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(54) **Cartridge style binary vane pump**

(57) A binary vane pump is provided. The binary vane pump includes a pressure plate (50) having a first discharge port (52), a thrust plate (60) having a second discharge port (66), a ring (30) positioned axially between the pressure plate (50) and thrust plate (60), the ring (30) having an inner cam surface (34), and a rotor (40) rotatably disposed within the ring (30), the rotor (40) having a plurality of slots (44) and a plurality of vanes (46), the vanes (46) of the plurality of vanes corresponding to respective slots (44) of the plurality of slots (44) and are

radially movable with the respective slots (44). A first and second pump chamber (37,38) are disposed within the ring (30), separated by the rotor (40), vanes (46), pressure plate (50) and thrust plate (60), the first pump chamber (37) configured to discharge fluid to the first discharge port (52) and the second pump chamber (38) configured to discharge fluid to the second discharge port (66). A shaft (42) extends through the pressure plate (50), thrust plate (60), ring (30) and rotor (40) and drives the rotor (40).

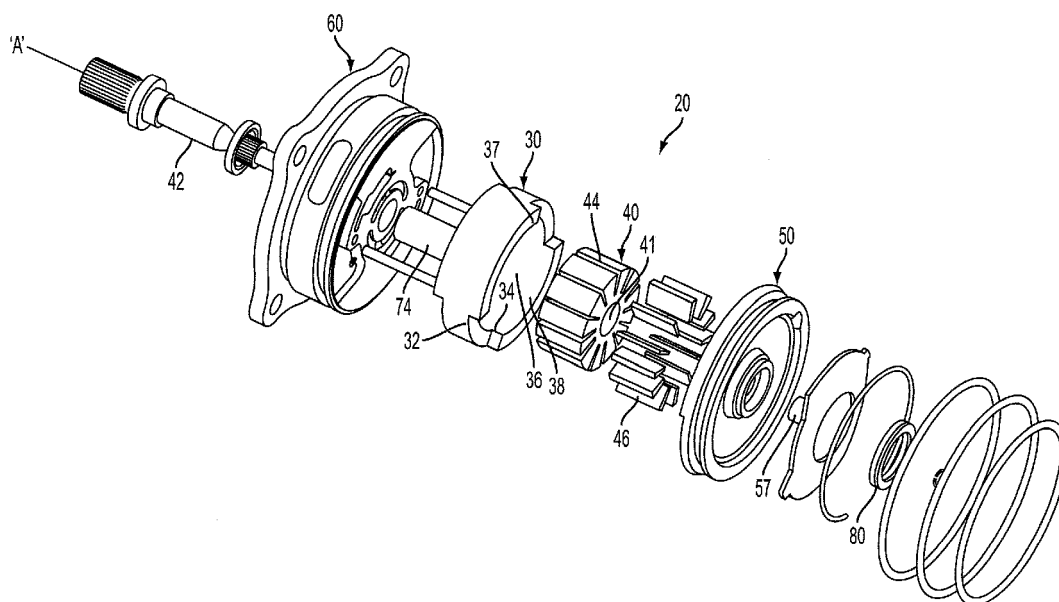


FIG. 2

Description

BACKGROUND OF THE INVENTION

[0001] The following description relates to a vane pump, and in particular, a binary vane pump with a variable output.

[0002] A conventional vane pump may include a thrust plate, ring and pressure plate. The vane pump may be configured as a balanced cartridge design having two pumping chambers. Each pumping chamber includes an intake port formed in the ring and a discharge port formed in the pressure plate. The respective intake ports and discharge ports are symmetrically arranged. Due at least in part to this arrangement, forces generated at one side of the pump are counteracted by the other side.

[0003] In the conventional vane pump, two pumping chambers formed in the ring are connected to a common output circuit. That is, the two pumping chambers discharge fluid to a common circuit via respective discharge ports. As a result, the pumping chambers both push against a common resistance in the common circuit, thereby providing a high flow rate even when a high flow rate may not be necessary. The common resistance on the two pumping chambers may require more mechanical torque/power to drive the pump.

[0004] Accordingly, it is desirable to provide a binary vane pump which separates the two pumping chambers and respective discharge ports so that the pump chambers are discharged to different flow paths. As such, flow output from the pump may be selectively controlled and the mechanical torque/power required to drive the pump may be reduced.

SUMMARY OF THE INVENTION

[0005] According to one aspect, there is provided a binary vane pump having a pressure plate including a first discharge port, a thrust plate including a second discharge port, a ring positioned axially between the pressure plate and thrust plate, the ring having an inner cam surface and a rotor rotatably disposed within the ring, the rotor comprising a plurality of slots and a plurality of vanes, vanes of the plurality vanes corresponding to respective slots of the plurality of slots and radially movable with the respective slots. A first pump chamber and a second pump chamber are disposed within the ring and the second pump chamber is separated from the first pump chamber by the rotor, vanes, pressure plate and thrust plate. The first pump chamber is configured to discharge fluid to the first discharge port and the second pump chamber configured to discharge fluid to the second discharge port. A shaft extends through the pressure plate, thrust plate, ring and rotor and is configured to rotate the rotor so the vanes are rotatable in the first and second pumping chambers.

[0006] These and other advantages and features will become more apparent from the following description

taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0008] FIG. 1 is a perspective view of a binary vane pump according to one aspect of the present invention;

[0009] FIG. 2 is an exploded view a binary vane pump according to one aspect of the present invention;

[0010] FIG. 3 illustrates an inner side of a pressure plate according to one aspect of the present invention;

[0011] FIG. 4 illustrates an outer side of the pressure plate of FIG. 3 according to one aspect of the present invention;

[0012] FIG. 5 illustrates an inner side of a pressure plate according to another aspect of the present invention;

[0013] FIG. 6 illustrates an outer side of the pressure plate of FIG. 5 according to another aspect of the present invention;

[0014] FIG. 7 illustrates an inner side of a thrust plate according to one aspect of the present invention;

[0015] FIG. 8 illustrates an inner side of a thrust plate according to another aspect of the present invention; and

[0016] FIG. 9 illustrates an outer side of a pressure plate according to another exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[0017] Referring now to the Figures, where the invention will be described with reference to specific embodiments, without limiting same, FIGS. 1 and 2 show a binary vane pump 20 in accordance with an exemplary embodiment of the present invention. The binary vane pump includes a ring 30, rotor 40, pressure plate 50, and thrust plate 60.

[0018] FIG. 2 shows an exploded view of the binary vane pump 20 according to an exemplary embodiment of the present invention. With reference to FIG. 2, the ring 30, rotor 40, pressure plate 50 and thrust plate 60 are positioned along an axis 'A'. The ring 30 includes a plurality of intakes 32. In an exemplary embodiment, the ring 30 includes four intakes 32. A first two intakes may be positioned on axially opposite sides of the ring 30. A second two intakes may be positioned on a diametrically opposite side of the ring from the first two intakes, and may be positioned on axially opposite sides of the ring 30.

[0019] An inner circumferential surface of the ring 30 includes an inner cam surface 34. The inner cam surface 34 defines a generally oblong or elongated shape such that ring includes a generally oblong or elongated main

chamber 36 having a minor diameter and a major diameter.

[0020] The rotor 40 is positioned in the main chamber 36 of the ring 30. The rotor 40 includes an opening 41 configured to receive a rotating shaft 42. The rotating shaft 42 extends along an axis 'A' and causes the rotor 40 rotate about the axis 'A'. The rotor 40 includes a plurality of radially extending slots 44 which receive respective vanes 46. The vanes 46 are movable in a radial direction of the rotor 40 within respective slots 44 so that the vanes 46 may contact the inner cam surface 34 during rotation of the rotor 40.

[0021] The rotor 40 is positioned within the main chamber 36 such that a variable clearance is formed between the rotor 40 and inner cam surface 34. The vanes 46 extend across the variable clearance and are movable with respect slots 44 to accommodate variances in the clearance. In an exemplary embodiment, the variable clearance is at a minimum value along the minor diameter. The variable clearance increases toward the major diameter and is at a maximum along the major diameter. The variable clearance decreases moving from the major diameter toward to the minor diameter.

[0022] The rotor 40 and the vanes 46 divide the main chamber 36 into a first pumping chamber 37 and a second pumping chamber 38. In an exemplary embodiment, a pumping chamber refers to a volume between the rotor 40 and the inner cam surface 34 of the ring which includes at least one intake 32 and at least one discharge, as described further below. In an exemplary embodiment, the first pumping chamber 37 is separated from the second pumping chamber 38 at or near the minor diameter by the rotor 40 and vanes 46 extending from the rotor 40. In addition, the pressure plate 50 and thrust plate 60 provide axial boundaries of the first pumping chamber 37 and second pumping chamber 38. Accordingly, in an exemplary embodiment, the first pumping chamber 37 is positioned diametrically opposite from the second pumping chamber 38 in the ring 30.

[0023] FIG. 3 illustrates an inner side of the pressure plate 50 according to an exemplary embodiment of the present invention. The pressure plate 50 includes an opening 51 centered on the axis 'A'. The inner side of the pressure plate 50 faces the ring 30, chamber 36, first pumping chamber 37, second pumping chamber 38, rotor 40 and vanes 46. The pressure plate 50 is substantially rotationally fixed relative to the ring 30 and serves as an axial boundary for the first and second pumping chambers 37, 38 (FIG. 2).

[0024] The pressure plate 50 includes a first discharge port 52. The first discharge port 52 is positioned on the pressure plate 50 at a location where fluid may be discharged from the first pumping chamber 37. The first discharge port 52 allows fluid to flow from the first pumping chamber 37 to a hydraulic load positioned downstream from the binary vane pump 20 via a first flow path.

[0025] A high system pressure is applied on an outer surface of the pressure plate 50 to compress the pressure

plate 50 and ring 30 together to minimize leakage paths. In an exemplary embodiment, the high system pressure results from resistance to the flow from the first pumping chamber 37 to into the first flow path.

[0026] A pumping volume is defined between two adjacent vanes 46, the rotor 40, the inner cam surface 34, the pressure plate 50 and the thrust plate 60. In operation, the pumping volume increases as adjacent vanes 46 rotate from the minor diameter toward the major diameter. The pumping volume becomes at least partially filled with the fluid during rotation. The pumping volume then decreases as the rotor 40 rotates and the adjacent vanes 46 move from the major diameter toward the minor diameter. The decrease in pumping volume causes an increase in pressure on the fluid. The increased pressure causes the fluid to flow from the pumping volume out through the first discharge port 52. The first discharge port 52 is positioned adjacent to the first pumping chamber 37 at a location where pressure within the pumping volume is sufficient to force the fluid to flow from the first pumping chamber 37 through the first discharge port 52 to the first flow path.

[0027] The inner side of the pressure plate 50 further includes a first undervane port 54. The first undervane port 54 may be formed as an opening extending through the pressure plate 50 and is configured to communicate the high system pressure applied on an outer or back surface of the pressure plate 50 to the vanes 46, to urge the vanes 48 radially outward from the rotor 40 and into contact with the inner cam surface 34. That is, high system pressure from outside the main chamber 36 may be exerted on the vanes 46 as an undervane pressure to act behind the vanes and urge the vanes 46 into contact with the inner cam surface 34 in the first pumping chamber 37. The vanes 46 are also urged into contact with the inner cam surface 34 due a centripetal force resulting from rotation of the rotor 40.

[0028] FIG. 4 illustrates an outer side of the pressure plate 50 shown in FIG. 3. The outer side of the pressure plate 50 faces away from the main chamber 36 according to an exemplary embodiment. The first discharge port 52 and first undervane port 54 are shown as openings extending completely through the pressure plate 50.

[0029] Alternatively, and with reference to FIG. 5, the first undervane port 54 may be formed as a groove or recess in the pressure plate rather than an opening extending through the pressure plate 50. By replacing an opening with a groove or recess, the stiffness of the pressure plate 50 may be improved.

[0030] In the exemplary embodiment shown in FIG. 5 where the first undervane port 54 is formed as a groove or recess, the first undervane port 54 is connected to the first discharge port 52 by a first channel 56. Accordingly, high system pressure may communicate with the first undervane port 54 via the first discharge port 52 and the first channel 56 so that the undervane pressure may be exerted on the vanes 46.

[0031] FIG. 6 illustrates an outer side of the pressure

plate 50 shown in FIG. 5. In this exemplary embodiment, the first discharge port 52 extends completely through the pressure plate 50. High system pressure communicates with the inner side of the plate 50 via the first discharge portion 52, first channel 56 and first undervane port 54 as described above.

[0032] With reference to FIG. 2, a first bushing 57 may be positioned about the shaft 42. In an exemplary embodiment, the first bushing 57 is press fit within the opening 51 of the pressure plate 50. Accordingly, the shaft 42 and first bushing 57 extending through the opening 51 in the pressure plate 50.

[0033] With reference to FIGS. 3 and 5, the inner side of the pressure plate 50 may further include a first bushing feed or bleed passage 58. In an exemplary embodiment, the first bushing feed or bleed passage 58 is formed as an aperture in the pressure plate 50. The first bushing feed or bleed passage allows lubrication to flow between the first bushing 57 and the shaft 42.

[0034] FIG. 7 shows the thrust plate 60 in accordance with an exemplary embodiment of the present invention. The thrust plate 60 includes an opening 61 centered along axis 'A'. The thrust plate extends in an axial direction and includes a circumferential wall 62 and an inner face 64. A second discharge port 66 and a second undervane port 68 are formed in the inner face 64.

[0035] The second discharge port 66 extends axially and radially within the thrust plate 60 and includes an exit 67 formed in the circumferential wall 62. In an exemplary embodiment, the second undervane port 68 extends axially within the thrust plate 60. A passage 70 within the thrust plate 60 fluidly connects the second undervane port 68 to the second discharge port 66.

[0036] Alternatively, and with reference to FIG. 8, the second undervane port 68 may be at least partially filled in so the second undervane port 68 is formed as a groove or recess in the inner face 64 of the thrust plate. In addition, the passage 70 may be replaced with a second channel 72 formed in the inner face 64 of the thrust plate 60. The second channel 72 extends between the second undervane port 68 and the second discharge port 66 so that the second undervane port 68 may fluidly communicate with the second discharge port 66.

[0037] Referring to FIG. 2, a second bushing 74 may be positioned around the shaft 42. In an exemplary embodiment, the second bushing 74 is press fit to the thrust plate in the opening 61, such that the second bushing 74 and shaft 42 extend through the opening 61 of the thrust plate 60.

[0038] The inner face 64 of the thrust plate 60 may further include a second bushing feed or bleed passage 76. In an exemplary embodiment, the second bushing feed or bleed passage 76 is formed as an aperture in the thrust plate 60. The second bushing feed or bleed passage 76 allows lubrication to flow between the second bushing 74 and the shaft 42.

[0039] While the first bushing 57 and second bushing 74 are described separately in the exemplary embodi-

ments above, it is understood that if second bushing 74 is of sufficient length and can support a sufficient load, then first bushing 57 may be omitted.

[0040] When assembled, the pressure plate 50 and the thrust plate 60 are positioned on axially opposite sides of the ring 30, rotor 40 and vanes 46. The first discharge port 52 and first undervane port 54 of the pressure plate 50 are positioned adjacent to the first pumping chamber 37 such that fluid may flow from the first pumping chamber 37 through the first discharge port 52. The second discharge port 66 and second undervane port 68 of the thrust plate 60 are positioned adjacent to the second pumping chamber 38 such that fluid may flow from the second pumping chamber 38 through second discharge port 66. Fluid is pumped through the second chamber 38 and discharged through the second discharge port 66 in a manner similar to that in the first pumping chamber 37 described above, i.e., by decreasing a pumping volume between adjacent vanes during rotation of a rotor.

[0041] The second discharge port 66 is fluidly coupled with a second flow path such that fluid is discharged from the second pumping chamber 38 to the second flow path via the second discharge port 66. The second flow path may include a valve to selectively direct flow from the second discharge port 66 to the hydraulic load. In this condition, the binary vane pump 10 works to pump fluid from the first pumping chamber 37 and second pumping chamber 38 through the first discharge port 52 and second discharge port 66, respectively, to the hydraulic load. Thus, both pumping chambers 37, 38 are combined to act on the hydraulic load. In an exemplary embodiment, this configuration may be used in high load scenarios.

[0042] In this "high load" configuration, the vanes 46 of the rotor 40 extend from the slots 44 and are urged into contact with the inner cam surface 34 in both the first pumping chamber 37 and second pump chamber 38. The vanes 46 are urged into contact with the inner cam surface 34 in the second pumping chamber 38 by a second undervane pressure applied via the second undervane port 68 from high system pressure in the second flow path.

[0043] The valve of the second flow path may be actuated so that fluid discharged from the second discharge port 66 flows through the second flow path but does not act on the hydraulic load. That is, with the valve in this position, the second flow path does not communicate with the high system pressure. As a result, in an exemplary embodiment, the second flow path operates as a low pressure conduit. Thus, the binary vane pump 10 works against a lower pressure to discharge fluid from the second pumping chamber 38 than the first pumping chamber 37. In this condition, it is the fluid from the first pumping chamber 37 acts on the hydraulic load. In an exemplary embodiment, this configuration may be used in low load scenarios.

[0044] In this "low load" configuration, the vanes 46 are urged into contact with the inner cam surface 34 by a low pressure applied through the second undervane

port 68. Because of the low pressure applied through the second undervane port 68, sliding friction, vane tip wear and inner cam surface 34 wear may be reduced.

[0045] Alternatively, and with reference to FIG. 9, the second undervane port 68 may be arranged in the pressure plate 50 and positioned adjacent to the second pumping chamber 38. In this embodiment, undervane pressure is applied to the vanes 46 in the second pumping chamber 38 from the high system pressure outside of the pressure plate 50. Thus, the first undervane port 54 and the second undervane port 68 may be formed in the pressure plate 50 to supply undervane pressure to the vanes 46 in the first pumping chamber 37 and second pumping chamber 38, respectively. Accordingly, the thrust plate 60 may not include an undervane port.

[0046] With further reference to FIGS. 2 and 6, the binary vane pump 20 of the present invention may also include a seal 80 positioned on the outer or back side of the pressure plate 50. The seal 80 seals between high and low pressure areas of the system. The seal is positioned against a seat 82 on the pressure plate 50. The diameter of the seat 82 may be selected during manufacturing so the pressure applied by the seal 80 on the seat 82 is at an acceptable level depending on a particular application. Accordingly, deflection of the pressure plate 50 during operation may be tuned by selecting a diameter of the seat 82 to control the pressure applied thereto.

[0047] The integration of the features above may be utilized to effectively achieve better control over flow and pressure, and thus, provide a more efficient use of mechanical torque/power. The binary vane pump 20 of the exemplary embodiment above may be used together with, for example, an automatic transmission system. That is, the hydraulic load described above may be a component of an automatic transmission system. It is understood that the binary vane pump 20 of the exemplary embodiments above may be used together with other hydraulic systems as well, and in particular, hydraulic systems where it may be advantageous to selectively control the flow from the pump.

[0048] In the exemplary embodiments above, the first pumping chamber 37 is arranged to work against a high system pressure. The second pumping chamber may selectively work against the high system pressure or a low system pressure, depending on the amount of flow needed to operate the hydraulic load. When the second pumping chamber 38 works against the low system pressure, power supplied to the binary vane pump 20 may be reduced. In addition, exposing the second pumping chamber 38 to a lower pressure may reduce wear on the vanes 46 and the inner cam surface 34, and also reduce sliding friction between the vanes 46 and the inner cam surface 34.

[0049] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of

variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description.

Claims

1. A binary vane pump comprising:

a pressure plate including a first discharge port;
a thrust plate including a second discharge port;
a ring positioned axially between the pressure plate and thrust plate, the ring having an inner cam surface;
a rotor rotatably disposed within the ring, the rotor comprising a plurality of slots and a plurality of vanes, vanes of the plurality vanes corresponding to respective slots of the plurality of slots and radially movable with the respective slots;
a first pump chamber disposed within the ring;
a second pump chamber disposed within the ring, separated from the first pump chamber by the rotor, vanes, pressure plate and thrust plate, the first pump chamber configured to discharge fluid to the first discharge port and the second pump chamber configured to discharge fluid to the second discharge port; and
a shaft extending through the pressure plate, thrust plate, ring and rotor and configured to rotate the rotor so the vanes are rotatable in the first and second pumping chambers.

2. The binary vane pump of claim 1, wherein the pressure plate further comprises a first undervane port configured to supply a first undervane pressure to the vanes in the first pumping chamber.

3. The binary vane pump of claim 2, wherein the plurality of vanes in the first pumping chamber are urged into contact with the inner cam surface by the first undervane pressure.

4. The binary vane pump of claim 2, wherein the first undervane port is configured as an opening extending through the pressure plate.

5. The binary vane pump of claim 2, wherein the first undervane port is configured as groove formed on an inner face of the pressure plate facing the ring and fluidly communicates with the first discharge port.

6. The binary vane pump of claim 5, further comprising a first channel formed on the inner face of the pressure plate extending between the first undervane port and the first discharge port. 5
7. The binary vane pump of claim 2, wherein the pressure plate further comprises a second undervane port configured to supply a second undervane pressure to vanes in the second pumping chamber. 10
8. The binary vane pump of claim 2, wherein the thrust plate further comprises a second undervane port configured to supply a second undervane pressure to the vanes in the second pumping chamber. 15
9. The binary vane pump of claim 8, wherein the plurality of vanes in the second pumping chamber are urged into contact with the inner cam surface by the second undervane pressure. 20
10. The binary vane pump of claim 9, wherein the first undervane pressure is greater than the second undervane pressure.
11. The binary vane pump of claim 8, wherein the second undervane port is fluidly connected to the second discharge port. 25
12. The binary vane pump of claim 8, wherein a second channel is formed on an inner surface of the thrust plate and extends between the second undervane port and the second discharge port to fluidly connect the second undervane port and second discharge port. 30
13. The binary vane pump of claim 1, further comprising a bushing surrounding the shaft. 35
14. The binary vane pump of claim 12, wherein the bushing comprises a first bushing press fit to the pressure plate and a second bushing press fit to the thrust plate 40
15. The binary vane pump of claim 12, wherein the pressure plate includes a first feed/bleed passage and the thrust plate comprises a second feed/bleed passage, the first and second feed/bleed passages configured feed lubricant to the first bushing and second bushing, respectively. 45
- 50

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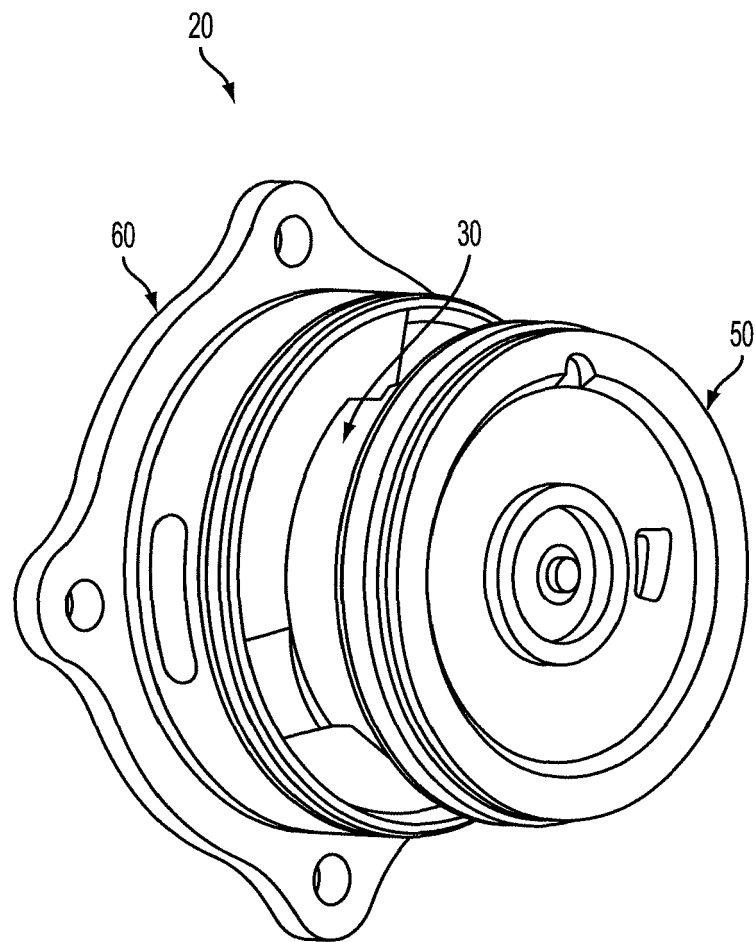


FIG. 1

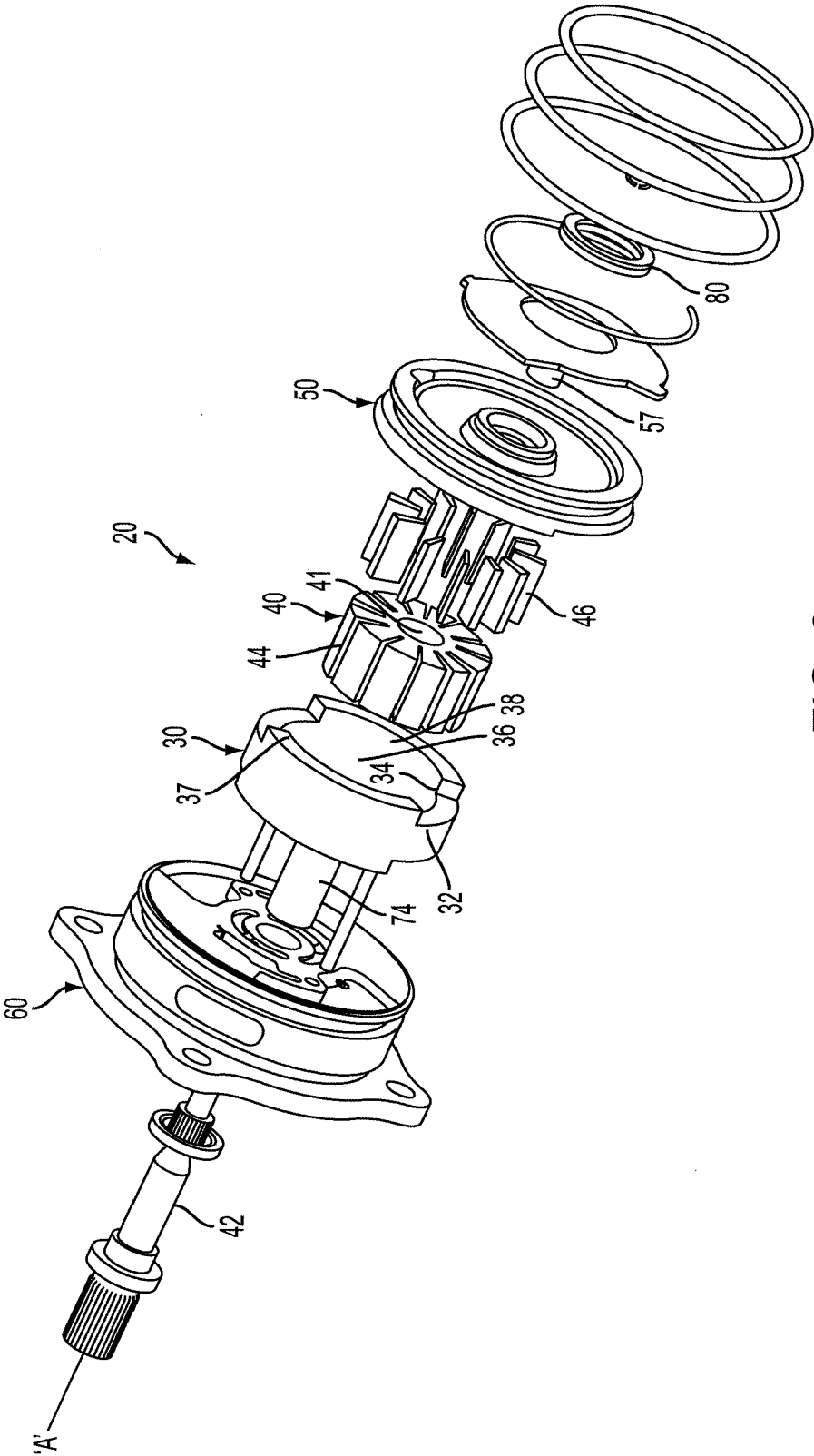


FIG. 2

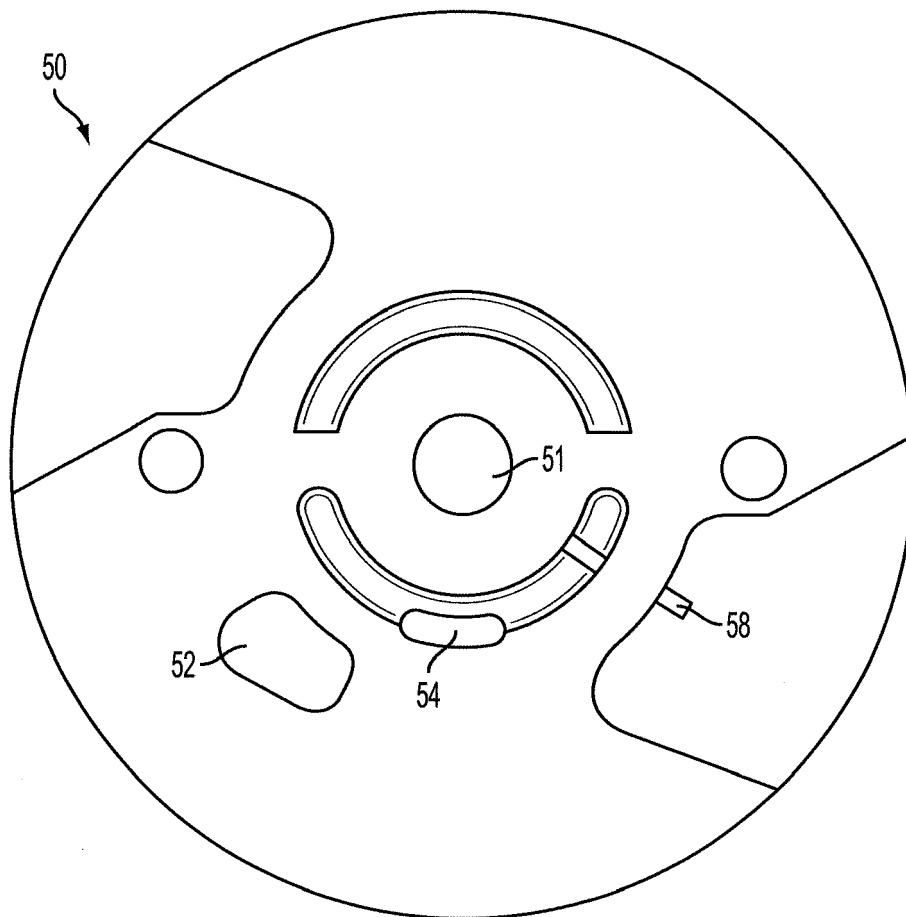


FIG. 3

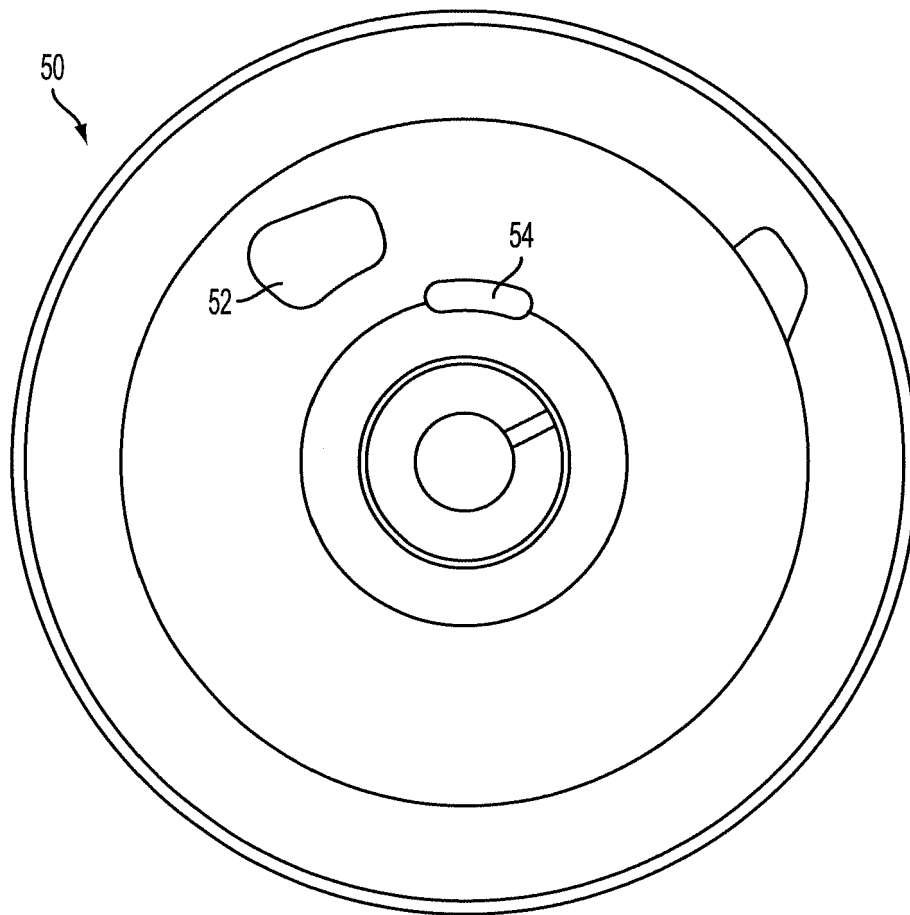


FIG. 4

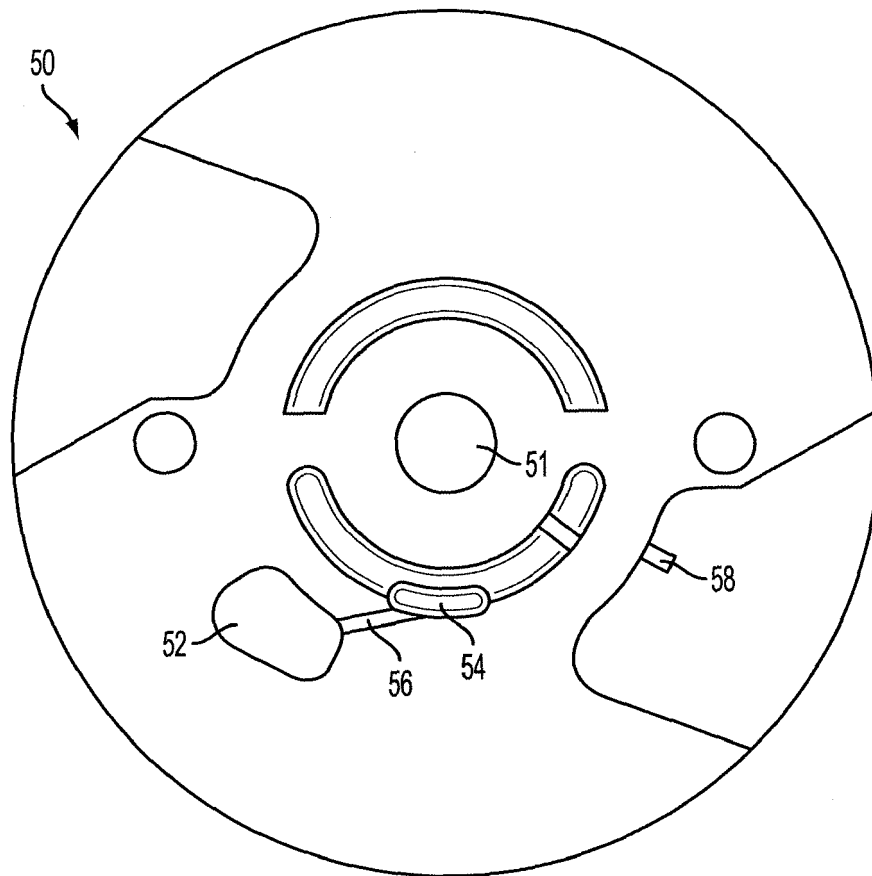


FIG. 5

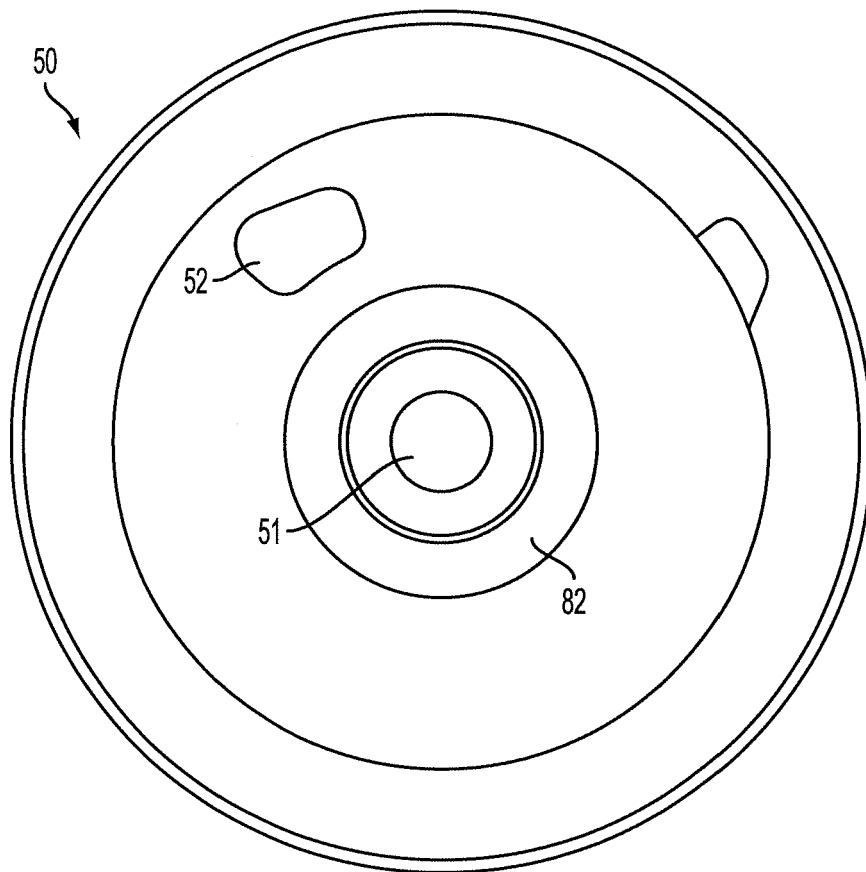


FIG. 6

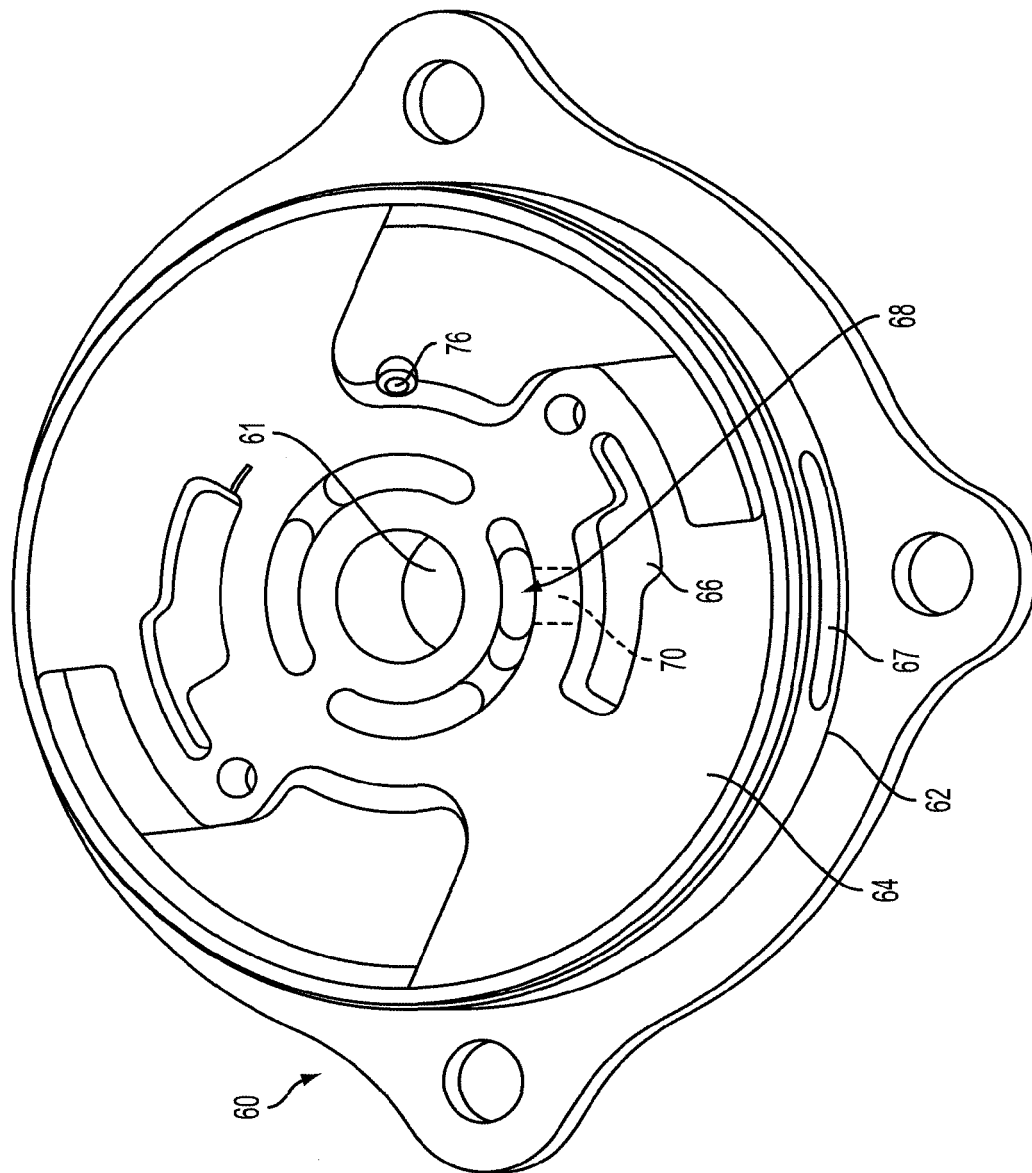


FIG. 7

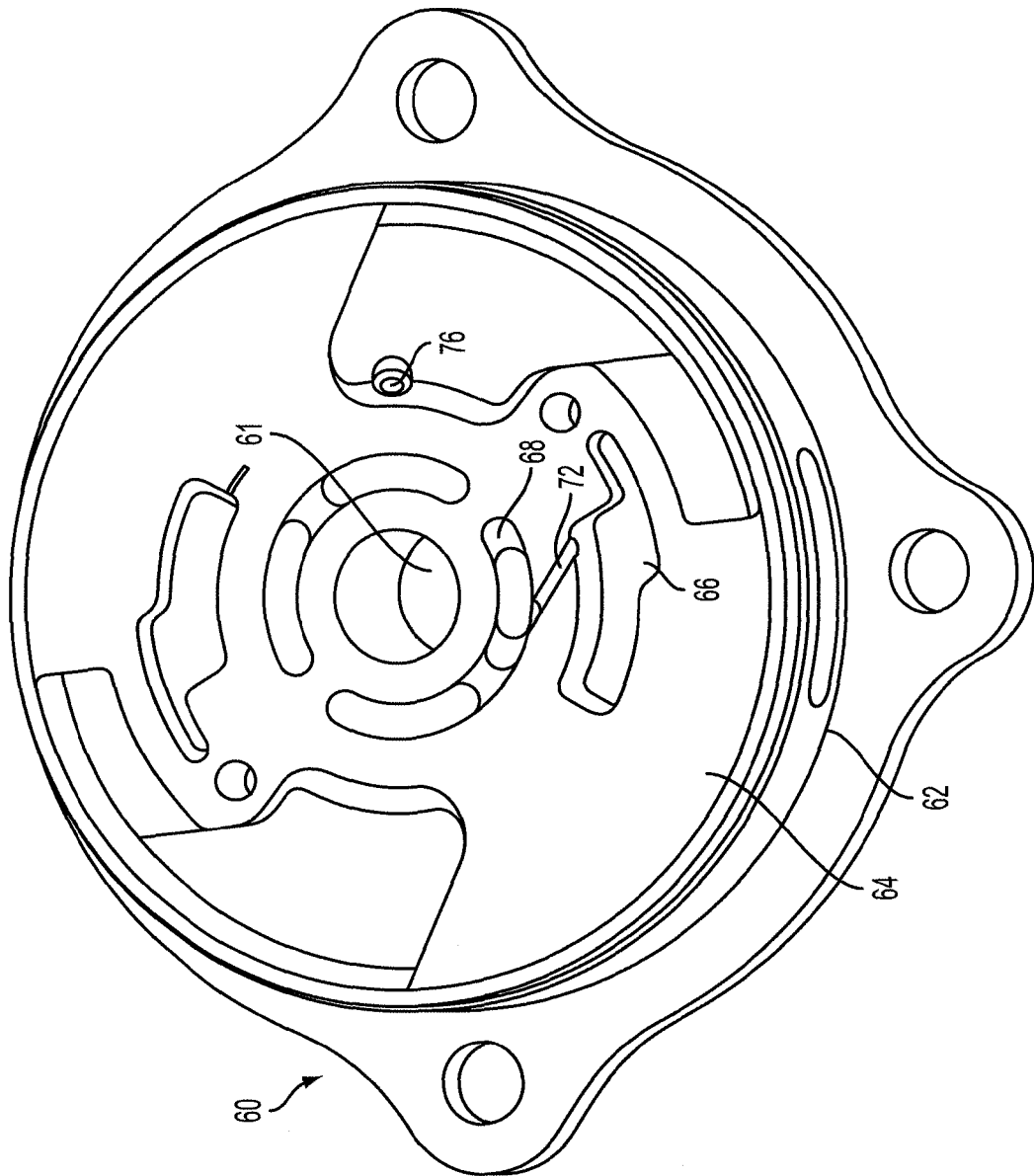


FIG. 8

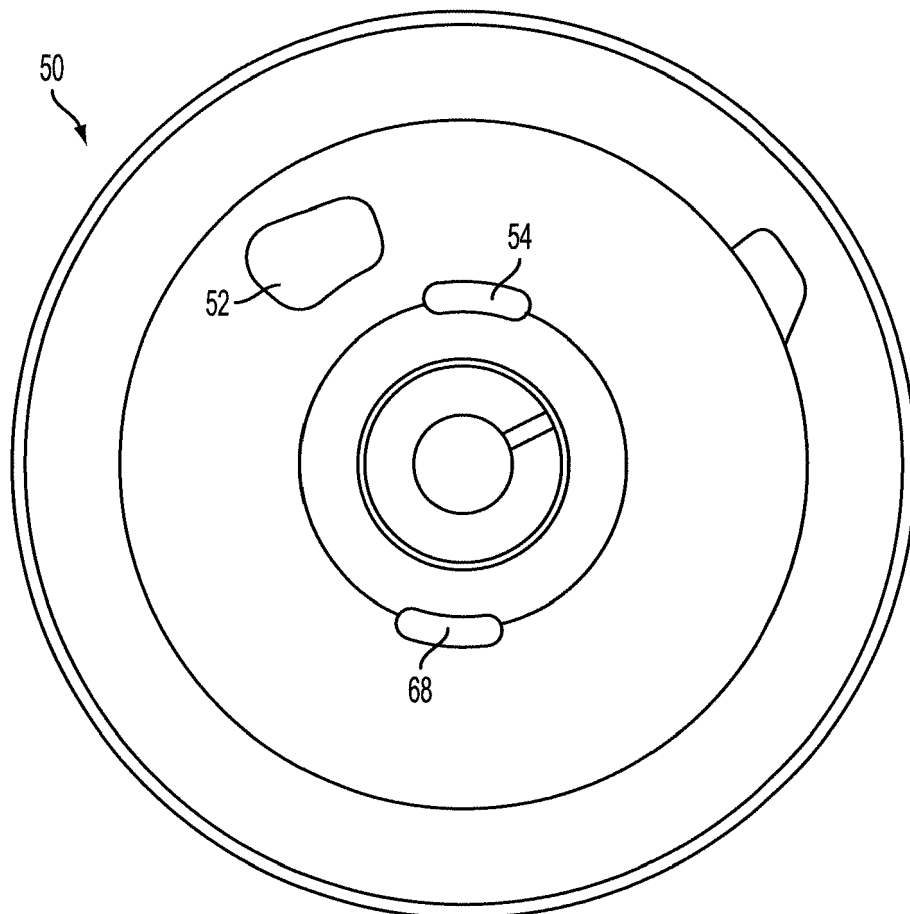


FIG. 9