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(54) FLUID FLOW MANAGER

(57) A valve with a shuttle for use in a flow management system includes a spill port and bypasses a backflow.

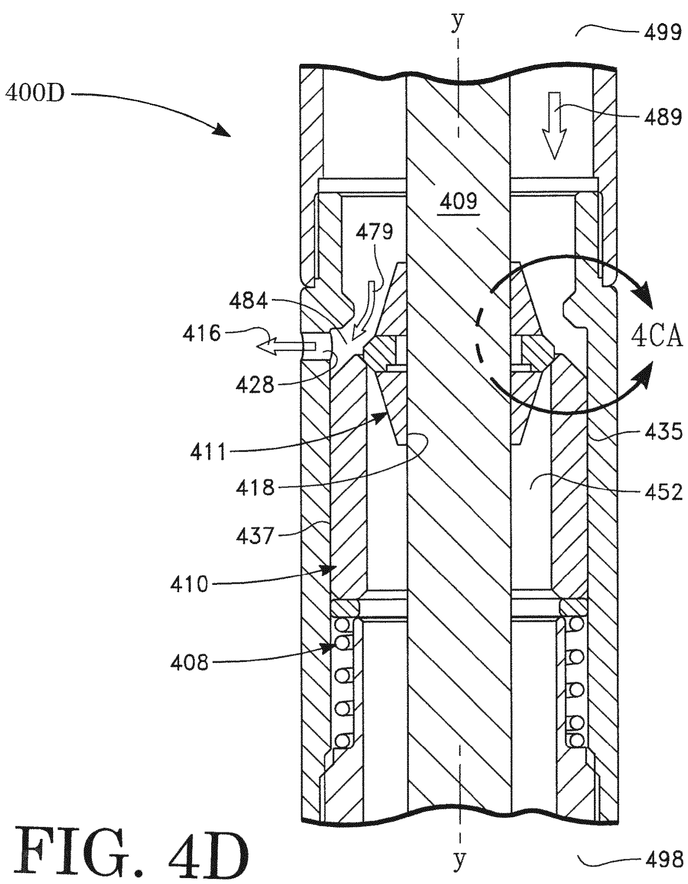


FIG. 4D

EP 3 715 581 A1

Description

PRIORITY CLAIM

[0001] This application claims the benefit of a) U.S. Provisional Patent Application No. 61/611,543 filed March 15, 2012 and b) U.S. Non-Provisional Patent Application No. 13/446,195 filed April 13, 2012 which are incorporated herein in their entirety and for all purposes.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a fluid flow manager including fluid flow components and systems using those components. In particular, the present invention relates to an improved valve with shuttle for use in fluid flow systems.

Discussion of the Related Art

[0003] Fluid flow managers typically include one or more of pumps and valves. To the extent these devices are located in hard to reach places, they present maintenance and maintenance downtime issues. Where pumps and valves are used to produce a natural resource such as a hydrocarbon, downtime can result in costly lost production and increased workman and material expenses.

[0004] In particular, downhole production strings including pumps and valves for lifting fluids such as particulate laden liquids and slurries present a maintenance problem. Here, both pumps and valves can lose capacity and in cases be rendered inoperative when conditions including fluid conditions and fluid velocities are outside an intended operating range. Such unintended operating conditions can foul, plug, and damage the equipment.

[0005] Despite the industry's resistance to change, there remains a need to improve production strings.

SUMMARY OF THE INVENTION

[0006] The present invention provides a fluid flow manager including a valve body with a drag part and a spill port.

[0007] In an embodiment, a fluid flow manager comprises: a valve body includes a middle body with a spill port, the middle body interposed between upper and lower bodies; a valve body cavity fluidly couples the middle, upper, and lower bodies; an internal nose extends from the valve body, the nose located within the valve body cavity; a substantially constant diameter shuttle located within the valve body cavity and moveable with respect to the valve body, the shuttle having a shuttle upper end closure; a sliding seal located between the shuttle and the a wall of the valve body cavity; a spring for urging the shuttle upper end closure to mate with an internal nose seat to form a stationery seal; a spring end seated in a valve body pocket having a valve body pocket wall with one or more ports for flushing the pocket; a drag part operable to mate with a shuttle seat to form a movable seal; the spill port in fluid communication with the valve upper body cavity when the stationery seal is open and the moveable seal is closed; the spill port fluidly isolated from the valve upper body cavity when the moveable seal is open and the stationery seal is closed; the valve operable to pass a flow along a valve centerline to the extent the flow enters the valve via the valve lower body; and, the valve operable not to pass a flow along a valve centerline to the extent the flow enters the valve via the valve upper body.

[0008] An embodiment provides a method of protecting a pump comprising the steps of: providing a fluid to be lifted and a pump for lifting the fluid; providing a valve downstream of the pump, the valve including a valve body with a spill port; a shuttle located in a chamber of the valve body; the shuttle having a through hole extending between a shuttle spring end and a shuttle end opposing the spring end; forming a stationery seal when a shuttle closure and a seat extending from the valve body come into contact; forming a moving seal when a drag part closure and a shuttle seat come into contact; a spring biasing the shuttle toward the valve body stationery seat; the valve passing a flow entering the shuttle through hole at the shuttle spring end; and, the valve spilling a flow that closes the moving seal.

[0009] An embodiment provides a pump off controller method comprising the steps of providing a fluid to be lifted and a pump for lifting the fluid; providing a valve downstream of the pump, the valve including a valve body with a spill port, a shuttle located in a chamber of the valve body, the shuttle having a through hole extending between a shuttle spring end and a shuttle end opposite the shuttle spring end, a valve center line shared by the valve body and the shuttle, a first seat located on a first end face of the shuttle and a first seat closure, the first seat closure having a central bore for accepting a rotatable shaft extending through the valve body, the first seat closure for translating along the rotatable shaft in response to fluid drag, a second seat located in the valve body chamber and a second seat closure located on a second end face of the shuttle, the first shuttle end face adjacent to the second shuttle end face, and a spring located substantially between the shuttle spring end and a valve body support; passing a flow entering the shuttle through hole at the shuttle spring end; and, spilling a flow that causes the first seat and the first seat closure to come into contact.

[0010] An embodiment provides a backspin protection method comprising the steps of: providing a fluid to be lifted from a reservoir and a pump for lifting the fluid; providing a valve downstream of the pump, the valve including a valve body with a spill port, a shuttle located in a chamber of the valve body, the shuttle having a through hole extending between a shuttle spring end and a shuttle end opposite the shuttle spring end, a valve center line shared by the valve body and the shuttle, a first seat located on a first end face of the shuttle and a first seat closure, the first seat closure having a central bore for accepting a rotatable shaft extending through the valve body, the first seat closure for translating along the rotatable shaft in response to fluid drag, a second seat located in the valve body chamber and a second seat closure located on a second end face of the shuttle, the first shuttle end face adjacent to the second shuttle end face, and a spring located substantially between the shuttle spring end and a valve body support; passing a flow entering the shuttle through hole at the shuttle spring end; and, reventing pump backspin by bypassing a flow that causes the moving seal to close and the stationery seal to open and channeling the bypassed flow to replenish the reservoir.

[0011] Yet another embodiment provides a pump cavitation prevention method comprising the steps of: providing a fluid to be lifted from a reservoir and a pump for lifting the fluid; providing a valve downstream of the pump, the valve including a valve body with a spill port, a shuttle located in a chamber of the valve body, the shuttle having a through hole extending between a shuttle spring end and a shuttle end opposite the shuttle spring end, a valve center line shared by the valve body and the shuttle, a first seat located on a first end face of the shuttle and a first seat closure, the first seat closure having a central bore for accepting a rotatable shaft extending through the valve body, the first seat closure for translating along the rotatable shaft in response to fluid drag, a second seat located in the valve body chamber and a second seat closure located on a second end face of the shuttle, the first shuttle end face adjacent to the second shuttle end face, and a spring located substantially between the shuttle spring end and a valve body support; passing a flow entering the shuttle through hole at the shuttle spring end; and, preventing pump cavitation by returning a reverse flow to the reservoir without passing the reverse flow through the pump.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention is described with reference to the accompanying figures. The figures listed below, incorporated herein and forming part of the specification, illustrate the invention and, together with the description, further serve to explain its principles enabling a person skilled in the relevant art to make and use the invention.

FIG. 1 is a schematic diagram of a valve in a flow management system in accordance with the present invention.

FIG. 2A is a diagram including the flow management system of FIG. 1.

FIG. 2B is a cross-sectional view A-A of the flow management system of FIG. 2A.

FIGS. 3A-C are views of a first bypass valve of the flow management system of FIG. 1.

FIG. 4A-F are views of a second bypass of the flow management system of FIG. 1.

FIG. 5 is an exploded view of a shuttle for use in valves of FIG. 1.

FIG. 6 is an assembled view of the shuttle of FIG. 5.

FIG. 7 is a schematic diagram of a pump-off controller implemented in a production string.

FIG. 8 is a schematic diagram of a valve of FIG. 1 used to implement a pump-off controller.

FIG. 9 is a flow chart showing a mode of operation of a valve of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] The disclosure provided in the following pages describes examples of some embodiments of the invention. The designs, figures, and description are non-limiting examples of certain embodiments of the invention. For example, other embodiments of the disclosed device may or may not include the features described herein. Moreover, disclosed advantages and benefits may apply to only certain embodiments of the invention and should not be used to limit the disclosed invention.

[0014] To the extent parts, components and functions of the described invention exchange fluids, the associated interconnections and couplings may be direct or indirect unless explicitly described as being limited to one or the other. Notably, indirectly connected parts, components and functions may have interposed devices and/or functions known to persons of ordinary skill in the art.

[0015] FIG. 1 shows an embodiment of the invention 100 in the form of a schematic diagram. A spill or bypass valve 108 is interconnected with a pump 104 via a pump outlet 106. The pump includes a pump inlet 102 and the valve includes a valve outlet 110 and a valve spill port 112. In various embodiments, the inlets, outlets and ports are one or more of a fitting, flange, pipe, or similar fluid conveyance.

[0016] FIG. 2A shows a section of a typical downhole production string 200A. The production string includes the bypass valve 108 interposed between the pump 104 and an upper tubing string 204. In some embodiments, a casing 208 surrounds one or more of the tubing string, valve, and pump. Here, an annulus 206 is formed between the tubing string and the casing. A production flow is indicated by an arrow 102 while a backflow is indicated by an arrow 202. In various embodiments, the bypass valve incorporates a spill port and in various embodiments the valve is operable to isolate backflows from one or more of the valve, portions of the valve, and the pump.

[0017] Some embodiments of the production string include an extended tubular element 203 coupled with the upper tubing string 204. For example, the extended tubular element may be a part of the valve or may be separate from the valve. In an embodiment, the extended tubular element is a valve body portion. And, some embodiments of the production string may use an electric submersible pump or they may use a rod driven pump as provided for by an optional rod 250 passing through the tubing string and interconnecting with the pump (pump interconnection is not shown).

[0018] FIG. 2B shows a cross-section A-A through the production string of FIG. 2A. Clearance(s) 260 between the rod 250 and the extended tubular element 203 and clearance(s) 262 between the extended tubular element and the casing 208 are shown. In particular, clearance(s) between the rod and the extended tubular element may be chosen to guide the rod and as such may be less than similar clearance(s) associated with the upper tubing string. In some embodiments, guards or ribs mounted within the extended tubular element or to the rod provide stand-offs to guide the rod.

[0019] FIG. 3A shows a bypass valve in a shuttle up and forward flow configuration 300A. FIG. 3B shows an enlarged middle portion of the valve with shuttle 300B. A valve body 302 includes an upper body 304, a middle body 305, and a lower body 306. In various embodiments, the shuttle is of a substantially constant diameter, variations being due to seal projections and the like.

[0020] The upper body includes a first through hole 369. In some embodiments, the first through hole passes through an outlet chamber 365 of an upper adapter 303. And, in some embodiments, an inner surface of the adapter 367 is threaded. As used herein, the phrase through hole indicates a passage. And, as persons of ordinary skill in the art will recognize, embodiments may have a through hole with a constant cross-section or a through hole of varying shape and/or cross-section as shown here.

[0021] The middle body includes a second through hole 371. In various embodiments, the second through hole provides or adjoins a shuttle chamber 361 and fluidly couples a valve outlet chamber 365 with a valve inlet chamber 364. The lower body includes a third through hole 373. In various embodiments, the third through hole passes through the inlet chamber 364. As used herein, the term couple refers to a connection that is either of a direct connection or an indirect connection that may further include interposed components.

[0022] Within the lower body 306, a spring shoulder such as an annular spring shoulder 344 for supporting a charge spring 308 projects inwardly from a first inner bore of the lower body 372. In some embodiments, the shoulder extends between the first inner bore of the lower body and a cylindrical spring guide 342.

[0023] And, in some embodiments, the shoulder 344 and the spring guide 342 are portions of a lower adapter 307 forming at least part of the lower body 306. In various embodiments, an upper end of the adapter 374 has a reduced outer diameter 376 such that the spring shoulder is formed where the diameter is reduced and the spring guide is formed along the length of the reduced diameter portion of the adapter. As shown, portions of the charge spring 308 are located in an annular pocket 363 between the first inner bore of the lower body 372 and the spring guide. The adapter and lower body may be integral or fitted together as by a threaded connection 346 or another suitable connection known to a skilled artisan.

[0024] In some embodiments, a spring guide port 356 provides a means for flushing the annular spring pocket 363. As seen, the port extends between the lower chamber 364 and the annular pocket 363. Action of the charge spring 308 and/or pressure differentials between the pocket and the lower chamber provide a flushing action operative to remove solids such as sand that might otherwise tend to accumulate in the annular pocket.

[0025] Within the middle body 305, a middle body bore 338 is for receiving a valve shuttle 310. The charge spring 308 is for urging the shuttle toward the valve outlet end 399. This shuttle urging may be via direct or indirect charge spring contact. For example, embodiments utilize direct contact between a shuttle lower end 321 and an upper end of the charge spring 378. Other embodiments utilize indirect contact such as via an annular transition ring 323 having an upper face 393 contacting the shuttle lower end and a lower face 325 contacting a charge spring upper end (as shown).

[0026] Near a lower end of the upper body 375, an inwardly projecting nose 330 includes a stationery seat 332 for engaging a closure 314 encircling a shuttle carrier upper end 313. In various embodiments, the shuttle has a tapered upper end 317 and the closure is part of or extends from this taper. In various embodiments the seat and closure are configured to meet along a line forming an angle $\theta < 90$ degrees with respect to a valve centerline y-y. Absent greater opposing forces, the charge spring 308 moves the shuttle 310 until the shuttle closure 314 is stopped against the stationery seat 332.

[0027] FIG. 3C shows the shuttle in a compressed spring position 300C. Unlike FIGS. 3A and 3B which show a normal forward flow through the valve 388 with the shuttle stationery seal 332 and closure 314 mated, FIG. 3C shows the shuttle 310 separated from the closure 314 during a reverse flow 389, the charge spring 308 being compressed by movement of the shuttle toward the valve inlet end 398. Notably, various embodiments provide one or more sliding seals about the shuttle such as a sliding seal 335 between the shuttle 310 and a middle body bore mated with the shuttle such as the middle body bore 338.

[0028] When there is sufficient forward flow 388 through the valve 300B, forward flow through a shuttle bore 352 causes a plug 354 to rise relative to the shuttle 310 (see FIGS. 3A, B). Movement of the plug is within the shuttle and in various embodiments plug movement is guided by a plug cage 327. Sufficient forward flow brings the plug to rest against an upper stop 351. In this position, flow passes freely through the shuttle bore and into the valve outlet chamber 365. The rising shuttle is stopped when the shuttle closure 314 mates with the stationery seat 332 forming an upper seal 331.

[0029] Forces acting on the plug include drag forces due to flow through the shuttle bore 352 and gravitational forces. In various embodiments, when drag forces are overcome by gravitational forces due to insufficient forward flow, the plug 354 falls relative to the shuttle 310 and comes to rest against a shuttle lower seat 326 forming a lower seal 333.

[0030] Plug 354 designs include features for mating with the shuttle lower seat 326 such as integral features and non-integral features; for example, a plug of a single material such as a metal or a polymer material. In an embodiment, the plug is spherical (as shown), made of metal, and includes an outer surface 355 for mating with the shuttle lower seat. Other embodiments provide a plug of multiple materials such as a metallic central portion within a polymeric outer covering. Materials include ferrous and non-ferrous metals, and plastics such as PEEK and HDPE.

[0031] Notably, during an inadequate flow event, the plug 354 falls relative to the shuttle 310, mates with the shuttle lower seat 326, and blocks flow through the shuttle mouth 360. Pressure forces due to the pressure at the valve outlet P2 may act on the blocked shuttle and move it toward the valve inlet 398, a process that compresses the charge spring 308. When the plug 354 and shuttle lower seat 326 are mated, forward flow is substantially limited. In various embodiments, forward flow is stopped but for unintended leakage.

[0032] As seen, to the extent that the fluid head at the valve outlet P2 results in a fluid head force on the shuttle sufficient to overcome resisting forces including compressing the charge spring 308, the shuttle 310 moves toward the inlet end of the valve 398. In various embodiments, a shuttle diameter 337, approximated in some embodiments as a middle body bore diameter 339, provides an estimate of the area acted on by the fluid head and thus the fluid head force. Skilled artisans will adjust valve performance including operation of the spill port 338 by determining valve variables such as a spring constant "k" ($F = k*x$) of the charge spring to adapt the valve for particular applications.

[0033] Considering the spill port 328, it is seen that forward flow 388 and the upper seal 331 associated with forward flow enable blocking of the spill port 328. For example, the spill port may be blocked by covering the port and/or by forming an isolation chamber (as shown). When the spill port is blocked, flow entering the valve inlet 398 passes through the shuttle through a shuttle bore 352, out a shuttle mouth 361, into the valve outlet chamber 365, and out of the valve outlet 399.

[0034] Referring to FIG. 3C, it is seen that reverse flow 389 and the lower seal 333 associated with reverse flow enable opening of the spill port 328 as the shuttle 310 moves toward the inlet end of the valve 398 and the upper seal 331 is opened. When the lower seal is closed, flow through the shuttle is blocked and the third seal blocks flow between the shuttle and the middle body bore 338. However, the upper seal is now open and reverse flow entering the valve can pass 379 between the shuttle and the nose 330 and leave the valve 316 via the spill port 328.

[0035] In some embodiments, reverse flow 389 and/or an adverse pressure gradient (outlet pressure P2 > inlet pressure P1) move the shuttle 310 toward the valve inlet end 398 by a distance within dimension S1. This shuttle stroke unblocks the spill port 328 allowing flow entering the outlet chamber 389 to move through a spill pocket 384 with boundaries including the middle body bore 338 and the shuttle 310 before exiting the valve body 302 via one or more spill ports 328. And, in some embodiments, the illustrated spill port is one of six spill ports arranged around a valve body periphery 386.

[0036] FIGS. 4A-C show a rod driven bypass valve in a bobbin up configuration 400A-C. FIG. 4A shows the valve in the bobbin up configuration. FIG. 4B shows an enlarged middle portion of the rod driven bypass valve in the bobbin up configuration. FIG. 4C shows the enlarged middle portion of the rod driven valve when the bobbin is down 400C. As seen in the figures, a valve body 402 includes an upper body or stand-off 404, a middle body 405, and a lower body 406.

[0037] The upper body includes a first through hole 469. In some embodiments, the first through hole passes through an outlet chamber 465 of an upper adapter 403. And, in some embodiments, an inner surface of the adapter 467 is threaded. As used herein, the phrase through hole indicates a passage. And, as persons of ordinary skill in the art will recognize, embodiments may have a through hole with a constant cross-section or a through hole of varying shape and/or cross-section as shown here. Embodiments of the adapter block a bobbin 411 from leaving the upper body 404.

[0038] The middle body includes a second through hole 471. In various embodiments, the second through hole provides or adjoins a shuttle chamber 461 and fluidly couples the valve outlet chamber 465 with a valve inlet chamber 464. The lower body includes a third through hole 473. In various embodiments, the third through hole passes through the inlet chamber 464. As used herein, the term couple refers to a connection that is either of a direct connection or an indirect connection that may further include interposed components.

[0039] Within the lower body 406, a spring shoulder such as an annular spring shoulder 444 for supporting a charge spring 408 projects inwardly from a first inner bore of the lower body 472. In some embodiments, the shoulder extends between the first inner bore of the lower body and a cylindrical spring guide 442.

[0040] And, in some embodiments, the shoulder 444 and the spring guide 442 are portions of a lower adapter 407 forming at least part of the lower body 406. In various embodiments, an upper end of the adapter 474 has a reduced outer diameter 476 such that the spring shoulder is formed where the diameter is reduced and the spring guide is formed along the length of the reduced diameter portion of the adapter. As shown, portions of the charge spring 408 are located in an annular pocket 463 between the first inner bore of the lower body 472 and the spring guide. The adapter and lower body may be integral or fitted together as by a threaded connection 446 or another connection known to a skilled artisan.

[0041] In some embodiments, a spring guide port 456 provides a means for flushing the annular spring pocket 463. As seen, the port extends between the lower chamber 464 and the annular pocket 463. Action of the charge spring 408 and/or pressure differentials between the pocket and the lower chamber provide a flushing action operative to remove solids such as sand that may otherwise tend to accumulate in the annular pocket.

[0042] Within the middle body 405, a middle body bore 438 is for receiving a valve shuttle 410. The charge spring 408 is for urging the shuttle toward the valve outlet end 499. This shuttle urging may be via direct or indirect charge spring contact. For example, embodiments utilize direct contact between a shuttle lower end 421 and an upper end of the charge spring 478. Other embodiments utilize indirect contact such as via an annular transition ring 423 having an upper face 493 contacting the shuttle carrier lower end and a lower face 425 contacting a charge spring upper end (as shown).

[0043] Near a lower end of the upper body 475, an inwardly projecting nose 430 includes a stationery seat 432 for engaging a closure 414 encircling a shuttle upper end 413. In various embodiments, the shuttle has a tapered upper end 417 and the closure is part of or extends from this taper. In various embodiments the seat and closure are configured to meet along a line forming an angle $\theta < 90$ degrees with respect to a valve centerline y-y. Absent greater opposing forces, the charge spring 408 moves the shuttle 410 until the shuttle closure 414 is stopped against the stationery seat 432 to form a first seal 431.

[0044] The rod driven valve includes a central, rotatable, pump driving rod. The rod section shown is a lower rod section 409 with a central axis about centered on the valve centerline y-y. Not shown is this or another rod section's interface with a pump or an upper rod portion that is coupled to a rotating drive means.

[0045] The lower pump driving rod 409 passes through the valve body 402. In particular the rod passes through the first through hole 469, through the shuttle bore 452, and through the third through hole 469. Like the valve of Figure 3A, the valve of FIG. 4A has a part dragged by fluid flow, the bobbin 411. The bobbin is slidably mounted on the rod above the shuttle as shown in FIG. 4A. The bobbin has a mounting hole for receiving the rod. Bobbin shapes include fluid-dynamic shapes suitable for utilizing drag forces operable to lift the bobbin when there is sufficient forward flow 488. For example, the bobbin may be shaped with substantially conical ends (as shown).

[0046] In an embodiment, the bobbin 411 includes a bobbin body 420 with a through hole 418 and a peripheral groove 412 defining a plane about perpendicular to the valve y-y axis. The groove is for receiving a bobbing ring 413 and the bobbin ring is for sealing a shuttle mouth 461. In various embodiments, the bobbin body is made from polymers such as plastics and from metals such as stainless steel. And, in various embodiments, the bobbin ring is made from polymers such as plastics and from metals such as stainless steel.

[0047] In some embodiments, the bobbin body 420 and ring 413 are integral and in some embodiments the bobbin has a bobbin hole insert (not shown) that is made from a material that differs from that of the bobbin body, for example, a metallic insert fitted into an outer plastic body. And, in an embodiment, the bobbin body is injection molded and a metallic bobbin ring is included in the mold during the injection molding process.

[0048] As further explained below, the bobbin 411 moves along the rod 409 in response to flow through the valve, rising above the shuttle 410 when there is sufficient forward flow 488, and falling to mate with the shuttle when there is insufficient forward flow and when there is reverse flow 489.

[0049] FIGS. 4D-E show the shuttle in a compressed spring position 400D-E. Unlike FIGS. 4A and 4B showing a normal forward flow through the valve 488 with the shuttle stationery seat 432 and closure 414 mated, FIGS. 4D-E show the shuttle 410 separated from the closure 414 during a reverse flow 489, the charge spring 408 being compressed by movement of the shuttle toward the valve inlet end 498. Notably, one or more sliding seals about the shuttle provide a sliding seal 435 between the shuttle 410 and a middle body bore mated with the shuttle such as the middle body bore 438.

[0050] When there is sufficient forward flow 488 through the valve 400B, flow through the shuttle bore 452 lifts the bobbin 411 above the shuttle 410 and the charge spring 408 holds the shuttle against the valve body protruding nose 430. With the bobbin lifted above the shuttle, flow passes freely through the shuttle bore and into the valve outlet chamber 465.

[0051] Figure 4F shows a valve embodiment similar to the valve of Figure 4A with an upper body 404 having a length 11. Here, an upper adapter 403 is configured, as by guards, spokes, annular obstructions or the like, to stop the bobbin from rising beyond the upper adapter. In various applications, a suitable length $\ell 1$ may depend upon factors such as fluid viscosity, bobbin geometry, fluid flow rate ranges, and spacing between the bobbin and surrounding structures. In some embodiments, length $\ell 1$ for 4 and 6 inch valve sizes is in the range of about 2 to 10 feet. And, in some embodiments, length $\ell 1$ is in the range of about 4 to 20 times the valve size. Skilled artisans may utilize knowledge of the application and its constraints to select suitable geometric variables including length 11.

[0052] Referring to FIG. 4C, the rising shuttle is stopped when the shuttle closure 414 mates with the stationery seat 432 forming the body-shuttle seal 431. Forces acting on the bobbin 411 include drag forces due to flow through the shuttle bore 452 and gravitational forces. In various embodiments, when drag forces are overcome by gravitational forces due to insufficient forward flow, the bobbin falls relative to the shuttle 410.

[0053] Notably, during an inadequate flow event, the bobbin 411 falls relative to the shuttle 410 (see FIG. 4E). On shuttle contact, the bobbin ring closure 480 comes to rest against a shuttle mouth seat 481 forming a shuttle-bobbin seal 482 and blocking flow through the shuttle. Pressure forces at the valve outlet P22 act on the blocked shuttle and move it toward the valve inlet 498, a process that compresses the charge spring 408. When the bobbin ring closure and shuttle mouth seat are mated, forward flow is substantially limited. In some embodiments, flow is stopped but for leakage such as unintended leakage.

[0054] As seen, to the extent that the fluid head at the valve outlet P22 results in a fluid head force on the shuttle sufficient to overcome resisting forces including compressing the charge spring 408, the shuttle 410 moves toward the inlet end of the valve 498. In various embodiments, a shuttle diameter 437, approximated in some embodiments as a middle body bore diameter 439, provides an estimate of the area acted on by the fluid head and thus the fluid head force. Skilled artisans will adjust valve performance by determining valve variables including a spring constant "k" (F = k*x) of the charge spring to adapt the valve for particular applications.

[0055] Turning now to the spill port 428, it is seen that forward flow 488 and the body-shuttle seal 431 associated with forward flow enable blocking of the spill port 428. For example, the spill port may be blocked by forming an isolation chamber and/or by isolating or sealing the port 493. When the spill port is blocked, flow entering the valve inlet 498 passes through the shuttle through bore 452, out a shuttle mouth 461, into the valve outlet chamber 465, and out of the valve outlet 499.

[0056] Referring to FIG. 4D, it is seen that reverse flow 489 and the shuttle-bobbin seal 482 associated with reverse flow enable opening of the spill port 428 as the shuttle 410 moves toward the inlet end of the valve 498 and the upper seal 431 is opened. When the shuttle-bobbin seal is closed, flow through the shuttle is blocked and a sliding shuttle-bore seal 435 blocks flow between the shuttle and the middle body bore 438. However, the shuttle-body seal 431 is now open and reverse flow entering the valve can pass around the nose 479 and leave the valve 416 via the spill port 428.

[0057] In some embodiments, reverse flow 489 and/or an adverse pressure gradient (outlet pressure P22 > inlet pressure P11) move the shuttle 410 toward the valve inlet end 498 by a distance within dimension S11. This shuttle stroke unblocks the spill port 428 allowing flow entering the outlet chamber 489 to move through a spill pocket 484 with boundaries including the middle body bore 438 and the shuttle 410 before exiting the valve body 416 via one or more spill ports 428. And, in some embodiments, the illustrated spill port is one of a plurality of spill ports arranged around a valve body periphery 486.

[0058] The shuttle 410 of the rod driven valve 400Ahas a periphery 437 that seals, at least in part, against an internal bore of the valve such as the middle body bore 438. While some embodiments provide a shuttle with a substantially continuous sealing surface (as shown) for providing a sliding seal 435, various other embodiments provide a discontinuous sealing surface. For example, seals in the form of raised surface portions, rings in groves, snap rings, O-rings, and other suitable sealing parts and assemblies known to skilled artisans may be used.

[0059] FIGS. 5-6 show shuttle sealing assemblies for use with the valves of FIGS. 3-4 above. Skilled artisans will appreciate the use of the valve sealing means shown on various valves including rod driven and non-rod driven valves. FIG. 5 shows an exploded view of a shuttle assembly having one or more removable seals 500. FIG. 6 shows an assembled view of the shuttle assembly of FIG. 5A 600. Here, a shuttle body 514 receives an upper sealing ring or seal 520, a cartridge or seal cartridge 522, a lower sealing ring or seal 530, and a lower retainer ring 532. Embodiments of a generally cylindrical outer surface of the shuttle body 518 include features such as threads for engaging mating parts such as threads of upper and lower seals 521, 531 and threads of the retaining ring 534.

[0060] Among other things, the shuttle assembly provides removable upper and lower seals 520 and 530 carried by respective seal recesses 525, 527 at opposed ends of the generally cylindrical seal cartridge 522. Internal threads of the seal cartridge 523 are for engaging external threads on the body 518 such that the upper seal can be fixed between a body rim such as an upper lip of the body 516 and a seal cartridge rim such as a shoulder 524 of the seal cartridge. The upper seal is located as the seal cartridge is advanced, as by threaded parts, onto the shuttle body.

[0061] The lower seal 530 is for locating between the seal cartridge 522 and a lower retaining ring or lower retainer 532 such that the lower seal can be fixed between a body rim such as a seal cartridge rim, for example a lower shoulder 526 of the seal cartridge and the lower retaining ring. In particular, an externally threaded end portion of the shuttle body 529 protrudes from the seal carrier 522 after assembly of the first seal 520. When the lower seal 530 is in place and carried by the lower seal recess 527 of the seal cartridge, fitting the lower retaining ring to the seal cartridge as by threads provides a means to locate the lower seal.

[0062] Embodiments include a shuttle body 514 with a raised face (not shown) that separates the upper and lower seals 520, 530. Here, the upper seal is bounded at the upper end by a rim of the shuttle body 516 while the lower seal is bounded at the lower end by the lower retaining ring 532.

[0063] Further, the shuttle body 514 and the seal cartridge 522 are engaged via mating threads including threads on the inside of the seal cartridge 523 and on an exterior of the lid carrier 518 such that the upper seal 520 is captured at the upper seal recess 525. In similar fashion, the retainer ring 532 and the seal cartridge are engaged via mating threads 542 on the inside of the retainer ring 534 and on an exterior of the lid carrier 518 such that the lower seal 530 is captured at the lower seal recess 527.

[0064] As skilled artisans will recognize, seal 520, 530 dimensions are chosen to provide for a desired engagement with a mating surface and in particular for engagement with a mating sealing surface such as that of the spill port(s) 428. Some seal peripheries may have respective crowns 450, 452 providing a seal movable with the shuttle body 514.

[0065] And, as skilled artisans will appreciate, embodiments of this disclosure provide securely located seals during extended periods of valve operation such as years and enable replacement of seals should the shuttle be refurbished. In addition, readily removable seals allows for fitting a shuttle with seals for different operating conditions such as different valves and different types of service. The shuttle of FIG. 5A may be adapted for use in rod driven valves and non-rod driven valves.

[0066] In various embodiments the valve parts of FIGS. 3-6 are made from metals or alloys of metals including one or more of ferrous or non-ferrous metals, polymers, steel, iron, brass, aluminum, stainless steel, and other materials skilled artisans know to be suitable. And, in various embodiments, one or more parts of the valve are made from non-metals. For example, valve seal parts such as closures and seats may be made from specialty seal polymers such as PTFE (polytetrafluoroethylene), POM (Polyoxymethylene) and PEEK (PolyEtherEtherKetone).

[0067] As can be seen from the above, various valve and/or valve and related equipment embodiments will react to flow conditions such as insufficient fluid flow, no fluid flow, or reverse fluid flow. For example, referring to the production string of FIG. 2 and the valves of FIGS. 3-4, the valve 108 and pump 104 are substantially removed from the fluid circuit when flow through the shuttle 310, 410 is blocked and the outlet chamber 365, 465 is isolated from the inlet chamber 364, 464.

[0068] A benefit of this isolation is protection of the valve 108 and pump 104. For example, one protection afforded is protection from solids (such as sand), normally rising with the fluid but during insufficient flow conditions moving toward the valve and pump, that might otherwise foul or block one or both of these and potentially other components. Blocking the flow path through the shuttle 352, 452 and opening the spill port(s) 328, 428 removes these solids outside the tubing string 203, 204.

[0069] Recent experience shows adaptations of the flow management systems of FIG. 1 retard and/or eliminate pump backspin associated with backflow events. This backspin protection is a significant improvement over hydraulic damping brake and small orfice on pumps used previously but prone to frequent failure.

[0070] Various embodiments and applications of the valves of FIGS. 3, 4 provide valve fouling/plugging protection and pump fouling/plugging/burn-out protection. For example, lower than design production flow rates causing valve/pump misoperation or damage in traditional production string equipment is avoided in many cases using embodiments of the valves of the present invention.

[0071] Notably, embodiments of the bypass valves of FIGS. 3, 4 can replace or supplement protection systems now associated with some production strings. One such protection system is the "pump-off controller" ("POC") used to protect pumps from failures due to abnormal operations such as reduced flow conditions and loss of flow conditions.

[0072] FIG. 7 shows an illustrative example in the form of a schematic diagram of a pump-off controller installation in a production string 700. A portion of the production string 712 includes a pump 702 lifting product from a reservoir 714 to a higher level such as a surface level 716. A pump-off controller 708 receives power from a power supply 707 and provides power to the pump 710 in accordance with a control algorithm. For example, a pressure indicating device 704 monitors a pressure near a pump discharge 711 and provides a signal indicative of pressure 706 to the pump-off controller. If the pump-off controller determines the indicated pressure is below a preselected low-pressure set point, the POC stops supplying power to the pump. Conditions causing low pump discharge pressure include insufficient product at the pump inlet 713 (sometimes described as a "dry suction"), pump fouling, and pump damage. Attempting to run the pump under any of these conditions has the potential to damage or further damage the pump.

[0073] FIG. 8 shows a pump-off controller embodiment of the present invention 800. A production string 801 includes a flow management system with a pump 836 interposed between a reservoir 838 and a valve 834. Product the pump lifts from the reservoir 829 passes first through the pump and then through a bypass valve 834. The bypass valve discharges 821 into a tubing space 804 of a tubing string 802 that is surrounded by a casing 812 creating an annulus 814 between the outer casing and the inner tubing.

[0074] FIG. 9 shows a mode of bypass valve operation that substitutes for or augments a production string pump-off controller 900. For example, after a period of normal operation 902, the pressure differential (inlet pressure P111 > outlet P222) driving the flow in a production string 821 begins to fall 904. As explained above, low flow conditions cause flow through the shuttle to be blocked (see FIGS. 3C, 4D). When the forces on the shuttle including force applied by the charge spring 308, 408 are insufficient to maintain the shuttle in a position blocking the spill port 328, 428, the shuttle moves toward the valve inlet 398, 498 and unblocks the spill port/opens the bypass 906. During bypass operation 908, flow through the valve along the valve centerline y-y is blocked and the spill port(s) is open, product flows from the upper tubing string 823, enters the valve outlet chamber 366, 466, and leaves the valve through its spill port(s) 328, 428. The spill port empties into a space such as an annulus between the tubing and the casing 814 and is returned 827 to the reservoir 838. Here, the shuttles of FIG. 3A, 4A, 5, 7 are exemplary.

[0075] Because the annulus 814 is fluidly coupled to the reservoir 838 (e.g. as shown in FIG. 8), valve bypass from the spill ports is returned to the reservoir 827 in the replenishment step 910. In various embodiments, filling the reservoir with the fluid from the valve bypass serves to provide fluid to the suction of the pump 836, lift the shuttle e.g., 310, 410 and unblock flow through the valve along its centerline y-y where forward flow such as normal forward flow is re-established in step 912. Re-establishment of normal flow is followed by a return to normal operation in step 914.

[0076] The pump-off control steps of FIG. 9 result, in various embodiments, in cyclic flows through the pump. The time between these cyclic flows is shorter than would occur with a traditional valve in a traditional production string configuration because such strings are unable to bypass flow to the reservoir.

[0077] As persons of ordinary skill in the art will appreciate, many production string pumps rely on the pumped product as pump lubrication and coolant. Therefore, reducing the duration of dry pumping periods reduces pump damage due to operation with insufficient lubricant and coolant. The benefits include one or more of longer pump life, fewer outages, and higher production from tight reservoirs.

[0078] The present invention has been disclosed in the form of exemplary embodiments. However, it should not be limited to these embodiments. Rather, the present invention should be limited only by the claims which follow where the terms of the claims are given the meaning a person of ordinary skill in the art would find them to have.

<u>Numbered Statement</u>

[0079] Various aspects of embodiments will be described with reference to the following numbered statements:

S1. A fluid flow manager comprising:

a valve body includes a middle body with a spill port, the middle body interposed between upper and lower bodies;
a valve body cavity fluidly couples the middle, upper, and lower bodies; an internal nose extends from the valve body, the nose located within the valve body cavity;
a substantially constant diameter shuttle located within the valve body cavity and moveable with respect to the valve body, the shuttle having a shuttle upper end closure;
a sliding seal located between the shuttle and the a wall of the valve body cavity;
a spring for urging the shuttle upper end closure to mate with an internal nose seat to form a stationery seal;
a spring end seated in a valve body pocket having a valve body pocket wall with one or more ports for flushing the pocket;
a drag part operable to mate with a shuttle seat to form a movable seal; the spill port in fluid communication with the valve upper body cavity when the stationery seal is open and the moveable seal is closed;
the spill port fluidly isolated from the valve upper body cavity when the moveable seal is open and the stationery seal is closed;
the valve operable to pass a flow along a valve centerline to the extent the flow enters the valve via the valve lower body; and,
the valve operable not to pass a flow along a valve centerline to the extent the flow enters the valve via the valve upper body.

S2. The fluid flow manager of statement S2 further comprising seal rings seated in grooves formed in part by a seal cartridge of the shuttle.

S3. The fluid flow manager of statement S3 further comprising shuttle parts for retaining the drag part within the shuttle.

S4. The fluid flow manager of statement S3 further comprising a drag part surface for mating with the shuttle seat.

S5. The fluid flow manager of statement S4 wherein the drag part has a spherically shaped outer surface.

S6. The fluid flow manager of statement S5 fluidly interposed between a tubing string for receiving flow leaving the valve via the upper valve body and a submersible electric pump for supplying flow to the lower valve body.

S7. The fluid flow manager of statement S2 further comprising:

one or more valve body cavity dimensions sufficient to allow a pump drive rod to extend through the valve ; and,
a drag part feature for slidably engaging the pump drive rod.

S8. The fluid flow manager of statement S7 further comprising:

an upper adapter for limiting travel of the drag part; and,
wherein the upper valve body includes or is connected to a stand-off for guiding the drive rod, the stand-off having a length of about 4 to 20 times the size of the valve

S9. The fluid flow manager of statement S6 further comprising peripheral drag part ring incorporating the drag part closure for mating with the shuttle seat.

S10. The fluid flow manager of statement S7 wherein the drag part ring is located between tapered drag part ends.

S11. The fluid flow manager of statement S5 fluidly interposed between a tubing string for receiving flow leaving the valve via the upper valve body and a submersible electric pump for supplying flow to the lower valve body.

S12. A method of protecting a pump comprising the steps of:

providing a fluid to be lifted and a pump for lifting the fluid;

providing a valve downstream of the pump, the valve including a valve body with a spill port;
a shuttle located in a chamber of the valve body;
the shuttle having a through hole extending between a shuttle spring end and a shuttle end opposing the spring end;
forming a stationery seal when a shuttle closure and a seat extending from the valve body come into contact;
forming a moving seal when a drag part closure and a shuttle seat come into contact;
a spring biasing the shuttle toward the valve body stationery seat;

the valve passing a flow entering the shuttle through hole at the shuttle spring end; and,
the valve spilling a flow that closes the moving seal.

S13. A pump off controller method comprising the steps of:

providing a fluid to be lifted and a pump for lifting the fluid;
providing a valve downstream of the pump, the valve including

a valve body with a spill port,
a shuttle located in a chamber of the valve body,
the shuttle having a through hole extending between a shuttle spring end and a shuttle end opposite the shuttle spring end,
a valve center line shared by the valve body and the shuttle,
a first seat located on a first end face of the shuttle and a first seat closure,
the first seat closure having a central bore for accepting a rotatable shaft extending through the valve body,
the first seat closure for translating along the rotatable shaft in response to fluid drag,
a second seat located in the valve body chamber and a second seat closure located on a second end face of the shuttle,
the first shuttle end face adjacent to the second shuttle end face, and
a spring located substantially between the shuttle spring end and
a valve body support;

passing a flow entering the shuttle through hole at the shuttle spring end; and,
spilling a flow that causes the first seat and the first seat closure to come into contact.

S14. A backspin protection method comprising the steps of:

providing a fluid to be lifted from a reservoir and a pump for lifting the fluid;
providing a valve downstream of the pump, the valve including

a valve body with a spill port,
a shuttle located in a chamber of the valve body,
the shuttle having a through hole extending between a shuttle spring end and a shuttle end opposite the shuttle spring end,
a valve center line shared by the valve body and the shuttle,
a first seat located on a first end face of the shuttle and a first seat closure,
the first seat closure having a central bore for accepting a rotatable shaft extending through the valve body,
the first seat closure for translating along the rotatable shaft in response to fluid drag,
a second seat located in the valve body chamber and a second seat closure located on a second end face of the shuttle,
the first shuttle end face adjacent to the second shuttle end face, and
a spring located substantially between the

shuttle spring end and
a valve body support;

passing a flow entering the shuttle through hole at the shuttle spring end; and,
preventing pump backspin by bypassing a flow that causes the moving seal to close and the stationery seal to open and channeling the bypassed flow to replenish the reservoir.

S15. The pump protection method of statement S13 further comprising the steps of providing a moving closure having opposed tapered ends and a sealing ring located therebetween.

S16. The pump protection method of statement S14 further comprising the steps of providing plural sealing rings located by a shuttle seal cartridge.

S17. A pump cavitation prevention method comprising the steps of:

providing a fluid to be lifted from a reservoir and a pump for lifting the fluid;
providing a valve downstream of the pump, the valve including

a valve body with a spill port,
a shuttle located in a chamber of the valve body,
the shuttle having a through hole extending between a shuttle spring end and a shuttle end opposite the shuttle spring end,
a valve center line shared by the valve body and the shuttle,
a first seat located on a first end face of the shuttle and a first seat closure,
the first seat closure having a central bore for accepting a rotatable shaft extending through the valve body,
the first seat closure for translating along the rotatable shaft in response to fluid drag,
a second seat located in the valve body chamber and a second seat closure located on a second end face of the shuttle,
the first shuttle end face adjacent to the second shuttle end face, and
a spring located substantially between the shuttle spring end and
a valve body support;

passing a flow entering the shuttle through hole at the shuttle spring end; and,
preventing pump cavitation by returning a reverse flow to the reservoir without passing the reverse flow through the pump.

Claims

1. A valve (400A) for use as part of a hydrocarbon well production string (200A), the valve being configured for use interposed between a pump (104) and an upper tubing string (204), the valve comprising:

a valve body (402) having a spill port (428) and configured to receive a rotatable rod (409) extending through the valve body along a valve centerline (Y-Y);
a shuttle (410) located within the valve body and moveable with respect to the valve body along the centerline, the shuttle being moveable between a first shuttle position, in which the shuttle covers the spill port to fluidly isolate an upper valve cavity from the spill port, and a second shuttle position in which the shuttle does not cover the spill port such that the upper valve cavity is in fluid communication with the spill port;
a spring (408) for urging the shuttle to the first position within the valve body;
a sliding seal (435) located between the shuttle and a wall (439) of the valve body cavity, said sliding seal blocking flow between the shuttle and said wall of the valve body cavity;
a drag part (411) configured to be, in use, slidably mounted on the rotatable rod and movable with respect with respect to the shuttle (410) between a first drag part position where the drag part (411) mates with a shuttle seat (481) to form a seal blocking flow through the shuttle bore; and a second drag part position where the seal is open to allow flow through the shuttle bore such that the upper valve cavity is in fluid communication with a lower valve cavity;
the valve being configured such that, in use:

if an upward flow enters the valve, the drag part is movable to the second drag part position by the flow and the shuttle is urged to the second shuttle position, such that the valve passes the flow to the upper tubing string; and
if a downward flow enters the valve the drag part is movable to the first drag part position and the shuttle is movable to the first shuttle position by the flow and gravitation forces such that the valve diverts the flow through the spill port.

2. A valve as claimed in claim 1 wherein the drag part (411) is moveable along the rotatable rod within an upper valve body (404).

3. A valve as claimed in claim 2 wherein the upper valve body (404) has a length that depends on at least one of fluid viscosity and fluid flow rate ranges for the

hydrocarbon well production string.

4. A valve as claimed in claim 2 or claim 3 wherein the upper valve body (404) has a length that depends on at least one of drag part geometry and spacing between the drag part and surrounding structures.

5. A valve as claimed in any of claims 2 to 4 wherein the upper valve body (404) has a length that is in the range of 4 to 20 times the valve size.

6. A valve as claimed in any preceding claim wherein the spring (408) has a spring end seated in a valve body pocket (463), said spring end encircling a pocket sidewall (342; 442), said sidewall having one or more ports (356; 456) for flushing the pocket.

7. A valve as claimed in any preceding claim wherein the drag part (411) comprises a bobbin having a bobbin ring (413) for mating with the shuttle in the first drag part position.

8. A method of protecting a pump (104) in a hydrocarbon well production string (200A) comprising the steps of:

providing a fluid to be lifted and a pump (104) for lifting the fluid;
providing a valve (400A) downstream of the pump, the valve including a valve body (402) with a spill port (428);
a shuttle (410) located in a chamber of the valve body;
the shuttle having a through hole extending between a shuttle spring end (421) and a shuttle end (413) opposing the spring end;
forming a stationery seal when a shuttle closure (414) and a seat (432) extending from the valve body come into contact;
forming a moving seal when a drag part closure (411) and a shuttle seat (481) come into contact;
a spring (408) biasing the shuttle to block the spill port;
the valve passing a flow entering the shuttle through hole at the shuttle spring end; and,
the valve spilling a flow that closes the moving seal.

9. A method as claimed in claim 8 further comprising: providing a rotatable shaft (409) extending through the valve body for operating the pump.

10. A method as claimed in claim 9 wherein the drag part closure (411), has a central bore for accepting the rotatable shaft (409) extending through the valve body, the drag part closure for translating along the rotatable shaft in response to fluid drag.

11. A method as claimed in claim 10 further comprising limiting movement of the drag part closure translating along the rotatable shaft in response to fluid drag within an upper valve body.

12. A method as claimed in claim 11 wherein the upper valve body (404) has a length that depends on at least one of fluid viscosity and fluid flow rate ranges for the hydrocarbon well production string.

13. A method as claimed in claim 11 or claim 12 wherein the upper valve body (404) has a length that depends on at least one of drag part geometry and spacing between the drag part and surrounding structures.

14. A method as claimed in any of claims 8 to 11 wherein the spring (408) has a spring end seated in a valve body pocket (463), said spring end encircling a pocket sidewall (342; 442), said sidewall having one or more ports (356; 456) such that compression of the spring in the pocket causes flushing of the pocket.

15. A valve as claimed in any preceding claim wherein the drag part (411) comprises a bobbin having a bobbin ring (413) for mating with the shuttle.

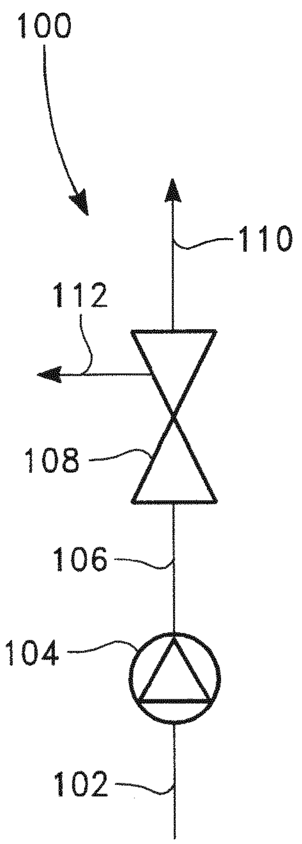


FIG. 1

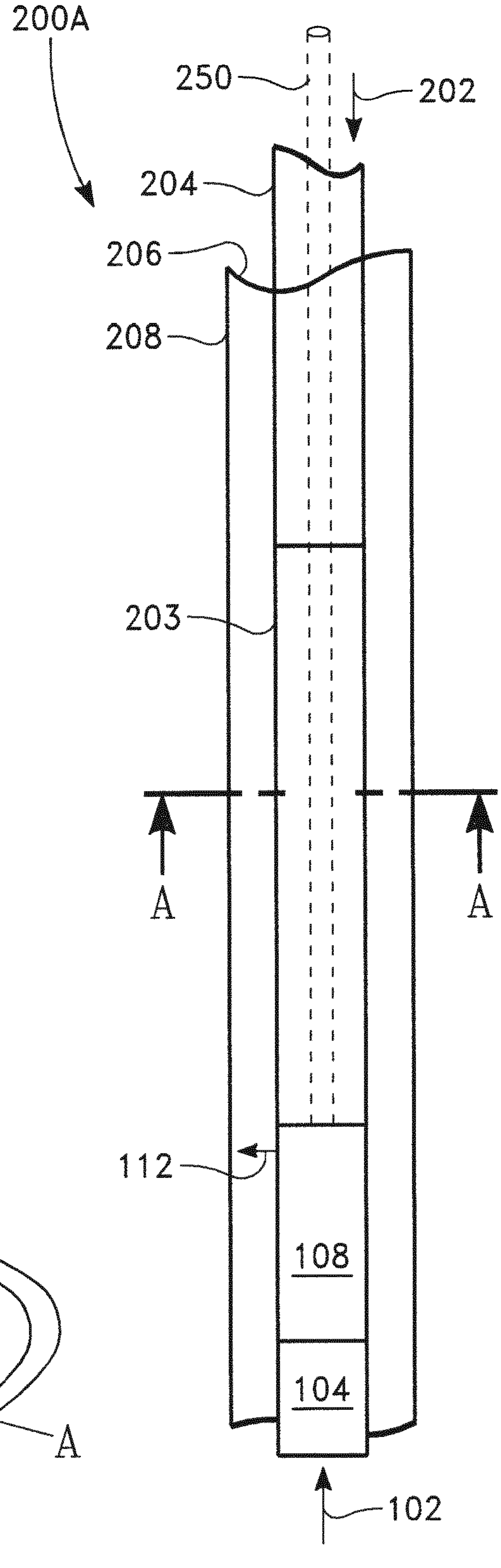


FIG. 2A

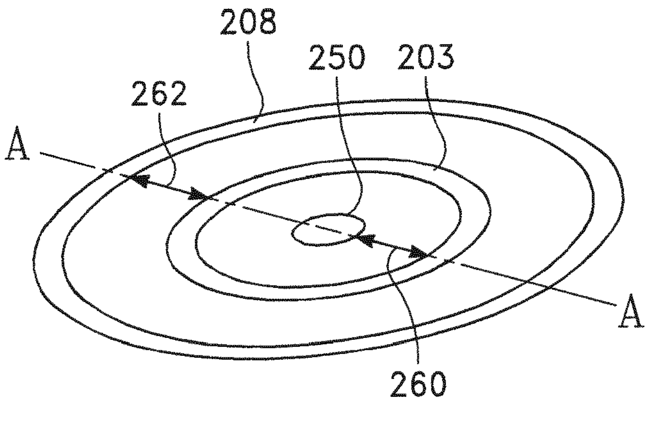


FIG. 2B

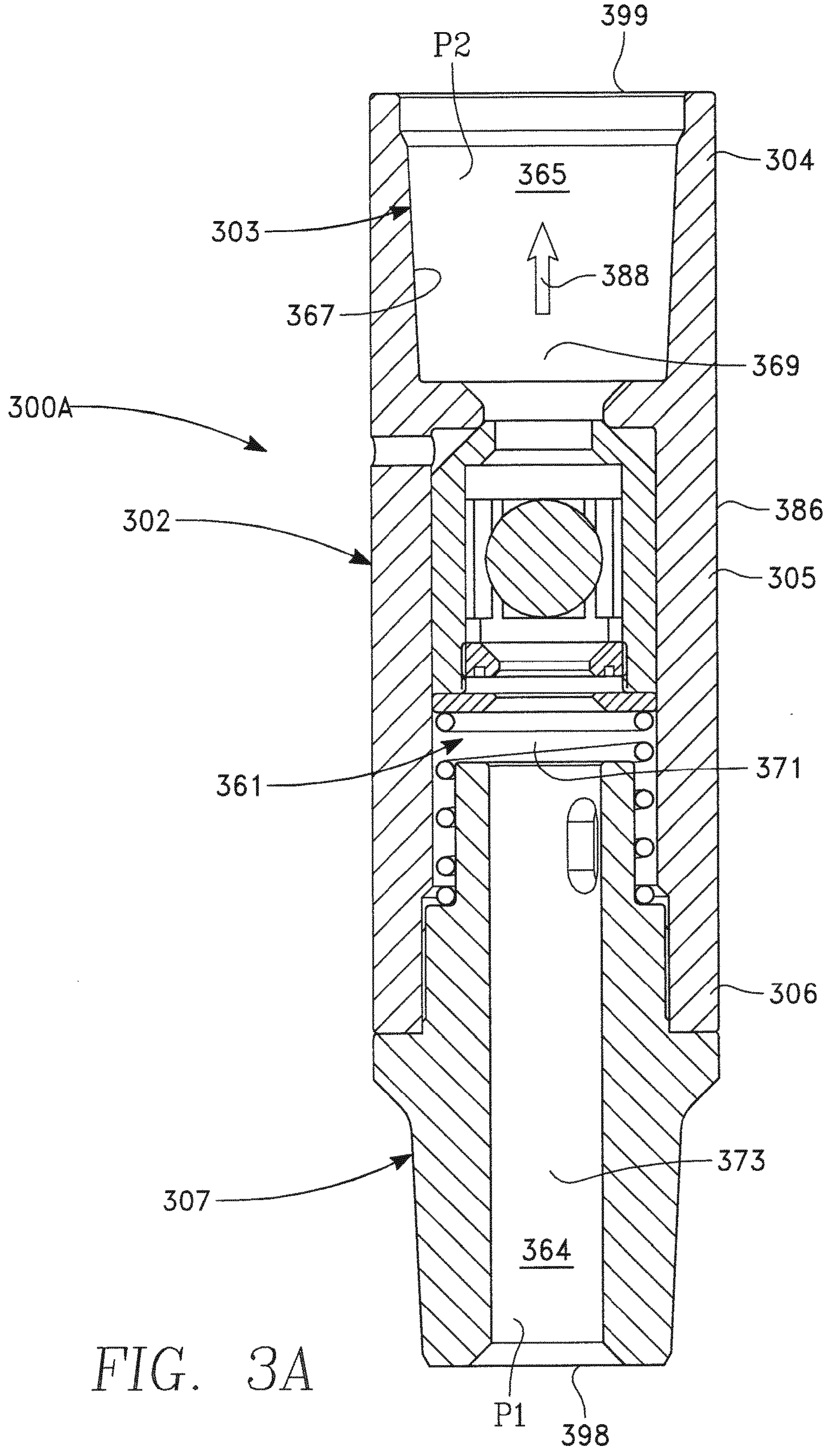

399
P2
365
304
303
388
367
369
300A
386
302
305
361
371
306
373
307
364
P1
398

FIG. 3A

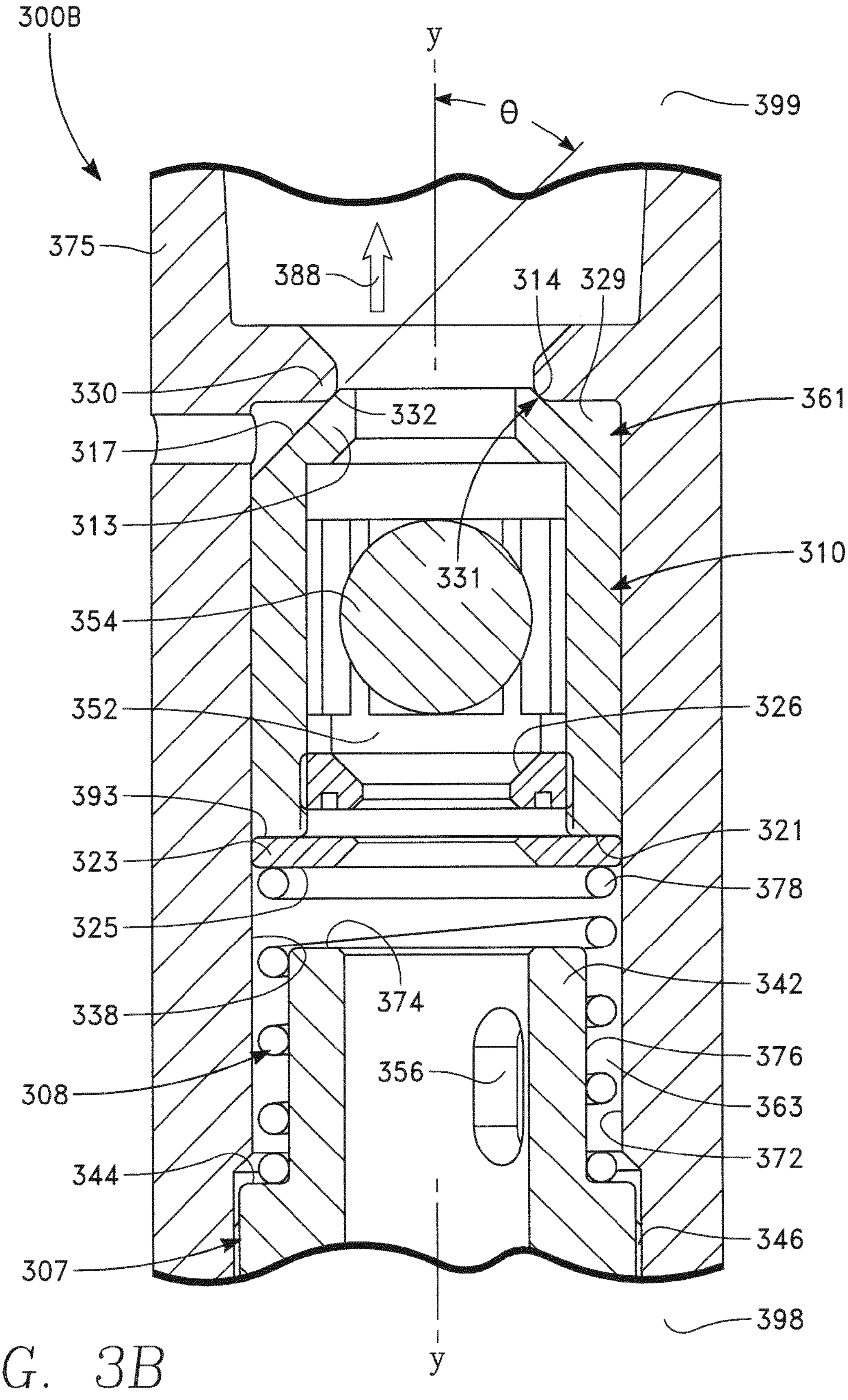

300B
y
θ
399
375
388
314
329
330
332
361
317
313
331
310
354
352
326
393
321
323
378
325
374
342
338
376
356
363
308
372
344
346
307
398
y

FIG. 3B

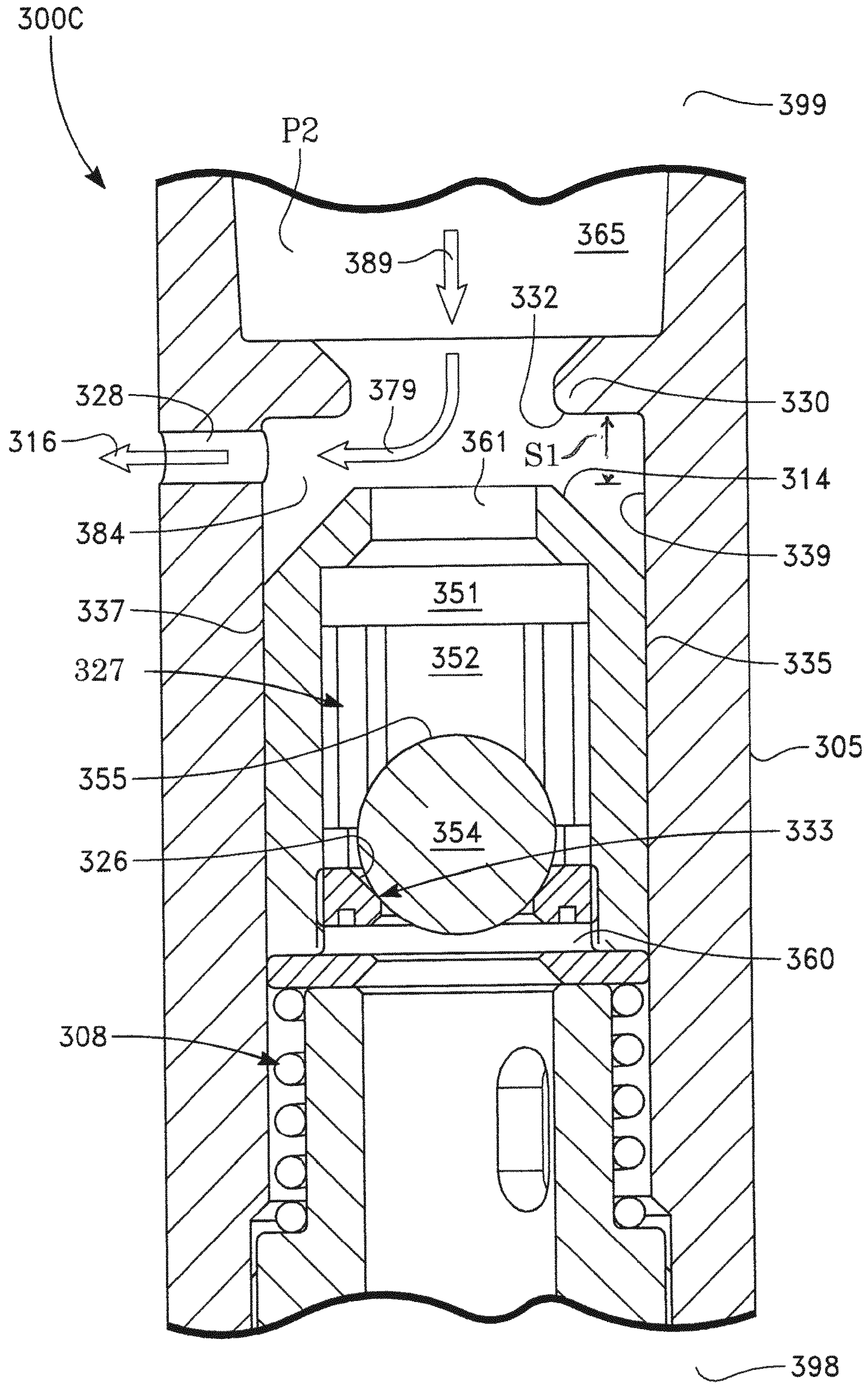

300C
399
P2
365
389
332
328
379
330
316
361
S1
314
384
339
351
337
352
335
327
305
355
354
333
326
360
308
398

FIG. 3C

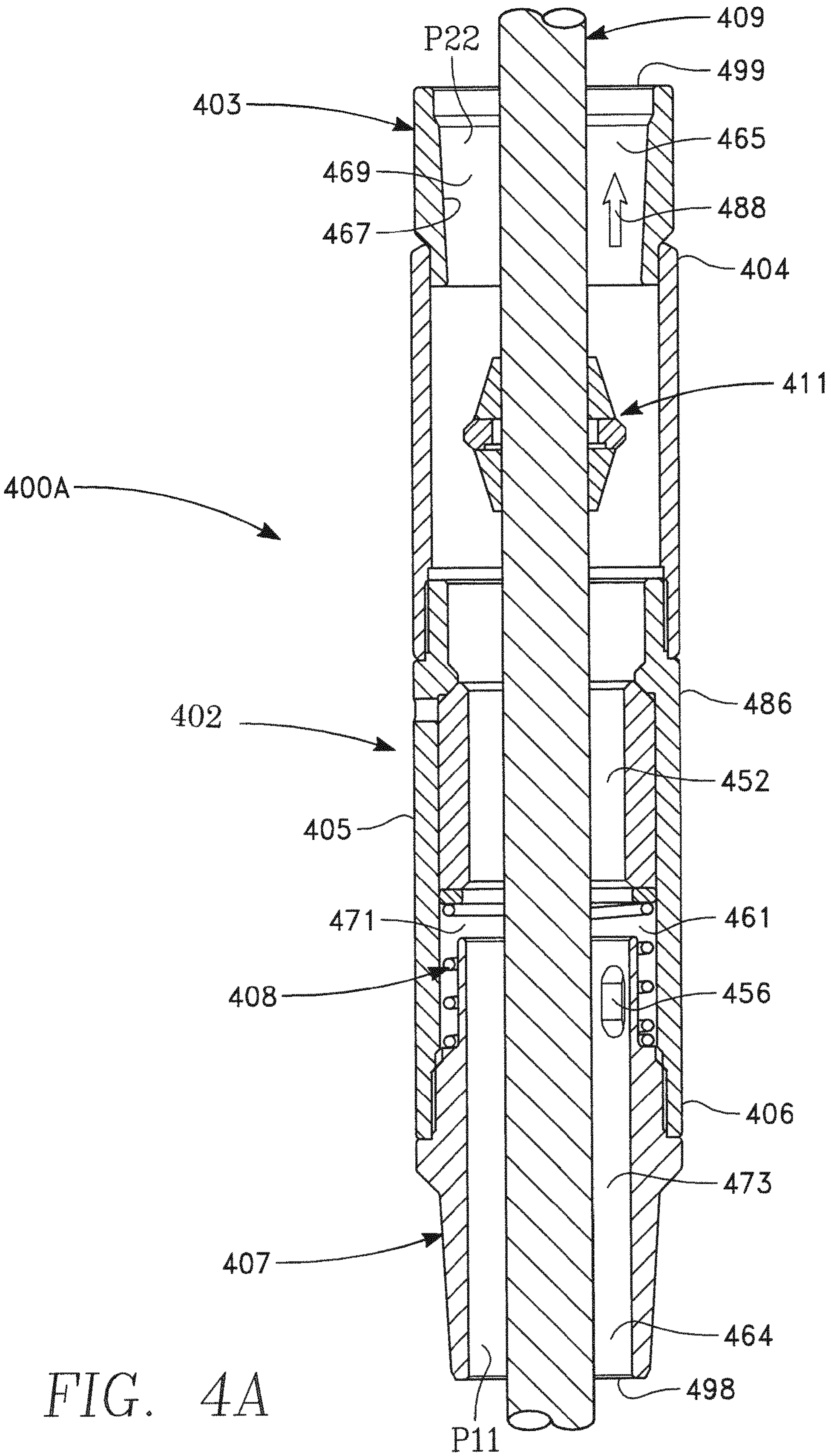

409
P22
499
403
465
469
488
467
404
411
400A
486
402
452
405
471
461
408
456
406
473
407
464
498
P11

FIG. 4A

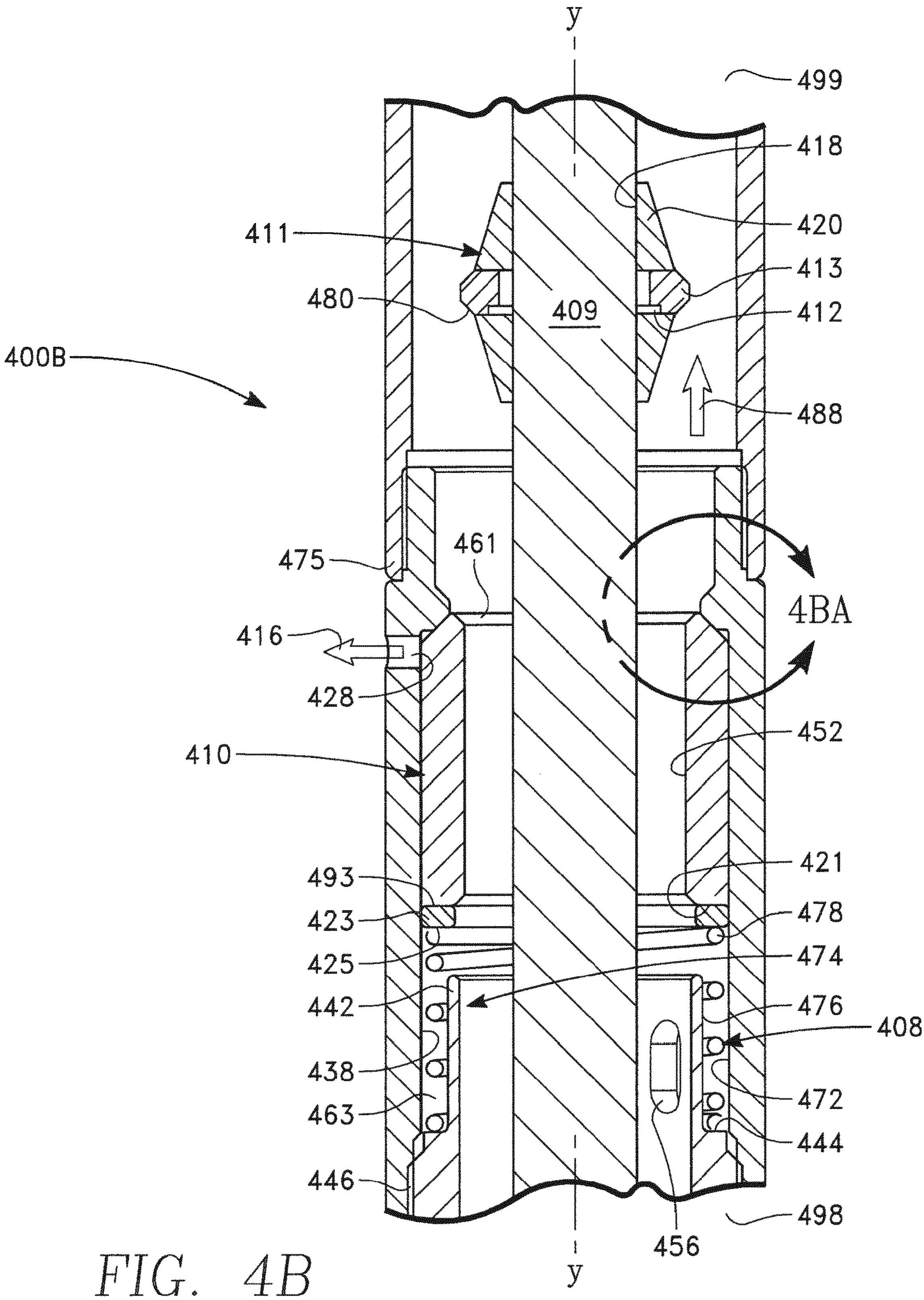

y
499
418
420
411
413
480
409
412
400B
488
475
461
4BA
416
428
452
410
493
421
423
478
425
474
442
476
408
438
472
463
444
446
498
456
y

FIG. 4B

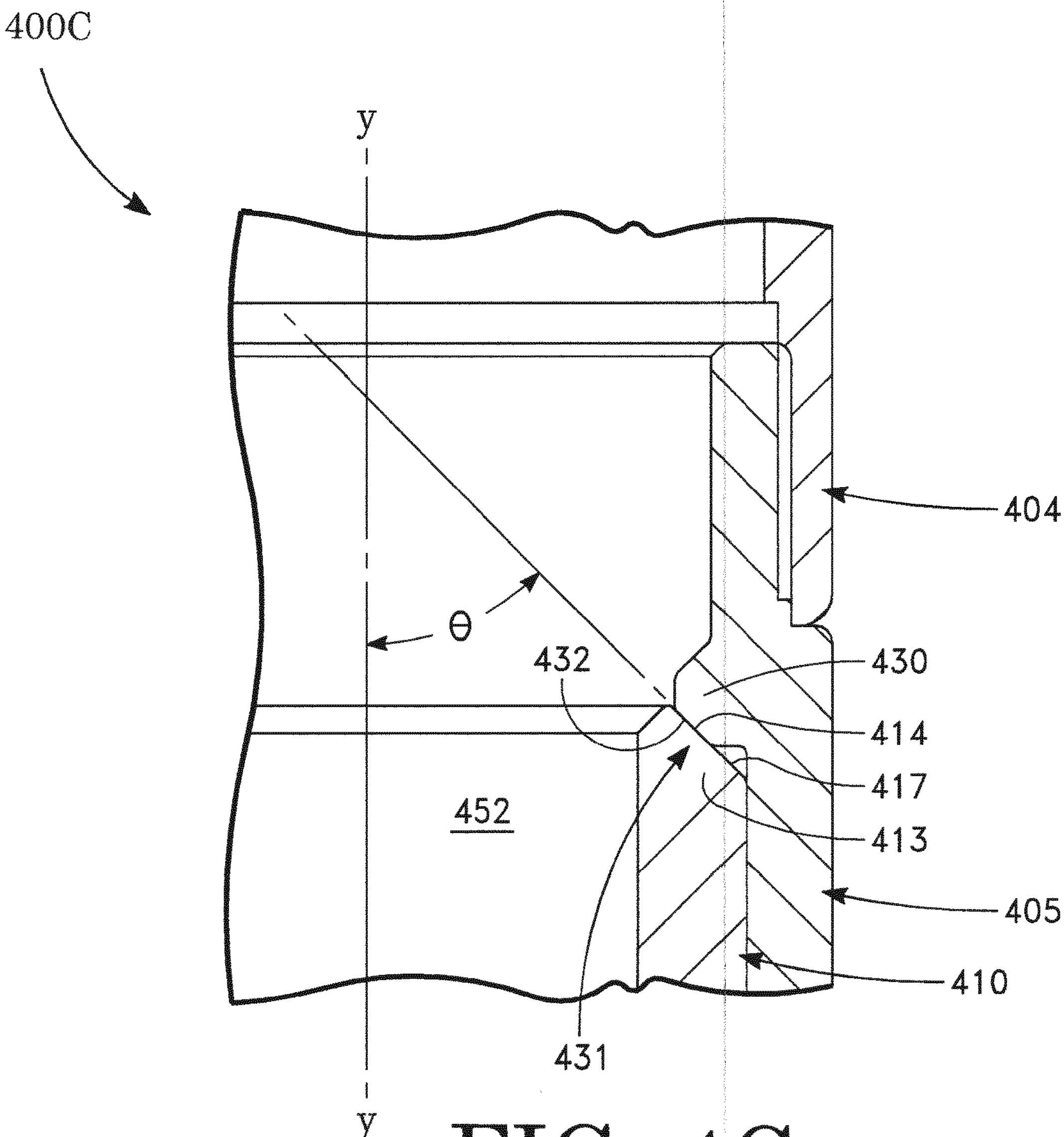


FIG. 4C

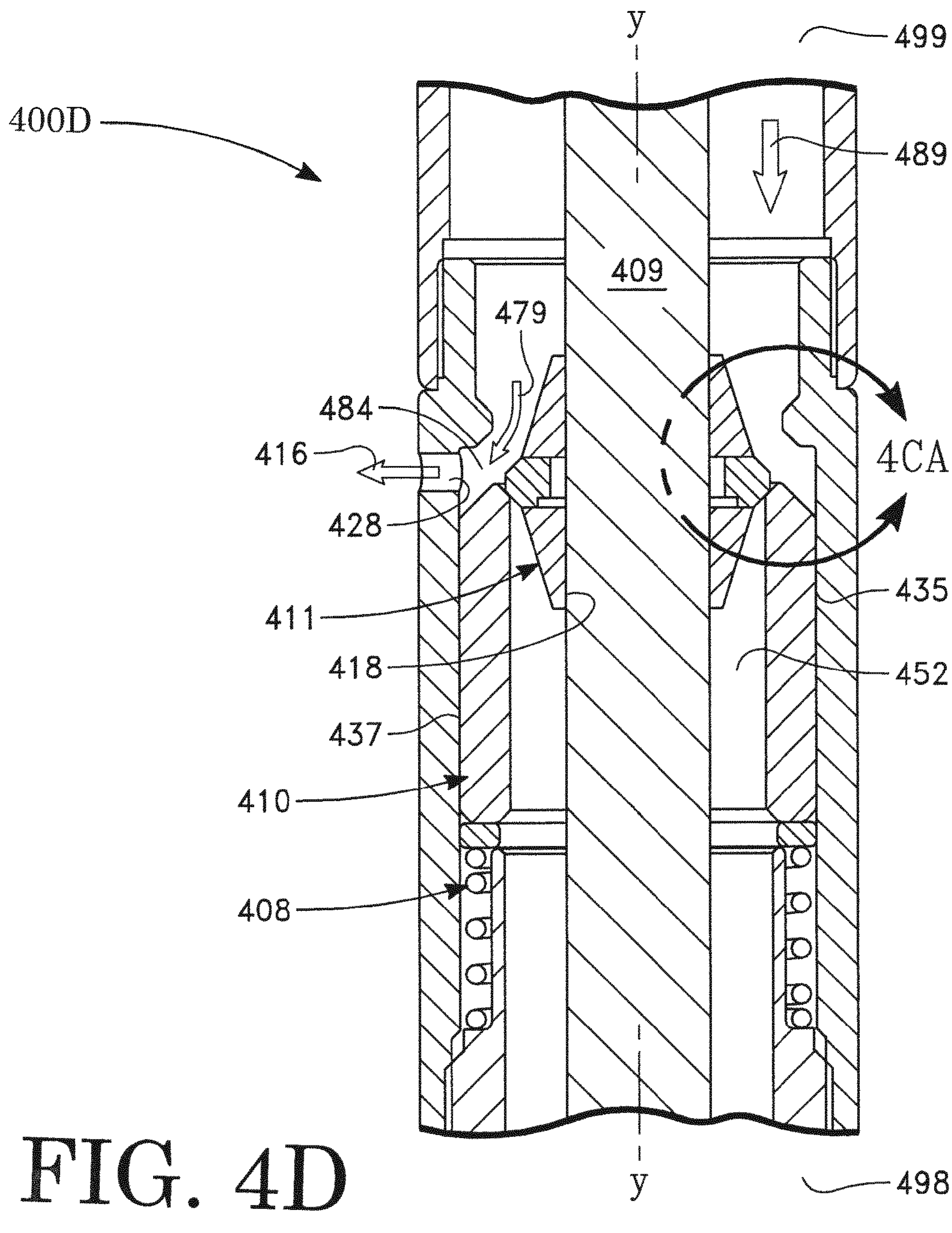

400D
y
499
489
409
479
484
416
4CA
428
411
435
418
452
437
410
408
y
498

FIG. 4D

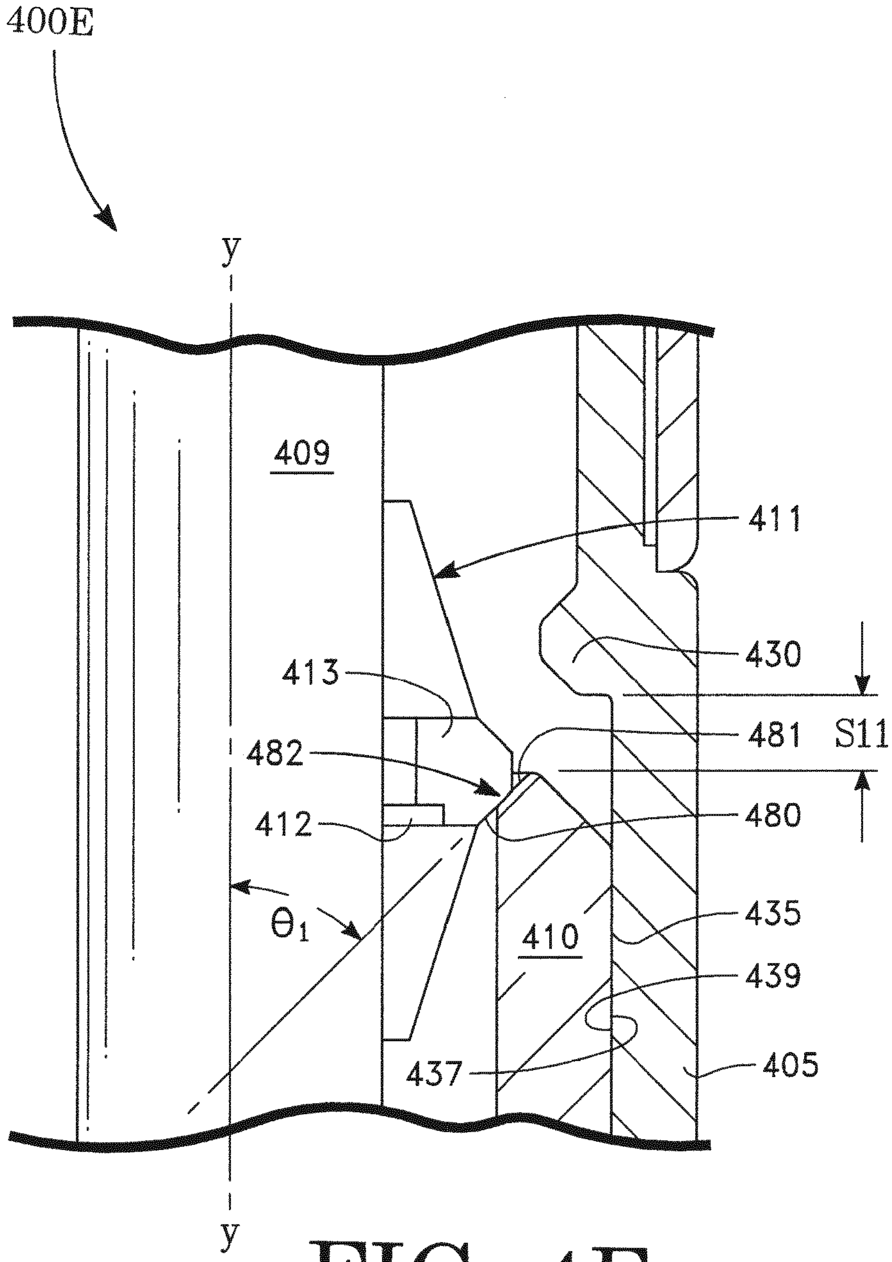

400E
y
409
411
430
413
S11
481
482
480
412
435
θ_1
410
439
437
405
y

FIG. 4E

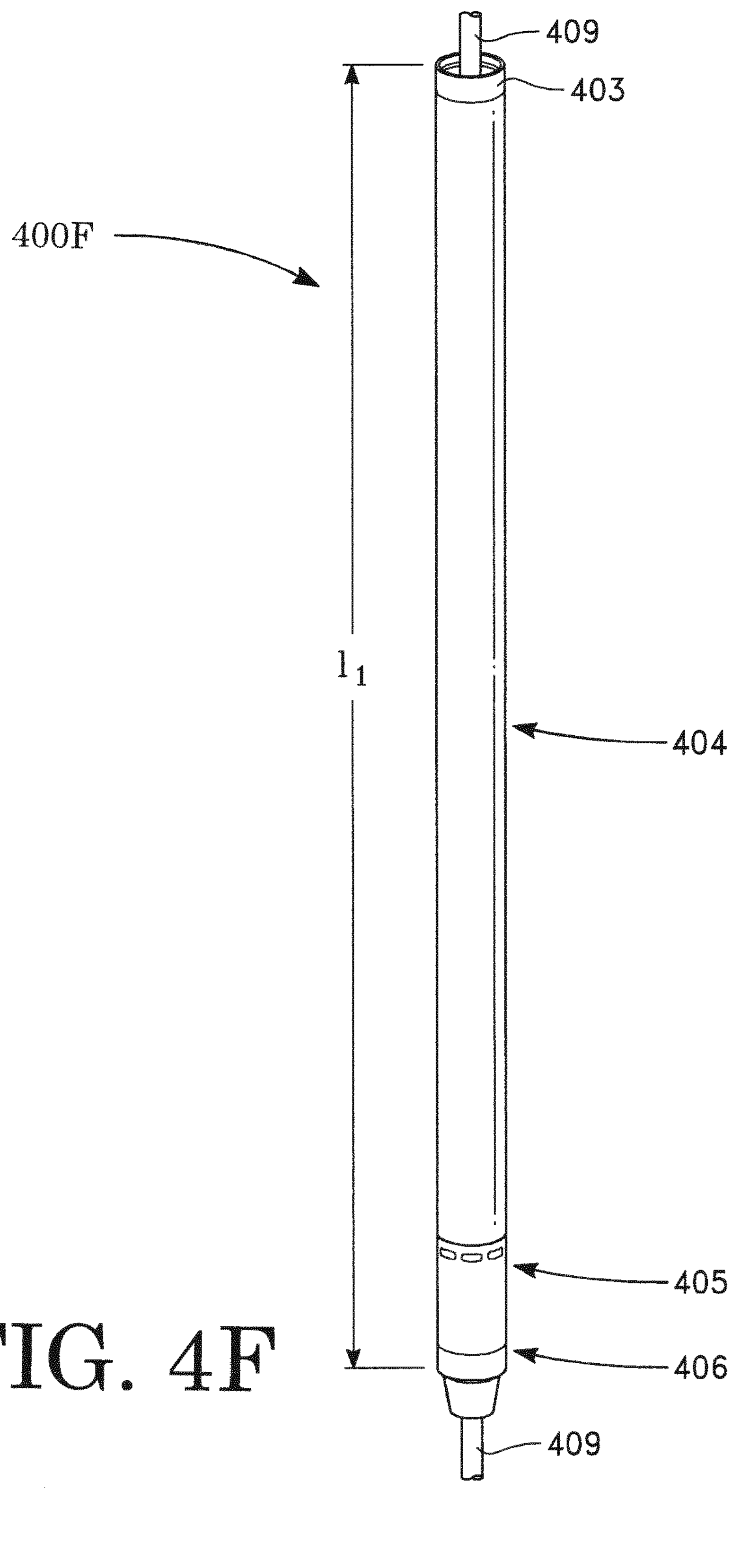
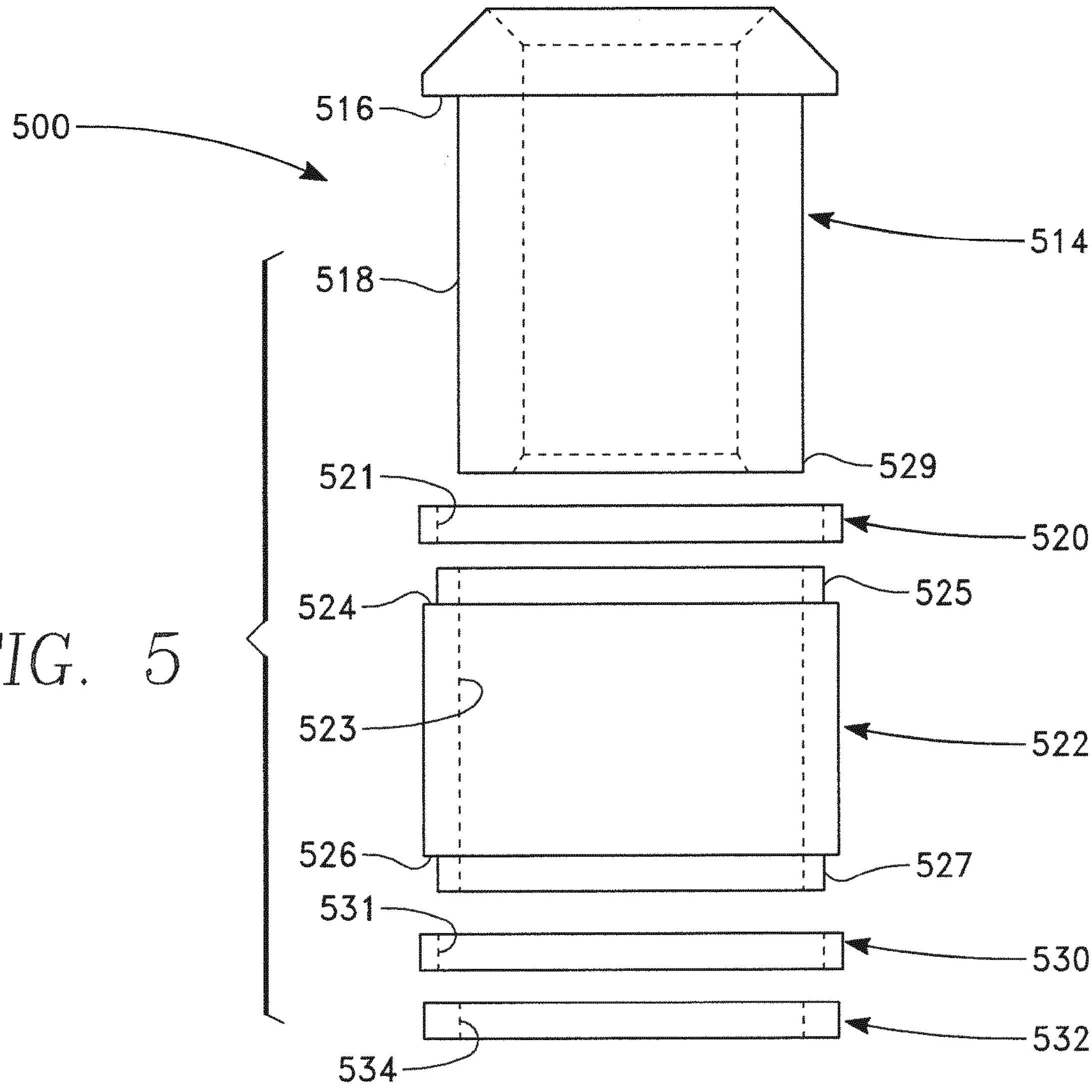
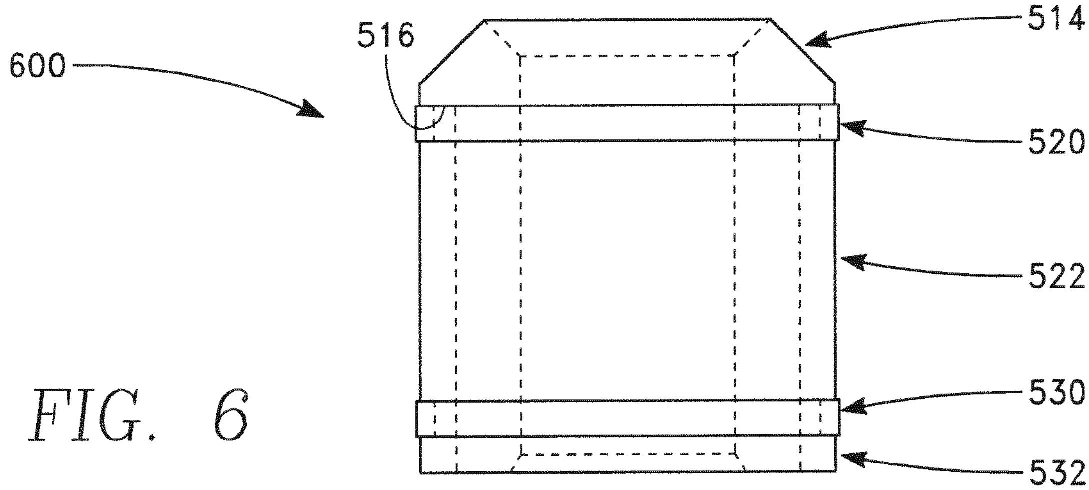


FIG. 4F



500
516
514
518
529
521
520
524
525
523
522
526
527
531
530
532
534

FIG. 5



516
514
600
520
522
530
532

FIG. 6

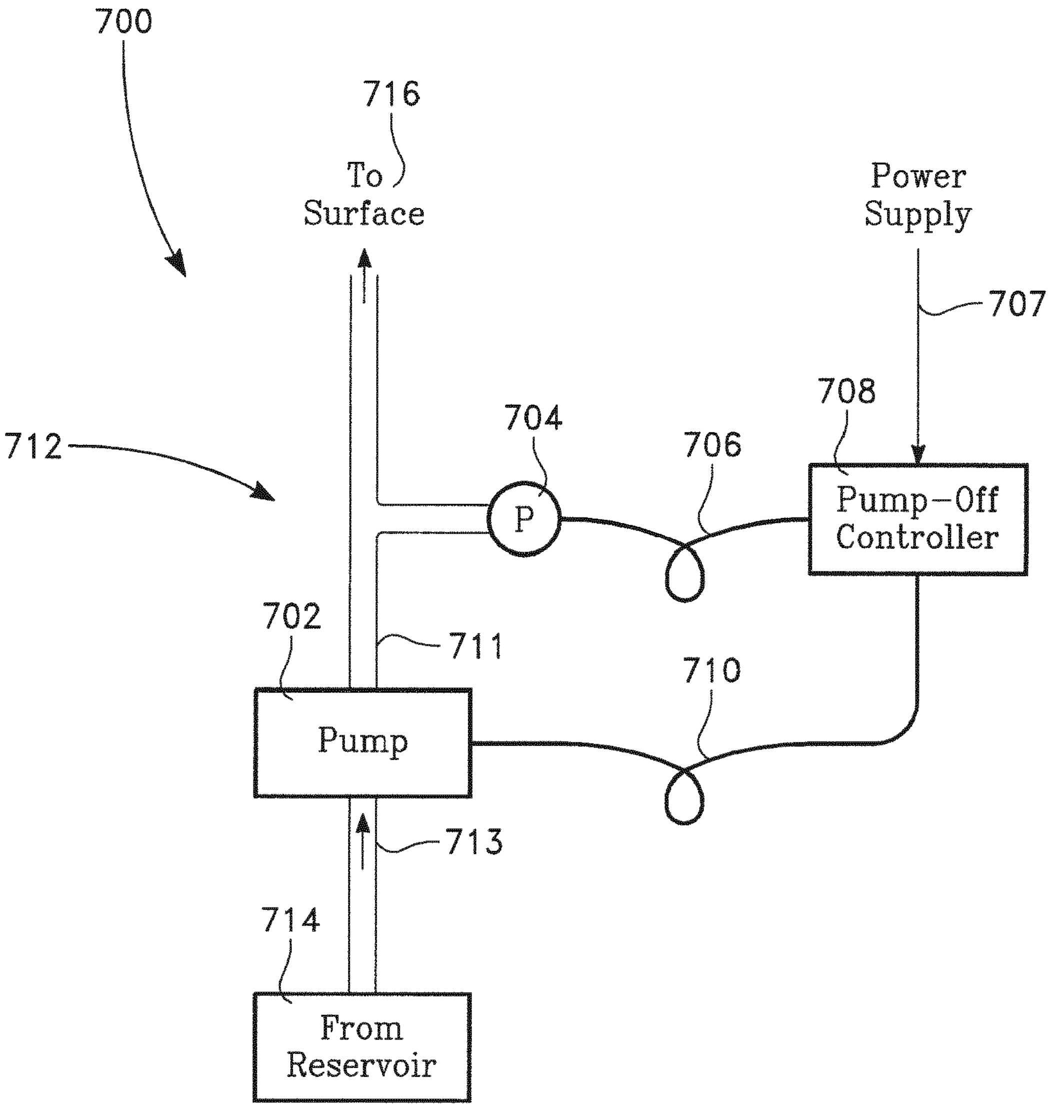

700
716
To
Surface
Power
Supply
707
708
704
706
712
P
Pump-Off
Controller
702
711
710
Pump
713
714
From
Reservoir

FIG. 7

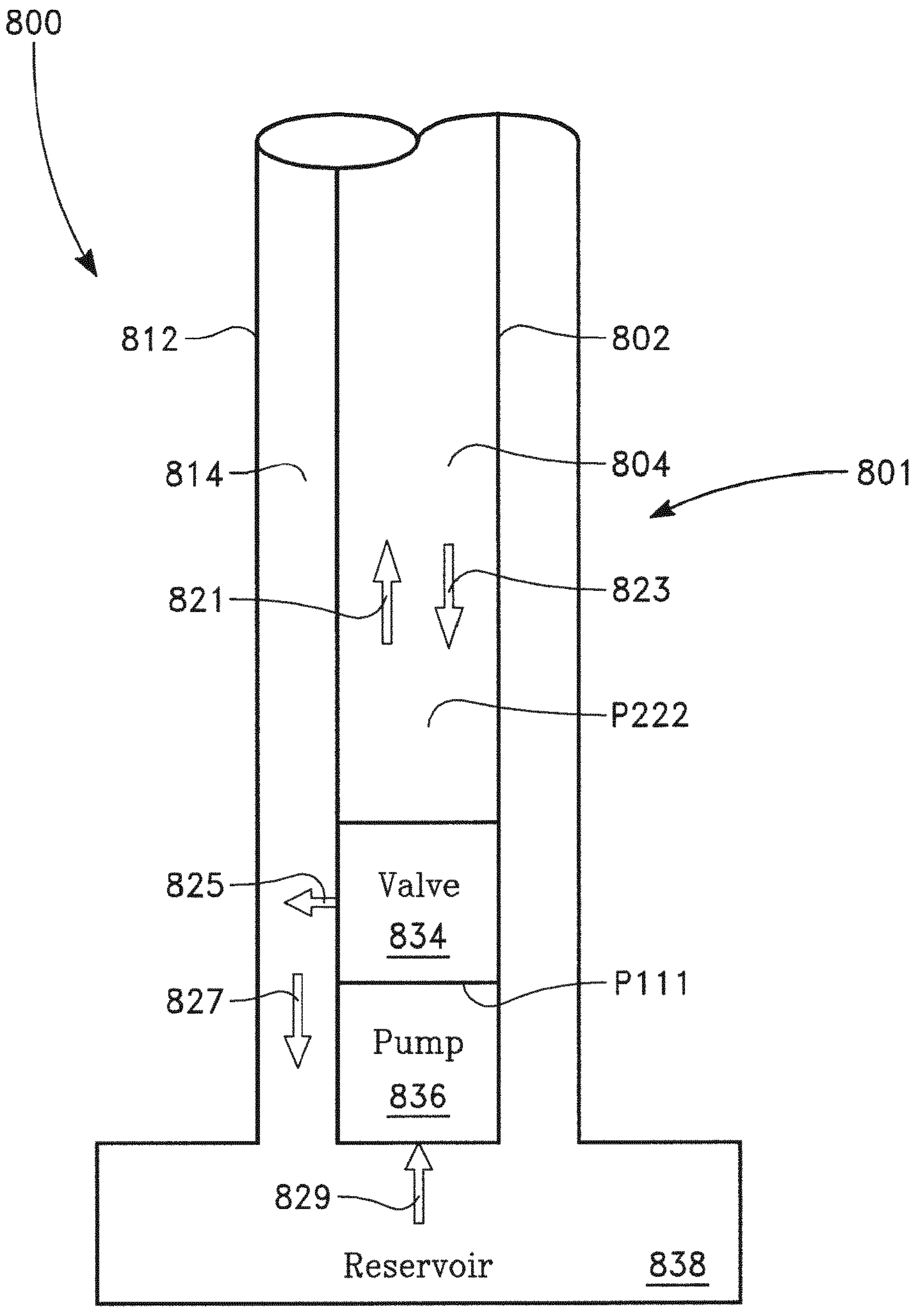

800
812
802
814
804
801
821
823
P222
825
Valve
834
827
P111
Pump
836
829
Reservoir
838

FIG. 8

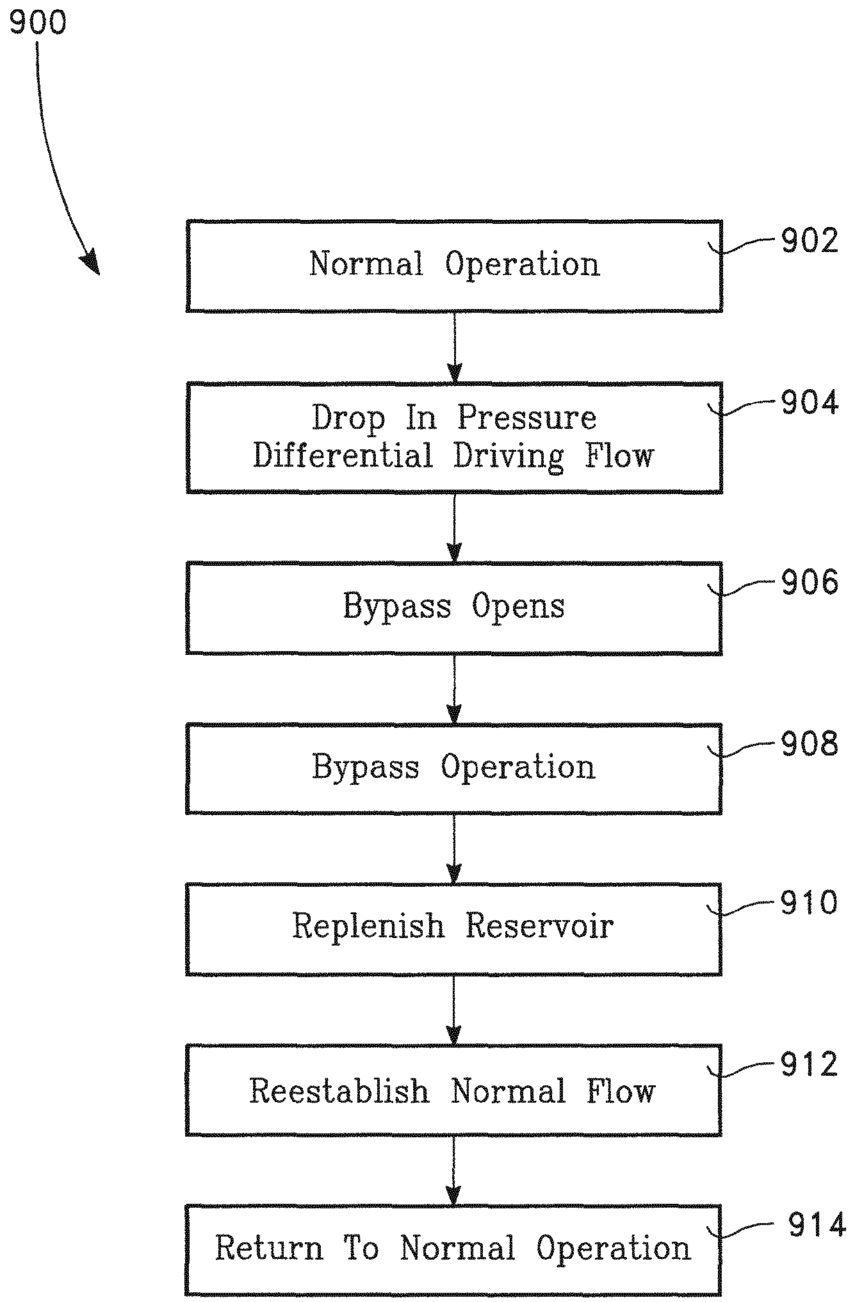

900
Normal Operation
902
Drop In Pressure
Differential Driving Flow
904
Bypass Opens
906
Bypass Operation
908
Replenish Reservoir
910
Reestablish Normal Flow
912
Return To Normal Operation
914

FIG. 9

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 15 7490

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2011/259428 A1 (OSBORNE LAWRENCE [US]) 27 October 2011 (2011-10-27) * figures 1-4, 7-8 * * paragraphs [0011] - [0023], [0046] - [0063] *	1,2, 7-11,15	INV. E21B34/08 E21B43/12
X	US 2011/259438 A1 (OSBORNE LAWRENCE [US]) 27 October 2011 (2011-10-27) * paragraphs [0015], [0020] - [0021], [0044] - [0055]; figures 1-4 *	1,2, 7-11,15	

TECHNICAL FIELDS SEARCHED (IPC)

E21B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	10 July 2020	Brassart, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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