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(54) **PRESSURE-ASSISTED TOILET FLUSH CARTRIDGE**

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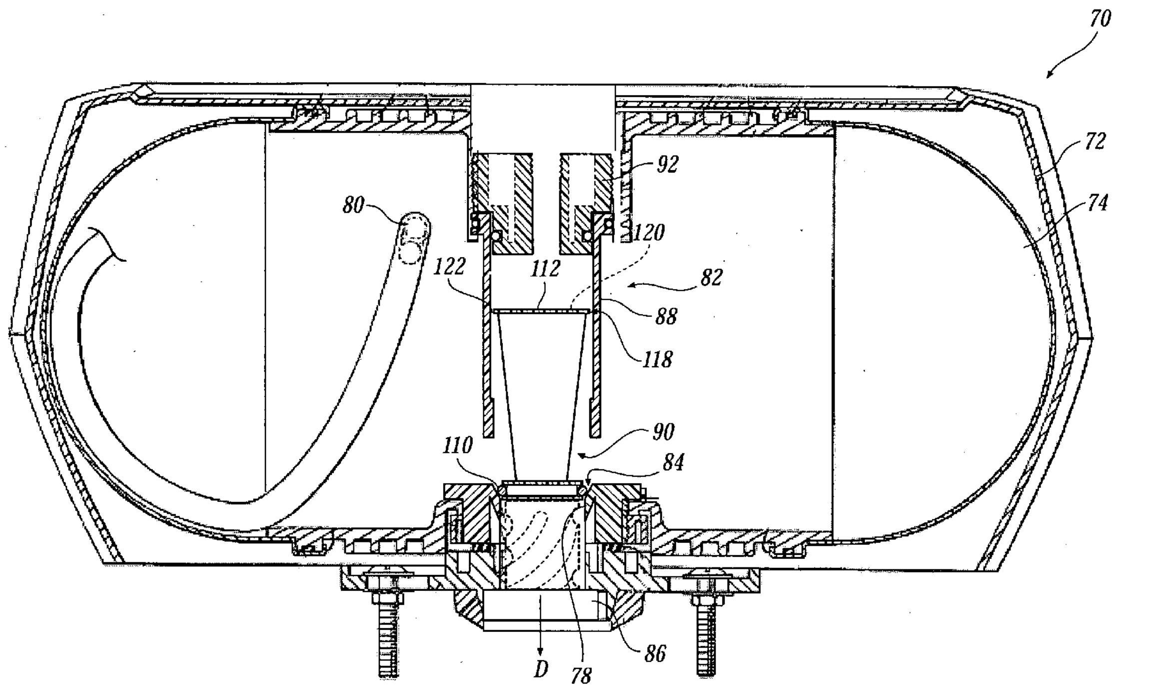
(57) **ABSTRACT**

A pressure assisted toilet flush cartridge that reduces noise output by controlling water flow. One aspect of the noise reduction is to reduce the initial discharge increase in flow rate. Another aspect is to create a vortex in discharge water to reduce cavitation and quiet the discharged water flow through the bowl.



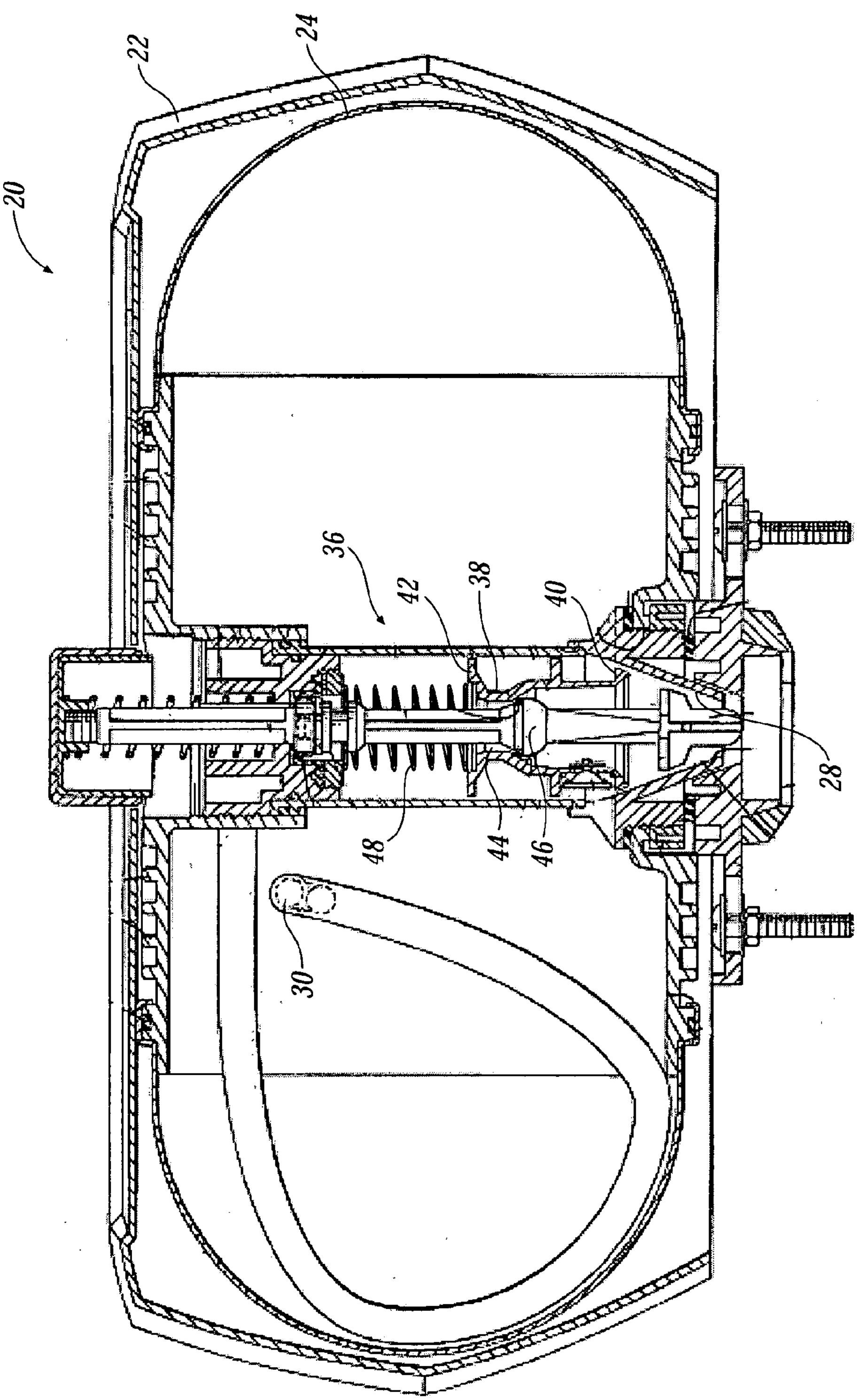


FIG. 1
(PRIOR ART)

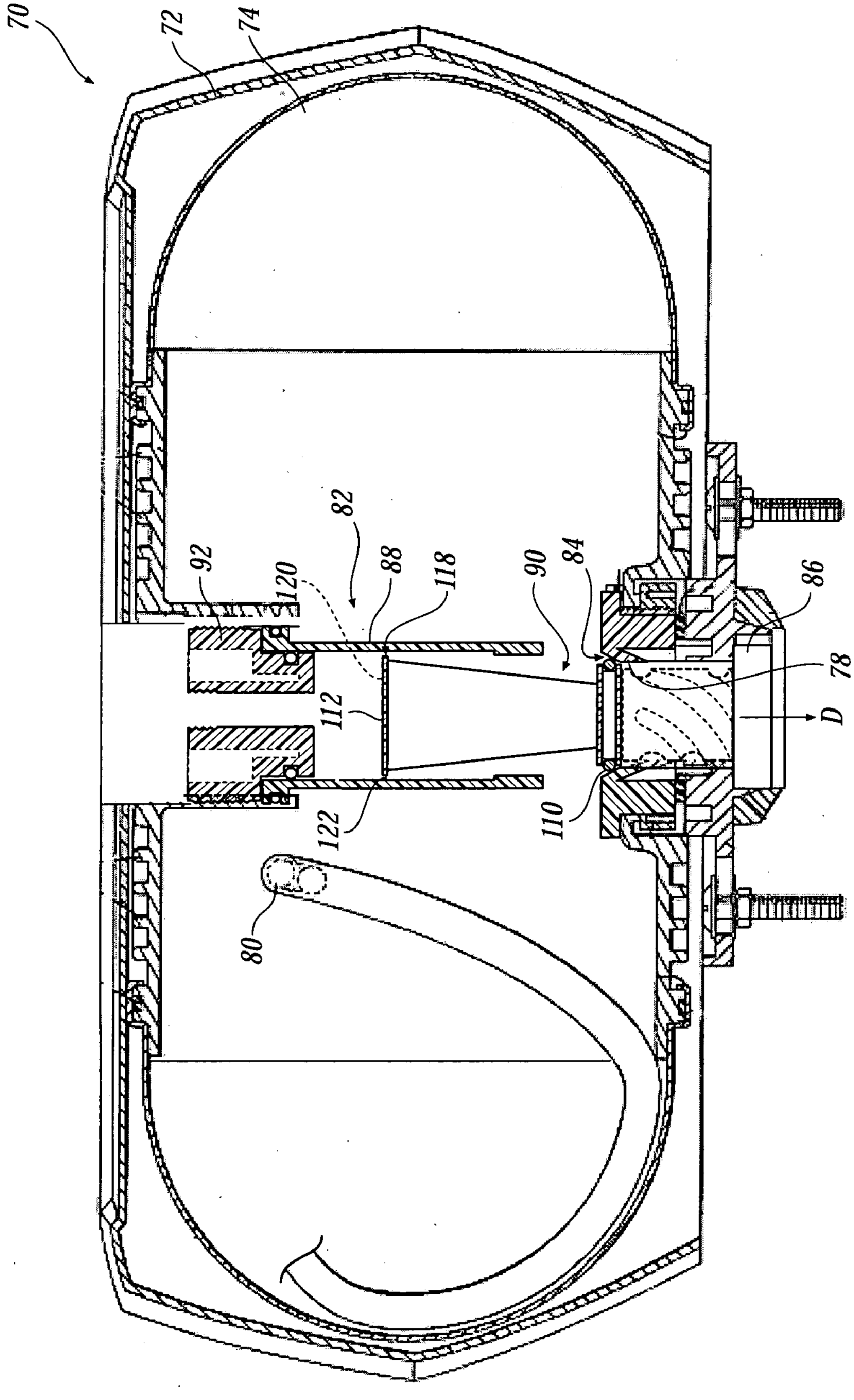


FIG. 2

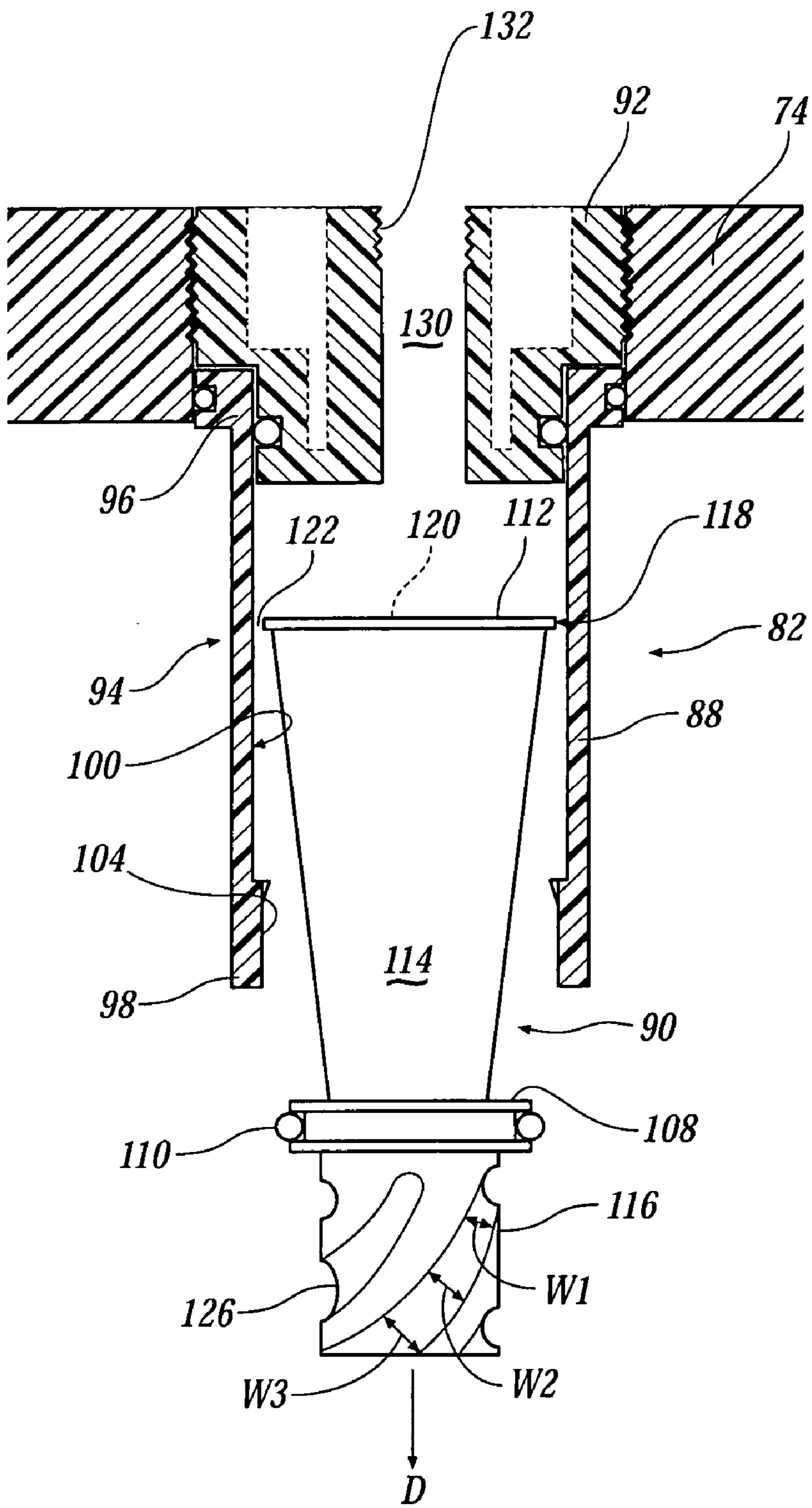

132
92
74
130
96
122
120
112
118
82
94
88
100
104
114
98
90
110
108
116
W1
126
W2
W3
D

FIG. 3

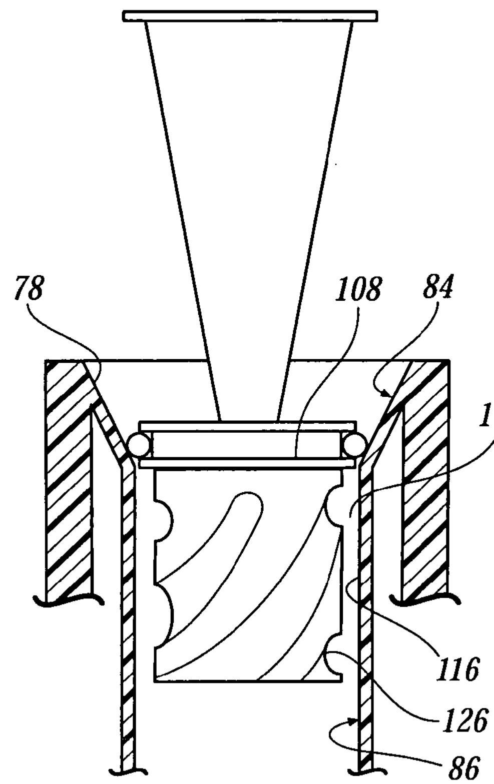


FIG. 3A

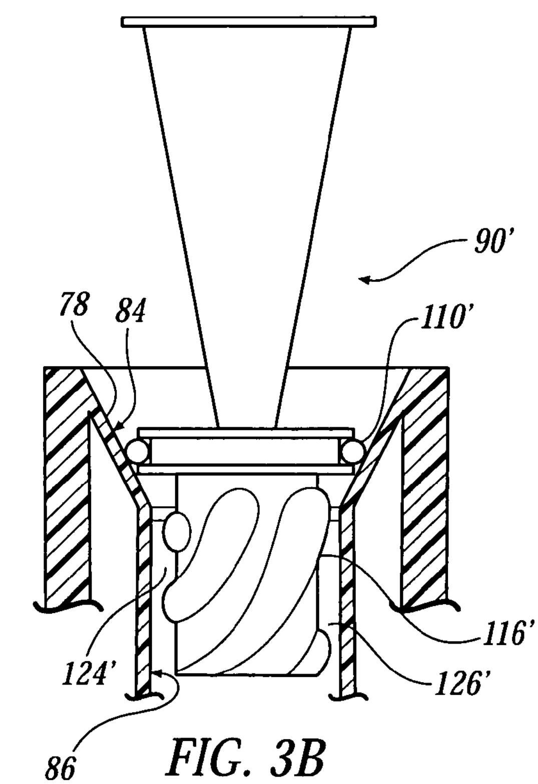


FIG. 3B

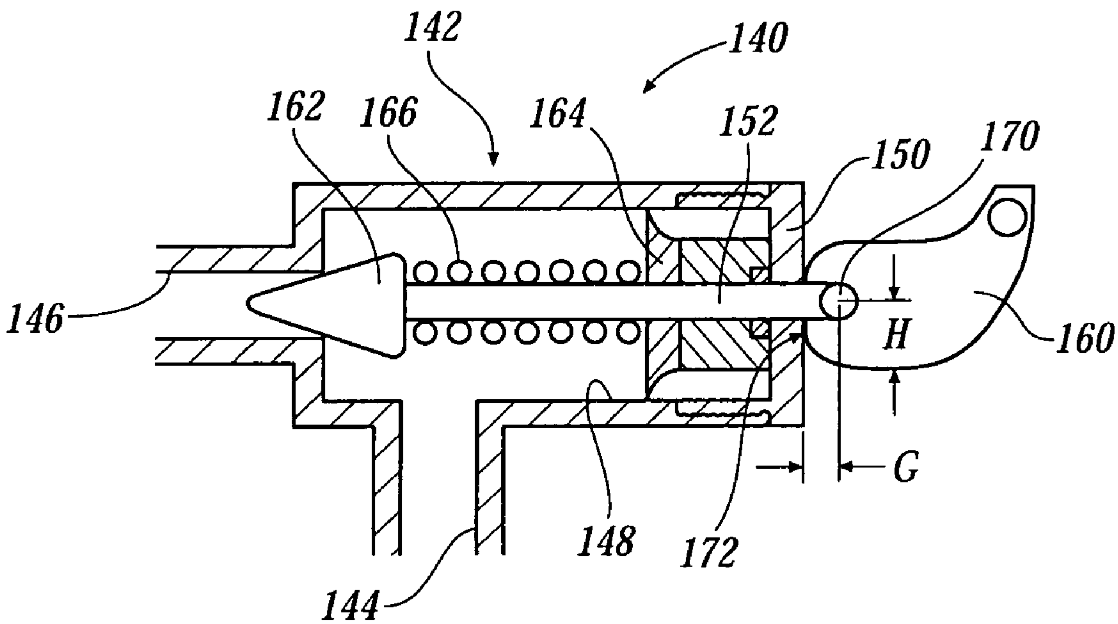


FIG. 4

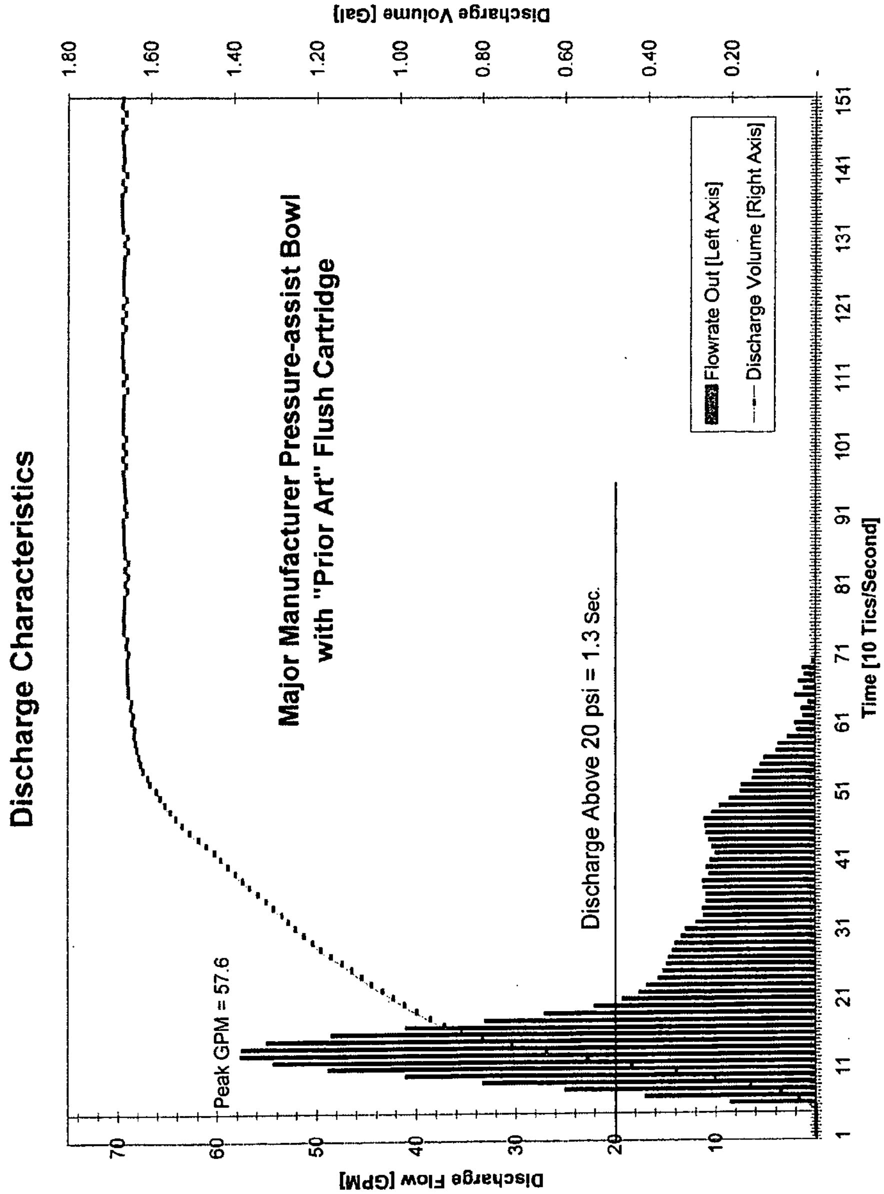


FIG. 5
(PRIOR ART)

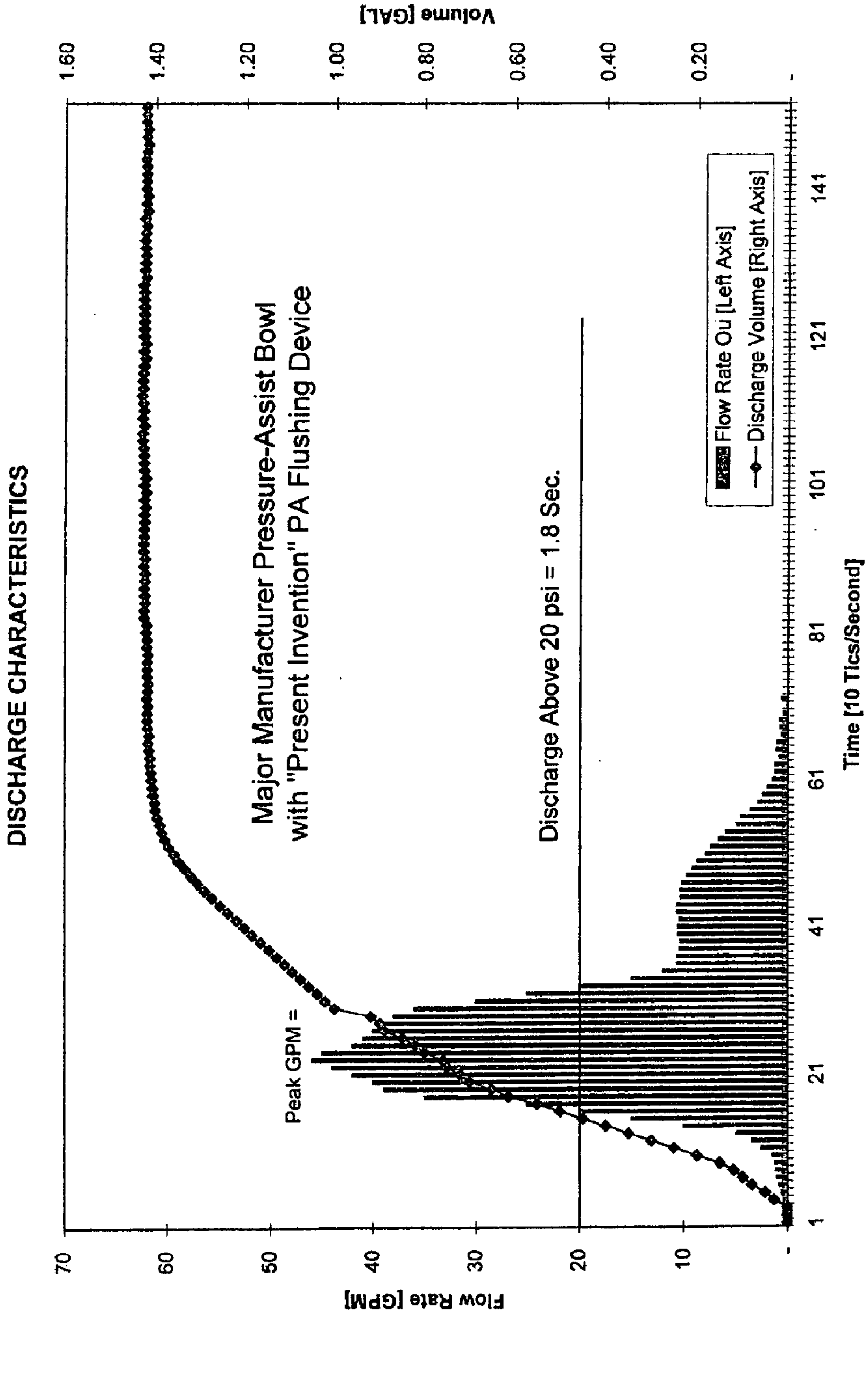

DISCHARGE CHARACTERISTICS
Major Manufacturer Pressure-Assist Bowl
with "Present Invention" PA Flushing Device
Discharge Above 20 psi = 1.8 Sec.
Peak GPM =
Flow Rate Ou [Left Axis]
Discharge Volume [Right Axis]
Flow Rate [GPM]
Volume [GAL]
Time [10 Tics/Second]
70
60
50
40
30
20
10
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
1
21
41
61
81
101
121
141

FIG. 6

PRESSURE-ASSISTED TOILET FLUSH CARTRIDGE

TECHNICAL FIELD

[0001] The present invention relates to a pressure assisted toilets, and more specifically to a flush cartridge for a pressure assisted toilet.

BACKGROUND OF THE INVENTION

[0002] A pressure assisted toilet system typically includes a vessel, a supply system and a flush cartridge. The supply system typically includes a backflow prevention and a pressure regulator to ensure that the vessel is maintained below a desired pressure. Since the vessel is fully sealed, it retains the supply pressure after each flush cycle refill. This supply pressure, typically 45-55 psi, pressurizes the pressure tank to its prescribed level and provides a motive force for a subsequent flush of a toilet bowl. Prior art pressure assisted toilet systems are found in U.S. Pat. Nos. 4,223,698, 5,361, 426, and RE37,921 the disclosures of which are hereby incorporated by reference in their entireties.

[0003] **FIG. 1** illustrates a prior art pressure assisted toilet system **20**. System **20** is typically encased in an outer vitreous china housing **22**, a vessel **24** having a discharge outlet **28** and an inlet **30**, and a flush valve cartridge **36**. Flush valve cartridge **36** includes a flush valve **38** having a seal **40**, a top flange **42**, and an escape hole **44** formed therein, a flush valve enlargement **46** interposed through and sealing with the escape hole **44**, and a flush valve spring **48**. Seal **40** of flush valve **38** seats against discharge outlet **28** in order to allow pressure tank **24** to fill with water. When ready to be flush, upper chamber **47** contains both water and air compressed by the pressure To flush system **20**, an actuation lever urges valve enlargement **46** downward, which permits water (and air) to flow through escape hole **44**, thereby reducing the pressure above flush valve **38** within cartridge **36**. With this pressure reduced, flush valve **38** is forced upward by the pressure differential created between the tank **24**, and the area above the flush valve. As the flush valve lifts, water is discharged through discharge outlet **28**.

[0004] A disadvantage of the prior art pressure assisted toilet system is that the noise generated during flushing has restricted its use in residential applications where excessive noise is undesirable. This noise is partially due to the rapid change in water flow rate, cavitation, and flow direction. Additionally, multiple parts are required to flush prior art toilets, thus adding to the expense of these systems. What is needed, therefore, is a pressure assisted toilet system that controls the flow of water such that noise is reduced to more acceptable levels.

SUMMARY OF THE INVENTION

[0005] The present invention relates to reducing the noise output of a pressure assisted toilet. The inventor has found that reducing the rate of initial water flow during a flush and swirling the water discharge from the pressure tank to the bowl individually reduce undesirable noise, and that a combination of these two reduce noise even further when compared to units such as, for example, the U.S. Pat. No. 4,223,698 Patent.

[0006] An embodiment of the pressure assisted toilet flush cartridge includes a generally cylindrical housing having a top end, a bottom end, an internal surface and a discharge aperture having a first predetermined area. The cartridge further includes a flush valve interposed within the housing and having a top flange, a generally conical hollow body with a top flange opening, and a lower extension, where the flange and the internal surface define a generally annular gap having a second predetermined area, and where the first predetermined area is larger than the second predetermined area.

[0007] Another embodiment of the present invention provides a flush valve for a pressure assisted toilet that includes a top outer edge circumscribing a predetermined area, a flush valve seal selectively in sealing contact with a vessel outlet and a generally hollow body connecting the top outer edge and the valve seal. The body has an opening and contains a predetermined volume of water, where the volume of water provides a motive force to assist reseating the flush valve seal to seat with a vessel outlet.

[0008] A further embodiment includes method of reducing noise in a pressure assisted toilet that includes imparting a swirling effect in a fluid discharged from the pressure tank to create a vortex.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

[0010] **FIG. 1** is a sectional elevation view of a prior art pressure assisted flush system including the flush cartridge.

[0011] **FIG. 2** is a similar sectional elevation view as in **FIG. 1** except that a flush cartridge in accordance with an embodiment of the present invention has replaced the prior art version

[0012] **FIG. 3** is an enlarged partial sectional elevation view of the flush cartridge of **FIG. 2**.

[0013] **FIG. 3A** is an enlarged sectional elevation of the flush cartridge of **FIG. 2**.

[0014] **FIG. 3B** is an enlarged sectional elevation view similar to **FIG. 3A**, illustrating an alternate embodiment of a portion of the flush cartridge.

[0015] **FIG. 4** is a sectional view of a conceptual actuator cartridge for the flush cartridge of **FIG. 2**.

[0016] **FIG. 5** is a graphical depiction of flow/volume results of a prior art flush cartridge.

[0017] **FIG. 6** is a graphical depiction of flow/volume results of an embodiment of a flush cartridge of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] **FIG. 2** illustrates a pressure assisted toilet flush system **70** in accordance with an embodiment of the present invention. The system **70** includes a vessel, or pressure tank, **74** having a discharge outlet **78** and an inlet **80**, and a flush cartridge **82**. Discharge outlet **78** is preferably defined in part by a frusto-conical interior surface **84** and a generally cylindrical surface **86**, as discussed below.

[0019] With reference to **FIGS. 2 and 3**, flush cartridge **82** includes a jacket, or outer housing, **88**, a flush valve **90**, and a top cap **92**. Outer housing **88** includes a cylindrical body (or jacket) **94** that extends from a top end **96** to a bottom end **98**, and an internal surface **100**. Top end **96** defines a larger inside diameter than bottom end **98**, and internal surface **100** is accordingly tapered from top end **96** to bottom end **98**. Internal surface **100** includes a retaining element **104** disposed thereon and extending inwardly from the internal surface **100**. Preferably, retaining element **104** is three equally spaced retaining lugs formed on the internal surface during forming of outer housing **88**.

[0020] The flush valve **90** includes a seal retaining portion **108**, a seal **110**, a top flange **112**, a generally hollow frusto-conical body **114** extending therebetween, a lower portion **116** extending below the seal **110**, and a top flange opening **120** that extends from body **114** past top flange **112**, thus providing a hole for filling body **114** of flush valve **90**, as discussed below. Preferably, seal **110** is a conventional o-ring that is restrained within seal retaining portion **108** and extending radially therefrom in sealing contact with discharge outlet **78** when flush valve **90** is closed, as discussed in greater detail below. Top flange **112** includes a top outer edge **118** that defines a predetermined area.

[0021] A generally annular gap **122** is located between top outer edge **118** and internal surface **100**. Gap **122** increases slightly as flush valve **90** rises within outer housing **88** due to the taper of internal surface **100**. Gap **122** allows fluid to pass from pressure tank **74** to flush cartridge **82**, as discussed below.

[0022] Lower portion **116** is illustrated with a helical groove **126** formed therein. Helical groove **126** is illustrated with a semi-circular section, although any suitable section may be formed on lower portion **116**. The effective width, W of helical groove **126** increases as helical groove **126** extends away from seal retaining portion **108**. As best seen in **FIG. 3**, helical groove **126** has an effective width W1 at the end closest to seal retaining portion **108**. Helical groove **126** has an effective width W2 at about the midpoint of helical groove **126** and an effective width W3 adjacent the end that is opposite seal retaining portion **108**. W3 is greater than W2, which is greater than W1. Preferably, W3 is about 50% greater than W1. Varying the size of the semi-circular passages of helical groove **126** varies both the effective area of gap **124** and the initial discharge flow rate and thus varies the rate of lift and the circularity of water into the bowl adjacent generally cylindrical surface **86**, as discussed below. With reasonable extremes, the more circularity, the greater the flow noise reduction.

[0023] While body **114** is described as being frusto-conical shaped, body **114** may be any suitable shape that retains fluid and connects top flange **12** to seal retaining portion **108**. Flange opening **120** allows water to enter body **114** while body **114** retains the water to provide a downward force (illustrated as D in **FIGS. 2 and 3**). Top cap **92** includes a top passageway **130** extending there through and connecting outer housing **88** with an actuation port **132**. The actuation of flush valve **90** via actuation port **132** is discussed with reference to **FIG. 4**, below.

[0024] With specific reference to **FIG. 3A**, a generally annular gap **124** is located between generally cylindrical surface **86** and lower portion **116** adjacent width W1 of helical groove **126**. Gap **124** allows water to travel from pressure tank **74** to the bowl (not shown). Gap **124** controls the discharge flow rate from pressure tank **74** as discussed in greater detail below.

[0025] The area of passageway **130** (**FIG. 3**) is greater than the combination of the area defined by gap **122** (**FIG. 3**) and the area defined by gap **124** (adjacent width W1, **FIG. 3A**). Preferably, the area of passageway **130** is at least 20% greater than the combination of the area defined by gap **122** and the effective area defined by gap **124**.

[0026] **FIG. 3A** illustrates the lower portion **116** of **FIG. 2** with helical groove **126**. **FIG. 3B** illustrates an alternate embodiment where a lower portion **116'** includes a helical protrusion **126'**. Helical protrusion **126'** creates an outwardly extending fin that imparts a swirling effect within the water discharged from pressure tank **74**

[0027] **FIG. 4** illustrates a simple actuator assembly **140**. Actuator assembly **140** includes an actuator body **142** having an inlet **144**, an outlet **146**, a cylindrical interior surface **148**, and an endcap **150**. Endcap **150** has a plunger **152** extending there through and connects an actuator handle **160** with a grommet seal **162**. Plunger **152** has an elastomeric cup seal **164** attached thereto with a return spring **166** extending between. Actuator handle **160** is rotatable with respect to plunger **152** via pin **170**. Actuator handle **160** includes an actuation surface **172** that defines a generally equiangular spiral. That is, actuation surface **172** is curved such that distance H is greater than distance G. Inlet **144** is in fluid communication with the actuation port **132**. Outlet **146** is open to the atmosphere within china housing **72** or can be connected to the vessel's outlet below seal **110**. While actuator assembly **140** can be made of any suitable material, acetal plastic would be preferred.

[0028] When installed, system **70** is filled with water through inlet **80**. The American National Standard mandates that the typical residential water pressure range between 20 psi to no more than 80 psi. Preferably, a pressure relief valve (not shown) is located in the water line between a water source and inlet **80** to restrict inlet water pressure to the desired pressure (usually around 25 psi). After filling, vessel **74** is pressurized to the inlet water pressure setting. This tank pressure urges seal **110** into a binding contact with discharge outlet **78** and grommet seal **162** into a binding contact with outlet **146**. Since air is compressible and water is not, as vessel **74** refills after being flushed, the air within the vessel **74** and flush cartridge **82** is compressed into flush cartridge **82**. During the first fill, some water will pass through gap **122** and enter body **114**. When the pressure within vessel **74**, flush cartridge **82**, and actuation assembly **140** equalize, flow into the assembly ceases.

[0029] In operation, an operator rotates actuation handle **160** such that grommet seal **162** is unseated from outlet **146**. This releases compressed fluid from actuator assembly **140** and outer housing **88** such that the pressure above flush valve **90** is reduced and falls below the pressure within vessel **74**. The pressure above flush valve **90** falls below the pressure within vessel **74** because the area of passageway **130** is greater than the area defined by gap **122** plus the area defined by gap. The relationship between outlets **130** and **146** to gaps **122** & **124** is critical because if their combined area is too close to equal, the flush valve's lift will be restricted causing an insufficient discharge flow rate to cause proper extraction of the water closet bowl. fluid released through outlet **146** flows into the china housing (not shown) and eventually through a drain passageway into the water closet bowl.

[0030] The greater pressure below flush valve **90** causes flush valve **90** to rise. When flush valve **90** rises, seal **110** unseats from discharge outlet **78**, thereby permitting water from vessel **74** to escape through discharge outlet **78**. After the majority of water within pressure tank **74** has discharged through discharge outlet **78**, thereby reducing the pressure within pressure tank **74**, flush valve **90** falls due to the force of gravity and seal **110** reseats on discharge outlet **78**. Because the water within body **114** of flush valve **90** is retained, this creates an extra force that ensures that the flush valve falls, or returns to a seated position. Flush valve lower portion **116** ensures that the flush valve **90** remains centered for proper seating and sealing. As pressure tank **74** refills, pressure within pressure tank **74** increases, thereby ensuring a proper seat between seal **110** and discharge outlet **78**, and grommet seal **162** and outlet **146**.

[0031] Helical grooves **126** divert the water flowing through gap **124** into a swirling pattern, or vortex, as a portion of the flowing water flows within each helical groove **126**. As flush valve **90** begins to lift from its seat on surface **84**, a limited amount of water is allowed to flow through discharge outlet **78** as the effective area defined by gap **124** is limited by dimension W1 of helical grooves **126** and the clearance between surface **86** and lower portion **116**. As flush valve **90** continues to rise, the effective area defined by gap **124** increases as the width of helical grooves increase, thereby permitting greater flow. This characteristic of flush valve **90** results in a gradual increase in flow of water through discharge outlet **78** as flush valve **90** rises.

[0032] As best seen in **FIG. 5**, a prior art flush valve, such as the flush valve disclosed in U.S. Pat. No. 4,223,698, without a helical groove formed on a lower portion, and installed on a major manufacturer's pressure-assisted bowl permits an initial spike in discharge flow that results in a maximum discharge flow of 57 gpm within 0.1 second after flushing. Of special interest is that the initial increase in flow rate of water discharged spikes as the flush valve is opened. At a tank test pressure of 50 psi and background noise level of 40 db, the operation illustrated in **FIG. 5** was measured at 84.2 db.

[0033] **FIG. 6** illustrates a similar flush valve with helical groove **126** formed on a lower surface extending through the discharge outlet **78** when the flush valve **90** is in the unseated position to restrain the maximum discharge flow to 46 gpm at approximately 0.2 seconds after flushing. When compared to **FIG. 5**, the initial increase in flow rate is more gradual, thereby reducing the flow noise. This gradual increase in flow rate is due, at least in part, to the width W1 of helical groove **126** being less than the width W3. Since the width W1 makes the effective area of gap **124** less as the flush valve **90** begins to rise, the volume of water permitted through discharge outlet **78** in about the initial second of flow is less than the volume of water permitted. Also, because of the changed relationship between inflow and outflow areas, the duration of discharge above 20 psi is extended, thus allowing improved extraction capability. At a water supply test pressure of 50 psi and background noise level of 40 db, the operation illustrated in **FIG. 6** was measured at 78.0 db. The graphical representations of **FIGS. 5 and 6** illustrate that the initial increase in flow rate of water discharged and existence of backpressure affect noise levels.

[0034] Additionally, the vortex imparted into the flow illustrated in **FIG. 6** reduces cavitation immediately past the lower portion **116** as the pressure is reduced due to the increase in area for water flow, thereby reducing noise. Also, the vortex flow through the inner areas of the bowl (not shown) reduces noise associated with normal pressurized water flow through a pressure assisted toilet bowl.

[0035] While the invention has been described with respect to specific examples including preferred modes of carrying out the invention, those skilled in the art will appreciate that there are numerous variations and permutations of the above described systems and techniques that fall within the spirit and scope of the invention as set forth in the appended claims. Specifically, bowl tolerances and hydraulic designs may effect the overall noise levels during a flush.

What is claimed is:

1. A mechanism for initiating a flush of a pressure assisted toilet, comprising:

a generally cylindrical housing having a top end, a bottom end, an internal surface and a discharge aperture having a first predetermined area;

a flush valve interposed within said housing and having a top flange, a generally hollow body with a top flange opening, and a lower extension, wherein said flange and said internal surface define a generally annular gap having a second predetermined area, and wherein said first predetermined area is larger than the second predetermined area.

2. The mechanism of claim 1, wherein said flush valve further comprises a flush valve seal selectively in sealing contact with a pressure tank outlet.

3. The mechanism of claim 2, wherein said hollow body selectively contains a predetermined volume of water, and wherein said volume of water provides a motive force to assist said flush valve seal to seat with the pressure tank outlet.

4. The mechanism of claim 2, wherein said lower extension selectively extends through the pressure tank outlet.

5. The mechanism of claim 1, wherein said housing further comprises a retaining element disposed on said internal surface, wherein said retaining element interferes with said top flange to prevent said flush valve from undesirably passing through said bottom end.

6. The mechanism of claim 1, wherein said wherein said lower extension has a generally helical muffler surface.

7. The mechanism of claim 6, wherein said generally helical muffler surface comprises a helical groove formed within said lower extension.

8. The mechanism of claim 1, wherein said lower extension imparts a vortex in fluid flowing past said lower extension.

9. The mechanism of claim 1, wherein said flush valve is actuated by a decrease in pressure within said housing.

10. A flush valve for a pressure assisted toilet, comprising:

an edge circumscribing a first predetermined area;

a flush valve seal selectively in sealing contact with a vessel outlet;

a generally hollow body connecting said edge and said valve seal and having an opening, wherein said hollow body selectively contains a predetermined volume of water, and wherein said volume of water provides a motive force to assist said flush valve seal to seat with a vessel outlet.

11. The flush valve of claim 10, further comprising a lower extension, wherein said lower extension has a generally helical muffler surface.

12. The flush valve of claim 11, wherein said generally helical muffler surface comprises a helical groove formed within said lower extension.

13. The flush valve of claim 11, wherein said generally helical muffler surface comprises a helical fin extending from said lower extension.

14. The flush valve of claim 10, wherein said flush valve is selectively interposed within an outer housing of a flush cartridge, the flush cartridge including a passageway of a second predetermined area, said edge and an internal surface of the outer housing define a generally annular gap having a third predetermined area;

wherein a lower portion of said flush valve is selectively interposed within a discharge outlet, said lower portion and the discharge outlet defining a gap having a fourth predetermined area; and

wherein the second predetermined area is greater than the combination of the third predetermined area and the fourth predetermined area.

15. The flush valve of claim 10, wherein said lower extension creates a vortex in fluid flowing past said lower extension.

16. A method of reducing flushing noise in a pressure assisted toilet, wherein the pressure assisted toilet includes a pressure-assisted tank, the method comprising:

imparting a swirling effect in a fluid discharged from the pressure tank to create a vortex.

17. The method of claim 16, further comprising:

determining an initial flow rate of water discharged from said pressure tank; and

reducing the initial flow rate.

18. The method of claim 16, wherein said vortex is created outside said pressure tank.

19. The method of claim 16, further comprising:

determining the a maximum flow rate of water discharged from said pressure tank; and

reducing said maximum flow rate.

20. The method of claim 16, further comprising limiting the initial discharge flow rate from the pressure tank by limiting the effective area for flow of fluid as the fluid begins to flow.

21. A flush valve cartridge for a toilet comprising:

an outer housing having an internal surface;

a passageway having a first predetermined area to permit flow of a fluid; and

a flush valve at least partially interposed within said outer housing, said flush valve including an edge and a lower portion, wherein said edge and said internal surface define a gap having a second predetermined area, said lower portion is at least partially interposed within a discharge outlet of the toilet, said lower portion and said discharge outlet defining a generally annular gap having a third predetermined area, and wherein said first predetermined area is larger than the combination of said second predetermined area and said third predetermined area.

22. The cartridge of claim 21, wherein said lower portion is selectively raised relative to the discharge outlet and said third predetermined area increases as said lower portion is selectively raised.

23. The cartridge of claim 21, wherein said flush valve further comprises a generally hollow body selectively adapted to fill with a fluid.

24. The cartridge of claim 21, further comprising a helical groove formed on said lower portion.

* * * * *