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(54) **VALVE ACTUATOR**

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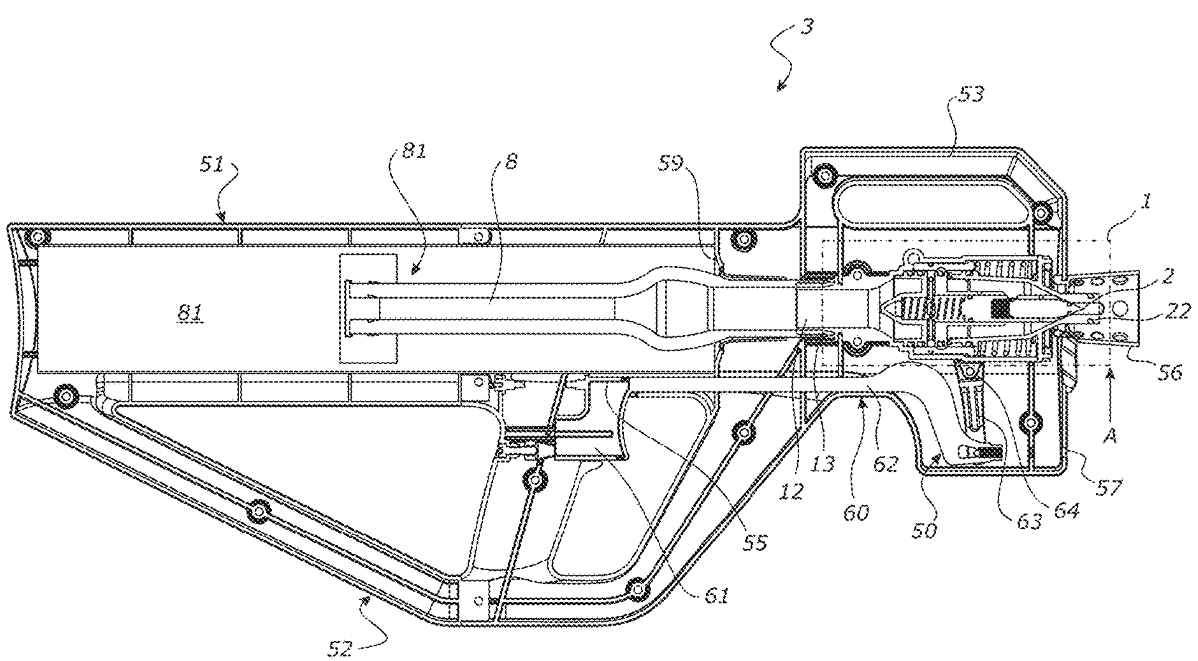
CPC ***F41B 9/0071*** (2013.01)

(57) **ABSTRACT**

Disclosed is an actuator for actuation of a fluid dispense valve in a pressurized fluid powered fluid dispensing device. The actuator comprising structure to generate a pressure differential between a first zone and a second zone. The zones being adjacent a valve member of the fluid dispense valve of the device such that upon generation of the pressure differential the valve member is moved from the zone of relatively higher pressure towards the zone of relatively lower pressure such that the valve is opened.



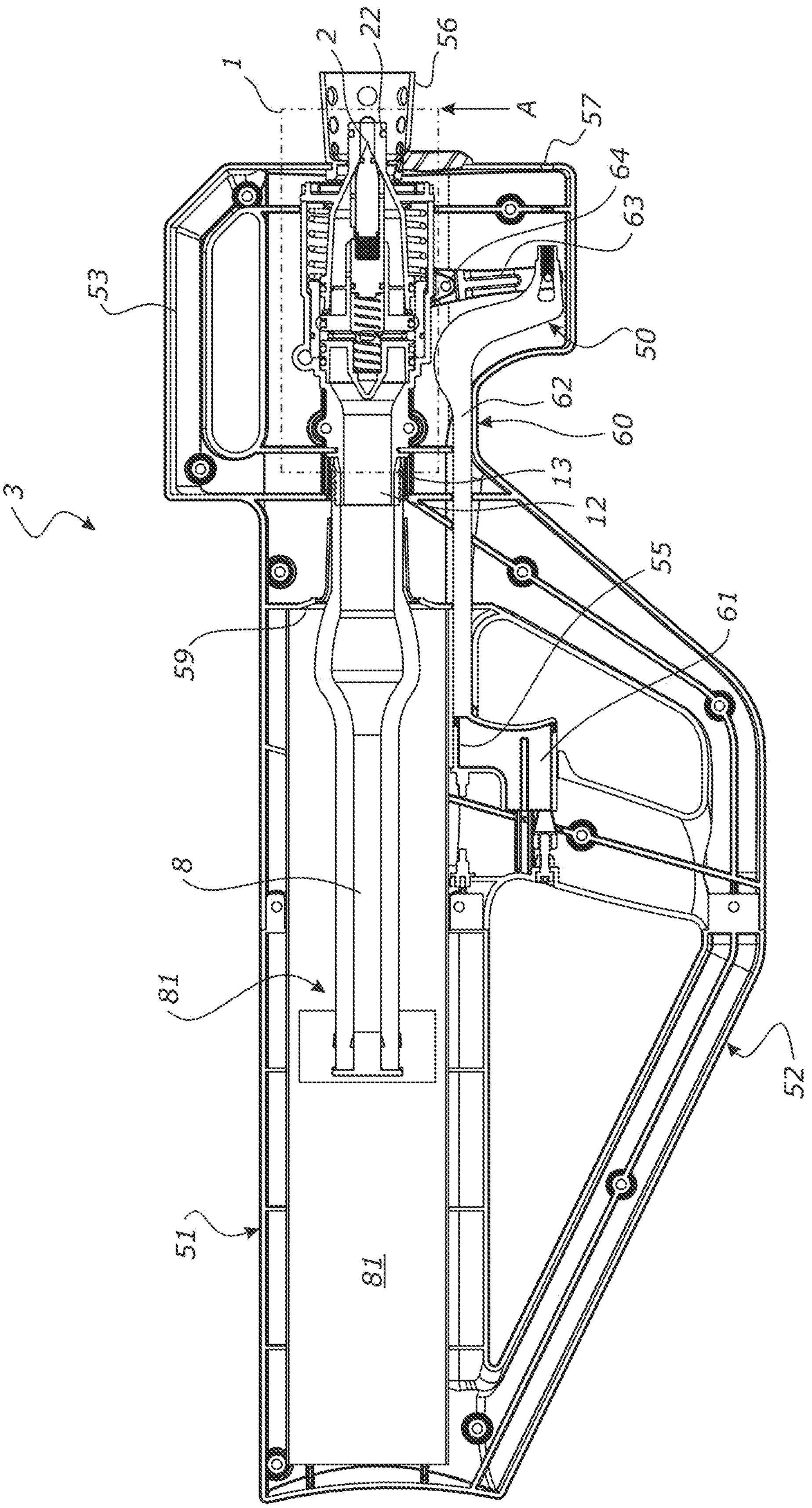


FIG. 1

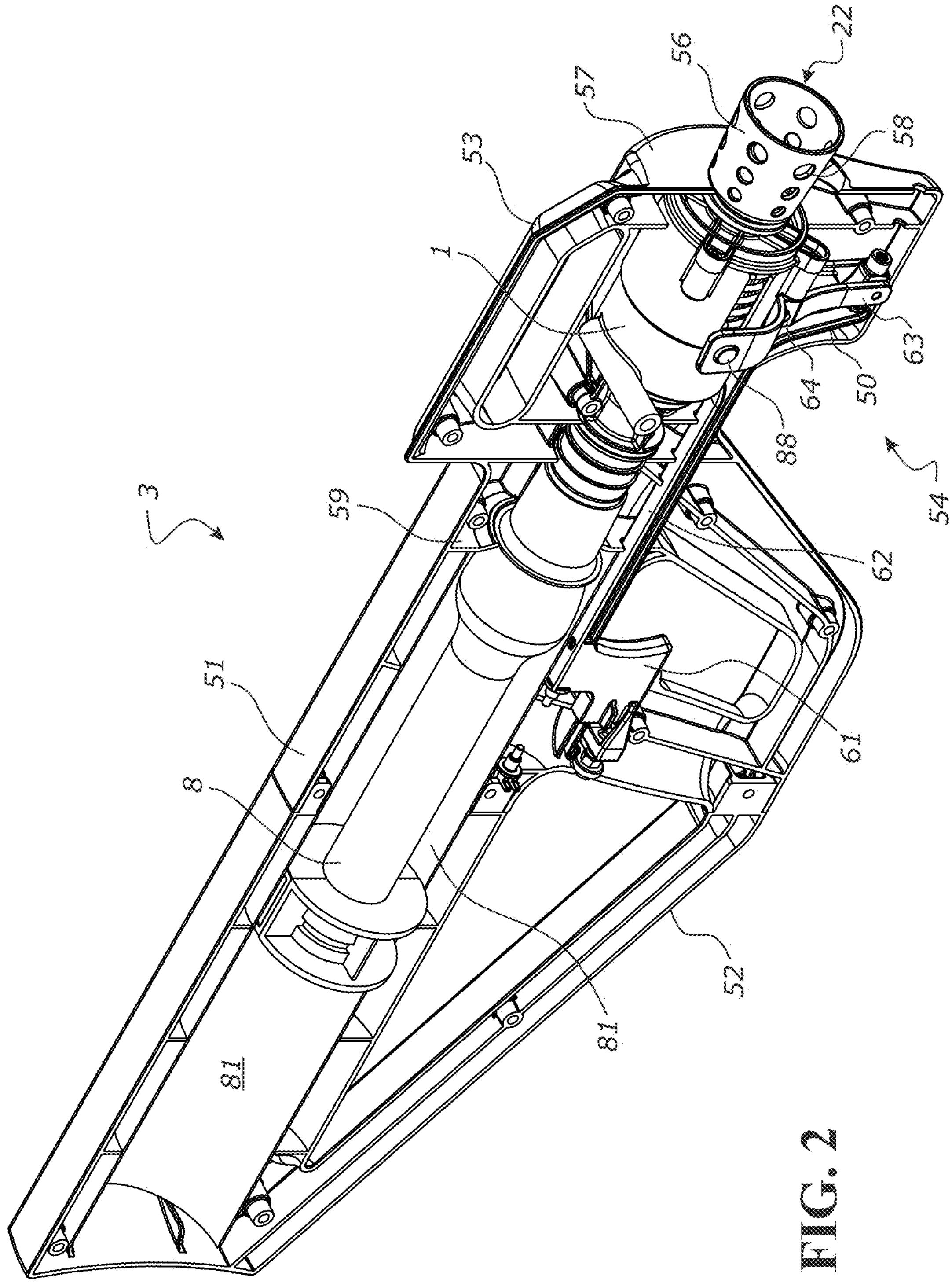


FIG. 2

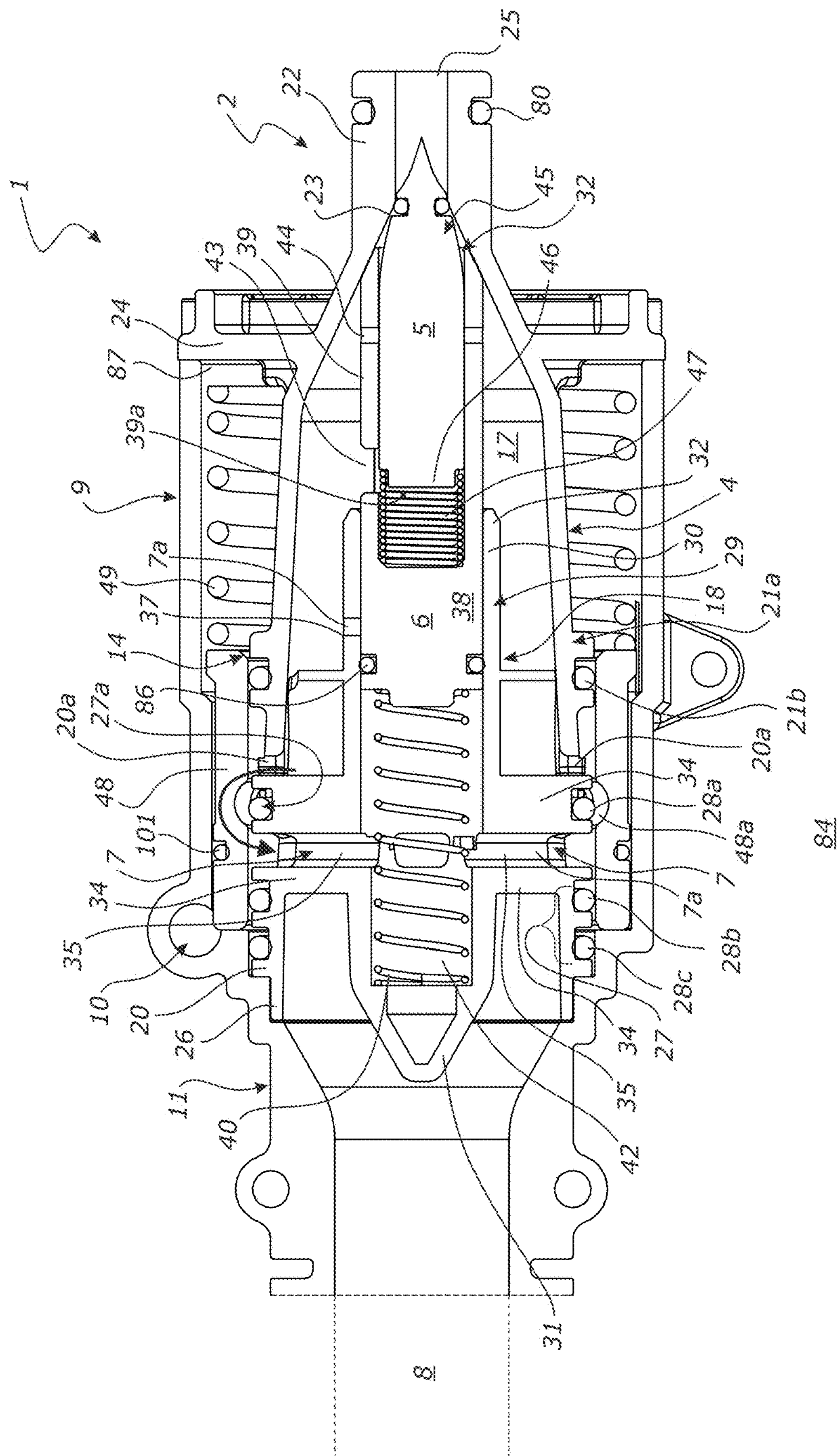
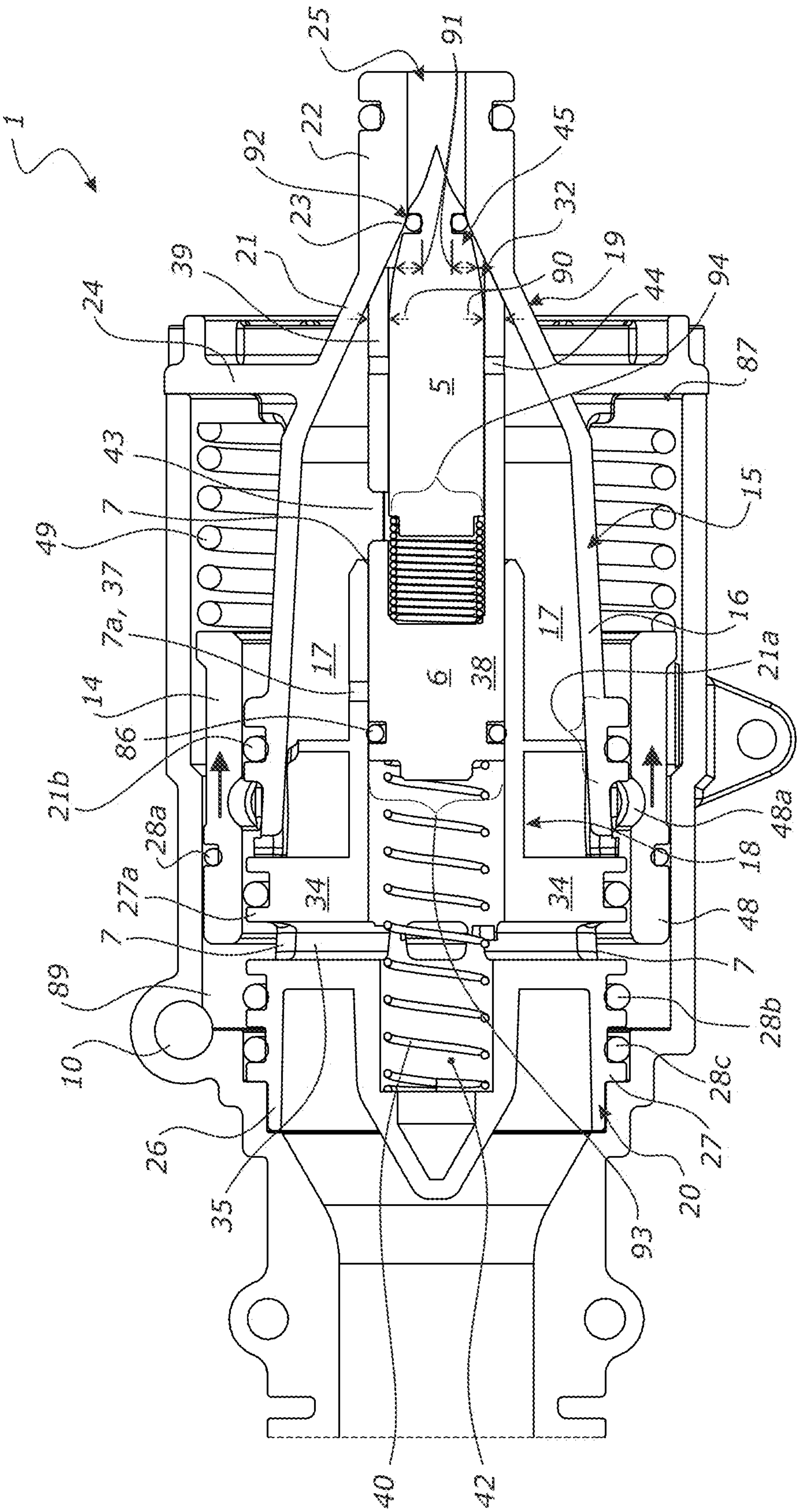


FIG. 3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21b
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28a
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FIG. 4

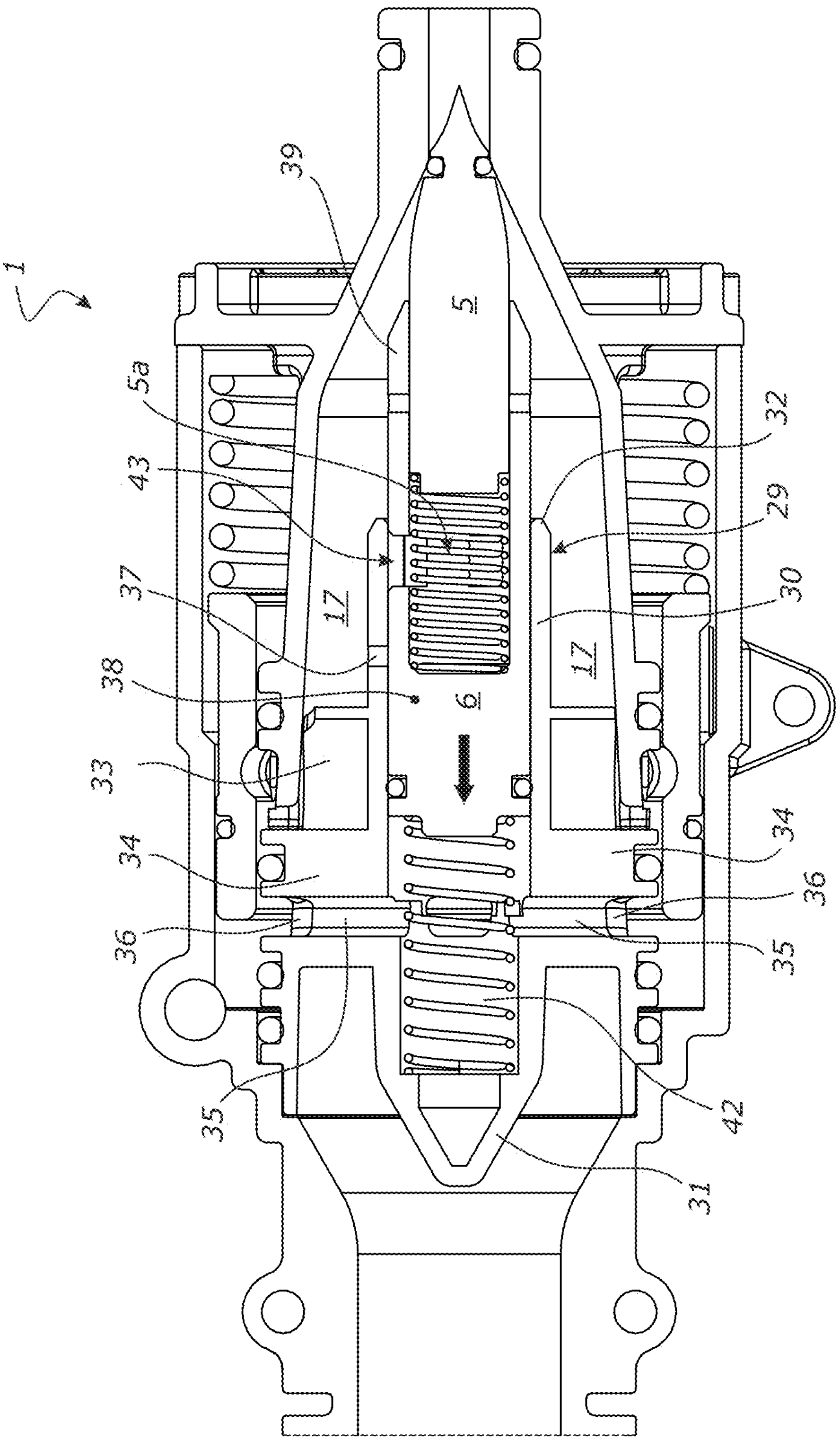

FIG. 5

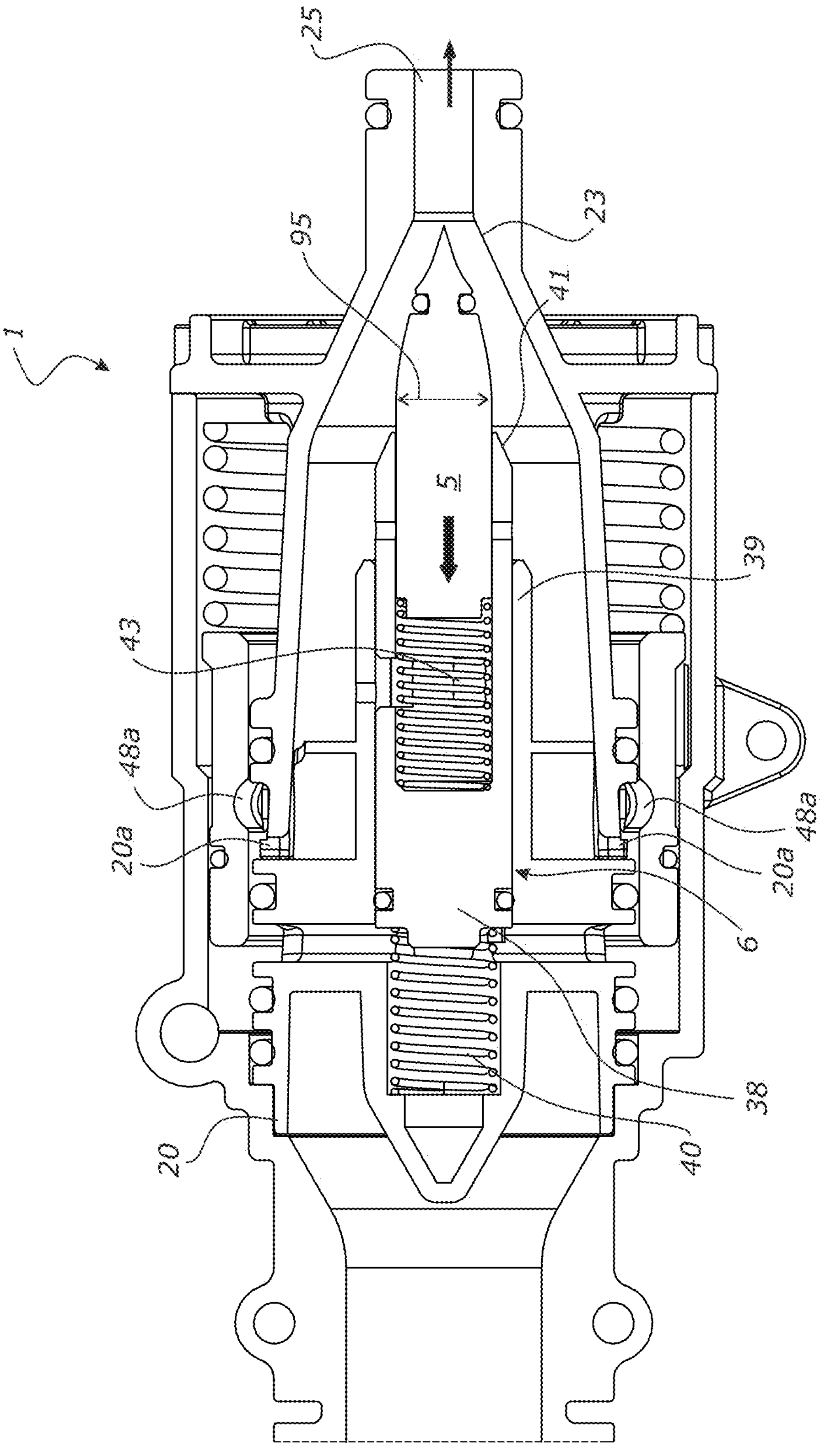

FIG. 6

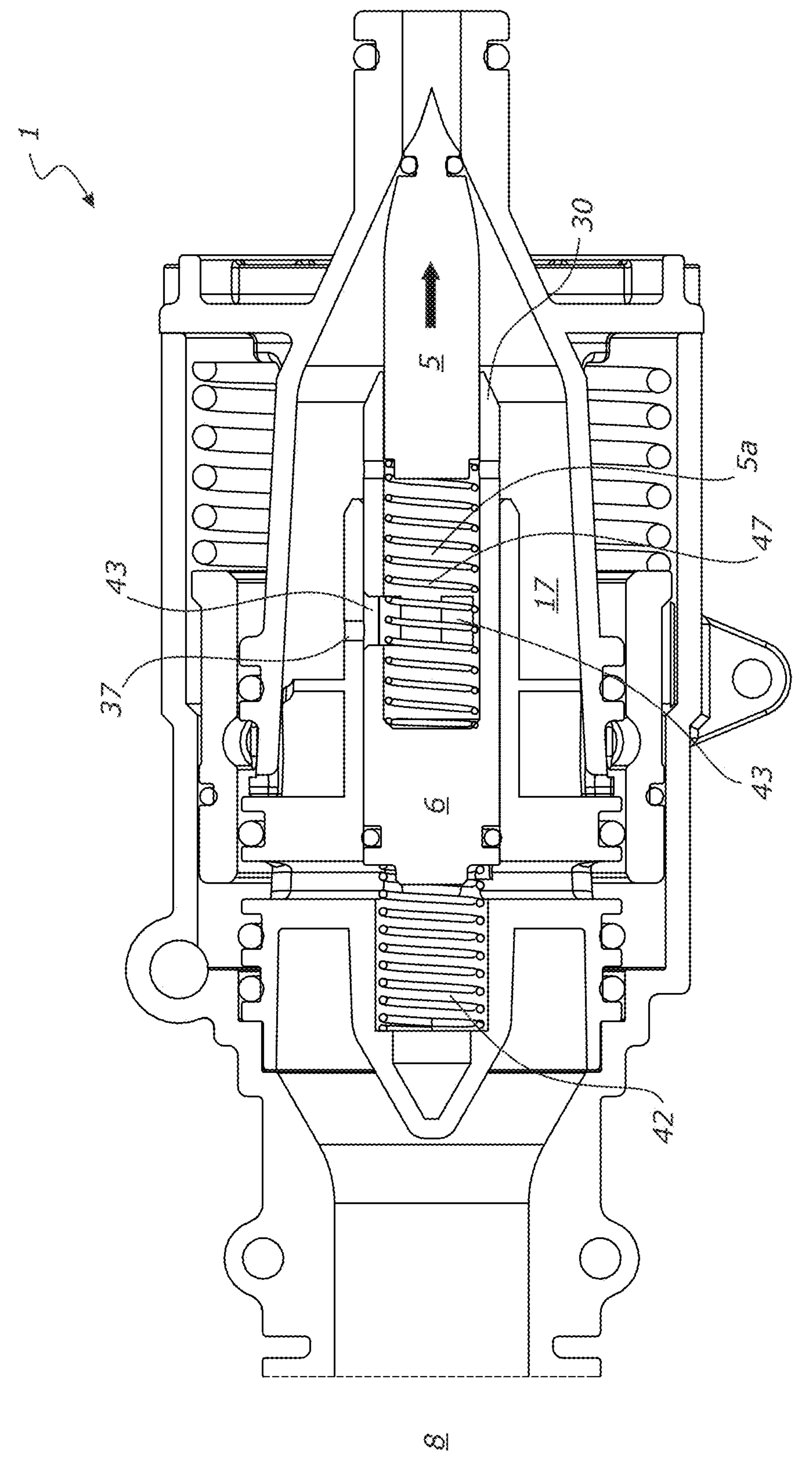

FIG. 7

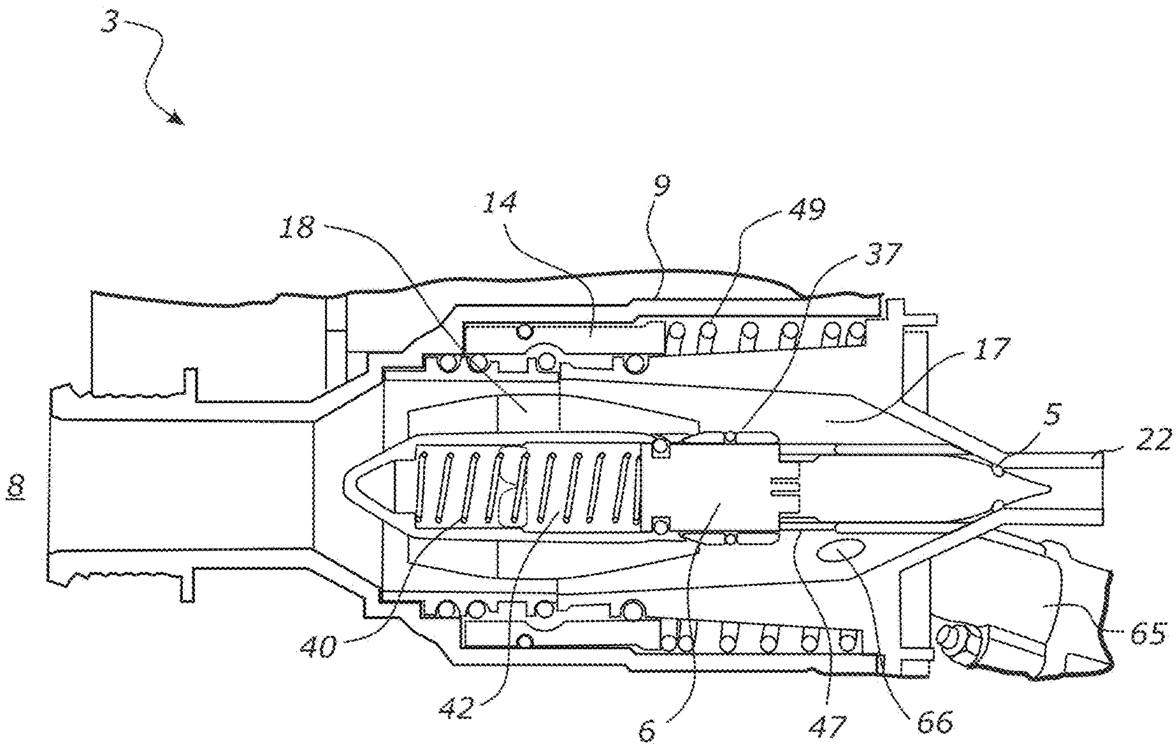

FIG. 8

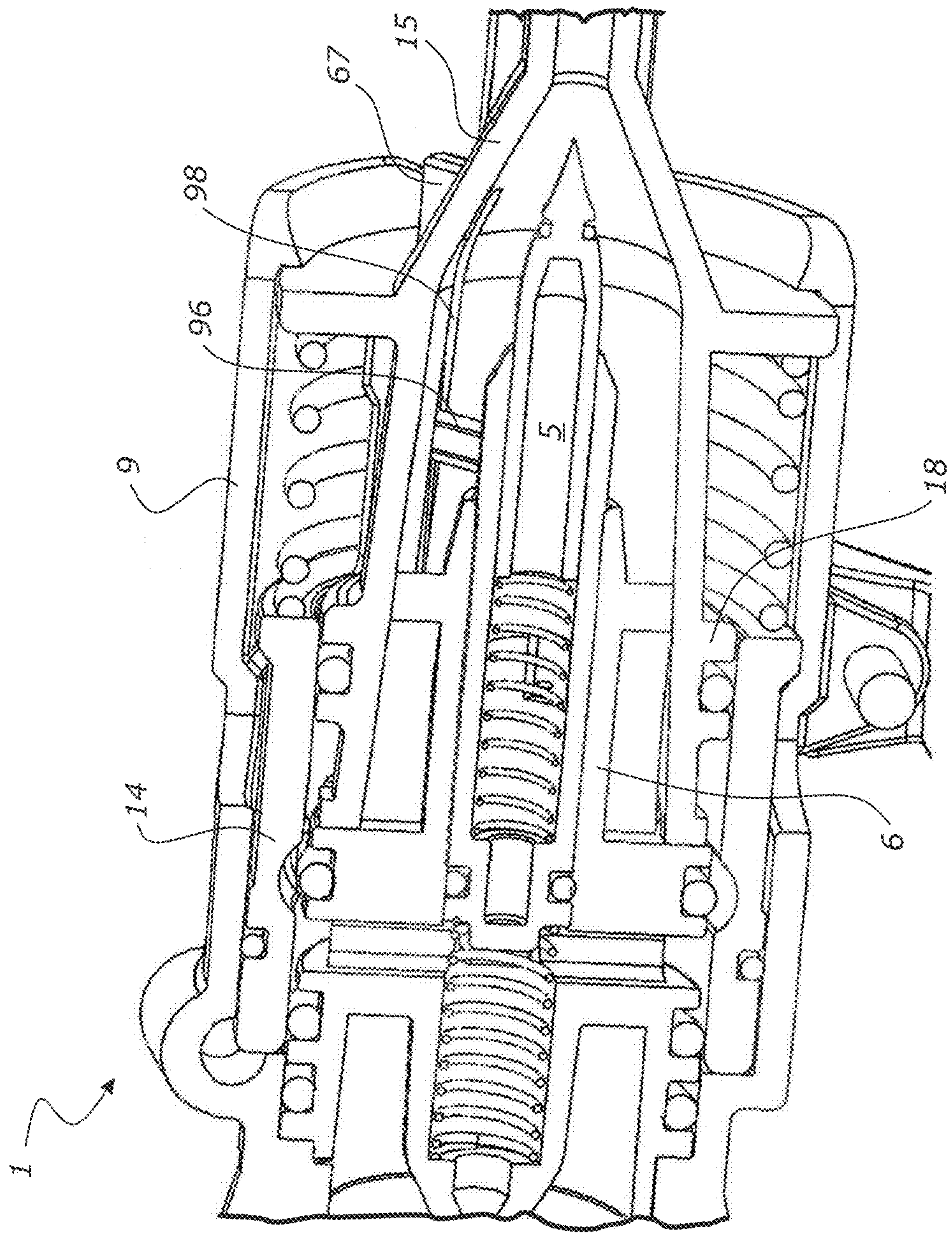

FIG. 9

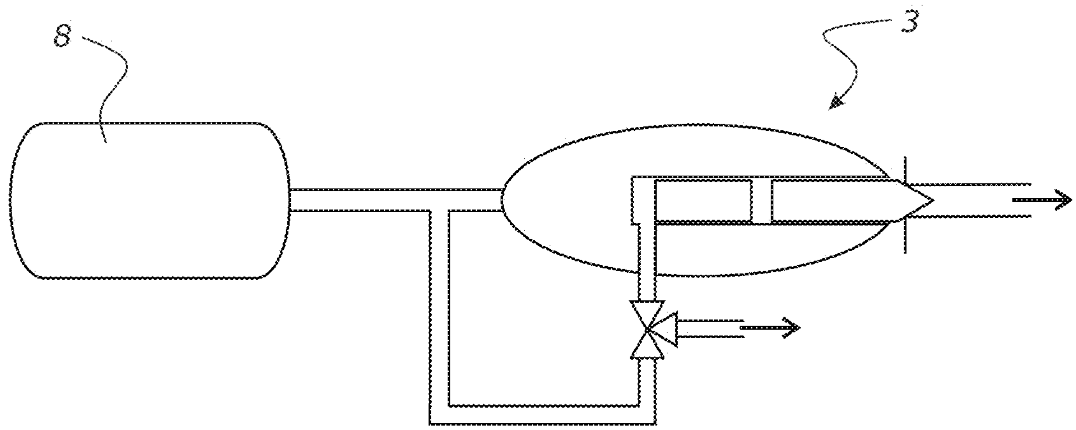

FIG. 10a

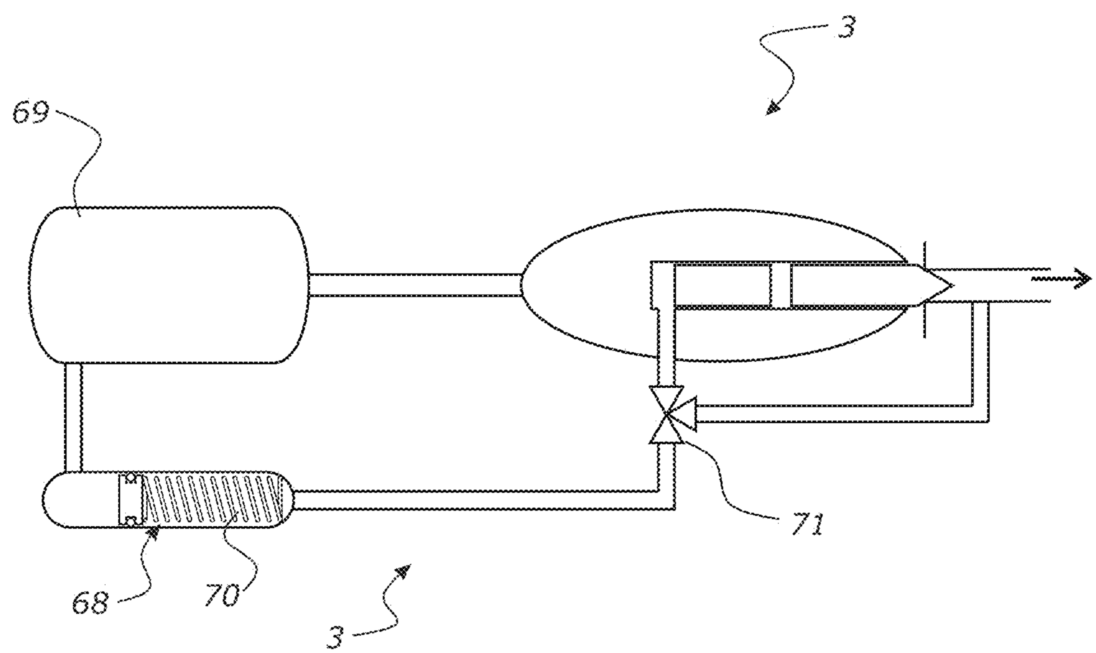

FIG. 10b

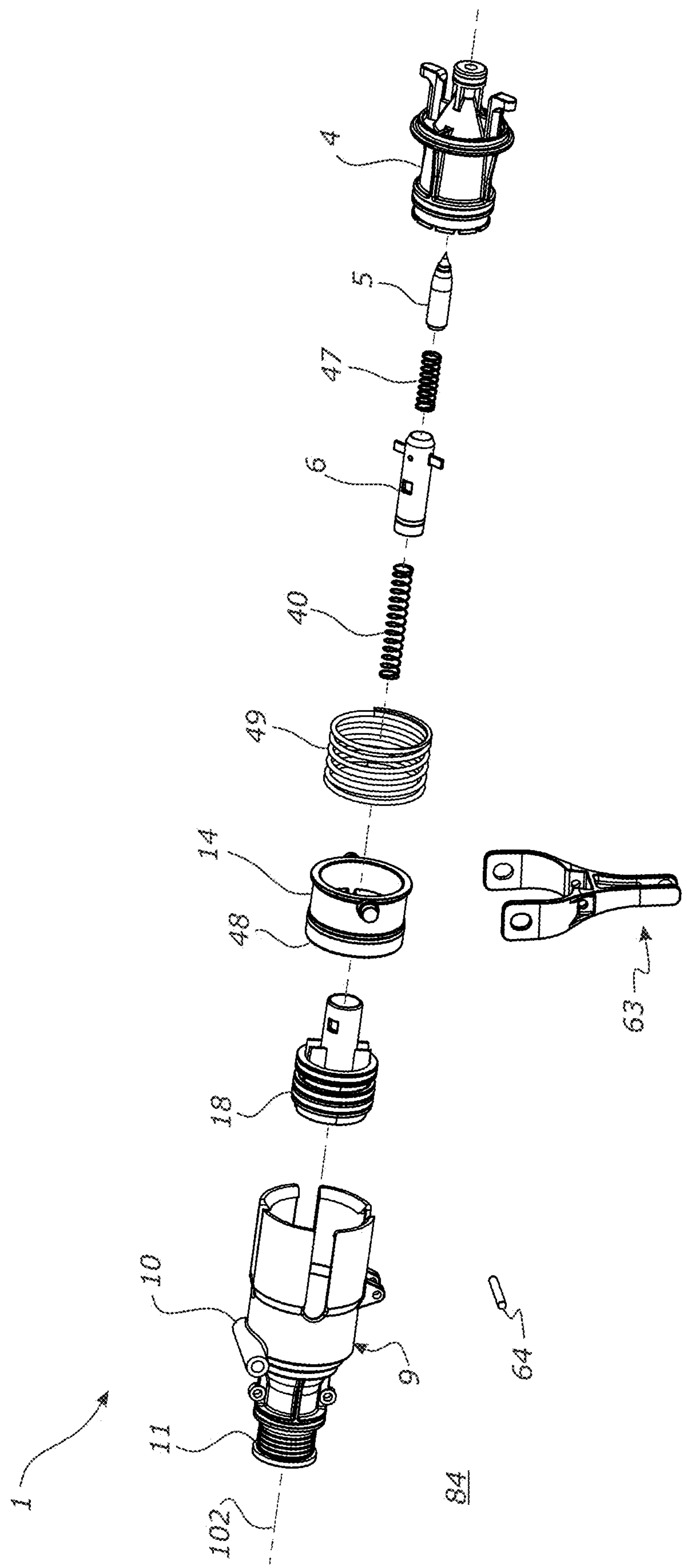

FIG. 11

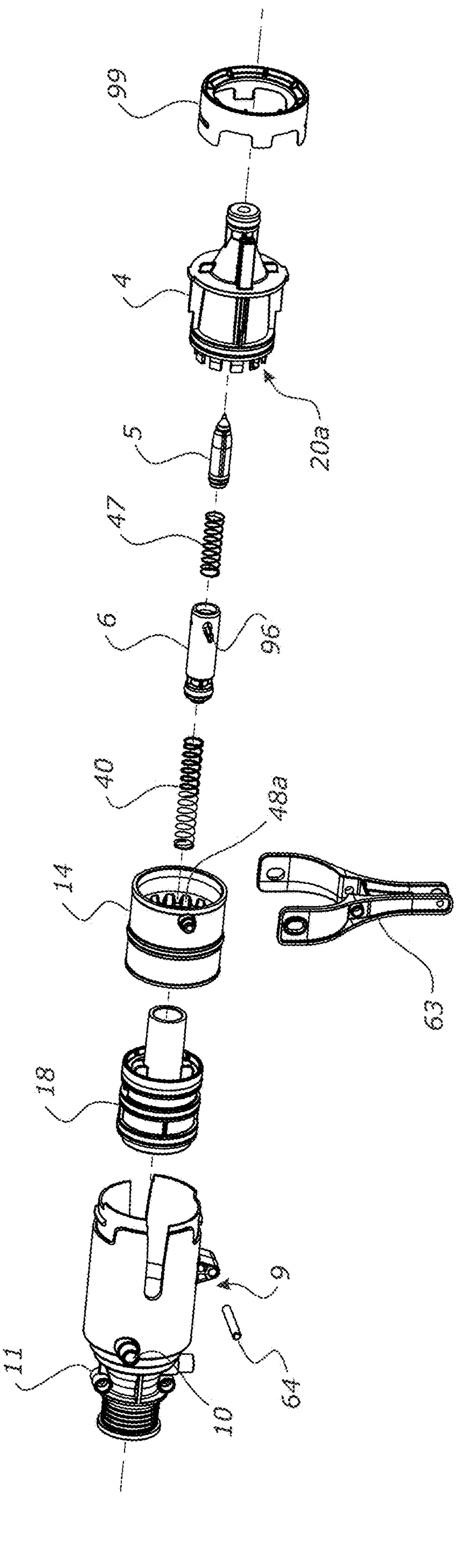

FIG. 12

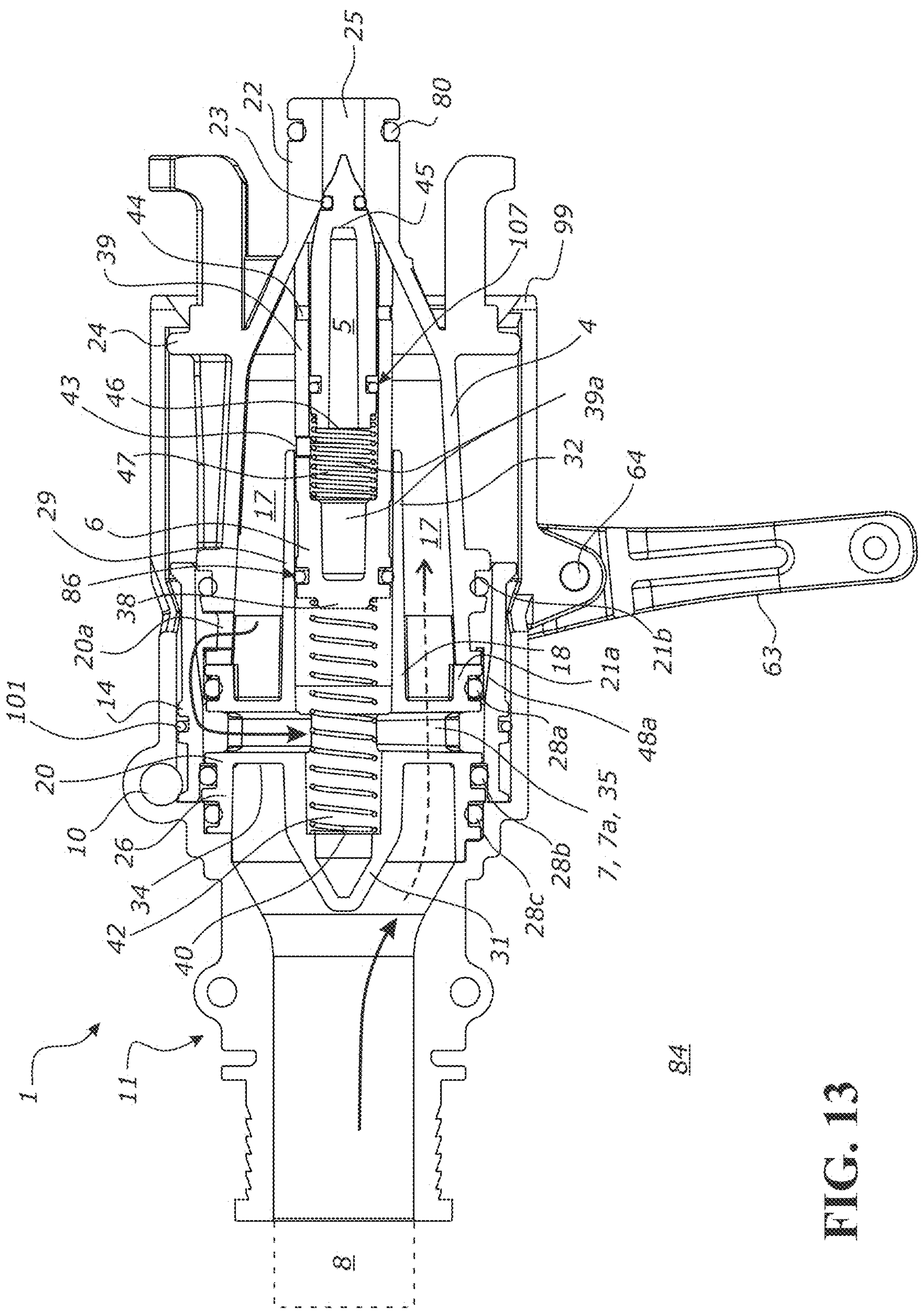
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FIG. 13

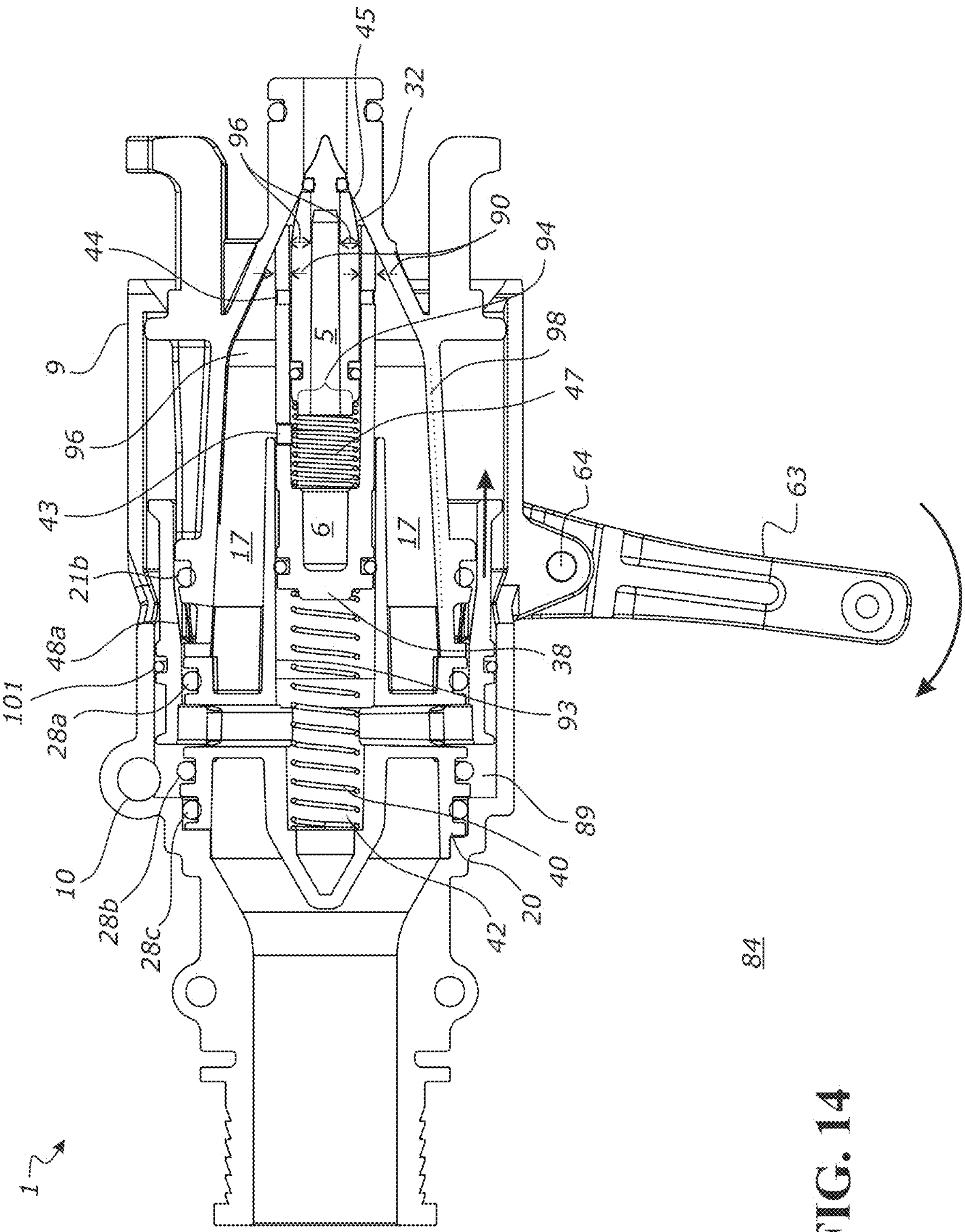
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FIG. 14

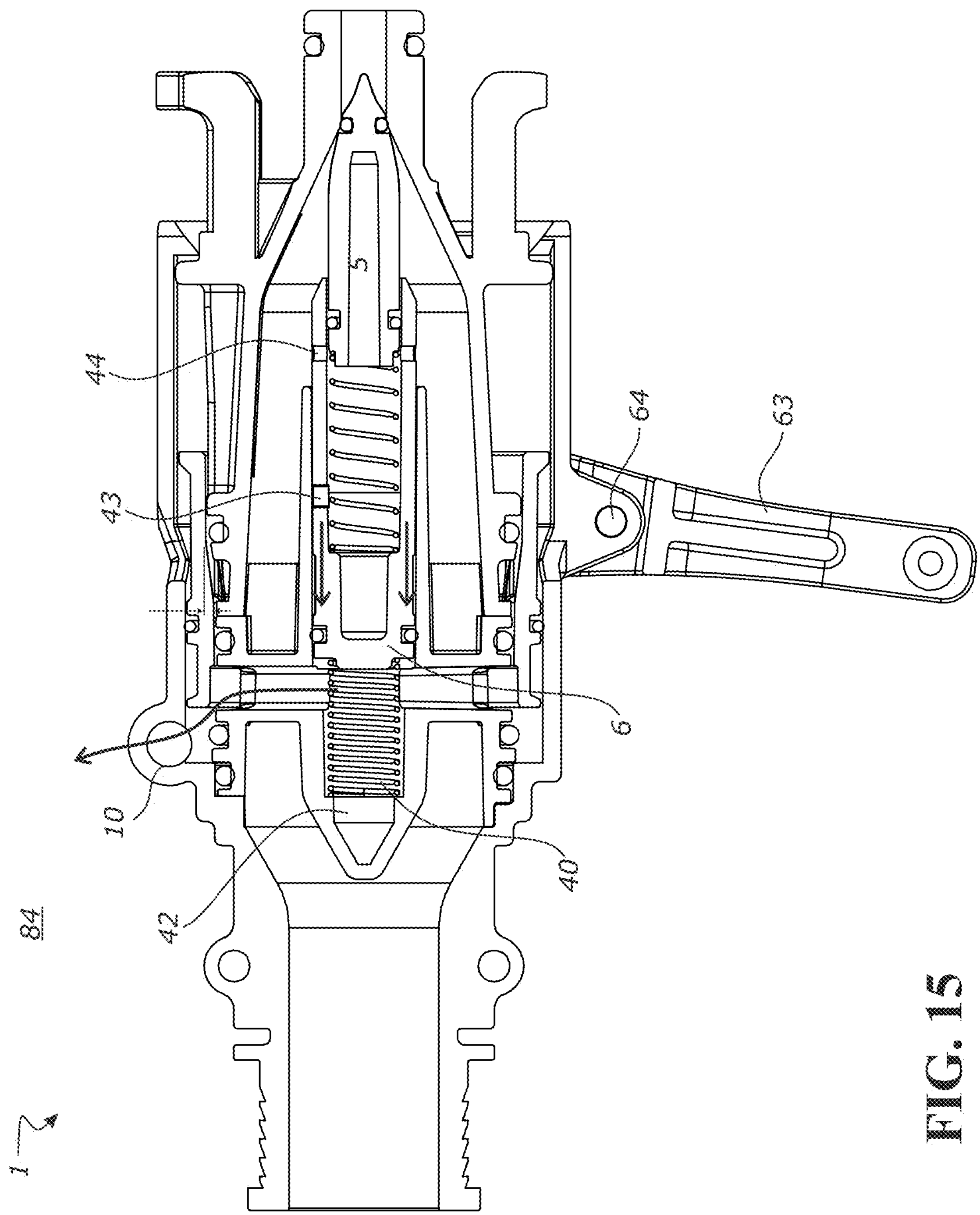

FIG. 15

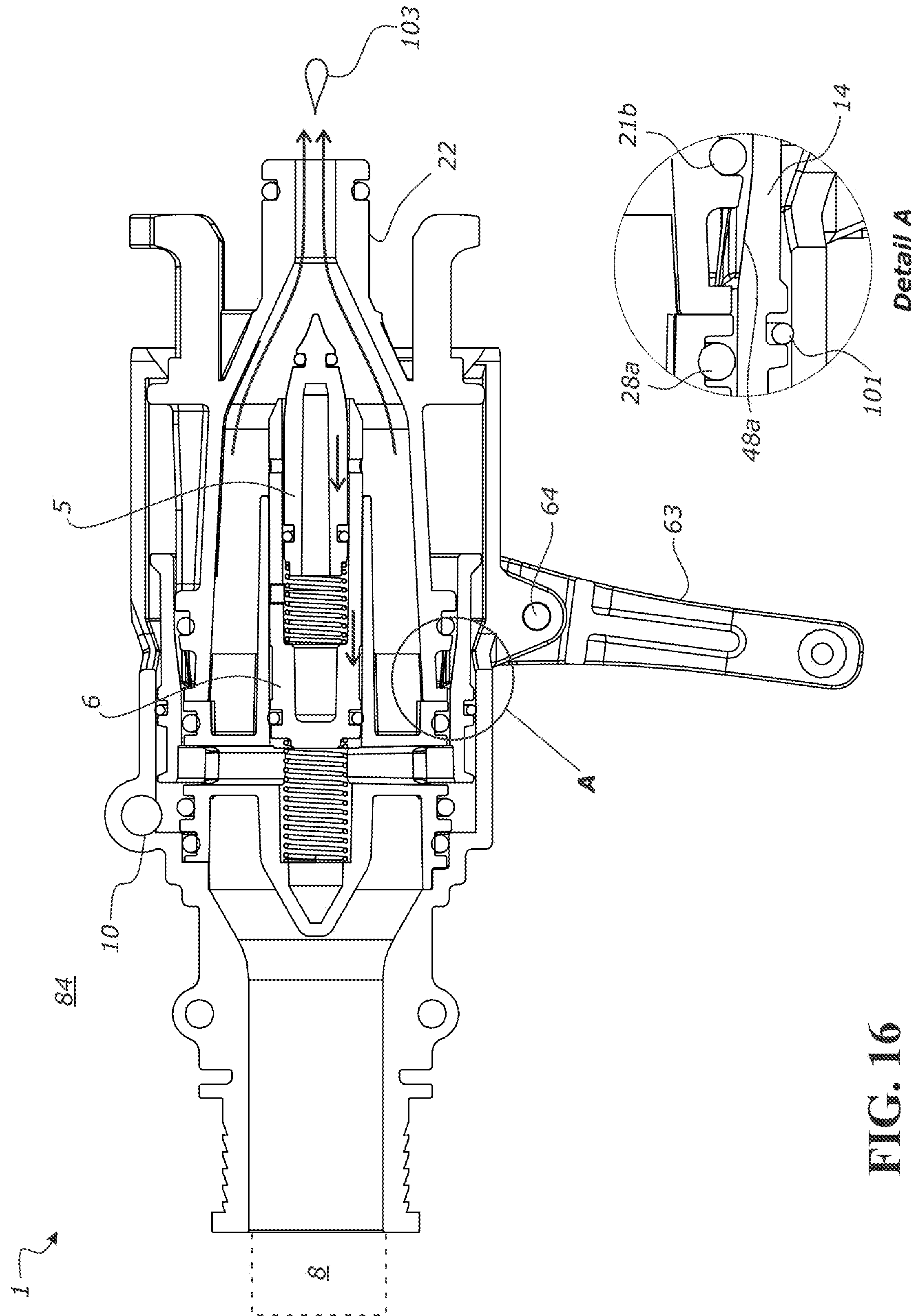

FIG. 16

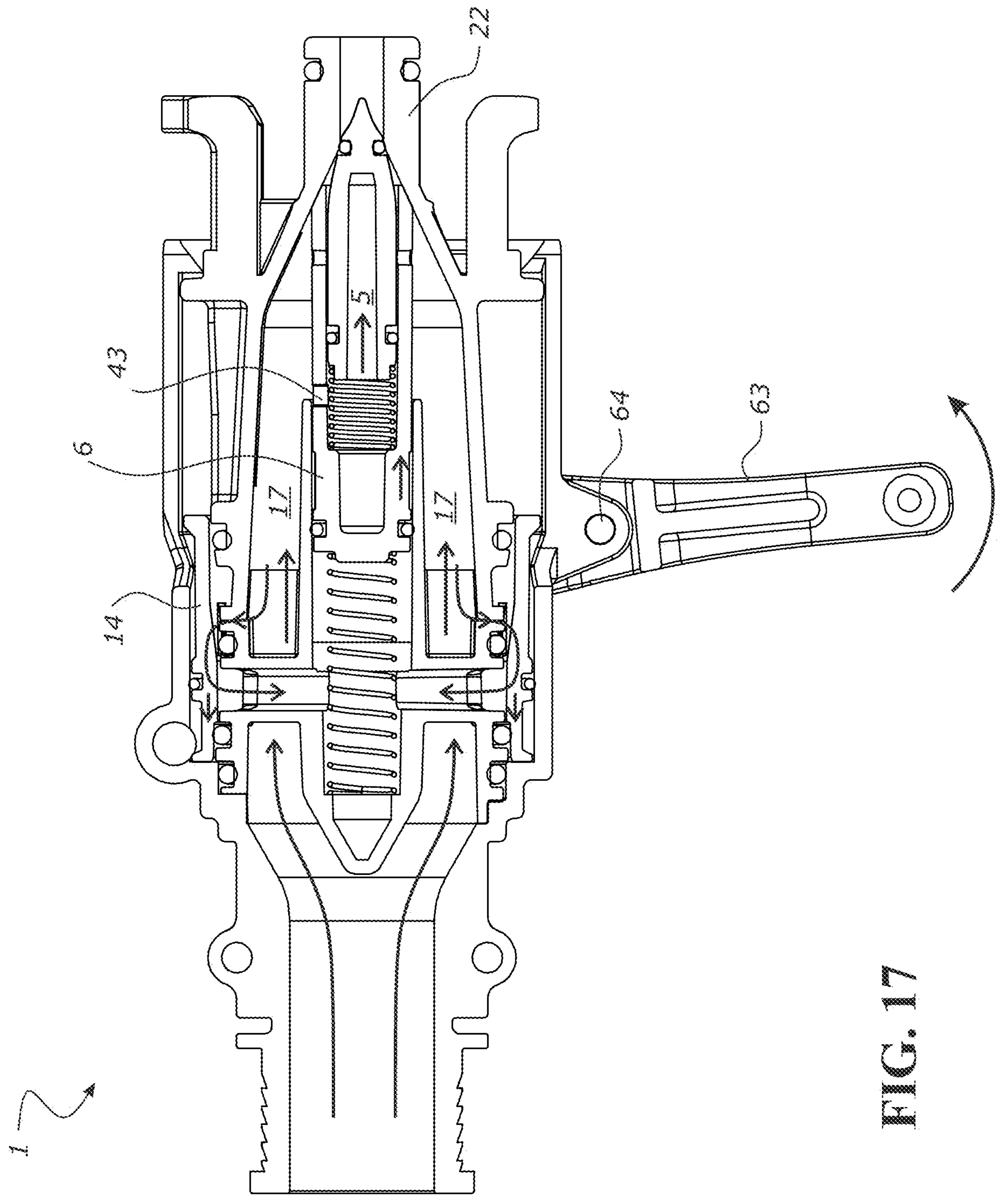

FIG. 17

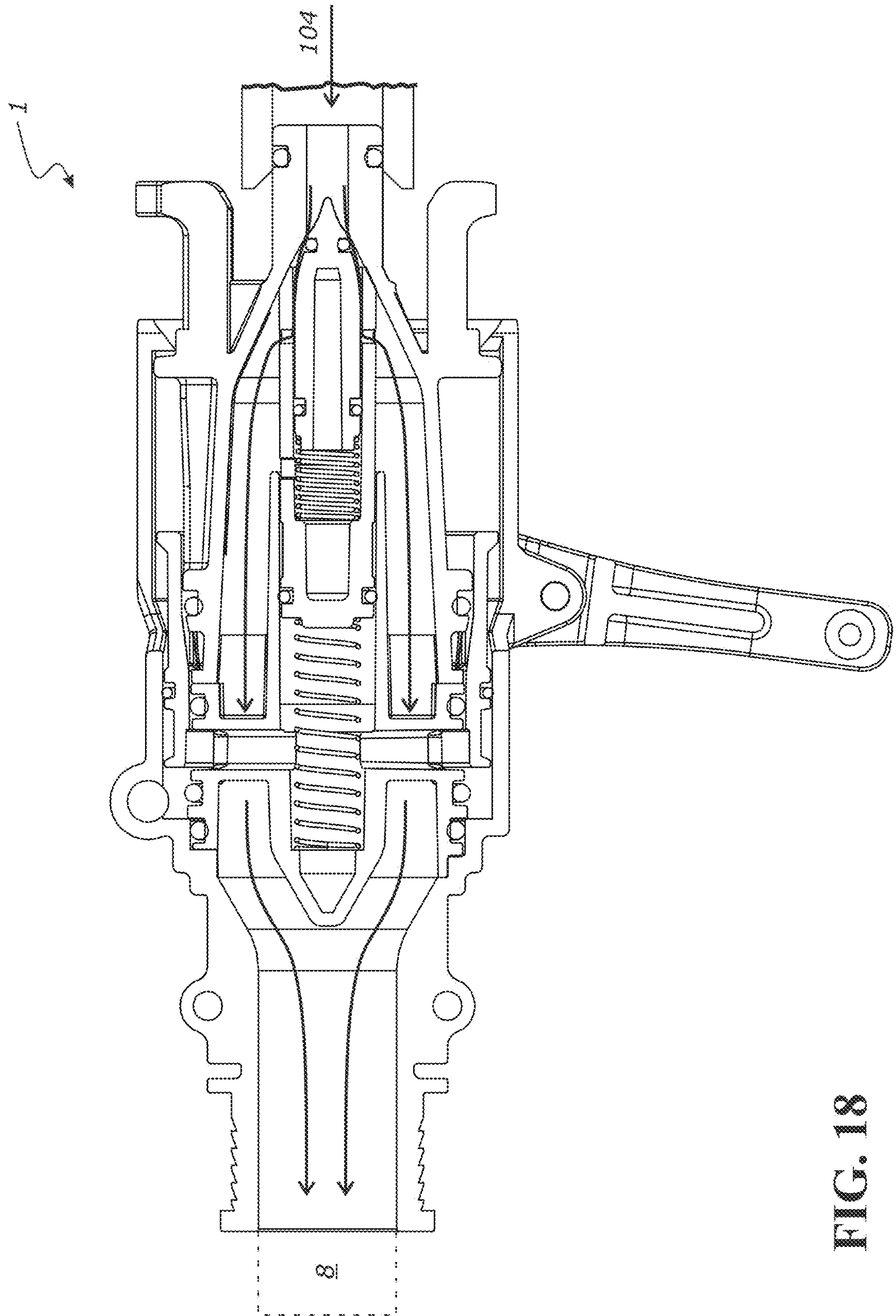

FIG. 18

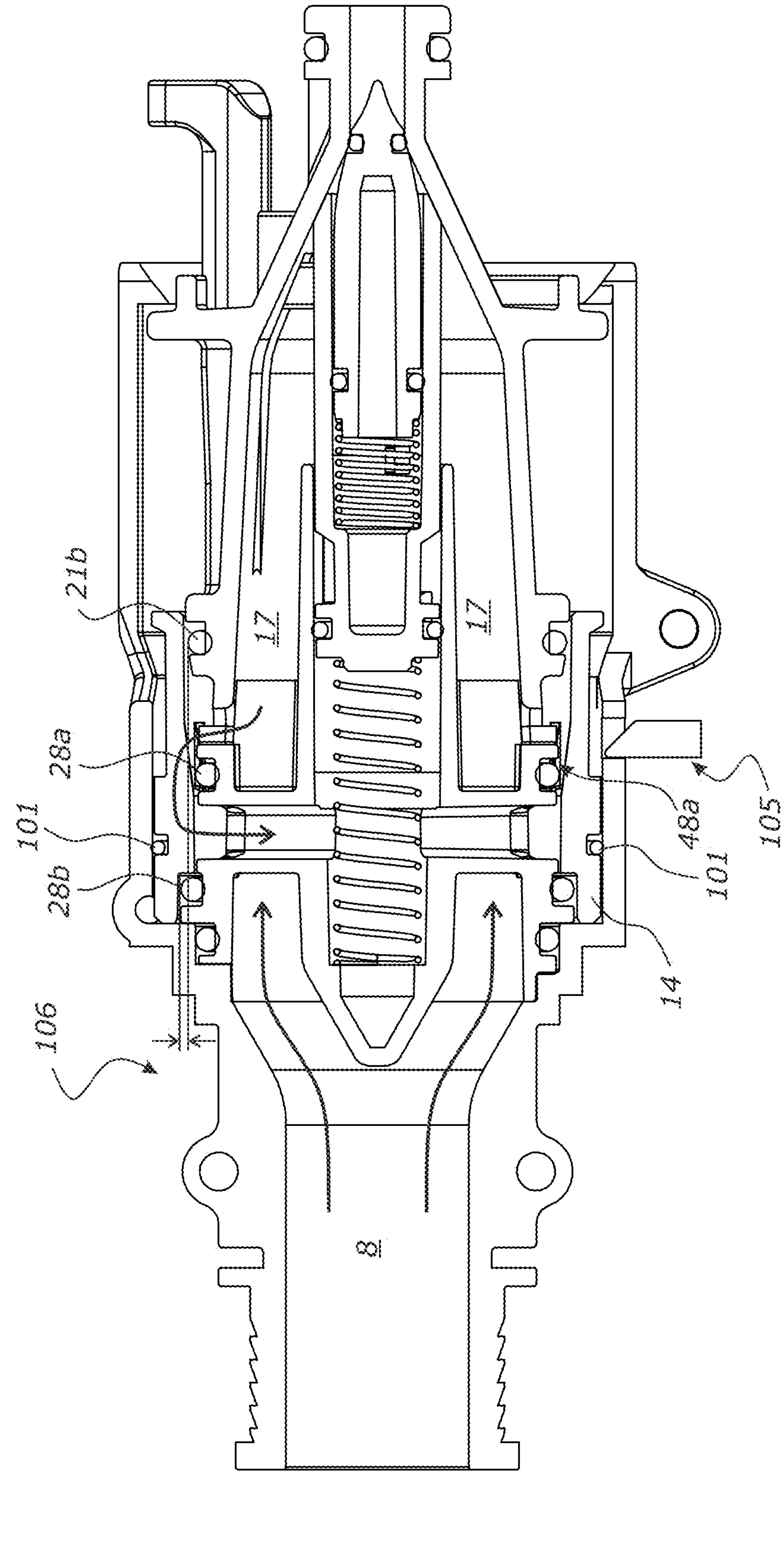

FIG. 19

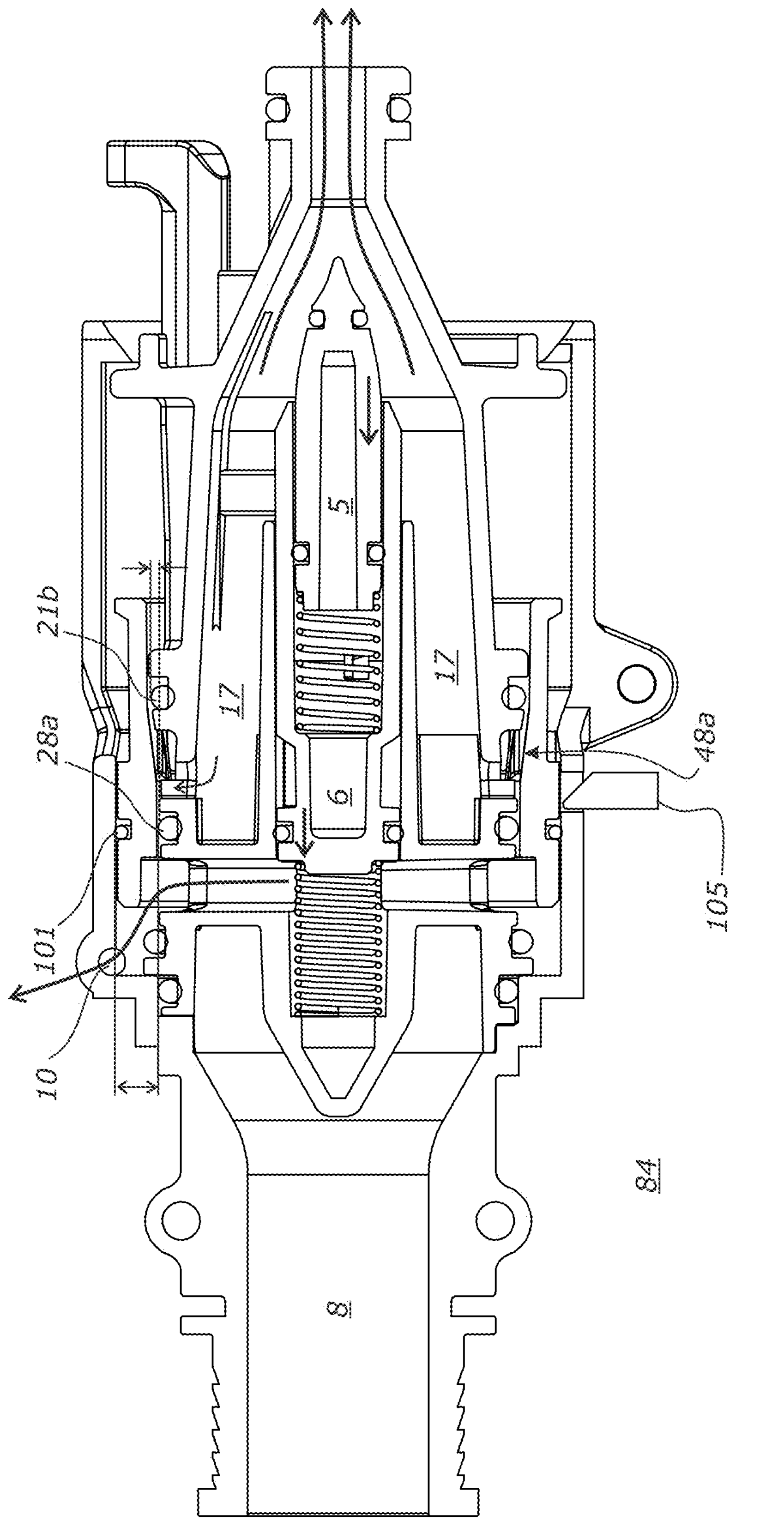

FIG. 20

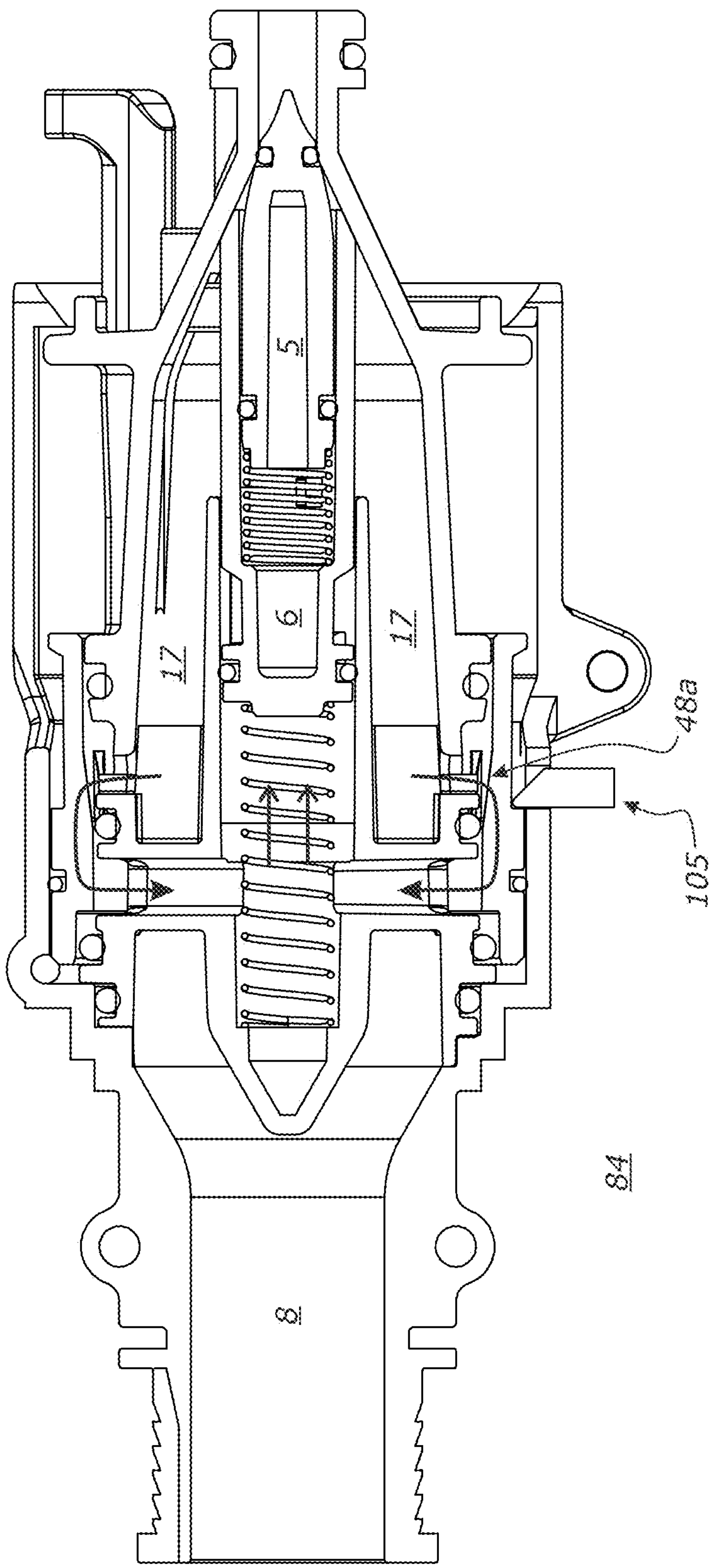

FIG. 21

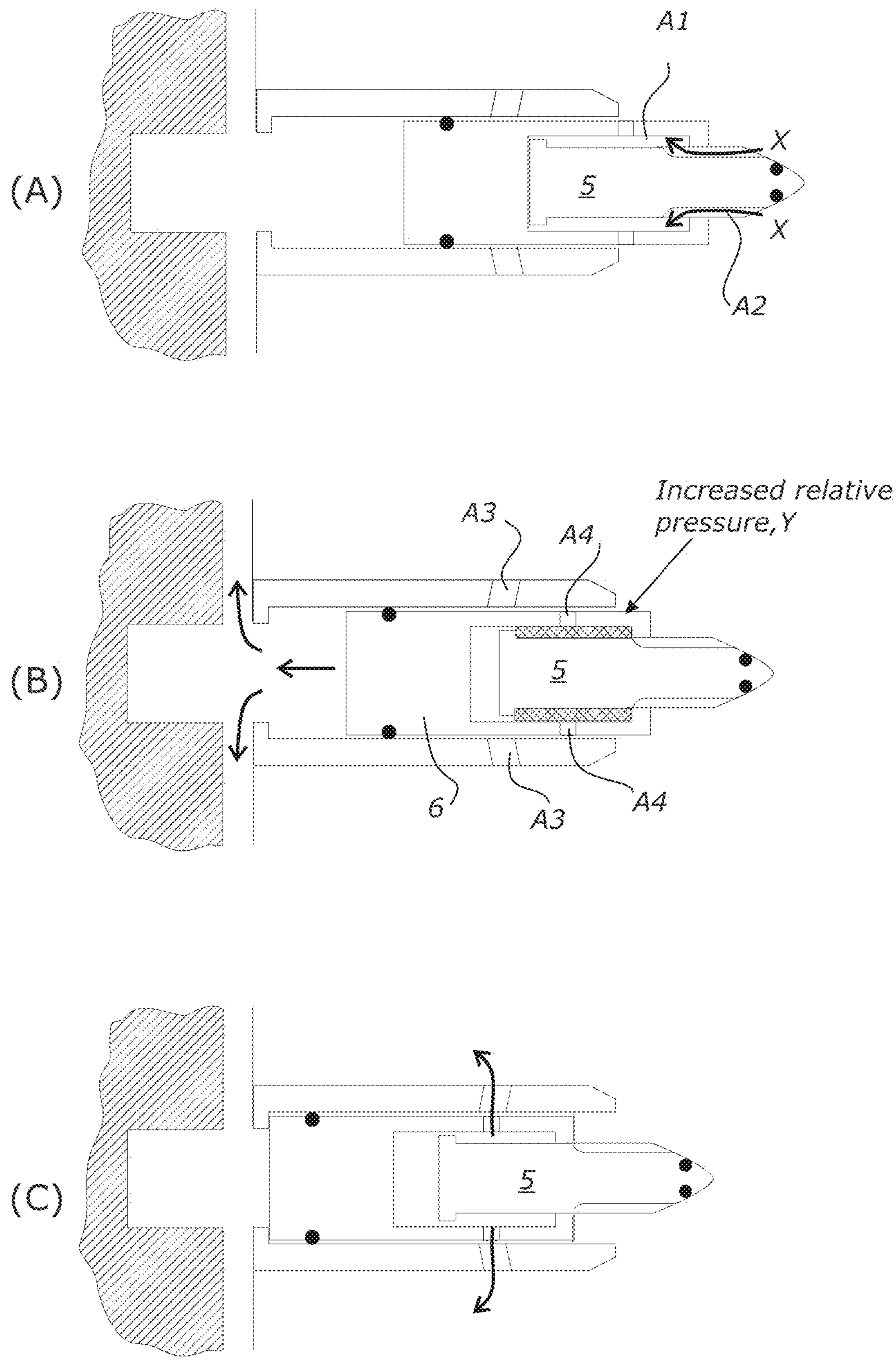

FIG. 22

VALVE ACTUATOR

TECHNICAL FIELD

[0001] The invention relates to actuators for valves, and specifically to actuators for valves for pressurized fluid powered fluid dispensing devices.

BACKGROUND OF THE INVENTION

[0002] There are many technical applications in which the speed at which a valve opens and closes to produce an effect on a downstream action or process is important. In many such applications it is the case that the faster a valve can be opened and closed, the more advantageous is the downstream effect so produced. One such application where valve operation speed can be of importance is in actuation of valves in pressurized fluid powered fluid dispensing devices. Examples of such devices include toys, such as so called "water blasters", paintball guns, and foam dart guns; agricultural liquid dispensers for liquids such as herbicides and fertilizers; and dart guns for veterinary use. Pressurized fluid powered fluid dispensing devices were first proposed to overcome the short comings of prior fluid dispensing systems which relied on the direct manual effort of a user to dispense fluid. For example, in some prior designs fluid is stored in a reservoir and a user is required to manually operate a pump by means of repeated pulling of a trigger to dispense it, an action that can only dispense a fluid stream at relatively low pressure and with considerable user effort. In order to address some of the shortcomings of such systems, devices have been proposed that store the fluid to be dispensed in a pressurized container, the pressure of the stored fluid being thus used to propel the fluid out of the dispenser upon opening of a valve by a user. One such system employs a pinch-trigger which is a device that is biased at rest to pinch closed a resiliently deformable exit pipe of a pressurized fluid storage reservoir until released by a user. Although such systems are an improvement on non-pressurized designs, they still suffer from the disadvantage that the fluid can only be dispensed in a stream according to the time taken for the release mechanism to open and close. For many applications, however, it would be an advantage to be able to deliver short, sharp bursts of fluid through fast opening and closing of the valve member such as cannot be achieved by direct, manual operation of the valve by a user. In the context of a toy water blaster, such bursts are often referred to as water "bullets".

[0003] In order to achieve relatively high valve opening and closing speeds in pressurized fluid powered fluid dispensing devices, two stage actuator mechanisms have been proposed which achieve relatively fast opening and closing speeds by employing systems wherein the trigger action by a user acts as a first stage which then triggers a second stage to operate the valve. The second stage is adapted to enable fast opening and closing of the valve in a variety of ways. One such system has been proposed as for example, in EP3901558A1, in which a first stage of operation is achieved by an electro-mechanically operated trigger which acts upon a second stage adapted to enable relatively fast opening and closing of the valve using a complex mechanical inertia/lost-motion linkage. Such devices are however expensive and complex to manufacture, and require batteries and electronic componentry making them expensive and difficult to dispose of sustainably at end of life.

[0004] In this specification where reference has been made to patent specifications, other external documents, or other sources of information, this is generally for the purpose of providing a context for discussing the features of the invention. Unless specifically stated otherwise, reference to such external documents is not to be construed as an admission that such documents, or such sources of information, in any jurisdiction, are prior art, or form part of the common general knowledge in the art.

[0005] It is an object of the present invention to provide an improved valve, or an improved method of actuating a valve, or to overcome the above shortcomings or address the above desiderata, or to at least provide the public with a useful choice.

SUMMARY OF THE INVENTION

[0006] According to a first aspect of the invention there is provided an actuator for actuation of a fluid dispense valve in a pressurized fluid powered fluid dispensing device, the actuator comprising structure to generate a pressure differential between a first zone and a second zone, the zones being adjacent a valve member of the fluid dispense valve of the device such that upon generation of the pressure differential the valve member is moved from the zone of relatively higher pressure towards the zone of relatively lower pressure such that the valve is opened. It is preferred that the actuator structure is adapted to create a partial vacuum adjacent the valve member such that upon generation of the partial vacuum the valve member is opened. The partial vacuum creation structure may comprise a pressure chamber adapted to be disposed in fluid communication with the valve member of the fluid dispense valve, the pressure chamber defining an internal volume, a pressurized fluid entry port to enable pressurization of the internal volume by pressurized fluid from a pressurized fluid source, the pressure chamber including a pressure release valve operable to enable release of pressurized fluid from the internal volume and an actuator body within the internal volume biased towards a first position and movable from the first position to a second position on operation of the pressure release valve to thereby generate in use, a partial vacuum chamber between the actuator body and the valve member to open the valve member.

[0007] The invention thus provides a rapid opening and closing of the valve and thus delivery of fast and compact fluid pulses by providing an actuator that is powered by the existing fluid pressure within the pressurized fluid powered fluid dispensing device and is therefore of low complexity and with a relatively low manufacturing and recycling cost.

[0008] In one embodiment, the actuator may further comprise the fluid dispense valve for use in a pressurized fluid powered fluid dispensing device, the actuator body defining an actuator body volume, the valve member of the fluid dispense valve being received in the actuator body volume in slidable relation thereto such that on movement of the actuator body from the first position to the second position, the partial vacuum chamber is generated in the actuator body volume.

[0009] It is preferred that the actuator comprises pressure equalization structure to cause closure of the valve member, the pressure equalization structure comprising a pressure equalization path into the partial vacuum chamber, the pressure equalization path being opened when the actuator body is in the second position. The pressure equalization structure may include a port defined by the actuator body, and structure to vary the rate of pressure equalization through the port. In one preferred embodiment, the pressure equalization structure may include a port defined by the actuator body and a port defined by the pressure chamber, the said ports being disposed for fluid communication there between, the actuator body and or the pressure chamber being rotatable relative to one another to vary the extent of fluid communication through the ports.

[0010] It is preferred that the pressure release valve is operable both to enable release of pressurized fluid from the pressure chamber and to obturate the pressurized fluid entry port.

[0011] In one convenient embodiment, the actuator may further comprise the outlet nozzle of the fluid dispensing device.

[0012] In one convenient embodiment, the actuator may further include an actuator housing, the actuator housing defining a fluid flow path for flow of pressurized fluid within the fluid dispensing device, the pressure chamber being mounted internally within the actuator housing, the actuator housing defining the pressure release port in fluid communication with the pressure chamber, and upstream and downstream fluid dispense and entry ports. It is preferred that the pressurized fluid entry port of the pressure chamber and the pressure equalization path are both in fluid communication with the fluid flow path.

[0013] In one convenient embodiment the actuator may be pressurizable from a pressurized fluid reservoir of the fluid dispensing device, a source of pressurized fluid that is located remotely from the device, or an onboard pressurized fluid cartridge.

[0014] According to a second aspect of the invention, there is provided a pressurized fluid powered fluid dispensing device comprising a pressurized fluid inlet, a fluid dispense nozzle, a valve, an energizable valve actuator and a valve actuator trigger, the trigger being operable to trigger the valve actuator to dispense fluid from the nozzle, wherein the valve actuator is energizable utilizing pressurized fluid from the pressurized fluid inlet.

[0015] It is preferred that the valve actuator comprises a pressure chamber, the pressure chamber being pressurizable using pressure from the pressurized fluid inlet. It is particularly preferred that the device is adapted such that pressure equalization between the actuator pressure chamber and the pressurized fluid inlet assists in closing the valve after opening.

[0016] In a preferred embodiment the duration of valve opening may be made to be variable by variation of the speed of pressure equalization. It is particularly preferred that pressure equalization is achieved via an equalization aperture, the size of the aperture being adjustable to vary the duration of valve opening.

[0017] In a preferred embodiment the device may comprise a manual trigger mechanism to allow for triggering of the actuator by a user.

[0018] In a preferred embodiment, the device may include a pressurizable fluid reservoir.

[0019] In a preferred embodiment the device may include structure defining a fluid fill aperture for filling the pressurizable fluid reservoir, the fill aperture being connectible to a source of pressurized fluid such as mains water, the fill aperture being in fluid connection to a fluid flow path to provide fluid flow to a pressurizable fluid reservoir. The fluid fill aperture may comprise the fluid dispense nozzle. In an alternative embodiment, the device may include a fluid pressurization device for pressurization of non pressurized fluid contained in the device. The fluid pressurization device may comprise a hand operable pump.

[0020] In preferred embodiments the pressurized fluid powered fluid dispensing device may comprise a water pistol, preferably a toy water pistol; a paintball gun; a dart gun such as a toy foam dart gun or a veterinary dart gun. In a further preferred embodiment the pressurized fluid powered fluid dispensing device may include a secondary fluid delivery system adapted to deliver a secondary fluid. The secondary fluid may be entrained in the primary fluid.

[0021] According to a third aspect of the invention, there is provided a method of opening a valve in a pressurized fluid powered fluid dispensing device, the method comprising the steps of pressurizing a fluid containing reservoir of the device, and thereby also pressurizing an actuator pressure chamber, initiating movement of an actuator body in the pressure chamber by releasing pressure through an orifice of the chamber, the actuator body being in fluid communication with a valve member of the valve such that by reducing pressure in the chamber a pressure drop is created in the chamber between the actuator and the valve member sufficient to cause movement of the valve member against the force of a biasing device to thereby open the valve.

[0022] In a preferred embodiment, the method includes the step of pressurizing the pressurized fluid powered fluid dispensing device by connecting the device to a source of pressurized fluid, such as mains water.

[0023] In another aspect the present invention consists in actuator for actuation of a fluid dispense valve in a pressurized fluid powered fluid dispensing device, the actuator comprising,

[0024] A housing structure, providing a fluid outlet, the housing structure supplied with fluid under pressure from a supply of pressurized fluid,

[0025] An obturator at least in part within the housing, which when in a first position seals off a dump chamber from external low pressure, the dump chamber supplied with fluid under pressure,

[0026] An actuator body at least in part within the housing, biased at least by the fluid under pressure in the dump chamber towards a first actuator body position,

[0027] A valve member at least in part within the housing, biased at least by the fluid under pressure in a volume defined between the actuator body and valve member, toward a first valve member position, which seals the fluid outlet,

[0028] On movement of the obturator to a second position fluid under pressure in the dump chamber is released to the low pressure, and supply of fluid under pressure to the dump chamber is also sealed off,

[0029] Fluid under pressure acting on the actuator body moves it from the first actuator position to a second actuator position, and in doing so the volume is also closed off from the fluid under pressure, the valve member is then biased by a pressure differential between the lower pressure in the volume and the surrounding fluid under pressure, toward a second valve member position which unseals the fluid outlet,

[0030] At least one pressure equalization port is then opened to equalize the pressure differential when the actuator body reaches its second position, and the actuator body then moves back to its first position under action of a bias,

This in turn moves the valve member back to its first position sealing the fluid let.

[0031] Preferably movement of the valve member from its first to second position is caused by a low pressure in the volume, and fluid under pressure acting on a sealing face of the valve member to form the pressure differential.

[0032] Preferably movement of the obturator from the second position back to its first position is provide by a bias.

[0033] Preferably the bias may be mechanical such as a spring, or a formed by fluid pressure acting on a pressure surface.

[0034] Preferably the size of the equalization port may be adjusted to control the time take for the valve member to close after opening.

[0035] Preferably the valve member and actuator body are at least in part contained within and can slide along, and can seal to, an actuator cylinder, itself contained at least in part within the housing, the actuator cylinder containing one equalization port, the actuator body containing another of the actuation ports.

[0036] Preferably the actuator cylinder forms the dump chamber.

[0037] In another aspect the present invention consists in a method of operating actuator for actuation of a fluid dispense valve in a pressurized fluid powered fluid dispensing device, the actuator comprising,

[0038] Suppling fluid under pressure to a housing structure,

[0039] biasing an actuator body at least in part within the housing, by the fluid under pressure in the dump chamber towards a first actuator body position,

[0040] biasing a valve member at least in part within the housing, by the fluid under pressure in a volume defined between the actuator body and valve member, toward a first valve member position, which seals the fluid outlet,

[0041] Moving an obturator at least in part within the housing, from

[0042] a first position at which it seals off a dump chamber from external low pressure, the dump chamber supplied with fluid under pressure, to

[0043] a second position to release fluid under pressure in the dump chamber to a low pressure, and sealing off supply of fluid under pressure to the dump chamber,

[0044] when the obturator moves to the second position, fluid under pressure acts on the actuator body, and moves it from a first actuator position to a second actuator position, and in doing so the volume is also closed off from the fluid under pressure, the valve member is then biased by a pressure differential between the lower pressure in the volume and the surrounding fluid under pressure, toward a second valve member position which unseals the fluid outlet,

[0045] opening at least one pressure equalization port to equalize the pressure differential when the actuator body reaches its second position, and the actuator body then moves back to its first position under action of a bias, this in turn moves the valve member back to its first position sealing the fluid let,

[0046] to therefore dispense fluid from an outlet of the fluid dispense valve.

[0047] In another aspect the present invention consists in an actuator for actuation of a fluid dispense valve as herein described with reference to any one or more of the accompanying drawings.

[0048] In another aspect the present invention consists in a device as herein described with reference to any one or more of the accompanying drawings.

[0049] In another aspect the present invention consists in a method as herein described with reference to any one or more of the accompanying drawings.

[0050] As used herein the term "and/or" means "and" or "or", or both.

[0051] As used herein "(s)" following a noun means the plural and/or singular forms of the noun.

[0052] The term "comprising" as used in this specification means "consisting at least in part of". When interpreting statements in this specification which include that term, the features, prefaced by that term in each statement, all need to be present, but other features can also be present. Related terms such as "comprise" and "comprised" are to be interpreted in the same manner.

[0053] It is intended that reference to a range of numbers disclosed herein (for example, 1 to 10) also incorporates reference to all rational numbers within that range (for example, 1, 1.1, 2, 3, 3.9, 4, 5, 6, 6.5, 7, 8, 9 and 10) and also any range of rational numbers within that range (for example, 2 to 8, 1.5 to 5.5 and 3.1 to 4.7).

[0054] To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and application of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting.

[0055] The invention will further be described by way of example and with reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0056] FIG. **1** is a longitudinal sectional view of an embodiment of a pressurized fluid powered fluid dispensing device according to a second aspect of the invention;

[0057] FIG. **2**. is a cut away isometric view of the device shown in FIG. **1**;

[0058] FIG. **3** is an enlarged sectional view of the part marked "A" in FIG. **1** in a first position, in accordance with a first aspect of the invention;

[0059] FIG. **4** is a view of the part of FIG. **3** in a second position;

[0060] FIG. **5** is a view of the part of FIG. **3** in a third position;

[0061] FIG. **6** is a view of the part of FIG. **3** in a fourth position;

[0062] FIG. **7** is a view of the part of FIG. **3** in a fifth position;

[0063] FIG. **8** is a part longitudinal sectional view of a further embodiment of device according to the second aspect of the invention;

[0064] FIG. **9** is a part longitudinal sectional view of a further embodiment of device according to the second aspect of the invention;

[0065] FIGS. **10***a* and **10***b* are schematic illustrations describing the method of operation of devices according to the second aspect of the invention,

[0066] FIG. **11** shows an exploded isometric view of the fluid dispense valve shown in FIGS. **3** to **7**, with the exception of the sealing elements,

[0067] FIG. **12** shows an exploded isometric view of the fluid dispense valve shown in FIGS. **13** to **17**, with the exception of the sealing elements,

[0068] FIG. **13** shows a similar view to that of FIG. **3**, a vertical cross section of a fluid dispense valve in the ready to dispense position, where instead of a spring bias to push the obturator sleeve to the ready position, the valve in FIG. **3** uses fluid pressure as the bias to reset the obturator sleeve, showing the fluid paths from the pressurized fluid reservoir through to the passageways, past the conical wall seal down the passages to behind the actuator body, and behind the valve member,

[0069] FIG. **14** shows a similar view to that of FIG. **4** where the fluid delivery valve has been triggered and the first stages of movement are ready to proceed,

[0070] FIG. **15** shows the first movement of the actuator body once the pressurized fluid behind it is dumped to atmospheric and a combination of fluid pressure and spring bias move it,

[0071] FIG. **16** shows the movement of the valve member in response to the low pressure behind it, the pressurized fluid in the passageway acting on the valve member to move it to the left as viewed allowing a shot of pressurized fluid to leave the nozzle,

[0072] FIG. **17** shows the fluid dispense valve reset and in the ready to fire position again the same as that shown in FIG. **13**, the obturator sleeve has been moved back to the left by the pressurized fluid acting on it, the actuator body has moved all the way to the right again, and the valve member has also, closing off the nozzle,

[0073] FIG. **18** shows the fluid dispense valve being filled from a source of fluid under pressure connected to the spigot and the fluid flow path past the forced open valve member and to the fluid reservoir,

[0074] FIG. **19** shows a cross section of a valve similar to that of FIG. **13** wherein the valve is configured for automatic operation once triggered, at the ready to fire position,

[0075] FIG. **20** shows a similar view to that of FIG. **19**, where the valve has been released to fire automatically, and the obturator has moved to the position to allow the valve system to operate and dispense fluid, in this case as a bullet of fluid,

[0076] FIG. **21** shows a similar view to that of FIG. **19** again where the valve is reset and ready to fire, the obturator has been latched and automatic operation has ceased, and

[0077] FIGS. **22***a*, **22***b* and **22***c* are schematic illustrations showing a sequence of operation of a further embodiment of device according to the invention.

DETAILED DESCRIPTION

[0078] Referring to the drawings, and in particular to FIGS. **1** and **3**, in accordance with a first aspect of the invention there is illustrated an actuator **1** for actuation of a fluid dispense valve **2** in a pressurized fluid powered fluid dispensing device **3** (FIGS. **1** and **2**), the actuator **1** comprising structure **4** to generate a partial vacuum adjacent a valve member **5** of the fluid dispense valve **2** of the device **3** such that upon generation of the partial vacuum the valve member **5** is opened.

[0079] An exploded view of the fluid dispense valve **2** is shown in FIG. **11** and a variation of this in FIG. **12** (for the variation shown in FIGS. **13** through **17**) that operates on the same inventive principle. The valve **2** consists of a secondary housing **9** which is connected to a pressurized fluid reservoir (not shown here, but visible in FIGS. **1** and **2**). Secondary housing **9** has an exhaust port **10** from an interior of the housing **9** to the external surrounding atmosphere **84**. Within the secondary housing **9** is contained the actuator cylinder **18**. This is slidingly and rotationally fixed in place relative to the housing **9**. The structure **4** when held or engaged to the housing **9** prevents sliding movement along the axis **102**. This is achieved by structure **4** sandwiching the actuator body **18** between it and the interior of the housing **9**. Rotational fixing can be achieved in many ways. In the preferred form there is a complimentary engagement between the interior of the housing **9** and the cylindrical mounting wall **26** of the actuator body **18** where the wall **26** engages the housing interior. In one preferred embodiment this is a triangular in plan protrusion along the axis **102** and a receiving complimentary notch in wall **26**. The actuator body **18** is fluidly sealed to the housing **9** interior by seal **28***c* on wall **26** as shown in FIG. **3**, in this case as an o-ring.

[0080] Between the exterior of the actuator cylinder **18** and interior of the housing **9** sits the obturator or closure **14** and its port closure sleeve **48**. Obturator **14** selectively seals, as will be described below, via its interior diameter to the exterior diameter of the actuator body **18** via seals **28***a* and **28***b*. The obturator **14** also slidingly seals, as will be described below, on its external diameter to the internal diameter of housing **9** via seal **101**. Obturator **14** is actuated by pivot arm **63** pivoting on pin **63**, activated, in the embodiment shown by trigger **61** by a user.

[0081] Obturator **14** is biased into the ready position by a bias, in the embodiment shown in FIGS. **3** through **11** this bias is a spring **49**, and in the embodiment shown in FIGS. **12** through **21** the bias is achieved from the fluid under pressure acting on surface **48***a* (see FIG. **16** and Detail A). Surface **48***a* is a ring-shaped surface exposed to the fluid under pressure, the ring shaped surface **48***a* defined between the sealing diameter of seals **28***a* and **21***b*. The same integers in FIGS. **11** through **21** refer to the same features and described with reference to FIGS. **1** through **10**. In this variation in FIGS. **13** to **21** surface **48***a* has two functions, firstly to provide the pressure surface **48***a* as described above to bias the obturator as described. Secondly when the obturator is in the ready to fire position as shown in FIG. **13**, surface **48***a* allows bypass of fluid under pressure from passage way **17** via gap **20***a* to the clearance surface **48***a* and in turn, in that ready to fire position, past seal **28***a* and then to passages **35** to charge chamber **42**. Surface **48***a* also provides a fluid communication bypass for fluid under pressure when the obturator **14** is in the fired position as shown in FIGS. **14** and **20**, where it provides clearance for fluid under pressure from passageway **17** via gap **20***a* to the volume defined between seals **28***a* and **21***b*, to then allow the fluid pressure to bias the obturator **14** back to the left.

[0082] Tube **29** of actuator cylinder **18** is supported by hollow extending arms **34** from cylindrical mounting ring **20**. Slidingly retained within the tube **29** is actuator body **6** which is biased toward spigot **22** end by spring **40** and fluidly sealed to the interior diameter of tube **29** by seal **86**. Defined behind actuator body **6** is dump chamber **42**, which in fluid communication with passages **35** in arms **34**. In the position shown in FIGS. **3** and **13** of obturator **14** this chamber **42** is charged with fluid under pressure from passages **17** via aperture or gap **20***a*, preferably a plurality of gaps **20***a*. Thus actuator body **6** is biased by the spring **40** toward spigot **22**.

[0083] Sliding and sealingly at least in part located within actuator body **6** is valve member **5**, in the preferred form there is a seal **107**. In the embodiment shown in FIGS. **3** through **7** this is a dynamic seal (ie there is no separate seal element sealing is achieved by the small tolerance between the two bodies, the pressure and speed of movement) and in the embodiment shown in FIGS. **13** through **17** it is a separate seal **107** mounted on valve member **5**. The hollow of actuator body **6** and base **46** of valve member **5** defining a chamber as internal volume **39***a* which also contains bias **47**, here shown as a coil spring. Valve member **5** is biased toward sealing at valve seat **23** against the interior of structure **4** at the conical nozzle portion **19** by a combination of bias **47** and fluid under pressure acting across the pressure surface defined by the sealing diameter of valve member **5** to the interior of actuator body **6**, that is the area defined by seal **107** diameter, within chamber or volume **39***a* which is fluid communication with the fluid under pressure in passage way **17** via equalization port **43**.

[0084] Actuator body **6** has portions **96** that slidingly engage in grooves **98** (see FIGS. **9**, **11**, **12** and **14**) of structure **4**. Rotation of structure **4**, for example by control element **67** will therefore rotate actuator body **6** relative to actuator cylinder **18**, and therefore vary the fluid communication path through apertures **37** and **43** (in FIGS. **6** and **17**). The smaller the size of this fluid communication through apertures **37** and **43** the slower is the valve member **5** to reset and close and thus the larger the amount of fluid dispensed **103** from the spigot. Likewise, the larger the fluid communication aperture due to the rotation between apertures **37** and **43** the quicker is the valve member **5** to close and therefore the smaller is the amount of fluid dispensed **103**. Passage ways **17** are fed with fluid under pressure from the reservoir **8** as shown by arrows in FIGS. **3** and **13**.

[0085] The valve assembly in FIGS. **3** to **7**, **11** and **13** to **21** is held together by clipping of the housing **9** over the structure **4**, whilst still slowing the structure **4** to be rotated relative to the housing **9**. A variation for holding the valve assembly together is shown in FIG. **12**, where there is a separate retaining cap **99** that holds the structure **4** to the housing **9** and over-engages the housing **9** by clipping thereto.

[0086] As illustrated here in FIGS. **3** and **13** the actuator structure which generates the pressure differential is in this embodiment partial vacuum generation structure **4** comprises a sealed to atmosphere **84** pressure chamber **4** in fluid communication with a valve member **5** of the valve **2**, the pressure chamber **4** containing an actuator body **6** reciprocable between a first position (shown here) and a second position (shown in FIG. **6**), the chamber **4** defining a pressure release port **7** and providing a pressure equalization path **7***a*, the chamber **4** being pressurizable, in use, by pressurized fluid from a pressurized fluid reservoir **8** of the fluid dispensing device **3**. The actuator body **6** is disposed within the pressure chamber **4** to be in proximity with the valve member **5** of the valve **2**, the arrangement being such that on pressurization of the pressure chamber **4** and subsequent release of pressurized fluid through the pressure release port **7**, movement of the actuator body **6** from the first position toward the second position is initiated to create a pressure drop in the pressure chamber **4** between the actuator body **6** and the valve member **5**, to move the valve member **5** (shown in FIGS. **6** and **16**) to thereby open the valve **2**, movement of the actuator body **6** to the second position initiating pressure equalization via the pressure equalization path **7***a* to allow return of the valve member **5** to the closed position (shown for example in FIG. **1**).

[0087] Referring to FIGS. **1** and **2**, the actuator **1** of the first aspect of the invention is shown in position in a water gun device **3** of the pressurized fluid type, in accordance with a second aspect of the invention. The device **3** is formed in the shape of a long weapon such as an automatic rifle and comprises valve actuator **1**, a pressurized fluid reservoir **8**, a valve actuator trigger **50**, a valve **2** and a fluid dispense nozzle **22**, wherein valve actuator **1** is energizable to open valve **2** using pressure from the pressurized fluid reservoir **8** to dispense fluid from the nozzle **22**.

[0088] As will be apparent from FIGS. **1** and **2**, the actuator **1**, reservoir **8** and trigger **50** are here provided as modules that can readily be fitted into many different forms of device **3**, such as for example, but not limited to paintball guns, dart guns including toy foam dart guns or veterinary dart guns, with suitable modification.

[0089] The water gun **3** has an outer shell **51** of generally elongate cylindrical form, with a trigger guard formation/handle **52** depending from a lower, in use surface, a top handle **53**, and a forend extension **54**. Within the trigger guard **52**, a trigger aperture **55** is formed in the outer shell **51**. As viewed, at the right hand end of the shell **51** a nozzle barrel **56** is provided in the form of a re-entrant cylindrical protrusion extending outwardly from the flat end surface **57** of the shell. A series of circular barrel ports **58** is formed in the wall of the nozzle barrel to simulate a ported gun barrel. Within the shell **51**, mounting formations **59** are formed extending from the inner surface at points along its longitudinal axis to allow for the mounting of internal components. A trigger lever channel **60** is provided along the lower, as viewed edge of the shell **51**.

[0090] The shell may be formed by any convenient means but here is formed by injection molding of a plastics material.

[0091] The internal components of the actuator **1** are illustrated in detail in FIGS. **3** to **7** and **11** to **21**, with FIGS. **3** and **13** showing the actuator in the at rest position, ready to fire. Actuator **1** comprises a generally cylindrical outer, or secondary housing **9** defining an internal volume and a vent to atmosphere in the form of exhaust port **10** to allow fluid to be released therefrom for example, to the surrounding atmosphere **84**, but may also be captured or used elsewhere. At its left hand end as viewed, outer housing **9** includes reservoir connector **11** and at its right hand end it defines a circular opening **87**. Reservoir connector **11** includes a circular section spigot **12** including an outer circumferential screw thread **13** (FIG. **1**).

[0092] Within the internal volume of housing **9** is mounted the sealed to atmosphere pressure chamber **4**, which in this embodiment is housed within an actuator housing, hereinafter referred to as inner casing **15**. Pressure release port obturator or closure **14** is mounted in sliding relation about casing **15**. Thus it can be seen that in this embodiment secondary, or outer housing **9** provides a convenient means for containing the various internal structures of the actuator **1** and otherwise connecting the actuator **1** to surrounding structures within a fluid dispensing device **3**, and pressurized fluid reservoir **8**, but as will be appreciated, it could be omitted.

[0093] Inner casing **15** is dimensioned to fit substantially within the internal volume of outer housing **9** and when in position further provides a closure for its right hand open end **87** as will be described below. Inner casing **15** comprises three main parts, namely frustoconical nozzle portion **19** partially contained within and without outer housing **9**, actuator cylinder **18** and pressure release port obturator or closure **14**. Frustoconical nozzle portion **19** and actuator cylinder **18** together define a circular section fluid flow passage **17** within inner casing **15**.

[0094] Frustoconical nozzle portion **19** includes conical wall **21**, which tapers towards straight section nozzle spigot **22**, the general shape being of a funnel. Internally, the transition point between the wall **21** of the tapered portion and the wall of spigot **22** defines a circular valve seat **23**. Externally, conical wall **21** includes circumferential flange **24** which extends outwardly a distance sufficient to reach outer housing **9** when the inner casing **15** is in position, closing circular opening **87**, and defines seal seat **21***a* for location seal **21***b* which may be an o-ring, wiper, lip seal or similar, shown here seal **21***b* is an o-ring seal. At its right hand end as viewed, nozzle spigot **22** terminates at nozzle aperture **25**. At its left hand end, conical wall **21** is open to receive actuator cylinder **18**.

[0095] Actuator cylinder **18** takes the form of generally constant section longitudinally extending tube **29** including tube wall **30**, terminating at one end in closed end **31** and at the other in open end **32**. Tube wall **30** further defines pressure equalization paths **7***a,* which here take the form of equalization apertures **37**, located adjacent tube open end **32**, and tube end **32** itself (FIGS. **3** and **4**, **13** and **14**). Actuator cylinder **18** is mounted coaxially within cylindrical mounting ring **20** via four circumferentially equally spaced radially extending arms **34** which extend outwardly from cylinder tube wall **30** to mounting ring **20**. The number of extending arms **34** may be of any number and for example two extending arms have been shown to work, three, five or more would also work. Alternatively, a flange may be used spanning between tube **30** and ring **20** with fluid apertures or passages from one side to the other in FIGS. **12** through **21** there are two mounting arms **34**. Mounting ring **20** includes axially extending cylindrical mounting wall **26**, the outer surface of which defines circumferential housing seal seat **27** with mounted O-ring seal **28**, and circumferential obturator seal seats **27***a* with mounted O-ring seals **28***a* (FIGS. **3** and **4**, **13** and **14**). Again while o-rings are mentioned here, the function of sealing may be achieved by any other appropriate seal, such as but not limited to wiper seals, lip seals or similar.

[0096] Each arm **34** contains a pressure release port **7** which here take the form of radially outwardly extending passages **35** which pass from the interior of the actuator cylinder **18** within arms **34** terminating in apertures **36** in the surface of mounting ring **20**. Passages **35** thus provide a means of fluid communication between fluid flow passage **17** and atmosphere, via actuator cylinder **18** and vent **10** when the closure **14** is open, described below.

[0097] Referring to FIGS. **3** and **13** actuator cylinder **18** and frustoconical wall portion **19** when assembled, together define a closed volume comprising fluid flow passage **17**, as stated. The parts are assembled such that tube **29** is passed into the left hand open end of frustoconical wall portion **19** to the point where the end of wall portion **19** contacts mounting ring **20**, gaps **20***a,* which act as pressurized fluid entry ports, being formed there between to allow pressurized fluid to flow into pressure chamber **4** (FIGS. **3** and **6**, **13** and **16**). In the preferred form the parts are held together at least in part by a friction fit between the actuator cylinder **18** and the wall portion **19**.

[0098] Referring to FIGS. **3** and **4**, **13** and **16** pressure release port obturator **14** comprises port closure sleeve **48** and sleeve biasing spring **49**. Sleeve **48** comprises a cylindrical collar dimensioned to fit closely around the outside of the assembled frustoconical wall portion **19** and actuator cylinder **18**, and cylindrical mounting ring **20** and in sealing relation with obturator O-ring seals **21***b,* **28***a.* It is provided on its inner surface with circumferential groove **48***a* approximately half way along its length. The position of sleeve **48** at rest (shown in FIGS. **3** and **13**) relative to inner casing **15** is determined by spring **49** which biases sleeve **48** to the left as viewed, spring **49** extending between sleeve **48** and flange **24**. Thus, it can be seen from FIG. **3** that at rest sleeve **48** closes off pressure release ports **7** from vent **10**, whilst allowing fluid to flow through the ports **7** from fluid flow path **17** via groove **48***a* (FIG. **3**), and sloping surface **48***a* in FIG. **13**, and gaps **20***a*.

[0099] Still with reference to FIGS. **3** to **7** and **13** to **17**, it can be seen that actuator cylinder **18** contains actuator body **6**. Actuator body **6**, sometimes referred to as a "hammer", comprises a solid cylindrical head section **38** with a hollow cylindrical tail section **39** extending therefrom defining an internal volume **39***a* (FIGS. **3** and **13**). The actuator body is **6** is disposed within the actuator cylinder **18** for axially reciprocal movement between a first position (FIG. **3**) and a second position (FIGS. **6** and **16**). An actuator body seal **86** is located to fluidly seal between the exterior of the actuator body **6** and the interior of the actuator cylinder **18**, whilst still allowing the reciprocal movement. The actuator body seal **86** fluidly separates the front and rear of the actuator body **6**. Actuator body **6** position at rest is biased towards the right as viewed by coil spring **40** or similar bias, and importantly, to the right of passages **35**, such that it extends out of tube open end **32** of actuator cylinder **18**, passing into frustoconical nozzle portion **19** and contacting the interior surface of conical wall **21** with which it closely abuts by virtue of chamfered end **41**. Thus, in its rest position actuator body **6** and actuator cylinder **18** together define a chamber **42**, sometimes referred to as a "dump chamber". Actuator body **6** further includes actuator equalization port **43** and valve member closure ports **44** which in the rest position shown in FIGS. **3** and **13** are all located outside of actuator cylinder **18**.

[0100] In the present embodiment as illustrated in FIGS. **1** and **2**, actuator **1** is provided in a form that includes fluid dispense valve **2** for use in the pressurized fluid powered fluid dispensing device **3** of the second aspect of the invention, although this is not essential. Thus, as illustrated in FIGS. **3** and **13**, actuator body **6** is located in close proximity with valve member **5**. Valve member **5** is a cylindrical, generally bullet shaped formation, including a tapered head **45** dimensioned to fit within nozzle spigot **22** and a stepped base **46** attached to a valve member coil spring **47** or similar bias by which it is attached to the interior of the tail section of the actuator body **6**. In FIG. **3** the valve member **5** is shown in the closed position, its tapered head **45** contacting valve seat **23** to close the valve.

[0101] Referring now to FIGS. **3** to **7** and likewise FIGS. **13** through **17**, operation of the actuator **1** will be described in the context of the water pistol device **3** of FIGS. **1** and **2**. In use, it is necessary for a user to first charge the device **3** with pressurized fluid, in this case, water. This is achieved by attaching nozzle spigot **22** to a suitable source of fluid, for example water under pressure such as a mains water tap, or hose or similar connection therefrom, as shown for example in FIG. **18** where fluid under pressure source **104** is sealed to spigot **22**. As will be appreciated, spigot **22** can be provided in any of the usual standard sizes for connection of hoses and the like to taps. Shown is spigot seal **80** on the exterior perimeter of the spigot **22** to aid sealing to the supply of pressurized fluid or water **104**, e.g. the hose or tap or similar. Once the spigot **22** is attached, the tap is opened and water is forced under pressure towards valve member **5**. The water pressure unseats valve member **5** (to the left as illustrated in FIG. **18**) allowing water to flow into fluid flow passage **17** of inner casing **15**, around arms **34** and through reservoir connector **11** into fluid reservoir **8**. Fluid reservoir **8** is of known type, and includes an expansion bladder into which the water passes. It may for example be manufactured from rubber, elastomer or similar materials. In other forms it may be a cylinder within which is a piston with a bias, such as a spring or gas, driving the piston to pressurize the cylinder and hence any fluid in it. As it fills, the expansion bladder expands within an expansion tube **81** to a set pressure beyond which water is allowed to exit via a pressure release safety valve (not shown). Fluid reservoir **8** expands longitudinally along the length of expansion tube **81** as well as radially of the longitudinal axis to fill expansion tube **81**. In this case the expansion tube **81** is provided in each half of the outer shell **51** shown in FIGS. **1** and **2**. In a preferred form the end of the fluid reservoir **8** has a seal stop **82** connected there to, which will also contact the end of the expansion tube **81** when the fluid reservoir is full.

[0102] The range of operating pressures that can be accommodated is in accordance with devices of this kind as known in the art. For example, normal domestic hose pressures are between 20 to 80 psi (approximately 1.3 bar to 5.55 bar), whilst the operating pressure of the valve, i.e. that supplied by the pressurized reservoir **8** is between 25 to 30 psi (approximately 1.7 to 2 bar) and preferably is 27 psi (approximately 1.86 bar), this range and operating pressures may of course vary without departing from the scope of the invention.

[0103] Once the set or desired pressure has been achieved the water tap can be closed and the nozzle spigot **22** released. At this point the actuator **1** within the device **3** and valve member **5**, will again be in the position shown in FIGS. **3** and **13** preventing flow of pressurized fluid past valve seat **23** and hence out of the valve **2**, however the fluid flow passage **17** of the inner casing will now be full of pressurized water. It is important to note that pressurized water is thus also contained within chamber **42**, the pressure release ports **7**, within arms **34** and groove **48***a,* with gaps **20***a* providing fluid communication with the fluid flow passage **17**. By virtue of port closure sleeve **48** and seals **28** and **21***b* however, pressurized water is prevented from passing into outer housing **9**. The weapon is now primed and ready to fire.

[0104] Referring to FIG. **1**, a simple trigger mechanism is illustrated which consists of a trigger **61** slidably mounted in trigger aperture **55**. Trigger **61** is attached to trigger lever **62** which is slidable within trigger lever channel **60** and attached at its distal end to bifurcated pivot arm **63**, pivotable about pin **64**. Pivot arm **63** includes rotatable attachment points by which it is connected to port closure sleeve **48**.

[0105] To fire a burst of water or a bullet **103**, trigger **61** is moved to the left as viewed, typically by a user's finger, which pulls trigger lever **62** to the left, causing pivot arm **63** to pivot to the left below the pin **64** and right about above the pin **64**. Pivot arm **63** is connected to the exterior of closure sleeve **48**, in the example shown by a pivotal connection **88** to allow relative rotational movement between the pivot arm **63** and sleeve **48**.

[0106] Turning to FIGS. **4** and **14**, this triggered movement of pivot arm **63** therefore forces port closure sleeve **48** to the right against the force of sleeve spring **49**, or in the case of that shown in FIG. **14** against the bias of the pressurized fluid acting on surface **48***a* as described with reference to FIG. **16**). This is illustrated in FIGS. **4** and **14**, which shows port closure sleeve **48** moved to the right, relative to its position in FIG. **3**. This opens previously closed pressure release ports **7** causing pressurized water contained in chamber **42** to rapidly pass through arms **34** into the space **89** defined by outer housing **9** and along the path of least resistance to exit through exhaust port **10**. At the same time however, fluid flow around groove **48***a* and through gaps **20***a* is now prevented by seals **28***a*. Similarly in FIG. **14/13** passages **35** are sealed off from passageway **17** by obturator **14** sealing on seal **28***a,* and thus fluid will follow the same path to volume **89** and then to atmosphere by exhaust port **10**.

[0107] The end surface of tail section **39** does not need to be sealed to the interior surface of conical wall **21**, though it may be contoured to lie more closely against it as shown in FIG. **4**, however in the variation shown in FIGS. **12** to **21** there is an additional seal on the valve member **5**. As such the fluid pressure in passageway **17** is acting on the end surface effective pressure area **89** (the area that lies between the outer and inner diameters of the actuator cylinder **18** at that tail section **39**). This is balanced at least by the fluid pressure in dump chamber **42**, and the opposing surfaces available in space **5***a* when port **43** is in fluid communication with passageway **17**.

[0108] Similarly, the tail end of the valve member **5** forms a first valve effective pressure area **91**, being the pressure area between the outer diameter of the valve member **5** and the sealing diameter **92** at the valve seat **23** when in the closed position as shown in FIG. **4**.

[0109] These pressure forces trying to open the valve **5** are in sum opposed by the bias **40** and **47**, and fluid pressure acting on the actuator head surface effective pressure area **93** and the valve head surface effective pressure area **94**, keeping the valve closed shown in FIG. **4**.

[0110] Referring now to FIGS. **5** and **15**, it can be seen that the rapid exit of pressurized water from the chamber **42** via exhaust port **10** to the relatively lower pressure of the atmosphere **84** surrounding the actuator **1** and the consequent pressure drop therein causes the actuator body **6** to move to the left, as viewed, against the force of biasing spring **40**, from its first, or at rest, position. Movement of the actuator body **6** to the left as viewed is caused by a combination of valve member coil spring **47** acting on the actuator body **6**, and initially water pressure in internal volume **39***a* from fluid flow passageway **17** via port **43**, acting on the actuator body face **85** and against base **46** of valve member **5**. As can be seen in FIGS. **5** and **15**, port **43** is closed off to water pressure partway through its travel to the left.

[0111] Continuing with FIGS. **5** and **15**, it can be seen that the rapid exit of pressurized water from the chamber **42** and the consequent pressure drop therein causes the movement of the actuator body **6** to the left, against he force of the biasing spring **40** from its first or at rest position, away from valve member **5** and opens or expands a space **5***a* therebetween and at the same time closes actuator equalization port **43** by bringing it into the open end of actuator cylinder **18**. As a result, pressurized water in flow passage **17** can no longer enter space **5***a* and the continued travel of the actuator body **6** to the left to its second position creates a partial vacuum, or lower pressure in space **5***a* between the actuator **6** and the valve member **5**, than the surrounding fluid in passage **17**. The tolerances of the outer diameter of actuator **6** and the internal diameter of the bore of the actuator cylinder **18** are such that under the rapid movement of the actuator body **6** there is effectively a dynamic seal between the two such that pressure in the time frame of the movement of the actuator body cannot equalize between space **5***a* and passage **17**. In other embodiments (described below) there is a physical seal **107** is present between the two.

[0112] Referring to FIGS. **6** and **16** the partial vacuum, or low pressure, in space **5***a* compared to passageway **17**, "pulls" the valve member **5** to the left, clear of the valve seat **23** to allow pressurized water to exit from passageway **17** through nozzle aperture **25**. Further fluid pressure can act, at least initially on opening of the valve member **5** against the second valve effective pressure area **95**, that is across the full diameter of the valve member **5**, further opening the valve.

[0113] Referring now to FIGS. **7** and **17**, when the actuator body **6** reaches the second position as shown, pressurized water or fluid flowing back into the partial vacuum chamber **5***a* created between the actuator body **6** and the valve member **5**, via alignment of equalization port **43** and pressure equalization path **7***a* (as aperture **37**), causes the valve member **5** to rapidly return to the right under the force of the spring **47** and the valve **2** is then closed. As will be appreciated, pressurized fluid can flow into the partial vacuum chamber **5***a* via the clearance between the actuator body **6** and the tube wall **30**, and/or via aperture **37** therein under longer time frames. Pressure around the actuator body **6** (that is between chamber **42** and space **5***a*) is thus equalized and actuator body **6** returns to the first position under the biasing force of actuator spring **40**. Thus, it will be appreciated from the foregoing that by varying the sizes, number and positions of equalization ports **43** and pressure equalization paths **7***a* (as aperture **37**), a variability in valve opening duration can be achieved as previously described. Pressure equalization of space **5***a* to chamber **42** can be controlled and varied by the relative alignment of aperture **37** and equalization port **43**. Put simply, the larger the volume of the passage or cross-sectional size of the orifice available for pressure equalization, the faster the valve **5** will close, thus providing a means of varying that volume or orifice size allows a user to vary valve opening duration at will. In the present embodiment this variation is achieved by providing actuator body **6** as rotatable relative to and within the cylinder **18** such that the circumferential position of port **43** and aperture **37** can be varied. Rotation will thus bring more or less of aperture **43** into register with aperture **37** according to the user's preference to cater for applications of the device **3** that require faster or slower valve opening duration. Rotation can be achieved by the user and is described below with reference to FIG. **9**.

[0114] Referring now to FIG. **8**, a second embodiment of device **3** is illustrated. In this embodiment, rather than the device being filled through the nozzle spigot **22**, a dedicated fill conduit **65** is provided through which pressurized fluid such as water can be passed into fluid flow passage **17** via aperture **66** and from there, via the pathway previously described, into the fluid reservoir **8**.

[0115] Referring now to FIG. **9** and FIGS. **11** to **21**, a further embodiment of actuator **1** in accordance with the first aspect of the invention is illustrated. This embodiment includes an externally operable control element **67** which can be operated by a user to rotate actuator body **6** within cylinder **18**, thereby providing a means of adjusting valve opening duration as described above, but here, without the need to partially disassemble the device **3**. Control element **67** is connected to inner casing **15**. A sliding engagement is present between the interior surface of inner casing **15** and actuator **6**. In the embodiment shown this is via portion **96** extending from

[0116] In a further embodiment, (not shown), the device **3** is provided without an onboard pressure reservoir. Thus, reservoir connector **11** of outer housing **9** is provided in the form of a user accessible high pressure connector of known type, such as for example M22, ⅜" threaded or quick connect, and pressurized fluid is fed from an external source via an umbilical. As a yet further alternative, the device **3** is provided with a user accessible cartridge compartment in place of reservoir **8** which is adapted to removably receive a CO_2 cylinder of known type, reservoir connector **11** being adapted to connect with and pierce an inserted cylinder to achieve pressurization of the device **3**.

[0117] FIGS. **10***a* and **10***b* are schematic drawings which illustrate different modes of operation of a device **3** according to the second aspect of the invention. FIG. **10***a* illustrates the mode of operation of operation of device **3** such as those illustrated above. FIG. **10***b* illustrates the mode of operation of a device **3** that includes additional or secondary fluid dispense apparatus **68**. Such a device could for example be a chemical spray gun in which a chemical such as a fertilizer or weed killer concentrate is diluted and dispensed. In FIG. **10***b* it can be seen that fluid pressure from reservoir **69**, in addition to providing the motive power for dispensing the primary fluid (shown by forward hatching) also pressurizes a secondary fluid storage chamber **70**. Instead of having a trigger mechanism that operates using the pressure from the primary fluid to open the valve, here a trigger mechanism **71** is provided that uses pressurized secondary fluid (rearward hatching) to both work the valve and also provide secondary fluid to the primary fluid stream as it is dispensed in order to use the force of the primary fluid to provide mixing of the primary and secondary fluids.

[0118] An automatic version of the valve as a variation in the bias of obturator **14** is described with reference to FIGS. **19** through **21**. The obturator **14** has a first pressure area (ring shaped) defined between the sealing diameters of seals **28***b* and **28***a* which pressure area biases the obturator to the right as viewed by the fluid under pressure present in sealed volume **89**, which is in fluid communication with passages **17** as described earlier through gap **20***a*. The obturator **14** is prevented from moving to the right as viewed by sear **105** engaged to the obturator as shown in FIG. **19** preventing its movement.

[0119] On disengagement of the sear **105** from the obturator **14**, for example by a trigger action as earlier described, but which trigger action pulls the sear downwards as viewed, the obturator **14** is then free to move to the right due to the pressure bias described above. As the obturator **14** initially opens and unseals from seal **28***b*, there is a greater pressure area formed briefly, again ring shaped, between seals **28***a* and **101**. This for a short period of time until volume **89** equalizes with atmospheric also acts to move obturator **14** to the right. The firing process of the valve as earlier described is now set in motion.

[0120] Once moved to the right and volume **89** has equalized with atmospheric **84**, as shown in FIG. **20**, the pressure on first pressure area is reduced as that pressure has vented to atmosphere through port **10**, again the same exhausting process as described earlier. The actuator body **6** and valve member **5** then follow the same activation as earlier described with reference to FIGS. **3** through **7** and **13** through **17** and dispense fluid from the spigot **22** and then close. Again, the amount dispensed can be controlled by the register of apertures **43** and **37** as earlier described to vary the fluid passage way therethrough.

[0121] After firing there is fluid under pressure from passage way **17** via gap **20***a* acting on a second pressure area (again also ring shaped, similar to that of area **48***a* in FIG. **16**) as defined now between the sealing diameters of seals **21***b* and **28***a*. Fluid under pressure is retained in the volume between seals **28***a* and **21***b* and acts on second pressure surface **48***a*. This creates a force that is higher than the force provided by the low pressure on the first pressure area, as this has exhausted to lower pressure atmospheric. The obturator **14** therefore, in the same return method as described in FIG. **16**, is now biased by the force on the second pressure area to move to the left to seal off volume **89** from exhaust port **10** and lower pressure atmosphere and the whole valve system repressurizes and resets to a ready to fire position the same as in FIGS. **3**, **13** and **17**.

[0122] Optionally, not shown here but shown in FIG. **3**, there is a bias as a spring acting on the obturator **14** to return it to the left.

[0123] However, if the trigger is still depressed and therefore sear **105** is not engaged to obturator **14** the obturator can now repeat the cycle, moving to the right, opening the volume **89** to the exhaust, sealing off flow of fluid to the volume **89**, and the valve will "fire", dispensing fluid again. Dispensing of fluid again can be thought of a small body of fluid released with velocity from the spigot **22**. The obturator **14** will then be biased back to the right, and so on.

[0124] This process will continue until either the fluid under pressure falls to that of atmospheric, though in reality given there is friction of the seal within the system the pressure will be slightly above atmospheric, or the pressurized reservoir **8** runs out of fluid.

[0125] The valve as described in FIGS. **1** to **21** can be used in a number of applications. For example, but not limited to, the gun-like water toy depicted. The valve also may be used in a hand-held shooter that may be mounted to the wrist being triggered by motion of the user's hand relative to the wrist, a ground mounted toy that periodically or randomly releases a jet of water vertically, such timing and amounts controlled as described above. A fluid powered vehicle or toy is also envisaged using the valve, where automatic (pulsed) and/or continuous (stream or jet) release of the fluid provides a jet to power the toy directly or indirectly. The release may be until exhaustion, or be by set amount of fluid being released or time passed.

[0126] FIGS. **22***a* to **22***c* are schematic drawings which illustrate a further embodiment of actuator in accordance with the first aspect of the invention. In this embodiment, rather than creating a partial vacuum, actuator structure **4** is adapted to create a zone of increased fluid pressure adjacent a part of the valve member **5** in order to move the valve member **5** from the zone of increased fluid pressure to a zone of relatively lower fluid pressure, to open the valve. For ease of exposition and clarity, structures which are common with the previously described embodiment have been omitted. FIG. **22***a* illustrates the device when it is pressurized and ready to fire. In this embodiment pressurized fluid X is allowed to enter upstream of the valve member **5** via fluid entry ports A**2**. As will be appreciated, this is upstream by reference to the direction of travel of the valve member **5** during the valve opening sequence. The fluid enters chamber **A1** which is thus brought to the operating pressure of the device. When the device is triggered, pressurized fluid is released to atmosphere from downstream of the valve member, as described previously with reference to FIG. **4**. This is shown in FIG. **22***b*. This initiates movement of the actuator body **6** to the left as viewed, hydro-locking chamber A1 and the valve member **5** also moves to the left and the valve is opened. Movement of the actuator **6** to the left as viewed brings into register equalization ports A3 and A**4** allowing pressure release indicated by arrows Z, and the valve member **5** is returned to the closed position. The actuator body **6** is returned to the closed position by a return spring (not shown).

[0127] In addition to the water or fluid based described here the present invention may be used in other area. For example further recreational applications are for paintball guns, and foam dart guns. In other areas the present invention may be used for agricultural liquid dispensers for liquids such as herbicides, pesticides and fertilizers; dart guns for veterinary use or application of veterinary treatments, e.g. cutaneously, subcutaneously, oral or nasal or other.

[0128] A fast acting valve in the present invention has advantage and can find application where precise or targeted application of a fluid is desirable, as above in agriculture, but also for example in industry, where quick and easy accurate application of a fluid is needed, for example assembly lubrication, thread-lock or other applications.

[0129] Further a fast acting valve such as the present invention may prove beneficial to allow for fast movement over an area with fast and accurate application, again such as in agriculture, but also in industry, for example application of inks or similar over a large area, or repeated applications.

[0130] The foregoing description of the invention includes preferred forms thereof. Modifications may be made thereto without departing from the scope of the invention.

1. An actuator for actuation of a fluid dispense valve in a pressurized fluid powered fluid dispensing device, the actuator comprising structure to generate a pressure differential between a first zone and a second zone, the zones being adjacent a valve member of the fluid dispense valve of the device such that upon generation of the pressure differential the valve member is moved by the pressurized fluid from the zone of relatively higher pressure of pressurized fluid towards the zone of relatively lower pressure of pressurized fluid such that the valve is opened.

2. An actuator according to claim **1**, the actuator comprising structure to generate a partial vacuum adjacent a valve member of the fluid dispense valve of the device such that upon generation of the partial vacuum the valve member is opened.

3. An actuator according to claim **2**, the partial vacuum creation structure comprising a pressure chamber adapted to be disposed in fluid communication with the valve member of the fluid dispense valve, the pressure chamber defining an internal volume, a pressurized fluid entry port to enable pressurization of the internal volume by pressurized fluid from a pressurized fluid source, the pressure chamber including a pressure release valve operable to enable release of pressurized fluid from the internal volume and an actuator body within the internal volume biased towards a first position and movable from the first position to a second position on operation of the pressure release valve to thereby generate in use, a partial vacuum chamber between the actuator body and the valve member to open the valve member.

4. An actuator according to claim **2**, further comprising the fluid dispense valve for use in a pressurized fluid powered fluid dispensing device, the actuator body defining an actuator body volume, the valve member of the fluid dispense valve being received in the actuator body volume in slidable relation thereto such that on movement of the actuator body from the first position to the second position, the partial vacuum chamber is generated in the actuator body volume.

5. An actuator according to claim **3**, comprising pressure equalization structure to cause closure of the valve member, the pressure equalization structure comprising a pressure equalization path into the partial vacuum chamber, the pressure equalization path being opened when the actuator body is in the second position.

6. An actuator according to claim **5**, the pressure equalization structure including a port defined by the actuator body, and structure to vary the rate of pressure equalization through the port.

7. An actuator according to claim **5**, the pressure equalization structure including a port defined by the actuator body and a port defined by the pressure chamber, the ports being disposed for fluid communication there between, the actuator body and or the pressure chamber being rotatable relative to one another to vary the extent of fluid communication through the ports.

8. An actuator according to claim **3**, the pressure release valve being operable both to enable release of pressurized fluid from the pressure chamber and to obturate the pressurized fluid entry port.

9. An actuator according to claim **4**, further comprising the outlet nozzle of the fluid dispensing device.

10. An actuator according to claim **3**, further including an actuator housing, the actuator housing defining a fluid flow path for flow of pressurized fluid within the fluid dispensing device, the pressure chamber being mounted internally within the actuator housing, the actuator housing defining the pressure release port in fluid communication with the pressure chamber, and upstream and downstream fluid dispense and entry ports.

11. An actuator according to claim **4**, wherein the pressurized fluid entry port of the pressure chamber and the pressure equalization path are both in fluid communication with the fluid flow path.

12. An actuator according to claim **3**, wherein the actuator is pressurizable from a pressurized fluid reservoir of the fluid dispensing device, a source of pressurized fluid that is located remotely from the device, or an onboard pressurized fluid cartridge.

13.-**25**. (canceled)

26. A method of operating a valve in a pressurized fluid powered fluid dispensing device, the method comprising the steps of providing a pressurized fluid source to the device, and thereby also pressurizing an actuator pressure chamber, initiating movement of an actuator body in the pressure chamber by releasing pressure through an orifice of the chamber, the actuator body being in fluid communication with a valve member of the valve such that by reducing pressure in the chamber a pressure drop is created in the chamber between the actuator and the valve member by the pressurized fluid sufficient to cause movement of the valve member against the force of a biasing device to thereby open the valve.

27. A method according to claim **26**, including the step of pressurizing the pressurized fluid powered fluid dispensing device by connecting the device to a source of pressurized fluid, such as mains water.

28. A method according to claim **26**, including the step of pressurizing a fluid containing reservoir of the device by connecting the device to a source of pressurized fluid, such as mains water.

29. An actuator for actuation of a fluid dispense valve in a pressurized fluid powered fluid dispensing device, the actuator comprising,

a housing structure, providing a fluid outlet, the housing structure supplied with fluid under pressure from a supply of pressurized fluid,

an obturator at least in part within the housing, which when in a first position seals off a dump chamber from external low pressure, the dump chamber supplied with fluid under pressure,

an actuator body at least in part within the housing, biased at least by the fluid under pressure in the dump chamber towards a first actuator body position,

a valve member at least in part within the housing, biased at least by the fluid under pressure in a volume defined between the actuator body and valve member, toward a first valve member position, which seals the fluid outlet,

on movement of the obturator to a second position fluid under pressure in the dump chamber is released to the low pressure, and supply of fluid under pressure to the dump chamber is also sealed off,

fluid under pressure acting on the actuator body moves it from the first actuator position to a second actuator position, and in doing so the volume is also closed off from the fluid under pressure, the valve member is then biased by a pressure differential between the lower pressure in the volume and the surrounding fluid under pressure, toward a second valve member position which unseals the fluid outlet,

at least one pressure equalization port is then opened to equalize the pressure differential when the actuator body reaches its second position, and the actuator body then moves back to its first position under action of a bias,

this in turn moves the valve member back to its first position sealing the fluid let.

30. An actuator as claimed in claim **29**, wherein movement of the valve member from its first to second position is caused by a low pressure in the volume, and fluid under pressure acting on a sealing face of the valve member to form the pressure differential.

31. An actuator as claimed in claim **29**, wherein movement of the obturator from the second position back to its first position is provided by a bias.

32. An actuator as claimed in claim **31**, wherein the bias may be mechanical such as a spring, or a formed by fluid pressure acting on a pressure surface.

33. An actuator as claimed in claim **29**. wherein the size of the equalization port may be adjusted to control the time take for the valve member to close after opening.

34. An actuator as claimed in claim **29**, wherein the valve member and actuator body are at least in part contained within and can slide along, and can seal to, an actuator cylinder, itself contained at least in part within the housing, the actuator cylinder containing one equalization port, the actuator body containing another of the actuation ports.

35. An actuator as claimed in claim **34**, wherein the actuator cylinder forms the dump chamber.

36.-**39**. (canceled)

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