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## MEDICAL VALVE

### Abstract


A valve for use in an endoscope may comprise a proximal valve stem member having a first lumen extending from a proximal opening at a proximalmost end of the proximal valve stem member to a distal opening at a distalmost end of the proximal valve stem member. A distal valve stem member may have a second lumen with a proximal opening at a proximalmost end of the distal valve stem member. The proximalmost end of distal valve stem member may be received within the distal opening of the first lumen. The distal valve stem may be movable relative to the proximal valve stem.



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## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. patent application Ser. No. 18/152,400, filed on Jan. 10, 2023, which is a continuation of U.S. patent application Ser. No. 16/887,206, filed on May 29, 2020, now U.S. Pat. No. 11,576,558, which claims the benefit of priority from U.S. Provisional Application No. 62/854,689, filed on May 30, 2019, each of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates generally to valves for medical devices, particularly endoscopes.

BACKGROUND

[0003] Endoscopes include functionality to deliver fluids (including air and water) and suction at a site of a procedure. Tubing for delivering fluids and/or suction extends from a handle of the endoscope, through a sheath of the endoscope, and to a distal tip of the endoscope. A combined air/water valve may be used to deliver air or water during the procedure. During a procedure, body fluids, tissues, or other material could enter or build up in the tubing and lead to clogging of the tubing. In order to aid in reprocessing of reusable endoscopes between procedures, pre-processing is performed in an endoscopy suite. For example, water or other fluids are flushed through the tubing after the endoscope is removed from a patient, in order to clear debris from the air/water and/or suction tubing. One option for accomplishing such pre-processing is a reusable cleaning valve. Where reusable air/water and cleaning valves are used, those valves must be subject to reprocessing between procedures. Therefore, a need exists for valves capable of delivering air/water, as well as performing cleaning functions.

SUMMARY

[0004] A valve for use in an endoscope may comprise a proximal valve stem member having a first lumen extending from a proximal opening at a proximalmost end of the proximal valve stem member to a distal opening at a distalmost end of the proximal valve stem member. A distal valve stem member may have a second lumen with a proximal opening at a proximalmost end of the distal valve stem member. The proximalmost end of distal valve stem member may be received within the distal opening of the first lumen. The distal valve stem may be movable relative to the proximal valve stem.

[0005] Any example of the valves described herein may additionally or alternatively include one or more of the features below. The proximal valve stem member may include a membrane within the first lumen that forms a fluid tight barrier between the proximal opening and the distal opening. In a first configuration, the proximalmost end of the distal valve stem member may be distal to an original location of the membrane so that the first lumen is not in fluid communication with the second lumen. In a second configuration, the membrane may be punctured and the proximalmost end of the distal valve stem may be proximal to the original location of the membrane so that the first lumen is in fluid communication with the second lumen. The distal valve stem member may have a shoulder that is contacted by the distalmost end of the proximal valve stem member in the second configuration. The proximal valve stem member may include a first aperture formed through a wall of the proximal valve stem member. The first aperture may be in fluid communication with the first lumen. The proximal valve stem member may include a second aperture formed through the wall of the proximal valve stem member, and wherein the second aperture is in fluid communication with the first lumen. The second lumen may be closed at a distalmost end of the second lumen. The distal valve stem member may have a third aperture formed through a wall of the distal valve stem member. The third aperture may be in fluid communication with the second lumen. The proximal valve stem member may include a button configured to be contacted by a finger of an operator. A proximal surface of the button may be at the proximalmost end of the proximal valve stem member. The proximal valve stem member may include at least one tab on a distal surface of the button. At least one seal may be disposed on an external surface of the distal valve stem member. At least two O-ring seals may be disposed on an external surface of the distal valve stem member. At least one O-ring seal may be disposed on an external surface of the proximal valve stem member. A one-way seal may be disposed on an external surface of the proximal valve stem member. The proximalmost end of the distal valve stem may be tapered.

[0006] In another example, a valve for use in an endoscope may comprise a proximal valve stem member having a first lumen extending from a proximal opening at a proximalmost end of the proximal valve stem member to a distal opening at a distalmost end of the proximal valve stem member. A membrane within the first lumen may form a fluid-tight barrier between the proximal opening and the distal opening. A distal valve stem member may be received within the distal opening of the first lumen. In a first configuration, the proximalmost end of the distal valve stem member may be distal to an original location of the membrane. In a second configuration, the membrane may be punctured and the proximalmost end of the distal valve stem may be proximal to the original location of the membrane. The distal valve stem member may have a second lumen with a proximal opening at a proximalmost end of the distal valve stem member. In the first configuration, the first lumen and the second lumen may not be in fluid communication. In the second configuration, the first lumen and the second lumen may be in fluid communication.

[0007] Any example of the valves described herein may additionally or alternatively include one or more of the features below. The second lumen may be closed at a distalmost end of the second lumen. The distal valve stem member may have an aperture formed through a wall of the distal valve stem member. The aperture may be in fluid communication with the second lumen. The proximal valve stem member may include first and second apertures through a wall of the proximal valve stem member. Each of the first and second aperture may be in fluid communication with the first lumen.

[0008] A method of delivering air and water may comprise: via a valve to a first configuration, delivering air to an air channel of a medical device; transitioning the valve from the first configuration to a second configuration to deliver water to a water channel of the medical device; and transitioning the valve from the second configuration to a third configuration to deliver the water to the air channel of the medical device.

[0009] Any method described herein may include one or more of the features or steps described below. The valve may be transitioned to the first configuration by covering a proximal hole of the valve. Transitioning the valve to the second configuration may include depressing the valve part-way. Transitioning the valve to a third configuration may include fully depressing the valve. The valve may include a proximal valve stem member having a first lumen extending from a proximal opening at a proximalmost end of the proximal valve stem member to a distal opening at a distalmost end of the proximal valve stem member. A membrane within the first lumen may form a fluid-tight barrier between the proximal opening and the distal opening. A distal valve stem member may be received within the distal opening of the first lumen. In the first and second configurations, the proximalmost end of the distal valve stem member is distal to an original location of the membrane. Transitioning from the second configuration to the third configuration may include puncturing the membrane and moving the proximalmost end of the distal valve stem

to a position proximal to the original location of the membrane.
[0010] It may be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed. As used herein, the terms “comprises,” “comprising,” or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements, but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. The term “exemplary” is used in the sense of “example,” rather than “ideal.” As used herein, the term “proximal” means a direction closer to a surface (e.g., a button) contacted by an operator for operating a valve and the term “distal” means a direction away from the surface (e.g., a button) for operating the valve. Although endoscopes are referenced herein, reference to endoscopes or endoscopy should not be construed as limiting the possible applications of the disclosed aspects. For example, the disclosed aspects may be used with duodenoscopes, bronchoscopes, ureteroscopes, colonoscopes, catheters, diagnostic or therapeutic tools or devices, or other types of medical devices.

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## Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0011] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate examples of the present disclosure and together with the description, serve to explain the principles of the disclosure.
[0012] FIGS. **1**A-**1**C show cross-sectional views of a first exemplary valve.
[0013] FIGS. **2**A-**2**C show cross-sectional views of a second exemplary valve.
[0014] FIGS. **3**A-**3**B and **4**A-**4**B show exemplary seals for use with the second exemplary valve.
[0015] FIGS. **5**A-**5**C show cross-sectional views of a third exemplary valve.
DETAILED DESCRIPTION
[0016] A valve may be configured to both deliver air and water during a procedure and to direct a fluid for cleaning air and water channels of an endoscope following the procedure. In embodiments, the valve may be a single-use valve, and therefore disposable after only one procedure and post-procedure, although in other embodiments the valve may be reusable. The valve may have up to four or more configurations. In a first configuration, the valve may deliver neither air nor water to channels in a sheath of the endoscope. In a second configuration, the valve may only deliver air to only an air channel of the sheath. In a third configuration, the valve may deliver only water to only a water channel of the sheath. In a fourth configuration, the valve may deliver only water to both the air and the water channels in order to perform pre-processing cleaning of the air and water channels.
[0017] FIGS. **1**A-**1**C show a cross-sectional view of an exemplary valve **10** in a valve cylinder **12**. Valve cylinder **12** may have surfaces **14** that define a cavity into which valve **10** may be inserted. Valve cylinder **12** may include connections to channels for inflow or outflow of air or water in a medial device, such as an endoscope. For example, valve cylinder **12** may have an air inlet **16** and an air outlet **18**. Valve cylinder **12** may also have a water inlet **20** and a water outlet **22**. From proximal to distal, the outlets may be ordered as follows: air outlet **18**, air inlet **16**, water outlet **22**, and water inlet **20**.
[0018] Valve **10** may have a valve stem **24**. Valve stem **24** may have a proximal member **26** and a distal member **28**. Portions of valve stem **24** including proximal member **26** and distal member **28**, may be made from metal (e.g., stainless steel, titanium, aluminum, etc.), from a polymer (e.g. polycarbonate, ABS, HDPE, Nylon, PEEK, thermoplastic, plastic, etc.), or from any other suitable material. Proximal member **26** and distal member **28** may be made from the same material or from different materials. Proximal member **26** and/or distal member **28** may be formed from a single,

continuous material.

[0019] Proximal member **26** may include a button **32**. Button **32** may be formed as one continuous structure with the rest of proximal member **26**, or button **32** may be a separate structure attached to the rest of proximal member **26**. Button **32** may have an outer circumference that is wider than a proximal opening of valve cylinder **12**, so that when button **32** is depressed, button **32** cannot pass through the proximal opening of valve cylinder **12**.

[0020] Proximal member **26** may have a proximal lumen **40**. Proximal member **26** may have a generally annular shape around lumen **40**. Proximal lumen **40** may have a proximalmost opening **41** on a proximalmost end of proximal member **26**. For example, proximal lumen **40** may be open on a proximalmost side of button **32**. Proximal opening **41** is shown with dashes to indicate that, as discussed below, proximal opening **41** may be covered by an operator (e.g., by the finger or thumb of an operator).

[0021] As shown in FIGS. **1**A and **1**B, a membrane **42** may extend completely across proximal lumen **40** toward a distal end **44** of proximal lumen **40**. For example, membrane **42** may be a small distance from a distalmost end of proximal lumen **40**. Alternatively, membrane **42** may be at a distalmost end of proximal lumen **40**. Membrane **42** may be formed of a thin material. Aspects of membrane **42** will be discussed in further detail with reference to FIGS. **1**B-**1**C.

[0022] A proximal aperture **46** may be formed in, and extend completely through, a wall of proximal member **26** and may fluidly connect proximal lumen **40** to an area external to proximal member **26**. Although one proximal aperture **46** is shown in FIGS. **1**A-**1**C, any number of proximal apertures may be used. One or more air apertures **48** may also be formed in, and extend completely through, a wall of proximal member **26** and may fluidly connect proximal lumen **40** to an area external to proximal member **26**. Although only one air aperture **48** is shown, any suitable number of apertures may be utilized.

[0023] Distal member **28** may include a neck **50** on a proximal end of distal member **28**. Neck **50** may have an outer diameter that is smaller than a diameter of lumen **40**. Neck **50** may terminate distally in a shoulder **52**. Neck **50** may have a proximal tapered portion **54**. A distal lumen **60** may pass through distal member **28**, including neck **50**. Distal lumen **60** may be open on a proximalmost side of distal member **28** (e.g., on a proximalmost end **62** of neck **50**) and may be closed on a distalmost side of distal member **28**. A diameter of distal lumen **60** may be smaller than a diameter of proximal lumen **40**. Tapered portion **54** may taper from an initial outer diameter (at a proximal end) until its outer diameter is substantially the same as a diameter of distal lumen **60**. The proximalmost end of tapered portion **54** may form a sufficiently sharp annular ring to cut through, puncture, or otherwise remove membrane **42** under sufficient force. Portions of membrane **42** that are severed by tapered portion **54** may be flushed away by fluids flowing through valve **10** (further details of the flushing process are discussed below) or may remain within valve **10**. A distal aperture **64** may be formed in, and extend completely through, a wall of distal member **28** and may fluidly connect distal lumen **60** to an area external to distal member **28**. Although one distal aperture **64** is shown in FIGS. **1**A-**1**C, any number of distal apertures may be used.

[0024] Neck **50** may be slidably received within proximal lumen **40** so that distal lumen **60** is in fluid communication with proximal lumen **40**. Proximal lumen **40** and/or neck **50** may have features (e.g., indentations, protrusions, tabs, etc.) (not shown) that retain neck **50** within lumen **40** and prevent a proximalmost end **62** of neck **50** from exiting a distalmost end **44** of proximal lumen **40**.

[0025] Valve stem **30** may be fitted with one or more seals. For example, valve stem **30** may include, in a direction from proximal to distal, a first seal **72**, a second seal **74**, a third seal **76**, and a fourth seal **78**. Seals **72**, **74**, **76**, and **78** may be, for example, O-rings. Seals **72**, **74**, **76**, and **78** may be formed from an elastomeric material. Valve stem **30** may also include a one-way seal **82**, which may be made of the same or different material as seals **72**, **74**, **76**, and **78** (e.g., an elastomeric material). One-way seal **82** may permit passage of fluid or other substances proximally past one-way seal **82** but may not permit passage of fluid or other substances distally past one-way seal **82** due to its flexibility and arrangement relative to its contacted structure. First seal **72** and second seal **74** may be disposed on proximal member **26**. Third seal **76** and fourth seal **78** may be disposed on distal member **28**. One-way seal **82** may be disposed on proximal member **26** between second seal **74** and third seal **76**. Alternatively, seals **72**, **74**, **76**, **78** and one-way seal **82** may be disposed on alternative portions of valve stem **30** or in different orders. Proximal aperture **46** may be disposed between first seal **72** and second seal **74**. Distal aperture **64** may be disposed between third seal **76** and fourth seal **78**.

[0026] Seals **72**, **74**, **76**, and **78** may be configured so as to form a slidable interference fit between seals **72**, **74**, **76**, and **78** and surface **14**. Thus, valve stem **30** can move relative to surface **14**, but fluids (e.g. water and air) cannot move between seals **72**, **74**, **76**, and **78** and surface **14**. Thus, seals **72**, **74**, **76**, and **78** prevent movement of fluids external to valve **10** in a proximal or distal direction past seals **72**, **74**, **76**, and **78**.

[0027] An inner diameter of one-way seal **82** may be sized so that there is a slight interference between an external surface of proximal member **26** and the inner diameter of one-way seal **82**, so that a tight seal is formed. An outer diameter of one-way seal **82** may be sized so as to form a slight interference fit with a portion of surface **14**. A thin flap of one-way seal **82** may extend radially outward from proximal member **26** at an angle transverse to a longitudinal axis of proximal member **26**. For example, the thin flap may extend at an angle between 10 degrees and 80 degrees relative to a longitudinal axis of proximal member **26**. The flap of one-way seal **82** may be expandable so that when fluid (e.g., water or air) moves in a distal direction toward one-way seal **82**, a positive pressure will expand the flap, maintaining a seal between one-way seal **82** and surface **14**. Fluid moving proximally toward one-way seal **82** will also create a positive pressure, but the positive pressure will produce a force normal to a longitudinal axis of proximal member **26** to radially compress the flap of one-way seal **82**. Thus, fluid (e.g., air or water) is permitted to move proximally past one-way seal **82**, between one-way seal **82** and surface **14**.

[0028] FIG. **1**A shows valve **10** in a first configuration and/or a second configuration. In the first configuration of valve **10**, neither air nor water is delivered to any outlets of valve **10** and will vent through proximalmost opening **41** to the atmosphere.

[0029] In the second configuration, air is delivered to an air channel of an endoscope but water is not delivered to any channel. The first configuration and second configuration may differ only in that proximalmost opening **41** at a proximalmost end of proximal lumen **40** is left open in the first configuration and is blocked (e.g., by an operator's thumb or finger) in the second configuration. In the first and second configurations, button **32** may not be pushed down. Valve **10** may include features such as tactile feedback features (not shown) to indicate that valve **10** is in a proper position within valve cylinder **12**. For example, valve **10** can include ridges, bumps, or other protrusions on an outside surface of proximal member **26**. Proximalmost end **62** of distal lumen **60** (and neck **50**) may be distal of membrane **42** so that proximal lumen **40** is not in fluid communication with distal lumen **60**.

[0030] In the first and second configurations, water inlet **20** may be distal to fourth seal **78**. Water outlet **22** may be between third seal **76** and fourth seal **78**. Thus, water from water inlet **20** may not move proximally of fourth seal **78**. Water outlet **22** is surrounded by third seal **76** and fourth seal **78**, and therefore fluids (air and water) cannot move longitudinally to water outlet **22** along surfaces **14** of cylinder **12**. And because membrane **42** is in place, distal lumen **60** and proximal lumen **40** are not in fluid communication. Thus, no fluids may exit water outlet **22**.

[0031] In the first configuration (e.g., when proximalmost opening **41** is not covered and neither air nor water is delivered), as shown in dashed-line arrows on FIG. **1**A, air may enter from air inlet **16**, pass proximally past one-way seal **82**, and then pass around a circumference of proximal member **26** of valve stem **24** to air aperture **48**. Air will enter air aperture **48** instead of passing out air outlet **18** because proximalmost opening **41** venting to the atmosphere provides the path of least resistance. Air may then vent proximally out of proximalmost opening **41**. Any air that would exit aperture **46** would be trapped between first seal **72** and second seal **74**, so air will instead vent from proximalmost opening **41**. Air may not travel distally past third seal **76** and thus may not exit water outlet **22**. Air inlet **16** may be proximal of third seal **76** but distal to one-way seal **82**. Though air entering from air inlet **16** could travel proximally past one-way seal **82** toward air outlet **18**, the path of least resistance will be for air to vent from proximalmost opening **41**, and therefore air will not exit air outlet **18**. Thus, in the first configuration, neither air nor water is delivered.

[0032] In the second configuration, also shown in FIG. **1**A, proximalmost opening **41** may be covered by, for example, an operator's thumb or finger. Proximalmost opening **41** may also be covered in the third and fourth configurations, discussed below. Otherwise, the second configuration may be identical to the first configuration, e.g., all of the structures of valve **10** are in the same locations relative to one another and cylinder **12**. Because air can no longer vent out of proximalmost opening **41**, as shown in solid-line arrows on FIG. **1**A, air entering from air inlet **16** may travel proximally past one-way seal **82**. Thus, air entering from air inlet **16** may pass through air outlet **18** to deliver air to an air channel of an endoscope. Air from air inlet **16** may not pass proximally of second seal **74** and thus may not enter proximal aperture **46**. air entering aperture **48** cannot exit proximalmost opening **41** as it is covered. Thus, in the second configuration, valve **10** will deliver air to an air channel of the endoscope.

[0033] FIG. **1**B shows valve **10** in a third configuration, in which water is delivered to a water channel of the endoscope but air is not delivered to any endoscope channel. To transition from the second configuration to the third configuration, button **32** may be depressed part-way. For example, button **32** may be depressed until a pliable feature on a distal surface of button **32** is in contact with an outer, proximal surface of cylinder **12**. For example, tabs **94** may contact an outer surface of cylinder **12**. Contact of features such as tabs **94** may cause tactile feedback to an operator to indicate that valve **10** is in the third configuration. Tabs **94** are merely exemplary, and any suitable feature may be used. For example, an annular flap/flange, expanded inflatable features, frangible piece, or other feature may be used. Tabs **94** may be made of the same material as button **32** or from a different material.

[0034] In transitioning from the second configuration to the third configuration, both proximal member **26** and distal member **28** may translate distally relative to cylinder **12**, as a result of button **32** being pressed downward. Membrane **42** may be sufficiently resilient that a force on button **32** to transition valve **10** from the second configuration to the third configuration may not cause a proximalmost end of neck **50** to break through membrane **42**. Therefore, membrane **42** may remain intact in the third configuration, and a force on neck **50** from membrane **42** may cause a distal translation of distal member **28** along with proximal member **26**. Distal member **28** (and proximal member **26**) may translate distally until distal member **28** rests on a distal surface of cylinder **12**, or until tabs **94** contact an upper, proximal surface of cylinder **12**. Additionally or alternatively, a frictional force between an outer surface of neck **50** and an inner surface of proximal lumen **40** may cause distal member **28** to move in unison with proximal member **26**.

[0035] In the third configuration, fourth seal **78** may be distal to water inlet **20**. Third seal **76** may be proximal of water outlet **22**. Thus, as shown in solid-line arrows, water from water inlet **20** may not move distally past fourth seal **78** but may move through water outlet **22** and through a water channel of an endoscope. Although water may move through distal aperture **64**, water may not move proximally past membrane **42**, which may be resilient enough to block proximal movement of water. Thus, water may not enter proximal lumen **40**. Water also may not move proximally past third seal **76**. One-way seal **82** may be distal to air inlet **16** so air can not pass to enter air aperture **48**. Second seal **74** may be proximal of air inlet **16**. Thus, air from air inlet **16** may not move into proximal lumen **40** through air aperture **48** or past seal **74**, thus will not exit air outlet **18**. And, because an operator's finger or thumb still covers proximalmost opening **41**, air cannot enter air aperture **48** and vent from proximalmost opening **41**. As a result, in the third configuration, the only fluid flow to the endoscope sheath is that of water through the water channel.

[0036] Valve **10** may be transitioned from the third configuration back to the first/second configuration. For example, valve **10** may have a spring (not shown) or other feature which biases valve **10** to the first configuration. Alternatively, valve **10** may be transitioned from the third configuration (or the first/second configuration) to the fourth configuration.

[0037] As shown in FIG. **1**C, the fourth configuration facilitates flushing of water from water inlet **20** through both water outlet **22** and air outlet **18**. The fourth configuration may be referred to as the cleaning configuration of valve **10**. To move from the third configuration to the fourth configuration, button **32** may be depressed until tabs **94** are collapsed against a surface of cylinder **12**. Substantially more force may be required to transition valve **10** to the fourth configuration than to the third configuration. While button **32** is depressed part-way in the third configuration, button **32** may be fully depressed in the fourth configuration. In the fourth configuration, tabs **94** may break (e.g., by cracking off at a proximal end of tabs **94**) or bend flat so as to be parallel with a proximal surface of button **32** and/or a proximal surface of endoscope cylinder **12**. A certain, minimum amount of force may be required to bend or break tabs **94**.

[0038] Because distal member **28** already rested on a distal surface of cylinder **12** in the third configuration, distal member **28** may not translate distally along with proximal member **26** when button **32** is depressed fully. Translation of proximal member **26** distally relative to distal member **28** may cause proximal tapered portion **54** to pierce membrane **42** and thereby fluidly connect distal lumen **60** and proximal lumen **40**. In the fourth configuration, proximal tapered portion **54** of distal member **28** may be proximal of the original location of membrane **42**. Therefore, as shown with solid-line arrows, in the fourth configuration of valve **10**, water may travel from water inlet **20** and out of water outlet **22**, as in the third configuration of valve **10**. However, unlike the third configuration, the fourth configuration also permits water to travel into proximal aperture **64**, through distal lumen **60**, into proximal lumen **40**, and out of proximal aperture **46**, so that water may flow between valve stem **30** and a surface of valve cylinder **12** to air outlet **18**. Because air aperture **48** may be covered by neck portion **50** in the fourth configuration, water may not pass through air aperture **48**.

[0039] The fourth configuration should not be used while an endoscope is inside of a body lumen of a patient. Valve **10** may contain mechanisms to prevent an operator from unintentionally transitioning valve **10** to the fourth configuration. For example, tabs **94** may provide resistance or other tactile feedback against pushing down button **32** past the third configuration. An operator may also receive tactile feedback from a distal end of distal member **28** contacting a distal surface of valve cylinder **12** in the third configuration, indicating to the operator that button **32** should not be further depressed while an endoscope is in use during a patient procedure. Additionally or alternatively, other methods may be used to prevent accidental transition of valve **10** into the fourth configuration. For example, a deformable mechanical stop may provide audible feedback (e.g., a “click” sound), valve **10** could require rotation prior to transitioning to the fourth configuration, and/or a visual indicator may provide feedback to an operator.

[0040] Because membrane **42** is broken in the fourth configuration, valve **10** may not again be used in any of the first, second, or third configurations. Therefore, valve **10** is a single-use valve, for use during only one pre-processing cleaning step. Alternatively, after use in one pre-processing cleaning, valve **10** could be used as only a pre-processing cleaning valve **10** without use during patient procedures. Alternatively, membrane **42** may be a strong, reusable seal that could be reset following use so that valve **10** is reusable over multiple procedures.

[0041] In order to make use of valve **10**, an operator may insert valve **10** into valve cylinder **12** of an endoscope prior to a procedure. During the procedure, the operator may use valve **10** in the first, second, and/or third configurations, depending on the operator's desire to make use of air or water during the procedure. Following the procedure, the endoscope may be removed from the patient for reprocessing. Button **32** may be fully depressed so that valve **10** transitions to the fourth configuration. Valve **10** may flush water through the air and water channels for a predetermined amount of time (e.g., thirty seconds). After flushing is complete, an operator could either move button **32** proximally to disable the flow of water or could simply remove valve **10** from valve cylinder **12**. Alternatively, button **32** may automatically move proximally to disable the flow of water. The endoscope would be subject to further reprocessing, and valve **10** may be disposed.

[0042] FIGS. **2**A-**2**C depict configurations of another exemplary valve **100**. Although the same valve cylinder **12** is referenced herein, it will be understood that valve **100** may be used in a different valve cylinder. FIG. **2**A shows valve **100** in a first/second configuration, FIG. **2**B shows valve **100** in a third configuration, and FIG. **2**C shows valve **100** in a fourth configuration. Valve **100** may have a valve stem **102**. Valve stem **102** may have a proximal portion **114** and a distal portion **116**. Proximal portion **114** of valve stem **102** may include a button **120**, which may be configured to be contacted by a finger of an operator in use of valve **100**. A spring **122** may be disposed in an annular groove within button **120** and against a distally-facing surface of button **120**. When valve **100** is inserted into cylinder **12**, a distal surface of spring **122** may rest upon a proximal surface of cylinder **12**.

[0043] Valve stem **102** may have an air release lumen **128**. Air release lumen **128** may extend through button **120** and have a proximalmost opening **130** on a proximal surface of button **120**. Proximalmost opening **130** is shown with dashed lines to indicate that proximalmost opening **130** may be covered by an operator (e.g., by a thumb/finger of an operator). A distal end of air release lumen **128** may be open to an exterior surface of valve stem **102** via an air aperture **126**, so that air release lumen **128** is in fluid communication with an area exterior to valve stem **102**. Air release lumen **128** may extend through a longitudinal axis of valve stem **102**, such as a central longitudinal axis of valve stem **102**.

[0044] Valve stem **102** may also have a water lumen **134**. Water lumen **134** may extend to a distalmost end of valve stem **102** and may have a distalmost opening **135** (see FIG. **2**C). Water lumen **134** may have one or more water apertures **136**. Water apertures **136** may be a plurality of openings on a circumferential surface of valve stem **102**. Water lumen **134** may be in fluid communication with an area exterior to valve stem **102** via water apertures **136**. Water lumen **134** may have a distal portion **140** that is below (distal to) air aperture **126** and that extends along a central longitudinal axis of valve stem **102**. At a point distal to a distalmost end of air release lumen **128**, water lumen **134** may divert from a central longitudinal axis of valve stem **102**. A proximal portion **142** of water lumen **134** may extend along a longitudinal axis of valve stem **102** that is off-centered. As shown in FIG. **2**A, proximal portion **142** of water lumen **134** may include a plurality of branches radially outward of a central longitudinal axis of valve stem **102** (e.g., two branches). Alternatively, a proximal portion **142** of water lumen **134** may extend annularly about air release lumen **128**. Each branch of proximal portion **142** of water lumen **134** may be in communication with a separate plurality of apertures **136**. Alternatively, apertures **136** may extend circumferentially around proximal portion **142** so that branches of proximal portion **142** share access to a set of apertures **136**.

[0045] A collapsible seal **160** may form an annular wall of valve stem **102** and may surround a part of distal portion **140** of water lumen **134**. Collapsible seal **160** may be formed of the same material as a remainder of valve stem **102** or from a different material. Collapsible seal **160** may be a single, unitary structure with the remainder of valve stem **102**. Alternatively, collapsible seal **160** may include separate or additional structures from the remainder of valve stem **102**. In certain examples, material of a remainder of valve stem **102** (apart from collapsible seal **160**) may be discontinuous at a location of collapsible seal **160**, and collapsible seal **160** may be bonded to a proximal and distal portion of valve stem **102** bordering collapsible seal **160**. For example, collapsible seal **160** may be made of a flexible polymer (e.g., TPE) having appropriate properties (such as an appropriately high durometer value). Collapsible seal **160** may be bonded to portions of distal portion **116** of valve stem **102** proximal and distal of collapsible seal **160** using, for example, adhesive or another suitable method. Alternatively, a thin cylinder of metal may extend through a center of collapsible seal **160**, and collapsible seal **160** may be bonded to the thin cylinder of metal. The cylinder of metal and/or collapsible seal **160** may be bonded to portions of distal portion **116** of valve stem **102** proximal and distal of collapsible seal **160**. The thin cylinder of metal may have an interior lumen that is in fluid communication with the rest of water lumen **134**. Exemplary collapsible seals **160** are discussed in further detail below, with respect to FIGS. **3**A-**3**B and **4**A-**4**B. A poppet valve **170** may extend within water lumen **134** and may have a proximal end at a distal inner surface of distal portion **140** distal of water lumen **134**. Poppet valve **170** may include a shaft **172** and a tapered plug **174**. Further functionality of poppet valve **170** will be described below. Shaft **172** may be fixedly attached to valve stem **102**. When a distal portion **116** of valve stem **102** is in the first, second, and third configurations, tapered plug **174** may be seated against distal portion **116**, creating a seal between mating surfaces of poppet valve **170** and distal portion **116**. When distal portion **116** of valve stem **102** Is in the fourth configuration, distal portion **116** is displaced proximally and moves away from tapered plug **174**. This displacement opens distalmost opening **135** of water lumen **134** to water inlet **20** and water outlet **22**.

[0046] Valve stem **102** may also be fitted with a plurality of seals. For example, valve stem **102** may include a first seal **180**, a second seal **182**, and a third seal **184**. Seals **180**, **182**, and **184** may be disposed in grooves of valve stem **102**. Seals **180**, **182**, and **184** may have any of the properties of seals **72**, **74**, **76**, or **78**, described above. Seals **180**, **182**, and **184** may have a slidable interference fit with a surface **14** of valve cylinder **12** so that fluids (e.g., air, water) cannot move proximally or distally between seal **180**, **182**, or **184** and the surface **14** of valve cylinder **12**. First seal **180** may be disposed proximally of water apertures **136**. Second seal **182** may be disposed distally of water apertures **136** and proximally of air aperture **126**. Third seal **184** may be disposed distally of air aperture **126** and collapsible seal **160**. Valve stem **102** may also have a one-way seal **186** that may have any of the properties of one-way seal **82**. One-way seal **186** may permit fluids (e.g., air and water) to move proximally past one-way seal **82** but not distally past one-way seal **186**.

[0047] Valve stem **102** may also include a plurality of coarse threads **190**. Coarse threads **190** are shown in dashed lines in FIGS. **2**A-**2**C because they may be on a circumferential outer surface of valve stem **102**. Coarse threads **190** may include alternative indentations and protrusions.

[0048] FIG. **2**A shows valve **100** in a first and/or second configuration. In the first and second configurations, button **120** may not be depressed and spring **122** may be in a relaxed, extended state. Spring **122** may be biased to the configuration of FIG. **2**A. First and second seals **180**, **182** may be proximal to air outlet **18**. One-way seal **186** may be between air outlet **18** and air inlet **16**. Collapsible seal **160** may be between air inlet **16** and water outlet **22**. Third seal **184** may be proximal of water inlet **20** and distal to water outlet **22**. Poppet valve **170** may be closed (plug **174** closes opening **135**) so that fluid cannot enter a distalmost opening **135** of water lumen **134**.

[0049] In a first configuration, proximalmost opening **130** may be left uncovered. Water from water inlet **20** may not move proximally past third seal **184**. Water from water inlet **20** may also not enter water lumen **134** because poppet valve **170** is closed. Therefore, water cannot exit into channels of the endoscope. As shown with dashed-line arrows, air from air inlet **16** will be drawn to air aperture **126**, through air release lumen **128** and out of proximalmost opening **130**. Air will be drawn to enter air aperture **126** instead of passing proximally of one-way seal **186** because air aperture **126** and proximalmost opening **130** provide the path of least resistance, as there is no resistance for the air to exit to atmospheric pressure. Therefore, when proximalmost opening **130** is uncovered, air incoming from air inlet **16** does not have sufficient pressure to bypass flexible seal **186**.

[0050] In a second configuration, air may be delivered to a body lumen of a patient during a procedure. In the second configuration, proximalmost opening **130** may be covered by, for example, a thumb or finger of an operator. Proximalmost opening **130** may also be covered in the third and fourth configurations, discussed below. Thus, as shown in solid-line arrows, air will be prevented from exiting proximalmost opening **130**. Instead, air from air inlet **16** will travel proximally past one-way seal **186** and out air outlet **18**. Air may not travel proximally past second seal **182** and may thus not exit a proximal opening of cylinder **12**.

[0051] To transition valve **100** to a third configuration, button **120** may be pressed distally, compressing spring **122** and moving valve stem **102** distally. In the third configuration, poppet valve **170** remains closed (plug **174** remains covering opening **135**). Shaft **172** of poppet valve **170** may be fixedly attached to valve stem **102** at a proximal end of shaft **172**. Collapsible seal **160** may be sufficiently stiff along an axial/longitudinal direction so as to enable movement of valve stem **102** as a unit (including distal portion **116** of valve stem **102**). First seal **180** is proximal of air outlet **18**, while second seal **182** is distal to air outlet **18**. Third seal **184** may be distal to water inlet **20**, one-way seal **186** may be distal to air inlet **16** and proximal of water outlet **22**, and collapsible seal **160** may be proximal of water outlet **22**. Therefore, as shown in solid-line arrows, water may enter from water inlet **20** and pass out of water outlet **22**, as no seals are between water inlet **20** and water outlet **22**. However, water cannot move proximally past collapsible seal **160**. Air from air inlet **16** may not move proximally of second seal **182** or one-way seal **186** to enter air aperture **126**. Thus, although proximalmost opening **130** may be covered by a finger or thumb of an operator, air may not exit air outlet **18**. Air may likewise not exit water outlet **22** because air cannot travel distally from air inlet **16** past one-way seal **186**.

[0052] Valve **100** may be transitioned back to the first or second configuration by releasing pressure on button **120**. Spring **122** may be biased to an expanded state of the first configuration. Thus, button **120** may move proximally to the position of the first/second configurations when button **120** is released.

[0053] To transition valve **100** to a fourth configuration, button **120** (and valve stem **102**) may be rotated in a counter-clockwise direction, which may engage coarse threads **190** and cause a distal portion **116** of valve stem **102** to be pulled upward. Coarse threads **190** may be operative (via, e.g., an internal mechanism) to pull upward on distal portion **116** of valve stem **102**. Upward motion of distal portion **116** may cause collapsible seal **160** to collapse. Collapse of collapsible seal **160** may cause poppet valve **170** to open (unseat from opening **135**). In an alternative embodiment, rotating button **120** may open a valve that ports air pressure from air inlet **16** to a distalmost chamber in valve **100**, distal to poppet valve **170** and the distal portion **116** of valve stem **102**. This action may drive the distal portion **116** of valve stem **102** proximally, compressing collapsible seal **160** and opening water channel **134** to water inlet **20**. Alternatively to poppet valve **170**, a porous elastomer seal may be used. When the porous elastomer is relaxed (e.g., in configurations 1-3 of FIGS. **2**A and **2**B), the pores may be closed, and fluid may not pass the porous seal. When the seal is stretched, such as in the fourth configuration of FIG. **2**C, the pores will be opened and fluids such as water may pass through the porous elastomer seal.

[0054] In the fourth configuration, third seal **184** may be aligned with water inlet **20**. Collapsible seal **160** may remain proximal of water outlet **22**. One-way seal **186** may remain distal to air inlet **16**, and second seal **182** may remain distal to air outlet **18**. First seal **180** may be proximal of air outlet **18**. Thus, as shown in solid-line arrows, water from water inlet **20** may move distally toward distalmost opening **135** of water lumen **134**. Because poppet valve **170** is open, water may enter water lumen **134** and travel proximally through water lumen **134** and through water apertures **136**. Water may then move between an outer circumference of valve stem **102** and a surface of valve cylinder **12** and out air outlet **18**. Water may also move proximally of water inlet **20** and to water outlet **22**. Thus, in the fourth configuration, water may flush the air and water channels of an endoscope.

[0055] Collapsing of collapsible seal **160** may be a non-reversible process. Thus, after collapsible seal **160** is transitioned to the fourth configuration, it may not be transitioned back to the first, second, or third configuration.

[0056] In order to make use of valve **100**, an operator may insert valve **100** into valve cylinder **12** of an endoscope prior to a procedure. During the procedure, the operator may use valve **100** in the first, second, and/or third configurations, depending on the operator's desire to make use of air or water during the procedure. Following the procedure, after the endoscope is removed from the patient for reprocessing, button **120** may be rotated so that valve **100** transitions to the fourth configuration. Valve **100** may flush water through the air and water channels for a predetermined amount of time (e.g., thirty seconds). After flushing is complete, an operator could shut off an air and water supply to disable the flow of air and water or could simply remove valve **100** from valve cylinder **12**. The endoscope would be subject to further processing, and valve **100** would be disposed.

[0057] FIGS. **3**A and **3**B show an exemplary first collapsible seal **200**, which may be used with valve **100**. Collapsible seal **200** may be constructed of a flexible material, such as an elastomeric material or flexible polymer such as TPE. FIG. **3**A shows collapsible seal **200** in a first, closed configuration. FIG. **3**B shows collapsible seal **200** in a second, open configuration. In the closed configuration of FIG. **3**A, an annular wall **202** of collapsible seal **200** projects inward into a central lumen **204** of collapsible seal **200**. Contact between annular walls **202** in central lumen **204** prevents fluid (e.g., water) from passing through central lumen **204**.

[0058] Collapsible seal **200** may be transitioned to the open configuration by inflating valve **200** using a fluid such as water or air. Air may be ported from air inlet **16** and actuated by a twist or push motion on the proximal end of a valve employing collapsible seal **200**. In the second configuration, wall **202** of collapsible seal **200** expands so that inner surfaces of wall **202** may be separated from one another and so that central lumen **204** is open and passible to fluid such as water. A circumferential outer surface of wall **202** may have a feature **206** (e.g., a protrusion), which causes walls **202** to engage with an inner surface of cylinder **12** and to block flow of fluid proximally past an outer surface of collapsible seal **200**.

[0059] FIGS. **4**A and **4**B show another exemplary collapsible seal **300**.

[0060] Collapsible seal **300** may be formed of a rigid or semi-rigid material such as plastic or metal. Collapsible seal **300** may have a plurality of longitudinal slots **302** formed around a circumferential surface of collapsible seal **300**. Longitudinal slots **302** may be covered by a material such as an elastomer (not shown) to make them impervious to fluids such as water and air. In the first configuration of collapsible seal **300**, shown in FIG. **4**A, an outer surface of collapsible seal **300** including slots **302** may be relatively parallel with a longitudinal axis of collapsible seal **300**.

[0061] In FIG. **4**B, collapsible seal **300** has transitioned to a second configuration via, e.g., the mechanisms described above for transitioning valve **100** to the fourth configuration of FIG. **2**C. In the second configuration, an annular wall of collapsible seal **300** bulges outward due to flexibility imparted by slots **302**. An exterior, circumferential surface of the wall of collapsible seal **300** may make contact with the walls of valve cylinder **12**, barring passage of fluid, such as water, proximally past an exterior of collapsible seal **300**. However, fluids such as water may travel proximally through a distal opening of collapsible seal **300** and through a central lumen of collapsible seal **300**.

[0062] FIGS. **5**A-**5**C show a cross-sectional view of an exemplary valve **500** in valve cylinder **12**. Valve **500** may have a valve stem **524**. Valve stem **524** may have a proximal member **526** and a distal member **528**. Portions of valve stem **524** including proximal member **526** and distal member **528**, may be made from metal (e.g., stainless steel, titanium, aluminum, etc.), from a polymer (e.g. polycarbonate, ABS, HDPE, Nylon, PEEK, thermoplastic, plastic, etc.), or from any other suitable material. Proximal member **526** and distal member **528** may be made from the same material or from different materials. Proximal member **526** and/or distal member **528** may be formed from a single, continuous material.

[0063] Proximal member **526** may include a button **532**. Button **532** may be formed as one continuous structure with the rest of proximal member **526**, or button **532** may be a separate structure attached to the rest of proximal member **526**. Button **532** may have an outer circumference that is wider than a proximal opening of valve cylinder **12**, so that when button **532** is depressed, button **532** cannot pass through the proximal opening of valve cylinder **12**.

[0064] Proximal member **526** may have a proximal lumen **540**. Proximal member **526** may have a generally annular shape around lumen **540**. Proximal lumen **540** may have a proximalmost opening **541** on a proximalmost end of proximal member **526**. For example, proximal lumen **540** may be open on a proximalmost side of button **532**. Proximal opening **541** is shown with dashes to indicate that, as discussed below, proximal opening **541** may be covered by an operator (e.g., by the finger or thumb of an operator).

[0065] As shown in FIGS. 5A and 5B, a membrane **542** may extend completely across proximal lumen **540** toward a distal end **544** of proximal lumen **540**. For example, membrane **542** may be a small distance from a distalmost end of proximal lumen **540**. Alternatively, membrane **542** may be at a distalmost end of proximal lumen **540**. Membrane **542** may be formed of a thin material. Aspects of membrane **542** will be discussed in further detail with reference to FIGS. 5B-5C.

[0066] A proximal aperture **546** may be formed in, and extend completely through, a wall of proximal member **526** and may fluidly connect proximal lumen **540** to an area external to proximal member **526**. Although one proximal aperture **546** is shown in FIGS. 5A-5C, any number of proximal apertures may be used. One or more air apertures **548** may also be formed in, and extend completely through, a wall of proximal member **526** and may fluidly connect proximal lumen **540** to an area external to proximal member **526**. Although only one air aperture **548** is shown, any suitable number of apertures may be utilized.

[0067] Distal member **528** may include a neck **550** on a proximal end of distal member **528**. Neck **550** may have an outer diameter that is smaller than a diameter of lumen **540**. Neck **550** may terminate distally in a shoulder **552**. Neck **550** may have a proximal tapered portion **554**. A distal lumen **560** may pass through distal member **528**, including neck **550**. Distal lumen **560** may be open on a proximalmost side of distal member **528** (e.g., on a proximalmost end **562** of neck **550**) and may be closed on a distalmost side of distal member **528**. A diameter of distal lumen **560** may be smaller than a diameter of proximal lumen **540**. Tapered portion **554** may taper from an initial outer diameter (at a proximal end) until its outer diameter is substantially the same as a diameter of distal lumen **560**. The proximalmost end of tapered portion **554** may form a sufficiently sharp annular ring to cut through, puncture, or otherwise remove membrane **542** under sufficient force. Portions of membrane **542** that are severed by tapered portion **554** may be flushed away by fluids flowing through valve **510** (further details of the flushing process are discussed below) or may remain within valve **510**. A distal aperture **564** may be formed in, and extend completely through, a wall of distal member **528** and may fluidly connect distal lumen **560** to an area external to distal member **528**. Although one distal aperture **564** is shown in FIGS. 5A-5C, any number of distal apertures may be used.

[0068] Neck **550** may be slidably received within proximal lumen **540** so that distal lumen **60** is in fluid communication with proximal lumen **540**. Proximal lumen **540** and/or neck **550** may have features (e.g., indentations, protrusions, tabs, etc.) (not shown) that retain neck **550** within lumen **540** and prevent a proximalmost end **562** of neck **550** from exiting a distalmost end **544** of proximal lumen **540**.

[0069] Valve stem **530** may be fitted with one or more seals. For example, valve stem **530** may include, in a direction from proximal to distal, a first seal **572**, a second seal **574**, a third seal **576**, and a fourth seal **578**. Seals **572**, **574**, **576**, and **578** may be, for example, O-rings. Seals **572**, **574**, **576**, and **578** may be formed from an elastomeric material. Valve stem **530** may also include a one-way seal **582**, which may be made of the same or different material as seals **572**, **574**, **576**, and **578** (e.g., an elastomeric material). One-way seal **582** may permit passage of fluid or other substances proximally past one-way seal **582** but may not permit passage of fluid or other substances distally past one-way seal **582** due to its flexibility and arrangement relative to its contacted structure. First seal **572** and second seal **574** may be disposed on proximal member **526**. Third seal **576** and fourth seal **578** may be disposed on distal member **528**. One-way seal **582** may be disposed on proximal member **526** between second seal **574** and third seal **576**. Alternatively, seals **572**, **574**, **576**, **578** and one-way seal **582** may be disposed on alternative portions of valve stem **530** or in different orders. Proximal aperture **546** may be disposed between first seal **572** and second seal **574**. Distal aperture **564** may be disposed between third seal **576** and fourth seal **578**.

[0070] Seals **572**, **574**, **576**, and **578** may be configured so as to form a slidable interference fit between seals **572**, **574**, **576**, and **578** and surface **14**. Thus, valve stem **530** can move relative to surface **14**, but fluids (e.g. water and air) cannot move between seals **572**, **574**, **576**, and **578** and surface **14**. Thus, seals **572**, **574**, **576**, and **578** prevent movement of fluids external to valve **10** in a proximal or distal direction past seals **572**, **574**, **576**, and **578**.

[0071] An inner diameter of one-way seal **582** may be sized so that there is a slight interference between an external surface of proximal member **526** and the inner diameter of one-way seal **582**, so that a tight seal is formed. An outer diameter of one-way seal **582** may be sized so as to form a slight interference fit with a portion of surface **14**. A thin flap of one-way seal **582** may extend radially outward from proximal member **526** at an angle transverse to a longitudinal axis of proximal member **526**. For example, the thin flap may extend at an angle between 10 degrees and 80 degrees relative to a longitudinal axis of proximal member **526**. The flap of one-way seal **582** may be expandable so that when fluid (e.g., water or air) moves in a distal direction toward one-way seal **582**, a positive pressure will expand the flap, maintaining a seal between one-way seal **582** and surface **14**. Fluid moving proximally toward one-way seal **582** will also create a positive pressure, but the positive pressure will produce a force normal to a longitudinal axis of proximal member **526** to radially compress the flap of one-way seal **582**. Thus, fluid (e.g., air or water) is permitted to move proximally past one-way seal **582**, between one-way seal **582** and surface **14**. Whereas one-way seal **82** of valve **10** may be disposed distally of air aperture **48**, one-way seal **582** of valve **510** may be disposed proximally of air aperture **548**.

[0072] FIG. **5**A shows valve **510** in a first configuration and/or a second configuration. In the first configuration of valve **510**, neither air nor water is delivered to any outlets of valve **510** and will vent through proximalmost opening **541** to the atmosphere.

[0073] In the second configuration, air is delivered to an air channel of an endoscope but water is not delivered to any channel. The first configuration and second configuration may differ only in that proximalmost opening **541** at a proximalmost end of proximal lumen **540** is left open in the first configuration and is blocked (e.g., by an operator's thumb or finger) in the second configuration. In the first and second configurations, button **532** may not be pushed down. Valve **510** may include features such as tactile feedback features (not shown) to indicate that valve **510** is in a proper position within valve cylinder **12**. For example, valve **510** can include ridges, bumps, or other protrusions on an outside surface of proximal member **526**. Proximalmost end **562** of distal lumen **560** (and neck **550**) may be distal of membrane **542** so that proximal lumen **540** is not in fluid communication with distal lumen **560**.

[0074] In the first and second configurations, water inlet **20** may be distal to fourth seal **578**. Water outlet **22** may be between third seal **576** and fourth seal **578**. Thus, water from water inlet **20** may not move proximally of fourth seal **578**. Water outlet **22** is surrounded by third seal **576** and fourth seal **578**, and therefore fluids (air and water) cannot move longitudinally to water outlet **22** along surfaces **14** of cylinder **12**. And because membrane **542** is in place, distal lumen **560** and proximal lumen **540** are not in fluid communication. Thus, no fluids may exit water outlet **22**.

[0075] In the first configuration (e.g., when proximalmost opening **541** is not covered and neither air nor water is delivered), as shown in dashed-line arrows on FIG. **5**A, air may enter from air inlet **16** and then pass around a circumference of proximal member **526** of valve stem **524** to air aperture **548**. Air will enter air aperture **548** instead of passing out air outlet **18** because proximalmost opening **541** venting to the atmosphere provides the path of least resistance. Air may then vent proximally out of proximalmost opening **541**. Any air that would exit aperture **546** would be trapped between first seal **572** and second seal **574**, so air will instead vent from proximalmost opening **541**. Air may not travel distally past third seal **576** and thus may not exit water outlet **522**. Air inlet **516** may be proximal of third seal **576** but distal to one-way seal **582**. Air entering from air inlet **16** will not travel proximally past one-way seal **582** toward air outlet **18**, because the path of least resistance will be for air to vent from proximalmost opening **541**, and therefore air will not exit air outlet **18**. Thus, in the first configuration, neither air nor water is delivered.

[0076] In the second configuration, also shown in FIG. **5**A, proximalmost opening **541** may be covered by, for example, an operator's thumb or finger. Proximalmost opening **541** may also be covered in the third and fourth configurations, discussed below. Otherwise, the second configuration may be identical to the first configuration, e.g., all of the structures of valve **510** are in the same locations relative to one another and cylinder **12**. Because air can no longer vent out of proximalmost opening **541**, as shown in solid-line arrows on FIG. **1**A, air entering from air inlet **16** may travel proximally past one-way seal **582**. Thus, air entering from air inlet **16** may pass through air outlet **18** to deliver air to an air channel of an endoscope. Air from air inlet **16** may not pass proximally of second seal **574** and thus may not enter proximal aperture **546**. Air entering aperture **548** cannot exit proximalmost opening **541** as it is covered. Thus, in the second configuration, valve **510** will deliver air to an air channel of the endoscope.

[0077] FIG. **5**B shows valve **510** in a third configuration, in which water is delivered to a water channel of the endoscope but air is not delivered to any endoscope channel. To transition from the second configuration to the third configuration, button **532** may be depressed part-way. For example, button **532** may be depressed until a pliable feature on a distal surface of button **532** is in contact with an outer, proximal surface of cylinder **12**. For example, tabs **594** may contact an outer surface of cylinder **12**. Contact of features such as tabs **594** may cause tactile feedback to an operator to indicate that valve **10** is in the third configuration. Tabs **594** are merely exemplary, and any suitable feature may be used. For example, an annular flap/flange, expanded inflatable features, frangible piece, or other feature may be used. Tabs **594** may be made of the same material as button **532** or from a different material.

[0078] In transitioning from the second configuration to the third configuration, both proximal member **526** and distal member **528** may translate distally relative to cylinder **512**, as a result of button **532** being pressed downward. Membrane **542** may be sufficiently resilient that a force on button **532** to transition valve **510** from the second configuration to the third configuration may not cause a proximalmost end of neck **550** to break through membrane **542**. Therefore, membrane **542** may remain intact in the third configuration, and a force on neck **550** from membrane **542** may cause a distal translation of distal member **528** along with proximal member **526**. Distal member **528** (and proximal member **526**) may translate distally until distal member **528** rests on a distal surface of cylinder **12**, or until tabs **594** contact an upper, proximal surface of cylinder **12**. Additionally or alternatively, a frictional force between an outer surface of neck **550** and an inner surface of proximal lumen **540** may cause distal member **528** to move in unison with proximal member **526**.

[0079] In the third configuration, fourth seal **578** may be distal to water inlet **20**. Third seal **576** may be proximal of water outlet **22**. Thus, as shown in solid-line arrows, water from water inlet **20** may not move distally past fourth seal **578** but may move through water outlet **22** and through a water channel of an endoscope. Although water may move through distal aperture **564**, water may not move proximally past membrane **542**, which may be resilient enough to block proximal movement of water. Thus, water may not enter proximal lumen **540**. Water also may not move proximally past third seal **576**. One-way seal **582** may be distal to air inlet **16** so air can not pass to enter air aperture **548**. Second seal **574** may be proximal of air inlet **16**. Thus, air from air inlet **16** may not move into proximal lumen **540** through air aperture **548** or past seal **574**, thus will not exit air outlet **18**. As a result, in the third configuration, the only fluid flow to the endoscope sheath is that of water through the water channel.

[0080] Valve **510** may be transitioned from the third configuration back to the first/second configuration. For example, valve **510** may have a spring (not shown) or other feature which biases valve **510** to the first configuration. Alternatively, valve **510** may be transitioned from the third configuration (or the first/second configuration) to the fourth configuration.

[0081] As shown in FIG. 5C, the fourth configuration facilitates flushing of water from water inlet **20** through both water outlet **22** and air outlet **18**. The fourth configuration may be referred to as the cleaning configuration of valve **510**. To move from the third configuration to the fourth configuration, button **532** may be depressed until tabs **594** are collapsed against a surface of cylinder **12**. Substantially more force may be required to transition valve **150** to the fourth configuration than to the third configuration. While button **532** is depressed part-way in the third configuration, button **532** may be fully depressed in the fourth configuration. In the fourth configuration, tabs **594** may break (e.g., by cracking off at a proximal end of tabs **594**) or bend flat so as to be parallel with a proximal surface of button **532** and/or a proximal surface of endoscope cylinder **12**. A certain, minimum amount of force may be required to bend or break tabs **94**.

[0082] Because distal member **528** already rested on a distal surface of cylinder **12** in the third configuration, distal member **528** may not translate distally along with proximal member **526** when button **532** is depressed fully. Translation of proximal member **526** distally relative to distal member **528** may cause proximal tapered portion **554** to pierce membrane **542** and thereby fluidly connect distal lumen **560** and proximal lumen **540**. In the fourth configuration, proximal tapered portion **554** of distal member **528** may be proximal of the original location of membrane **542**. Therefore, as shown with solid-line arrows, in the fourth configuration of valve **510**, water may travel from water inlet **20** and out of water outlet **22**, as in the third configuration of valve **510**. However, unlike the third configuration, the fourth configuration also permits water to travel into proximal aperture **564**, through distal lumen **560**, into proximal lumen **540**, and out of proximal aperture **546**, so that water may flow between valve stem **530** and a surface of valve cylinder **12** to air outlet **18**. Because air aperture **548** may be covered by neck portion **550** in the fourth configuration, water may not pass through air aperture **548**.

[0083] The fourth configuration should not be used while an endoscope is inside of a body lumen of a patient. Valve **510** may contain mechanisms to prevent an operator from unintentionally transitioning valve **510** to the fourth configuration. For example, tabs **594** may provide resistance or other tactile feedback against pushing down button **532** past the third configuration. An operator may also receive tactile feedback from a distal end of distal member **528** contacting a distal surface of valve cylinder **12** in the third configuration, indicating to the operator that button **532** should not be further depressed while an endoscope is in use during a patient procedure. Additionally or alternatively, other methods may be used to prevent accidental transition of valve **510** into the fourth configuration. For example, a deformable mechanical stop may provide audible feedback (e.g., a “click” sound), valve **510** could require rotation prior to transitioning to the fourth configuration, and/or a visual indicator may provide feedback to an operator.

[0084] Because membrane **542** is broken in the fourth configuration, valve **510** may not again be used in any of the first, second, or third configurations. Therefore, valve **510** is a single-use valve, for use during only one pre-processing cleaning step. Alternatively, after use in one pre-processing cleaning, valve **510** could be used as only a pre-processing cleaning valve **510** without use during patient procedures. Alternatively, membrane **542** may be a strong, reusable seal that could be reset following use so that valve **510** is reusable over multiple procedures.

[0085] In order to make use of valve **510**, an operator may insert valve **510** into valve cylinder **12** of an endoscope prior to a procedure. During the procedure, the operator may use valve **510** in the first, second, and/or third configurations, depending on the operator's desire to make use of air or water during the procedure. Following the procedure, the endoscope may be removed from the patient for reprocessing. Button **532** may be fully depressed so that valve **510** transitions to the fourth configuration. Valve **510** may flush water through the air and water channels for a predetermined amount of time (e.g., thirty seconds). After flushing is complete, an operator could either move button **532** proximally to disable the flow of water or could simply remove valve **510** from valve cylinder **12**. Alternatively, button **532** may automatically move proximally to disable the flow of water. The endoscope would be subject to further reprocessing, and valve **510** may be disposed.

[0086] While principles of the present disclosure are described herein with reference to illustrative examples for particular applications, it should be understood that the disclosure is not limited thereto. Those having ordinary skill in the art and access to the teachings provided herein will recognize additional modifications, applications, and substitution of equivalents all fall within the scope of the examples described herein. Accordingly, the invention is not to be considered as limited by the foregoing description.

## Claims

**1**. A valve stem for a medical device, the valve stem comprising: a first wall defining a first lumen extending along a longitudinal axis; a second wall defining a second lumen extending along the longitudinal axis and annularly around the first lumen; and a valve extending from the first wall and through the second lumen, wherein the valve is configured to close an opening through the second wall when the second wall is in a first configuration and the valve is configured to be spaced from the opening when the second wall is in a second configuration.

**2**. The valve stem of claim 1, wherein: the valve incudes a shaft and a plug, wherein the shaft is disposed within the second lumen and a distal end of the shaft is attached to the plug, and in the first configuration, the plug is disposed in the opening and in the second configuration, the plug is distal to the opening.

**3**. The valve stem of claim 1, further comprising: a plurality of apertures in fluid communication with the second lumen and proximal of the opening.

**4**. The valve stem of claim 3, further comprising: a first seal; and a second seal, wherein the plurality of apertures are between the first seal and the second seal.

**5**. The valve stem of claim 3, wherein the second lumen comprises a plurality of branches in fluid communication with the plurality of apertures.

**6**. The valve stem of claim 3, wherein the second lumen comprises a plurality of branches and each branch is in communication with a separate set of two or more apertures of the plurality of apertures.

**7**. The valve stem of claim 1, wherein the first lumen and the second lumen are coaxial.

**8**. The valve stem of claim 1, wherein the opening is a first opening and a second opening is located proximal of the first opening and is in fluid communication with the first lumen.

**9**. The valve stem of claim 1, wherein the valve stem has a first stem configuration for delivering air to an air channel of the medical device exterior of the second wall, a second stem configuration for delivering a liquid to a liquid channel of the medical device along the exterior of the second wall, and a third stem configuration for delivering the liquid to the air channel of the medical device along the second lumen.

**10**. The valve stem of claim 1, wherein the second wall is configured to be non-adjustable to the first configuration from the second configuration.

**11**. A valve assembly for a medical device, the valve assembly comprising: a valve cylinder comprising an air inlet, an air outlet, a water inlet, and a water outlet; a valve stem positioned within the valve cylinder, the valve stem comprising: a first wall; a second wall defining a distal opening and a proximal opening; and a valve extending from the first wall and through the distal opening, wherein the valve is configured to close the distal opening when the second wall is in a first configuration and the valve is configured to be spaced from the distal opening when the second wall is in a second configuration to allow water to flow from the water inlet to the air outlet via the distal opening and the proximal opening.

**12**. The valve of claim 11, wherein the valve stem is rotated relative to the valve cylinder to adjust the second wall from the first configuration to the second configuration.

**13**. The valve assembly of claim 11, wherein: the valve stem has a first stem configuration for delivering air to an air channel of the medical device exterior of the second wall, a second stem configuration for delivering a liquid to a liquid channel of the medical device along the exterior of the second wall, and a third stem configuration for delivering the liquid to the air channel of the medical device along a lumen extending between the first wall and the second wall, the second wall is in the first configuration when the valve stem is in the first stem configuration and the second stem configuration, and the second wall is in the second configuration when the valve stem is in the third stem configuration.

**14**. The valve assembly of claim 11, wherein the second wall is configured to advance in a proximal direction relative to the first wall to position the second wall in the second configuration.

**15**. The valve assembly of claim 11, wherein the first wall defines a first lumen and the second wall defines a second lumen extending annularly around the first lumen.

**16**. The valve assembly of claim 11, further comprising: a plurality of apertures extending through the second wall, wherein the proximal opening is an aperture of the plurality of apertures.

**17**. A method of delivering air and water, the method comprising: via a valve stem in a first stem configuration in a valve cylinder, delivering air to an air channel of a medical device; transitioning the valve stem from the first stem configuration to a second stem configuration in the valve cylinder to deliver water to a water channel of the medical device; and transitioning the valve stem from the second stem configuration to a third stem configuration in the valve cylinder to deliver the water to the air channel of the medical device, wherein transitioning the valve stem from the second stem configuration to the third stem configuration comprises axially spacing a valve of the valve stem from a distal opening in the valve stem to allow water to flow from the distal opening to a proximal opening through the valve stem.

**18**. The method of claim 17, wherein transitioning the valve stem from the second stem configuration to the third stem configuration comprises rotating the valve stem relative to the valve cylinder.

**19**. The method of claim 17, wherein: the valve stem comprises a first wall, a second wall defining the distal opening, and the valve extending from the first wall and through the distal opening, and spacing the valve of the valve stem from the distal opening comprises advancing the second wall in a proximal direction relative to the first wall, the valve, and the valve cylinder.

**20**. The method of claim 17, wherein: the valve stem comprises a first wall defining a first lumen, a second wall defining a second lumen in communication with the distal opening and the proximal opening, and the valve extending from the first wall and closing the distal opening in the first stem configuration and the second stem configuration, and transitioning between the first stem configuration and the second stem configuration comprises longitudinally adjusting the first wall, the second wall, and the valve relative to the valve cylinder.