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Jandl

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(54) NEEDLE VALVE ASSEMBLY WITH FLOATING SEAT APPARATUS

(75) Inventor: **Steven Alan Jandl**, Madison, WI (US)

(73) Assignee: **GENERAL ELECTRIC COMPANY**, Schenectady, NY (US)

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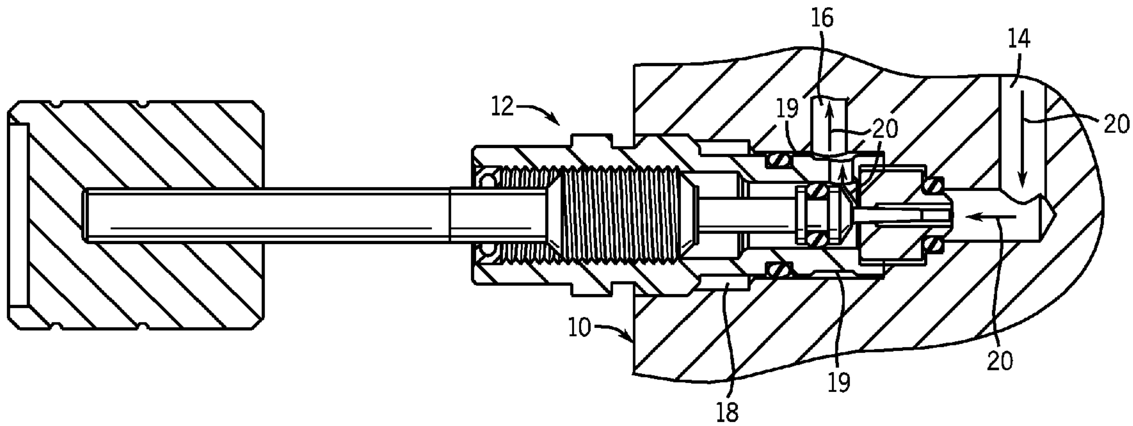
(57) **ABSTRACT**

A valve assembly includes a valve body defining a valve channel, and a floating seat defining a seat orifice in fluid communication with the valve channel. The valve assembly also includes a needle at least partially disposed within the valve channel. The floating seat is adapted to move relative to the valve body in a manner adapted to accommodate a misalignment between the needle and the floating seat.



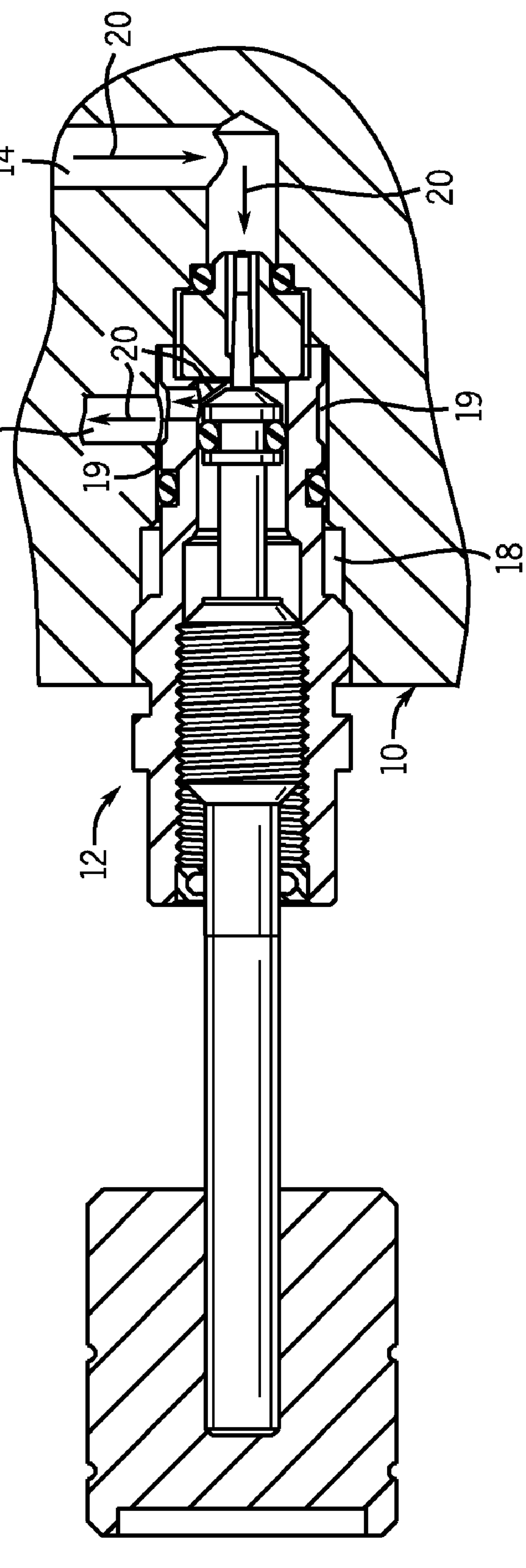


FIG. 1

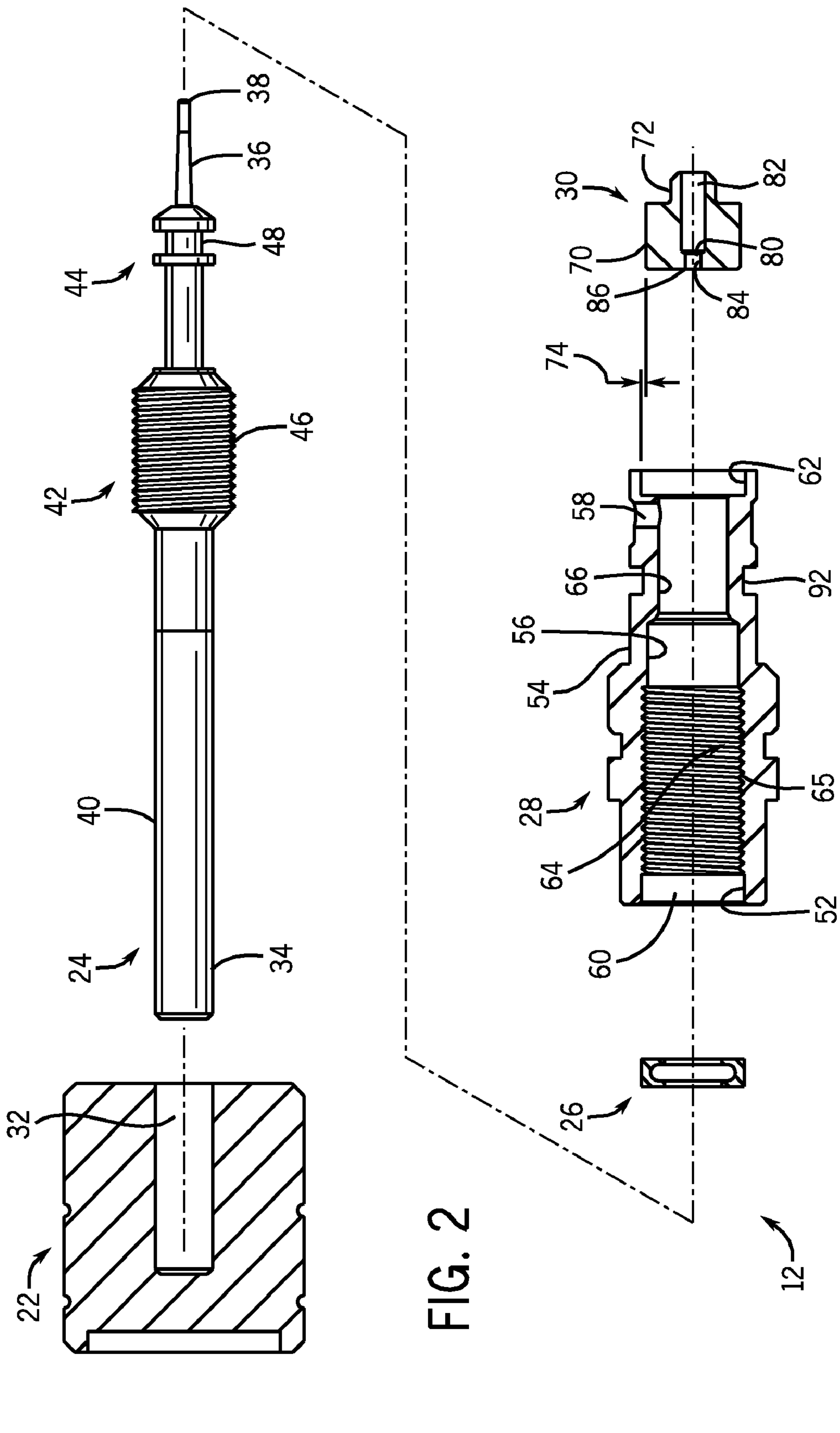

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FIG. 2

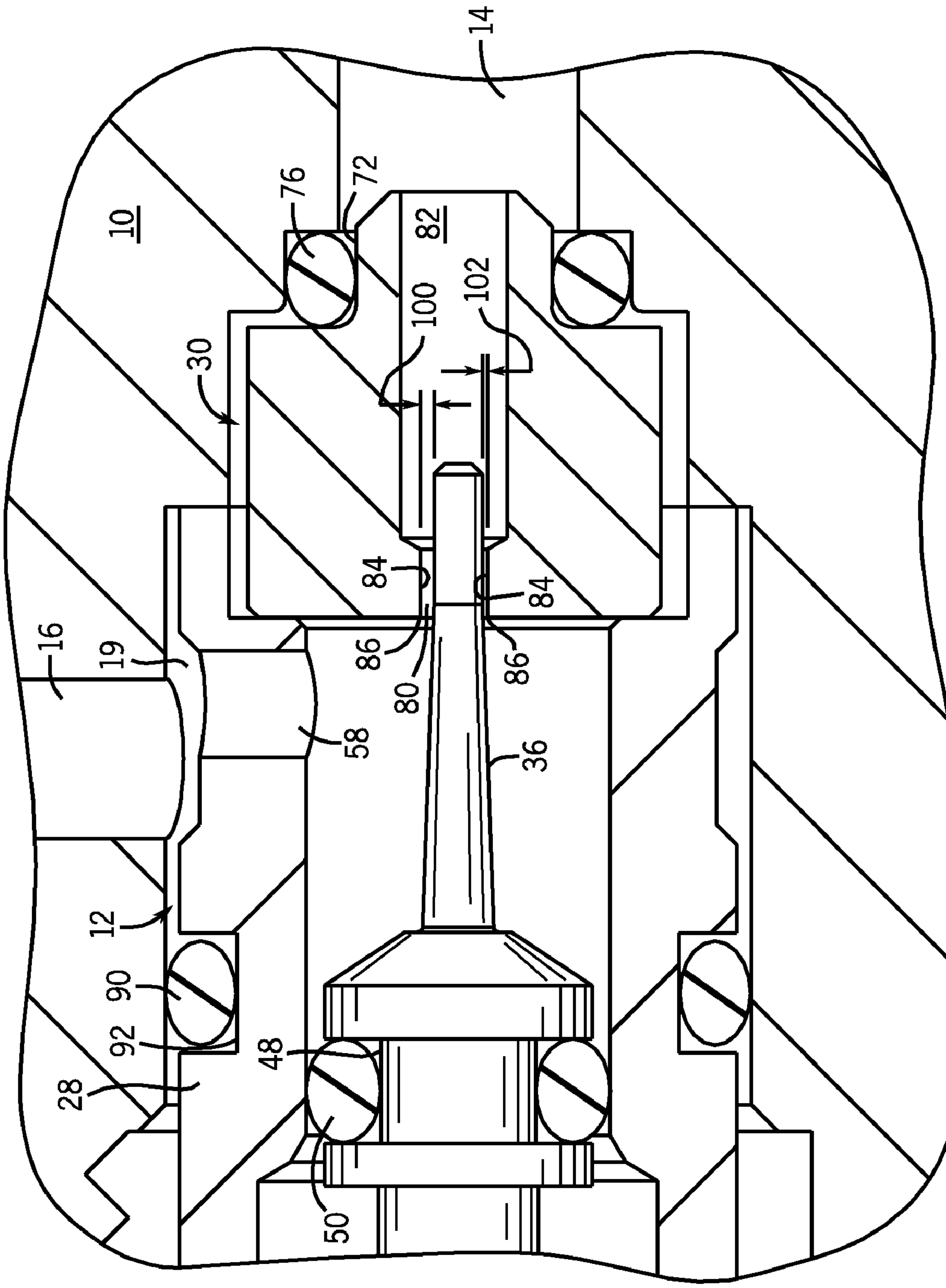

FIG. 3

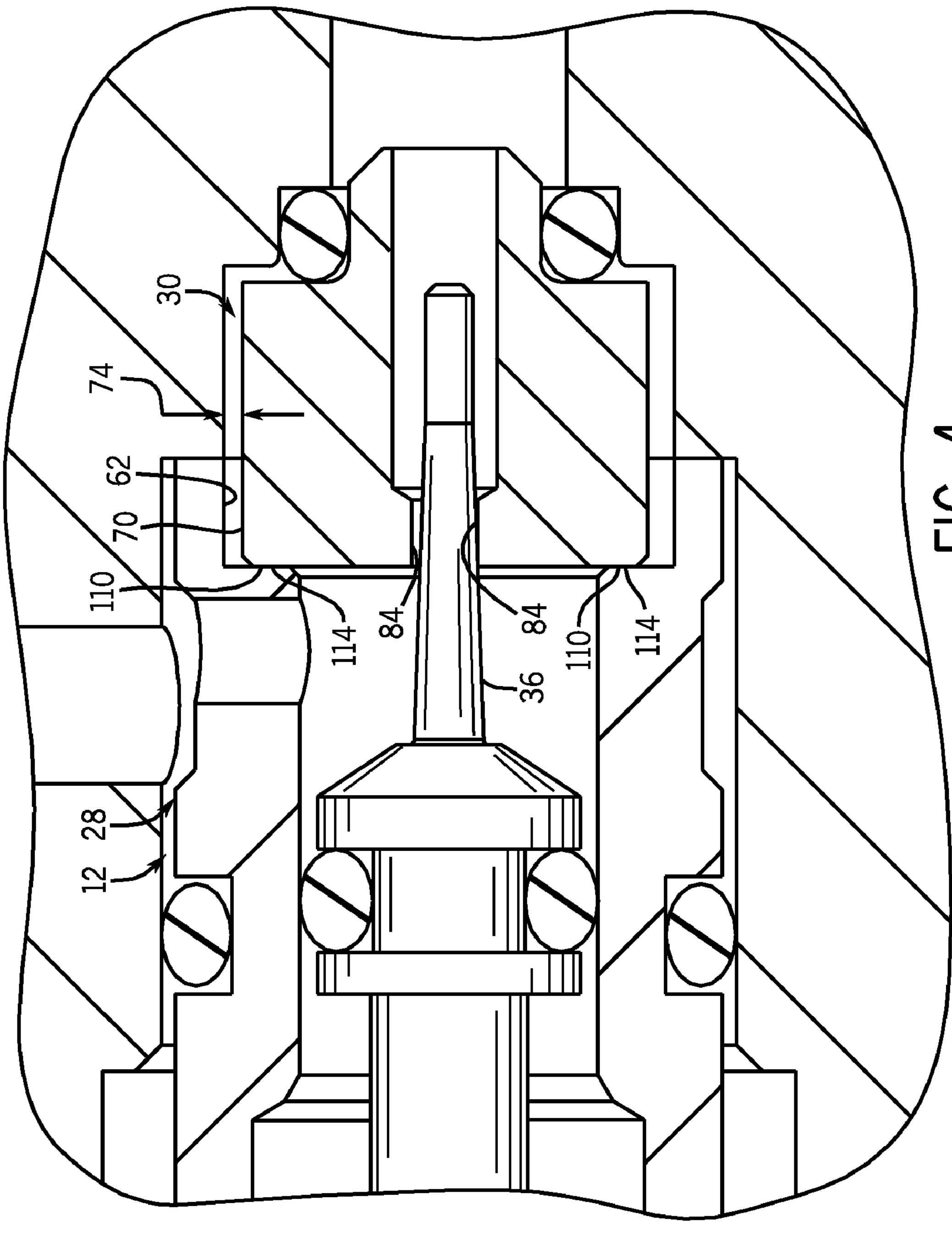

FIG. 4

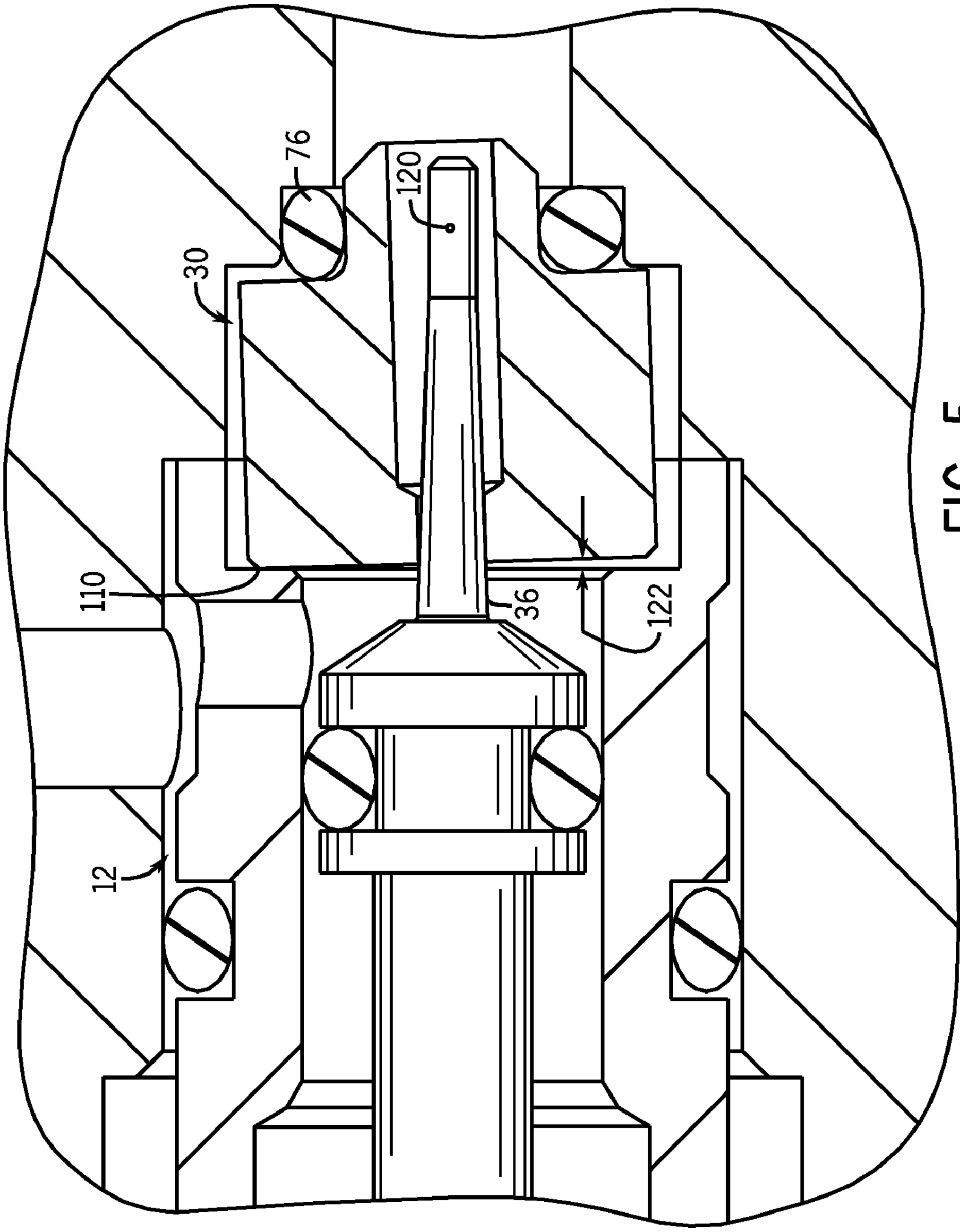

FIG. 5

NEEDLE VALVE ASSEMBLY WITH FLOATING SEAT APPARATUS

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to a needle valve assembly having a floating seat apparatus.

[0002] Needle valve assemblies may be implemented to regulate a fluid flow rate. Conventional needle valve assemblies comprise a needle having tapered terminal end, and a seat defining an orifice. The tapered end of the needle is translatable into the orifice to occlude the orifice by a variable amount. In this manner, a user can translate the needle toward or away from the seat to regulate the rate of fluid flow through the orifice.

[0003] One problem with conventional needle valve assemblies is that they are sensitive to component misalignment. As an example, if the needle is too low relative to the seat, the needle will prematurely engage the lower edge of the seat orifice as the valve assembly is being closed. Additional translation of the needle will generate a force at the interface between the needle valve and seat, and the magnitude of this force will increase as the needle is translated further into the seat orifice. This force can diminish the precision with which the valve assembly regulates fluid flow, and may also cause the valve assembly to leak or prematurely fail.

BRIEF DESCRIPTION OF THE INVENTION

[0004] The above-mentioned shortcomings, disadvantages and problems are addressed herein which will be understood by reading and understanding the following specification.

[0005] In an embodiment, a valve assembly including a valve body defining a valve channel, and a floating seat defining a seat orifice in fluid communication with the valve channel. The valve assembly also includes a needle at least partially disposed within the valve channel. The floating seat is adapted to move relative to the valve body in a manner adapted to accommodate a misalignment between the needle and the floating seat.

[0006] In another embodiment, a valve assembly includes a valve body defining a valve channel, and a floating seat disposed in contact with the valve body such that a slip interface is defined therebetween. The floating seat defines a seat orifice in fluid communication with the valve channel. The valve assembly also includes a spindle at least partially disposed within the valve channel. The spindle defines a needle at a terminal end portion. The needle is selectively translatable through the seat orifice to regulate a fluid flow through the valve channel. The floating seat is adapted to move relative to the spindle in a manner adapted to accommodate a misalignment between the needle and the floating seat.

[0007] In another embodiment, a system includes a manifold defining a valve assembly cavity, and a valve assembly disposed at least partially within the valve assembly cavity. The valve assembly includes a valve body defining a valve channel, and a floating seat disposed in contact with the valve body such that a slip interface is defined therebetween. The floating seat defines a seat orifice in fluid communication with the valve channel. The valve assembly also includes a spindle at least partially disposed within the valve channel. The spindle defines a needle at a terminal end portion. The needle is translatable at least partially through the seat orifice to regulate a fluid flow through the valve channel. The floating seat is adapted to move relative to the spindle in a manner adapted to accommodate a misalignment between the needle and the floating seat.

[0008] Various other features, objects, and advantages of the invention will be made apparent to those skilled in the art from the accompanying drawings and detailed description thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a sectional representation of manifold and a valve assembly;

[0010] FIG. **2** is an exploded sectional representation of the valve assembly of FIG. **1**;

[0011] FIG. **3** is a sectional representation depicting the valve assembly of FIG. **1** in a fully open position;

[0012] FIG. **4** is a sectional representation depicting the valve assembly of FIG. **1** in a partially open position; and

[0013] FIG. **5** is a sectional representation depicting the valve assembly of FIG. **1** in a fully occluded position.

DETAILED DESCRIPTION OF THE INVENTION

[0014] In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments that may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the embodiments, and it is to be understood that other embodiments may be utilized and that logical, mechanical, electrical and other changes may be made without departing from the scope of the embodiments. The following detailed description is, therefore, not to be taken as limiting the scope of the invention.

[0015] Referring to FIG. **1**, a manifold **10** and valve assembly **12** are depicted in accordance with an embodiment. The manifold **10** and valve assembly **12** may be implemented to regulate the flow of a fluid. For purposes of this disclosure, the term "fluid" is defined to include a continuous, amorphous substance whose molecules move freely past one another and that has the tendency to assume the shape of its container. It should therefore be appreciated that the term "fluid" as previously defined may include a liquid or a gas. According to one embodiment, the manifold **10** and the valve assembly **12** are components of an anesthesia machine (not shown) and are implemented to regulate the flow of a gas (e.g., oxygen, nitrous oxide, or air) to a patient (not shown). Alternate implementations for the manifold **10** and/or the valve assembly **12** may be envisioned.

[0016] The manifold **10** defines an inlet passage **14**, an outlet passage **16** and a valve assembly cavity **18**. The valve assembly cavity **18** is adapted to retain the valve assembly **12**. A portion of the valve assembly cavity **18** is adapted to receive fluid and will therefore be referred to a fluid cavity **19**. The fluid cavity **19** is in direct fluid communication with the outlet passage, and may be selectively coupled with the inlet passage **14** via the valve assembly **12**. Arrows **20** represent fluid flow through the inlet passage **14**, through the valve assembly **12**, through the fluid cavity **19**, and through the outlet passage **16**. As will be described in detail, the valve assembly **12** may be implemented to regulate the fluid flow represented by arrows **20**.

[0017] Referring to FIG. **2**, an exploded sectional representation depicts the valve assembly **12** in accordance with an embodiment. According to the depicted embodiment, the valve assembly **12** includes a knob **22**, a spindle **24**, a bushing **26**, a valve body **28** and a valve seat **30**. The knob **22** defines a generally cylindrical internal channel **32** adapted to retain the spindle **24**. The knob **22** is an optional component that may be incorporated to provide a mechanical advantage and thereby facilitate the rotation of the spindle **24** in a precise manner.

[0018] The spindle **24** defines a terminal end portion **34** and a generally opposite terminal end portion **36**. The end portion **34** may be secured within the internal channel **32** of the knob **22**. The end portion **36** tapers to a point **38** and may therefore also be referred to as the needle **36**. The spindle **24** comprises a generally cylindrical body **40** having a first increased diameter portion **42**, and a second increased diameter portion **44**. The first increased diameter portion **42** defines external spindle metering threads **46** adapted to convert spindle rotation into translation. The second increased diameter portion **44** defines an o-ring groove **48** adapted to accommodate an o-ring **50** (shown in FIG. **3**). As will be described in detail hereinafter, the O-ring **50** is configured to form a seal between the spindle **24** and the valve body **28**.

[0019] The bushing **26** is generally annular, and is configured to support and align the spindle **24** within the valve body **28** in a manner that allows for spindle **24** rotation. The bushing **26** is configured to receive the spindle **24**, and may be retained within a bushing groove **52** of the valve body **28** as will be described in detail hereinafter. Accordingly, the outer diameter of the bushing **26** is slightly greater than the inner diameter of the busing groove **52**, and the inner diameter of the bushing **26** is slightly greater than the outer diameter of the spindle body **40**. The bushing **26** may comprise a durable, low friction material. According to one embodiment, the bushing **26** is press-fit into the bushing groove **52** such that the bushing **26** remains fixed relative to the valve body **28**. Spindle **24** rotation may be facilitated with a lubricant (not shown) disposed at the interface between the spindle **24** and the bushing **26**, or with a low friction bushing sleeve (not shown).

[0020] The valve body **28** is generally hollow, and comprises an external surface **54**, an internal surface **56** and fluid flow port **58**. At least a portion of the external surface **54** of the valve body **28** is in contact with the manifold **10** (shown in FIG. **1**) for purposes of retaining the valve body **28** within the valve assembly cavity **18** (shown in FIG. **1**). The external surface **54** defines an o-ring groove **92** adapted to retain an o-ring **90** (shown in FIG. **3**). The o-ring **90** is configured to form a seal between the valve body **28** and the manifold **10** (shown in FIG. **1**).

[0021] The internal surface **56** defines a variable diameter internal valve channel **60**. The internal surface **56** terminates at one end with the bushing groove **52**, and terminates at an opposite end with a seat groove **62**. The bushing groove **52** is adapted to retain the bushing **26**, and the seat groove **62** is adapted to receive the seat **30**. The internal surface **56** of the valve body **28** comprises a threaded section **64** defining internal valve metering threads **65**, and a sealing surface **66**. The valve metering threads **65** are adapted to engage the spindle metering threads **46** when the spindle **24** is disposed within the valve channel **60**. The port **58** is in fluid communication with the valve channel **60**.

[0022] The valve seat **30** is also referred to as the floating seat **30** because it is configured to move (e.g., translate and/or rotate) relative to the spindle **24** and the valve body **28** in order to accommodate component misalignment. The valve seat **30** defines a terminal end portion **70** and a generally opposite terminal end portion **72**. The terminal end portion **70** is generally cylindrical and is disposed within the seat groove **62**. There is a radial design clearance or gap **74** between the seat groove **62** and the end portion **70** to allow for valve seat **30** motion. The terminal end portion **72** is adapted to receive an o-ring **76** (shown in FIG. **3**). The o-ring **76** is configured to form a seal between the valve seat **30** and the manifold **10** (shown in FIG. **1**). The valve seat **30** also defines an orifice **80** near terminal end **70**, and an internal channel **82** in fluid communication with the orifice **80**. The orifice **80** is more precisely defined by an annular surface **84** having an external edge **86**.

[0023] Having described the components of the manifold **10** and valve assembly **12**, their operation will now be explained in accordance with an embodiment. FIGS. **3-5** depict a sequence of events during which the valve assembly **12** is operated through its full range of motion from fully open in FIG. **3**, to partially open in FIG. **4** and to fully occluded in FIG. **5**. For purposes of illustrating the operation of the valve assembly **12**, the needle **36** and the seat **30** are shown as being axially misaligned such that the needle **36** is low relative to the seat **30**. It should be appreciated that, while many valve assemblies are produced with minimal misalignment, it is not uncommon for component manufacturing tolerances and build variation to yield significant misalignment. It is well known that such misalignment can contribute to premature wear, component failure, and operational imprecision.

[0024] Referring to FIG. **3**, the valve assembly **12** is shown in its fully open position. In this position, fluid is able to flow at a maximum rate through the internal channel **82**, the orifice **80**, the port **58**, the fluid cavity **19**, and the manifold outlet passage **16**. The o-ring **76** disposed on the terminal end portion **72** of seat **30** may be implemented to prevent fluid from passing between the seat **30** and the manifold **10**, and to thereby direct any fluid flow into internal channel **82**. The o-ring **50** disposed within the spindle o-ring groove **48** may be implemented to prevent fluid from passing between the spindle **24** and the valve body **28**, and to thereby direct such fluid flow into the port **58**. The o-ring **90** disposed within the valve body o-ring groove **92** may be implemented to prevent fluid flow from passing between the valve body **28** and the manifold **10**, and to thereby direct such fluid flow into the manifold outlet passage **16**.

[0025] The valve assembly **12** is depicted as having a needle **36** that is misaligned relative to the seat **30**. More precisely, the misalignment is depicted as comprising a needle **36** that is low relative to the seat **30**. This misalignment renders the gap **100** defined between the needle **36** and the top portion of the annular surface **84** greater than the gap **102** defined between the needle **36** and the bottom portion of the annular surface **84**.

[0026] Referring to FIG. **4**, the valve assembly **12** is shown in a partially open position at which the previously described component misalignment has caused the needle **36** to prematurely engage the bottom portion of the annular surface **84**. In a more conventional design wherein the valve seat is fixed relative to the valve body, any additional translation of the needle **36** through the orifice **80** could generate a force at the point of contact. This generated force could damage the needle **36** and/or the seat **30** thereby impairing valve assembly **12** durability. In an effort to maintain optimal durability, the seat **30** is configured to move in a manner adapted to accommodate component misalignment. For purposes of this disclosure, reference to a valve seat "configured to move in a manner adapted to accommodate component misaligmnent" should be defined to include valve seat translation and/or rotation having the effect of diminishing the magnitude of the force generated by a misaligned needle as it initially engages and thereafter continues to pass through a seat orifice.

[0027] Seat **30** motion is facilitated by providing the radial design clearance **74** between the seat groove **62** and the seat end portion **70**. Additionally, a slip interface **110** defined at the contact surface between the seat **30** and the valve body **28** is configured to facilitate relative motion or slip between the respective components. Relative motion may be facilitated by selecting a component material having a relatively low coefficient of friction, or through the application of a lubricant **114** disposed at the slip interface **110**. When the seat **30** is in the steady state position depicted in FIG. **4**, the slip interface **110** between the seat **30** and valve body **28** defines a generally annular contact surface. According to an alternate embodiment (not shown), the slip interface may define a semi-spherical contact surface such that the seat can pivot relative to the valve body while retaining generally consistent interface engagement.

[0028] Referring to FIG. **5**, the valve assembly **12** is shown in its fully occluded position at which no fluid can pass through the seat orifice **80**. It can be seen that the seat **30** has moved to accommodate misalignment with the needle **36**. Seat **30** motion has been exaggerated for purposes of more clearly illustrating the operation of the valve assembly **12**. Seat **30** motion has been depicted as primarily comprising counter-clockwise rotation about an imaginary point **120** to accommodate a specific type of misalignment (i.e., a needle that is low relative to the valve seat). It should be appreciated, however, that the seat **30** can translate and/or rotate in a variety of different manners to most effectively accommodate relative needle **36** misalignment in a direction defined by any of the 360 degrees or freedom. By translating and/or rotating in the manner described, the seat **30** is able to at least partially absorb the force generated by a misaligned needle as it passes further through the seat, and to realign with the needle such that the needle is more centered within the seat aperture. This absorption and realignment eliminates or diminishes the magnitude of the force applied to the needle **36** and the seat **30**, and thereby improves valve assembly **12** durability.

[0029] When the seat **30** has been rotated in the manner depicted in FIG. **5**, the slip interface **110** between the seat **30** and valve body **28** defines an arcuate contact region or, in the most extreme case, a point contact disposed at the top of seat **30**. The bottom of the seat **30** has been rotated away and is no longer in contact with the valve body **28** such that a gap or separation **122** is defined therebetween. It should also be appreciated that translation and/or rotation of the seat **30** tends to compress the o-ring **76**. The o-ring **76** is therefore preferably composed of an elastomer that may be repeatedly compressed and expanded without experiencing permanent deformation. As the needle **36** is retracted to open the valve assembly **12**, the o-ring **76** will expand and thereby apply a force tending to return the seat **30** to the steady state position shown in FIGS. **3-4**.

[0030] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

I claim:

1. A valve assembly comprising:

a valve body defining a valve channel;

a floating seat defining a seat orifice in fluid communication with the valve channel; and

a needle at least partially disposed within the valve channel;

wherein the floating seat is adapted to move relative to the valve body in a manner adapted to accommodate a misalignment between the needle and the floating seat.

2. The valve assembly of claim **1**, wherein the floating seat is disposed in contact with the valve body such that a slip interface is defined therebetween, said slip interface configured to enable relative motion between the floating seat and the valve body.

3. The valve assembly of claim **1**, further comprising a lubrication disposed at the slip interface.

4. The valve assembly of claim **1**, wherein the valve body defines a seat groove adapted to receive the floating seat, and wherein the seat groove is dimensioned to provide a radial design clearance between the valve body and the floating seat in order to accommodate said floating seat movement.

5. The valve assembly of claim **1**, further comprising an o-ring disposed about the periphery of the floating seat, said O-ring being configured to elastically deform in a manner adapted to accommodate said floating seat movement.

6. The valve assembly of claim **1**, wherein the o-ring is composed of an elastomer.

7. The valve assembly of claim **1**, wherein the needle is selectively translatable through the seat orifice to regulate a fluid flow

8. The valve assembly of claim **1**, wherein the floating seat is adapted to move relative to the valve body in a manner tending to center the needle within the seat orifice.

9. A valve assembly comprising:

a valve body defining a valve channel;

a floating seat disposed in contact with the valve body such that a slip interface is defined therebetween, said floating seat defining a seat orifice in fluid communication with the valve channel; and

a spindle at least partially disposed within the valve channel, the spindle defining a needle at a terminal end portion, the needle being selectively translatable through the seat orifice to regulate a fluid flow through the valve channel;

wherein the floating seat is adapted to move relative to the spindle in a manner adapted to accommodate a misalignment between the needle and the floating seat.

10. The valve assembly of claim **9**, further comprising a lubrication disposed at the slip interface.

11. The valve assembly of claim **9**, wherein the valve body defines a seat groove adapted to receive the floating seat, and wherein the seat groove is dimensioned to provide a radial design clearance between the valve body and the floating seat in order to accommodate said floating seat movement.

12. The valve assembly of claim **9**, further comprising an o-ring disposed about the periphery of the floating seat, said

O-ring being configured to elastically deform in a manner adapted to accommodate said floating seat movement.

13. The valve assembly of claim **9**, wherein the floating seat is adapted to move relative to the spindle in a manner tending to center the needle within the seat orifice.

14. A system comprising:

a manifold defining a valve assembly cavity; and

a valve assembly disposed at least partially within the valve assembly cavity, said valve assembly comprising:

a valve body defining a valve channel;

a floating seat disposed in contact with the valve body such that a slip interface is defined therebetween, said floating seat defining a seat orifice in fluid communication with the valve channel; and

a spindle at least partially disposed within the valve channel, the spindle defining a needle at a terminal end portion, the needle being translatable at least partially through the seat orifice to regulate a fluid flow through the valve channel;

wherein the floating seat is adapted to move relative to the spindle in a manner adapted to accommodate a misalignment between the needle and the floating seat.

15. The system of claim **14**, further comprising a lubrication disposed at the slip interface.

16. The system of claim **14**, wherein the valve body defines a seat groove adapted to receive the floating seat, and wherein the seat groove is dimensioned to provide a radial design clearance between the valve body and the floating seat in order to accommodate said floating seat movement.

17. The system of claim **14**, further comprising an o-ring disposed about the periphery of the floating seat, said o-ring being configured to elastically deform in a manner adapted to accommodate said floating seat movement.

18. The system of claim **14**, wherein the floating seat is adapted to move relative to the spindle in a manner tending to center the needle within the seat orifice.

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