth surface 67 that may engage a sealing surface 69 of the inlet flange 53 when the seal 63 is in a second position relative to the inlet flange 53, as will be described below. When the seal 63 is in the second position, the fourth surface 67 engages the sealing surface 69. The seal 63 prevents fluid flow through the at least one passageway 59 through the inlet flange 53, because, as is best shown in Fig. 5, the seal 63 seats against the sealing surface 69 blocking the passageway 59. Fluid is not able to flow out of the at least one passageway 57 past the seal 63, so fluid is not able to flow from the at least one passageway 57, around the seal 63, and into the at least one passageway 59. Therefore, the seal 63, in the second position, prevents the at least one passageway 57 and the at least one passageway 59 from fluid communication with one another.

[0041] Thus, the seal 63 and the inlet flange 53 cooperate to form a first check valve assembly 70, as will be described in more detail below. In a preferred embodiment, the at least one passageway 59 is a plurality of similar passageways that are symmetrically positioned around the inlet flange 53, so that the seal 63 is evenly supported by the inlet flange 53 when seated in the second position.

[0042] In an alternative embodiment, the seal 63 is a non-metallic seal that has featureless first and second end faces, i.e. the third and fourth surfaces 66 and 67. A longitudinal central bore is defined by the inner wall, i.e. the second surface 65, extending between the first and second end faces, i.e. the third and fourth surfaces 66 and 67. In this preferred embodiment a groove is formed in the inner wall, i.e. the second surface 65, and extends from the first end face to the second end face, i.e. from the third surface 66 to the second surface 67.

[0043] The pump assembly 60 will now be further described. The second end portion 56 of the piston 50 is mounted so that the piston 50 may reciprocate within the bore 62 of the housing 61. The piston 50 slides against the walls of the bore 62 as the piston 50 reciprocates. A seal 71 may be provided or formed by the piston 50 and the walls of the bore 62. The seal 71, the seal 63, and the piston 50 define an inlet chamber 72 within the bore 62. A fluid inlet 73 is communicably connected to the inlet chamber 72 to supply fluid to the pump assembly 60, as will be described below. Alternatively, it will be appreciated that the seal 71 may not be provided, and the inlet chamber 72 may extend such that the fluid of the inlet chamber 72 may be used to lubricate the piston 50 and the walls of the bore 62 to facilitate the reciprocal movement therebetween. In a more preferred embodiment, an o-ring (not shown) may be disposed around the shaft 51 of the piston 50 near the second end portion 56 of the piston 50 instead of the seal 71 such that the inlet chamber 72 extends below the intersection of the walls of the bore 62 and the piston 50.

[0044] At the end of the bore 62 opposite the piston 50, a second check valve assembly 74 is provided. The second check valve assembly 74 includes a ball 75 and a seat 76. Preferably, the second check valve assembly 74 is formed of a material that is sufficient to sustain operation of the pump assembly 60 under operating conditions within the pump assembly 60 as described herein, such as the relatively high operating pressures of a pump assembly within a vehicle brake system. Additionally, in a preferred

embodiment, second check valve assembly 74 is comprised of materials that are compatible with hydraulic brake fluid. A pumping chamber 77 is defined within the bore 62 between the second check valve assembly 74 and the combination of the piston 50 and the seal 63. As is evident from the structure of the pump 60 and as will be evident from the operation of the pump 60 described below, the pump 60 is highly efficient due to the relatively small unswept volume of the piston 50.

[0045] The operation of the pump assembly 60 will now be described. At the end of a pumping stroke, when the piston 50 is closest to the second check valve assembly 74, the seal 63 is in the second position, thereby seated against the sealing surface 69 of the inlet flange 53 (the first check valve assembly 70 is shut). During a fluid inlet stroke, the piston 50 moves away from the second check valve assembly 74. The seal 63 is disposed between the retaining flange 52 and the inlet flange 53, and, as the piston 50 moves away from the second check valve assembly 74, pressure in the pumping chamber 77 drops below the pressure in the inlet chamber 72 as the pumping chamber 77 expands. The differential pressure unseats the seal 63 from the inlet flange 53, opening the first check valve assembly 70 and allowing fluid to flow from the inlet chamber 72 through the passageways 59, 57, and 58, into the pumping chamber 77. The seal 63 will generally have greater friction to the wall of the bore 62 than to the piston 50, and will tend to remain stationary as the piston 50 moves. However, as the piston 50 continues to move away from the second check valve assembly 74, the retaining flange 52 will eventually intercept the seal 63, and the seal 63 will be drug away from the second check valve assembly 74 by the retaining flange 52 of the piston 50, so that the seal 63 is now in the first position thereof. Once the seal 63 has been intercepted by the retaining flange 52, the seal 63 will remain seated against the retaining flange 52 as long as the piston 50 continues to move in the same direction, e.g., away from the second check valve assembly 74.

[0046] During a pumping stroke, the piston 50 moves back toward the second check valve assembly 74. As the piston 50 moves, the seal 63 again tends to remain stationary due to friction with the wall of the bore. Additionally, as the pumping chamber gets smaller as the piston 50 moves toward the second check valve assembly 74, pressure starts to rise, even with the first check valve assembly 70 still open, due to head losses in the passageways. Thus, the seal 63 moves out of the second position thereof. As the piston 50 continues to move toward the second check valve assembly 74, the inlet flange 53 will eventually intercept the seal 63, and the seal 63 will be drug toward the second check valve assembly 74 by the inlet flange 53 of the piston 50. Once the seal 63 has been intercepted by the inlet flange 53, the seal 63 will remain in the second position thereof, i.e. seated against the inlet flange 53, as long as the piston 50 continues to move in the same direction, e.g., toward the second check valve assembly 74. When the seal 63 is in the second position thereof, the first check valve assembly 70 is in the closed position, as illustrated in Fig. 5. With the seal 63 seated against the sealing surface 69 of the inlet flange 53, fluid cannot flow into the at least one passageway 59 from the at least one passageway 57. Therefore, the pumping chamber 77 is isolated from the inlet chamber 72. Thus, as the piston 50 moves further into the bore 62, the volume of the pumping chamber 77 decreases, and pressure is raised in the fluid within the pumping chamber 77.

[0047] As the piston 50 continues to move toward the second check valve assembly 74, the fluid pressure within the chamber 77 continues to build until the fluid pressure within the chamber 77 is greater than the resistance required to unseat the ball 75 from the seat 76 of the second check valve assembly 74. When the ball 75 is unseated, the second check valve assembly 74 opens and pressurized fluid is discharged from the pump 60 via an outlet 78.

[0048] As the piston 50 continues to move toward the second check valve assembly 74, the volume of the inlet chamber 72 increases. The increase in volume of the inlet chamber 72 may create negative pressure or a vacuum

pressure within the inlet chamber 72. This vacuum pressure within the inlet chamber 72 pulls fluid from the fluid inlet 73 into the inlet chamber 72. Thus, the pump assembly 60 may be a self-priming or pre-charging pump, and the pump assembly 60 may operate with negative pressure conditions within the inlet chamber 72. At the end of a pumping stroke, the first end portion 54 of the piston 50 is relatively close to the second check valve assembly 74. With the piston 50 in this position, the first check valve assembly 70 and the second check valve assembly 74 are in relatively close proximity to one another, such that the pumping chamber 77 is relatively small, as compared to the pumping chambers of conventional pumps. The axial distance between the first check valve assembly 70 and the second check valve assembly 74 is minimized so that the pump assembly 60 has a relatively small unswept volume.

[0049] It will be appreciated that the size and design of the seal 63, the at least one passageway 58 of the retaining flange 52, and the at least one passageway 59 of the inlet flange 53, must be coordinated so that the seal 63 and piston 50 cooperate such that the pump 60 operates as described above. Conversely, it will be appreciated that the seal 63, the at least one passageway 58 of the retaining flange 52, and the at least one passageway 59 of the inlet flange 53 could be any size or shape capable of performing as described above.

[0050] Referring now to Fig. 6, there is illustrated a portion of a second embodiment of a pump assembly, indicated generally at 160, in accordance with this invention. The pump assembly 160 is similar to the pump assembly 60, and only those elements that differ will be described herein, and corresponding elements have been given the same reference numeral incremented by 100.

[0051] The piston 150 includes a retaining flange 152, an inlet flange 153, and an intermediate portion 155 disposed therebetween. Unlike the intermediate portion 55 of the piston 50, the intermediate portion 155 of the piston 150 does not have a passageway formed therethrough. Instead, the intermediate portion 155 is preferably circular in cross-section, and is slidingly

engaged by a seal 163. The seal 163 may reciprocate between the retaining flange 152 and the inlet flange 153, in a manner similar to that described above for the seal 63.

[0052] The seal 163 differs from the seal 63 in that the seal 163 has at least one passageway 180 formed therethrough. The at least one passageway 180 has an outer radius R_1 from the axis A. The outer radius R_1 is smaller than the inner radius R_4 of the at least one passageway 159 in the inlet flange 153. The outer radius R_1 is larger than the inner radius R_3 of the at least one passageway 158 in the retaining flange 152.

[0053] The seal 163 and the inlet flange 153 form a check valve assembly 170. However, the structure of the check valve assembly 170 varies from structure of the check valve assembly 70. The at least one passageway 158 in the retaining flange 152 is communicably connected to the at least one passageway 180 in the seal 163. In a preferred embodiment, the at least one passageway 180 is a plurality of passageways sized such that no matter how the seal 163 is rotated relative to the retaining flange 152, the at least one passageway 180 is communicably connected to the at least one passageway 158 of the retaining flange 152, when the seal 163 is seated against the surface 168.

[0054] When the seal 163 is in a first position relative to the inlet flange 153, the seal 163 is unseated from the sealing surface 169 of the inlet flange 153, and may be seated against the surface 168 of the retaining flange 152, as described in the previous embodiment and as shown in Fig. 6. When the seal 163 is in the first position, fluid is allowed to flow through the at least one passageway 159, below the seal 163, through the passageway 180, through the at least one passageway 158, and into the pumping chamber 177. Thus, the check valve assembly 170 is in a flow-through position. When the seal 163 is in a second position, seated against the sealing surface 169 of the inlet flange 153, the at least one passageway 180 in the seal 163 is prevented from communicating with the at least one passageway 159. Thus, the check valve

assembly 170 is in a closed position, such that the pump 160 works in a manner similar to that described for the pump 60.

[0055] Referring further to the drawings, there is illustrated in Fig. 7, a third embodiment of a piston, indicated generally at 250, in accordance with this invention. The piston 250 comprises a shaft 251, a retaining flange 252, and an inlet flange 253. The retaining flange 252 extends substantially perpendicular from the shaft 251 near a first end portion 254 of the shaft 251. The inlet flange 253 extends substantially perpendicular from the shaft 251 below and spaced apart from the retaining flange 252. The retaining flange 252 and the inlet flange 253 cooperate to define an intermediate portion 255 of the shaft 251 disposed between retaining flange 252 and the inlet flange 253. The retaining flange 252 may have a generally circular cross section, and has a radius taken from the axis A that is larger than a radius R_1 taken from the axis A of the intermediate portion 255, the purpose of which will be described below. The inlet flange 253 may have a generally circular cross section, and has a radius taken from the axis A that is larger than the radius R_1 of the intermediate portion 255.

[0056] The shaft 251 is generally elongated along longitudinal axis A. The shaft 251 includes a second end portion 256, opposite the first end portion 254. The intermediate portion 255, described above is disposed between the first end portion 254 and the second end portion 256. The second end portion 256 is engaged by a driving mechanism (not shown) for reciprocatingly driving the piston 250. The intermediate portion 255 of the shaft 251 may have a generally circular cross section. The intermediate portion 255 extends outwardly from the axis A to the radius R_1 , as is shown in Figs. 9 and 10, and as will be described further below.

[0057] Referring now to Fig. 8, an annular high-pressure seal 257 is disposed around the intermediate portion 257 of the piston 250. In a preferred embodiment, the high-pressure seal 257 has a generally rectangular radial cross section as illustrated for each portion of the seal 257 shown on either side of

the axis A in Fig. 8. However, it will be appreciated that the seal may have any radial cross-section. In a preferred embodiment, the seal 257 is not as thick as the intermediate portion 255 is long, such that the seal 257 can reciprocate between the retaining flange 252 and the inlet flange 253 of the piston 250, as will be described below. The seal 257 is preferably elastomeric. The seal 257 may preferably include a low friction plastic, such as nylon. In a preferred embodiment, the seal 257 includes a base material, such as Polytetrafluoroethylene (PTFE) sold under the tradename Teflon® and manufactured by DuPont, and a filler material, such as carbon. In a more preferred embodiment, the seal 257 includes carbon fiber, or other high tensile strength fibers suitable for use in composite materials.

[0058] The seal 257 has at least one passageway 258 formed therethrough. In a preferred embodiment, the at least one passageway 258 comprises a plurality of longitudinally extending grooves, preferably with semi-circular cross-section, that have been formed in or machined through the seal 257 around an inner periphery of the seal 257. In a more preferred embodiment, the at least one passageway 258 comprises a plurality of longitudinally extending notches molded in the seal 257, with preferably rectangular or diamond-shaped cross-section. However, it will be appreciated that the at least one passageway 258 may be formed in the seal 257 in any manner, and may have any suitable cross-section. The at least one passageway 258 is formed through the seal 257 such that the at least one passageway 258 does not extend outwardly into the seal 257 any further than a radius R_2 from the axis A as shown in Fig. 9.

[0059] The piston 250 is suitable for use in a pump assembly, such as the third embodiment of a pump assembly, indicated generally at 259, in Figs. 9 and 10. The pump assembly 259 comprises a housing 260 having a bore 261 formed therethrough. The piston 250 is mounted for reciprocal movement within the bore 261 of the housing 260. In a preferred embodiment, the piston 250 is comprised of materials that are compatible with hydraulic brake fluid.

[0060] Preferably, the seal 257 is formed of a material that is sufficient to sustain operation of the pump assembly 259 under operating conditions within the pump assembly 259 as described herein, such as the relatively high operating pressures of a pump assembly within a vehicle brake system. In a preferred embodiment, the seal 257 is formed of a material that is sufficient to sustain operation of the pump assembly 259 with an operating pressure range of about 0 to about 50 bars absolute pressure within the pump assembly 259, as will be described in more detail below. However, it will be appreciated that operating pressure within the pump assembly 259 may vary, and may be a negative pressure under some operating conditions, as will be described below. In a preferred embodiment, the seal 257 is formed of a material that is sufficient to sustain operation of the pump assembly 259 in a temperature range of about -40 degrees Celsius to about 120 degrees Celsius. Additionally, in a preferred embodiment, the seal 257 is comprised of materials that are compatible with hydraulic brake fluid.

[0061] The retaining flange 252 and the housing 260 cooperate to form an outlet passageway 262 through the bore 261. As illustrated, the outlet passageway 262 is generally annular and extends about the periphery of the retaining flange 252, although such is not required. The outlet passageway 262 may have any desired shape and may be disposed about or through any portion of the retaining flange 252. The outlet passageway 262 has an inner radius R_3 taken from the axis A. The outlet passageway 262 is formed between retaining flange 252 and the housing 260 such that the outlet passageway 262 does not extend further into the retaining flange 252 any closer than the radius R_3 from the axis A, as seen in Fig. 8. In a preferred embodiment, the inner radius R_3 may be smaller than the outer radius R_2 of the seal 257 and may be larger than the outer radius R_1 of the intermediate portion 255.

[0062] The inlet flange 253 and the housing 260 cooperate to form an inlet passageway 263 through the bore 261. As illustrated, the inlet passageway 263 is generally annular and extends about the periphery of the inlet flange 253,

although such is not required. The inlet passageway 263 may have any desired shape and may be disposed about or through any portion of the inlet flange 253. The inlet passageway 263 has an inner radius R_4 taken from the axis A. The inlet passageway 263 is formed between inlet flange 253 and the housing 260 such that the inlet passageway 263 does not extend further into the inlet flange 253 any closer than the radius R_4 from the axis A, as seen in Fig. 8. In a preferred embodiment, the radius R_4 is greater than the radius R_2 , the outer radius of the at least one passageway 258, such that even though the at least one passageway 258 and the passageway 263 may be aligned to overlap radially, the at least one passageway 258 and the passageway 263 are not directly communicably connected with one another.

[0063] The seal 257 has a first surface 264 that slidingly engages the walls of the housing 260 that form the bore 261 to form a dynamic seal therebetween. The seal 257 also has a second surface 265 that slidingly engages the outer periphery of the intermediate portion 255 of the piston 250, although such is not required. The seal 257 is able to move relative to the intermediate portion 255 between a first position, in which the seal 257 contacts the retaining flange 252 and a second position, in which the seal 257 contacts the inlet flange 253 as will be described below.

[0064] The seal 257 further includes a third surface 266 that engages a surface 268 of the retaining flange 252 when the seal 257 is in the first position thereof. As indicated above, in a preferred embodiment, the at least one passageway 258 is a plurality of similar passageways in the form of grooves that are symmetrically positioned around the seal 257, so that the seal 257 is evenly axially supported by the retaining flange 252 when seated in the first position.

[0065] The seal 257 has a fourth surface 267 that may engage a sealing surface 269 of the inlet flange 253 when the seal 257 is in a second position relative to the inlet flange 253, as will be described below. When the seal 257 is in the second position, the fourth surface 267 engages the sealing surface

269. The seal 257 prevents fluid flow through the at least one passageway 259 through the inlet flange 253, because, as is best shown in Fig. 9, the seal 257 seats against the sealing surface 269 blocking the passageway 263. Fluid is not able to flow out of the at least one passageway 258 past the seal 257, so fluid is not able to flow from the at least one passageway 258, around the seal 257, and into the passageway 263. Therefore, the seal 257, in the second position, prevents the at least one passageway 258 and the passageway 263 from fluid communication with one another.

[0066] Thus, the seal 257 and the inlet flange 253 cooperate to form a first check valve assembly 270, as will be described in more detail below. In a preferred embodiment, the at least one passageway 258 is a plurality of similar passageways that are symmetrically positioned throughout the seal 257, so that the seal 257 is evenly supported by the inlet flange 253 when seated in the second position.

[0067] The pump assembly 259 will now be further described. The second end portion 256 of the piston 250 is mounted so that the piston 250 may reciprocate within the bore 261 of the housing 260. The piston 250 slides against the walls of the bore 261 as the piston 250 reciprocates. A seal 271 may be provided or formed by the piston 250 and the walls of the bore 261. The seal 271, the seal 257, and the piston 250 define an inlet chamber 272 within the bore 261. A fluid inlet 273 is communicably connected to the inlet chamber 272 to supply fluid to the pump assembly 259, as will be described below. Alternatively, it will be appreciated that the seal 271 may not be provided, and the inlet chamber 272 may extend such that the fluid of the inlet chamber 272 may be used to lubricate the piston 250 and the walls of the bore 261 to facilitate the reciprocal movement therebetween. In a more preferred embodiment, an o-ring (not shown) may be disposed around the shaft 251 of the piston 250 near the second end portion 256 of the piston 250 instead of the seal 271 such that the inlet chamber 272 extends below the intersection of the walls of the bore 261 and the piston 250.

[0068] At the end of the bore 261 opposite the piston 250, a second check valve assembly 274 is provided. The second check valve assembly 274 includes a ball 275 and a seat 276. Preferably, the second check valve assembly 274 is formed of a material that is sufficient to sustain operation of the pump assembly 259 under operating conditions within the pump assembly 259 as described herein, such as the relatively high operating pressures of a pump assembly within a vehicle brake system. Additionally, in a preferred embodiment, second check valve assembly 274 is comprised of materials that are compatible with hydraulic brake fluid. A pumping chamber 277 is defined within the bore 261 between the second check valve assembly 274 and the combination of the piston 250 and the seal 257. As is evident from the structure of the pump 259 and as will be evident from the operation of the pump 259 described below, the pump 259 is highly efficient due to the relatively small unswept volume of the piston 250.

[0069] The operation of the pump assembly 259 will now be described. At the end of a pumping stroke, when the piston 250 is closest to the second check valve assembly 274, the seal 257 is in the second position, thereby seated against the sealing surface 269 of the inlet flange 253 (the first check valve assembly 270 is shut). During a fluid inlet stroke, the piston 250 moves in a direction I away from the second check valve assembly 274. The seal 257 is disposed between the retaining flange 252 and the inlet flange 253, and, as the piston 250 moves away from the second check valve assembly 274, pressure in the pumping chamber 277 drops below the pressure in the inlet chamber 272 as the pumping chamber 277 expands. The differential pressure unseats the seal 257 from the inlet flange 253, opening the first check valve assembly 270 and allowing fluid to flow from the inlet chamber 272 through the passageways 263, 258, and 262, into the pumping chamber 277. The seal 257 will generally have greater friction to the wall of the bore 261 than to the piston 250, and will tend to remain stationary as the piston 250 moves. However, as the piston 250 continues to move away from the second check valve assembly 274, the retaining flange 252 will eventually intercept the seal 257, and the seal 257 will

be urged away from the second check valve assembly 274 by the retaining flange 252 of the piston 250, so that the seal 257 is now in the first position thereof. Once the seal 257 has been intercepted by the retaining flange 252, the seal 257 will remain seated against the retaining flange 252 as long as the piston 250 continues to move in the same direction, e.g., away from the second check valve assembly 274.

[0070] During a pumping stroke, the piston 250 moves in a direction P, back toward the second check valve assembly 274. As the piston 250 moves, the seal 257 again tends to remain stationary due to friction with the wall of the bore. Additionally, as the pumping chamber gets smaller as the piston 250 moves toward the second check valve assembly 274, pressure starts to rise, even with the first check valve assembly 270 still open, due to head losses in the passageways. Thus, the seal 257 moves out of the second position thereof. As the piston 250 continues to move toward the second check valve assembly 274, the inlet flange 253 will eventually intercept the seal 257, and the seal 257 will be urged toward the second check valve assembly 274 by the inlet flange 253 of the piston 250. Once the seal 257 has been intercepted by the inlet flange 253, the seal 257 will remain in the second position thereof, i.e. seated against the inlet flange 253, as long as the piston 250 continues to move in the same direction, e.g., toward the second check valve assembly 274. When the seal 257 is in the second position thereof, the first check valve assembly 270 is in the closed position, as illustrated in Fig. 10. With the seal 257 seated against the sealing surface 269 of the inlet flange 253, fluid cannot flow into the at least one passageway 258 from the inlet passageway 263. Therefore, the pumping chamber 277 is isolated from the inlet chamber 272. Thus, as the piston 250 moves further into the bore 261, the volume of the pumping chamber 277 decreases, and pressure is raised in the fluid within the pumping chamber 277.

[0071] As the piston 250 continues to move toward the second check valve assembly 274, the fluid pressure within the chamber 277 continues to build

until the fluid pressure within the chamber 277 is greater than the resistance required to unseat the ball 275 from the seat 276 of the second check valve assembly 274. When the ball 275 is unseated, the second check valve assembly 274 opens and pressurized fluid is discharged from the pump 259 via an outlet 278.

[0072] As the piston 250 continues to move toward the second check valve assembly 274, the volume of the inlet chamber 272 increases. The increase in volume of the inlet chamber 272 may create negative pressure or a vacuum pressure within the inlet chamber 272. This vacuum pressure within the inlet chamber 272 pulls fluid from the fluid inlet 273 into the inlet chamber 272. Thus, the pump assembly 259 may be a self-priming or pre-charging pump, and the pump assembly 259 may operate with negative pressure conditions within the inlet chamber 272. At the end of a pumping stroke, the first end portion 254 of the piston 250 is relatively close to the second check valve assembly 274. With the piston 250 in this position, the first check valve assembly 270 and the second check valve assembly 274 are in relatively close proximity to one another, such that the pumping chamber 277 is relatively small, as compared to the pumping chambers of conventional pumps. The axial distance between the first check valve assembly 270 and the second check valve assembly 274 is minimized so that the pump assembly 259 has a relatively small unswept volume.

[0073] It will be appreciated that the size and design of the seal 257, the at least one passageway 258, the passageway 262, and the passageway 263, must be coordinated so that the seal 257 and piston 250 cooperate such that the pump 259 operates as described above. Conversely, it will be appreciated that the seal 257, the at least one passageway 258, the passageway 262, and the passageway 263 could be any size or shape capable of performing as described above.

[0074] Referring now to Figs. 11 through 14, there is illustrated a portion of a fourth embodiment of a pump assembly, indicated generally at 359, in

accordance with this invention. The pump assembly 359 is similar to the pump assembly 259, and only those elements that differ will be described herein, and corresponding elements have been given the same reference numeral incremented by 100.

[0075] In the above-described embodiment, the retaining flange 252 is integral to the piston 250. The retaining flange 252 and the piston 250 may be formed as an integral unit, or the retaining flange 252 may be formed separately and permanently fixed to the piston 250 by any suitable means, such as welding or permanent adhesive, etc. However, it is also contemplated that the retaining flange may be formed separately and non-permanently affixed to the piston 250. The retaining flange may be pressed on, affixed with a snap fit, affixed with threading or any other non-permanent method. Such an arrangement may be advantageous in facilitating the positioning of an original or replacement seal onto the piston. In the example illustrated in Fig. 11, the piston 350 includes a cir-clip 352 disposed around the piston 350 to form a retaining flange, similar in function to the retaining flange 252. The piston 350 further includes an inlet flange 353 and an intermediate portion 355 disposed between the cir-clip 352 and the inlet flange 353. Unlike the retaining flange 252 of the piston 250, the cir-clip 352 of the piston 350 does not have an annular passageway, like passageway 262, formed about the outer annular periphery of the cir-clip 352. Instead, the cir-clip 352 is preferably semi-circular in cross-section, and may have a passageway 362 formed about the portion of the piston 350 in which the cir-clip 352 does not extend. In a preferred embodiment, the cir-clip 352 does not extend about a portion of the piston 350 that is about 110° of the circumference of the piston 350. Additionally, the passageway 362 formed by the piston 350, the cir-clip 352, and the housing 360 may extend between a portion of the cir-clip 352 and the piston 350 and/or between a portion of the cir-clip 352 and the housing 360, as shown in Fig. 12. The seal 357 may reciprocate between the cir-clip 352 and the inlet flange 353, in a manner similar to that described above for the seal 257.

[0076] Preferably, the seal 357 differs from the seal 257 in that the seal 357 does not have a passageway formed therethrough. Instead, the seal 357, the piston 350, and the housing 360 cooperate to form at least one passageway 358 between the seal 357 and the piston 350 about an inner periphery of the seal 357. Preferably, the at least one passageway 358 formed between the seal 357 and the piston 350 is generally annular, although such is not required. It will be appreciated that the seal 357 may include various passageways formed therein, such as the at least one passageway 258 described in the prior embodiment. The at least one passageway 358 has an outer radius R_2 from the axis A. The outer radius R_2 is smaller than an inner radius R_4 of a passageway 363 formed by the inlet flange 353 and the housing 360. The at least one passageway 358 has an inner radius R_1 from the axis A. The inner radius R_1 is larger than the inner radius R_3 of the passageway 362 formed by the retaining flange 352 and the housing 360. The inner radius R_1 may also be larger than an outer radius of the passageway 362, although such is not required. If the inner radius R_1 is larger than an outer radius of the passageway 362, as shown in Figs. 13 and 14, the piston 350 may be shaped such that the at least one passageway 358 and the passageway 362 are communicably connected. It will be appreciated that the piston 350, the at least one passageway 358, the passageway 362, and the housing 360 may be shaped in any manner relative to one another, such that the piston 350, the at least one passageway 358, the passageway 362, and the housing 360 cooperate so that the at least one passageway 358 and the passageway 362 are communicably connected.

[0077] The seal 357 and the inlet flange 353 form a check valve assembly 370. However, the structure of the check valve assembly 370 varies from structure of the check valve assembly 270. The at least one passageway 358 is communicably connected to the passageway 362 formed by the cir-clip 352, the piston 350, and the housing 360. In a preferred embodiment, the at least one passageway 358 is shaped such that no matter how the seal 357 is rotated relative to the cir-clip 352, the at least one passageway 358 is communicably connected to the passageway 362.

When the seal 357 is in a first position relative to the inlet flange 353, the seal 357 is unseated from the sealing surface 369 of the inlet flange 353, and may be seated against the surface 368 of the cir-clip 352, as described in the previous embodiment and as shown in Fig. 13. When the seal 357 is in the first position, fluid from the fluid inlet 373 is allowed to flow from the inlet chamber 372 through the passageway 363, below the seal 357, through the at least one passageway 358, through the passageway 363, and into a pumping chamber 377. Thus, the check valve assembly 370 is in a flow-through position. When the seal 357 is in a second position, seated against the sealing surface 369 of the inlet flange 353, as shown in Fig. 10, the at least one passageway 358 is prevented from communicating with the passageway 363. Thus, the check valve assembly 370 is in a closed position, such that the pump 359 works in a manner similar to that described for the pump 259.

[0078] The pistons 50, 150, 250, 350 seals 57, 157, 257, 357 and pump assemblies, 59, 159, 259, 359 have been described for use in a vehicle braking system, including, but not limited to, vehicle braking systems having anti-lock braking systems, and/or integrated or stand alone traction control and vehicle stability control systems. However, it will be appreciated that the pistons 50, 150, 250, 350 the seals 57, 157, 257, 357 and pump assemblies 59, 159, 259, 359 may be used in any vehicle component or in any other device requiring a piston, seal, or pump assembly.

[0079] It will further be appreciated that the components of the various embodiments described herein may be used in any combination in accordance with the present invention.

[0080] The principle and mode of operation of this invention have been explained and illustrated in its preferred embodiment. However, it must be understood that this invention may be practiced otherwise than as specifically explained and illustrated without departing from its spirit or scope.

What is claimed is:

1. A pump apparatus comprising:
a housing having a bore formed therethrough;
a piston disposed within said bore for reciprocal movement therein; and
an annular seal disposed around said piston for reciprocal movement thereon, wherein at least one passageway is formed at least one of in said piston and by said annular seal cooperating with at least one of said piston and said housing, wherein said piston, said at least one passageway, and said annular seal cooperate to form a check valve assembly, said check valve assembly dividing said bore into an inlet chamber and a pumping chamber, said annular seal being moveable to a first position relative to said piston in which said check valve assembly is in a flow-through position to fill said pump chamber with fluid from said inlet chamber during a fluid inlet stroke, said annular seal being moveable to a second position relative to said piston in which said check valve assembly is closed.
2. The pump apparatus of Claim 1 wherein said at least one passageway is formed in said piston.
3. The pump apparatus of Claim 2 wherein said check valve assembly is closed to pressurize the fluid within the pumping chamber during a pumping stroke.
4. The pump apparatus of Claim 3 wherein the pump apparatus further comprises a fluid inlet communicably connected to said inlet chamber and adapted to supply said inlet chamber with fluid.

The pump apparatus of Claim 4 wherein the pump apparatus further comprises a fluid outlet communicably connected to said pumping chamber and adapted to release pressurized fluid from said pumping chamber.

6. The pump apparatus of Claim 5, wherein said piston has a longitudinal axis A and said piston comprises an inlet flange extending outwardly substantially perpendicular to said axis A, and wherein said at least one passageway in said piston comprises at least one longitudinally extending passageway formed in said inlet flange.

7. The pump apparatus of Claim 6, wherein said at least one passageway in said inlet flange is comprised of at least one longitudinally extending groove with a semi-circular cross-section machined through said inlet flange.

8. The pump apparatus of Claim 7, wherein said at least one passageway in said inlet flange has an inner radius R_4 defined from said axis A that is larger than an inner radius of said seal defined from said axis A when said seal is centered about said axis A.

9. The pump apparatus of Claim 6, wherein said piston comprises a retaining flange, and wherein said at least one passageway in said piston further comprises at least one passageway formed in said retaining flange.

10. The pump apparatus of Claim 9, wherein said at least one passageway in said retaining flange is comprised of at least one groove with a semi-circular cross-section machined through said retaining flange.

11. The pump apparatus of Claim 9, wherein said at least one passageway in said retaining flange has an inner radius R_3 defined from said

axis A that is smaller than an inner radius of said seal defined from said axis A when said seal is centered about said axis A.

12. The pump apparatus of Claim 9, wherein said at least one passageway in said retaining flange and said at least one passageway in said inlet flange are communicably connected when said check valve assembly is in said flow-through position.

13. The pump apparatus of Claim 9, wherein an intermediate portion of said piston is disposed between said inlet flange and said retaining flange, said intermediate portion having at least one passageway formed therein, said at least one passageway in said piston further comprising said at least one passageway of said intermediate portion.

14. The pump apparatus of Claim 9, wherein said at least one passageway in said intermediate portion is comprised of at least one groove with a semi-circular cross-section machined through said intermediate portion.

15. The pump apparatus of Claim 14, wherein said at least one passageway in said intermediate portion, said at least one passageway in said inlet flange, and said at least one passageway in said retaining flange are communicably connected when said check valve assembly is in said flow-through position.

16. The pump apparatus of Claim 14, wherein said at least one passageway in said intermediate portion has an outer radius R_1 defined from said axis A that is smaller than an inner radius R_4 of said at least one passageway in said inlet flange defined from said axis A.

17. The pump apparatus of Claim 9, wherein said seal includes at least one passageway formed therein, said at least one passageway in said seal

and said at least one passageway in said piston are communicably connected when said check valve assembly is in said flow-through position.

18. The pump apparatus of Claim 17, wherein said at least one passageway in said seal has an outer radius defined from said axis A that is smaller than an inner radius R_4 of said at least one passageway in said inlet flange defined from said axis A.

19. A pump apparatus comprising:

- a housing having a bore formed therethrough;
- a piston disposed within said bore for reciprocal movement therein;
- an inlet flange, said inlet flange extending outwardly from said piston, said inlet flange having at least one passageway formed therein;
- a retaining flange, said retaining flange extending outwardly from said piston, said retaining flange having at least one passageway formed therein;
- an intermediate portion, said intermediate portion disposed between said inlet flange and said retaining flange, said intermediate portion having at least one passageway formed therein, said at least one passageway formed in said retaining flange being communicable with said at least one passageway formed in said intermediate portion of said piston;
- an annular seal disposed around said intermediate portion of said piston, said seal slidingly engaging the walls of said bore, said seal and said piston cooperating to form a check valve assembly, said bore being divided into an inlet chamber and a pumping chamber by said check valve assembly, said seal being moveable to a first position spaced apart from said inlet flange such that said check valve assembly is in a flow-through position to allow fluid to fill the pumping chamber, said seal being moveable to a second position sealing against said inlet flange such that said check valve assembly is in a closed position to allow fluid within said pumping chamber to be pressurized during movement of said piston in a pumping stroke;
- a fluid inlet communicably connected to said inlet chamber and adapted to supply said inlet chamber with fluid; and
- a fluid outlet communicably connected to said pumping chamber and adapted to release pressurized fluid from said pumping chamber.

20. The pump apparatus of Claim 19, wherein said at least one passageway in said inlet flange is comprised of at least one groove with a semi-circular cross-section machined through said inlet flange.

21. The pump apparatus of Claim 19, wherein said at least one passageway in said retaining flange is at least one groove with a semi-circular cross-section machined through said retaining flange.

22. The pump apparatus of Claim 19, wherein said annular seal is comprised of at least one of Polytetrafluoroethylene and Carbon Fiber.

23. The pump apparatus of Claim 19, wherein said check valve is in the closed position when said seal is seating on said inlet flange.

24. A piston and seal assembly for a vehicle braking system pump comprising:

a piston having an inlet flange, a retaining flange, and an intermediate portion disposed between said inlet flange and said retaining flange, said intermediate portion having at least one passageway formed therein, said inlet flange having at least one passageway formed therein, said retaining flange having at least one passageway formed therein, said at least one passageway formed in said retaining flange being communicable with said at least one passageway formed in said intermediate portion of said piston; and

an annular seal disposed around said intermediate portion of said piston, said seal and said piston cooperating to form a first check valve assembly, said seal being moveable to a first position relative to said inlet flange in which said first check valve assembly is in a flow-through position, said seal being moveable to a second position relative to said inlet flange in which said first check valve assembly is in a closed position.

25. A pump comprising:

a housing having a bore formed therethrough;

a piston disposed within said bore for reciprocal movement therein, said piston having an inlet flange, a retaining flange, and an intermediate portion disposed between said inlet flange and said retaining flange, said inlet flange having at least one passageway formed therein, said retaining flange having at least one passageway formed therein;

an annular seal disposed around said intermediate portion of said piston, said seal and said inlet flange cooperating to divide said bore into an inlet chamber and a pumping chamber;

a fluid inlet communicably connected to said inlet chamber, said seal being moveable to a first position relative to said inlet flange from said inlet chamber to permit fluid communication between said at least one passageway in said inlet flange and said at least one passageway in said retaining flange to allow fluid to fill said pumping chamber from said inlet chamber; and

a fluid outlet communicably connected to said pumping chamber to release pressurized fluid from said pumping chamber, said seal being moveable to a second position relative to said inlet flange in which said seal contacts said at least one passageway in said inlet flange to prevent fluid communication between said at least one passageway in said inlet flange and said at least one passageway in said retaining flange such that fluid within said pumping chamber is pressurized by movement of said piston during a pumping stroke and released through said fluid outlet.

26. A pump for a vehicle braking system comprising:

a housing having a bore formed therethrough;

a piston disposed within said bore for reciprocal movement therein, said piston defining a longitudinal axis, said piston having an inlet flange, a retaining flange, and an intermediate portion disposed between said inlet flange and said retaining flange, said inlet flange having a plurality of longitudinally extending grooves with semi-circular cross-section formed in a radially outer surface thereof, said intermediate portion having a plurality of longitudinally extending grooves with semi-circular cross-section formed in a radially outer surface thereof, said plurality of grooves in said intermediate portion being communicably connected to said plurality of grooves in said inlet flange, said retaining flange having a plurality of longitudinally extending grooves with a semi-circular cross-section formed in a radially outer surface thereof, said piston being comprised of materials compatible with hydraulic brake fluid and adapted to withstand differential pressure consistent with use in a vehicle brake system;

an annular seal disposed around said intermediate portion of said piston, said seal and said intermediate portion cooperating to divide said bore into an inlet chamber and a pumping chamber, said seal being comprised of materials compatible with hydraulic brake fluid and adapted to withstand differential pressure consistent with use in a vehicle brake system;

a fluid inlet communicably connected to said inlet chamber to supply said inlet chamber with fluid, said seal being moveable to a first position relative to said inlet flange in which said plurality of grooves in said inlet flange are communicably connected to said pumping chamber, such that fluid from said inlet chamber fills said pumping chamber;

a fluid outlet communicably connected to said pumping chamber; and
a check valve disposed within said fluid outlet, said check valve being normally closed, said seal being moveable to a second position relative to said inlet flange in which said plurality of grooves in said inlet flange are prevented from communicating with said pumping chamber, such that the pressure of the

fluid within the pumping chamber builds until said check valve opens and pressurized fluid is released from said pumping chamber through said fluid outlet, said check valve being comprised of materials compatible with hydraulic brake fluid and adapted to withstand differential pressure consistent with use in a vehicle brake system.

27. The pump apparatus of Claim 1 wherein the piston is disposed within said bore for reciprocal movement along a longitudinal axis therein, said piston having an inlet flange extending outwardly substantially perpendicular to said longitudinal axis, and said piston having a retaining flange.

28. The pump apparatus of Claim 27 wherein said at least one passageway is formed by said annular seal cooperating with at least one of said piston and said housing.

29. The pump apparatus of Claim 28 wherein said at least one passageway is at least one longitudinally extending passageway.

30. The pump apparatus of Claim 29 wherein said retaining flange and said housing cooperate to form an outlet passageway of said check valve assembly.

31. The pump apparatus of Claim 30 wherein said at least one longitudinally extending passageway communicates directly with said outlet passageway to said pumping chamber.

32. The pump apparatus of Claim 31, wherein said at least one longitudinally extending passageway comprises a plurality of longitudinally extending passageways formed in said annular seal.

33. The pump apparatus of Claim 31, wherein said at least one longitudinally extending passageway is comprised of at least one longitudinally extending groove with semi-circular cross-section defined in said annular seal.

34. The pump apparatus of Claim 32, wherein said piston comprises an inlet flange extending outwardly substantially perpendicular to said longitudinal axis, said inlet flange and said housing cooperating to form an inlet passageway to said check valve assembly.

35. The pump apparatus of Claim 34, wherein said inlet passageway in said bore has an inner radius R_4 defined from said longitudinal axis that is larger than an outer radius R_2 of said at least one longitudinally extending passageway defined from said longitudinal axis when said annular seal is centered about said longitudinal axis, such that when said annular seal abuts said inlet flange said at least one longitudinally extending passageway and said inlet passageway do not overlap one another and there is no fluid communication therebetween.

36. The pump apparatus of Claim 32, wherein said piston comprises a retaining flange, and wherein said retaining flange and said housing cooperate to form an outlet passageway of said check valve assembly that extends annularly about said retaining flange.

37. The pump apparatus of Claim 36, wherein said outlet passageway has an inner radius R_3 defined from said longitudinal axis that is smaller than an outer radius R_2 of said at least one longitudinal passageway in said annular seal defined from said longitudinal axis when said seal is centered about said longitudinal axis, such that said at least one longitudinal passageway and said outlet passageway are in fluid communication.

38. The pump apparatus of Claim 36, wherein said piston comprises an inlet flange extending outwardly substantially perpendicular to said longitudinal axis, and said inlet flange and said housing cooperating to form an inlet passageway within said bore, and wherein said outlet passageway and said inlet passageway are communicably connected when said check valve assembly is in said flow-through position.

39. The pump apparatus of Claim 38, wherein said outlet passageway, said inlet passageway, and said at least one longitudinally extending passageway are communicably connected when said check valve assembly is in said flow-through position.

40. The pump apparatus of Claim 32, wherein a cir-clip is disposed around said piston, and is longitudinally fixed to said piston to retain said annular seal on said piston between said cir-clip and said inlet flange.

41. The pump apparatus of Claim 40, wherein said cir-clip and said housing cooperate to form an outlet passageway of said check valve assembly.

42. The pump apparatus of Claim 41, wherein said outlet passageway has an inner radius R_3 defined from said longitudinal axis that is smaller than an outer radius R_2 of said at least one longitudinally extending passageway defined from said longitudinal axis when said seal is centered about said longitudinal axis, such that said outlet passageway provides continuous fluid communication between said at least one longitudinally extending passageway and said pumping chamber.

43. The pump apparatus of Claim 42, wherein said outlet passageway and said inlet passageway are communicably connected when said check valve assembly is in said flow-through position.

44. The pump apparatus of Claim 41, wherein said outlet passageway has an inner radius R_3 defined from said longitudinal axis that is smaller than an inner radius R_1 of said at least one longitudinally extending passageway defined from said longitudinal axis when said seal is centered about said longitudinal axis, such that said outlet passageway provides continuous fluid communication between said at least one longitudinally extending passageway and said pumping chamber.

45. The pump apparatus of Claim 44, wherein said piston, said annular seal, and said clip cooperate such that said outlet passageway and said inlet passageway are communicably connected when said check valve assembly is in said flow-through position.

46. The pump apparatus of Claim 41, wherein said outlet passageway, said inlet passageway, and said at least one longitudinally extending passageway are communicably connected when said check valve assembly is in said flow-through position.

47. A pump apparatus comprising:

a housing having a bore formed therethrough;

a piston disposed within said bore for reciprocal movement therein; said piston comprising:

an inlet flange, said inlet flange extending generally radially outwardly from said piston, said inlet flange and said housing cooperating to define at least one inlet passageway;

a retaining flange, said retaining flange extending generally radially outwardly from said piston, said retaining flange and said housing cooperating to define at least one outlet passageway;

an intermediate portion between said inlet flange and said retaining flange; and

an annular seal disposed around said intermediate portion of said piston, said seal slidably engaging the wall of said bore and the outer surface of said intermediate portion, said seal having at least one longitudinally extending passageway formed therein in continuous fluid communication with said outlet passageway, said housing, said seal, and said piston cooperating to form a check valve assembly, said bore being divided into an inlet chamber and a pumping chamber by said check valve assembly, said seal being moveable to a first position spaced apart from said inlet flange such that said at least one longitudinally extending passageway communicates directly with said pumping chamber and such that said check valve assembly is in a flow-through position to allow fluid to fill said pumping chamber through said at least one inlet passageway, said seal being moveable to a second position sealing against said inlet flange such that said check valve assembly is in a closed position to prevent fluid flow through said at least one outlet passageway and to allow fluid within said pumping chamber to be pressurized during movement of said piston in a pumping stroke.

48. The pump apparatus of Claim 47, wherein said at least one longitudinally extending passageway is comprised of at least one groove with semi-circular cross-section formed through said seal.

49. A pump apparatus comprising:
a housing having a bore formed therethrough;
a piston disposed within said bore for reciprocal movement therein; said piston defining a generally radially outwardly extending inlet flange, said inlet flange and said housing cooperating to define at least one inlet passageway;
a separately formed retaining flange fixed longitudinally to said piston, said retaining flange and said housing cooperating to form an outlet passageway within said bore, said piston further comprising an intermediate portion between said inlet flange and said retaining flange; and
an annular seal disposed around said intermediate portion of said piston, said annular seal being retained on said piston between said cir-clip and said inlet flange, said seal slidingly engaging the wall of said bore and the outer surface of said intermediate portion, said seal, and said piston, cooperating to form at least one longitudinally extending passageway and cooperating to form a check valve assembly, said bore being divided into an inlet chamber and a pumping chamber by said check valve assembly, said seal being moveable to a first position spaced apart from said inlet flange such that said at least one longitudinally extending passageway communicates directly with said outlet passageway to said pumping chamber and such that said check valve assembly is in a flow-through position to allow fluid to fill said pumping chamber through said at least one inlet passageway, said seal being moveable to a second position sealing against said inlet flange such that said check valve assembly is in a closed position to prevent fluid from flowing through said at least one outlet passageway and to allow fluid within said pumping chamber to be pressurized during movement of said piston in a pumping stroke.

50. The pump apparatus of Claim 49, wherein said retaining flange is comprised of a cir-clip.

51. The pump apparatus of Claim 49, wherein said cir-clip is generally U-shaped and extends around about 110° of the circumference of said piston.

52. A pump apparatus comprising:
a housing having a bore formed therethrough;
a piston disposed within said bore for reciprocal movement along a longitudinal axis therein, said piston having an inlet flange and a retaining flange, said inlet and retaining flanges extending outwardly substantially perpendicular to said longitudinal axis; and
an annular seal disposed around said piston between said inlet flange and said retaining flange for reciprocal movement thereon, said annular seal having a smooth end face disposed adjacent said retaining flange, said annular seal cooperating with said piston to form at least one passageway, said passageway, said piston, said annular seal, and said housing cooperating to form a check valve assembly, said check valve assembly dividing said bore into an inlet chamber and a pumping chamber, said annular seal being moveable to a first position relative to said inlet flange in which said inlet chamber communicates with said pumping chamber through said at least one longitudinally extending passageway to fill said pumping chamber with fluid from said inlet chamber during a fluid inlet stroke, said annular seal being moveable to a second position relative to said inlet flange in which said check valve assembly is closed to permit pressurizing the fluid within said pumping chamber during a pumping stroke.

53. A pump apparatus comprising:

a housing having a bore formed therethrough;

a piston disposed within said bore for reciprocal movement therein, said piston comprising:

an inlet flange, said inlet flange extending outwardly from said piston, said inlet flange and said housing forming at least one inlet passageway;

a retaining flange, said retaining flange extending outwardly from said piston, said retaining flange and said housing forming at least one outlet passageway through said bore, said outlet passageway having an inner radius R_3 ;

an intermediate portion, said intermediate portion disposed between said inlet flange and said retaining flange; and

an annular seal disposed around said intermediate portion of said piston, said seal slidingly engaging the walls of said bore, said seal defining at least one passageway therein, said at least one passageway having a maximum outer radius R_2 greater than the radius R_3 .

54. A non-metallic annular seal for a pump, having:

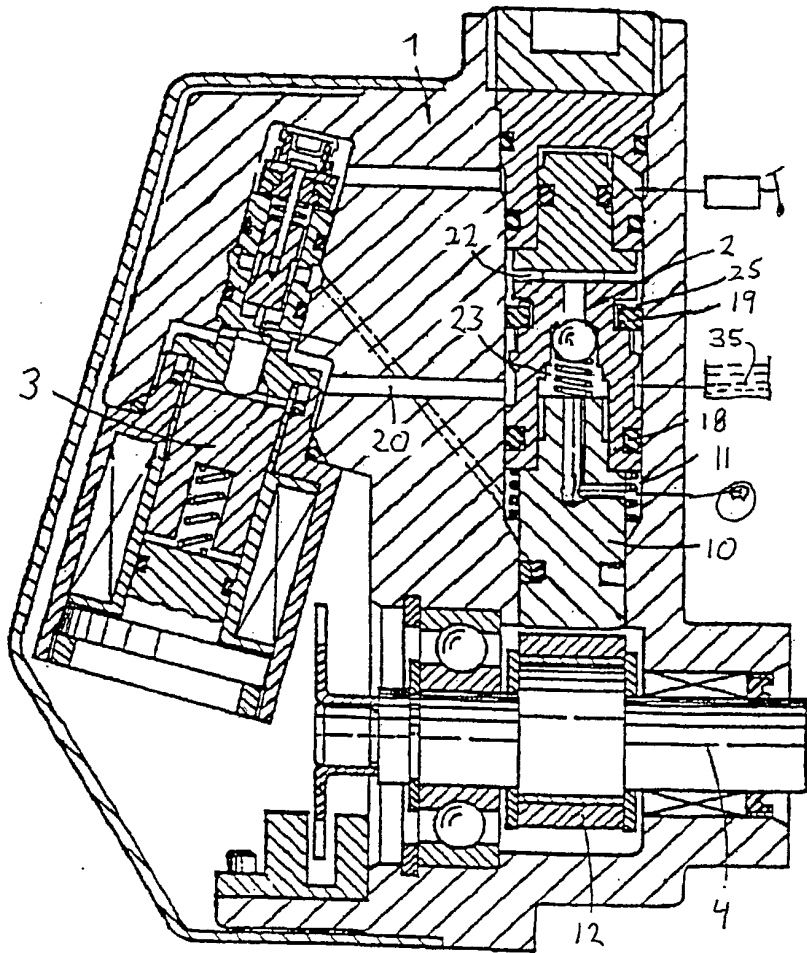
a featureless first end face;

a featureless second end face; and

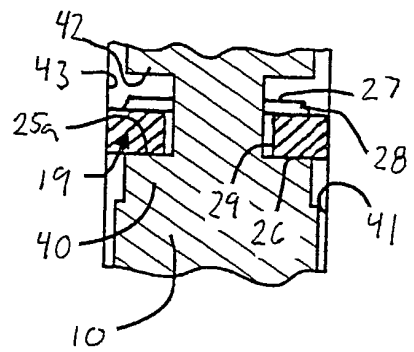
a longitudinal central bore defined by an inner wall extending between said first end face and said second end face, said inner wall having a groove formed therein which extends from said first end face to said second end face.

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— FIG. 1
PRIOR ART



— FIG. 2
PRIOR ART

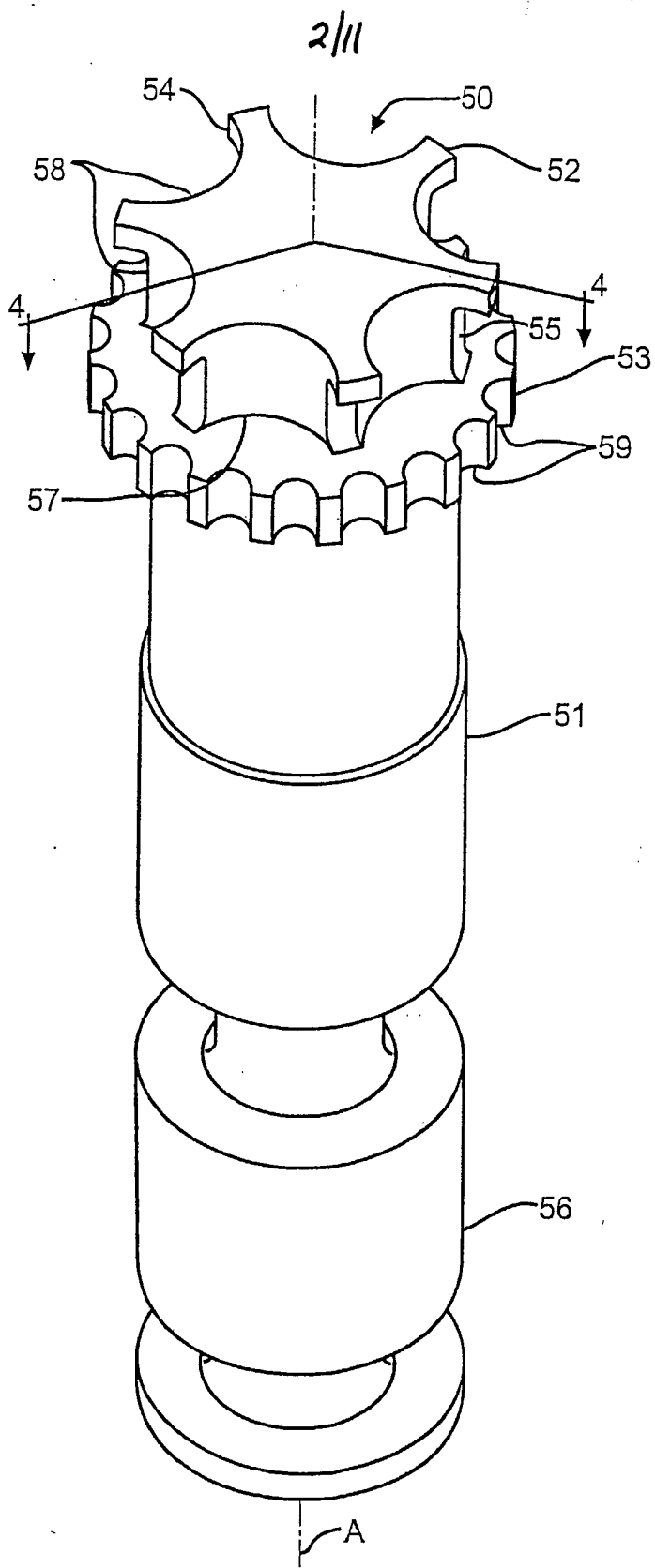


FIG. 3

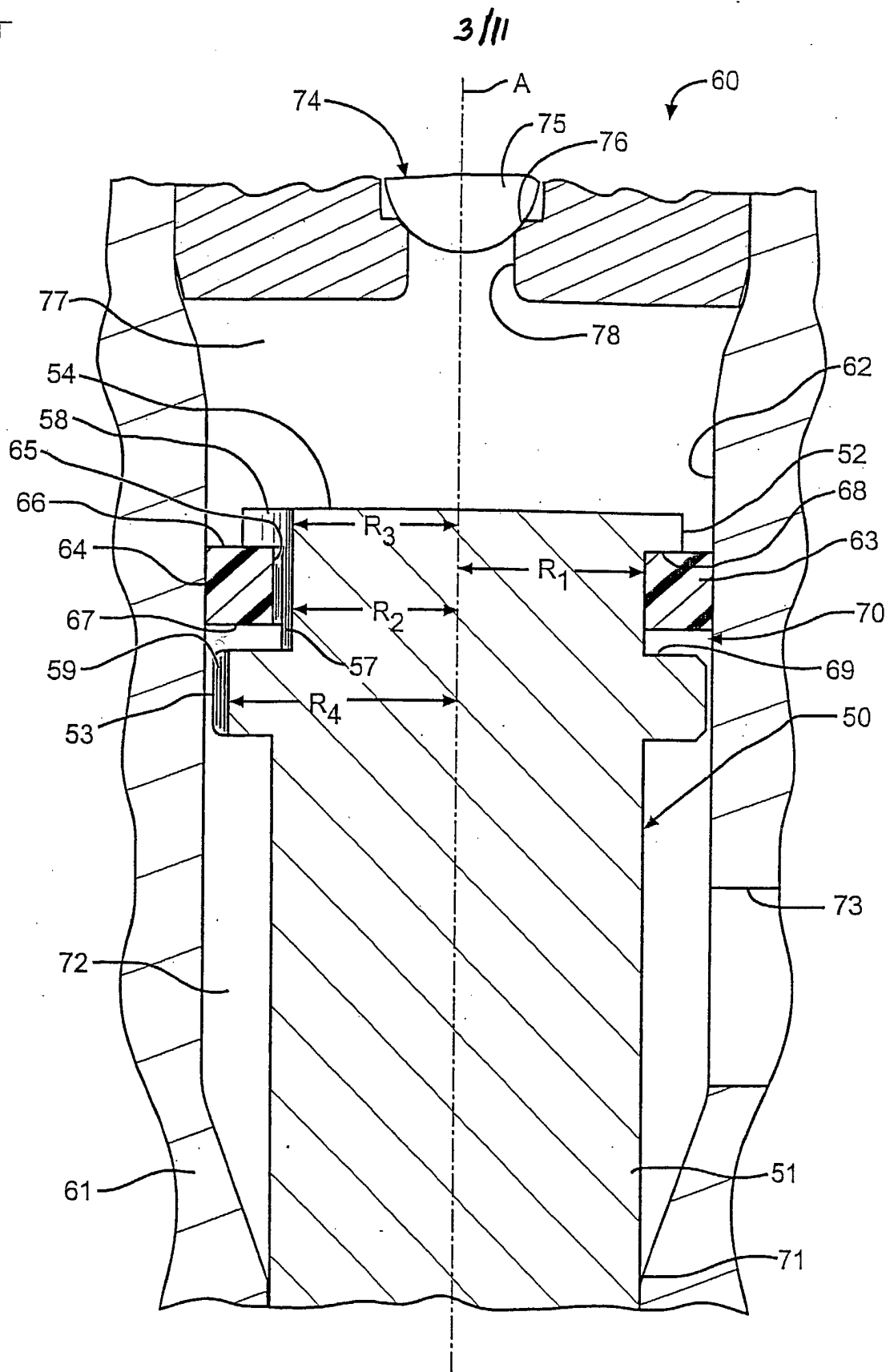


FIG. 4

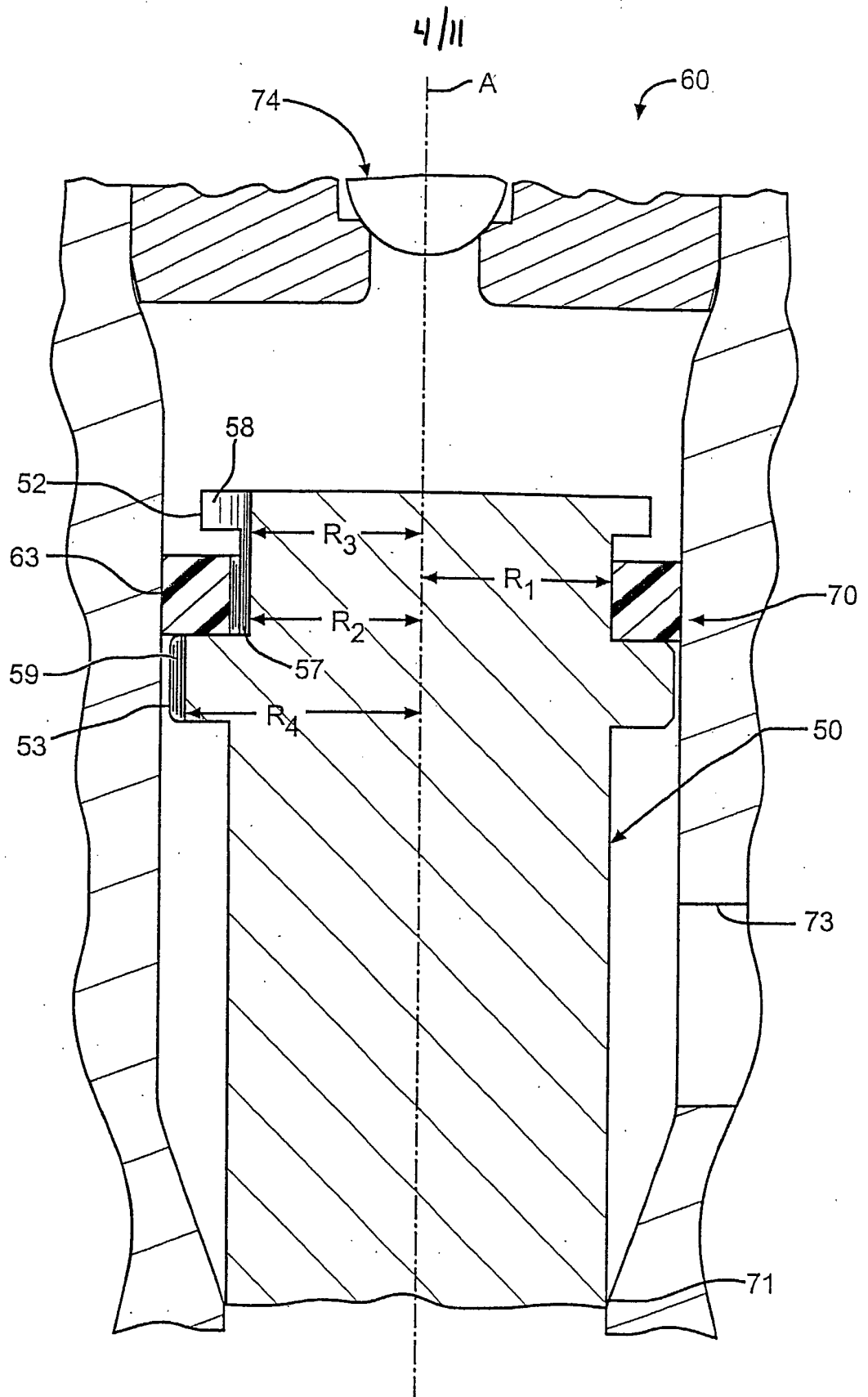


FIG. 5

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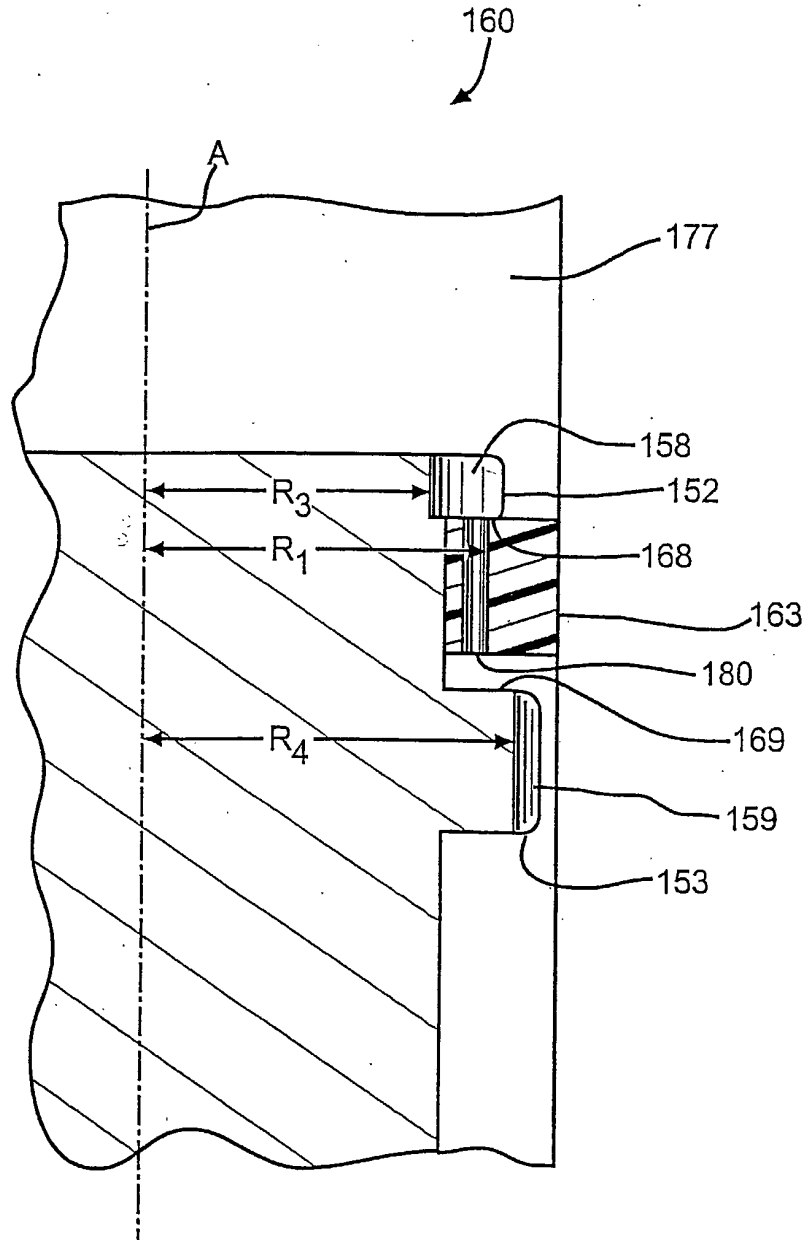


FIG. 6

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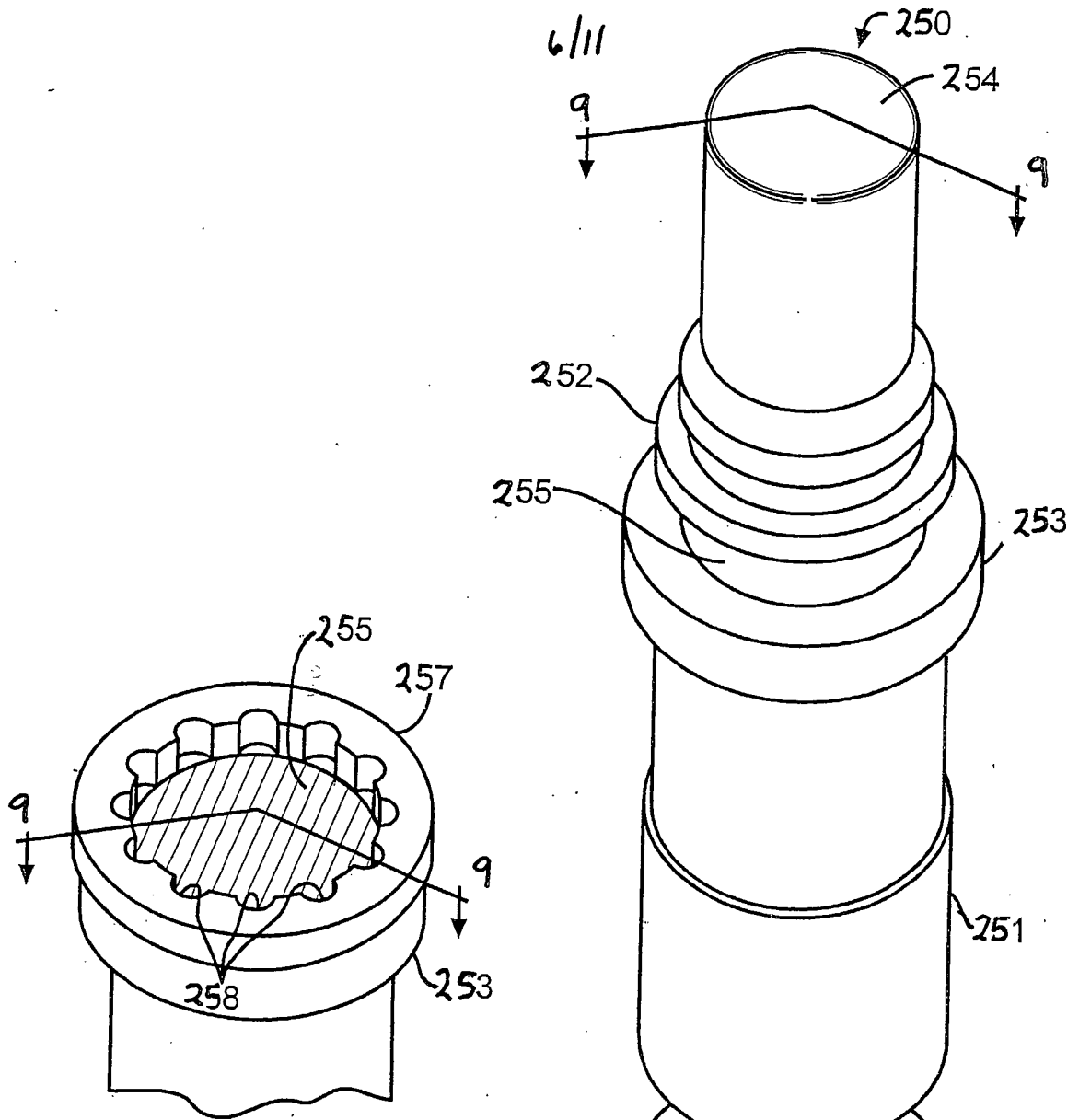


FIG. 8

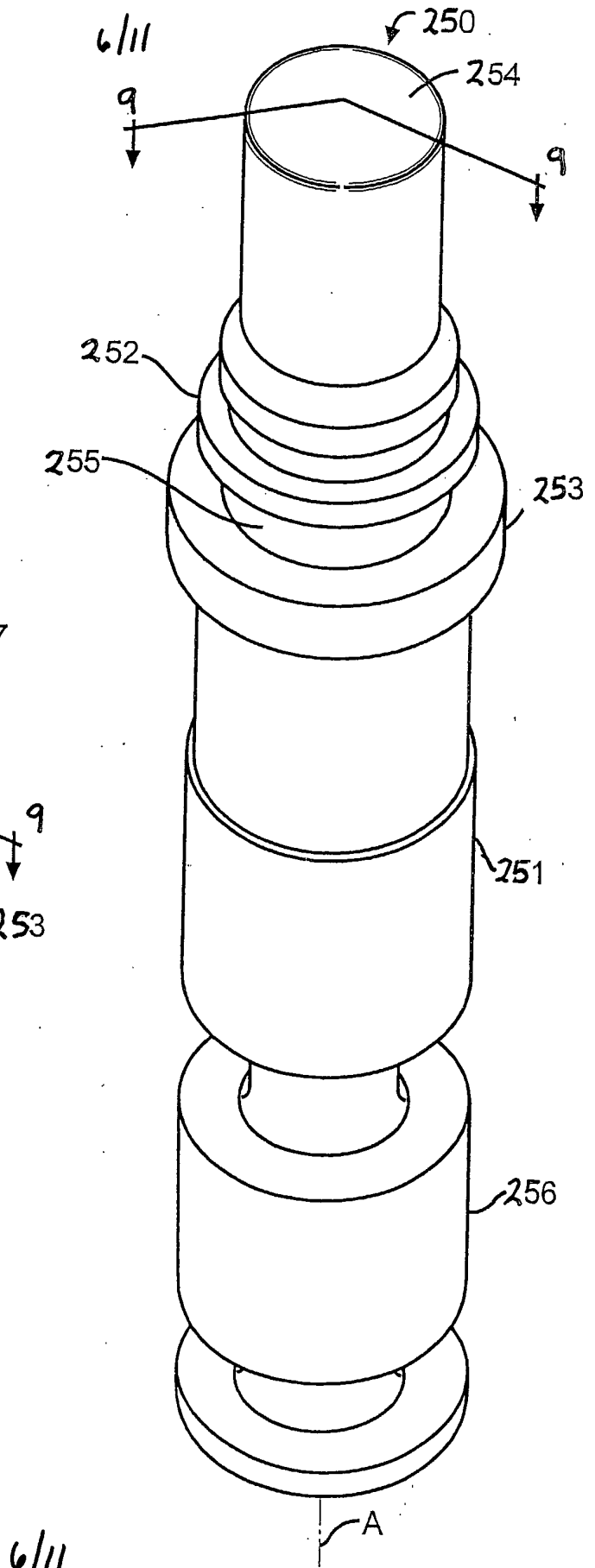


FIG. 7

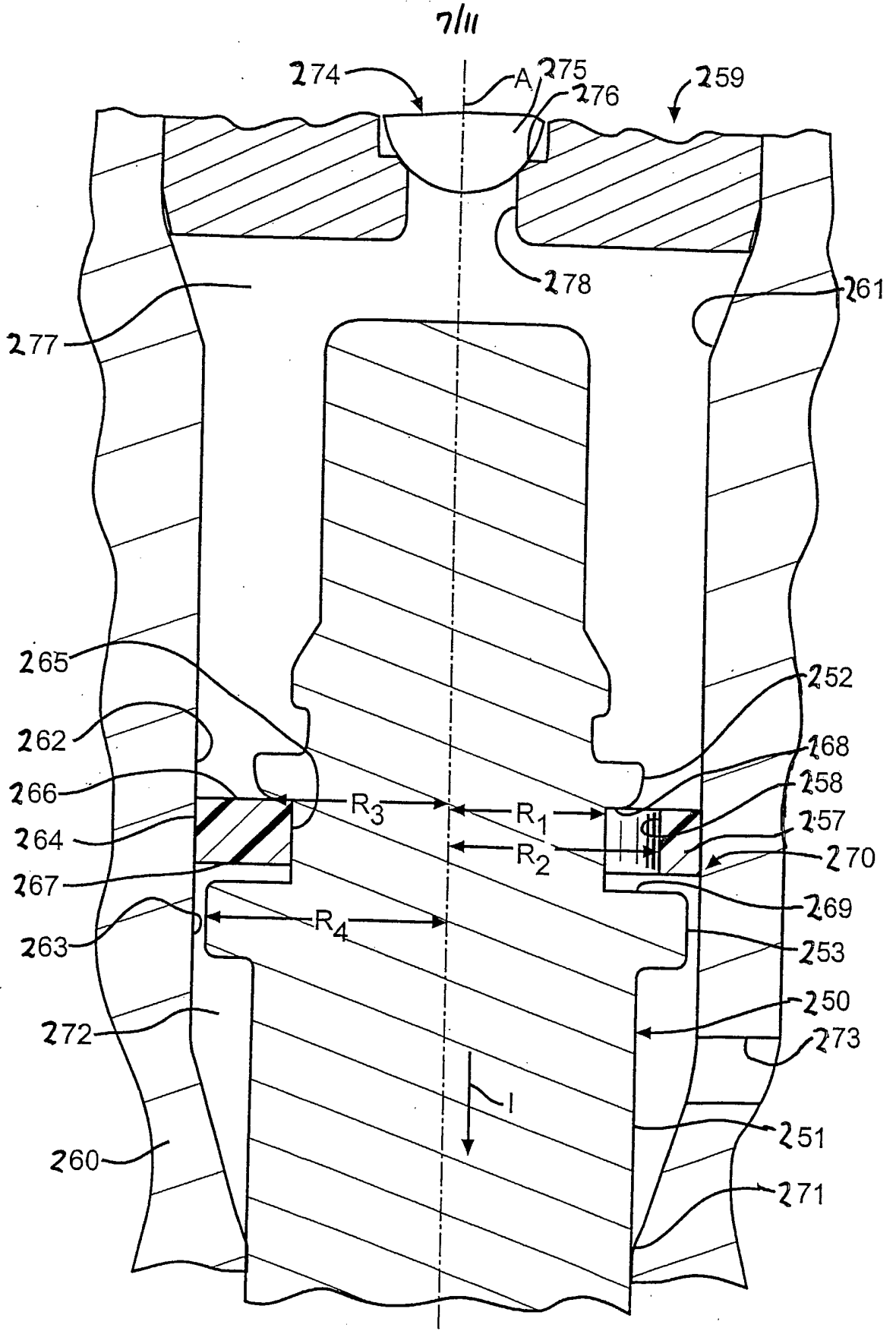
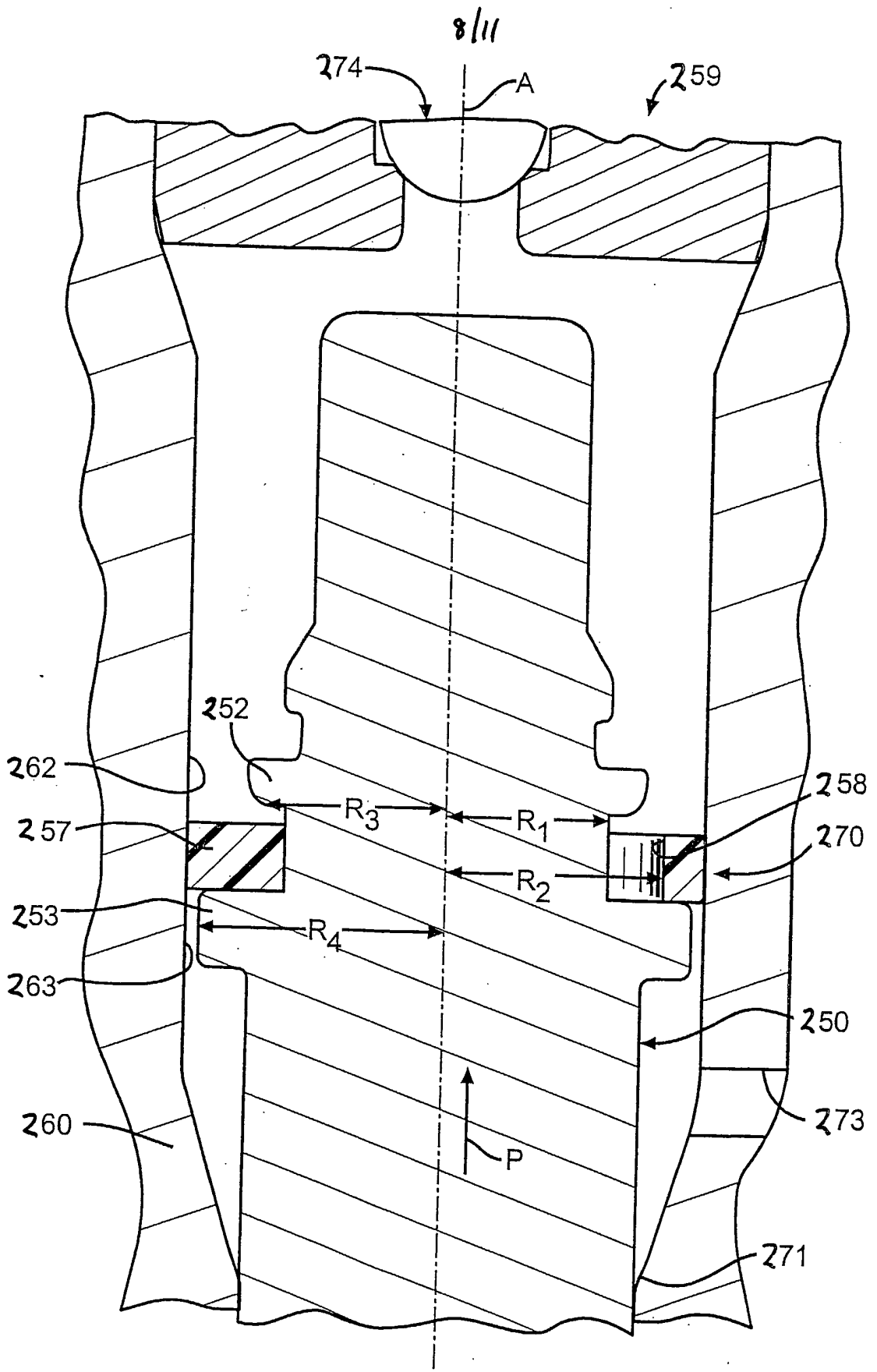


FIG. 9

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—FIG. 10

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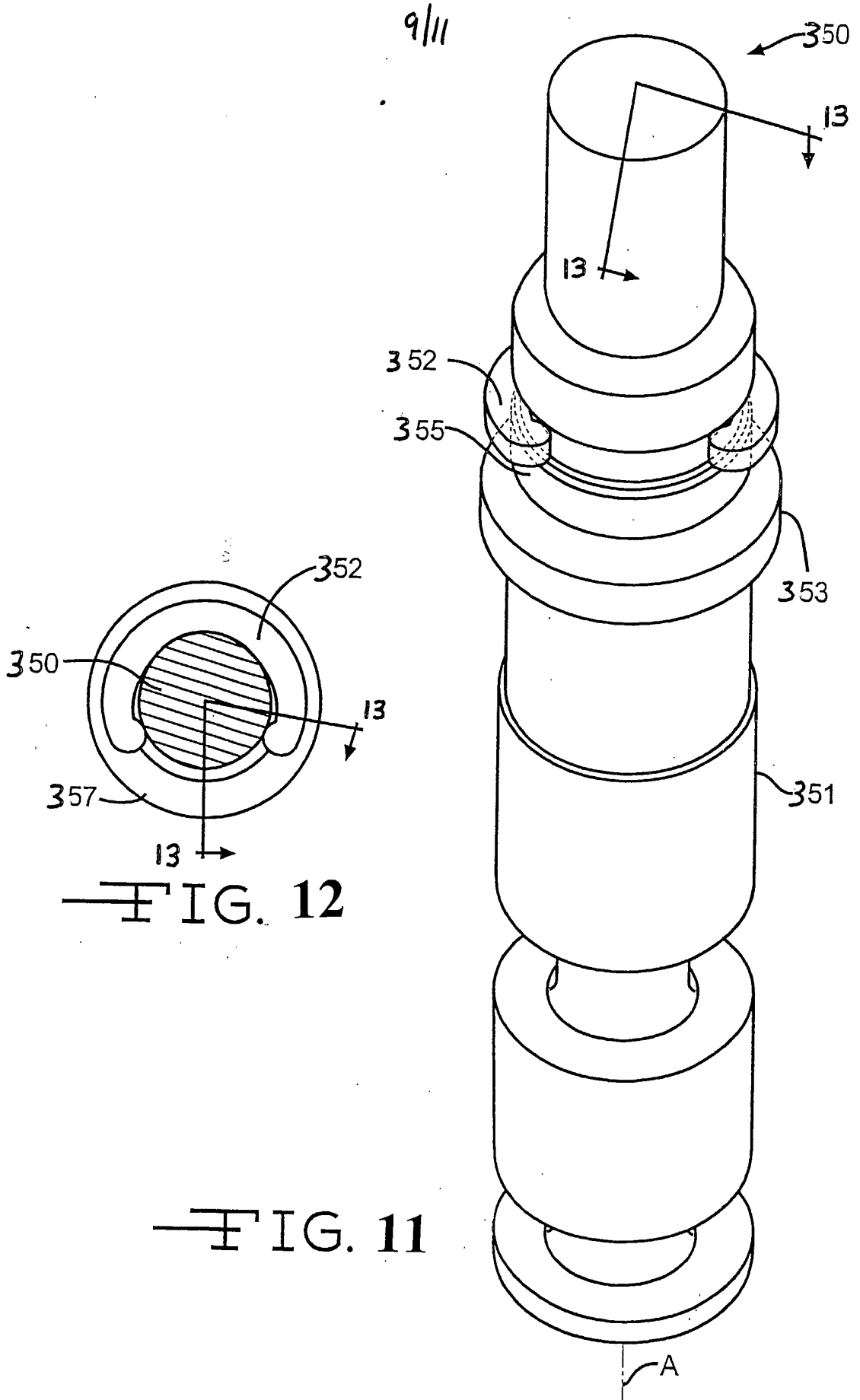


FIG. 12

FIG. 11

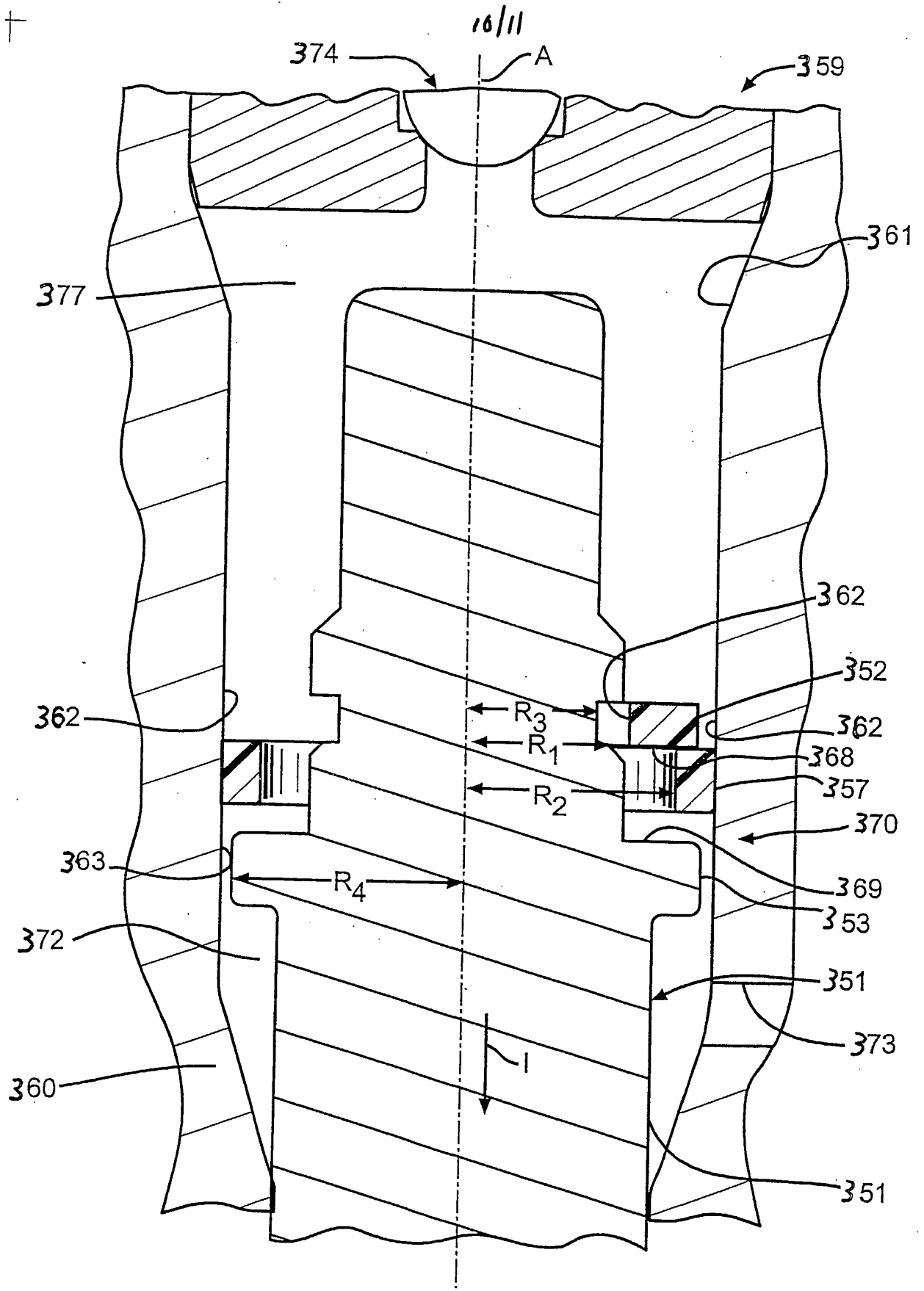


FIG. 13

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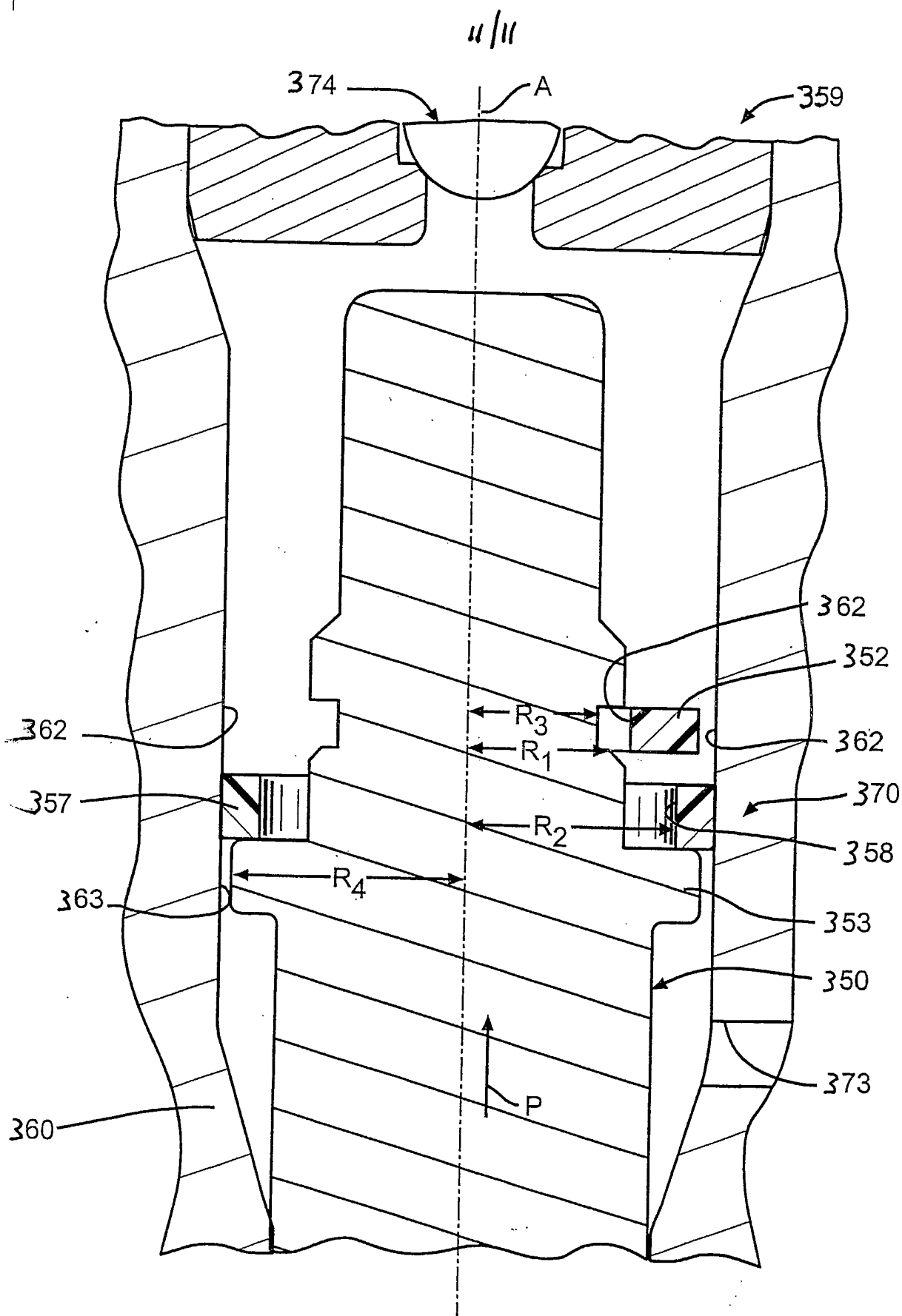


FIG. 14

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/032607

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60T8/40 F04B53/12 F04B1/04 F16J15/16

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)
IPC 7 B60T F04B F16J

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 practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CH 308 083 A (ANDERMATT CARL) 30 June 1955 (1955-06-30) page 3, line 91 - page 4, line 16; figures 1,4,6 page 3, line 20 - line 66; figures 2,3 page 4, line 70 - line 84; figure 8	1-9, 11-16, 19,20, 23-25, 27-29,52
A	----- -/--	26, 34, 35, 37-39, 47, 49, 53, 54

Further documents are listed in the continuation of box C.

Patent family members are listed in 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 document 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

17 January 2005

Date of mailing of the international search report

03/02/2005

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Authorized officer

Meijs, P

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/032607

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 3 224 378 A (GRAHAM GEORGE C) 21 December 1965 (1965-12-21) column 3, line 49 - column 4, line 25; figures 7-13 column 4, line 64 - column 5, line 39; figures 16-18	1-5, 27-29, 52 8, 9, 11-15, 19, 23-26, 34, 35, 38, 39, 47, 49, 53, 54
X A	GB 742 113 A (BLUEMEL BROTHERS LTD) 21 December 1955 (1955-12-21) page 2, line 17 - line 87; figures 1,2	1-5, 27-31, 52, 53 19, 23-26, 34, 35, 47, 49
X Y A	PATENT ABSTRACTS OF JAPAN vol. 010, no. 047 (M-456), 25 February 1986 (1986-02-25) -& JP 60 198382 A (TOSHIBA KIKAI KK), 7 October 1985 (1985-10-07) abstract; figure	1-6, 9, 11-13, 17-19, 22-25, 27-29, 52 54 26, 47, 49, 53
X Y A	US 4 556 261 A (FARR GLYN P R) 3 December 1985 (1985-12-03) cited in the application column 3, line 14 - line 26; figures 1,2 column 3, line 22 - line 23	1, 27-36, 38, 39, 47, 48 54 19, 24-26, 49, 52, 53
X	US 4 114 059 A (ALBARIC JACQUES E ET AL) 12 September 1978 (1978-09-12) column 6, line 38 - line 53; figures 3,4	54

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2004/032607

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: -

Claim 1 is unclear, in particular lines 5 and 6 are unclear and have been understood as follows: "thereon, wherein at least one passageway is formed in at least one of said piston or said annular seal cooperating with at least one of said piston and"

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

 International Application No
 PCT/US2004/032607

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
CH 308083	A	30-06-1955	NONE	
US 3224378	A	21-12-1965	NONE	
GB 742113	A	21-12-1955	NONE	
JP 60198382	A	07-10-1985	NONE	
US 4556261	A	03-12-1985	EP 0110539 A1 GB 2128699 A , B JP 59149853 A BR 8306731 A	13-06-1984 02-05-1984 27-08-1984 13-11-1984
US 4114059	A	12-09-1978	BE 858324 A1 JP 1101690 C JP 53032308 A JP 56046341 B	01-03-1978 25-06-1982 27-03-1978 02-11-1981