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(54) ARTILLERY WEAPON

(57) An artillery weapon (10) comprising a carriage (100) and an ordnance (200) having a barrel (202) operable to travel between an in-battery position and an out-of-battery position. The artillery weapon (10) further comprises a multifunction cylinder (300) mounted to, and moveable with the ordnance (200). The multifunction cylinder (300) comprises a regulator unit (302) comprising a fluid housing (304) for retaining a working fluid (306), the fluid housing (304) being in fluid communication with a buffer system (308), the buffer system (308) configured to deliver fluid to, and receive fluid from, the fluid housing (304) in response to the barrel (202) moving relative to the carriage (100). The regulator unit fluid housing (304) is in fluid communication with a hydraulic accumulator chamber (310) via a first flow aperture (312). There is also provided an accumulator piston (314) provided in, and operable to move along the accumulator chamber (310). The buffer system (308), regulator unit (302), hydraulic accumulator chamber (310) and first flow aperture (312) are configured such that displacement of the barrel (202) along the barrel axis (204) from an in-battery position to an out-of-battery position causes fluid flow from the buffer system (308) to the fluid housing (304), and thereby causes fluid flow through the first flow aperture (312) into a first accumulator sub-chamber region (316), causing the accumulator piston (314) to move along the accumulator chamber (310) in a first direction and thereby cause gas in a second accumulator sub-chamber region (318) to compress.

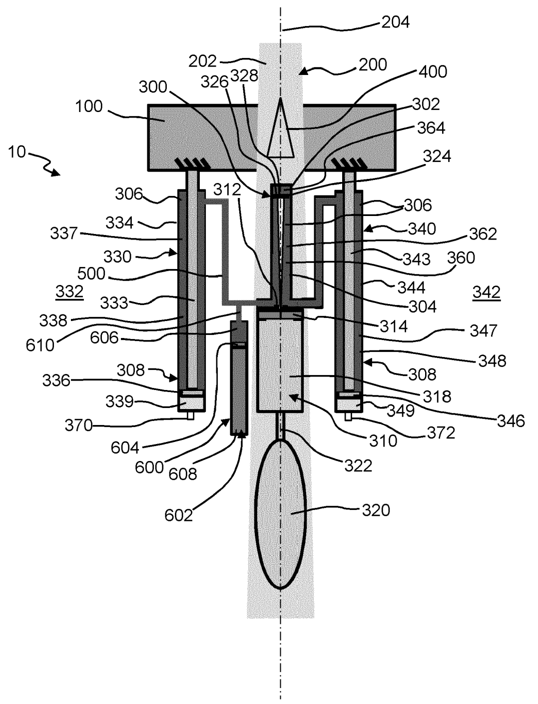

Fig. 1

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Description

FIELD

[0001] The present disclosure relates to an artillery weapon.

[0002] In particular the disclosure is concerned with an artillery weapon with a recoil mitigation system.

BACKGROUND

[0003] It is common for guns, whether towed, fixed, vehicle mounted or otherwise to comprise a recoil system to slow the recoiling ordnance. This slowing over an extended distance reduces the force transmitted to the gun carriage. This attenuation of recoil motion is often performed by hydropneumatic buffers. Conventionally the buffers are mounted to either side of the gun, on the platform (e.g. carriage) that supports the gun.

[0004] It is also common for the recoil system to comprise a recuperator, also mounted to the carriage, which returns the ordnance to its starting position once recoil energy has been dissipated and the ordnance is at the rearward most point in its stroke.

[0005] The buffers comprise flow restrictors to control flow of fluid into and out of the buffers in response to recoil of the gun barrel. If not damping to the same extent, this can cause the damping to be unbalanced and cause a torque which turns the weapon system (and hence the barrel) to one side during firing. This may result in the gun needing to be repositioned before being fired again and/or exerts extra load on the barrel and carriage, reducing their operational life and stability.

[0006] Additionally, conventional systems start to damp the recoil as soon as the weapon is fired (i.e. as soon as the barrel starts to move rearwards and prior to the projectile leaving the barrel), which can cause the barrel to deviate from its set elevation angle, directing the fired projectile off course.

[0007] Hence an artillery weapon which manages recoil such that recoil damping does not cause the weapon system (and hence the barrel) to turn and require to be repositioned before being refired, and which does not cause the barrel to deviate from its set elevation until after the projective being fired has left the barrel, is highly desirable.

SUMMARY

[0008] According to the present disclosure there is provided an apparatus and system as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

[0009] Accordingly there may be provided an artillery weapon (10). The artillery weapon (10) may comprise a carriage (100) and an ordnance (200) having a barrel (202) having a barrel axis (204) extending along the length of the barrel (202). The barrel (202) may be mounted to the carriage (100) such that the barrel (202) is operable to travel along the barrel axis (204) between an in-battery position and an out-of-battery position relative to the carriage (100). The artillery weapon (10) may further comprise a multifunction cylinder (300) mounted to, and moveable with the ordnance (200). The multifunction cylinder (300) may comprise a regulator unit (302) comprising a fluid housing (304) for retaining a working fluid (306), the fluid housing (304) being in fluid communication with a buffer system (308). The regulator unit fluid housing (304) may also be in fluid communication with a hydraulic accumulator chamber (310) via a first flow aperture (312). There may be provided an accumulator piston (314) in, and operable to move along, the accumulator chamber (310) to define a first accumulator sub-chamber region (316) on one side of the accumulator piston (314) and a second accumulator sub-chamber region (318) on the other side of the accumulator piston (314). The buffer system (308), regulator unit (302), hydraulic accumulator chamber (310) and first flow aperture (312) may be configured such that displacement of the barrel (202) along the barrel axis (204) from the in-battery position to the out-of-battery position causes fluid flow from the buffer system (308) to the fluid housing (304), and thereby causes fluid flow through the first flow aperture (312) into the first accumulator sub-chamber region (316), causing the accumulator piston (314) to move along the accumulator chamber (310) in a first direction and thereby cause gas in the second accumulator sub-chamber region (318) to compress.

[0010] The buffer system (308) may be configured to deliver fluid to the fluid housing (304) in response to the barrel (202) moving relative to the carriage (100) when moving from the in-battery position to the out-of-battery position. The buffer system (308) may be configured to receive fluid from the fluid housing (304) in response to the barrel (202) moving relative to the carriage (100) when moving from the out-of-battery position to the in-battery position.

[0011] The barrel (202) may be configured to be displaced along the barrel axis (204) from the in-battery position to the out-of-battery position in response to a projectile (400) being fired from the barrel (202), such that recoil energy of the barrel (202) as it moves from the in-battery position to the out-of-battery position is absorbed by gas in the second accumulator sub-chamber region (318).

[0012] The buffer system (308), regulator unit (302), hydraulic accumulator chamber (310) and first flow aperture (312) may be configured such that pressure of compressed gas in the second accumulator sub-chamber region (318) causes the accumulator piston (314) to move along the accumulator chamber (310) in a second direction opposite to the first direction and thereby causes fluid flow through the first flow aperture (312) from the first accumulator sub-chamber region (316) into the fluid housing (304), causing fluid flow from the fluid housing

(304) into the buffer system (308) to cause displacement of the barrel (202) along the barrel axis (204) from the out-of-battery position to the in-battery position.

[0013] The buffer system (308), regulator unit (302), hydraulic accumulator chamber (310) and first flow aperture (312) may be configured such that the pressure of compressed gas in the second accumulator sub-chamber region (318) causes the accumulator piston (314) to move along the accumulator chamber (310) in a second direction to the in-battery position after recoil motion of the barrel (202) is complete.

[0014] The accumulator chamber (310) may be in fluid communication with a gas reservoir (320) via a flow passage (322), the gas reservoir (320) having a volume configured to limit gas pressure change in the accumulator chamber (310) during recoil to a predetermined value.

[0015] A control rod (324) may extend from the accumulator piston (314) from the first accumulator sub-chamber region (316) through the first flow aperture (312) into the fluid housing (304). The control rod (324) may be moveable with the accumulator piston (314). The control rod (324) may increase in diameter along its length from the accumulator piston (314). The diameter of the control rod (324) may be smaller than the cross-sectional area of the first flow aperture (312) along at least some of the stroke of the accumulator piston (314) such that as the control rod (324) moves relative to the first flow aperture (312) from the fluid housing (304) into the first accumulator sub-chamber region (316), the flow area around the control rod (324) decreases to thereby increase resistance to flow of fluid from the fluid housing (304) into the first accumulator sub-chamber region (316).

[0016] The fluid housing (304) may define a fluid housing chamber (360) for retaining the working fluid (306). A control rod support piston (326) may be mounted to the control rod (324) in, and operable to move along, the fluid housing chamber (360), to define a first fluid housing sub-chamber region (362) on one side of the control rod piston (326) and a second fluid housing sub-chamber region (364) on the other side of the control rod support piston (326). The control rod support piston (326) may be spaced apart from the accumulator piston (314) along the length of the control rod (324). The control rod support piston (326) may define passages (328) for the regulation of fluid flow between the first fluid housing sub-chamber region (362) and the second fluid housing sub-chamber region (364).

[0017] The buffer system (308) may comprise a first plain buffer (330) mounted to the carriage (100) on a first side (332) of the ordnance (200) and a second plain buffer (340) mounted to the carriage (100) on a second side (342) of the ordnance (200) each of the first plain buffer (330) and second plain buffer (340) being hydro pneumatic and comprising a buffer cylinder (334, 344) and a buffer piston (336, 346) slideable within/relative to the buffer cylinder (334, 344). The first plain buffer cylinder (334) and second plain buffer cylinder (344) may be in fluid communication with the fluid housing (304). Movement of the ordnance (200) relative to the carriage (100) from the in-battery position to the out-of-battery position may result in movement of each buffer cylinder (334, 344) relative to its respective buffer piston (336, 346) to cause fluid flow from the buffer system (308) to the fluid housing (304). Movement of the ordnance (200) relative to the carriage (100) from the out-of-battery position to the in-battery position may result in movement of each buffer cylinder (334, 344) relative to its respective buffer piston (336, 346) to permit fluid flow from the fluid housing (304) to the buffer system (308).

[0018] Each buffer cylinder (334, 344) may be mounted to, and operable to move with, the barrel (202) and each buffer piston (336, 346) may be mounted to the carriage (100).

[0019] Each buffer piston (336, 346) may be mounted to, and operable to move with, the barrel (202) and each buffer cylinder (334, 344) may be mounted to the carriage (100).

[0020] The buffer cylinder (334, 344) of each of the first plain buffer (330) and second plain buffer (340) may define a buffer chamber (337, 347). The buffer piston (336, 346) in each of the first plain buffer (330) and second plain buffer (340) may be provided in, and operable to move along the respective buffer cylinder (334, 344) to define a first buffer sub-chamber (338, 348) on one side of the buffer piston (336, 346) and a second buffer sub-chamber (339, 349) on the other side of the buffer piston (336, 346). Each first buffer sub-chamber (338, 348) may be in fluid communication with the fluid housing (304).

[0021] Each second buffer sub chamber (339, 349) may be open to atmosphere via a port (370, 372).

[0022] The second buffer sub chamber (339, 349) may be closed and configured to be in fluid communication with a source (700) of pressurised fluid, such that flow of pressurised fluid into the second buffer sub chamber (339, 349) causes movement of the ordnance (200) relative to the carriage (100) from the in-battery position to the out-of-battery position.

[0023] The weapon (10) may further comprise a free recoil auxiliary cylinder (600) which defines a free recoil chamber (602). A free recoil piston (604) may be provided in, and operable to move along the free recoil chamber (602) to define a first recoil sub-chamber (606) on one side of the free recoil piston (604) and a second recoil sub-chamber (608) on the other side of the second free recoil piston (604). The first recoil sub-chamber (606) may define a second fluid flow aperture (610) and the second fluid flow aperture (610) may be in fluid communication with the fluid housing (304) such that movement of the ordnance (200) relative to the carriage (100) from the in-battery position to the out-of-battery position results in movement of the free recoil piston (604) relative to the free recoil auxiliary cylinder (600) to permit fluid flow into to the free recoil chamber (602).

[0024] The second recoil sub-chamber (608) may contain a compressible fluid to provide a resistance to motion of the free recoil piston (604) as the free recoil piston (604) moves along the free recoil chamber (602), the compressible fluid increasing in pressure as the free recoil piston (604) moves along the free recoil chamber (602) such that the force acting on the free recoil piston (604) increases as the free recoil piston (604) moves along the free recoil chamber (602) to increase the resistance to fluid flow into the first recoil sub-chamber (606).

[0025] When the pressure in the second recoil sub-chamber (608) is below a predetermined level and/or while the free recoil piston (604) is moving relative to the free recoil chamber (602), there may be no fluid flow from the fluid housing (304) into the first accumulator sub-chamber region (316). When the pressure in the second recoil sub-chamber (608) increases to above a predetermined level and/or the free recoil piston (604) stops moving relative to the free recoil chamber (602), fluid may flow from the fluid housing (304) into the first accumulator sub-chamber region (316).

[0026] The predetermined pressure level may be set to a value based on a function of mass of the ordnance (200).

[0027] The buffer system (308), fluid housing (304) of the multifunction cylinder (300) and the first recoil sub-chamber (606) may be fluidly linked by a fluid manifold (500).

[0028] Hence there is provided an artillery weapon which manages recoil such that the barrel does not deviate from its aimed position set elevation until after the projective being fired has left the barrel, and in which damping does not cause the barrel to move and require to be reset before being refired.

[0029] This is enabled by regulation of fluid flow from the buffer system being provided on the barrel (i.e. in a single location) rather than (as in examples of the related art) the buffer system itself (i.e. in two locations - namely on each of the buffers). This ensures damping provided by the buffer system does not apply a torque to the barrel, and so it is not forced to one side or the other during recoil, such that the position of the barrel does not need to be reset before being fired again.

[0030] Additionally the provision of an free recoil auxiliary cylinder enables the projectile to leave the gun barrel before recoil starts to be damped, ensuring the barrel remains at its desired orientation and elevation to direct the projectile as desired by the user.

BRIEF DESCRIPTION OF THE FIGURES

[0031] Embodiments of the invention will now be described by way of example only with reference to the figures, in which:

Figure 1 shows a plan view of a **first example** of an artillery weapon according to the present disclosure in an in-battery position;

Figure 2 shows a plan view of an artillery weapon of figure 1 at the end of free recoil;

Figure 3 shows a plan view of an artillery weapon of figure 1 in an out-of-battery position;

Figure 4 shows a plan view of a **second example** of an artillery weapon according to the present disclosure in an in-battery position;

Figure 5 shows a plan view of a **third example** of an artillery weapon according to the present disclosure in an in-battery position;

Figure 6 shows a plan view of a **fourth example** of an artillery weapon according to the present disclosure in an in-battery position;

DETAILED DESCRIPTION

[0032] The present disclosure relates to an artillery weapon 10. Various examples of the artillery weapon 10 of the present disclosure are shown in the figures. Figures 1 to 3 shows a plan view of a first example of an artillery weapon according to the present disclosure in different operational states. Figure 4 shows a plan view of a second example of an artillery weapon, in the same state as the first example as shown in figure 1. Figure 5 shows a plan view of a third example of an artillery weapon according to the present disclosure, in the same state as the first example as shown in figure 1. Figure 6 shows a plan view of a fourth example of an artillery weapon according to the present disclosure, in the same state as the first example as shown in figure 1.

[0033] Each example of the artillery weapon 10 comprises a carriage 100 and an ordnance 200 having a barrel 202. Although not shown in the figures, the carriage 100 may comprise, or be carried on, a platform for moving the artillery weapon 10, supported from the ground by wheels for transporting the artillery weapon from one location to another.

[0034] The barrel 202 has a barrel axis 204 extending along the length of the barrel 202. That is, the bore of the barrel 202 is centred on the barrel axis 204. The barrel 202 is mounted to the carriage 100 such that the barrel 202 is operable to travel along the barrel axis 204 between an in-battery position and an out-of-battery position relative to the carriage 100. That is to say, the barrel 202 is configured to be displaced along the barrel axis 204 from the in-battery position to the out-of-battery position in response to a projectile 400 being fired from the barrel 202.

[0035] *"In-battery"* defines a forward position of the ordnance 200 before (and ready for) firing. The *"in-battery"* configuration/state of the different examples is shown in figures 1, 4, 5, 6. *"Out-of-battery"* defines a position of the ordnance 200 when fully recoiled, e.g. after firing. The *"out-of-battery"* configuration/state is shown in figure 3. Hence when fired the cannon moves (i.e. recoils) from an *"in-battery"* position (as shown in figure 1) along the barrel axis 204 to an *"out-of-battery"* position (as shown in figure 3). The cannon is then moved from the *"out-of-battery"* position back along the barrel axis

204 to the *"in-battery"* position in order to fire again. The examples of figures 4, 5, 6 work in the same way.

[0036] The artillery weapon 10 comprises a multifunction cylinder 300 mounted to, and moveable with the ordnance 200. The multifunction cylinder 300 comprises a regulator unit 302. The regulator unit 302 has a fluid housing 304 for retaining a working fluid 306.

[0037] The fluid housing 304 is in fluid communication with a buffer system 308. The buffer system 308 is configured to deliver fluid to the fluid housing 304 in response to the barrel 202 moving relative to the carriage 100 when moving from the in-battery position to the out-of-battery position. The buffer system 308 is also configured to receive fluid from the fluid housing 304 in response to the barrel 202 moving relative to the carriage 100 when moving from the out-of-battery position to the in-battery position.

[0038] The regulator unit fluid housing 304 is in fluid communication with a hydraulic accumulator chamber 310 via a first flow aperture 312. An accumulator piston 314 is provided in, and operable to move along the accumulator chamber 310, to define a first accumulator sub-chamber region 316 on one side of the accumulator piston 314 and a second accumulator sub-chamber region 318 on the other side of the accumulator piston 314.

[0039] The buffer system 308, regulator unit 302, hydraulic accumulator chamber 310 and first flow aperture 312 are configured such that displacement of the barrel 202 along the barrel axis 204 from the in-battery position to the out-of-battery position causes fluid flow from the buffer system 308 to the fluid housing 304, and thereby causes fluid flow through the first flow aperture 312 into the first accumulator sub-chamber region 316, which in turn causes the accumulator piston 314 to move along the accumulator chamber 310 in a first direction and thereby cause gas in the second accumulator sub-chamber region 318 to compress.

[0040] Hence the volume of the first accumulator sub-chamber region 316 and second accumulator sub-chamber region 318 are defined in dependence on the position of the accumulator piston 314 along the accumulator chamber 310.

[0041] The accumulator piston 314 defines a fluid seal between the first accumulator sub-chamber region 316 and second accumulator sub-chamber region 318. Hence the first accumulator sub-chamber region 316 and second accumulator sub-chamber region 318 are fluidly isolated from one another.

[0042] The first flow aperture 312 may be provided as a single orifice in a plate between the regulator unit 302 and accumulator piston 314. Alternatively the first flow aperture 312 may comprise a series of plates, each with an orifice, which define a series of chambers defined by the plates and orifices (orifices same or different sizes), between the regulator unit 302 and accumulator piston 314.

[0043] A control rod 324 extends from the accumulator piston 314 from the first accumulator sub-chamber region 316 through the first flow aperture 312 into the fluid housing 304. The diameter of the control rod 324 is smaller than the cross-sectional area of the first flow aperture 312 along at least some of the stroke of the accumulator piston 314. That is to say the diameter of the control rod 324 is smaller than the cross-sectional area of the first flow aperture 312 along at least some of the length of the control rod 324. The control rod 324 is moveable with the accumulator piston 314. The control rod 324 increases in diameter along its length from the accumulator piston 314.

[0044] Hence as the control rod 324 moves relative to the first flow aperture 312 from the fluid housing 304 into the first accumulator sub-chamber region 316, the flow area around the control rod 324 decreases to thereby increase resistance to flow of fluid from the fluid housing 304 into the first accumulator sub-chamber region 316 thereby maintaining flow resistance through aperture 312 at the appropriate level as the speed of the recoiling mass slows during the recoil stroke..

[0045] Hence the interaction of the control rod 324 and first flow aperture 312 provides a throttling arrangement for the flow of working fluid during movement of the barrel 202 from the in-battery position to the out-of-battery position.

[0046] The fluid housing 304 defines a fluid housing chamber 360 for retaining the working fluid 306. In some examples, as shown in the figures, a control rod support piston 326 is mounted to the control rod 324 in, and operable to move along, the fluid housing chamber 360, to define a first fluid housing sub-chamber region 362 on one side of the control rod piston 326 and a second fluid housing sub-chamber region 364 on the other side of the control rod support piston 326.

[0047] The buffer system 308, regulator unit 302, hydraulic accumulator chamber 310 and first flow aperture 312 may be configured such that pressure of compressed gas in the second accumulator sub-chamber region 318 causes the accumulator piston 314 to move along the accumulator chamber 310 in a second direction opposite to the first direction and thereby causes fluid flow through the first flow aperture 312 from the first accumulator sub-chamber region 316 into the fluid housing 304, causing fluid flow from the fluid housing 304 into the buffer system 308. Flow in this direction may be un-damped, by allowing it to flow through a larger orifice adjacent to the control orifice. This larger orifice is closed when fluid moves in the first direction, in the manner of a non-return valve. Thus, when recoil is complete, this results in displacement of the barrel 202 along the barrel axis 204 from the out-of-battery position to the in-battery position.

[0048] The first direction and second direction are parallel to the barrel axis 204, and opposite to one another.

[0049] Hence the buffer system 308, regulator unit 302, hydraulic accumulator chamber 310 and first flow aperture 312 are configured such that the pressure of compressed gas in the second accumulator sub-chamber region 318 causes the accumulator piston 314 to move along the accumulator chamber 310 in a second direction to the in-battery position after recoil motion of the barrel 202 is complete.

[0050] The multifunction cylinder 300 thus is configured to act as both the regulator for the buffer system as well as providing a recuperator.

[0051] The recuperator functionality is provided by the second accumulator sub-chamber region 318 which, after recoil, causes the working fluid to flow from the first accumulator sub-chamber region 316 back to the buffer system to cause the ordnance 200 to return to battery.

[0052] The accumulator chamber 310 is in fluid communication with a gas reservoir 320 via a flow passage 322. The gas reservoir 320 has a volume configured to limit gas pressure change in the accumulator chamber 310 during recoil to a predetermined value.

[0053] In examples where present, the control rod support piston 326 is spaced apart from the accumulator piston 314 along the length of the control rod 324. The control rod support piston 326 defines passages 328 for the regulation of fluid flow between the first fluid housing sub-chamber region 362 and the second fluid housing sub-chamber region 364. The passages 328 may be configured to allow free passage of fluid. Alternatively the passages 328 may be configured to provide damping to the movement of the control rod 324, and hence the ordnance, for example to prevent a hard stop when the ordnance returns to battery.

[0054] The buffer system 308 comprises a first plain buffer 330 mounted to the carriage 100 on a first side 332 of the ordnance 200 and a second plain buffer 340 mounted to the carriage 100 on a second side 342 of the ordnance 200. That is to say, the buffer system 308 comprises a first plain buffer 330 mounted to the carriage 100 on a first side 332 of the barrel axis 204 and a second plain buffer 340 mounted to the carriage 100 on a second side 342 of the barrel axis 204.

[0055] The first plain buffer 330 and second plain buffer 340 may be mounted in the same plane, wherein the plane may intersect the barrel axis 204 or be offset from the barrel axis 204.

[0056] Each of the first plain buffer 330 and second plain buffer 340 may be hydro pneumatic.

[0057] Each of the first plain buffer 330 and second plain buffer 340 may be a buffer cylinder 334, 344 and a buffer piston 336, 346 slideable within/relative to the buffer cylinder 334, 344. As shown in the figures, a piston rod 333, 343 may extend from each of the pistons 336, 346. The first plain buffer cylinder 334 and second plain buffer cylinder 344 are in fluid communication with the fluid housing 304.

[0058] In the examples of figures 1 to 4, the first plain buffer cylinder 334 and second plain buffer cylinder 344 are in fluid communication with the fluid housing 304 via inlets 384, 386 which feed directly in into the first plain buffer cylinder 334 and second plain buffer cylinder 344 respectively.

[0059] In the examples of figures 5, 6, the first plain buffer cylinder 334 and second plain buffer cylinder 344 are in fluid communication with the fluid housing 304 via flow passages 380, 382 which extend along the buffer piston rods 333, 343 respectively.

[0060] Hence in all examples, the apparatus is configured such that movement of the ordnance 200 relative to the carriage 100 from the in-battery position to the out-of-battery position results in movement of each buffer cylinder 334, 344 relative to its respective buffer piston 336, 346 to cause fluid flow from the buffer system 308 to the fluid housing 304.

[0061] The buffer cylinder 334, 344 of each of the first plain buffer 330 and second plain buffer 340 define a buffer chamber 337, 347. The buffer piston 336, 346 in each of the first plain buffer 330 and second plain buffer 340 is provided in, and operable to move along the respective buffer chamber 336, 346 to define a first buffer sub-chamber 338, 348 on one side of the buffer piston 336, 346 and a second buffer sub-chamber 339, 349 on the other side of the buffer piston 336, 346, and each first buffer sub-chamber 338, 348 is in fluid communication with the fluid housing 304.

[0062] Hence the volume of each first buffer sub-chamber 338, 348 and each second buffer sub-chamber 339, 349 are defined in dependence on the position of the respective piston 336, 346 relative to the respective cylinder 334, 344.

[0063] Each buffer cylinder 334, 344 defines a fluid seal between each first buffer sub-chamber 338, 348 and each second buffer sub-chamber 339, 349. Hence each first buffer sub-chamber 338, 348 and each second buffer sub-chamber 339, 349 are fluidly isolated from one another.

[0064] In some examples, as shown in figures 1 to 4, each buffer cylinder 334, 344 is mounted to, and operable to move with, the barrel 202 and each buffer piston 336, 346 is mounted (e.g. coupled / fixed) to the carriage 100. In such examples each buffer piston 336, 346 is mounted (e.g. coupled / fixed) to the carriage 100 via their respective piston rod 333, 343. In other examples, for example as shown in figures 5, 6, each buffer piston 336, 346 is mounted to, and operable to move with, the barrel 202 and each buffer cylinder 334, 344 is mounted (e.g. coupled / fixed) to the carriage 100. In such examples each buffer piston 336, 346 is mounted (e.g. coupled / fixed) to the barrel 202 via their respective piston rod 333, 343.

[0065] That is to say, the apparatus of the present disclosure comprises two buffer cylinders arranged on opposite sides of the ordnance. In the examples of figures 1 to 4 the buffer pistons 336, 346 are mounted to the gun carriage (e.g. via their respective piston rods 333, 343), whereas the buffer cylinders are mounted to the ordnance and move with the ordnance as it travels between the in-battery position and out-of-battery position and back again. In the examples of figures 5, 6 the buffer cylinders are fixed to the carriage, whereas the buffer pistons 336, 346 fixed to the ordnance (e.g. via their respective piston rods 333, 343) and move with the ordnance as it travels between the in-battery position and out-of-battery position and back again.

[0066] The apparatus is thus configured such that movement of the ordnance 200 relative to the carriage 100 from the out-of-battery position to the in-battery position results in movement of each buffer cylinder 334, 344 relative to its respective buffer piston 336, 346 to permit fluid flow from the fluid housing 304 to the buffer system 308.

[0067] In the examples of figures 1 to 3 and figure 5, each second buffer sub chamber 339, 349 is open to atmosphere via a port 370, 372. That is to say, in the examples of figures 1 to 4 and figure 5, each second buffer sub chamber 339, 349 is configured to exhaust air to atmosphere, or intake air from the atmosphere, via the port 370, 372.

[0068] In the examples of figures 4, 6, the second buffer sub chamber 339, 349 is closed and configured to be in fluid communication with a source 700 of pressurised fluid, such that flow of pressurised fluid into the second buffer sub chamber 339, 349 causes movement of the ordnance 200 relative to the carriage 100 from the in-battery position to the out-of-battery position.

[0069] In the example of figure 4, the second buffer sub chamber 339, 349 is in fluid communication with the source 700 of pressurised fluid via a flow inlet 706 which feeds a flow passage 702 provided in the piston rod 333, 343, such that flow of pressurised fluid into the second buffer sub chamber 339, 349 via the flow inlet 706 and flow passage 702 causes movement of the ordnance 200 relative to the carriage 100 from the in-battery position to the out-of-battery position.

[0070] In the example of figure 6, the second buffer sub chamber 339, 349 is in fluid communication with the source 700 of pressurised fluid via a flow inlet 706 which directly feeds the buffer sub chambers 339, 349 such that flow of pressurised fluid into the second buffer sub chamber 339, 349 via the flow inlet 706 causes movement of the ordnance 200 relative to the carriage 100 from the in-battery position to the out-of-battery position.

[0071] That is to say, in the examples of figures 4, 6, the buffers are linked to a separate hydraulic system which can be used to draw the ordnance out-of-battery, for example to shorten the artillery weapon for transport and/or storage of the gun. The separate hydraulic system is compensated as appropriate to account for oil drawn into the buffers on recoil.

[0072] As shown in each example of the figures, the weapon apparatus 10 may further comprise a free recoil auxiliary cylinder 600 which defines a free recoil chamber 602. A free recoil piston 604 is provided in, and operable to move along the free recoil chamber 602 to define a first recoil sub-chamber 606 on one side of the free recoil piston 604 and a second recoil sub-chamber 608 on the other side of the second free recoil piston 604.

[0073] Hence the volume of the first recoil sub-chamber 606 and second recoil sub-chamber 608 are defined in dependence on the position of the free recoil piston 604 along the free recoil chamber 602.

[0074] The free recoil piston 604 defines a fluid seal between the first recoil sub-chamber 606 and second recoil sub-chamber 608. Hence the first recoil sub-chamber 606 and second recoil sub-chamber 608 are fluidly isolated from one another.

[0075] The first recoil sub-chamber 606 may define a second fluid flow aperture 610 and the second fluid flow aperture 610 may be in fluid communication with the fluid housing 304.

[0076] In all examples, the buffer system 308, fluid housing 304 of the multifunction cylinder 300 and the first recoil sub-chamber 606 are fluidly linked by a fluid manifold 500.

[0077] That is to say, the buffer system 308, fluid housing 304 of the multifunction cylinder 300 and the first recoil sub-chamber 606 are in fluid communication via the fluid manifold 500, such that a pressure change in one cylinder of the system causes change in pressure for all cylinders.

[0078] Hence movement of the ordnance 200 relative to the carriage 100 from the in-battery position to the out-of-battery position results in movement of the free recoil piston 604 relative to the free recoil auxiliary cylinder 600 to permit fluid flow into to the free recoil chamber 602.

[0079] The second recoil sub-chamber 608 may contains a compressible fluid to provide a resistance to motion of the free recoil piston 604 as the free recoil piston 604 moves along the free recoil chamber 602, the compressible fluid increasing in pressure as the free recoil piston 604 moves along the free recoil chamber 602 such that the force acting on the free recoil piston 604 increases as the free recoil piston 604 moves along the free recoil chamber 602 to increase the resistance to fluid flow into the first recoil sub-chamber 606.

[0080] The pressure in the second recoil sub-chamber 608 may be below a predetermined level and/or while the free recoil piston 604 is moving relative to the free recoil chamber 602, there is no fluid flow from the fluid housing 304 into the first accumulator sub-chamber region 316.

[0081] When the pressure in the second recoil sub-chamber 608 increases to above a predetermined level and/or the free recoil piston 604 stops moving relative to the free recoil chamber 602, fluid flows from the fluid housing 304 into the first accumulator sub-chamber region 316.

[0082] The predetermined pressure level is set to a value based on a function of mass of the ordnance 200. Hence the pressure in the free-recoil cylinder is a function of the mass of the recoiling/moveable components (e.g. the ordnance plus the mass of all the parts of the recoil system that move with it). The predetermined pressure level chosen to be sufficiently low so as to require less force to compress (i.e. move piston 604) it than force required to move piston 314. With such an arrangement, the free recoil auxiliary cylinder 600 and free recoil piston 604 thereby a system by which working fluid from the buffers can flow undamped, thereby allowing the ordnance to move undamped during the initial part of a recoil stroke of the ordnance. Thus damping only starts when the free recoil piston 604 stops moving relative to the free recoil chamber 602. The capacity of the free recoil auxiliary cylinder 600 is chosen such that the projectile has left the gun barrel before the recoil piston 604 stops moving relative to the free recoil chamber 602, and hence before the barrel recoil starts to be damped, ensuring the barrel remains at its desired orientation and elevation to direct the projectile as desired by the user.

[0083] Hence, as shown on figures 1 to 3 (and as equally applies to the examples of figures 4, 5, 6), on firing of a projectile 400 the barrel 202 moves from the in-battery position (as shown in figure 1) to the out-of-battery position (as shown in figure 3) which results in movement of each buffer cylinder 334, 344 relative to its respective buffer piston 336, 346 to cause fluid flow from the buffer system 308 to the fluid housing 304 and manifold 500. This in turn causes the free recoil piston 604 to move relative to the free recoil auxiliary cylinder 600 to permit fluid flow into to the free recoil chamber 602, as shown in figure 2. Hence during this stage there is no fluid flow from the fluid housing 304 into the first accumulator sub-chamber region 316.

[0084] When the pressure in the second recoil sub-chamber 608 increases to above the predetermined level and/or the free recoil piston 604 stops moving relative to the free recoil chamber 602 (which is timed to be after the projectile 400 has exited the barrel 202), fluid flows from the fluid housing 304 into the first accumulator sub-chamber region 316 to move the accumulator piston 314 in the first direction, and the recoil energy of the barrel 202 is absorbed by gas in the second accumulator sub-chamber region 318 as it is compressed by the movement of the accumulator piston 314 and by energy lost to heat as the fluid is forced through orifice 312.

[0085] When recoil is complete (as shown in figure 3), the pressure of compressed gas in the second accumulator sub-chamber region 318 causes the accumulator piston 314 to move along the accumulator chamber 310 in the second direction, thereby displacing fluid from the first accumulator sub-chamber region 316 back into the fluid manifold 500 and buffer system 308 to allow the barrel 202 to return to the in-battery position.

[0086] The configuration of the apparatus of the present disclosure enables for the management of recoil such that the barrel is not caused to move during firing, and therefore improves accuracy during firing and avoids the need for the position of the barrel and/or weapon as a whole to be reset before being refired.

[0087] This is enabled by employment of the free recoil period which allows the ordnance to recoil without with a minimal degree of resistance. This means that a minimal load is applied to the gun structure and therefore it is subject to a minimal deflection prior to shot exit.

[0088] Throttling of both buffers in a single location (i.e. by the first flow aperture 312 of the multifunction cylinder 300 on the barrel) results in the recoil load for a symmetrically balanced recoiling mass being balanced symmetrically between the two buffers. This is because the two buffers are not subject to inevitable imbalances in throttling, as would occur if a separate throttle is provided in each buffer (as in examples of the prior art).

[0089] Put another way, throttling in a single location (i.e. by the first flow aperture 312 of the multifunction cylinder 300 on the barrel) means that the torque which will be applied to the weapon system (e.g. a gun carriage) is of a more predictable nature, as it is only a function of recoiling mass Centre of Gravity position, not of buffer throttling imbalance between two separately throttled buffers. This predictability may allow for fine adjustment of recoiling mass Centre of Gravity position.

[0090] If the recoiling mass is balanced perfectly symmetrically between the two buffers, then throttling in a single location, according to the arrangement of the present disclosure, means that the two buffers are loaded equally, as they are not subject to the inevitable imbalances of a separate throttle in each buffer.

[0091] If the recoiling mass is not balanced perfectly symmetrically between the two buffers, then throttling in a single location, according to the arrangement of the present disclosure, means that the torque which will be applied to the gun carriage is of a more predictable nature, as it is only a function of recoiling mass CoG position, not of buffer throttling imbalance between two separately throttled buffers. This predictability may allow for fine adjustment of recoiling mass CoG position to correct that imbalance.

[0092] Additionally throttling in only one location simplifies manufacture and maintenance.

[0093] Additionally the provision of a free recoil auxiliary cylinder enables the projectile to leave the gun barrel before recoil starts to be damped, ensuring the barrel remains at its desired orientation and elevation to direct the projectile as desired by the user.

[0094] The artillery weapon of the present disclosure also provides for variable damping throughout the recoil stroke of the barrel so that the recoil force remains approximately constant as the speed of the recoiling ordnance decreases.

[0095] The artillery weapon of the present disclosure is further advantageous as a substantial part of the recoil system (e.g. the multifunction cylinder 300, and parts of the buffer system 308 for example the buffer cylinders 334, 344 or buffer pistons 336, 346) is mounted on the recoiling ordnance, which thereby increases it recoiling mass and hence reduces recoil force on the carriage. That is to say the arrangement of the present disclosure allows a larger proportion of recoil system to be recoiled, thus increasing recoiling mass and reducing recoil force.

[0096] The use of a pneumatic recuperator driven by buffer fluid avoids the need for fragile compensator bladders to account for buffer oil volume changes.

[0097] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0098] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0099] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0100] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An artillery weapon comprising:

a carriage and an ordnance having a barrel having a barrel axis extending along the length of the barrel, the barrel mounted to the carriage such that the barrel is operable to travel along the barrel axis between an in-battery position and an out-of-battery position relative to the carriage;
the artillery weapon further comprising a multifunction cylinder mounted to, and moveable with the ordnance; wherein the multifunction cylinder comprises:

a regulator unit comprising a fluid housing for retaining a working fluid, the fluid housing being in fluid communication with a buffer system,
the regulator unit fluid housing also being in fluid communication with a hydraulic accumulator chamber via a first flow aperture;
an accumulator piston being provided in, and operable to move along the accumulator chamber to define a first accumulator sub-chamber region on one side of the accumulator piston and a second accumulator sub-chamber region on the other side of the accumulator piston;
the buffer system, regulator unit, hydraulic accumulator chamber and first flow aperture configured such that displacement of the barrel along the barrel axis from the in-battery position to the out-of-battery position causes fluid flow from the buffer system to the fluid housing, and thereby causes fluid flow through the first flow aperture into the first accumulator sub-chamber region, causing the accumulator piston to move along the accumulator chamber in a first direction and thereby cause gas in the second accumulator sub-chamber region to compress.

2. An artillery weapon as claimed in claim 1 wherein the buffer system is configured to deliver fluid to the fluid housing in response to the barrel moving relative to the carriage when moving from the in-battery position to the out-of-battery position; and the buffer system is configured to receive fluid from the fluid housing in response to the barrel moving relative to the carriage when moving from the out-of-battery position to the in-battery position.

3. An artillery weapon as claimed in claim 1 or claim 2 wherein the barrel is configured to be displaced along the barrel axis from the in-battery position to the out-of-battery position in response to a projectile being fired from the barrel, such that recoil energy of the barrel as it moves from the in-battery position to the out-of-battery position is absorbed by gas in the second accumulator sub-chamber region.

4. An artillery weapon as claimed in any one of claims 1 to 3 wherein the buffer system, regulator unit, hydraulic accumulator chamber and first flow aperture are configured such that pressure of compressed gas in the second accumulator sub-chamber region causes the accumulator piston to move along the accumulator chamber in a second direction opposite to the first direction and thereby causes fluid flow through the first flow aperture from the first accumulator sub-chamber region into the fluid housing, causing fluid flow from the fluid housing into the buffer system to cause displacement of the barrel along the barrel axis from the out-of-battery position to the in-battery position.

5. An artillery weapon as claimed in claim 4 when dependent on claim 3 wherein the buffer system, regulator unit, hydraulic accumulator chamber and first flow aperture are configured such that the pressure of compressed gas in the second accumulator sub-chamber region causes the accumulator piston to move along the accumulator chamber in a second direction to the in-battery position after recoil motion of the barrel is complete.

6. An artillery weapon as claimed in any one of the preceding claims wherein the accumulator chamber is in fluid communication with a gas reservoir via a flow passage, the gas reservoir having a volume configured to limit gas pressure change in the accumulator chamber during recoil to a predetermined value.

7. An artillery weapon as claimed in any one of the preceding claims wherein a control rod extends from the accumulator piston from the first accumulator sub-chamber region through the first flow aperture into the fluid housing; the control rod being moveable with the accumulator piston; and the control rod increases in diameter along its length from the accumulator piston; and
the diameter of the control rod is smaller than the cross-sectional area of the first flow aperture along at least some of the stroke of the accumulator piston such that: as the control rod moves relative to the first flow aperture from the fluid housing into the first accumulator sub-chamber region, the flow area around the control rod decreases to thereby increase resistance to flow of fluid from the fluid housing into the first accumulator sub-chamber region.

8. An artillery weapon as claimed in any one of the preceding claims wherein the fluid housing defines a fluid housing chamber for retaining the working fluid, and a control rod support piston is mounted to the control rod in, and operable to move along, the fluid housing chamber, to define a first fluid housing sub-chamber region on one side of the control rod piston and a second fluid housing sub-chamber region on the other side of the control rod support piston, the control rod support piston being spaced apart from the accumulator piston along the length of the control rod; and the control rod support piston defines passages for the regulation of fluid flow between the first fluid housing sub-chamber region and the second fluid housing sub-chamber region.

9. An artillery weapon as claimed in any one of the preceding claims wherein the buffer system comprises a first plain buffer mounted to the carriage on a first side of the ordnance and a second plain buffer mounted to the carriage on a second side of the ordnance each of the first plain buffer and second plain buffer being hydro pneumatic and comprising:

a buffer cylinder and a buffer piston slideable within/relative to the buffer cylinder;
the first plain buffer cylinder and second plain buffer cylinder being in fluid communication with the fluid housing;
such that movement of the ordnance relative to the carriage from the in-battery position to the out-of-battery position results in movement of each buffer cylinder relative to its respective buffer piston to cause fluid flow from the buffer system to the fluid housing; and
movement of the ordnance relative to the carriage from the out-of-battery position to the in-battery position results in movement of each buffer cylinder relative to its respective buffer piston to permit fluid flow from the fluid housing to the buffer system;
wherein either:

each buffer cylinder is mounted to, and operable to move with, the barrel and each buffer piston is mounted to the carriage; or
each buffer piston is mounted to, and operable to move with, the barrel and each buffer cylinder is mounted to the carriage.

10. An artillery weapon as claimed in claim 9 wherein:

the buffer cylinder of each of the first plain buffer and second plain buffer define a buffer chamber;
the buffer piston in each of the first plain buffer and second plain buffer is provided in, and operable to move along the respective buffer cylinder to define a first buffer sub-chamber on one side of the buffer piston and a second buffer sub-chamber on the other side of the buffer piston, and each first buffer sub-chamber is in fluid communication with the fluid housing.

11. An artillery weapon as claimed in claim 10 wherein each second buffer sub chamber is open to atmosphere via a port.

12. An artillery weapon as claimed in claim 10 wherein the second buffer sub chamber is closed and configured to be in fluid communication with a source of pressurised fluid, such that flow of pressurised fluid into the second buffer sub chamber causes movement of the ordnance relative to the carriage from the in-battery position to the out-of-battery position.

13. An artillery weapon as claimed in any one of the preceding claims wherein the weapon further comprises a free recoil auxiliary cylinder which defines a free recoil chamber;

a free recoil piston provided in, and operable to move along the free recoil chamber to define a first recoil sub-chamber on one side of the free recoil piston and a second recoil sub-chamber on the other side of the second free recoil piston;
wherein the first recoil sub-chamber defines a second fluid flow aperture and the second fluid flow aperture is in fluid communication with the fluid housing such that movement of the ordnance relative to the carriage from the in-battery position to the out-of-battery position results in movement of the free recoil piston relative to the free recoil auxiliary cylinder to permit fluid flow

into to the free recoil chamber; and

the second recoil sub-chamber contains a compressible fluid to provide a resistance to motion of the free recoil piston as the free recoil piston moves along the free recoil chamber, the compressible fluid increasing in pressure as the free recoil piston moves along the free recoil chamber such that the force acting on the free recoil piston increases as the free recoil piston moves along the free recoil chamber to increase the resistance to fluid flow into the first recoil sub-chamber;

wherein when the pressure in the second recoil sub-chamber is below a predetermined level and/or while the free recoil piston is moving relative to the free recoil chamber, there is no fluid flow from the fluid housing into the first accumulator sub-chamber region; and

when the pressure in the second recoil sub-chamber increases to above a predetermined level and/or the free recoil piston stops moving relative to the free recoil chamber, fluid flows from the fluid housing into the first accumulator sub-chamber region.

14. An artillery weapon as claimed in claim 13 wherein the predetermined pressure level is set to a value based on a function of mass of the ordnance.

15. An artillery weapon as claimed in claim 13 or claim 14 wherein the buffer system, fluid housing of the multifunction cylinder and the first recoil sub-chamber are fluidly linked by a fluid manifold.

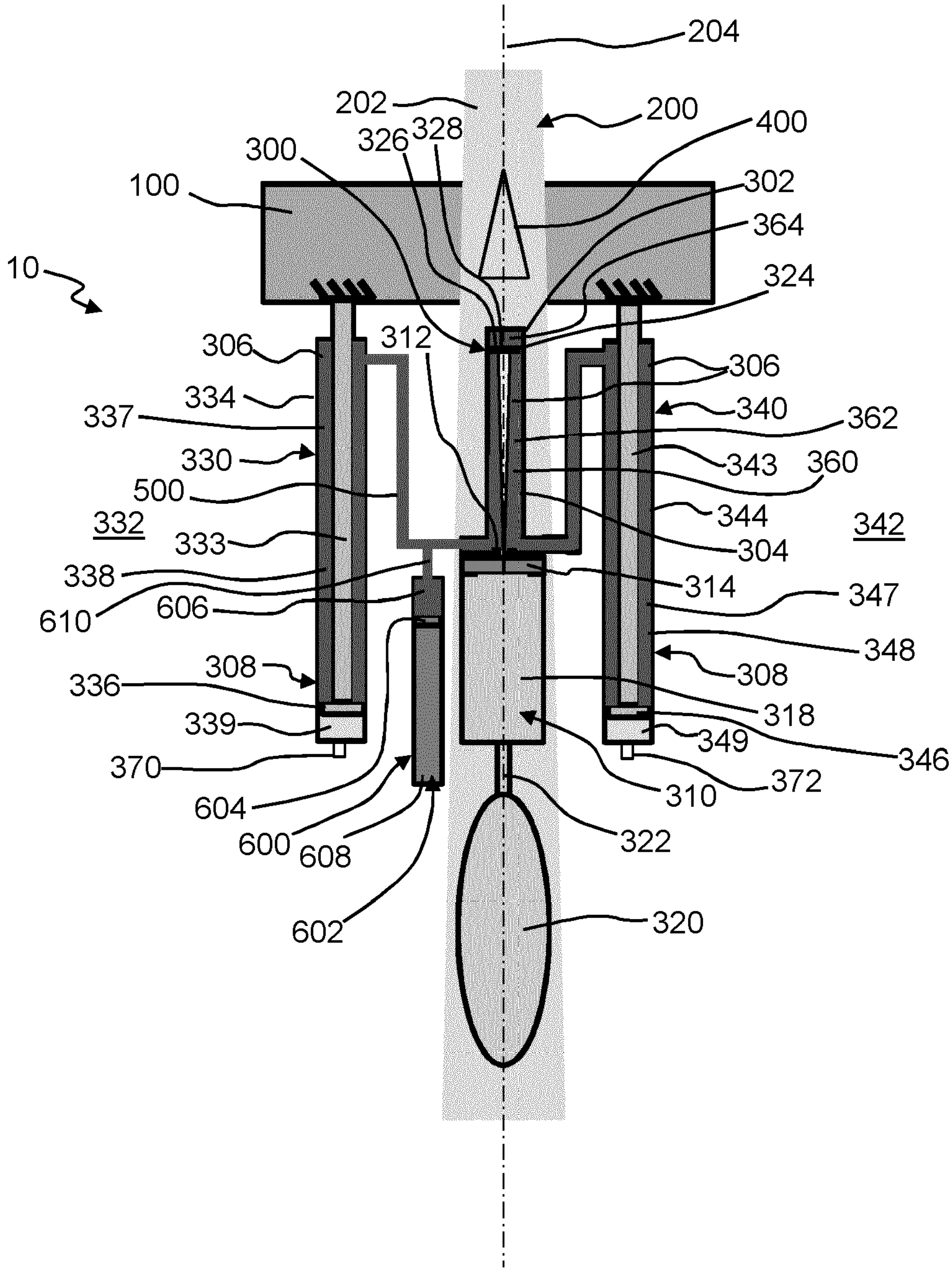
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Fig. 1

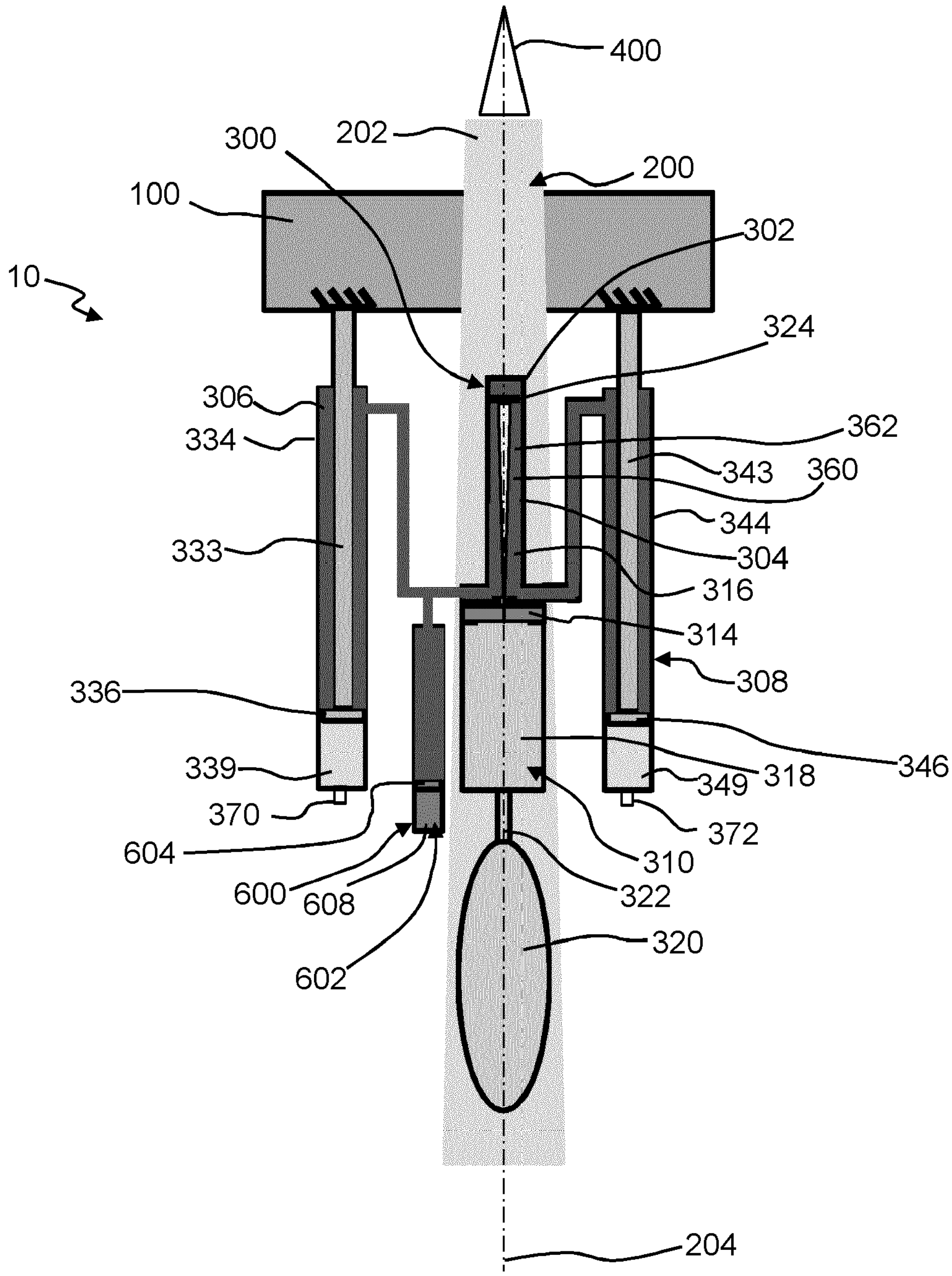
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Fig. 2

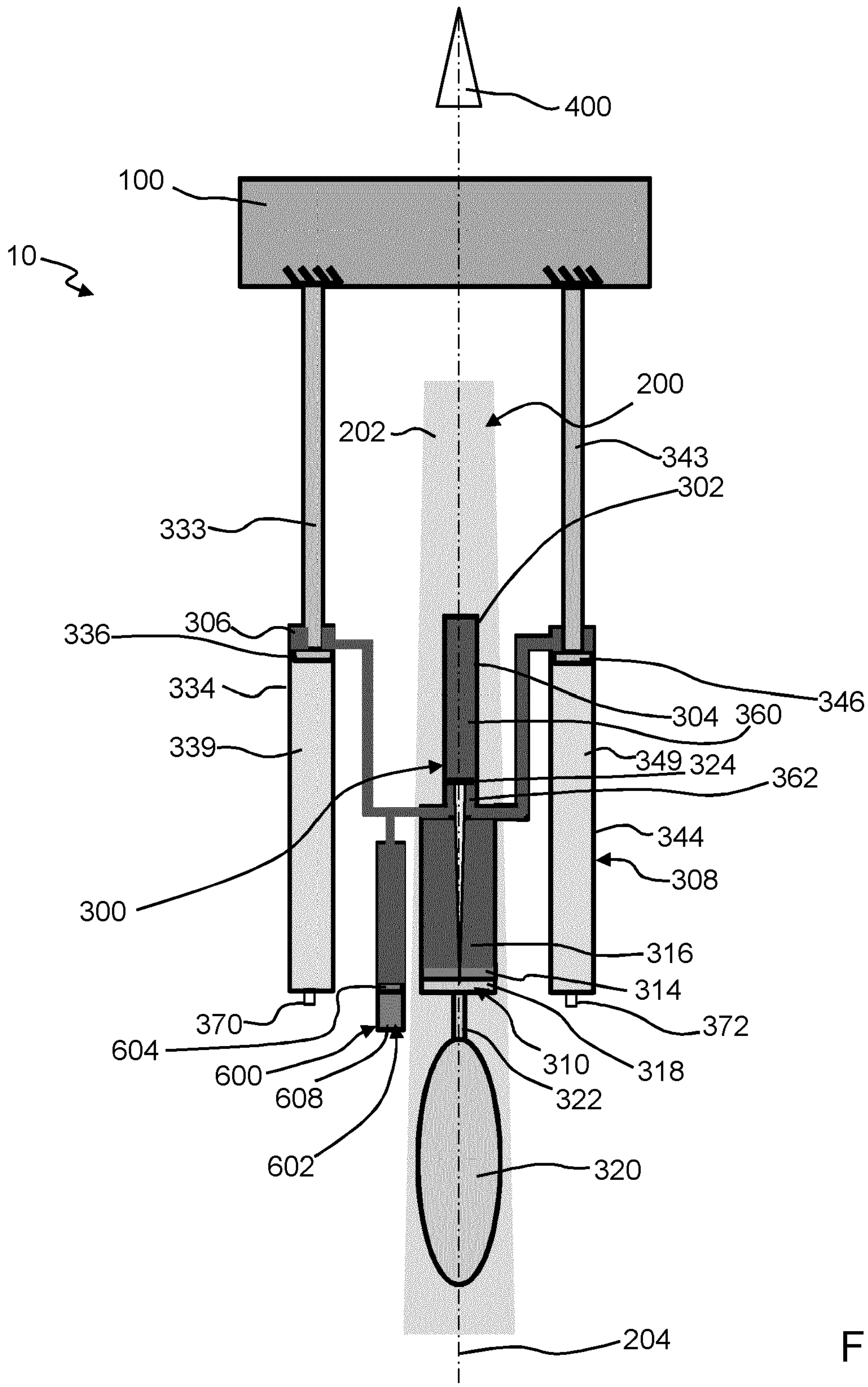
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Fig. 3

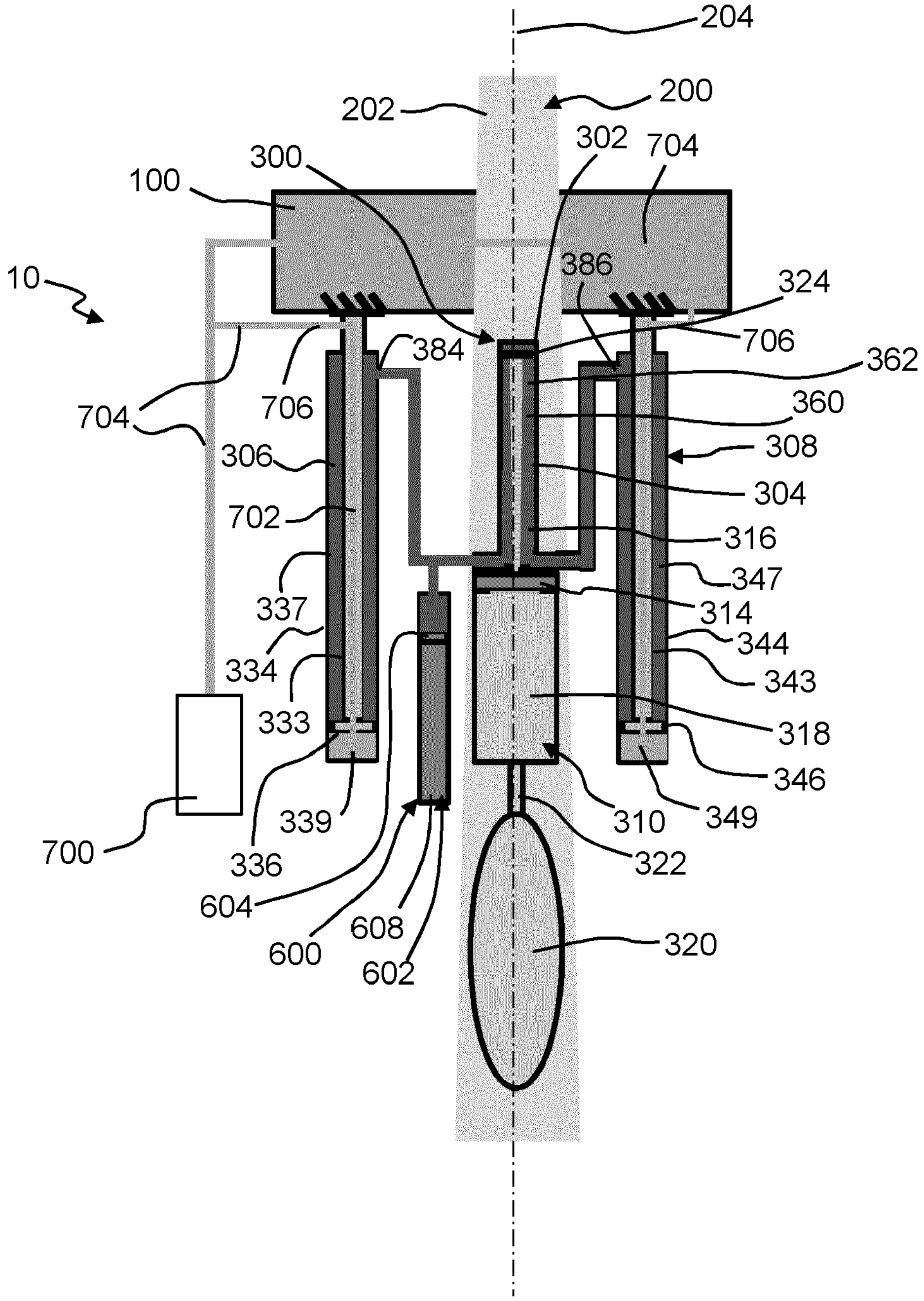
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Fig. 4

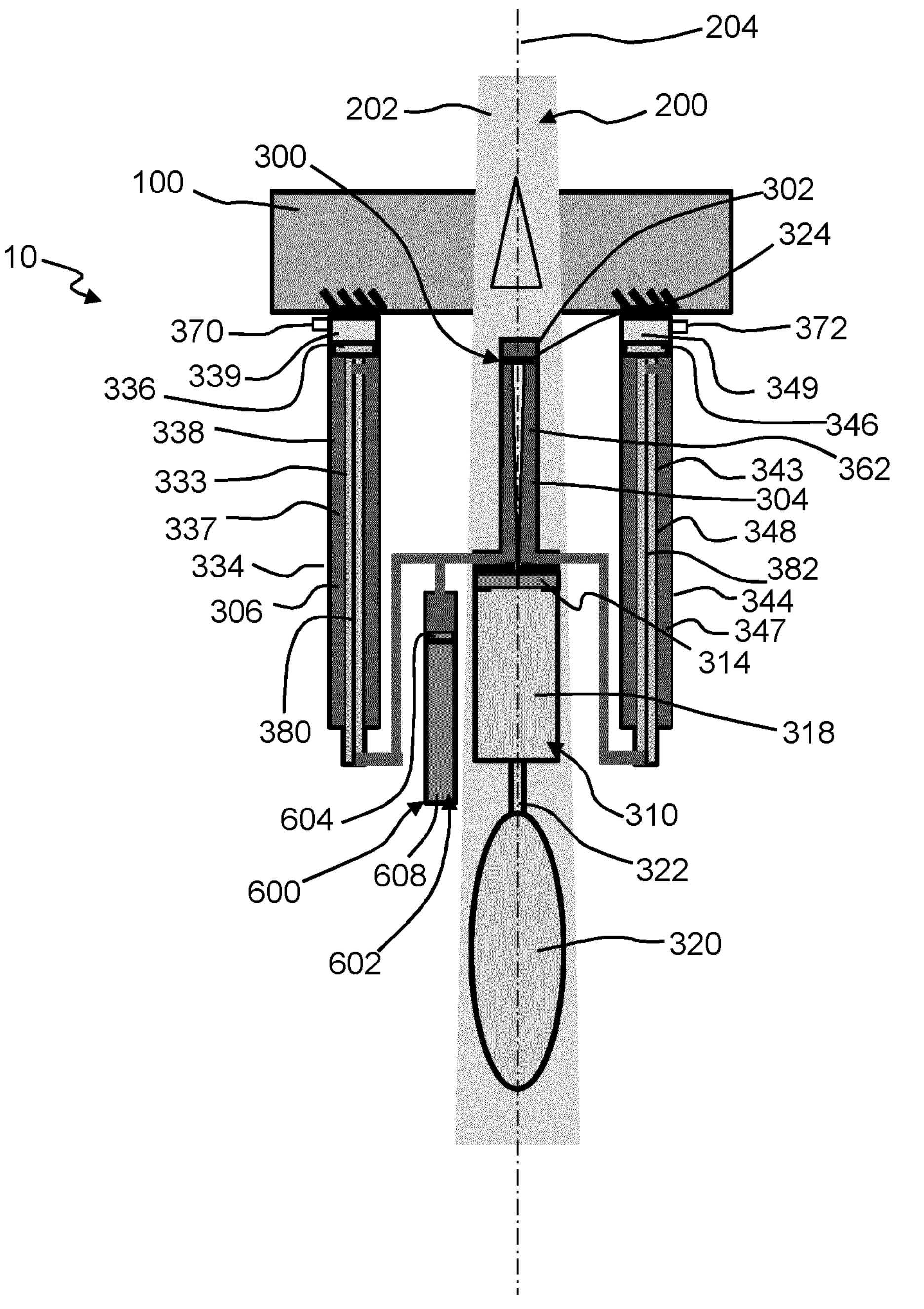
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Fig. 5

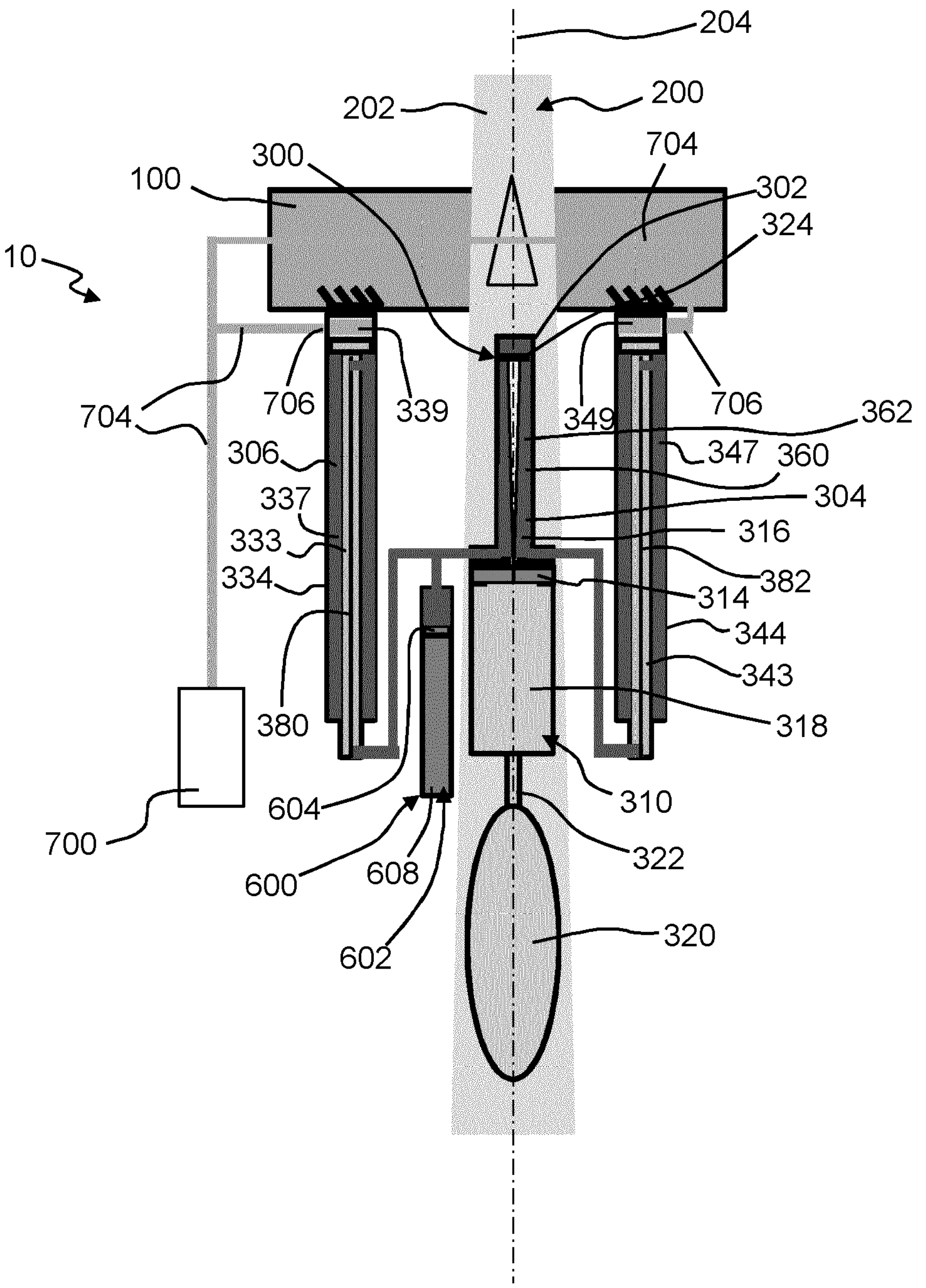
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Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 22 27 5150

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	19 April 2023	Vermander, Wim

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X : particularly relevant if taken alone
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