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[Continued on next page]

- (54) Title:** PASSIVE ROTATION OF A VALVE USING FLUID FLOW

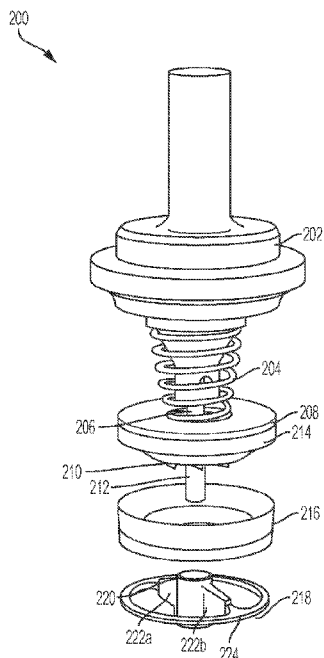


FIG. 2

- (57) Abstract:** The present disclosure relates to passively rotating a valve using fluid flow. Some aspects may involve a valve including a body, a lower stem, and vanes. The body may include a bottom portion that can be positioned with respect to a seat for preventing fluid flow when the valve is in a closed position. The lower stem may extend axially from the bottom portion of the body to position the bottom portion with respect to the seat. The vanes may extend from the body and be responsive to the fluid flow while the valve is in an open position such that the valve and the lower stem rotate with respect to the seat.



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TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
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PASSIVE ROTATION OF A VALVE USING FLUID FLOWTechnical Field

[0001] The present disclosure relates generally to valves for use with wellbore operations, and more particularly (although not necessarily exclusively), to using energy of fluid flow to rotate a valve for pumping fluid.

Background

[0002] Pumping systems for a well, such as an oil or gas well for extracting hydrocarbon fluids from a subterranean formation, can involve maintenance as different components wear. Operating the pumping system can cause specific portions of a component to wear more quickly than other portions of the component. Components that wear unevenly may involve maintenance that is more frequent and may lead to increased costs. Even when the pumping system is located at the surface of the well, the well may be inoperable while maintenance is being performed on the pumping system.

Brief Description of the Drawings

[0003] FIG. 1 shows a block diagram of an example of a pump system with positive displacement pumps that include suction and discharge valves for use with a wellbore according to one aspect of the present disclosure.

[0004] FIG. 2 shows an exploded, perspective view of a valve assembly according to one aspect of the present disclosure.

[0005] FIG. 3 shows a perspective view of a valve with vanes extending from the bottom of the valve according to one aspect of the present disclosure.

[0006] FIG. 4 shows a perspective view of a valve with vanes extending from the top of the valve according to one aspect of the present disclosure.

[0007] FIG. 5 shows a perspective view of a valve with vanes extending radially from the valve according to one aspect of the present disclosure.

[0008] FIG. 6 shows a perspective view of a valve with vanes extending from the bottom of the valve at an acute angle according to one aspect of the present disclosure.

[0009] FIG. 7 shows a perspective view of a bottom retainer for a valve assembly and with profiled support arms according to one aspect of the present disclosure.

[0010] FIG. 8 shows a perspective view of a wing-style valve with vanes according to one aspect of the present disclosure.

[0011] FIG. 9 shows a cross-sectional diagram of a valve assembly in an open position with fluid flow according to one aspect of the present disclosure.

[0012] FIG. 10 shows a flow chart of an example of a process for passively rotating the valve assembly of FIG. 9 using fluid flow according to one aspect of the present disclosure.

Detailed Description

[0013] Certain aspects and features of the present disclosure relate to rotating a valve using a force from fluid flowing through a pump. The valve may include a seal for cooperating with a seat to allow the valve to prevent fluid from flowing through the pump while the valve is in a closed position. In an open position, the seal or seat can be moved to allow fluid flow through the pump. The valve can include vanes that can respond to the fluid flowing through the pump and cause the valve to rotate with respect to the seat.

[0014] In some aspects, the valve may be part of a pumping system associated with wellbore operations. In additional or alternative examples, the valve may be a suction or discharge valve for pumping of mud, cement, water, sand slurries, or any other fluid. For example, the valve may be part of a valve assembly in a positive displacement pump for pumping hydraulic fracking fluid into a wellbore.

[0015] A positive displacement pump can be positioned at the surface of the well for use with wellbore operations and can include a suction valve and discharge valve. A positive displacement pump can trap a fixed amount of fluid in a cavity and then discharge the trapped fluid. The cavity can expand and contract based on the movement of a piston. Fluid may flow through the suction valve and into the cavity as the cavity expands. As the cavity contracts, the fluid may flow out of the pump through the discharge valve.

[0016] One component of a positive displacement pump is a valve assembly that controls the suction or discharge of fluid from the pump. A suction valve assembly can move from a closed position to an open position to allow fluid to enter the pump. A

discharge valve assembly can move from a closed position to an open position to allow fluid to exit the pump.

[0017] A valve assembly for a positive displacement plunger or piston pump may include a combination of a top retainer, spring, valve, seal, seat, and bottom retainer. The top retainer may differ in design between the suction and discharge valve assemblies, but the top retainer may function the same. On either the suction or discharge stroke of the pump, the valve can be lifted from contact with the seat (e.g. pushed upward) due to the pressure imbalance across the valve, to allow fluid to enter or exit the pump.

[0018] Due in part to the high rates of erosion and the large stress changes experienced during operation, the valves can wear and may eventually fail. Valves may fail due to excessive wear in one section of the valve seal and body. Even when the valve surface is cylindrical, the velocity distribution of the fluid around the valve may not be uniform. For example, a bottom retainer may create a blockage in the flow path that accelerates the fluid in the unblocked areas. Additionally or alternatively, the downstream flow path may affect the flow distribution through the valve, accelerating the fluid toward the discharge side of the pump.

[0019] In some aspects, valves and seats may be made from materials that can help reduce wear on the valves and seats. But, focused wear can still create grooves in the valve, such as in the seal of the valve, that can cause the valve to fail due to a portion of the valve experiencing greater wear than another portion. Rotating the valve during operation can cause the surface of the valve to contact a different location on the seat and be exposed to a different portion of the fluid flow. Concentrated wear can be distributed over the valve surface, rather than just one location, which may prolong the life of the valve body, seal, and seat.

[0020] In some aspects, adding vanes, blades, or other structures to the valve surface or assembly can cause the valve to rotate with respect to fluid flow. The momentum of the fluid flow past the valve body may impart a rotational moment on the valve by impinging the vanes or other structures. Provided the induced moment is larger than the frictional resistance (e.g., from the valve spring and guide bushings), the valve can rotate. The design of the valves and vanes, as well as the operating flow rate of the pump, may affect the degree of valve rotation.

[0021] The vanes may be formed and attached to the valve in different ways. In some aspects, the vanes can be cut from plate steel, press formed to a desired curvature, and welded to the valve. In some aspects, the vanes can be forged as part of the valve. In some aspects, the vanes may be machined with the valve body. In some aspects, the valve body and the vanes can be created using laser metal additive manufacturing. In some aspects, the vanes can be three-dimensionally printed with acrylonitrile butadiene styrene, or other polymer, and attached to the valve with epoxy.

[0022] The vanes may be attached to any portion of the valve. In some examples, the vanes can extend from a bottom portion of the valve proximate to the seat. In other examples, the vanes can extend from a top portion of the valve proximate to the top retainer and spring. In other examples, the vanes can extend radially from exterior surfaces coupling the top portion and the bottom portion. In other examples, vanes may extend from a combination of the top portion, the bottom portion, and exteriors of the valve.

[0023] In some aspects, the vanes are profiled edges of wings of a wing-style valve. The wings extend from a lower stem and can translate along the inner bore of the valve seat. By having a portion of the wings remain in the valve seat while the valve is in both an open position and a closed position, the valve remains in alignment with respect to the seat. The wings may have a profiled edge such that the fluid flow can contact the profiled edge when the valve is in the open position to create torque on the valve. A profiled edge may be an external surface of the wing that couples two sides. For example, two sides of a wing may be coupled at an edge, and a profiled edge may be formed by beveling or rounding the edge. Alternatively, the wing may be forged with the profiled edge coupling the two sides. The profiled edge may form a vane and when the valve is in the open position, the profiled edges may respond to the fluid flow and cause the valve to rotate with respect to the seat.

[0024] In some aspects, rotating the valve can extend the life of the valve, which may result in significant cost savings in hardware, maintenance, and non-productive time. Rotating the valve can keep the valve seat clean, distribute the operating wear over the entire surface of the valve, and prevent the seal and the seat surfaces from developing aligned channels that can result in jetting and eventual failure of the valves.

[0025] In addition to cost savings, there may be health and safety benefits for rotating valves. By extending the valve life, the number of parts to be transported to the job

location can be reduced, the amount of time field technicians are exposed to potentially hazardous environments when performing maintenance on the pumps can be reduced, and the number of times the trapped pressure in the pump is released can be reduced.

[0026] These illustrative examples are given to introduce the reader to the general subject matter discussed here and are not intended to limit the scope of the disclosed concepts. The following sections describe various additional features and examples with reference to the drawings in which like numerals indicate like elements, and directional descriptions are used to describe the illustrative aspects but, like the illustrative aspects, should not be used to limit the present disclosure.

[0027] FIG. 1 shows a block diagram of an example of a pump system 100 according to one aspect of the present disclosure. The pump system 100 includes positive displacement pumps 104a-f fluidly coupled to a treatment fluid source 102. In some aspects, the treatment fluid source 102 may include a low pressure manifold fluidly coupled to a blender. The blender may combine one or more components (e.g. water, sand, and gel) to form a treatment fluid that is pumped to the low pressure manifold. The low pressure manifold may be fluidly coupled to each of the positive displacement pumps 104a-f.

[0028] Within each positive displacement pump 104a-f is a suction valve 106a-f and a discharge valve 108a-f. The suction valves 106a-f can allow low-pressure treatment fluid to enter the positive displacement pumps 104a-f while the discharge valves 108a-f can allow high-pressure treatment fluid to flow to a common manifold 110. From the common manifold 110, the treatment fluid can be pumped into the wellbore 112.

[0029] In some aspects, the treatment fluid may be a hydraulic fracking fluid that can be pumped into the wellbore to release production fluid such as oil and gas. The suction valves 106a-f and discharge valves 108a-f may include vanes that can allow the suction valves 106a-f and discharge valves 108a-f to rotate. By rotating the suction valves 106a-f and discharge valves 108a-f, the concentrated wear may be reduced and the life of the suction valves 106a-f and discharge valves 108a-f may be prolonged. Prolonging the life of the suction valves 106a-f and discharge valves 108a-f may reduce the maintenance cost for the pump system 100 and can reduce the non-productive time.

[0030] Although FIG. 1 depicts each of the positive displacement pumps 104a-f with a suction valve 106a-f and a discharge valve 108a-f, a different combination of pumps and

valves may be used. For example, a pumping system may include a single positive displacement pump with a discharge valve feeding directly into a wellbore. Alternatively, a pumping system may include several pumps and each pump may have several suction valves and a single discharge valve feeding into a common manifold.

[0031] FIG. 2 shows an exploded, perspective view of a valve assembly 200 according to one aspect of the present disclosure. The valve assembly 200 includes a top retainer 202, at least a portion of which is surrounded by a spring 204. The top retainer 202 includes a housing for accepting an upper stem 206 extending axially from a top portion of valve 208. Vanes 210 and lower stem 212 extend axially from a bottom portion of valve 208. The valve 208 also includes a seal 214 coupled to its bottom portion. A seat 216 is located adjacent to the bottom portion of the valve 208 such that the lower stem 212 can pass through an opening within the seat 216. A bottom retainer 218 is located adjacent to the other side of the seat 216 such that a portion of the lower stem can be housed within an opening in the bottom retainer.

[0032] Although the valve 208 in FIG. 2 is depicted as cylindrical, valves of other shapes may be used. Furthermore, descriptions of a portion of a valve as a top, bottom, or exterior used herein are intended to denote a component relative to other components in a valve assembly and are not intended to imply that a particular orientation is required.

[0033] The top retainer 202 in FIG. 2 has a conical shape that includes a series of cylindrical sections. In some aspects, the cylindrical section with the largest diameter may prevent a fluid flow from passing through the top retainer 202. For example, in a discharge valve assembly a top retainer may redirect the flow towards an exit of the pump. In alternative aspects, cylindrical sections may include openings to allow fluid to flow therethrough. For example, in a suction valve assembly a top retainer may allow a fluid flow therethrough and into a pump. A cylindrical section closest to the valve 208 forms a housing in which a portion of the upper stem 206 may be positioned during operation of the valve assembly 200. The closest cylindrical section, as well as additional cylindrical sections farther from the valve 208, may pass through a portion of the spring 204 such that one end of the spring 204 can couple to the top retainer 202.

[0034] The other end of the spring 204 can couple to the valve 208. The spring 204 can apply a force in a closed position of the valve assembly 200 to retain the seal 214

against the seat 216 such the valve assembly 200 can prevent fluid flow therethrough. In a closed position, fluid may be unable to flow from the bottom retainer side of the valve 208 (referred to as upstream) between the seal 214 and the seat 216 to the top retainer side of the valve 208 (referred to as downstream). Fluid can be unable to flow through the valve assembly 200 and may accumulate upstream of the valve 208 to create a pressure differential across the valve 208. The pressure differential across the valve 208 can exceed a threshold amount and cause an opening between the seal 214 and the seat 216, such that the valve assembly 200 is in an open position. In the open position, fluid may flow through the opening between the seal 214 and the seat 216. As the fluid flows through the valve assembly 200, the pressure differential across the valve 208 may be reduced. The pressure differential across the valve 208 can fall below a threshold amount such that the spring 204 may cause the opening between the seal 214 and the 216 to close.

[0035] The vanes 210 extend from the bottom portion of the valve such that fluid flowing through the valve assembly 200 in an open position may contact the vanes. The force of the fluid contacting the vanes 210 may generate enough torque on the valve 208 to cause the valve 208 to rotate with respect to the seat 216. In addition to the valve 208 rotating, the upper stem 206, vanes 210, lower stem 212, and seal 214 may rotate as well.

[0036] The seal 214 is included in valve 208 and forms an external surface of the valve 208 that may contact the seat 216 to prevent fluid flow through the valve assembly 200. The seat 216 may have a ring shape and include an opening for fluid to flow therethrough. An inner edge of the ring may be beveled such that the seat 216 includes an inner surface with a similar attitude as a surface of the seal 214. When the valve assembly 200 is in an open position, fluid may flow through the opening in the seat 216 and between the inner surface of the seat 216 and the surface of the seal 214. When the valve assembly 200 is in a closed position, the inner surface of the seat 216 may be in contact with the surface of the seal 214 and may prevent fluid flow through the valve assembly 200. In some aspects, the seat and opening therethrough may be any shape

[0037] The bottom retainer 218 can be the furthest upstream component of the valve assembly 200. The bottom retainer 218 includes an inner member 220 with two support arms 222a-b extending radially from the inner member 220 to an outer ring 224. The inner member 220 is cylindrical in FIG. 2, but an inner member according to other

examples can be other shapes. The inner member 220 may have an opening therein for housing a portion of the lower stem 212 to maintain alignment of the seal 214 with respect to the seat 216. In some examples, any number of support arms 222a-b may maintain alignment of the opening in the inner member 220 with the lower stem 212.

[0038] FIG. 2 depicts a stem-guided valve 208 such that the top retainer 202 can house a portion of the upper stem 206 and the bottom retainer 218 can house a portion of the lower stem 212. Positioning a portion of the upper stem 206 in the top retainer 202 and lower stem 212 in the bottom retainer 218 can maintain alignment of the seal 214 and the seat 216. But, any type of valve may be used (e.g., a wing-style valve). In some aspects, the top retainer 202 and the bottom retainer 218 may be a different shape, size, and configuration, depending on the type of pump, the type of valve, and the location of the valve. For example, a valve assembly using wing-style valves, may include a bottom retainer combined with a seat. A wing-style valve may include wings that extend radially from the lower stem. A portion of these wings may remain within the opening in the seat during operation of the valve assembly. In additional or alternative aspects, the wings may include vanes by having a profiled edge or surface that may respond to a fluid flow by applying torque to the valve. Although the vanes 210 in FIG. 2 are depicted as extending perpendicular from the bottom portion of valve 208, the design and position of the vanes 210 may vary. For example, the vanes 210 may be manufactured with a different vane height, entrance angle, exit angle, or bucket depth. The height of the vane 210 may have an impact on the observed torque. In some aspects, extending the vanes 210 as close to the bottom retainer 218 as possible may result in the vanes 210 interacting with the high velocity fluid being pumped through the opening between the seal 214 and the seat 216. In additional or alternative aspects, the vanes 210 may extend from the top portion of the valve 208 or extend radially from an exterior surface coupling the top portion to the bottom portion.

[0039] FIG. 3 shows a perspective view of a valve 300 for a valve assembly with vanes 304 extending from a bottom portion of the valve 300 according to one aspect of the present disclosure. The valve 300 includes a seal 302 that can prevent fluid flow through the valve assembly when in the closed position. The vanes 304 extend perpendicularly from the bottom portion of the valve 300 and include a curved surface for responding to a fluid

flow and causing torque on the valve 300 when the valve assembly is in an open position. A lower stem 306 extends axially from the bottom portion of the valve. The lower stem 306 can be positioned such that a portion of the lower stem 306 remains within an opening in a bottom retainer when the valve assembly is in an open position and when the valve assembly is in a closed position. Positioning the lower stem 306 such that a portion remains within the opening in the bottom retainer may allow the seal 302 to remain in alignment with a seat. Although not depicted in FIG. 3, the valve 300 may include an upper stem as well as lower stem 306.

[0040] The vanes 304 extend from the bottom portion of the valve 300 at a position with respect to the seal 302 such that the vanes 304 allow the seal 302 to contact a seat. In some aspects, the vanes 304 may be positioned axisymmetrically around the lower stem 306. In additional or alternative aspects, the vanes 304 can each include two curved surfaces. An apex of the curved surfaces can determine the direction of the torque induced on the valve 300 when the valve assembly is in an open position. For example, positioning the vanes 304 axisymmetrically around the lower stem 306 with the apexes extending clockwise may induce clockwise torque. In other aspects, the vanes 304 may have flat surfaces and be positioned nonsymmetrical. Although a plurality of vanes 304 are depicted in FIG. 3, valve 300 may have one or more vanes 304. The design of each vane 304 (e.g., thickness, length, height, curvature, inlet and outlet angles) as well as the number of vanes 304 may determine the amount of torque induced on valve 300 when the valve assembly is in an open position.

[0041] Furthermore, in FIG. 3 the vanes 304 couple indirectly to the lower stem 306. In other aspects, the vanes 304 may directly couple to the lower stem 306. In additional or alternative aspects, the vanes 304 may couple indirectly to the bottom portion by coupling directly to the lower stem 306.

[0042] By positioning the vanes 304 on the bottom portion of the valve 300, a portion of the fluid flow may contact the vanes 304 prior to the portion of the fluid flow passing between the seal 302 and a seat. Additionally, when the valve assembly is in the closed position, there may be minimal fluid motion near the surface of the vanes 304, which may prevent the valve 300 from experiencing torque while the valve assembly is in the closed position. Positioning the vanes 304 on the bottom portion can reduce the negative

effects if a vane 304 breaks. In the event that a portion of a vane 304 breaks off during operation due to erosion, the valve 300 can prevent most large pieces from passing through the pump to the wellhead.

[0043] FIG. 4 shows a perspective view of a valve 400 for a valve assembly with vanes 404 extending from a top portion of the valve 400 according to one aspect of the present disclosure. The valve 400 also includes a seal 402 and an upper stem 406.

[0044] The seal 402 can prevent fluid flow when the valve assembly is in a closed position. The seal 402 may be any part of the bottom portion of the valve 400 with the vanes 404 on the top portion of the valve 400. The upper stem 406 extends from the top portion of the valve 400. The upper stem 406 can be positioned such that a portion of the upper stem 406 remains within a housing of a top retainer. Positioning the upper stem 406 to remain within the top retainer may allow the seal 402 to remain in alignment with respect to a seat. Although not depicted in FIG. 4, the valve 400 may include a lower stem as well as upper stem 406.

[0045] The vanes 404 extend from the top portion of the valve 400 and span from the edge of the top portion towards the upper stem 406. Vanes 404 that extend from the top portion of the valve 400 may allow for a simpler manufacturing process, which may reduce the cost of the valve 400. The vanes 404 may be thin structures with two broad surfaces, similar in some ways to a blade. The two surfaces can be curved and extend perpendicularly from valve 400. In other aspects, the vanes 404 may extend at non-perpendicular angles and may have flat surfaces. Although a plurality of vanes 404 are depicted in FIG. 4, valve 400 may have one or more vanes 404. The design of each vane 404 (e.g., thickness, length, height, curvature, inlet and outlet angles) as well as the number of vanes 404 may determine the amount of torque induced on valve 400 when the valve assembly is in an open position.

[0046] In some aspects, the upper stem 406 may extend farther from the top portion than at least one of the vanes 404. In additional or alternative aspects, at least one of the vanes 404 may extend farther from the top portion than the upper stem 406. In some aspects, the vanes 404 may couple to a portion of the upper stem 406. For example, the vanes 404 may directly couple to the upper stem 406 and indirectly extend from the top portion of the valve 400.

[0047] FIG. 5 shows a perspective view of a valve 500 for a valve assembly with vanes 504 extending radially from the valve 500 according to one aspect of the present disclosure. The valve 500 also includes a seal 502 and an upper stem 506.

[0048] The seal 502 can contact a seat to prevent fluid flow through the valve assembly when the valve assembly is in the closed position. With the vanes 504 on the top portion of the valve 500, the seal 502 may couple to any part of the bottom portion of the valve 500. The upper stem 506 extends from the top portion of the valve 500. The upper stem 506 can be positioned such that a portion of the upper stem 506 remains within the housing of a top retainer. Positioning a portion of the upper stem 506 to remain within the housing of the top retainer may allow the seal 502 to remain in alignment with respect to the seat. Although not depicted in FIG. 5, the valve 500 may include a lower stem in addition to the upper stem 506.

[0049] The vanes 504 extend perpendicularly from the exterior of the valve 500 but gradually curve in a clockwise direction. In alternative aspects, the vanes 504 may curve in a counterclockwise direction. Vanes 504 extending radially from the valve 500 may allow for the higher possible torque than other positions of vanes. Higher fluid velocities, which can produce the higher momentum transfer, may occur as the fluid passes through the narrow opening between the seal 502 and the seat. By positioning vanes 504 around the exteriors of the valve 500, the vanes 504 may interact with the high velocity fluid passing through the opening.

[0050] Although a plurality of vanes 504 are depicted in FIG. 5, valve 500 may have one or more vanes 504. The design of each vane 504 (e.g., thickness, length, height, curvature, inlet and outlet angles) as well as the number of vanes 504 may determine the amount of torque induced on valve 500 when the valve assembly is in an open position.

[0051] Although FIG. 5 depicts a cylindrical valve 500 with vanes 504 extending radially from a circumference of the valve 500, valves of other shapes may be used. For example, a rectangular valve can be used with a top portion, bottom portion, and four exteriors or sides coupling the top portion with the bottom portion. The vanes may extend radially from the four exteriors.

[0052] FIG. 6 shows a perspective view of a valve 600 for a valve assembly with vanes 604 extending at an acute angle according to one aspect of the present disclosure.

The valve 600 includes a seal 602 and a lower stem 606 similar to the seal and the lower stem in FIG. 3. The vanes 604 extend from a bottom portion of the valve 600 at an acute angle such that each vane is tilted in a clockwise direction creating a pocket. The pockets may increase the counter-clockwise torque applied to the valve 600 when the valve assembly is in an open position. Although FIG. 6 depicts the vanes 604 tilted in a clockwise manner, the vanes 604 may be tilted in a counter-clockwise manner and at a different angle. In additional or alternative aspects, vanes 604 extending from a top portion and exterior portions may form pockets by extending at acute angles.

[0053] FIG. 7 shows a perspective view of a bottom retainer 700 for a valve assembly and that has profiled support arms 702a-b according to one aspect of the present disclosure. The bottom retainer 700 can also include an inner member 704 and ring 706.

[0054] The inner member 704 may be cylindrical with an opening therein for housing a portion of a lower stem. The ring 706 may have an outer diameter such that fluid flowing through the valve assembly can flow through the inner diameter of the ring 706, rather than flowing in other passages. Each of the profiled support arms 702a-b has an end coupled to the ring 706 and another end coupled to the inner member 704. The profiled support arms 702a-b can position the inner member 704 in alignment with the lower stem. In some examples, any number of profiled support arms may maintain alignment of the opening in the inner member 704 with the lower stem. In some aspects, at least one of the profiled support arms 702a-b may extend from the inner member 704 towards the ring 706. In additional or alternative aspects, at least one of the profiled support arms 702a-b may extend from the ring 706 towards the inner member 704.

[0055] Each of the profiled support arms 702a-b includes a surface that can alter the path of the fluid flow as the fluid flow contacts with the surface. The surface may be formed by beveling or rounding an edge of the profiled support arm 702a-b. The amount of swirl introduced can be based on the number of profiled support arms and the angle of each surface. Introducing a swirl to the fluid flow can increase the torque experienced by the valve.

[0056] FIG. 8 shows a perspective view of a wing-style valve 800 for a valve assembly with vanes 806 according to one aspect of the present disclosure. The valve 800 includes a

seal 802 that can prevent fluid flow through the valve assembly when in the closed position. The lower stem 804 extends axially from a bottom portion of the valve 800.

[0057] The vanes 806 extend both from the bottom portion of valve 800 and radially from the lower stem 804. The vanes 806 and the lower stem 804 may be positioned such that a portion of the vanes 806 and lower stem 804 remain within the opening in a seat. Positioning the vanes 806 and the lower stem 804 such that a portion remains within the opening may maintain alignment of the seal 802 and the seat.

[0058] In some aspects, the vanes 806 may directly contact the bottom portion of valve 800. In additional or alternative aspects, each vane 806 may be a profiled edge of a wing extending from the lower stem 804. A wing may be a member that extends from the lower stem 804 and can translate along the inner bore of the seat. By having a portion of the wings remain in the valve seat when the valve 800 is in both an open position and a closed position, the valve 800 can remain in alignment with respect to the seat.

[0059] A profiled edge may be an external surface of the wing that couples two sides. For example, two sides of a wing may be coupled at an edge, and a profiled edge may be formed by beveling or rounding the edge. Alternatively, the wing may be forged with the profiled edge coupling the two sides.

[0060] FIG. 9 shows a cross-sectional diagram of a valve assembly 900 in an open position with fluid flow 920 according to one aspect of the present disclosure. The valve assembly 900 includes similar components to the valve assembly 200 in FIG. 2: a top retainer 902, a spring 904, an upper stem 906, a valve 908 with vanes 910, a lower stem 912, a seal 914, a seat 916, and a bottom retainer 918. The valve assembly 900 is in an open position with an opening between the seal 914 and the seat 916 that forms a part of a path for fluid flow 920.

[0061] The path of fluid flow 920 can be determined based on several factors, such as the pump type, fluid type, vane location, and the side of the pump (suction/discharge) that the valve is positioned. The particular flow pattern of the fluid flow 920 can cause concentrated wear on a particular area of the valve 908 with respect to the seat 916.

[0062] For example, the fluid flow 920 can accelerate as fluid passes between the seal 914 and the seat 916. In some aspects, the downstream fluid flow 920 can accelerate as the fluid approaches the exit to the valve assembly 900. The velocity of the fluid flow 920

as the fluid contacts a portion of the valve 908 can affect the amount of wear caused to the portion of the valve 908. Rotating the valve 908 with respect to the seat 916 can spread the wear across the valve 908 and prevent a particular portion of the valve 908 from wearing substantially more than other portions.

[0063] Although FIG. 9 depicts the vanes 910 on a bottom portion of the valve 908, vanes may extend from several portions of a valve. As the fluid flow 920 contacts the vanes 910, torque may be induced on the valve 908 and may cause the valve 908 to rotate with respect to the seat 916.

[0064] FIG. 10 shows a flow chart of an example of a process for passively rotating the valve assembly 900 of FIG. 9 using the fluid flow 920 according to one aspect of the present disclosure. Although the process of FIG. 10 is described with reference to valve assembly 900, the process may be implemented with respect to any type of valve assembly.

[0065] In block 1002, the valve assembly 900 moves to the open position, such as the position depicted in FIG. 9, and allow fluid flow 920 between the seal 914 and the seat 916. In some aspects, a pump may increase the pressure differential across valve 908 until the pressure differential across the valve 908 reaches a certain threshold amount to cause the valve assembly 900 to move to an open position and create an opening between the seal 914 and the seat 916. For example, the pressure differential across a suction valve may increase as the pump decreases downstream fluid pressure. In other examples, the pressure differential across a discharge valve may increase as the pump increases upstream fluid pressure.

[0066] As the valve assembly 900 moves to an open position, the upper stem 906 may move towards the top retainer 902 to increase the portion of the upper stem 906 housed by the top retainer 902. The lower stem 912 may also move away from the bottom retainer 918 to reduce the portion of the lower stem 912 housed by the bottom retainer 918. With the valve assembly 900 in the open position, the fluid flow 920 may pass through the valve assembly 900 and may cause concentrated wear on an area of the valve 908 with respect to the seat 916.

[0067] In some aspects, opening the valve assembly 900 may allow high-pressure hydraulic fracking fluid to be discharged from a positive displacement pump and into a wellbore. In other aspects, opening the valve assembly 900 may allow low-pressure

hydraulic fracking fluid to enter a pump. In additional or alternative aspects, the fluid flow 920 may consist of a sand slurry, water, mud, or cement.

[0068] In block 1004, the valve 908 and lower stem 912 rotate with respect to the seat 916 in response to the fluid flow 920 contacting the vanes 910. Before the fluid flow 920 passes through the opening between the seal 914 and seat 916, the fluid flow 920 may contact with the vanes 910. The energy transferred from the fluid contacting the vanes 910 may induce torque on the valve 908 and cause the valve 908 to rotate with respect to the seat 916. The upper stem 906, vanes 910, lower stem 912, and seal 914 may also rotate. By rotating the valve 908, a different portion of the valve 908 may be within the area of concentrated wear caused by the fluid flow 920. As a result, operating wear may be normalized across the valve 908.

[0069] In some aspects, vanes may extend from another portion of the valve 908 including a top portion or exteriors that couple the top portion and bottom portion. The fluid flow 920 may contact the vanes after passing between the seal 914 and seat 916.

[0070] Some vanes may use more torque to be rotated. Particularly, at lower pump flow rates, more torque may be used to overcome the frictional resistance of the spring 904 and guide bushings. In some aspects, the spring 904 design may be modified to reduce the frictional resistance. In additional or alternative aspects, a swirl may be introduced to the fluid flow 920 as it passes the bottom retainer 918. The bottom retainer 918 may include profiled support arms having surfaces that can change the direction of the fluid flow 920 as the fluid flow 920 contacts the surfaces. Changing the direction of the fluid flow 920 may introduce a swirl into the fluid flow 920. The swirl may induce torque on the valve 908 or may increase the torque produced by contact between the fluid flow 920 and the vanes 910.

[0071] In block 1006, the valve assembly 900 moves to a closed position and prevents fluid flow 920 between the seal 914 and the seat 916. The fluid flow 920 passes through the valve assembly 900, and the pressure differential across the valve 908 is reduced. Eventually, the closing force of the spring 904 returns valve assembly 900 to the closed position. In the closed position, the seal 914 cooperates with the seat 916 to prevent fluid flow. Furthermore, the upper stem 906 may move away from the top retainer 902, reducing the portion of the upper stem 906 housed by the top retainer 902. Additionally,

the lower stem 912 may move toward the bottom retainer 918 and increase the portion of the lower stem 912 housed by the bottom retainer 918.

[0072] Due to the rotation of the valve in block 1004, the seal 914 may now contact a different portion of the seat 916. By contacting a different portion of the seat 916, the wear across seal 914 is further normalized.

[0073] In some aspects, passive rotation of a valve using fluid flow is provided according to one or more of the following examples:

[0074] Example #1: A valve may include a body with a bottom portion positionable with respect to a seat for preventing fluid flow in a closed position of the valve. The valve may also include a lower stem extending axially from the bottom portion to position the bottom portion with respect to the seat. The valve may also include at least one vane extending from the body for responding to fluid flow in an open position of the valve to cause the valve and the lower stem to rotate with respect to the seat.

[0075] Example #2: The valve of Example #1 may feature the at least one vane extending from the bottom portion. Also, the at least one vane may include a surface for responding to a portion of the fluid flow before the portion of the fluid flow passes between the body and the seat.

[0076] Example #3: The valve of Example #2 may feature the at least one vane coupled to the lower stem and a portion of the at least one vane is may be positionable within an opening in the seat for maintaining the bottom portion in alignment with the seat.

[0077] Example #4: The valve of Example #1 may feature the at least one vane extending from a top portion of the body and the at least one vane may include a surface for responding to a portion of the fluid flow after the portion of the fluid flow passes between the body and the seat.

[0078] Example #5: The valve of Example #1 may feature the body with one or more exteriors coupling a top portion of the body and the bottom portion. The at least one vane may extend from the one or more exteriors and the at least one vane may include a surface for responding to a portion of the fluid flow after the portion of the fluid flow passes between the body and the seat.

[0079] Example #6: The valve of Example #1 may feature the at least one vane including a curved surface for responding to the fluid flow in the open position of the valve

by using energy of the fluid flow to induce torque on the valve and the lower stem in a direction based on an apex of the curved surface.

[0080] Example #7: The valve of Example #1 may feature a portion of the lower stem positionable in a housing of a bottom retainer positioned upstream in the fluid flow to align the bottom portion with respect to the seat. The bottom retainer may include at least one profiled support arm for introducing a swirl to the fluid flow, and the at least one vane may extend from the body for further responding to the swirl in the fluid flow.

[0081] Example #8: The valve of Example #1 may feature the at least one vane extending from the body for responding to fluid flow in the open position of the valve by causing the valve and the lower stem to rotate with respect to the seat such that operating wear is spread across the valve.

[0082] Example #9: The valve of Example #1 may feature the valve positionable in a positive displacement pump for pumping hydraulic fracking fluid into a wellbore.

[0083] Example #10: A valve assembly may include a valve movable between an open position and a closed position. The valve may include a seal. The valve assembly may also include a seat positionable with the seal to prevent fluid flow in the closed position. The valve assembly may also include a lower stem extending from a bottom portion of the valve for aligning the seal with the seat. The valve assembly may also include at least one vane extending from the valve for responding to the fluid flow to cause the valve and the lower stem to rotate with respect to the seat.

[0084] Example #11: The valve assembly of Example #10 may further include a spring coupleable to a top portion of the valve for providing a force to prevent the fluid flow. The valve assembly of Example #10 may further include a bottom retainer positionable in the fluid flow. The bottom retainer may include a housing portion with an opening for accepting a portion of the lower stem and positionable to maintain alignment of the seal with respect to the seat. The bottom retainer may also include at least one support arm extending from the housing portion for maintaining a position of the housing portion, and the at least one support arm may include a surface to introduce a swirl to the fluid flow as the fluid flow passes the bottom retainer.

[0085] Example #12: The valve assembly of Example #10 may feature the at least one vane extending from at least one of the bottom portion for responding to a portion of

the fluid flow before the portion of the fluid flow passes between the seal and the seat, a top portion of the valve for responding to the portion of the fluid flow after the portion of the fluid flow passes between the seal and the seat, and exterior portions of the valve for responding to the portion of the fluid flow after the portion of the fluid flow passes between the seal and the seat.

[0086] Example #13: The valve assembly of Example #10 may feature a valve that further includes a forged portion including the at least one vane. The at least one vane may extend at an acute angle from the valve creating a pocket for responding to the fluid flow to cause energy of the fluid flow to induce rotation of the valve and the lower stem with respect to the seat.

[0087] Example #14: The valve assembly of Example #10 may feature the lower stem including a first member extending from the bottom portion of the valve. The lower stem may also include at least one second member extending from the first member, the at least one second member positionable to extend at least partially into an opening in the seat and align the seal with respect to the seat and the at least one vane is a portion of the at least one second member such that the at least one second member includes a surface for responding to the fluid flow by causing the valve and the lower stem to rotate with respect to the seat.

[0088] Example #15: The valve assembly of Example #10 may feature the valve assembly positionable in a positive displacement pump for pumping hydraulic fracking fluid into a wellbore.

[0089] Example #16: The valve assembly of Example #10 may feature the at least one vane extending from the valve for responding to the fluid flow to cause the valve and the lower stem to rotate with respect to the seat such that operating wear is spread across the valve.

[0090] Example # 17: A method may include moving a valve including a seal, a lower stem extending axially from a bottom portion of the valve, and at least one vane to an open position at which fluid flows between the seal and a seat. The method may also include rotating the valve and the lower stem with respect to the seat using energy from the fluid contacting the at least one vane. The method may also include moving the valve to a closed

position at which the seat cooperates with the seal and prevents the fluid flowing between the seat and the seal.

[0091] Example #18: The method of Example #17 may feature moving the valve to the open position with a portion of the lower stem remaining within a housing of a bottom retainer positioned upstream of the fluid with respect to the valve such that the seal remains in alignment with respect to the seat. The method of Example #17 may also include introducing a swirl to the fluid as it flows across a surface of the bottom retainer.

[0092] Example #19: The method of Example #17 may feature the valve positioned in a positive displacement pump for pumping hydraulic fracking fluid into a wellbore.

[0093] Example #20: The method of Example #17 may feature rotating the valve to normalize the operating wear across the valve due to at least one of contact of the seal with the seat and the fluid flowing between the seal and the seat.

[0094] The foregoing description of certain examples, including illustrated examples, has been presented only for the purpose of illustration and description and is not intended to be exhaustive or to limit the disclosure to the precise forms disclosed. Numerous modifications, adaptations, and uses thereof will be apparent to those skilled in the art without departing from the scope of the disclosure.

Claims

What is claimed is:

1. A valve comprising:
 - a body with a bottom portion positionable with respect to a seat for preventing fluid flow in a closed position of the valve;
 - a lower stem extending axially from the bottom portion to position the bottom portion with respect to the seat; and
 - at least one vane extending from the body for responding to fluid flow in an open position of the valve to cause the valve and the lower stem to rotate with respect to the seat.
2. The valve of claim 1, wherein the at least one vane extends from the bottom portion and the at least one vane comprises a surface for responding to a portion of the fluid flow before the portion of the fluid flow passes between the body and the seat.
3. The valve of claim 2, wherein the at least one vane is coupled to the lower stem and a portion of the at least one vane is positionable within an opening in the seat for maintaining the bottom portion in alignment with the seat.
4. The valve of claim 1, wherein the at least one vane extends from a top portion of the body and the at least one vane comprises a surface for responding to a portion of the fluid flow after the portion of the fluid flow passes between the body and the seat.
5. The valve of claim 1, wherein the body includes one or more exteriors coupling a top portion of the body and the bottom portion and the at least one vane extends from the one or more exteriors and the at least one vane comprises a surface for responding to a portion of the fluid flow after the portion of the fluid flow passes between the body and the seat.
6. The valve of claim 1, wherein the at least one vane includes a curved surface for responding to the fluid flow in the open position of the valve to use energy of the fluid flow

to induce torque on the valve and the lower stem in a direction based on an apex of the curved surface.

7. The valve of claim 1, wherein a portion of the lower stem is positionable in a housing of a bottom retainer positioned upstream in the fluid flow to align the bottom portion with respect to the seat, the bottom retainer further comprising at least one profiled support arm for introducing a swirl to the fluid flow, and the at least one vane extending from the body for further responding to the swirl in the fluid flow.

8. The valve of claim 1, wherein the at least one vane extends from the body for responding to fluid flow in the open position of the valve to cause the valve and the lower stem to rotate with respect to the seat such that operating wear is spread across the valve.

9. The valve of claim 1, wherein the valve is positionable in a positive displacement pump for pumping hydraulic fracking fluid into a wellbore.

10. A valve assembly, the valve assembly comprising:
a valve movable between an open position and a closed position, the valve including a seal;
a seat positionable with the seal to prevent fluid flow in the closed position;
a lower stem extending from a bottom portion of the valve for aligning the seal with the seat; and
at least one vane extending from the valve for responding to the fluid flow to cause the valve and the lower stem to rotate with respect to the seat.

11. The valve assembly of claim 10, further comprising:
a spring coupleable to a top portion of the valve for providing a force to prevent the fluid flow; and
a bottom retainer positionable in the fluid flow and comprising:
a housing portion with an opening for accepting a portion of the lower stem and positionable to maintain alignment of the seal with respect to the seat; and

at least one support arm extending from the housing portion for maintaining a position of the housing portion, and the at least one support arm includes a surface to introduce a swirl to the fluid flow as the fluid flow passes the bottom retainer.

12. The valve assembly of claim 10, wherein the at least one vane extends from at least one of the bottom portion for responding to a portion of the fluid flow before the portion of the fluid flow passes between the seal and the seat, a top portion of the valve for responding to the portion of the fluid flow after the portion of the fluid flow passes between the seal and the seat, and exterior portions of the valve for responding to the portion of the fluid flow after the portion of the fluid flow passes between the seal and the seat.

13. The valve assembly of claim 10, wherein valve further includes a forged portion comprising the at least one vane, and the at least one vane extends at an acute angle from the valve creating a pocket for responding to the fluid flow to cause energy of the fluid flow to induce rotation of the valve and the lower stem with respect to the seat.

14. The valve assembly of claim 10, wherein the lower stem comprises:
a first member extending from the bottom portion of the valve; and
at least one second member extending from the first member, the at least one second member positionable to extend at least partially into an opening in the seat and align the seal with respect to the seat and the at least one vane is a portion of the at least one second member such that the at least one second member includes a surface for responding to the fluid flow by causing the valve and the lower stem to rotate with respect to the seat.

15. The valve assembly of claim 10, wherein the valve assembly is positionable in a positive displacement pump for pumping hydraulic fracking fluid into a wellbore.

16. The valve assembly of claim 10, wherein the at least one vane extends from the valve for responding to the fluid flow to cause the valve and the lower stem to rotate with respect to the seat such that operating wear is spread across the valve.

17. A method comprising:

moving a valve including a seal, a lower stem extending axially from a bottom portion of the valve, and at least one vane to an open position at which fluid flows between the seal and a seat;

rotating the valve and the lower stem with respect to the seat using energy from the fluid contacting the at least one vane; and

moving the valve to a closed position at which the seat cooperates with the seal and prevents the fluid flowing between the seat and the seal.

18. The method of claim 17, wherein moving the valve to the open position further comprises a portion of the lower stem remaining within a housing of a bottom retainer positioned upstream of the fluid with respect to the valve such that the seal remains in alignment with respect to the seat, and the method further comprises introducing a swirl to the fluid as it flows across a surface of the bottom retainer.

19. The method of claim 17, wherein the valve is positioned in a positive displacement pump for pumping hydraulic fracking fluid into a wellbore.

20. The method of claim 17, wherein rotating the valve further comprises normalizing the operating wear across the valve due to at least one of contact of the seal with the seat and the fluid flowing between the seal and the seat.

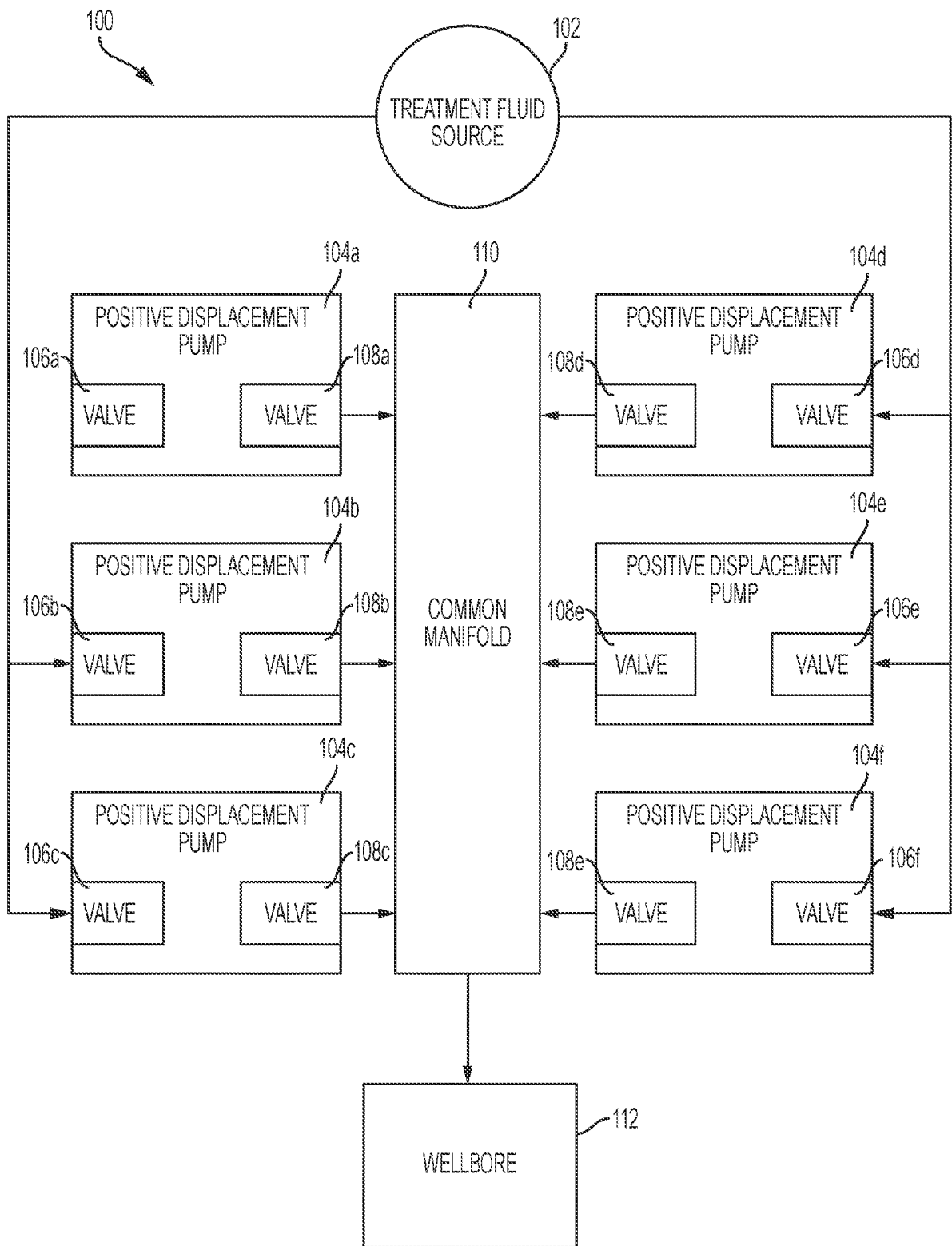


FIG. 1

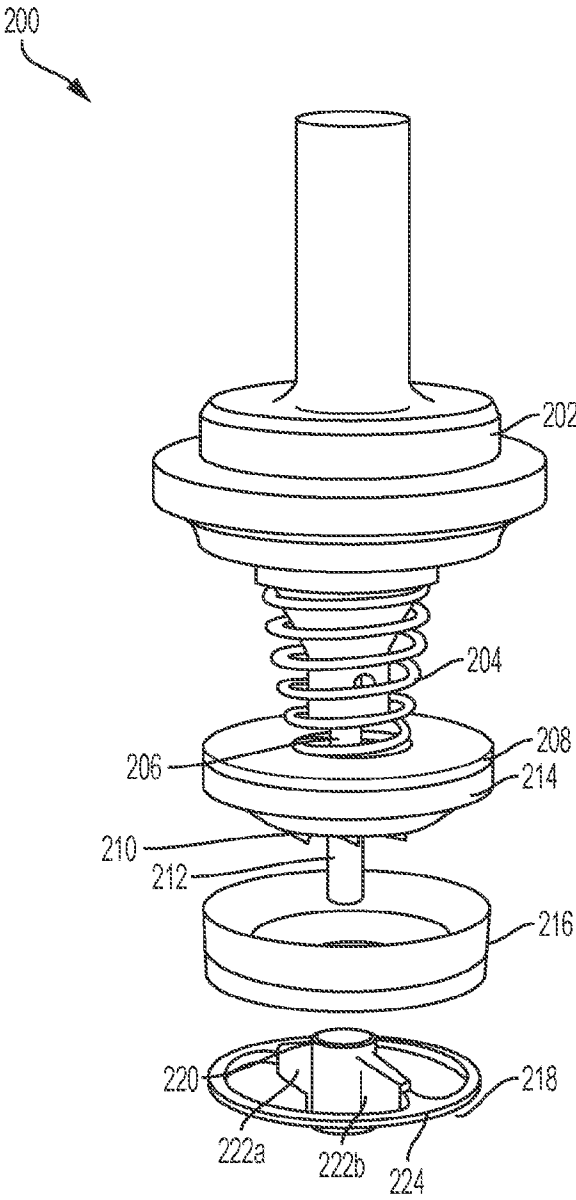


FIG. 2

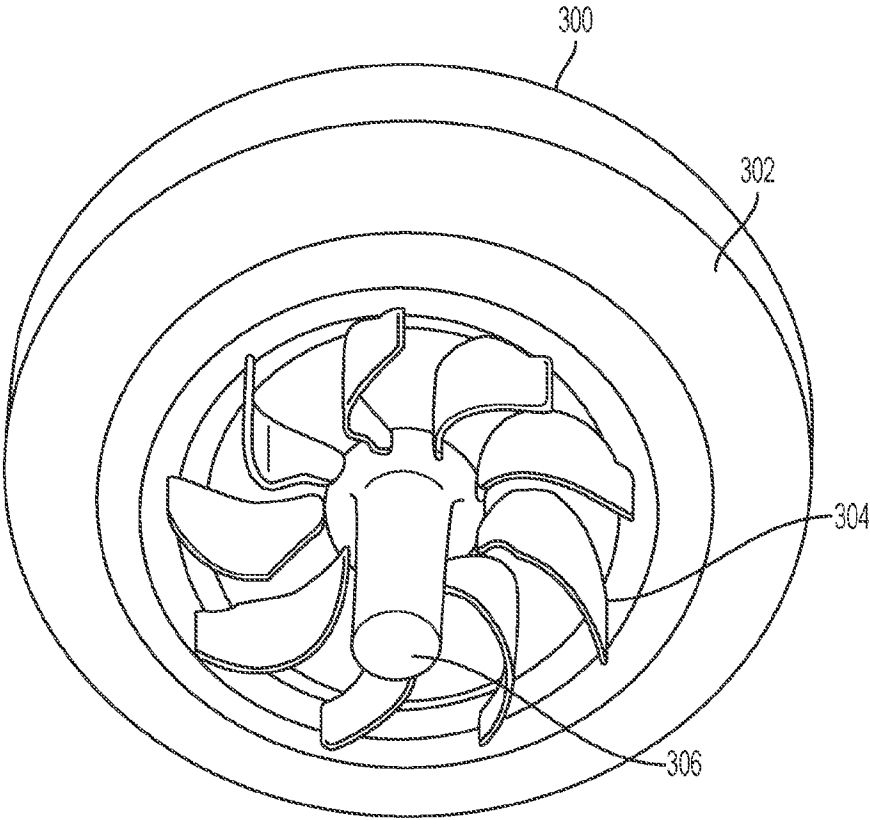


FIG. 3

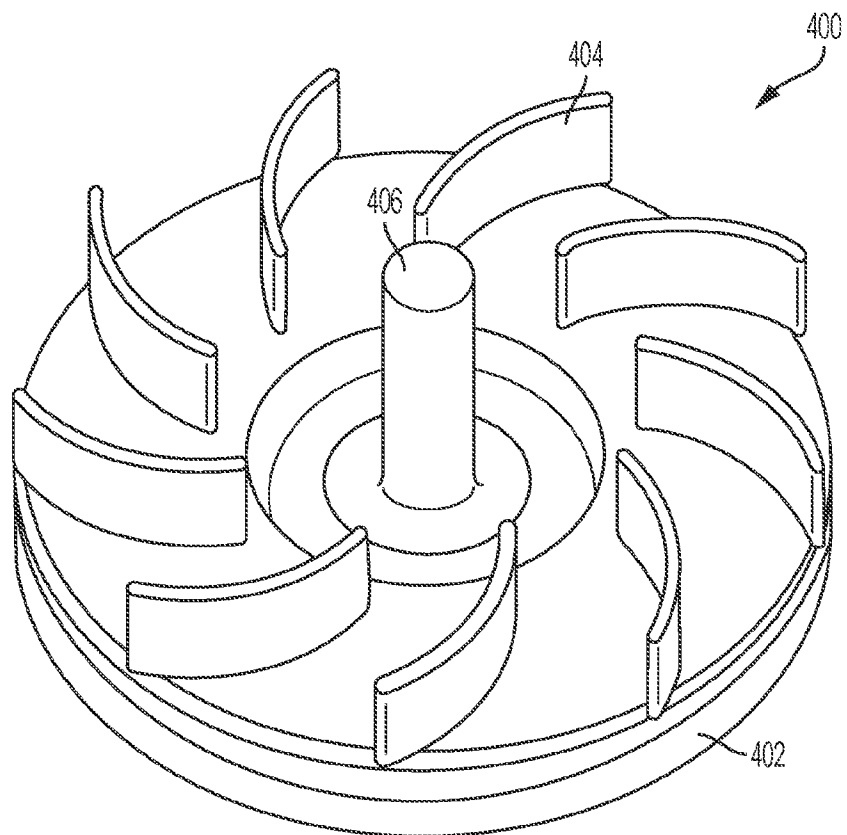


FIG. 4

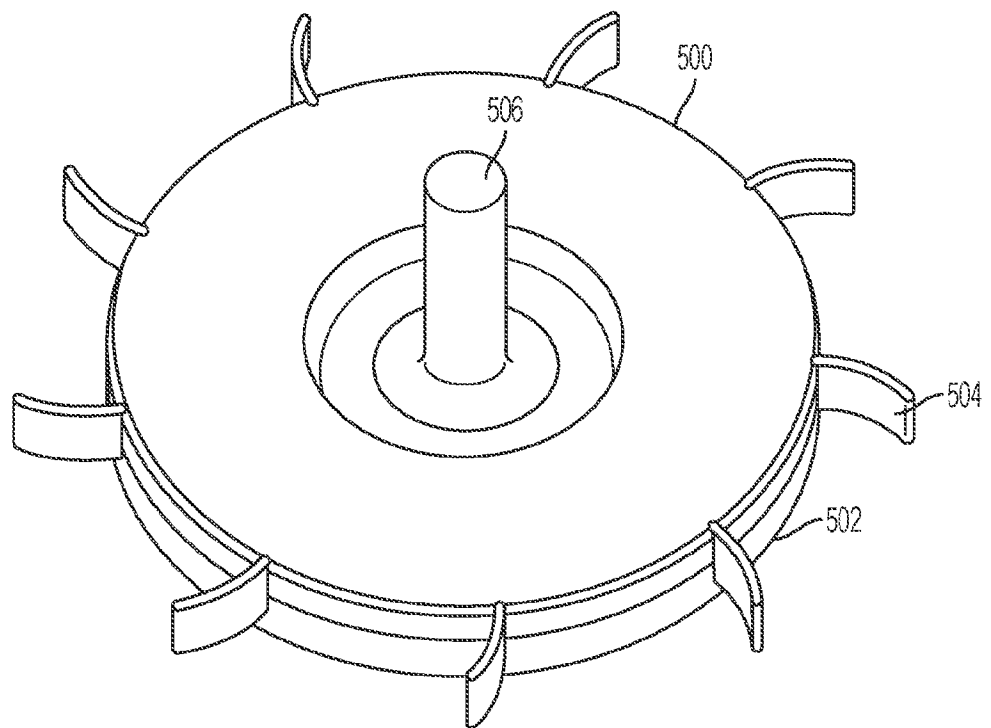


FIG. 5

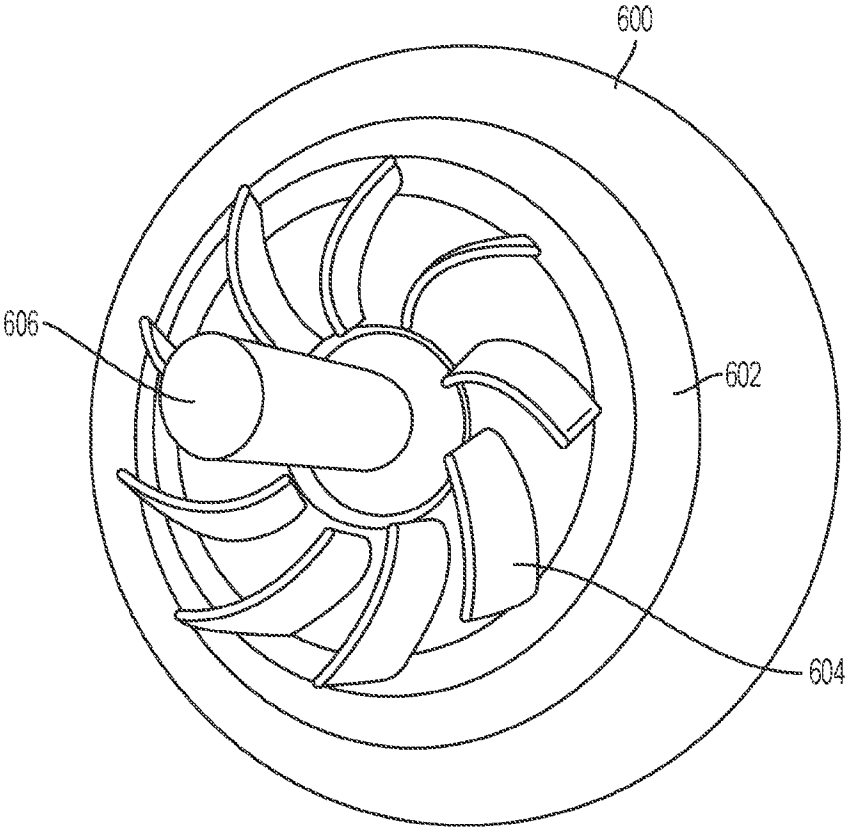


FIG. 6

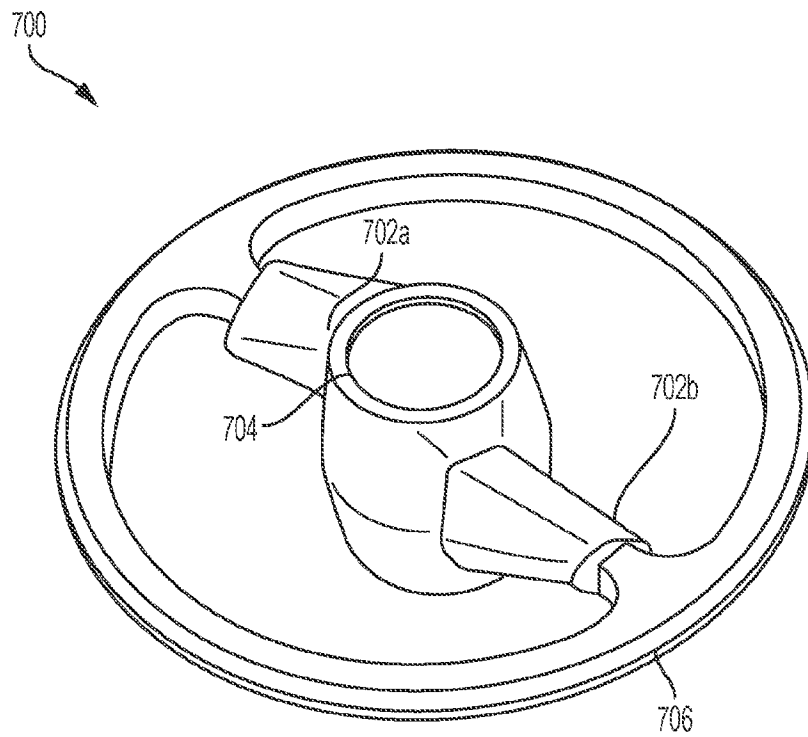


FIG. 7

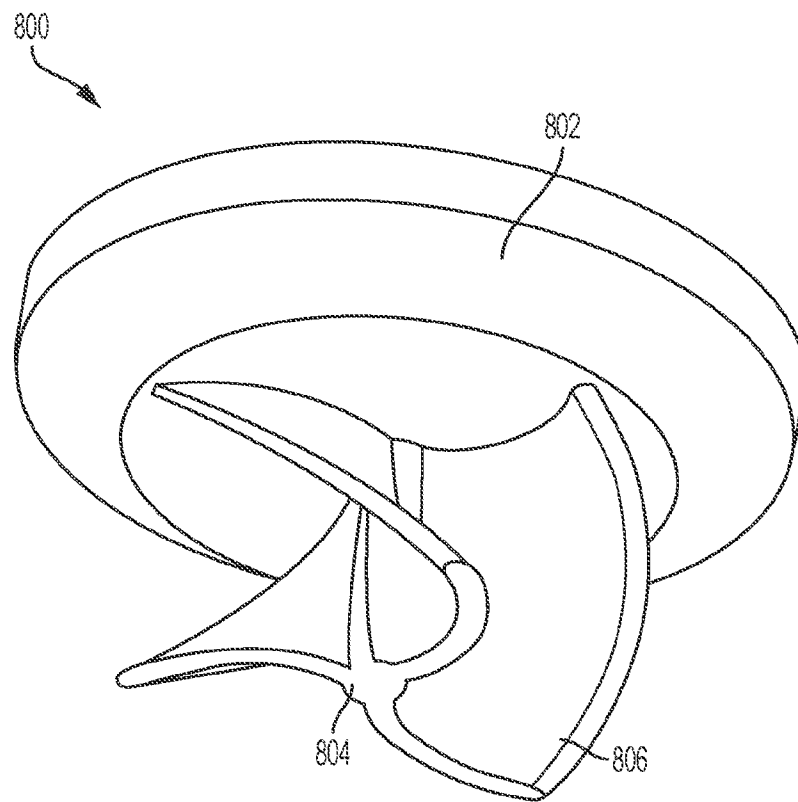


FIG. 8

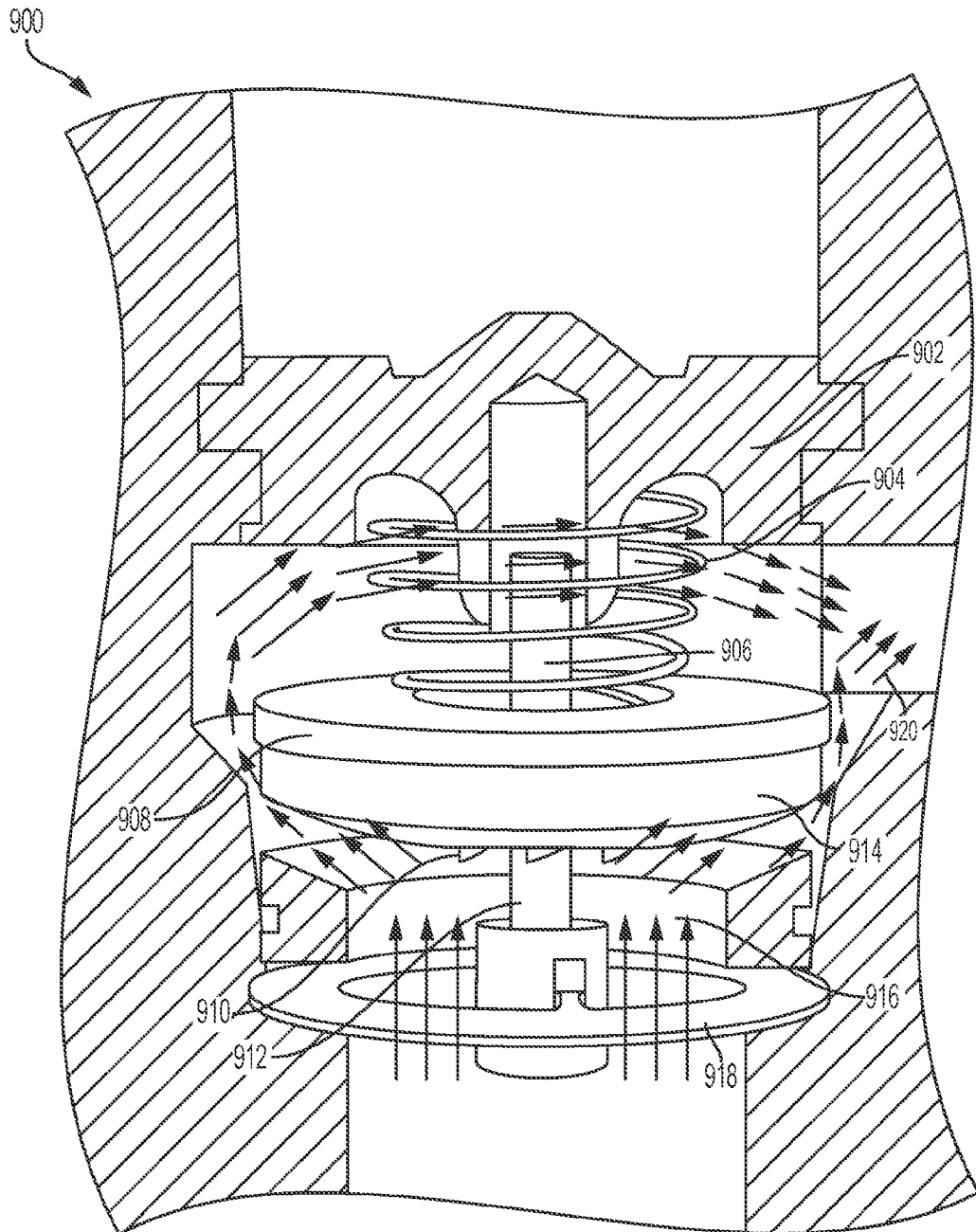


FIG. 9

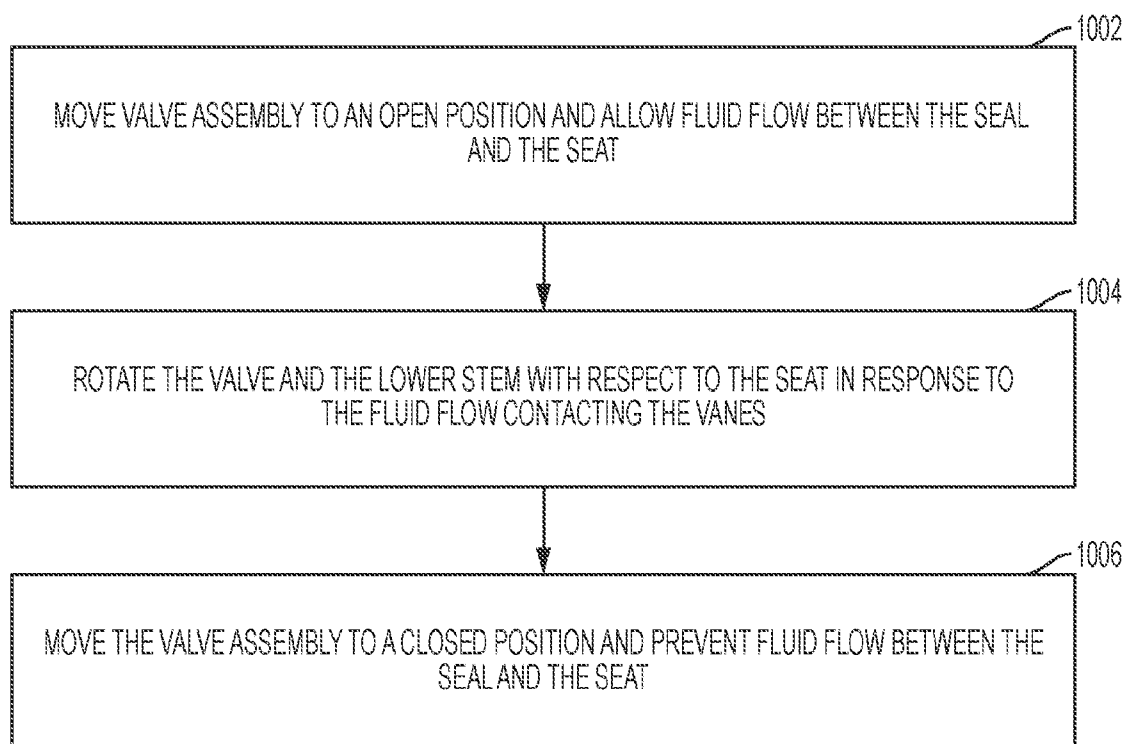


FIG. 10

A. CLASSIFICATION OF SUBJECT MATTER**E21B 34/06(2006.01)i, E21B 43/12(2006.01)i, E21B 17/00(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 34/06; F16K 17/12; F16K 15/02; F04D 29/62; F16K 15/06; F16K 51/00; F16K 27/02; F16L 29/00; E21B 43/12; E21B 17/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: valve, vane, stem, rotation, passive, seat, seat and spring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015-0020885 A1 (TRANE INTERNATIONAL INC.) 22 January 2015 See abstract, paragraphs [0030]-[0051] and figures 2-5.	1-20
A	US 2006-0108556 A1 (ROSE, COY W.) 25 May 2006 See abstract, paragraphs [0047]-[0050] and figures 1-6.	1-20
A	EP 0842361 B1 (TACO INC.) 02 April 2003 See paragraphs [0019]-[0033] and figures 2-7.	1-20
A	US 2015-0068622 A1 (FLOMATIC CORPORATION) 12 March 2015 See abstract, paragraphs [0027]-[0038] and figures 1-9.	1-20
A	WO 98-55729 A1 (WEATHERFORD/LAMB, INC.) 10 December 1998 See abstract, page 7, line 24 - page 9, line 20 and figures 2-12.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"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

14 October 2016 (14.10.2016)

Date of mailing of the international search report

14 October 2016 (14.10.2016)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/013546

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