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(54) **DUAL-TRAP TOILET HAVING IMPROVED PRESSURIZATION AND FLUSHING**

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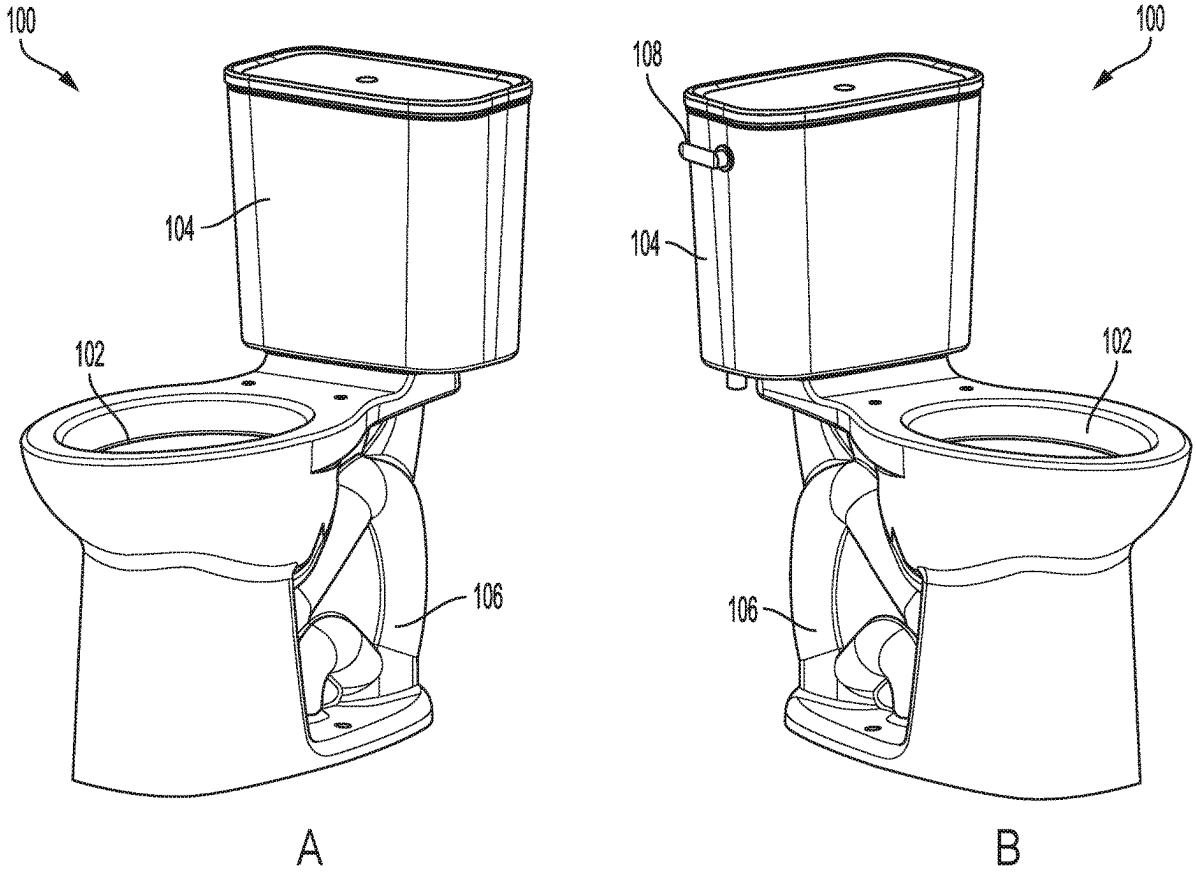
CPC ***E03D 11/13*** (2013.01); *E03D 2201/00* (2013.01)

(57) **ABSTRACT**

A toilet assembly may comprise a toilet tank to hold flush water, a flush valve assembly positioned in the toilet tank, a trapway in flow communication with the toilet bowl, a container positioned in the toilet tank, and a connecting tube extending from an interior of the container to the trapway. Between flush cycles, the tank may store a volume of flush water. The flush water may be divided between different regions of the tank that are defined by the structure of the container. Between flush cycles, the container and the trapway may contain pressurized air. A force exerted by pressurized air in the trapway on water in a lower trap may cause an upstream water level in the lower trap to be lower than a downstream water level in the lower trap.



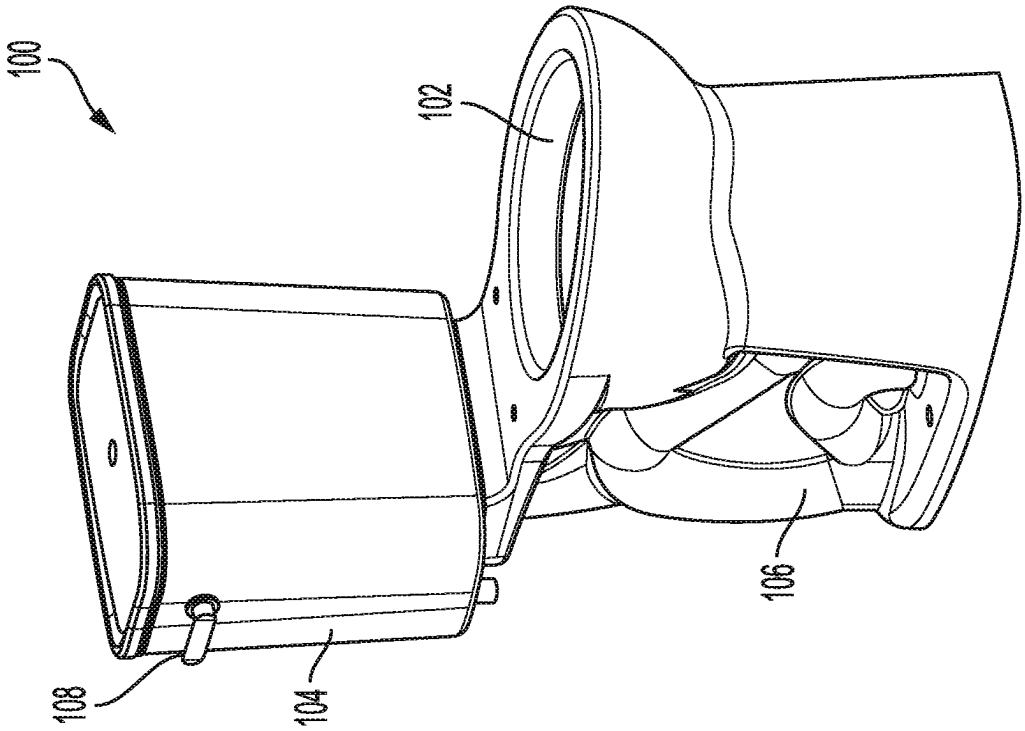


FIG. 1B

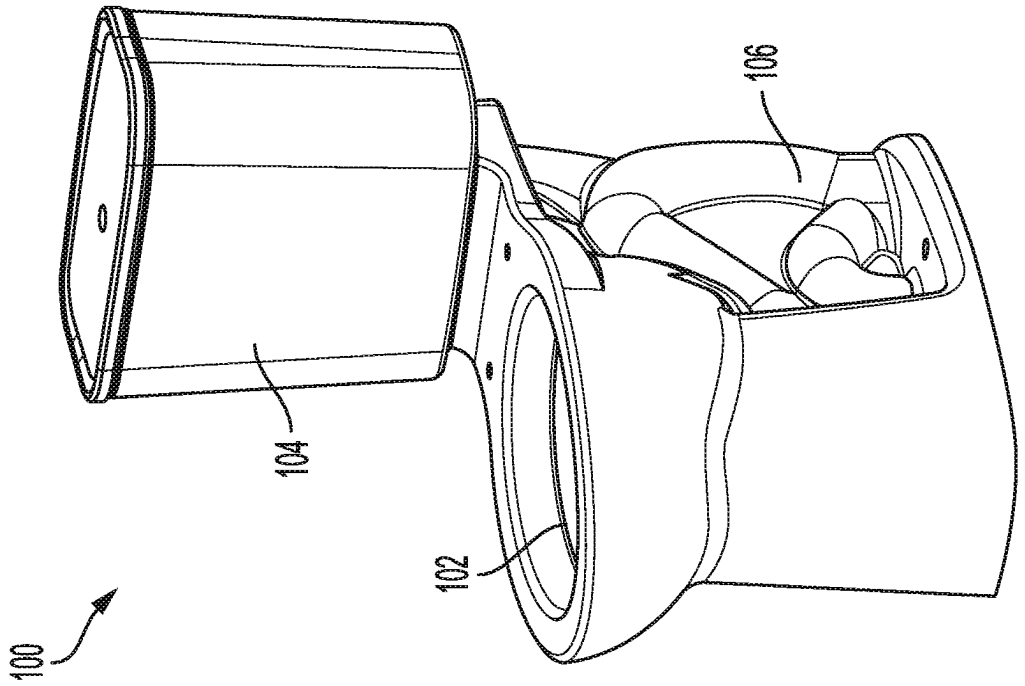


FIG. 1A

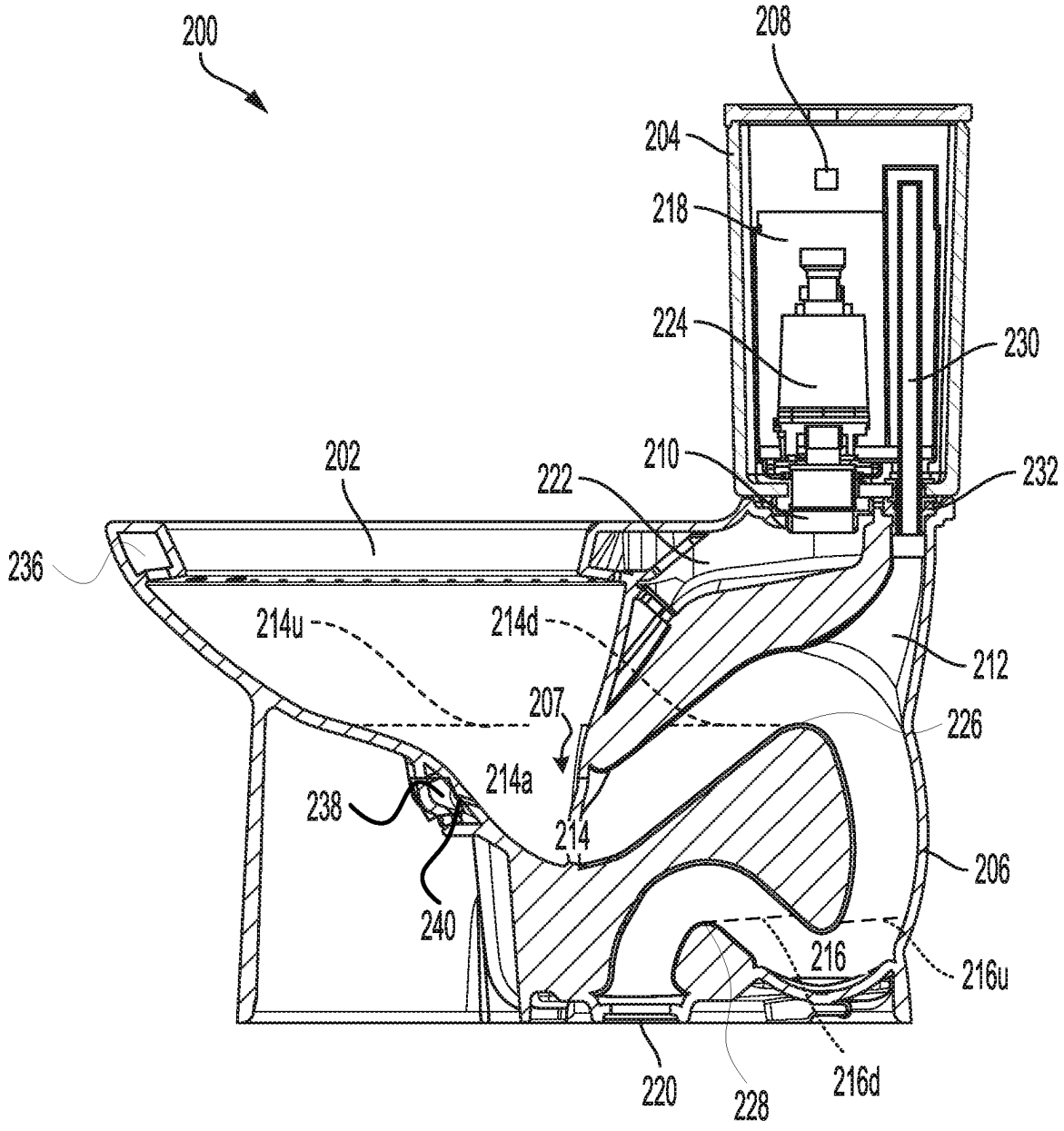

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FIG. 2

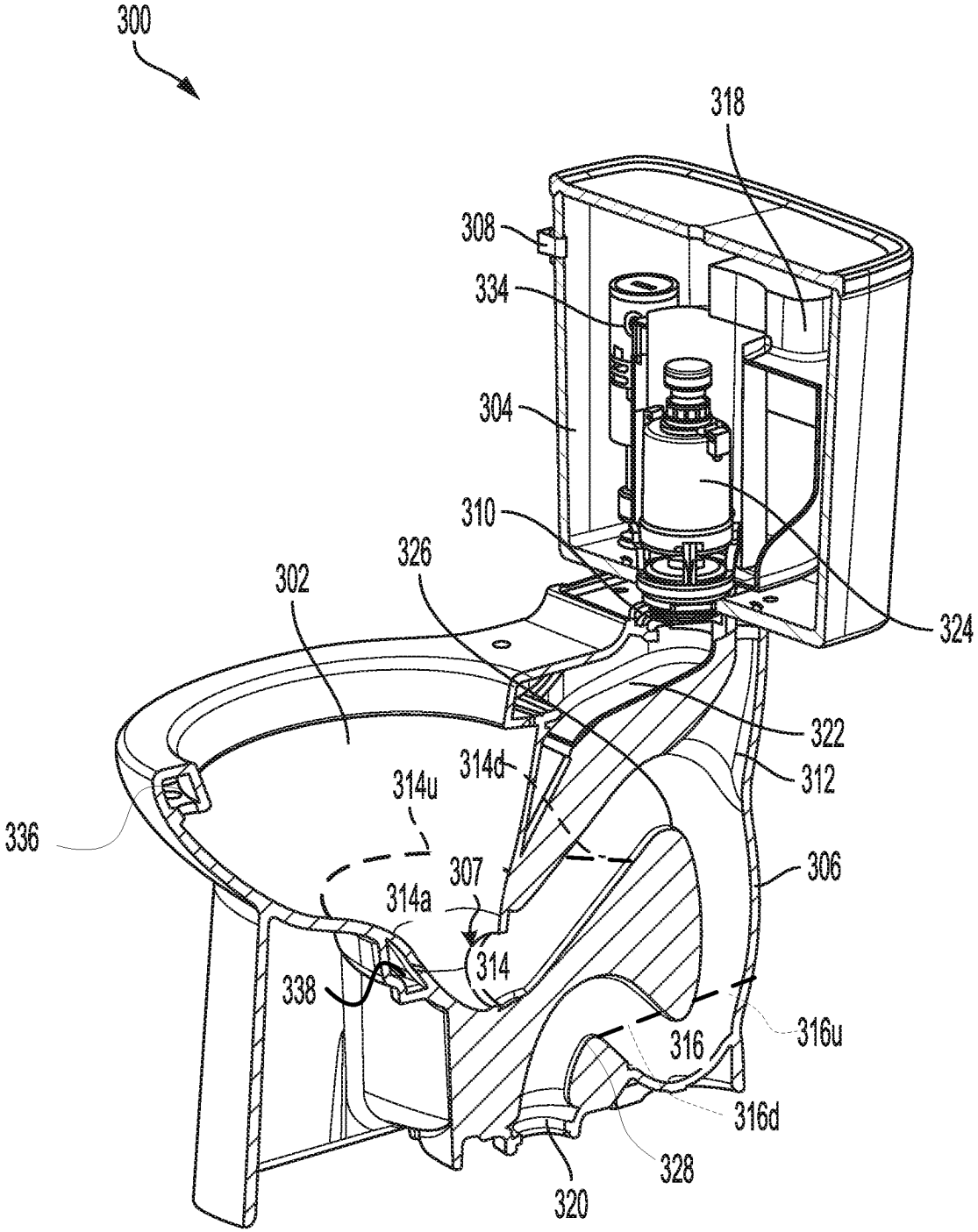
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FIG. 3

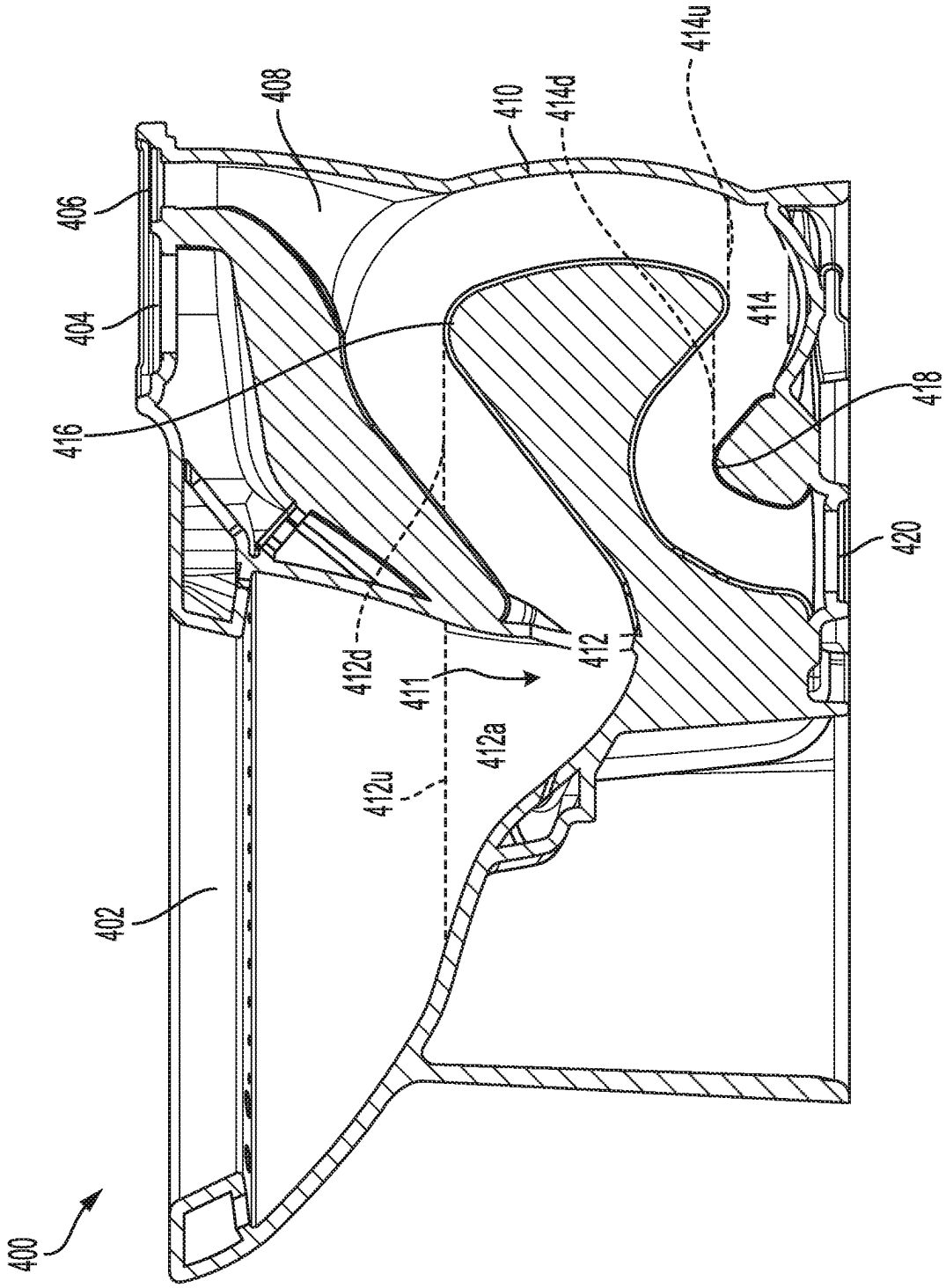
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FIG. 4

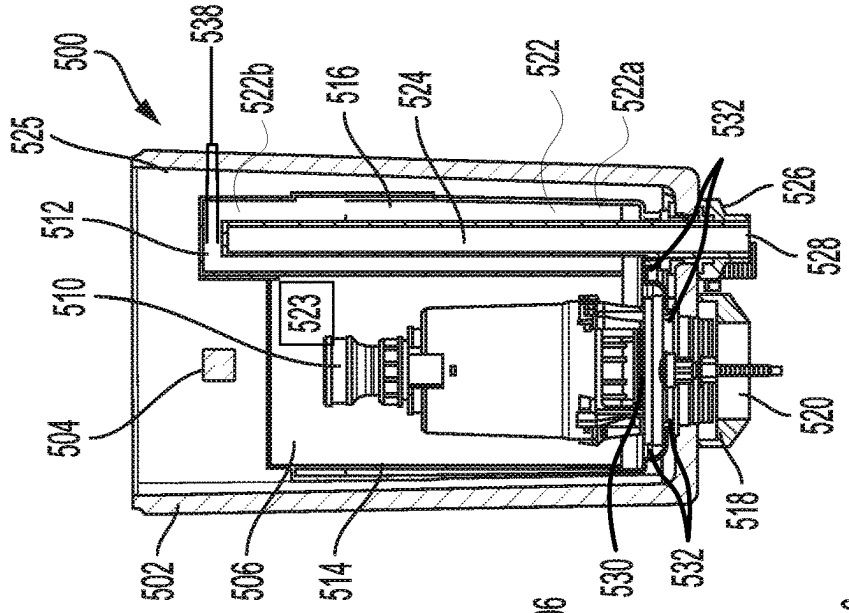

FIG. 5C

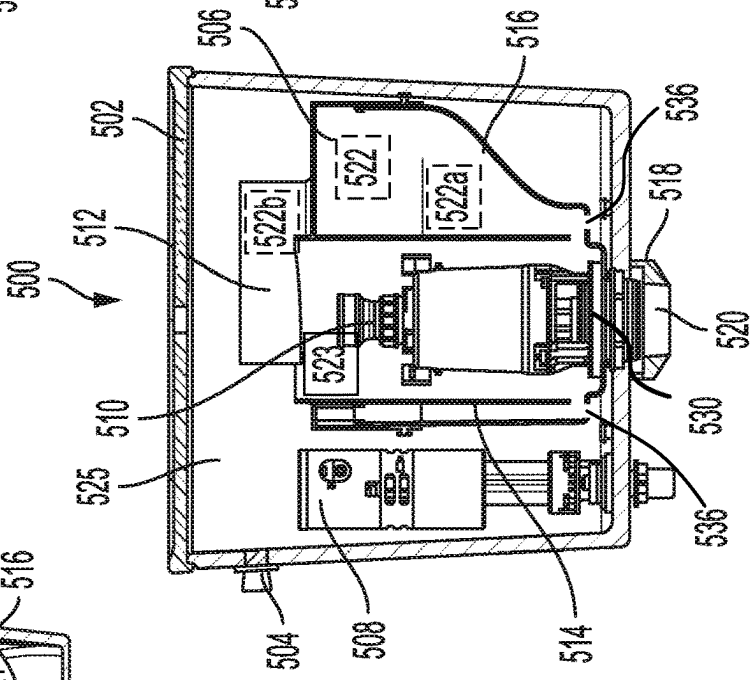

FIG. 5B

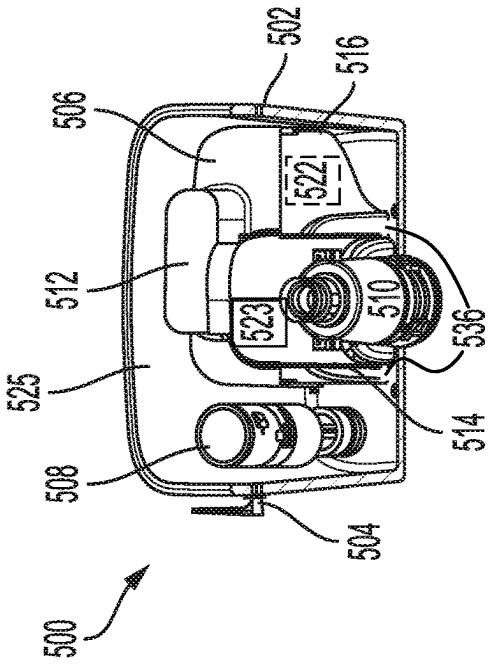

FIG. 5A

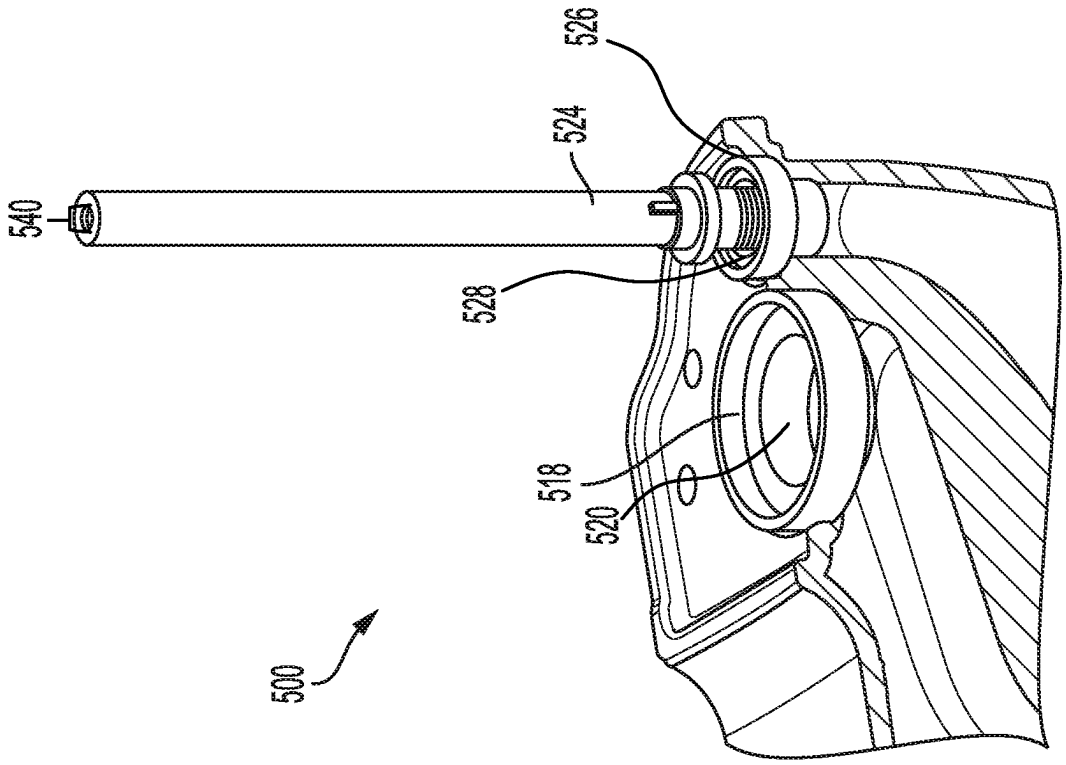

FIG. 5D

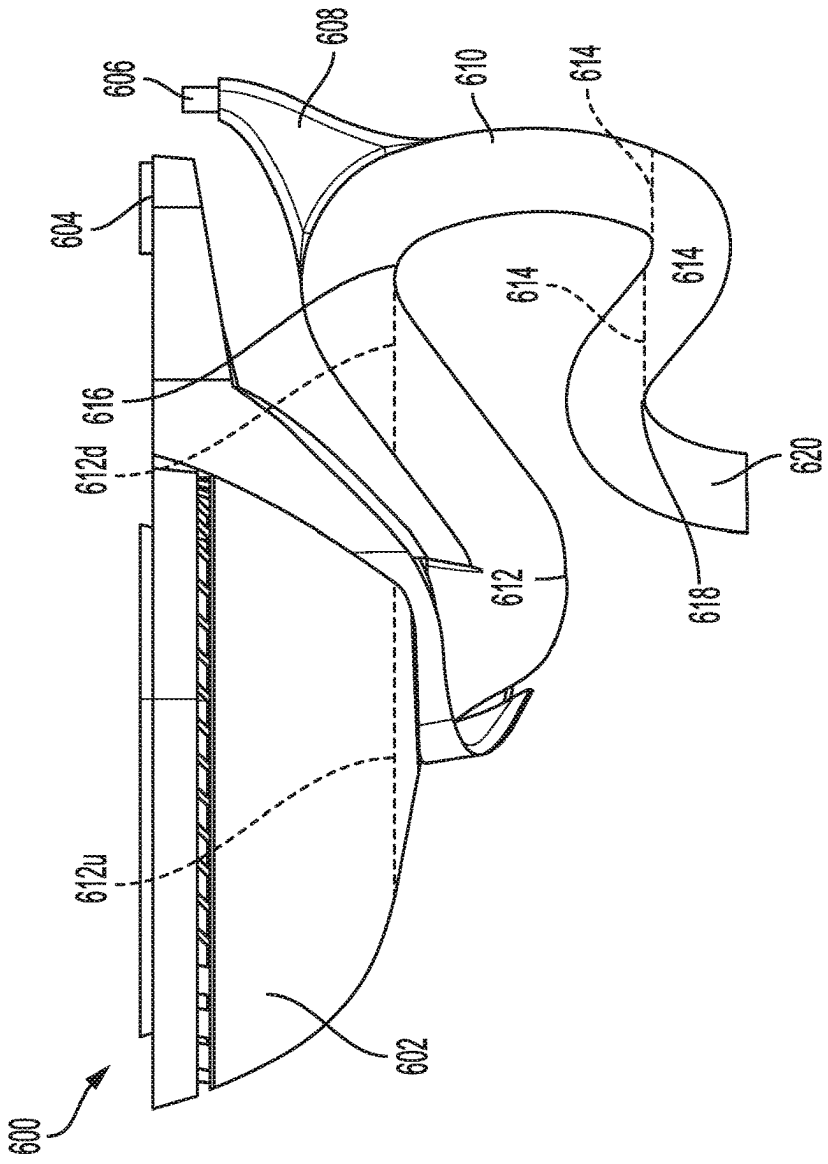
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FIG. 6A

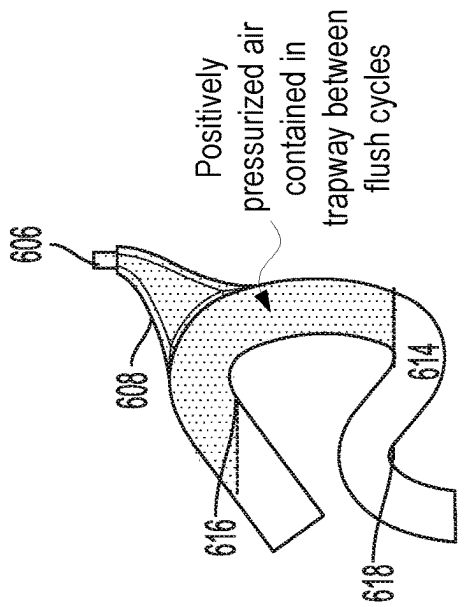
Positively pressurized air contained in trapway between flush cycles
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FIG. 6B

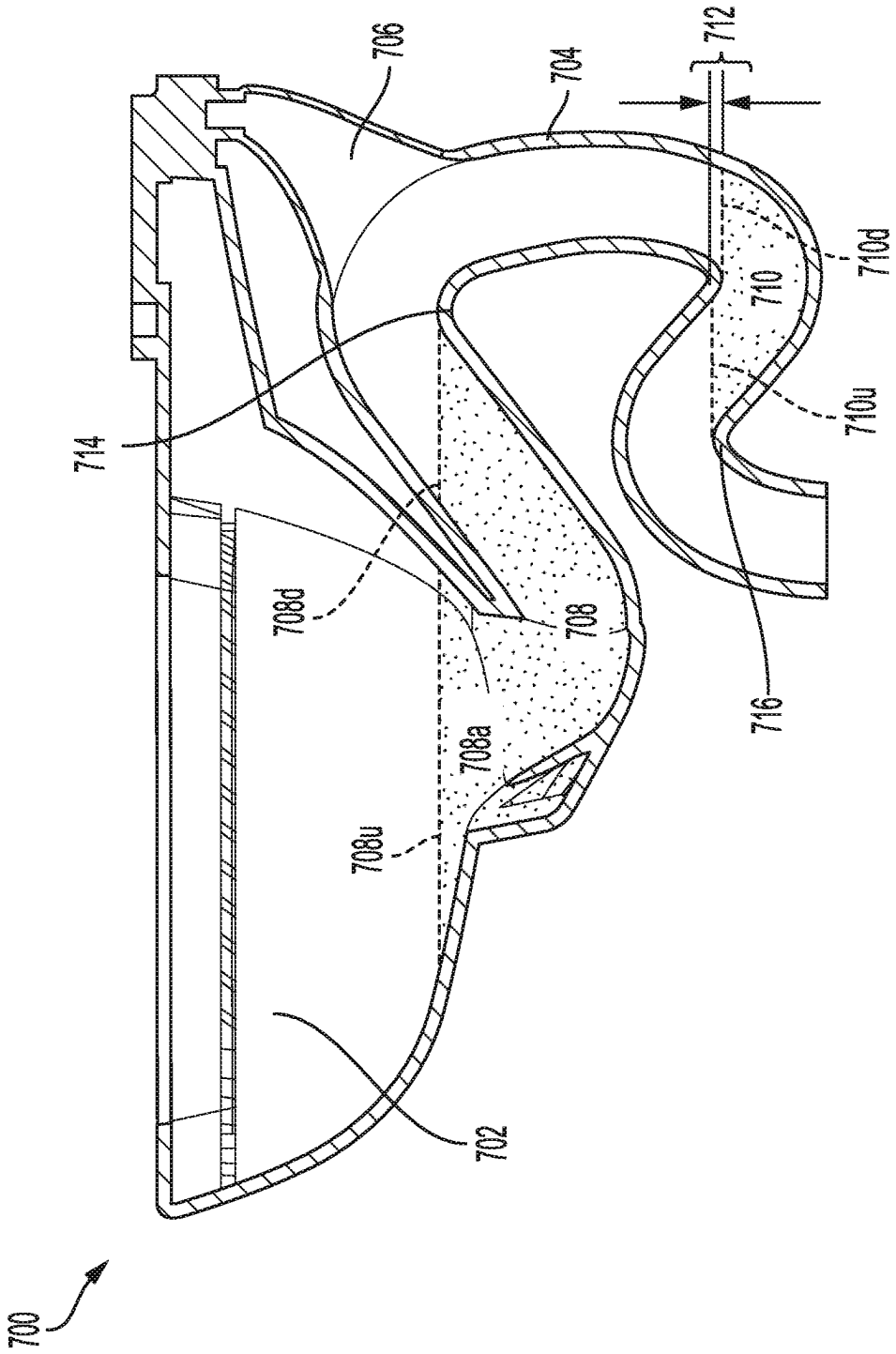

FIG. 7

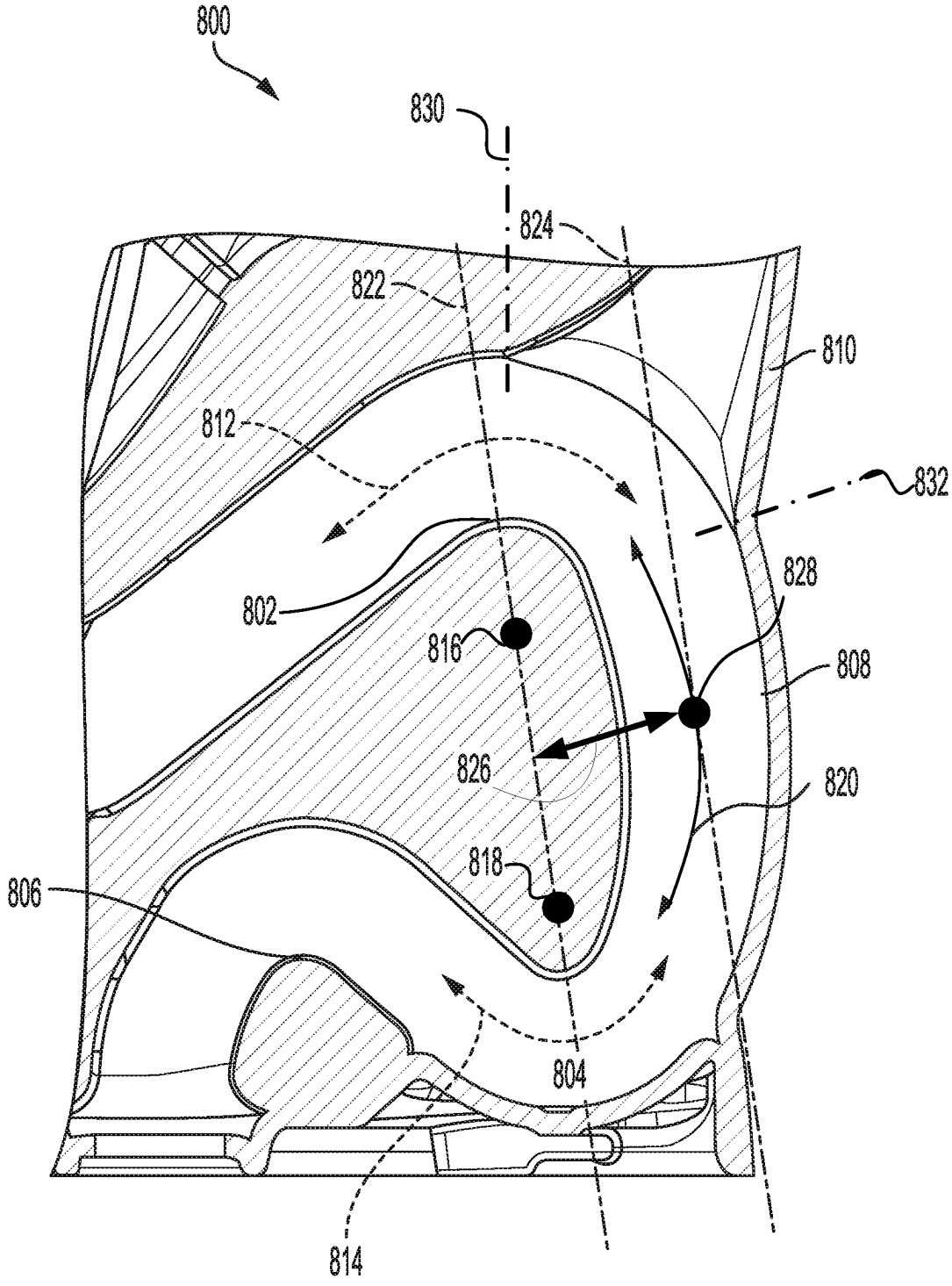
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FIG. 8

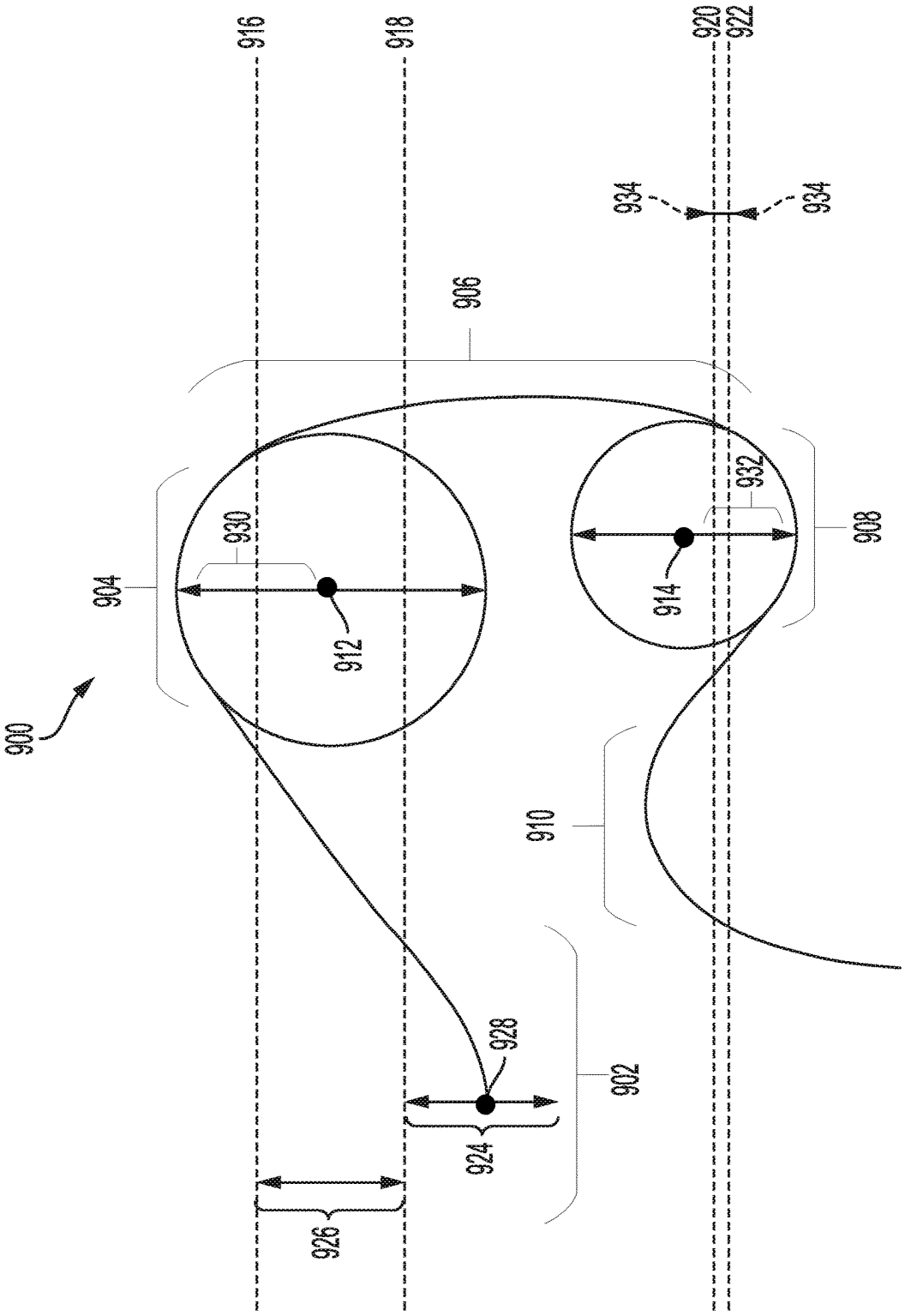
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FIG. 9

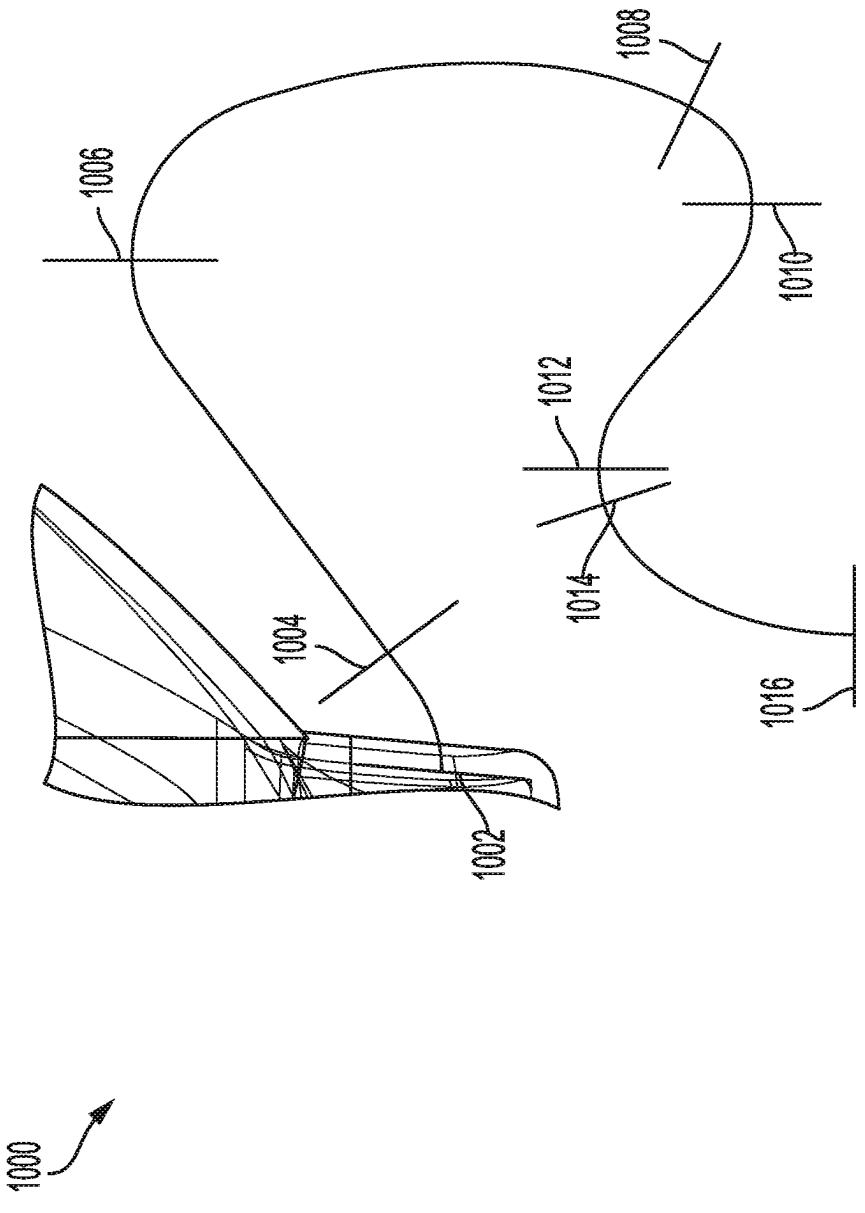

FIG. 10

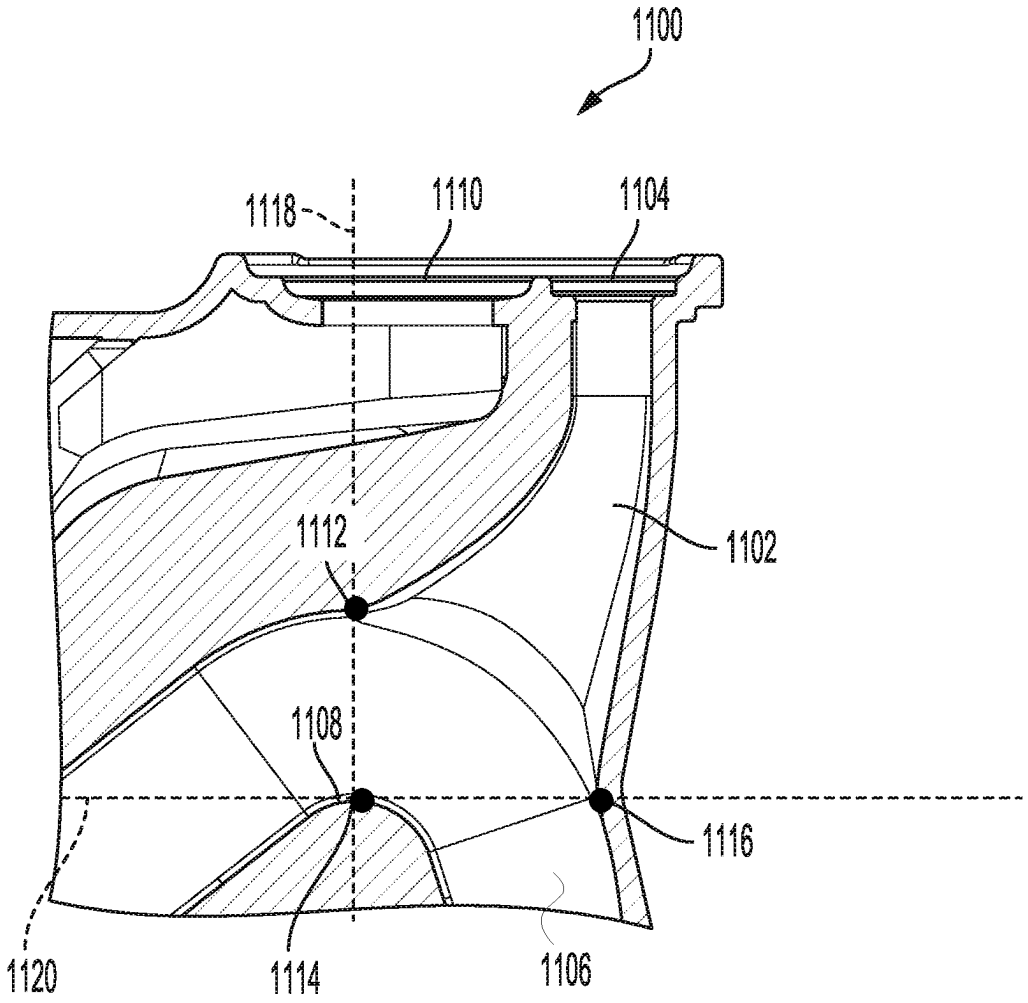

FIG. 11

DUAL-TRAP TOILET HAVING IMPROVED PRESSURIZATION AND FLUSHING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 63/333,971, filed Apr. 22, 2022, U.S. Provisional Application No. 63/333,973, filed Apr. 22, 2022, and U.S. Provisional Application No. 63/333,977, filed Apr. 22, 2022, the entire contents of which are incorporated herein by reference.

FIELD

[0002] The present disclosure relates generally to dual-trap toilets.

BACKGROUND

[0003] Conventional dual-trap toilets comprise a trapway that is configured to trap water in two separate locations. A first upstream trap may be located directly downstream of the toilet bowl and may be configured to hold water in the toilet bowl in between flush cycles. A second downstream trap may be located between the first trap and an outlet from the trapway to a drainage pipe. The dual-trap configuration may prevent sewer gases from leaking out of the sewer through drainage pipe while also providing a quieter flush cycle than other flush toilets (e.g., single trap toilets).

SUMMARY

[0004] As discussed above, dual-trap toilets may comprise a trapway that is configured to hold both water and pressurized air between flush cycles. Specifically, dual-trap toilets may comprise a trapway configured to trap water in an upstream trap and a downstream trap between flush cycles. Between flush cycles, positively pressurized air may be contained in the trapway between the upstream trap and the downstream trap. This pressurized air may be fluidly coupled to a second portion of positively pressurized air contained in the toilet tank. When a flush cycle is initiated, water may be discharged from the toilet tank into the toilet bowl, which may cause the pressure of the air in the trapway to drop. The drop in pressure may create a siphon in the trapway that pulls the contents of the toilet bowl into and out of the trapway.

[0005] The distribution of flush water and pressurized air in the trapway, along with the position, shape, and size of various components of the trapway, may impact the efficiency with which fluids flow through the trapway during a flush cycle. The present disclosure provides dual-trap toilet assemblies configured to optimize the distribution of flush water and pressurized air in order to provide more efficient flush cycles. The trapway may have a variable diameter at different locations along the fluid flow path in order to reduce clogging. An interface between the trapway and the toilet tank may be positioned and shaped to optimize flow of air and water during flush cycles.

[0006] A first toilet assembly may comprise a toilet tank to hold flush water, a flush valve assembly positioned in the toilet tank, a toilet bowl, a trapway in flow communication with the toilet bowl, a container positioned in the toilet tank, and a connecting tube extending from an interior of the container to the trapway. The container may be in flow communication with the toilet tank and may have an open lower end and a closed upper end, wherein the upper end of the container contains a first portion of pressurized air when the toilet assembly is between flush cycles. The trapway may comprise a sump trap, a first upstream weir, a lower trap, and a second downstream weir. The connecting tube may be coupled to the trapway at a position between the sump trap and the lower trap and may provide flow communication between the container and the trapway. The trapway may contain a second portion of pressurized air when the toilet assembly is between flush cycles. A volume of the first portion of pressurized air may be less than or equal to 30% of a volume of the second portion of pressurized air.

[0007] In some embodiments of the first toilet assembly, between flush cycles, the first portion of pressurized air is positioned above flush water in the container.

[0008] In some embodiments of the first toilet assembly, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in one or both of the first portion of pressurized air and the second portion of pressurized air.

[0009] In some embodiments of the first toilet assembly, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in one or both of the first portion of pressurized air and the second portion of pressurized air.

[0010] In some embodiments of the first toilet assembly, between flush cycles, the first portion of pressurized air and the second portion of pressurized air are pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

[0011] In some embodiments of the first toilet assembly, the first upstream weir is positioned above a highest point of a trapway inlet by an offset distance of greater than or equal to 2 inches.

[0012] In some embodiments of the first toilet assembly, the first upstream weir is positioned at point that, between flush cycles, is vertically higher than a water seal of the toilet bowl by a distance of greater than or equal to 0.2 inches.

[0013] In some embodiments of the first toilet assembly, the flush valve assembly comprises a valve body extending from a valve inlet to a valve outlet and a valve cover having a seal to enclose the valve inlet.

[0014] In some embodiments of the first toilet assembly, the container comprises a continuous side wall, an upper end wall, and an inner wall that together bound a vacuum chamber of the container.

[0015] In some embodiments of the first toilet assembly, the inner wall bounds an inner chamber of the container.

[0016] In some embodiments of the first toilet assembly, a vertical distance between a top surface of the connecting tube and an inner surface of the upper end wall is greater than or equal to 10 mm and less than or equal to 35 mm.

[0017] In some embodiments of the first toilet assembly, an internal diameter of the connecting tube is greater than or equal to 12 mm and less than or equal to 20 mm.

[0018] In some embodiments of the first toilet assembly, between flush cycles, a vertical distance between a top surface of the connecting tube and a water level in the toilet tank is greater than or equal to 45 mm and less than or equal to 55 mm.

[0019] A second toilet assembly may comprise a toilet tank to hold flush water, a flush valve assembly positioned in the toilet tank, a toilet bowl, a trapway in flow commu-

nication with the toilet bowl, a container positioned in the toilet tank, and a connecting tube extending from an interior of the container to the trapway. The container may be in flow communication with the toilet tank and may have an open lower end and a closed upper end. The trapway may comprise a sump trap, a first upstream weir, a lower trap, and a second downstream weir. The connecting tube may be coupled to the trapway at a position between the sump trap and the lower trap and may provide flow communication between the container and the trapway. The trapway may contain pressurized air when the toilet assembly is between flush cycles. The pressurized air in the trapway may exert force on water in the lower trap such that an upstream water level in the lower trap is lower than a downstream water level in the lower trap by an offset distance of greater than or equal to 15 mm between flush cycles.

[0020] In some embodiments of the second toilet assembly, between flush cycles, the container comprises pressurized air positioned above flush water.

[0021] In some embodiments of the second toilet assembly, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in the pressurized air in the trapway.

[0022] In some embodiments of the second toilet assembly, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in the pressurized air in the trapway.

[0023] In some embodiments of the second toilet assembly, between flush cycles, the pressurized air in the trapway is pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

[0024] A third toilet assembly may comprise a toilet tank, a flush valve assembly positioned in the toilet tank, a toilet bowl, a trapway in flow communication with the toilet bowl, a container positioned in the toilet tank, wherein the container comprises an inner chamber and a vacuum chamber, and a connecting tube extending from an interior of the container to the trapway. The container may be in flow communication with the toilet tank and may have an open lower end and a closed upper end. The trapway may comprise a sump trap, a first upstream weir, a lower trap, and a second downstream weir. The connecting tube may be coupled to the trapway at a position between the sump trap and the lower trap and may provide flow communication between the container and the trapway. During a flush cycle, the toilet assembly may flush a volume of flush water. A first portion of the volume of flush water may be stored in the tank prior to the flush cycle, a second portion of the volume of flush water may be stored in the vacuum chamber prior to the flush cycle, and a third portion of the volume of flush water may stored in the inner chamber prior to the flush cycle. The third portion is greater than or equal to 40% of the volume of flush water.

[0025] In some embodiments of the third toilet assembly, the first portion is less than or equal to 20% of the volume of flush water.

[0026] In some embodiments of the third toilet assembly, the second portion is less than or equal to 40% of the volume of flush water.

[0027] In some embodiments of the third toilet assembly, between flush cycles, the container comprises pressurized air positioned above flush water in the vacuum chamber.

[0028] In some embodiments of the third toilet assembly, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in pressurized air in the trapway.

[0029] In some embodiments of the third toilet assembly, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in pressurized air in the trapway.

[0030] In some embodiments of the third toilet assembly, between flush cycles, pressurized air in the trapway is pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

BRIEF DESCRIPTION OF THE FIGURES

[0031] The following figures show various views and/or associated data for dual-trap toilets, in accordance with some embodiments. The dual-trap toilets shown in the figures may, in some embodiments, have any one or more of the characteristics described herein.

[0032] FIGS. **1**A and **1**B show perspective views of a dual-trap toilet, in accordance with some embodiments.

[0033] FIG. **2** shows a cross-sectional view of a dual-trap toilet, in accordance with some embodiments.

[0034] FIG. **3** shows a perspective cutaway view of a dual-trap toilet, in accordance with some embodiments.

[0035] FIG. **4** shows a partial cross-sectional view of a dual-trap toilet, in accordance with some embodiments.

[0036] FIGS. **5**A-**5**D show various cutaway and cross-sectional views of a tank of a dual-trap toilet, in accordance with some embodiments.

[0037] FIGS. **6**A and **6**B show views of a toilet bowl and/or trapway of a dual-trap toilet, in accordance with some embodiments.

[0038] FIG. **7** shows a cross-sectional view of a dual-trap toilet and a lower seal offset height, in accordance with some embodiments.

[0039] FIG. **8** shows a portion of a trapway for a dual-trap toilet, in accordance with some embodiments.

[0040] FIG. **9** shows dimensions for a flow path for a trapway for a dual-trap toilet, in accordance with some embodiments.

[0041] FIG. **10** shows trap diameter dimensions for a trapway for a dual-trap toilet, in accordance with some embodiments.

[0042] FIG. **11** shows an interface between a connecting tube and a trapway of a dual-trap toilet, in accordance with some embodiments.

DETAILED DESCRIPTION

[0043] Dual-trap toilets comprise a trapway that is configured to trap water in two separate locations. In some embodiments, dual-trap toilets may have a trapway including a sump trap, a first upstream weir, a lower trap, and a second downstream weir. A container positioned in the toilet tank may be coupled by a connecting tube that extends between an interior of the container and the trapway. The connecting tube may be coupled to the trapway at a position between the sump trap and the lower trap and may provide flow communication between the container and the trapway. Between flush cycles, the container and the trapway may contain positively pressurized air. The positively pressurized air in the trapway between flush cycles may push upwards

on water in the sump trap and may result in a larger water spot in the toilet bowl than would be present if not for the positively pressurized air. Additionally, the positively pressurized air in the trapway between flush cycles may push downwards on water in the lower trap, such that a water level in an upstream end of the lower trap may be lower than a water level in a downstream end of the lower trap.

[0044] Upon initiation of a flush cycle, a flush valve seal may lift off of a flush valve inlet to the flush valve to open the flush valve, and flush water may be discharged from the toilet tank and the container through the flush valve and into the toilet bowl. As used herein, the term "flush water" may refer to any water that passes out of a toilet tank (or any subcomponent thereof, such as a container positioned inside a toilet tank, an inner chamber of said container, and/or a vacuum chamber of said container) during a flush cycle. Discharging the flush water during a flush cycle may exert a negative pressure on air in an upper end of the container, connecting tube, and trapway portion between the sump trap and the lower trap. The negative pressure may cause a drop to atmospheric pressure or to partial vacuum. The negative pressure may help create a siphon to pull water and waste through the sump area and into and out of the trapway.

[0045] During a flush cycle, flush water may exit the tank, a container positioned within the tank, an inner chamber of the container, and/or a vacuum chamber of the container. In some embodiments, some or all or none of the flush water may flow from the tank (considered separately from the container positioned within the tank) during a flush cycle. In some embodiments, some or all some or all or none of the flush water may flow from the container (considered separately from the tank) during a flush cycle. In some embodiments, some or all some or all or none of the flush water may flow from the vacuum chamber of the container (considered separately from other portions of the container and from the tank) during a flush cycle. In some embodiments, some or all some or all or none of the flush water may flow from the inner chamber of the container (considered separately from other portions of the container and from the tank) during a flush cycle.

[0046] One or more components of a dual trap toilet may be configured to optimize a ratio of positively pressurized air located in various portions of the toilet between flush cycles. In some embodiments, a first portion of positively pressurized air is located in an upper end of the container in the tank between flush cycles, while a second portion of positively pressurized air is located in the trapway between water in the sump trap and water in the lower trap between flush cycles. (In some embodiments, the second portion of positively pressurized air may also include air located in the connecting tube and/or in an interface portion between the connecting tube and the trapway.)

[0047] A flush cycle may be considered completed upon closing the flush valve and re-filling the toilet tank, sump trap, and lower trap. Upon completion of a flush cycle, new flush water entering the toilet tank may also enter the container via one or more openings positioned in the container wall. Entry of water into the container may compress air into an upper end of the container and may return the air contained in the regions defined by the upper end of the container, the connecting tube, and the trapway portion between a sump trap and a lower trap to atmospheric pressure and/or to a positive pressure above atmospheric pressure.

[0048] A dual-trap toilet may have a trapway that is shaped to optimize flow of air and water during flush cycles. The trapway may flow from an upstream end that couples to the toilet bowl to a downstream end that couples to a drain pipe. From upstream end to downstream end, the trapway may include a sump trap, a portion extending upward from the sump trap, a first (upstream) weir, a connecting portion extending downward from the first (upstream) weir, a lower trap, a portion extending upward from the lower trap, a second (downstream) weir, and a portion extending downward from the second (downstream) weir.

[0049] An interface between (or included as part of) the connecting tube may be positioned and shaped to optimize flow of air and water during flush cycles. The interface may have an upper end that couples to a lower end of the connecting tube, and may have a lower end that couples to the trapway. The lower end may couple to the trapway at a location between the sump trap and the lower trap, such that positively-pressurized air may be delivered, through the interface, to the area of the trapway between the water in the sump trap and the water in the lower trap. The lower end may couple to an upper wall of the trapway above the first upstream weir and/or to an upper/outer wall of the connecting portion.

[0050] The trapway may a variable diameter at different locations along the trapway; said variable diameter may optimize flow of air and water during flush cycles. The interface may have an upper end that couples to a lower end of the connecting tube and may have a lower end that couples to the trapway. The lower end may couple to the trapway at a location between the sump trap and the lower trap, such that positively-pressurized air may be delivered, through the interface, to the area of the trapway between the water in the sump trap and the water in the lower trap. The lower end may couple to an upper wall of the trapway above the first upstream weir and/or to an upper/outer wall of the connecting portion. In some embodiments, a diameter of the trapway may be measured at any of the trapway components referred to above and may in some embodiments differ from one or more other components at any of the trapway components referred to above. When trapway diameter is referenced, it may be understood to refer to a diameter of a circular trapway and/or to a diameter in at least one direction of an elliptical and/or irregularly-shaped trapway.

Dual-Trap Toilets

[0051] Dual-trap toilets comprise a trapway that is configured to trap water in two separate locations. A first upstream trap may be located directly downstream of the toilet bowl and may be configured to hold water in the toilet bowl in between flush cycles. A second downstream trap may be located between the first trap and an outlet from the trapway to a drainage pipe. The dual-trap configuration may prevent sewer gases from leaking out of the sewer through drainage pipe while also providing a quieter flush cycle than other flush toilets (e.g., single trap toilets).

[0052] FIGS. **1**A and **1**B show perspective views of a dual-trap toilet, in accordance with some embodiments. Specifically, FIGS. **1**A and **1**B illustrate perspective views of a dual-trap toilet **100** comprising a toilet bowl **102**, a toilet tank **104**, and a trapway **106**. In some embodiments, toilet bowl **102**, toilet tank **104**, and trapway **106** may be in flow communication. In some embodiments, as shown in FIG. **1**B, toilet **100** may comprise a flush control **108**. Flush

control **108** may comprise one or more handles, push buttons, levers, chains, position sensors, and/or motion sensors that are configured to initiate a flush cycle when engaged by a user.

[0053] Between flush cycles, toilet bowl **102** may contain a volume of water. In some embodiments, a volume of water contained in toilet bowl **102** between flush cycles may be about 0.5 gallons, about 0.75 gallons, about 1 gallon, about 1.25 gallons, about 1.5 gallons, about 1.75 gallons, about 2 gallons, about 3 gallons, about 4 gallons, or about 5 gallons. In some embodiments, a volume of water contained in toilet bowl **102** between flush cycles may be greater than or equal to 2.5 gallons, 3.5 gallons, 4.5 gallons, 5.5 gallons, 6.5 gallons, 7.5 gallons, or 8.5 gallons. In some embodiments, a volume of water contained in toilet bowl **102** between flush cycles may be less than or equal to 2 gallons, 1.5 gallons, 1 gallon, 0.5 gallons, or 0.1 gallons.

[0054] Toilet tank **104** may be configured to contain flush water. Toilet tank **104** may be configured to fluidly connect to a water supply. In some embodiments, when a flush cycle is initiated, toilet tank **104** may be configured to discharge a volume of contained flush water into toilet bowl **102**. Toward the end of a flush cycle, toilet tank **104** may be configured to replenish the discharged volume of water by receiving water from the water supply.

[0055] When a flush cycle is initiated (e.g., by a user who engages flush control **108**), the contents of toilet bowl **102** may be siphoned into trapway **106**. Trapway **106** may be configured to fluidly connect to a sewer system (or to one or more drain pipes that connect to a sewer system). During a flush cycle, the siphoned contents of toilet bowl **102** may be directed through trapway **106** and into the sewer system.

[0056] Trapway **106** may comprise a sump trap and a lower trap. The sump trap may be directly downstream of toilet bowl **102** and the lower trap may be downstream of the sump trap. When toilet **100** is between flush cycles, water may collect in both the sump trap and the lower trap. The collection of water in the sump trap and the lower trap may form a series of water seals which prevent leakage of sewer gas out of trapway **106**. The water that collects in the sump trap between flush cycles may be the volume of water contained in toilet bowl **102** between flush cycles, as described above.

[0057] When toilet **100** is between flush cycles, toilet tank **104** and trapway **106** may be configured to contain positively pressurized air. The positively pressurized air contained in trapway **106** may be contained between a sump trap and a lower trap and may exert upward pressure on water collected in the sump trap and downward pressure on water collected in the lower trap. In some embodiments, the upward pressure exerted on the water collected in the sump trap by the pressurized air contained in trapway **106** may raise the water level of water contained in toilet bowl **102** between flush cycles. The raised water level of water contained in toilet bowl **102** may reduce or prevent soiling of toilet bowl **102**.

[0058] In some embodiments, when a flush cycle is initiated and flush water is discharged from toilet tank **104** into toilet bowl **102**, a negative pressure may be exerted on the air contained in toilet tank **104** and the air contained in trapway **106**. The negative pressure may cause the pressure within toilet tank **104** and/or trapway **106** to decrease to atmospheric pressure and/or to a partial vacuum. This decrease in pressure may generate a siphon in trapway **106** that may cause the contents of toilet bowl **102** to be pulled into and subsequently out of trapway **106**.

[0059] Toward the end of a flush cycle, water may again collect in toilet bowl **102** and trapway **106**. Upon completion of a flush cycle, toilet tank **104** may be configured to receive new flush water from a water supply. As toilet tank **104** refills with flush water, the air contained in toilet tank **104** may be compressed, thereby increasing the pressure of the air contained in toilet tank **104** and/or the air contained in trapway **106** to atmospheric pressure and/or to a pressure above atmospheric pressure. When the air contained in toilet tank **104** and/or the air contained in trapway **106** return(s) to positively pressurized states, the flush cycle may be completed.

[0060] FIG. **2** shows a cross-sectional view of a dual-trap toilet, in accordance with some embodiments. Specifically, FIG. **2** illustrates a cross-sectional view of a toilet **200** comprising a toilet bowl **202**, a toilet tank **204**, a trapway **206**, and a flush control **208**. In some embodiments, toilet bowl **202**, toilet tank **204**, trapway **206**, and/or flush control **208** may include features of toilet bowl **102**, toilet tank **104**, trapway **106**, and/or flush control **108** shown in FIG. **1**A and/or FIG. **1**B.

[0061] A container **218** and a flush valve **224** may be positioned within and in flow communication with toilet tank **204**. Container **218** may have an irregular toroidal structure that defines a vacuum chamber, an inner chamber, and an outer region in toilet tank **204** that is external to and surrounds both container **218** and the inner chamber. In some embodiments, flush valve **224** may be positioned in the inner chamber defined by container **218** such that container **218** encircles flush valve **224**.

[0062] Between flush cycles, toilet tank **204** may be configured to contain flush water. Between flush cycles, a first volume of flush water may be contained the outer region in toilet tank **204** that is external to and surrounds container **218** and the inner chamber defined by the structure of container **218**, a second volume of flush water may be contained in the central cavity region defined by the structure of container **218**, and a third volume of flush water may be contained in a vacuum chamber contained within the internal irregular annular region of container **218**.

[0063] Toilet bowl **202** may be fluidly connected to toilet tank **204** via a fluid pathway **222**. Flush valve **224** may be in flow communication with fluid pathway **222** which may, in turn, be in flow communication with toilet bowl **202**. In some embodiments, a flush valve gasket **210** may be positioned at an interface between flush valve **224** and fluid pathway **222**. Flush valve gasket **210** may form a mechanical seal between flush valve **224** and fluid pathway **222** in order to prevent flush water and/or air from leaking out of toilet tank **204** and into toilet bowl **202** between flush cycles (i.e., to prevent water and/or air leakage from toilet tank **204** when flush valve **224** is closed).

[0064] Fluid pathway **222** may be in flow communication with a rim channel **236** that encircles the rim of toilet bowl **202**. During a flush cycle, a portion of flush water may be transmitted from toilet tank **204**, through fluid pathway **222**, and into rim channel **236**. The flush water may then be transmitted into toilet bowl **202** from rim channel **236** through one or more rim outlets.

[0065] The portion of flush water transmitted from toilet tank **204**, through fluid pathway **222**, and into rim channel **236** may be between about 0.5-2 liters, about 1-3 liters,

about 1-4 liters, or about 1-5 liters. Optionally, the portion of flush water transmitted from toilet tank **204**, through fluid pathway **222**, and into rim channel **236** may be less than or equal to 1, 1.2, 1.4, 1.6, 1.8, 2, 2.2, 2.4, 2.6, 2.8, 3, 3.2, 3.4, 3.6, 3.8, 4, 4.2, 4.4, 4.6, 4.8, or 5 liters. Optionally, the portion of flush water transmitted from toilet tank **204**, through fluid pathway **222**, and into rim channel **236** may be greater than or equal to 1, 1.2, 1.4, 1.6, 1.8, 2, 2.2, 2.4, 2.6, 2.8, 3, 3.2, 3.4, 3.6, 3.8, 4, 4.2, 4.4, 4.6, 4.8, or 5 liters.

[0066] In some embodiments, less than 50% of the total volume of flush water delivered from toilet tank **204** to toilet bowl **202** during a flush cycle may be transmitted through rim channel **236**. In some embodiments, greater than 50% of the total volume of flush water delivered from toilet tank **204** to toilet bowl **202** during a flush cycle may be transmitted through rim channel **235**.

[0067] A lower portion of toilet bowl **202**, referred to hereinafter as sump area **214***a*, may be in flow communication with a first upstream portion **214***u* of trapway **206** through a trapway inlet **207**. The first upstream portion **214***u* of trapway **206**, sump area **214***a* of toilet bowl **202**, and a first downstream portion **214***d* of trapway **206** may together form a sump trap **214**, which may contain flush water between flush cycles.

[0068] In some embodiments, fluid pathway **222** may be in flow communication with a jet channel **238**. Jet channel may be adjacent to an upstream end of trapway **206** and may be fluidically coupled to sump trap **214** via a jet hole **240**. During a flush cycle, a portion of flush water may be transmitted from toilet tank **204**, through fluid pathway **222**, and into jet channel **238**. In some embodiments, the flush water that is transmitted into jet channel **238** may be transferred into sump trap **214** through jet hole **240** in order to generate a siphon in toilet **200**. In some embodiments, the flush water that is transmitted into jet channel **238** may be transferred into sump trap **214** through jet hole **240** at the end of the flush cycle to refill sump trap **214**.

[0069] In some embodiments, the ratio of the volume of flush water transmitted through rim channel **236** during a flush cycle to the volume of flush water transmitted through jet hole **240** during a flush cycle may be approximately 7:1, 6:1, 5:1, 4:1, 3:1, 2:1, 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, or 1:7. Optionally, the ratio of the volume of flush water transmitted through rim channel **236** during a flush cycle to the volume of flush water transmitted through jet hole **240** during a flush cycle may be less than or equal to 7:1, 6:1, 5:1, 4:1, 3:1, 2:1, 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, or 1:7. Alternatively, the ratio of the volume of flush water transmitted through rim channel **236** during a flush cycle to the volume of flush water transmitted through jet hole **240** during a flush cycle may be greater than or equal to 7:1, 6:1, 5:1, 4:1, 3:1, 2:1, 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, or 1:7.

[0070] Trapway **206** may comprise a first upstream weir **226** configured to contain the water that collects in sump trap **214**. First upstream weir **226** may be a high point of a lower wall of trapway **206** that is downstream of the first downstream portion **214***u* of trapway **206** and may be positioned above a highest point of trapway inlet **207**. In some embodiments, first upstream weir **226** may be positioned above the highest point of toilet bowl **202**-trapway **206** interface by an offset distance of about 0.5 inches, about 1 inch, about 1.5 inches, about 2 inches, about 2.5 inches, or about 3 inches. In some embodiments, first upstream weir **226** may be positioned above the highest point of toilet bowl **202**-trapway **206** interface by an offset distance greater than or equal to 2 inches, 2.5 inches, 3 inches, 3.5 inches, or 4 inches. In some embodiments, first upstream weir **226** may be positioned above the highest point of toilet bowl **202**-trapway **206** interface by an offset distance less than or equal to 6 inches, 5.5 inches, 5 inches, 4.5 inches, or 4 inches.

[0071] Trapway **206** may be configured to fluidly connect to a sewer system via a trapway outlet **220**. As a result, sewer gases may enter trapway **206** through trapway outlet **220**. The water that is contained in sump trap **214** between flush cycles may form a water seal in toilet bowl **202**. The water seal may prevent sewer gases which may have entered trapway **206** from leaking out of toilet bowl **202**. Between flush cycles, the water seal in toilet bowl **202** may be vertically lower than first upstream weir **226**. In some embodiments, a vertical distance between the water seal in toilet bowl **202** and first upstream weir **226** may be about 0.1 inches, about 0.2 inches, about 0.3 inches, about 0.4 inches, or about 0.5 inches. In some embodiments, a vertical distance between the water seal in toilet bowl **202** and first upstream weir **226** may be greater than or equal to 0.2 inches, 0.5 inches, 0.8 inches, or 1 inch. In some embodiments, a vertical distance between the water seal in toilet bowl **202** and first upstream weir **226** may be less than or equal to 2 inches, 1.8 inches, 1.5 inches, or 1.2 inches.

[0072] Trapway **206** may comprise a lower trap **216** positioned downstream of first upstream weir **226** between a second upstream portion **216***u* of trapway **206** and a second downstream portion **216***d* of trapway **206**. Between flush cycles, water may collect in lower trap **216** to form a pair of water seals to provide a second barrier against sewer gases which may enter trapway **206** via trapway outlet **220**. The downstream water seal of the pair of water seals may be vertically higher than an upstream water seal of the pair of water seals. Trapway **206** may comprise a second downstream weir **228** configured to contain water in lower trap **216**. Second downstream weir **228** may be a high point of a lower wall of trapway **206** that is downstream of the second downstream portion **216***d* of trapway **206**.

[0073] Container **218** may house a connecting tube **230** configured to provide flow communication between container **218** and trapway **206**. Connecting tube **230** may extend from an interior region of container **218** into trapway **206**. In some embodiments, connecting tube **230** may be coupled to trapway **206** at a position between sump trap **214** and lower trap **216**. A trapway-tank interface **212** may be positioned between sump trap **214** and lower trap **216** and may be configured to couple to connecting tube **230**. In some embodiments, connecting tube **230** may comprise a backflow preventer.

[0074] FIG. **3** shows a perspective cutaway view of a dual-trap toilet, in accordance with some embodiments. Specifically, FIG. **3** illustrates a cross-sectional view of a toilet **300** comprising a toilet bowl **302**, a toilet tank **304**, a trapway **306**, and a flush control **308**. In some embodiments, toilet **300** may include one or more features of toilet **200** shown in FIG. **2** and/or toilet **100** shown in FIGS. **1**A and **1**B.

[0075] Toilet tank **304** may comprise one or more features of toilet tank **204** of toilet **200** shown in FIG. **2**. In some embodiments, toilet tank **304** may be configured to house a container **318**, a flush valve **324**, and a fill valve **334**. Container **318** and flush valve **324** may include one or more features of container **218** and flush valve **224**, respectively.

Fill valve **334** may be configured to fluidly connect to a water supply in order to facilitate the transmission of flush water from the water supply to toilet tank **304**. In some embodiments, fill valve **334** may comprise a backflow preventer.

[0076] Toilet bowl **302** may be fluidly coupled to flush valve **324** via a fluid pathway **322**. A flush valve gasket **310** may form a mechanical seal between flush valve **324** and fluid pathway **322** in order to prevent water from leaking out of toilet tank **304** and into toilet bowl **302** in between flush cycles. In some embodiments, fluid pathway **322** may be in flow communication with a rim channel **336** and/or a jet channel **338**. Rim channel **336** may include one or more features of rim channel **236** shown in FIG. **2**. Jet channel **338** may include one or more features of jet channel **238** shown in FIG. **2**.

[0077] Trapway **306** may comprise one or more features of trapway **206** of toilet **200** shown in FIG. **2** and/or trapway **106** of toilet **100** shown in FIGS. **1**A and **1**B. Trapway **306** may comprise a sump trap **314** (defined by a first upstream portion **314***u* of trapway **306**, a sump area **314***a* in toilet bowl **302**, and a first downstream portion **314***d* of trapway **306**), a first upstream weir **326**, a lower trap **316** (positioned between a second upstream portion **316***u* of trapway **306** and a second downstream portion **316***d* of trapway **306**), and a second downstream weir **328**. Trapway **306** may be fluidly coupled to toilet tank **304** via a trapway-tank interface **312**. In some embodiments, trapway **306** may comprise an outlet **320** configured to fluidly connect to a drainage pipe into a sewer system.

[0078] FIG. **4** shows a partial cross-sectional view of a dual-trap toilet, in accordance with some embodiments. Specifically, FIG. **4** shows a partial cross-sectional view of a toilet **400**. Toilet **400** may comprise a toilet bowl **402** that is fluidly coupled to a toilet tank via a flush valve outlet **404**. Toilet bowl **402** may be fluidly coupled to a trapway **410** through a trapway inlet **411**. A sump trap **412** may be defined by a first upstream portion **412***u*, a sump area **412***a*, and a first downstream portion **412***d* of trapway **410**. A first upstream weir **416** of trapway **410** may be positioned downstream of sump trap **412**. A lower trap **414** may be positioned between a second upstream portion **414***u* and a second downstream portion **414***d* of trapway **410**, and a second downstream weir **418** may be positioned downstream of lower trap **414**. Trapway **410** may be fluidly coupled to a toilet tank via a trapway-tank interface **408**. In some embodiments, one or more features of toilet **400** may include one or more features of toilet **300** shown in FIG. **3**, toilet **200** shown in FIG. **2**, and/or toilet **100** shown in FIGS. **1**A-**1**B.

The Distribution of Flush Water and Pressurized Air in the Toilet Tank

[0079] As described with reference to FIGS. **1**-**4**, dual-trap toilets may comprise a toilet tank that is configured to contain flush water. The toilet tank may house a container that may be coupled to the trapway by a connecting tube that is configured to provide flow communication between the container and the trapway. The container may be divided into a plurality of chambers. In between flush cycles, the flush water in the toilet tank may be divided between a region of the toilet tank outside of the container and the plurality of chambers within the container. One of the chambers (a vacuum chamber) may have a closed upper end and may be configured to contain pressurized air when the toilet is between flush cycles. The pressurized air in the vacuum chamber may have a pressure greater than the ambient pressure of air in the toilet tank. The connecting tube may fluidically couple the upper end of the vacuum chamber to the trapway. As a result of the coupling between the trapway and the upper end of the vacuum chamber, the trapway may also contain pressurized air when the toilet is between flush cycles.

[0080] In addition to the vacuum chamber, the container may comprise an inner chamber that may have an upper end that is open to the toilet tank, allowing air to flow freely between the inner chamber and the region of the tank that is outside of the container. The inner chamber may also house a flush valve that is fluidically coupled to a toilet bowl of the dual-trap toilet. Upon initiation of a flush cycle, a flush valve seal may be lifted from an inlet to the flush valve to open the flush valve, and flush water may be discharged from the toilet tank and the container through the flush valve and into the toilet bowl. The discharging flush water may reduce the pressure of the air contained in the vacuum chamber of the container and air contained in the trapway of the toilet. This reduction in pressure may induce a siphon that pulls the contents of the toilet bowl into the trapway and subsequently into the sewer system.

[0081] As flush water exits the toilet tank, the water level in the vacuum chamber may rapidly drop, and air pressure within the vacuum chamber and within the trapway may drop from positive pressure to negative pressure (e.g., below the ambient pressure of air within the toilet tank). Upon completion of a flush cycle, the flush valve may close, and the toilet tank may re-fill with flush water. The air pressure within the upper end of the vacuum chamber—and, as a result of the coupling provided by the connecting tube, the air pressure within the trapway—may continue to increase until the toilet tank has replenished its flush water supply. Once the toilet tank has replenished its flush water supply, the toilet may return to its between-flush-cycle state.

[0082] FIGS. **5**A-**5**D show various cutaway and cross-sectional views of a tank of a dual-trap toilet, in accordance with some embodiments. Specifically, FIGS. **5**A-**5**C show a top-view cutaway (FIG. **5**A), a cross-sectional view (FIG. **5**B), a side-view cutaway (FIG. **5**C), and a close-up view (FIG. **5**D) of various components of a toilet tank **500** of a dual trap toilet. In some embodiments, tank **500** may include one or more features of toilet tank **304** of toilet **300** shown in FIG. **3**, toilet tank **204** of toilet **200** shown in FIG. **2**, and/or toilet tank **104** of toilet **100** shown in FIGS. **1**A-**1**B.

[0083] Tank **500** may be formed from a tank wall **502**. In some embodiments, a flush control **504** may be positioned on tank wall **502**. In some embodiments, tank **500** may house a container **506**, a fill valve **508**, and a flush valve **510**. Fill valve **508** may be configured to fluidly couple to a water supply via one or more openings in tank wall **502**. Flush valve **510** may be fluidly coupled to a flush valve outlet **520** that fluidly connects to a toilet bowl of the dual-trap toilet. In some embodiments, flush valve **510** may comprise a valve body that extends from a valve inlet to a flush valve outlet **520**. In some embodiments, flush valve **510** may comprise a valve cover with a seal **530** configured to enclose the valve outlet **520**.

[0084] Flush control **504** may be configured to initiate a flush cycle upon receiving input from a user. Specifically, upon receiving input from a user, flush control **504** may be

configured to cause flush valve seal **530** to lift away from valve outlet **520** to flush valve **510** in order to open flush valve **510**, thereby causing flush water that is contained in tank **500** to be discharged into the toilet bowl of the dual-trap toilet. Flush water may be discharged from tank **500** through a plurality of openings **532**. The discharge of flush water into the toilet bowl may induce a siphon in a trapway of the dual-trap toilet. In some embodiments, when the level of flush water in tank **500** has fallen below a threshold level with respect to flush valve **510** (e.g., below a lower edge of a head of flush valve **510**), the siphon may be broken. Upon completion of the flush cycle, flush valve seal **530** may close, and fill valve **508** may open so that the supply of flush water in tank **500** may be replenished. In some embodiments, a flush valve gasket **518** may be positioned between flush valve **510** and flush valve outlet **520** in order to prevent flush water from leaking into the toilet bowl in between flush cycles.

[0085] Container **506** may have an irregular toroidal (i.e., "donut"-shaped) structure defined by an inner wall **514**, a continuous side wall **516**, and an upper wall **512** that together define a plurality of interior chambers within container **506**. These interior chambers may form an irregular annular region and may include a vacuum chamber **522** comprising a lower portion **522***a* and an upper portion **522***b* as well as an inner chamber **523**. Vacuum chamber **522** may be bounded by inner wall **514**, continuous side wall **516**, and upper wall **512**. Inner chamber **523** may be a central cavity region bounded by inner wall **514**. Flush valve **510** may be positioned within inner chamber **523**.

[0086] Vacuum chamber **522** may be fluidically coupled to inner chamber **523** and to tank **500** through a plurality of openings **536** in a lower end of container **506**. In some embodiments, the plurality of openings **536** may comprise at least 2, at least 3, at least 4, at least 5, at least 6, at least 7, at least 8, at least 9, or at least 10 openings. In some embodiments, the plurality of openings **536** may comprise between 2-4, 4-6, 6-8, 8-10, 10-12, 12-14, or 14-16 openings.

[0087] One or more of the regions of tank **500** defined by the structure of container **506** may be configured to contain a portion of the total volume of flush water held in tank **500** between flush cycles. In addition, between flush cycles, one or more of the regions of tank **500** defined by the structure of container **506** may be configured to contain pressurized air. The manner in which the total volume of flush water is distributed among the chambers may provide for efficient flush operation (e.g., may provide a high MAP score at low flush water volume).

[0088] Prior to the initiation of a flush cycle, tank **500** (including container **506**) may store a total volume of flush water. In some embodiments, the total volume of flush water stored in tank **500** may be about 0.5 gallons, about 0.75 gallons, about 1 gallon, about 1.25 gallons, about 1.5 gallons, about 1.75 gallons, about 2 gallons, about 3 gallons, about 4 gallons, or about 5 gallons. In some embodiments, the total volume of flush water stored in tank **500** may be greater than or equal to 2.5 gallons, 3.5 gallons, 4.5 gallons, 5.5 gallons, 6.5 gallons, 7.5 gallons, or 8.5 gallons. In some embodiments, the total volume of flush water stored in tank **500** may be less than or equal to 2 gallons, 1.5 gallons, 1 gallon, 0.5 gallons, or 0.1 gallons.

[0089] A first portion of the total volume of flush water in tank **500** may be stored in a region of tank **500** that is exterior to container **506** (i.e., a region that excludes vacuum chamber **522** and inner chamber **523** of container **506**). In some embodiments, the first portion may be about 10%, about 20%, about 30%, about 40%, or about 50% of the total volume of flush water in tank **500**. In some embodiments, the first portion may be less than or equal to 50%, 40%, 30%, 20%, 10%, or 5% of the total volume of flush water in tank **500**. In some embodiments, the first portion may be greater than or equal to 20%, 30%, 40%, 50%, or 60% of the total volume of flush water in tank **500**.

[0090] In some embodiments, less than one quarter of the flush water during a flush cycle may flow from a region of tank **500** that is exterior to container **506** (i.e., a region that excludes vacuum chamber **522** and inner chamber **523** of container **506**). In some embodiments, the percentage of flush water flowing from tank **500** (considered separately from the container and/or subcomponents of the container) may be less than or equal to 30%, 25%, 24%, 22%, 20%, 18%, 16%, 15%, or 10%. In some embodiments, the percentage of flush water flowing from tank **500** (considered separately from the container and/or subcomponents of the container) may be greater than or equal to 30%, 25%, 24%, 22%, 20%, 18%, 16%, 15%, or 10%. In some embodiments, the percentage of flush water flowing from tank **500** (considered separately from the container and/or subcomponents of the container) may be greater than or equal to 16% and less than or equal to 20%. In some embodiments, the percentage of flush water flowing from tank **500** (considered separately from the container and/or subcomponents of the container) may be greater than or equal to 14% and less than or equal to 22%. In some embodiments, the percentage of flush water flowing from tank **500** (considered separately from the container and/or subcomponents of the container) may be equal to about 18%.

[0091] A second portion of the total volume of flush water in tank **500** may be stored in vacuum chamber **522** when the toilet is between flush cycles. In some embodiments, the second portion may be about 10%, about 20%, about 30%, about 40%, or about 50% of the total volume of flush water in tank **500**. In some embodiments, the second portion may be less than or equal to 50%, 40%, 30%, 20%, 10%, or 5% of the total volume of flush water in tank **500**. In some embodiments, the second portion may be greater than or equal to 20%, 30%, 40%, 50%, or 60% of the total volume of flush water in tank **500**.

[0092] In some embodiments, less than one third of the flush water during a flush cycle may flow from vacuum chamber **522**. In some embodiments, the percentage of flush water flowing from vacuum chamber **522** may be less than or equal to 40%, 35%, 34%, 32%, 30%, 28%, 26%, 25%, or 20%. In some embodiments, the percentage of flush water flowing from vacuum chamber **522** may be greater than or equal to 40%, 35%, 34%, 32%, 30%, 28%, 26%, 25%, or 20%. In some embodiments, the percentage of flush water flowing from vacuum chamber **522** may be greater than or equal to 27% and less than or equal to 31%. In some embodiments, the percentage of flush water flowing from vacuum chamber **522** may be greater than or equal to 25% and less than or equal to 33%. In some embodiments, the percentage of flush water flowing from vacuum chamber **522** may be equal to about 29%.

[0093] A third portion of the total volume of flush water in tank **500** may be stored in inner chamber **523** when the toilet is between flush cycles. In some embodiments, the third

portion may be about 40%, about 50%, about 60%, about 70%, about 80%, or about 90% of the total volume of flush water in tank **500**. In some embodiments, the third portion may be less than or equal to 90%, 80%, 70%, 60%, or 50% of the total volume of flush water in tank **500**. In some embodiments, the third portion may be greater than or equal to 30%, 40%, 50%, 60%, or 70% of the total volume of flush water in tank **500**.

[0094] In some embodiments, more than half of the flush water during a flush cycle may flow from inner chamber **523**. In some embodiments, the percentage of flush water flowing from inner chamber **523** may be greater than or equal to 40%, 45%, 50%, 52%, 54%, 56%, 58%, 60%, 65%, or 70%. In some embodiments, the percentage of flush water flowing from inner chamber **523** may be less than or equal to 40%, 45%, 50%, 52%, 54%, 56%, 58%, 60%, 65%, or 70%. In some embodiments, the percentage of flush water flowing from inner chamber **523** may be greater than or equal to 54% and less than or equal to 58%. In some embodiments, the percentage of flush water flowing from inner chamber **523** may be greater than or equal to 52% and less than or equal to 60%. In some embodiments, the percentage of flush water flowing from inner chamber **523** may be equal to about 56%.

[0095] As shown, the upper end **522***b* of vacuum chamber **522** may be closed off from the interior of tank **500** by upper wall **512** of container **506**. This may allow vacuum chamber **522** to contain positively pressurized air in upper end **522***b* when the toilet is between flush cycles. A connecting tube **524** may be positioned within vacuum chamber **522** and may fluidically couple the upper portion **522***b* of vacuum chamber **522** to the toilet's trapway. As a result, the trapway may also contain pressurized air when the toilet is between flush cycles. Connecting tube may include a connecting tube gasket **526** positioned between a connecting tube outlet **528** and the trapway in order to prevent flush water from leaking out of tank **500** and into the trapway. In some embodiments, the positive pressurization of the first portion of pressurized air in vacuum chamber **522** may be equal to the positive pressurization of the second portion of pressurized air in the trapway.

[0096] In some embodiments, the positive pressurization of the first portion of pressurized air in vacuum chamber **522** may be any of about 0.1 cm of water, 0.2 cm of water, 0.3 cm of water, 0.5 cm of water, about 0.8 cm of water, about 1.1 cm of water, about 1.4 cm of water, about 1.7 cm of water, about 2.0 cm of water, about 2.3 cm of water, about 2.6 cm of water, or about 2.9 cm of water, to any of about 3.2 cm of water, about 3.5 cm of water, about 3.8 cm of water, about 4.1 cm of water, about 4.4 cm of water, about 4.7 cm of water, about 5.0 cm of water, or more. In some embodiments, the positive pressurization of the first portion of pressurized air in vacuum chamber **522** may be greater than or equal to 0.1 cm of water, 0.2 cm of water, 0.3 cm of water, 0.5 cm of water, 0.8 cm of water, 1.1 cm of water, 1.4 cm of water, 1.7 cm of water, 2.0 cm of water, 2.3 cm of water, 2.6 cm of water, or 2.9 cm of water. In some embodiments, the positive pressurization of the first portion of pressurized air in vacuum chamber **522** may be less than or equal to 3.2 cm of water, 3.5 cm of water, 3.8 cm of water, 4.1 cm of water, 4.4 cm of water, 4.7 cm of water, or 5.0 cm of water. As used herein, reference to positive pressurization in centimeters of water may refer to pressurization above atmospheric pressure by an amount of additional pressure equal to the given centimeters of water. For example, "positive pressurization of 5 cm of water" may refer to 5 cm of water above atmospheric pressure, or an absolute pressure of about 1.0048 atm.

[0097] Between flush cycles, the first portion of positively pressurized air contained in vacuum chamber **522** may have a first volume and the second portion of positively pressurized air contained in the trapway may have a second volume. The first volume of pressurized air contained in vacuum chamber **522** may be less than the second volume of pressurized air contained in the trapway. In some embodiments, the first volume may be less than or equal to half the second volume. In some embodiments, the first volume may be less than or equal to 50%, 40%, 30%, 28%, 26%, 24%, 22%, 20%, 18%, 16%, 14%, 12%, or 10% the second volume. In some embodiments, the first volume may be greater than or equal to 20% and less than or equal to 24%. In some embodiments, the first volume may be greater than or equal to 18% and less than or equal to 26% the second volume. In some embodiments, the first volume may be equal to about 22% the second volume.

[0098] The position of connecting tube **524** within vacuum chamber **522** may impact the timing of vacuum formation for siphon initiation during a flush cycle. A vertical distance **538** between a top surface of connecting tube **524** and an inner top surface of vacuum chamber **522** may be greater than or equal to 5, 10, 15, 20, 25, 30, or 35 mm. Alternatively, a vertical distance **538** between a top surface of connecting tube **524** and an inner top surface of vacuum chamber **522** may be less than or equal to 45, 40, 35, 30, 25, 20, or 15 mm. Connecting tube **524** may be positioned in vacuum chamber **522** such that, between flush cycles, a vertical distance between a top surface of connecting tube **524** and a water level in tank **500** exterior to container **506** is greater than or equal to 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, or 75 mm. Alternatively, connecting tube **524** may be positioned in vacuum chamber **522** such that, between flush cycles, a vertical distance between a top surface of connecting tube **524** and a water level in tank **500** exterior to container **506** is less than or equal to 100, 95, 90, 85, 80, 75, 70, 65, 60, 55, or 50 mm.

[0099] The size of connecting tube **524** may also impact the timing of vacuum formation for siphon initiation during a flush cycle. An opening **540** in the top surface of connecting tube **524** may have a diameter of about 2, about 4, about 6, about 8, about 10, about 12, about 14, about 16, about 18, or about 20 mm. In some embodiments, opening **540** may have a diameter greater than or equal to 2, 4, 6, 8, 10, 12 or 14 mm. In some embodiments, opening **540** may have a diameter less than or equal to 20, 18, 16, 14, 12, or 10 mm. An internal diameter of connecting tube **524** may be about 12, about 14, about 16, about 18, about 20, or about 22 mm. In some embodiments, an internal diameter of connecting tube **524** may be greater than or equal to 10, 12, 14, 16, 18, 20, 22, or 24 mm. In some embodiments, an internal diameter of connecting tube **524** may be less than or equal to 30, 28, 26, 24, 22, 20, 18, or 16 mm.

Pressurized Air in the Trapway

[0100] Between flush cycles, the trapway of a dual-trap toilet may contain a volume of positively pressurized air. The volume of positively pressurized air contained in the trapway may be a second of two portions of positively pressurized air contained in the dual-trap toilet. In some

embodiments, the second portion of positively pressurized air may also include air located in a connecting tube (e.g., connecting tube **524** of tank **500** shown in FIG. **5**) and/or in an interface portion between the connecting tube and the trapway. The first of the two portions of positively pressurized air contained in the dual trap toilet may be contained in the toilet tank. Between flush cycles, the positively pressurized air in the trapway may push upwards on water being held in the sump trap, which may result in a larger water spot in the toilet bowl than would be present if not for the positively pressurized air in the trapway. Between flush cycles, the positively pressurized air in the trapway may push downwards on water being held in the lower trap such that a water level in an upstream end of the lower trap may be lower than a water level in a downstream end of the lower trap. In some embodiments, when a flush cycle is initiated, the discharge of flush water into the toilet bowl may exert a negative pressure on the air in the tank and/or the air in the trapway, causing the pressure to drop to atmospheric pressure or to a partial vacuum. This drop in pressure may generate a siphon in the trapway that may pull the contents of the toilet bowl into and out of the trapway. Upon completion of the flush cycle, the flush water in the toilet tank may be replenished, which may restore the positive pressurization of the air contained in the trapway.

[0101] FIGS. **6**A and **6**B show views of a toilet bowl and/or trapway of a dual-trap toilet, in accordance with some embodiments. Specifically, FIG. **6**A shows a toilet bowl **602** and a trapway **610** of a dual-trap toilet **600**. Trapway **610** comprises a sump trap **612** (positioned between a first upstream portion **612***u* and a first downstream portion **612***d* of trapway **610**), a first upstream weir **616**, a lower trap **614** (positioned between a second upstream portion **614***u* and a second downstream portion **614***d* of trapway **610**), a second downstream weir **618**, and a trapway outlet **620**. Trapway outlet may be configured to fluidly couple to a drainage pipe that connects to a sewer system. FIG. **6**B shows a portion of trapway **610** located between a downstream end of sump trap **612** and second downstream weir **618**. In some embodiments, the portion of trapway **610** that is located between the downstream end of sump trap **612** and the upstream end of lower trap **614** may be configured to contain positively pressurized air in between flush cycles.

[0102] Upon initiation of a flush cycle, toilet bowl **602** may be configured to receive flush water from the toilet tank of dual-trap toilet **600** via a flush water inlet **604**. The discharge of flush water from the toilet tank, through flush water inlet **604**, and into toilet bowl **602** may exert a negative pressure on the volume of pressurized air contained in trapway **610** between the downstream end of sump tank **612** and the upstream end of lower trap **614**. The negative pressure exerted air in trapway **610** may cause the pressure of the air in trapway **610** to drop to atmospheric pressure or to partial vacuum. This drop in the pressure of the air in trapway **610** may create a siphon in trapway **610** that pulls the contents of toilet bowl **602** (e.g., flush water and/or waste) out of toilet bowl **602**, through trapway **610**, and into the sewer system via trapway outlet **620**.

[0103] The portion of trapway **610** that contains the positively pressurized air between flush cycles may be fluidly coupled to a volume of pressurized air contained in a toilet tank of dual-trap toilet **600**. In some embodiments, the fluid coupling between trapway **610** and the toilet tank may be facilitated by a connecting tube that is positioned in the toilet tank (e.g., connecting tube **524** of toilet tank **500** shown in FIG. **5**C). The connecting tube may couple to trapway **610** via a connecting tube outlet **606** that is fluidly coupled to a trapway-tank interface **608**.

[0104] In some embodiments, the positive pressurization of the portion of pressurized air in the toilet tank may be equal to the positive pressurization of the portion of pressurized air in the trapway. In some embodiments, between flush cycles, the portion of positively pressurized air contained in the toilet tank may have a first volume and the portion of positively pressurized air contained in trapway **610** may have a second volume. The second volume of pressurized air contained in trapway **610** may be greater than the first volume of pressurized air contained in the toilet tank. In some embodiments, the second volume may be greater than or equal to twice the first volume. In some embodiments, the first volume of pressurized air in the toilet tank may be less than or equal to 50%, 40%, 30%, 28%, 26%, 24%, 22%, 20%, 18%, 16%, 14%, 12%, or 10% the second volume of pressurized air in trapway **610**. In some embodiments, the first volume may be greater than or equal to 20% and less than or equal to 24% the second volume of pressurized air in trapway **610**. In some embodiments, the first volume may be greater than or equal to 18% and less than or equal to 26% the second volume of pressurized air in trapway **610**. In some embodiments, the first volume may be equal to about 22% the second volume of pressurized air in trapway **610**.

[0105] FIG. **7** shows a cross-sectional view of a dual-trap toilet and a lower seal offset height, in accordance with some embodiments. Specifically, FIG. **7** shows a dual-trap toilet **700** comprising a toilet bowl **702** and a trapway **704**. Trapway **704** may comprise a sump trap **708** (defined by a first upstream portion **708***u* and a first downstream portion **708***d* of trapway **704** and comprising a sump area **708***a* of toilet bowl **702**), a first upstream weir **714**, a lower trap **710** (positioned between a second upstream portion **710***u* and a second downstream portion **710***d* of trapway **704**), and a second downstream weir **716**. In some embodiments, trapway **704** may be fluidly coupled to a toilet tank of dual-trap toilet **700** via a trapway-tank interface **706**. Between flush cycles, sump trap **708** may be configured to hold a first volume of water. The volume of water held in sump trap **708** may create a water spot in toilet bowl **702**. Between flush cycles, lower trap **710** may be configured to hold a second volume of water. In some embodiments, the first volume of water held in sump trap **708** and the second volume of water held in lower trap **710** may provide a series

[0106] In some embodiments, between flush cycles, trapway **704** may be configured to contain a volume of positively pressurized air. The volume of pressurized air may be contained between a downstream end **708***d* of sump trap **708** and an upstream end **710***u* of lower trap **710**. In some embodiments, between flush cycles, the positively pressurized air may exert upward pressure on water in sump area **708***a*. This may create a larger water spot in toilet bowl **702** than would be possible without the positively pressurized air in trapway **704**.

[0107] In some embodiments, between flush cycles, positively pressurized air in trapway **704** may exert downward pressure on water being held in lower trap **710**. Specifically, the positively pressurized air in trapway **704** may exert a downward pressure on an upstream end **710***u* of lower trap **710**. This downward pressure may cause the upstream water

level in lower trap **710** to be offset from the downstream water level in lower trap **710** by an offset distance **712**. In some embodiments, offset distance **712** may be greater than or equal to 1 mm, 2 mm, 3 mm, 5 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm, 15 mm, 16 mm, 17 mm, 18 mm, 19 mm, or 20 mm. In some embodiments, offset distance **712** may be less than or equal to 1 mm, 2 mm, 3 mm, 5 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm, 15 mm, 16 mm, 17 mm, 18 mm, 19 mm, or 20 mm. In some embodiments, offset distance **712** may be greater than 14 mm and less than 16 mm. In some embodiments, offset distance **712** may be greater than 13 mm and less than 17 mm. In some embodiments, offset distance **712** may be equal to about 15 mm.

Trapway Shape

[0108] The shape of a trapway of a dual-trap toilet may be configured to optimize flow of air and water during a flush cycle. An upstream end of the trapway may be fluidly coupled to an outlet in the toilet bowl of the dual-trap toilet and a downstream end of the trapway may be configured to fluidly couple to an inlet to a drainage pipe that leads to a sewer system. Between the upstream end and the downstream end, the trapway may comprise a sump trap, a first upstream weir, a first connecting portion extending downward from the first upstream weir, a lower trap, a second connecting portion extending upward from the lower trap, a second downstream weir, and a third connecting portion extending downward from the second downstream weir. The shape of the first connecting portion may form an arc that extends laterally outwards from the first upstream weir and then bends laterally back toward the lower trap. The first connecting portion may comprise a single arced portion, multiple arced portions (e.g., having different arc radii and/or arcing in different directions), a single straight-line portion, and/or multiple straight-line portions.

[0109] FIG. **8** shows a trapway of a dual-trap toilet, in accordance with some embodiments. Specifically, FIG. **8** shows a trapway portion **800** comprising a first upstream weir **802**, a lower trap **804**, a second downstream weir **806**, and a connecting portion **808**. First upstream weir **802** may be positioned downstream of a sump trap of the dual-trap toilet. Connecting portion **808** may extend from a downstream end of first upstream weir **802** to an upstream end of lower trap **804**.

[0110] As shown, first upstream weir **802** may comprise a first arced shape **812** that arcs about a first center-point **816**. Similarly, lower trap **804** may comprise a second arced shape **814** that arcs about a second center-point **818**. Connecting portion **808** may extend outwards laterally (e.g., horizontally) and then arc back inwards laterally while extending downwards vertically. Connecting portion **808** may comprise a central arced path **820** between first upstream weir **802** and lower trap **804**. First arced shape **812**, second arced shape **814**, and/or central arced path **820** may trace the center of a fluid flow path through trapway portion **800**.

[0111] An upstream end of central arced path **820** may extend laterally away from first upstream weir **802**, while a downstream end of central arced path **820** may extend laterally toward lower trap **804**. In some embodiments, connecting portion **808** may be greater than or equal to 80, 90, 100, 110, 120, 130, 140, or 150 mm in (vertical) height. In some embodiments, connecting portion **808** may be less than or equal to 80, 90, 100, 110, 120, 130, 140, or 150 mm in (vertical) height. In some embodiments, a lateral extent over which connecting portion **808** extends in the lateral (e.g., horizontal) direction may be greater than or equal to 20, 30, 40, 50, 60, 70, or 80 mm. In some embodiments, a lateral extent over which connecting portion **808** extends in the lateral (e.g., horizontal) direction may be less than or equal to 20, 30, 40, 50, 60, 70, or 80 mm.

[0112] The distance at which a portion of connecting portion **808** is disposed from first upstream weir **802** and from lower trap **804** may be understood with reference to a first line **822** extending between first center-point **816** and second center-point **818** and a second line **824** that is parallel to the first line and forms a tangent with central arced path **820** of connecting portion **808**. First line **822** may be vertical or may angle outward or in the same direction in which central arced path **820** protrudes outward, as it extends downward, or may angle inward, in an opposite direction in which central arced path **820** protrudes outward, as it extends downward.

[0113] In some embodiments, a point **828** at which second line **824** is tangent to central arced path **820** may be equidistant between first upstream weir **802** and lower trap **804**. In some embodiments, point **828** at which second line **824** is tangent to central arced path **820** may be closer to first upstream weir **802** than lower trap **804**. In some embodiments, point **828** at which second line **824** is tangent to central arced path **820** may be closer to lower trap **804** than first upstream weir **802**.

[0114] Second line **824** may be offset from first line **822** by an offset distance **826**. In some embodiments, offset distance **826** may be greater than or equal to 40, 50, 60, 62, 64, 66, 68, 70, 80, or 90 mm. In some embodiments, offset distance **826** may be less than or equal to 40, 50, 60, 62, 64, 66, 68, 70, 80, or 90 mm. In some embodiments, offset distance **826** may be greater than 64 and less than 68 mm. In some embodiments, offset distance **826** may be of greater than 62 and less than 70 mm. In some embodiments, offset distance **826** may be about 65.7 mm.

[0115] Trapway portion **800** may be fluidly coupled to a toilet tank of the dual-trap toilet via an interface **810** which may be located at a position between the sump trap (which may be located upstream of first upstream weir **802**) and lower trap **804**. Interface **810** may be fluidly coupled to a connecting tube that is positioned within the toilet tank and configured to provide fluid communication between the toilet tank and the trapway. In some embodiments, interface **810** may be a portion of the connecting tube.

[0116] Interface **810** may have an upper end that couples to a lower end of the connecting tube and may have a lower end that couples to trapway portion **800**. The lower end may couple to the trapway at a location between the sump trap (which may be located upstream of first upstream weir **802**) and lower trap **804** such that positively-pressurized air may be delivered, through the interface, to connecting portion **808**. The lower end of interface **810** may couple to an upper wall of trapway portion **800** above first upstream weir **802** and/or to an upper/outer wall of the connecting portion **808**.

[0117] The lower end of interface **810** may extend from a first edge **830** that couples to the trapway at a most-upstream extent (referring to the direction of flow of water in the trapway) to a second edge **832** that couples to the trapway at a most-downstream extent (referring to the direction of flow of water in the trapway). The lower end of interface **810** may be wider in at least one direction than an upper end of

trapway portion **800**. In some embodiments, the lower end of interface **810** may be wider in a first dimension that it is in a second dimension. Optionally, interface **810** may have a generally triangular or "shark fin" shape extending from a narrow (e.g., circular) upper end to a lower end that is wider in one dimension.

[0118] First edge **830** may be positioned directly above first upstream weir **802**. In some embodiments, first edge **830** may be positioned on the upper wall of the trapway at a location that is less than or equal to 1, 2, 3, 4, 5, 10, or 15 mm from a location directly above first upstream weir **802**. In some embodiments, first edge **830** may be positioned on the upper wall of the trapway at a location that is greater than or equal to 1, 2, 3, 4, 5, 10, or 15 mm from a location directly above first upstream weir **802**.

[0119] Second edge **832** may be positioned directly level with first upstream weir **802**. In some embodiments, second edge **832** may be positioned on the upper/outer wall of the trapway at a location that is less than or equal to 1, 2, 3, 4, 5, 10, or 15 mm from a location directly level with first upstream weir **802**. In some embodiments, second edge **832** may be positioned on the upper/outer wall of the trapway at a location that is greater than or equal to 1, 2, 3, 4, 5, 10, or 15 mm from a location directly level with first upstream weir **802**.

[0120] In some embodiments, a wall of interface **810** may be tangent to the upper wall of the trapway at first edge **830** of the lower end of interface **810**. In some embodiments, a wall of interface **810** may be tangent to the upper/outer wall of the trapway at second edge **832** of the lower end of interface **810**.

[0121] FIG. **9** shows dimensions for a flow path for a trapway for a dual-trap toilet, in accordance with some embodiments. Specifically, FIG. **9** shows a flow path **900** for a dual-trap toilet trapway that comprises a sump trap **902**, a first upstream weir **904**, a connecting portion **906**, a lower trap **908**, and a second downstream weir **910**. Sump trap **902** may be downstream of and fluidly coupled to a toilet bowl of the dual-trap toilet. During a flush cycle, fluid may be transmitted along flow path **900**. In other words, during a flush cycle, fluid may flow from sump trap **902**, over first upstream weir **904**, through connecting portion **906**, through lower trap **908**, and over second downstream weir **910** before being transmitted out of the trapway.

[0122] Between flush cycles, sump trap **902** may trap a volume of flush water in the toilet bowl of the dual-trap toilet that may create a water spot in the toilet bowl. Between flush cycles, the water spot depth **926** may be defined by a first water spot line **916** and a second water spot line **918**. In some embodiments, water spot depth **926** may be greater than or equal to 40, 50, 60, 70, 80, or 90 mm. In some embodiments, water spot depth **926** may be less than or equal to 40, 50, 60, 70, 80, or 90 mm. In some embodiments, water spot depth **926** may be greater than or equal to 50 mm and less than or equal to 60 mm. In some embodiments, between flush cycles, connecting portion **906** may contain a volume of positively pressurized air that applies an upward pressure on the water spot, resulting in a greater water spot depth **926**.

[0123] Sump trap **902** may be fluidly coupled to the toilet bowl via a sump inlet that is centered at a sump inlet center-point **928** that is positioned along flow path **900**. In some embodiments, an inlet diameter **924** of the sump trap outlet may be greater than or equal to 50, 60, 70, 80, 90, or 100 mm. In some embodiments, inlet diameter **924** may be less than or equal to 60, 60, 70, 80, 90, or 100 mm. In some embodiments, inlet diameter **924** may be greater than or equal to 60 mm and less than or equal to 70 mm.

[0124] First upstream weir **904** may form a first arced shape that is centered at a first center-point **912**. Similarly, lower trap **908** may form a second arced shape that is centered at a second center-point **914**. A first radius **930** of the first arced shape may be the distance from the center of flow path **900** through first upstream weir **904** to first center-point **912**. A second radius **932** of the second arced shape may be the distance from the center of flow path **900** through lower trap **908** to second center-point **914**. In some embodiments, first radius **930** may be greater than second radius **932**. In some embodiments, first radius **930** may be less than second radius **932**. In some embodiments, first radius **930** and second radius **932** may be equal.

[0125] In some embodiments, first radius **930** may be greater than or equal to 40, 50, 60, 70, or 80 mm. In some embodiments, first radius **930** may be less than or equal to 40, 50, 60, 70, or 80 mm. In some embodiments, first radius **930** may be greater than or equal to 50 mm and less than or equal to 70 mm.

[0126] In some embodiments, second radius **932** may be greater than or equal to 20, 30, 40, 50, 60, or 70 mm. In some embodiments, second radius **932** may be less than or equal to 20, 30, 40, 50, 60, or 70 mm. In some embodiments, second radius **932** may be greater than or equal to 20 mm and less than or equal to 70 mm.

[0127] Between flush cycles, lower trap **908** may contain a volume of water. As mentioned above, between flush cycles, connecting portion **906** may contain a volume of positively pressurized air. The volume of pressurized air may exert a downward pressure on the volume of water that is held in lower trap **908** between flush cycles. This downward pressure may cause an upstream water level **920** of lower trap **908** to be offset by an offset distance **934** from a downstream water level **922** of lower trap **908**. In some embodiments, offset distance **934** may be greater than or equal to 2, 3, 4, 5, 10, 15, or 20 mm. In some embodiments, offset distance **934** may be less than or equal to 2, 3, 4, 5, 10, 15, or 20 mm. In some embodiments, offset distance **934** may be greater than or equal to 4.75 mm and less than or equal to 5.25 mm.

Trapway Diameter Dimensions

[0128] In order to optimize the flow of air and water during flush cycles, a dual-trap toilet may have trapway that varies in diameter at different locations along the trapway. The interface may have an upper end that couples to a lower end of the connecting tube and may have a lower end that couples to the trapway. The lower end may couple to the trapway at a location between the sump trap and the lower trap, such that positively-pressurized air may be delivered, through the interface, to the area of the trapway between the water in the sump trap and the water in the lower trap. The lower end may couple to an upper wall of the trapway above the first upstream weir and/or to an upper/outer wall of the connecting portion. A diameter of the trapway may be measured at any of the trapway components referred to above and may, in some embodiments, differ from one or more other components at any of the trapway components referred to above. When trapway diameter is referenced, it may be understood to refer to a diameter of a circular

trapway and/or to a diameter in at least one direction of an elliptical and/or irregularly-shaped trapway.

[0129] FIG. **10** shows trap diameter dimensions for a trapway for a dual-trap toilet, in accordance with some embodiments. Specifically, FIG. **10** shows a flow path **1000** for a dual-trap toilet trapway. In some embodiments, the trapway may have a variable diameter at different locations along flow path **1000**. The trapway diameter at each location along flow path **1000** may be the length of a straight line from one side of the trapway boundary to the opposite side of the trapway boundary that passes through flow path **1000**.

[0130] Location **1002** may be a sump trap outlet into the trapway. The cross-section of the sump trap outlet may be approximately "D"-shaped. In some embodiments, the cross-sectional area of the trapway at location **1002** may be greater than or equal to 15, 20, 25, 30, 35, 40, 45, 50, or 55 cm^2. In some embodiments, the cross-sectional area of the trapway at location **1002** may be less than or equal to 65, 60, 55, 50, 45, 40, 35, 30, or 25 cm^2. In some embodiments, the cross-sectional area of the trapway at location **1002** may be between about 20-25, 25-30, 30-35, 35-40, 40-45, or 45-50 cm^2. In some embodiments, the cross-sectional area of the trapway at location **1002** can be about 34, 34.5, 35, 35.5, 36, 36.5, or 37 cm^2.

[0131] In some embodiments, the cross-section of the sump trap outlet may comprise additional or alternative shapes. In some embodiments, at its widest point, the width of the sump trap outlet may be greater than or equal to 50, 60, 70, 80, 90, or 100 mm. In some embodiments, at its widest point, the width of the sump trap outlet may be less than or equal to 60, 60, 70, 80, 90, or 100 mm. In some embodiments, at its widest point, the width of the sump trap outlet may be greater than or equal to 60 mm and less than or equal to 70 mm.

[0132] Location **1004** may be a downstream end of a sump trap. The diameter of the trapway at location **1004** may be greater than, less than, or equal to the diameter of the trapway at location **1002**.

[0133] Location **1006** may be a peak of a first upstream weir. In some embodiments, the diameter of the trapway at location **1006** (and/or at one or more locations further downstream) may be greater than or equal to 52, 56, 60, 64, 68, 72, or 76 mm. In some embodiments, the diameter of the trapway at location **1006** (and/or at one or more locations further downstream) may be less than or equal to 52, 56, 60, 64, 68, 72, or 76 mm. In some embodiments, the diameter of the trapway at location **1006** (and/or at one or more locations further downstream) may be greater than or equal to 63 mm and less than or equal to 67 mm. In some embodiments, the diameter of the trapway at location **1006** (and/or at one or more locations further downstream) may be greater than or equal to 61 mm and less than or equal to 69 mm. In some embodiments, the diameter of the trapway at location **1006** (and/or at one or more locations further downstream) may be about 65 mm.

[0134] In some embodiments, the trapway may have a funnel-like shape between location **1002** and location **1006**. In other words, the cross-sectional area of the trapway may gradually narrow between location **1002** and location **1006**. This form factor may aid in the passing of solid waste.

[0135] Location **1008** may be an upstream end of a lower trap. In some embodiments, the diameter of the trapway at location **1008** may be greater than or equal to 42, 46, 50, 54, 58, 62, or 66 mm. In some embodiments, the diameter of the trapway at location **1008** (and/or at one or more locations further downstream) may be less than or equal to 42, 46, 50, 54, 58, 62, or 66 mm. In some embodiments, the diameter of the trapway at location **1008** (and/or at one or more locations further downstream) may be greater than or equal to 52 mm and less than or equal to 56 mm. In some embodiments, the diameter of the trapway at location **1008** (and/or at one or more locations further downstream) may be greater than or equal to 50 mm and less than or equal to 58 mm. In some embodiments, the diameter of the trapway at location **1008** (and/or at one or more locations further downstream) may be about 54 mm.

[0136] Location **1010** may be a lowermost point of the lower trap. In some embodiments, the diameter of the trapway at location **1010** may be wider than a diameter of the trapway at location **1008** and/or may be wider than a diameter of the trapway at one or more points downstream from location **1010** (e.g., locations along a second downstream weir). In some embodiments, a widened diameter of the trapway at location **1010** may reduce clogging at that position in the trapway. In some embodiments, the diameter of the trapway at location **1010** may be greater than, equal to, or less than a diameter of the trapway at one or more upstream locations (e.g., locations **1002**-**1006**).

[0137] Location **1012** may be a peak of a second downstream weir. In some embodiments, the diameter of the trapway at location **1012** may be greater than or equal to 30, 40, 50, 60, or 70 mm. In some embodiments, the diameter of the trapway at location **1012** may be less than or equal to 30, 40, 50, 60, or 70 mm.

[0138] Location **1014** may be location downstream of the peak of the second downstream weir. In some embodiments, location **1014** may be offset from location **1012** by an offset distance of at least 5, at least 10, at least 20, at least 30, at least 40, or at least 50 mm. In some embodiments, the diameter of the trapway at location **1014** may be greater than the diameter of the trapway at location **1012**. In some embodiments, the diameter of the trapway at location **1014** may be less than the diameter of the trapway at location **1012**. In some embodiments, the diameter of the trapway at location **1014** may be equal to the diameter of the trapway at location **1012**.

[0139] Finally, location **1016** may be a trapway outlet. The trapway may be fluidly coupled to a drainage pipe that connects to a sewer system at location **1016**. In some embodiments, the diameter of the trapway at location **1016** may be greater than or equal to 50, 60, 70, 80, 90, or 100 mm. In some embodiments, the diameter of the trapway at location **1016** may be less than or equal to 60, 60, 70, 80, 90, or 100 mm. In some embodiments, the diameter of the trapway at location **1016** may be greater than or equal to 60 mm and less than or equal to 70 mm.

Interface Between the Trapway and the Connecting Tube

[0140] The tank of a dual-trap toilet may house a container that is configured to hold a portion of the flush water in between flush cycles. In some embodiments, a connecting tube that is configured to provide flow communication between the container and the trapway may be positioned inside the container. The dual-trap toilet may have an interface between (or included as part of) the connecting tube that is positioned and shaped to optimize flow of air and water during flush cycles. The interface may have an upper end that couples to a lower end of the connecting tube and

may have a lower end that couples to the trapway. The lower end may couple to the trapway at a location between the sump trap and the lower trap, such that positively-pressurized air may be delivered, through the interface, to the area of the trapway between the water in the sump trap and the water in the lower trap. The lower end may couple to an upper wall of the trapway above the first upstream weir and/or to an upper/outer wall of the connecting portion.

[0141] FIG. **11** shows an interface between a connecting tube and a trapway of a dual-trap toilet, in accordance with some embodiments. Specifically, FIG. **11** shows a portion **1100** of a dual-trap toilet comprising an interface **1102** between a connecting tube outlet **1104** and a trapway **1106**. Connecting tube outlet **1104** may be fluidly coupled to a connecting tube that is positioned within a container that is housed in a toilet tank of the dual-trap toilet. The toilet tank may also couple to the toilet bowl via a flush valve outlet **1110** that is adjacent to connecting tube outlet **1104**.

[0142] Interface **1102** may couple to trapway **1106** at a location between a sump trap and a lower trap of trapway **1106**. In some embodiments, an upstream portion of the lower end of interface **1102** may couple to trapway **1106** at a first point **1112** on an upper wall of trapway **1106** above first upstream weir **1108**. A downstream portion of the lower end of interface **1102** may couple to trapway **1106** at a second point **1116** that is downstream of first point **1112**. In some embodiments, second point **1106** may be defined by a first line **1118** and a second line **1120**. First line **1118** may be a vertical line that intersects first point **1112**. First line **1118** may intersect a lower portion of the trapway wall at a third point **1114**. Second line **1120** may be a horizontal line that intersects third point **1114**. Second point **1116** may be located along second line **820** on a side of the trapway wall that is opposite to third point **1114**.

Exemplary Embodiments

[0143] Below is an enumerated listing of certain embodiments. In some embodiments, any one or more of the features of any one or more of the embodiments below may be combined with any one or more of the other embodiments, even if the dependencies of the embodiments do not explicitly indicate that the embodiments may be combined in such manner. In some embodiments, any one or more of the features of any one or more of the embodiments below may be combined with any one or more features or aspects otherwise disclosed in this application.

[0144] 1. A toilet assembly, comprising

[0145] a toilet tank to hold flush water;

[0146] a flush valve assembly positioned in the toilet tank;

[0147] a toilet bowl;

[0148] a trapway in flow communication with the toilet bowl;

[0149] a container positioned in the toilet tank, and

[0150] a connecting tube extending from an interior of the container to the trapway, wherein:

[0151] the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end, wherein the upper end of the container contains a first portion of pressurized air when the toilet assembly is between flush cycles,

[0152] the trapway comprises a sump trap, a first upstream weir, a lower trap, and a second downstream weir, and

[0153] the connecting tube is coupled to the trapway at a position between the sump trap and the lower trap, and provides flow communication between the container and the trapway, and

[0154] the trapway contains a second portion of pressurized air when the toilet assembly is between flush cycles, wherein a volume of the first portion of pressurized air is less than or equal to 30% of a volume of the second portion of pressurized air.

[0155] 2. The toilet assembly of embodiment 1, wherein, between flush cycles, the first portion of pressurized air is positioned above flush water in the container.

[0156] 3. The toilet assembly of any one of embodiments 1-2, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in one or both of the first portion of pressurized air and the second portion of pressurized air.

[0157] 4. The toilet assembly of any one of embodiments 1-3, wherein, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in one or both of the first portion of pressurized air and the second portion of pressurized air.

[0158] 5. The toilet assembly of any one of embodiments 1-4, wherein, between flush cycles, the first portion of pressurized air and the second portion of pressurized air are pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

[0159] 6. The toilet assembly of any one of embodiments 1-5, wherein the first upstream weir is positioned above a highest point of a trapway inlet by an offset distance of greater than or equal to 2 inches.

[0160] 7. The toilet assembly of any one of embodiments 1-6, wherein the first upstream weir is positioned at point that, between flush cycles, is vertically higher than a water seal of the toilet bowl by a distance of greater than or equal to 0.2 inches.

[0161] 8. The toilet assembly of any one of embodiments 1-7, wherein the connecting tube comprises a backflow preventer.

[0162] 9. The toilet assembly of any one of embodiments 1-8, wherein the flush valve assembly comprises a valve body extending from a valve inlet to a valve outlet and a valve cover having a seal to enclose the valve inlet.

[0163] 10. The toilet assembly of any one of embodiments 1-9, wherein the container comprises a continuous side wall, an upper end wall, and an inner wall that together bound a vacuum chamber of the container.

[0164] 11. The toilet assembly of embodiment 10, wherein the inner wall bounds an inner chamber of the container.

[0165] 11. The toilet assembly of embodiment 10 or 11, wherein a vertical distance between a top surface of the connecting tube and an inner surface of the upper end wall is greater than or equal to 10 mm and less than or equal to 35 mm.

[0166] 12. The toilet assembly of any one of embodiments 1-11, wherein an internal diameter of the connecting tube is greater than or equal to 12 mm and less than or equal to 20 mm.

[0167] 13. The toilet assembly of any one of embodiments 1-12, wherein, between flush cycles, a vertical distance between a top surface of the connecting tube and a water level in the toilet tank is greater than or equal to 45 mm and less than or equal to 55 mm.

[0168] 14. A toilet assembly, comprising:

[0169] a toilet tank to hold flush water;

[0170] a flush valve assembly positioned in the toilet tank;

[0171] a toilet bowl;

[0172] a trapway in flow communication with the toilet bowl;

[0173] a container positioned in the toilet tank, and

[0174] a connecting tube extending from an interior of the container to the trapway, wherein:

[0175] the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end,

[0176] the trapway comprises a sump trap, a first upstream weir, a lower trap, and a second downstream weir,

[0177] the connecting tube is coupled to the trapway at a position between the sump trap and the lower trap, and provides flow communication between the container and the trapway, and

[0178] the trapway contains pressurized air when the toilet assembly is between flush cycles, wherein the pressurized air in the trapway exerts force on water in the lower trap such that an upstream water level in the lower trap is lower than a downstream water level in the lower trap by an offset distance of greater than or equal to 15 mm between flush cycles.

[0179] 15. The toilet assembly of embodiment 14, wherein, between flush cycles, the container comprises pressurized air positioned above flush water.

[0180] 16. The toilet assembly of any one of embodiments 14-15, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in the pressurized air in the trapway.

[0181] 17. The toilet assembly of any one of embodiments 14-16, wherein, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in the pressurized air in the trapway.

[0182] 18. The toilet assembly of any one of embodiments 14-17, wherein, between flush cycles, the pressurized air in the trapway is pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

[0183] 19. The toilet assembly of any one of embodiments 14-18, wherein the first upstream weir is positioned above a highest point of a trapway inlet by an offset distance of greater than or equal to 2 inches.

[0184] 20. The toilet assembly of any one of embodiments 14-19, wherein the first upstream weir is positioned at point that, between flush cycles, is vertically higher than a water seal of the toilet bowl by a distance of greater than or equal to 0.2 inches.

[0185] 21. The toilet assembly of any one of embodiments 14-20, wherein the connecting tube comprises a backflow preventer.

[0186] 22. The toilet assembly of any one of embodiments 14-21, wherein the flush valve assembly comprises a valve body extending from a valve inlet to a valve outlet and a valve cover having a seal to enclose the valve inlet.

[0187] 23. The toilet assembly of any one of embodiments 14-22, wherein the container comprises a continuous side wall, an upper end wall, and an inner wall that together bound a vacuum chamber of the container.

[0188] 24. The toilet assembly of embodiment 23, wherein the inner wall bounds an inner chamber of the container.

[0189] 25. The toilet assembly of embodiment 23 or 24, wherein a vertical distance between a top surface of the connecting tube and an inner surface of the upper end wall is greater than or equal to 10 mm and less than or equal to 35 mm.

[0190] 26. The toilet assembly of any one of embodiments 14-25, wherein an internal diameter of the connecting tube is greater than or equal to 12 mm and less than or equal to 20 mm.

[0191] 27. The toilet assembly of any one of embodiments 14-26, wherein, between flush cycles, a vertical distance between a top surface of the connecting tube and a water level in the toilet tank is greater than or equal to 45 mm and less than or equal to 55 mm.

[0192] 28. A toilet assembly, comprising:

[0193] a toilet tank;

[0194] a flush valve assembly positioned in the toilet tank;

[0195] a toilet bowl;

[0196] a trapway in flow communication with the toilet bowl;

[0197] a container positioned in the toilet tank, wherein the container comprises an inner chamber and a vacuum chamber, and

[0198] a connecting tube extending from an interior of the container to the trapway, wherein:

[0199] the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end,

[0200] the trapway comprises a sump trap, a first upstream weir, a lower trap, and a second downstream weir, and

[0201] the connecting tube is coupled to the trapway at a position between the sump trap and the lower trap, and provides flow communication between the container and the trapway, and

[0202] during a flush cycle, the toilet assembly flushes a volume of flush water, wherein:

[0203] a first portion of the volume of flush water is stored in the tank prior to the flush cycle;

[0204] a second portion of the volume of flush water is stored in the vacuum chamber prior to the flush cycle;

[0205] a third portion of the volume of flush water is stored in the inner chamber prior to the flush cycle, wherein the third portion is greater than or equal to 40% of the volume of flush water.

[0206] 29. The toilet assembly of embodiment 28, wherein the first portion is less than or equal to 20% of the volume of flush water.

[0207] 30. The toilet assembly of any one of embodiments 28-29, wherein the second portion is less than or equal to 40% of the volume of flush water.

[0208] 31. The toilet assembly of any one of embodiments 28-30, wherein, between flush cycles, the container comprises pressurized air positioned above flush water in the vacuum chamber.

[0209] 32. The toilet assembly of any one of embodiments 28-31, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in pressurized air in the trapway.

[0210] 33. The toilet assembly of any one of embodiments 28-32, wherein, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in pressurized air in the trapway.

[0211] 34. The toilet assembly of any one of embodiments 28-33, wherein, between flush cycles, pressurized air in the trapway is pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

[0212] 35. The toilet assembly of any one of embodiments 28-34, wherein the first upstream weir is positioned above a highest point of a trapway inlet by an offset distance of greater than or equal to 2 inches.

[0213] 36. The toilet assembly of any one of embodiments 28-35, wherein the first upstream weir is positioned at point that, between flush cycles, is vertically higher than a water seal of the toilet bowl by a distance of greater than or equal to 0.2 inches.

[0214] 37. The toilet assembly of any one of embodiments 28-36, wherein the connecting tube comprises a backflow preventer.

[0215] 38. The toilet assembly of any one of embodiments 28-37, wherein the flush valve assembly comprises a valve body extending from a valve inlet to a valve outlet and a valve cover having a seal to enclose the valve inlet.

[0216] 39. The toilet assembly of any one of embodiments 28-38, wherein the container comprises a continuous side wall, an upper end wall, and an inner wall that together bound the vacuum chamber.

[0217] 40. The toilet assembly of embodiment 39, wherein the inner wall bounds the inner chamber.

[0218] 41. The toilet assembly of embodiment 39 or 40, wherein a vertical distance between a top surface of the connecting tube and an inner surface of the upper end wall is greater than or equal to 10 mm and less than or equal to 35 mm.

[0219] 42. The toilet assembly of any one of embodiments 28-41, wherein an internal diameter of the connecting tube is greater than or equal to 12 mm and less than or equal to 20 mm.

[0220] 43. The toilet assembly of any one of embodiments 28-42, wherein, between flush cycles, a vertical distance between a top surface of the connecting tube and a water level in the toilet tank is greater than or equal to 45 mm and less than or equal to 55 mm.

[0221] 44. A toilet assembly, comprising:

[0222] a toilet tank to hold flush water;

[0223] a flush valve assembly positioned in the toilet tank;

[0224] a toilet bowl;

[0225] a trapway in flow communication with the toilet bowl;

[0226] a container positioned in the toilet tank, and

[0227] a connecting tube extending from an interior of the container to the trapway,

[0228] wherein:

[0229] the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end,

[0230] the trapway comprises a sump trap, a first upstream weir, a connecting portion, a lower trap, and a second downstream weir,

[0231] the first upstream weir comprises a first arced shape arcing about a first center-point;

[0232] the lower trap comprises a second arced shape arcing about a second center-point;

[0233] the connecting portion forms a central arced path between the first upstream weir and the lower trap, wherein the central arced path extends laterally away from the first upstream weir and then extends laterally back toward the lower trap;

[0234] a first line extending through the first center-point and the second center-point is offset from a second line by at an offset distance of greater than or equal to 60 mm, wherein the second line is tangent to the central arced path and parallel to the first line; and

[0235] the connecting tube is coupled to the trapway at a position between the sump trap and the lower trap and provides flow communication between the container and the trapway.

[0236] 45. The toilet assembly of embodiment 44, wherein the second line is tangent to the central arced path at a location that is closer to the first upstream weir than to the lower trap.

[0237] 46. The toilet assembly of any one of embodiments 44-45, wherein the first arced shape has a larger radius than the second arced shape.

[0238] 47. The toilet assembly of embodiment 46, wherein the first arced shape has a radius of greater than or equal to 50 mm and less than or equal to 70 mm.

[0239] 48. The toilet assembly of any one of embodiments 44-47, wherein the second arced shape has a radius of greater than or equal to 20 mm and less than or equal to 70 mm.

[0240] 49. The toilet assembly of any one of embodiments 44-48, wherein, between flush cycles, the container comprises pressurized air positioned above flush water.

[0241] 50. The toilet assembly of any one of embodiments 44-49, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in pressurized air in the trapway.

[0242] 51. The toilet assembly of any one of embodiments 44-50, wherein, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in pressurized air in the trapway.

[0243] 52. The toilet assembly of any one of embodiments 44-51, wherein, between flush cycles, pressurized air in the trapway is pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

[0244] 53. The toilet assembly of any one of embodiments 44-52, wherein the first upstream weir is positioned above a highest point of a trapway inlet by an offset distance of greater than or equal to 2 inches.

[0245] 54. The toilet assembly of any one of embodiments 44-53, wherein the first upstream weir is positioned at point that, between flush cycles, is vertically higher than a water seal of the toilet bowl by a distance of greater than or equal to 0.2 inches.

[0246] 55. The toilet assembly of any one of embodiments 44-54, wherein the connecting tube comprises a backflow preventer.

[0247] 56. The toilet assembly of any one of embodiments 44-55, wherein the flush valve assembly comprises a valve body extending from a valve inlet to a valve outlet and a valve cover having a seal to enclose the valve inlet.

[0248] 57. The toilet assembly of any one of embodiments 44-56, wherein the container comprises a continuous side wall, an upper end wall, and an inner wall that together bound a vacuum chamber of the container.

[0249] 58. The toilet assembly of embodiment 57, wherein the inner wall bounds an inner chamber of the container.

[0250] 59. The toilet assembly of embodiment 57 or 58, wherein a vertical distance between a top surface of the connecting tube and an inner surface of the upper end wall is greater than or equal to 10 mm and less than or equal to 35 mm.

[0251] 60. The toilet assembly of any one of embodiments 44-59, wherein an internal diameter of the connecting tube is greater than or equal to 12 mm and less than or equal to 20 mm.

[0252] 61. The toilet assembly of any one of embodiments 44-60, wherein, between flush cycles, a vertical distance between a top surface of the connecting tube and a water level in the toilet tank is greater than or equal to 45 mm and less than or equal to 55 mm.

[0253] 62. A toilet assembly, comprising a toilet tank to hold flush water;

[0254] a flush valve assembly positioned in the toilet tank;

[0255] a toilet bowl;

[0256] a trapway in flow communication with the toilet bowl;

[0257] a container positioned in the toilet tank, and

[0258] a connecting tube extending from an interior of the container to the trapway,

[0259] wherein:

[0260] the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end,

[0261] the trapway comprises a sump trap, a first upstream weir, a lower trap, and a second downstream weir; and

[0262] the connecting tube is coupled to the trapway via an interface located at a position between the sump trap and the lower trap, and provides flow communication between the container and the trapway, wherein an upper end of the interface couples to the connecting tube and a lower end of the interface couples to the trapway, wherein a first edge of the lower end of the interface is located on an upper wall of the trapway directly above the first upstream weir.

[0263] 63. The toilet assembly of embodiment 62, wherein a second edge of the lower end of the interface is located on the upper wall of the trapway at a position having a same height as the first upstream weir.

[0264] 64. The toilet assembly of any one of embodiments 62-63, wherein a wall of the interface is tangent to the upper wall of the trapway at the first edge of the lower end of the interface.

[0265] 65. The toilet assembly of any one of embodiments 62-64, wherein the lower end of the interface is wider in at least one direction than the upper end of the interface.

[0266] 66. The toilet assembly of any one of embodiments 62-65, wherein the lower end of the interface is wider in a first direction than in a second direction.

[0267] 67. The toilet assembly of any one of embodiments 62-66, wherein, between flush cycles, the container comprises pressurized air positioned above flush water.

[0268] 68. The toilet assembly of any one of embodiments 62-67, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in pressurized air in the trapway.

[0269] 69. The toilet assembly of any one of embodiments 62-68, wherein, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in pressurized air in the trapway.

[0270] 70. The toilet assembly of any one of embodiments 62-69, wherein, between flush cycles, pressurized air in the trapway is pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

[0271] 71. The toilet assembly of any one of embodiments 62-70, wherein the first upstream weir is positioned above a highest point of a trapway inlet by an offset distance of greater than or equal to 2 inches.

[0272] 72. The toilet assembly of any one of embodiments 62-71, wherein the first upstream weir is positioned at point that, between flush cycles, is vertically higher than a water seal of the toilet bowl by a distance of greater than or equal to 0.2 inches.

[0273] 73. The toilet assembly of any one of embodiments 62-72, wherein the connecting tube comprises a backflow preventer.

[0274] 74. The toilet assembly of any one of embodiments 62-73, wherein the flush valve assembly comprises a valve body extending from a valve inlet to a valve outlet and a valve cover having a seal to enclose the valve inlet.

[0275] 75. The toilet assembly of any one of embodiments 62-74, wherein the container comprises a continuous side wall, an upper end wall, and an inner wall that together bound a vacuum chamber of the container.

[0276] 76. The toilet assembly of embodiment 75, wherein the inner wall bounds an inner chamber of the container.

[0277] 77. The toilet assembly of embodiment 75 or 76, wherein a vertical distance between a top surface of the connecting tube and an inner surface of the upper end wall is greater than or equal to 10 mm and less than or equal to 35 mm.

[0278] 78. The toilet assembly of any one of embodiments 62-77, wherein an internal diameter of the connecting tube is greater than or equal to 12 mm and less than or equal to 20 mm.

[0279] 79. The toilet assembly of any one of embodiments 62-78, wherein, between flush cycles, a vertical distance between a top surface of the connecting tube and a water level in the toilet tank is greater than or equal to 45 mm and less than or equal to 55 mm.

[0280] 80. A toilet assembly, comprising a toilet tank to hold flush water;

[0281] a flush valve assembly positioned in the toilet tank;

[0282] a toilet bowl;

[0283] a trapway in flow communication with the toilet bowl;

[0284] a container positioned in the toilet tank, and

[0285] a connecting tube extending from an interior of the container to the trapway,

[0286] wherein:

[0287] the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end,

[0288] the trapway comprises a sump trap, a first upstream weir, a lower trap, and a second downstream weir, wherein the trapway is wider at the a lowermost point of the lower trap than at the second downstream weir; and

[0289] the connecting tube is coupled to the trapway at a position between the sump trap and the lower trap, and provides flow communication between the container and the trapway.

[0290] 81. The toilet assembly of embodiment 80, wherein the trapway is wider at a lowermost portion of the lower trap than at an upstream end of the lower trap.

[0291] 82. The toilet assembly of any one of embodiments 80-81, wherein the trapway is wider at the first upstream weir than at an upstream end of the lower trap.

[0292] 83. The toilet assembly of any one of embodiments 80-82, wherein the trapway is equal in diameter at the first upstream weir than at the lowermost point of the lower trap.

[0293] 84. The toilet assembly of any one of embodiments 80-83, wherein the trapway is wider at the first upstream weir than at the lowermost point of the lower trap.

[0294] 85. The toilet assembly of any one of embodiments 80-84, wherein the trapway is narrower at the first upstream weir than at the lowermost point of the lower trap.

[0295] 86. The toilet assembly of any one of embodiments 80-85, wherein, between flush cycles, the container comprises pressurized air positioned above flush water.

[0296] 87. The toilet assembly of any one of embodiments 80-86, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in pressurized air in the trapway.

[0297] 88. The toilet assembly of any one of embodiments 80-87, wherein, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in pressurized air in the trapway.

[0298] 89. The toilet assembly of any one of embodiments 80-88, wherein, between flush cycles, pressurized air in the trapway is pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

[0299] 90. The toilet assembly of any one of embodiments 80-89, wherein the first upstream weir is positioned above a highest point of a trapway inlet by an offset distance of greater than or equal to 2 inches.

[0300] 91. The toilet assembly of any one of embodiments 80-90, wherein the first upstream weir is positioned at point that, between flush cycles, is vertically higher than a water seal of the toilet bowl by a distance of greater than or equal to 0.2 inches.

[0301] 92. The toilet assembly of any one of embodiments 80-91, wherein the connecting tube comprises a backflow preventer.

[0302] 93. The toilet assembly of any one of embodiments 80-92, wherein the flush valve assembly comprises a valve body extending from a valve inlet to a valve outlet and a valve cover having a seal to enclose the valve inlet.

[0303] 94. The toilet assembly of any one of embodiments 90-93, wherein the container comprises a continuous side wall, an upper end wall, and an inner wall that together bound a vacuum chamber of the container.

[0304] 95 The toilet assembly of embodiment 80-94, wherein the inner wall bounds an inner chamber of the container.

CONCLUSION

[0305] In some embodiments, dual-trap toilets described and/or shown herein may share any one or more characteristics in common with dual-trap toilets described, shown, and/or referenced in PCT publication no. WO2022046876A1, in PCT publication no. WO2022051331A1, and/or in PCT application no. PCT/US2021/060307 (filed Nov. 22, 2021), the entirety of each of which is hereby incorporated by reference.

[0306] Any one or more characteristics of any of the embodiments (including claims) described, shown, and/or referenced herein may be combined, in whole or in part, with any one or more characteristics of any one or more other embodiments (including claims) described, shown, and/or referenced herein.

[0307] The foregoing description, for the purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the techniques and their practical applications. Others skilled in the art are thereby enabled to best utilize the techniques and various embodiments with various modifications as are suited to the particular use contemplated.

[0308] Although the disclosure and examples have been fully described with reference to the accompanying figures, it is to be noted that various changes and modifications will become apparent to those skilled in the art. Such changes and modifications are to be understood as being included within the scope of the disclosure and examples as defined by the claims. Finally, the entire disclosure of the patents and publications referred to in this application are hereby incorporated herein by reference.

1. A toilet assembly, comprising

a toilet tank to hold flush water;

a flush valve assembly positioned in the toilet tank;

a toilet bowl;

a trapway in flow communication with the toilet bowl;

a container positioned in the toilet tank, and

a connecting tube extending from an interior of the container to the trapway,

wherein:

the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end, wherein the upper end of the container contains a first portion of pressurized air when the toilet assembly is between flush cycles,

the trapway comprises a sump trap, a first upstream weir, a lower trap, and a second downstream weir, and

the connecting tube is coupled to the trapway at a position between the sump trap and the lower trap, and provides flow communication between the container and the trapway, and

the trapway contains a second portion of pressurized air when the toilet assembly is between flush cycles, wherein a volume of the first portion of pressurized air is less than 30% of a volume of the second portion of pressurized air.

2. The toilet assembly of claim 1, wherein, between flush cycles, the first portion of pressurized air is positioned above flush water in the container.

3. The toilet assembly of claim 1, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in one or both of the first portion of pressurized air and the second portion of pressurized air.

4. The toilet assembly of claim 1, wherein, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in one or both of the first portion of pressurized air and the second portion of pressurized air.

5. The toilet assembly of claim 1, wherein, between flush cycles, the first portion of pressurized air and the second portion of pressurized air are pressurized at a pressure greater than or equal to 0.5 cm of water above atmospheric pressure and less than or equal to 5 cm of water above atmospheric pressure.

6. The toilet assembly of claim 1, wherein the first upstream weir is positioned above a highest point of a trapway inlet by an offset distance of greater than or equal to 2 inches.

7. The toilet assembly of claim 1, wherein the first upstream weir is positioned at point that, between flush cycles, is vertically higher than a water seal of the toilet bowl by a distance of greater than or equal to 0.2 inches.

8. The toilet assembly of claim 1, wherein the flush valve assembly comprises a valve body extending from a valve inlet to a valve outlet and a valve cover having a seal to enclose the valve inlet.

9. The toilet assembly of claim 1, wherein the container comprises a continuous side wall, an upper end wall, and an inner wall that together bound a vacuum chamber of the container.

10. The toilet assembly of claim 9, wherein the inner wall bounds an inner chamber of the container.

11. The toilet assembly of claim 9, wherein a vertical distance between a top surface of the connecting tube and an inner surface of the upper end wall is greater than or equal to 10 mm and less than or equal to 35 mm.

12. The toilet assembly of claim 1, wherein an internal diameter of the connecting tube is greater than or equal to 12 mm and less than or equal to 20 mm.

13. The toilet assembly of claim 1, wherein, between flush cycles, a vertical distance between a top surface of the connecting tube and a water level in the toilet tank is greater than or equal to 45 mm and less than or equal to 55 mm.

14. A toilet assembly, comprising

a toilet tank to hold flush water;

a flush valve assembly positioned in the toilet tank;

a toilet bowl;

a trapway in flow communication with the toilet bowl;

a container positioned in the toilet tank, and

a connecting tube extending from an interior of the container to the trapway,

wherein:

the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end,

the trapway comprises a sump trap, a first upstream weir, a lower trap, and a second downstream weir, and

the connecting tube is coupled to the trapway at a position between the sump trap and the lower trap, and provides flow communication between the container and the trapway, and

the trapway contains pressurized air when the toilet assembly is between flush cycles, wherein the pressurized air in the trapway exerts force on water in the lower trap such that an upstream water level in the lower trap is lower than a downstream water level in the lower trap by an offset distance of greater than or equal to 15 mm between flush cycles.

15. The toilet assembly of claim 14, wherein, between flush cycles, the container comprises pressurized air positioned above flush water.

16. The toilet assembly of claim 14, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in pressurized air in the trapway.

17. The toilet assembly of claim 14, wherein, re-filling the toilet tank with water to end a flush cycle, increased pressure is created in the pressurized air in the trapway.

18. A toilet assembly, comprising

a toilet tank;

a flush valve assembly positioned in the toilet tank;

a toilet bowl;

a trapway in flow communication with the toilet bowl;

a container positioned in the toilet tank, wherein the container comprises an inner chamber and a vacuum chamber, and

a connecting tube extending from an interior of the container to the trapway,

wherein:

the container is in flow communication with the toilet tank, the container having an open lower end and a closed upper end,

the trapway comprises a sump trap, a first upstream weir, a lower trap, and a second downstream weir, and

the connecting tube is coupled to the trapway at a position between the sump trap and the lower trap, and provides flow communication between the container and the trapway, and

during a flush cycle, the toilet assembly flushes a volume of flush water, wherein:

a first portion of the volume of flush water is stored in the tank prior to the flush cycle;

a second portion of the volume of flush water is stored in the vacuum chamber prior to the flush cycle;

a third portion of the volume of flush water is stored in the inner chamber prior to the flush cycle, wherein the third portion is greater than or equal to 40% of the volume of flush water.

19. The toilet assembly of claim 18, wherein the first portion is less than or equal to 20% of the volume of flush water.

20. The toilet assembly of claim 18, wherein the second portion is less than or equal to 40% of the volume of flush water.

21. The toilet assembly of claim 18, wherein, between flush cycles, the container comprises pressurized air positioned above flush water in the vacuum chamber.

22. The toilet assembly of claim 18, wherein, upon discharging water into a flush valve core to initiate a flush cycle, reduced pressure is created in pressurized air in the trapway.

23. The toilet assembly of claim **18**, wherein, upon re-filling the toilet tank with water to end a flush cycle, increased pressure is created in pressurized air in the trapway.

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