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(54) **VALVE**

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(57) **ABSTRACT**

A valve includes a housing having an inlet, an outlet and a ram receiving chamber. A ram has a first end and a second end and is slidably supported in the ram receiving chamber. The ram has a central pin on the second end of the ram. An actuating element is connected to the ram. A plate is fixedly connected to the housing. The plate has a central bore. The plate and the ram selectively abut to form a valve seat. The inlet is in fluid communication with the ram receiving chamber. The ram has an outer wall. Fluid communicates between a portion of the ram receiving chamber adjacent to the first end of the ram and a portion of the ram receiving chamber adjacent to the second end of the ram. In the closed position, the ram abuts with the plate. The pin protrudes through the central bore in the plate. In the open position, the actuating element displaces the ram such that the ram is spaced from the plate.

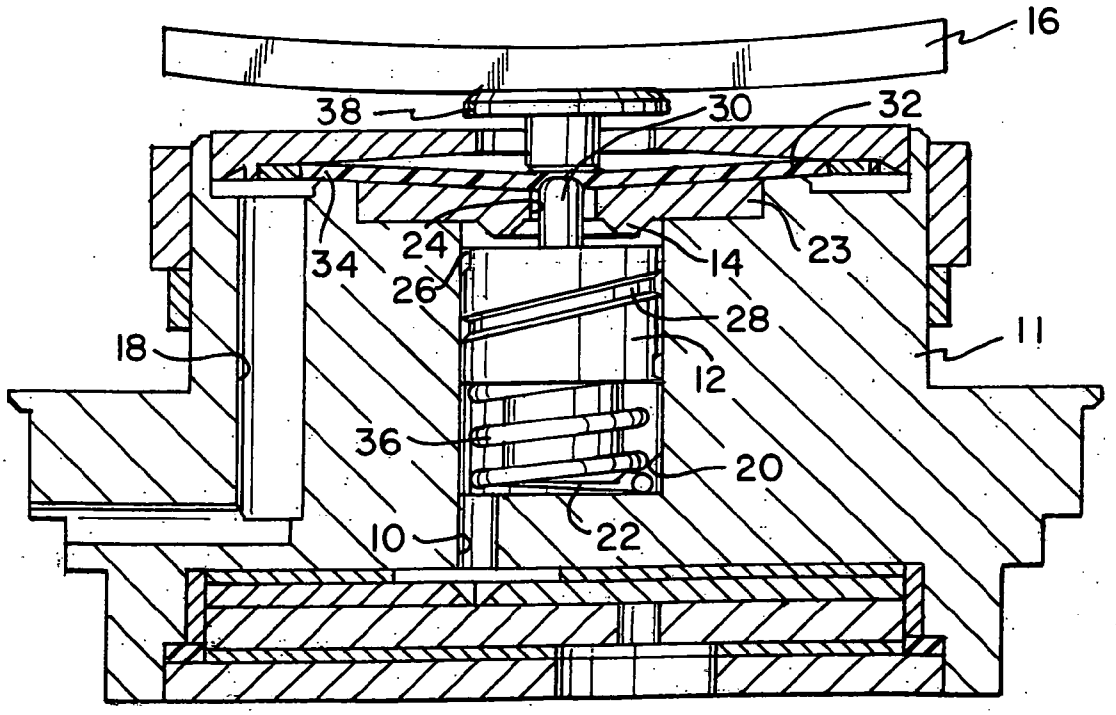

FIG. 1

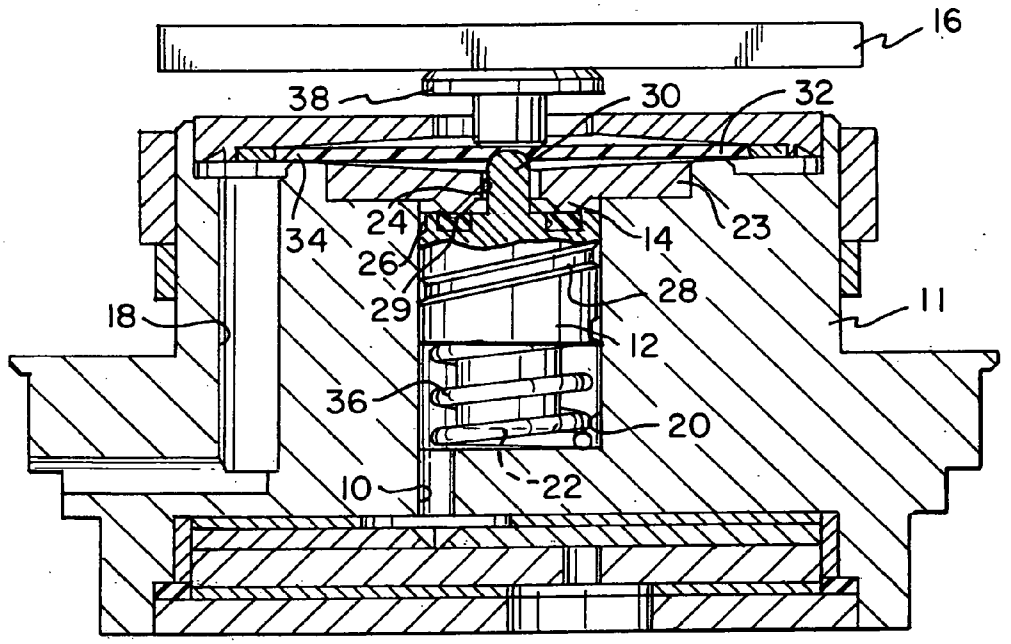
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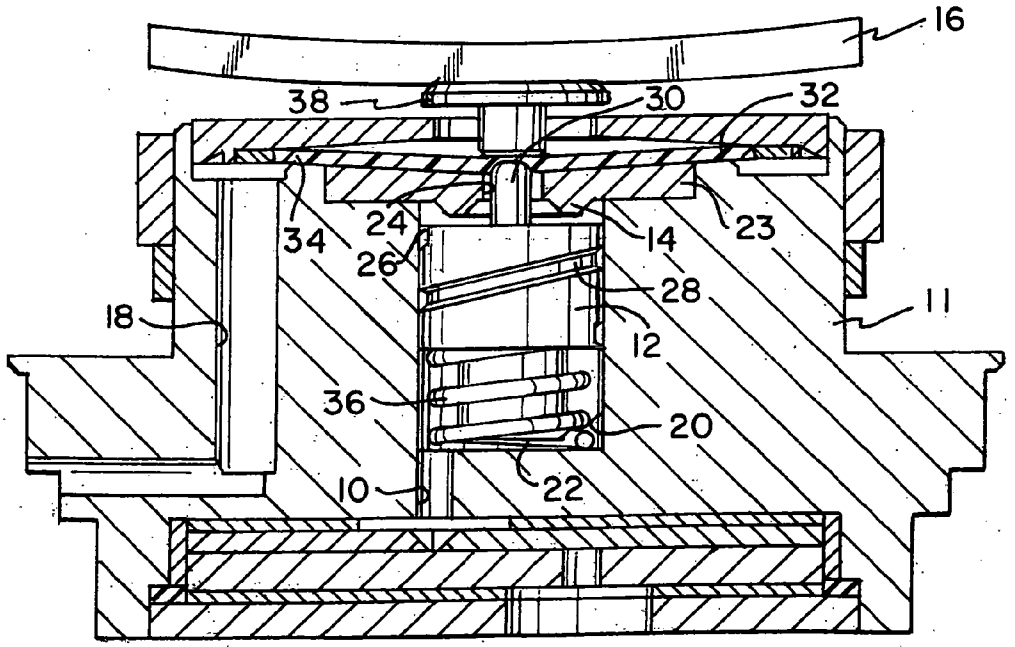
FIG. 2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VALVE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a valve. More specifically, the present invention relates to a valve for use in implantable infusion pumps.

[0003] 2. Discussion of Related Art

[0004] Valves of various embodiments are known for a long time. Valves have an inlet, a valve body interacting with a valve seat, an actuating element acting upon the valve body and on outlet. An example of a prior art valve is disclosed in "Brockhaus, Naturwissenschaften und Technik", 1983, Bd. 5, S. 192.

[0005] It is an object of the present invention to create a compact and reliable valve, which is suitable for the conveyance of very small quantities of liquid. It is also an object of the present invention to provide a valve that if it fails, will do so in a safe state. It is a further object to provide a valve that has a compact design, which would be well suited for an implantable medical device. It is a further object of the present invention to provide a valve that has a minimal displacement, thereby allowing for minimal energy consumption. It is a further object of the present invention to provide a valve that has a minimal dead volume.

SUMMARY OF THE INVENTION

[0006] According to the present invention these and other objects are solved in an exemplary embodiment of a valve having a housing, an inlet, an outlet and a ram receiving chamber. A ram has a first end and a second end and is slidably supported in the ram receiving chamber. The ram has a central pin on the second end of the ram. An actuating element is connected to the ram. A plate is fixedly connected to the housing. The plate has a central bore. The ram and plate selectively abut to form a valve seat. The inlet is in fluid communication with the ram receiving chamber. The ram has an outer wall. Fluid communicates between a portion of the ram receiving chamber adjacent to the first end of the ram and a portion of the ram receiving chamber adjacent to the second end of the ram. In the closed position, the ram abuts with the plate. The pin protrudes through the central bore in the plate. In the open position, the actuating element displaces the ram such that the ram is spaced from the plate.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0007] **FIG. 1** is a sectional view of a valve in accordance with an exemplary embodiment of the present invention, shown in the closed position; and

[0008] **FIG. 2** is a sectional view of the valve of **FIG. 1**, shown in the open position.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0009] Referring now to **FIGS. 1 and 2**, the valve includes a cylindrical ram **12** forming the valve body. Ram **12** is axially slidably supported within a cylindrical ram receiver **20**, which is in the form of a bore in a valve housing **11**. An inlet **10** is in fluid communication with one axial end **22**, sometimes referred to as the lower face, of ram **12**. The other axial end **26** of ram **12** is sometimes referred to as the upper face.

[0010] A groove **28** is formed in the outer wall of ram **12**. Groove **28** provides fluid communication between the chamber adjacent to the lower face **22** within the housing **11** and the chamber adjacent to the upper face **26**. Groove **28** is in a currently preferred exemplary embodiment a spiral groove. But groove **28** could be axial. Additionally, ram **12** could have multiple grooves, such as two, three or even more grooves. Alternatively, ram **12** could have no grooves, but a relatively small annular gap would exist between the outer circumferential wall of ram **12** and the inner cylindrical wall of cam receiving chamber **20**. In another alternative design, the groove or grooves could be formed in the inner cylindrical wall of the cam receiving chamber **20** and not in the outer surface of the ram. In addition, the groove or grooves could be formed in the inner cylindrical wall of the cam receiving chamber **20** and in the outer surface of ram **12**. Thus, in any embodiment, liquid entering via inlet **10** flows to the area of the cam receiving chamber adjacent to lower face **22** of the ram **12** and is conveyed from this area to the area of the cam receiving chamber adjacent to upper face **26** of the ram **12** via groove(s) **28** or via the annular gap between the outer circumferential wall of ram **12** and the inner cylindrical wall of cam receiving chamber **20**.

[0011] A gasket **29** is formed in the upper face **26** of ram **12**. In a currently preferred exemplary embodiment, gasket **29** is made of an elastically yielding plastic material, preferably silicone. But gasket **29** could be made of any biocompatible deformable plastic or soft metal. A plate **23** is fixedly connected to housing **11**. Plate **23** includes a downwardly depending annular projection **14** that forms a valve seat for gasket **29** of ram **12**. As illustrated in **FIG. 1**, the valve is in the closed position. Thus, gasket **29** abuts against projection **14** to prevent fluid from travelling past the valve seat to an outlet **18** of the valve. Plate **23** has a central recess or bore **24**, thereby forming an annular channel between bore **24** and an upwardly projecting pin **30** of ram **12**. Pin **30** protrudes through bore **24** of plate **23**. In the open position illustrated in **FIG. 2**, ram **12** is displaced downwards such that the gasket **29** is spaced from the projection **14**. Thus, the liquid can flow past the valve seat from the outer area above front face **26** to the inner area above front face **26** and through the annular channel between bore **24** and pin **30**. The fluid then flows through a gap **34** between a plate **23** and a membrane **32** to the outlet **18** and out of the valve housing **11**.

[0012] In a currently preferred exemplary embodiment, projection **14** has a trapezoidically shape in cross-section as illustrated. But projection **14** could have different shapes, such as, for example, hemispherical. In another embodiment projection **14** could be formed on the front face **26** or ram **12** and gasket **29** could be formed in plate **23**.

[0013] Central pin **30** is provided on the front face **26** and is directed towards plate **23**. An actuating element **16**, preferably in the form of a bending plate, acts upon the central pin **30**. Actuating element **16** has a downwardly projecting projection **38**, which is aligned with pin **30**. A flexible membrane **32** is disposed between the free end of the pin **30** and the free end of the projection **38** of actuating element **16**. Membrane **32** forms a hermetic seal within the housing. Thus, the fluid within the valve housing **11** doesn't contact projection **38** or actuating element **16**. In a currently

preferred exemplary embodiment, actuating element **16** is a piezoelectric element, which requires very little energy to move from the position illustrated in the drawing Figure to the downward position, thereby opening the valve. In addition, in a currently preferred exemplary embodiment, membrane **32** is made of titanium. But membrane **32** could be made of stainless steel. In addition, membrane **32** could have a bellows shape.

[**0014**] A coil spring **36** rests within the ram receiver **20** and acts upon the lower face **22** of ram **12**. Thus, spring **36** biases ram **12** in the upper direction to the position illustrated in the drawing, thereby closing the valve.

[**0015**] Even if the valve were to fail, the valve would be brought to the illustrated closed position due to the coil spring **36** acting on ram **12**. Additionally, the fluid flowing into the valve will apply a pressure on the entire lower face **22** of ram **12**, but only on an outer annular portion of upper face **26**. The fluid will naturally bias ram **12** upwardly against projection **14** of plate **23**. Thus, if the valve in accordance with the present invention fails, it will do so in a safe state. This is especially important to prevent unwanted volume of fluids from being infused into the body.

[**0016**] The valve in accordance with the present invention has a compact design, which is well suited for an implantable medical device, such as, for example, an implantable infusion pump. Within such a pump, the pump inlet is in fluid communication with the valve inlet, and the pump outlet is in fluid communication with the valve outlet. The valve has a minimal displacement, thereby allowing for minimal energy consumption. The valve also has a minimal dead volume.

[**0017**] In the specification, terms, such as, for example, "upper", "lower", "upwardly" and "downwardly", etc. are used with reference to the drawing figures to ease the description of the present invention. However, these terms are not to be so limited as the valve could be oriented in virtually any direction. Thus, for example, the term "upwardly" may not necessarily be upward when the valve is used.

What is claimed is:

1. A valve comprising:

a housing having an inlet, an outlet and a ram receiving chamber;

a ram having a first end and a second end, the ram is slidably supported in the ram receiving chamber, the ram has a central pin on the second end of the ram;

an actuating element being connected to the ram;

a plate being fixedly connected to the housing, the plate has a central bore, the ram and the plate selectively abut to form a valve seat;

wherein the inlet is in fluid communication with the ram receiving chamber, the ram has an outer wall, a portion of the ram receiving chamber adjacent to the first end of the ram is in fluid communication with a portion of the ram receiving chamber adjacent to the second end of the ram; in the closed position the ram abuts with the plate ; the pin protrudes through the central bore in the plate, in the open position the actuating element displaces the ram such that the ram is spaced from the plate.

2. The valve according to claim 1, wherein the actuating element is a piezoelectrical bending plate.

3. The valve according to claim 1, wherein the ram receiving chamber is cylindrical.

4. The valve according to claim 1, further comprising a flexible membrane connected to the housing and disposed between a free end of the pin and the actuating element.

5. The valve according to claim 4, wherein the membrane is made of titanium.

6. The valve according to claim 4, wherein the membrane forms a hermetic seal within the housing.

7. The valve according to claim 4, wherein a gap is disposed between the plate and the membrane, the gap is in fluid communication with the outlet.

8. The valve according to claim 7, wherein the gap is annular.

9. The valve according to claim 1, further comprising a spring disposed within the ram receiving chamber, the ram is biased by the spring into the closed position.

10. The valve according to claim 9, wherein the spring is a coil spring, the spring acts upon the first end of the ram.

11. The valve according to claim 1, wherein the actuating element has a projection that is axially aligned with the central pin.

12. The valve according to claim 1, wherein the ram is cylindrical in shape.

13. The valve according to claim 12, wherein the ram is displaced axially.

14. The valve according to claim 1, wherein the ram has a gasket on the second end of the ram.

15. The valve according to claim 14, wherein the plate has a depending projection, the gasket and the depending projection selectively abut to form the valve seat.

16. The valve according to claim 15, wherein the depending projection has a trapezoidal shape in cross-section.

17. The valve according to claim 14, wherein the gasket is made of an elastically yielding plastic material.

18. The valve according to claim 1, wherein the ram has a groove disposed in its outer wall.

19. An implantable infusion pump comprising:

a housing having a pump inlet, a pump outlet

a valve having a housing, an inlet fluidly connected to the pump inlet, and an outlet fluidly connected to the pump outlet, the valve having a ram receiving chamber;

a ram having a first end and a second end, the ram is slidably supported in the ram receiving chamber, the ram has a central pin on the second end of the ram;

an actuating element being connected to the ram;

a plate being fixedly connected to the housing, the plate has a central bore, the ram and the plate selectively abut to form a valve seat;

wherein the inlet is in fluid communication with the ram receiving chamber, the ram has an outer wall, a portion of the ram receiving chamber adjacent to the first end of the ram is in fluid communication with a portion of the ram receiving chamber adjacent to the second end of the ram; in the closed position the ram abuts with the plate; the pin protrudes through the central bore in the plate, in the open position the actuating element displaces the ram such that the ram is spaced from the plate.

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