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(54) **TOILET BOWL VENTING SYSTEM**

(57) A damp-proof venting device comprising a proximity sensor switch, fan blower, two solenoid valves and a control unit, powered by an external power supply, vents toilet bowl malodour directly into the toilet's sewerage drain, bypassing the toilet's primary water trap via an independent pressure-driven air passage sealed by a secondary independent water trap. Said control unit regulates the operation of venting unit's air blower and two solenoid valves, thus ensuring directionality of displaced air during the venting stage as well as sealing the venting passage after use under all possible circumstances, all in synchronicity with the toilet's engagement by user.

A slight variation of said device allows for retrofitting onto geometry and space-accommodating market-available toilet models.

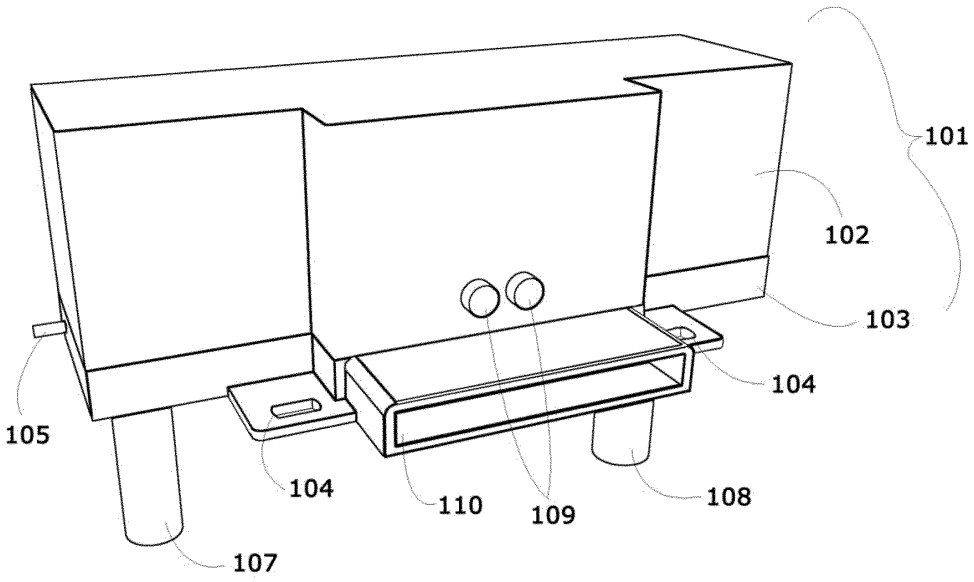

Fig 1a

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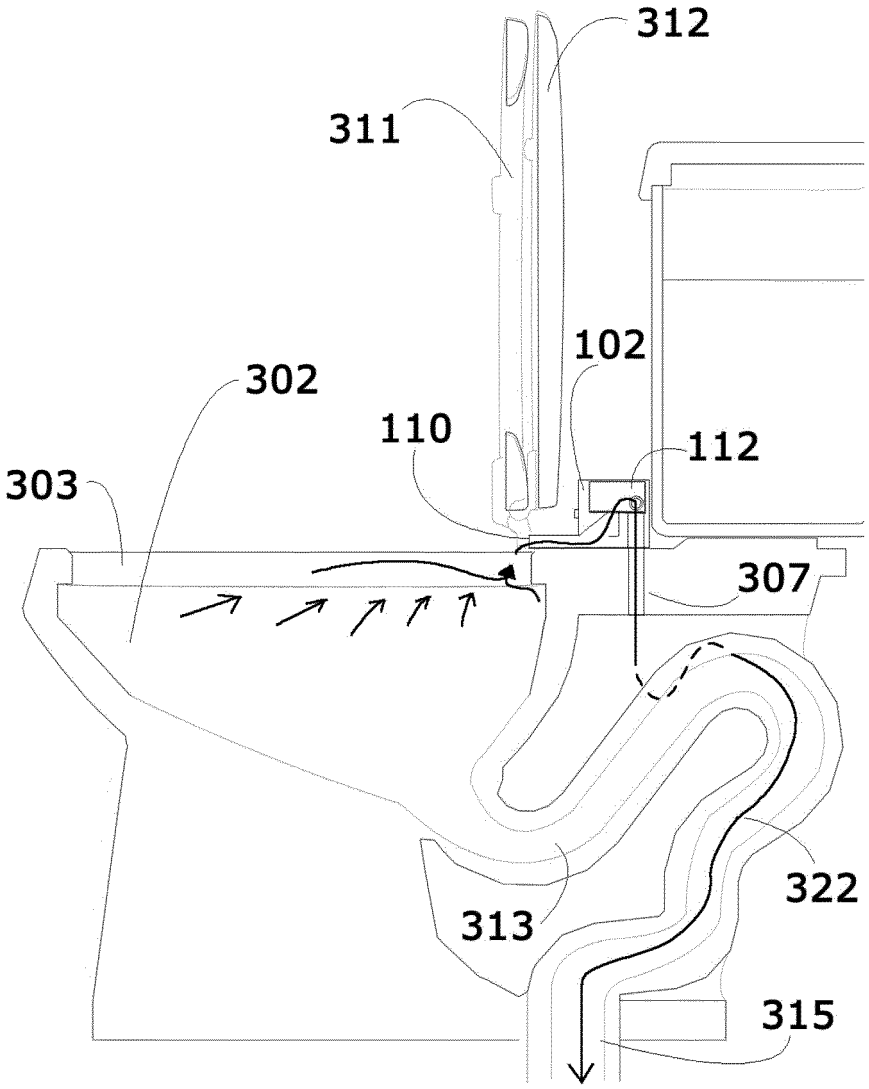

Fig 6b

Description

Background of the invention

[0001] The present invention relates to the comfortable, hygienic, efficient, practical and reliable redirection of toilet bowl malodour directly from the toilet bowl into the toilet's sewerage drain via a geometrically-compatible venting device incorporated within a prepared toilet commode or retrofitted onto a regular toilet commode. Said device is economical to mass produce, install and operate, offering a reliable solution to the age-old problem of toilet odours.

[0002] Many attempts have been made to provide a solution to toilet molodour. These attempts can be grouped into three vent exit-point categories: 1) Ejecting toilet room volume air via an extraction fan to outside of toilet room space, 2) Filtering or deodorising toilet bowl air prior to ejecting it into, or outside of, toilet room space, and 3) Directly venting toilet bowl air outside of toilet room space.

[0003] Firstly, ejection of toilet room volume air is the least convenient as well as the least efficient. This is due to the need for evacuating the toilet room's complete air volume as a result of malodour's diffusion - as opposed to the limited malodorous air volume within the toilet bowl. Furthermore, additional construction work is required, resulting in the creation of holes within windows and masonry as well as obtrusive ducting in some cases.

[0004] Secondly, malodour treatment requires the replacement of consumable filtering or deodorising cartridges, which incurs a continuous expense and produces unnecessary waste. Also, said consumables' effectiveness diminishes with time, resulting in incomplete odour treatment when nearing the end of the consumable's life, while said consumable cannot be guaranteed to be readily available throughout said toilet's lifetime. Meanwhile, deodorisers cause discomfort to many, irritating air passages and triggering allergic-type reactions.

[0005] Thirdly, direct toilet bowl malodour ejection is carried out either via the toilet's sewerage drain, via specially-installed dedicated piping other than the toilet's direct sewerage drain, or via external air ducting network. Exiting via toilet's sewerage drain can be the most ideal method, as it does not involve the installation of dedicated venting ducts with all associated expense and obtrusiveness. The aforementioned is, of course, provided that all aspects related to the total screening of the venting apparatus (and the user) from contamination from the sewerage system are properly addressed under all circumstances. Various attempts have been made to address this sealing issue, but most, if not all, fail to provide complete practicable ergonomic and economic solutions, which explains the obvious failure of these systems to succeed in the market.

[0006] Further to the methods of vented malodour exit points are the methods of malodorous air uptake from toilet bowl. Said methods include air intake via toilet seat, via the toilet's flush water apertures or via singular or plural air inlets within the toilet bowl. Many of such methods directly expose toilet excreta with locales favourable to the proliferation of bacteria and viruses, such as edges, channels, openings and baffles. Said locales are also challenging to clean.

[0007] An inevitable consequence of having piping and tubing that channel malodorous air flow from the seat is the operational wear-and-tear of the seat's hinged piping point/s, as well as the system's dependence on the integrity of the seat itself - an unnecessary, costly and bothersome inconvenience in the case of its replacement.

[0008] In the case of withdrawing air through the toilet's pre-existing flush water apertures, the method requires a complex venting system that traverses through the toilet's flush system, which, in the case of bowl flooding, may suck water into the venting apparatus and would also be an additional burden to deal with during any form of toilet maintenance. This method also results in an interruption in venting during the flushing stage, which might render the whole venting operation useless.

[0009] Other forms of air intake methods, such as tubing associated within the toilet bowl area, favour bacterial proliferation and are difficult to clean.

[0010] Many venting systems are located within the flush tank or in a chamber beneath the toilet commode's bowl. Said venting units' locations - and their relevant components' - accessibility, affects the unit's practicality and convenience relating to any maintenance work.

[0011] In cases of toilet bowl overflow, all of the aforementioned direct bowl air-venting methods are at risk of intake of waste water into their venting systems. This can damage the system's electromechanical and electrical parts. If the system is not rendered unserviceable, it will require considerable cleaning and maintenance to remove all traces of excreta particulates, which will become a continuous source of malodour as well as a haven for bacteria, viruses and other causes of disease. Therefore, malodour extraction point should lie above toilet bowl's flood level to protect the venting system's components from excreta-laden water.

[0012] Furthermore, a reliable control system is vital to having a reliable venting system. Automatic control of a venting system relies on sensors to signal the user's presence and departure. Various sensing methods have been proposed, such as pressure switches on or below toilet seat, but such switches rely on mechanical triggers, which increase the chance of wear and faults. Motion sensors have been proposed, but these create a signal when there is a change in field of view and therefore cannot properly measure presence, or lack thereof, a seated person. In the case of cheap, reliable and ubiquitous proximity sensors such as infrared or ultrasonic types, practical control steps are rarely addressed that prevent unwanted activation and/or deactivation of the ventilation system caused by irrelevant triggers such as toilet seat or cover raising/lowering or fleeting movements in the vicinity of the toilet seat.

[0013] In all cases relating to venting units integrated into public toilets, the venting unit and its supporting components need to be tamper and theft-resistant.

Prior art

[0014] WIPO patent WO2015087100 A1 describes an infrared sensor-activated system that evacuates toilet bowl via an extraction nozzle adapted to the shape of the toilet rim. Primarily, the system fails to address the issue of toilet malodour removal, opting for the inadequate costly and impractical method of filtration. Though the invention avoids toilet bowl flood level with its toilet rim top surface shape-adapted nozzle, the nozzle itself has no fixed fastening method, making it flimsy and impractical. Even though the invention proposes the use of the system in public toilets, it fails to address the matter of tampering and theft of said system and its components.

[0015] US patent US 2015/0074886 A1 describes the evacuation of toilet gasses via an inlet nozzle positioned behind toilet seat and guided to a sensor-activated fan unit within the toilet commode, where it is filtered and further guided to a sewer pipe in communication with the invention and the toilet itself. Albeit for a one-way gate and an insect screen, the invention fails to satisfy common sanitary and building codes appropriately-sized water trap requirements between sewerage and spaces within dwellings- US patents US 2015/0107009 A1 and US 2015/0211222 A1 fail to provide an appropriate sealing method as well. Furthermore, having the invention's electromechanical components placed in a body beneath flush tank and below bowl flood level is inappropriate, as already mentioned above. Said invention also fails to address the specific geometric constraints posed by various toilet models.

[0016] Aforementioned US patent US 2015/0074886 A1 refers to a sensor that controls the invention but fails to describe how it functions.

[0017] US patent US 2015/0211222 A1 describes a system for toilet odour elimination that sucks in bowl gasses via a connection point inserted in the flush water pipe between flush tank and toilet bowl. Again, the system is in communication with toilet's drain without an adequate sealing method. Said patent mentions the presence of either a pressure switch under the toilet seat or an infrared sensor but fails to describe its detailed operation steps or how to deal with unwanted activating signals resulting.

[0018] WIPO patent WO2013/010293 directly collects toilet gasses through its flush water apertures. Similarly, Chinese patent CN 104302850A extracts toilet bowl gasses via a complicated system, posing manufacturing and installation challenges as well as increasing production costs.

[0019] Apart from pursuing the inconvenient and inefficient method of filtration and deodorisation, Chinese patent CN104379847 describes a system whose exhaust pipe outlet is located outside of the toilet room, necessitating the creation of an opening in the toilet room's walls or windows, which is generally intrusive, and usually prohibited in rented and multi storey buildings.

[0020] Apart from pursuing the inconvenient and inefficient method of filtration and deodorisation, Chinese patent CN104379847 describes a system whose exhaust pipe outlet is located outside of the toilet room, necessitating the creation of an opening in the toilet room's walls or windows, which lends to problems already mentioned above.

[0021] European patent EP 2 239 380 A2 describes an air ventilation fan that draws malodorous air from the toilet bowl through the toilet's flush holes and conduits and then through an air outlet in the toilet bowl to be ejected through one or more ventilation ducts in the toilet's wall and/or ceiling spaces. Limitations of this method have already been described above.

[0022] US patent US 8,789,213 B2 offers, without providing a sealing backup, a secondary water trap through a flapper check valve, which may prove insufficient in the event of the drying up of the water seal in the secondary water trap due to prolonged power failure. Also, the constraint of having to use a specifically-manufactured toilet commode with lack of provisions to retrofit the system onto non-prepared toilets limits its commercial viability.

[0023] The aforementioned invention also fails to provide practical control system operating steps that avoid the unintended operation of the venting unit such as the opening/closing of toilet seat cover- a point inadequately and impractically addressed by the removal of seat cover- which will result in the inefficient and unreliable operation of the ventilating unit.

[0024] In conclusion, the ideal toilet bowl venting system combines all the aforementioned advantages into one compact, affordable unit that directly removes malodourous gasses from their origin (the toilet bowl) from above the toilet bowl's overflow line, and to provide the greatest level of reliability, comfort and energy saving for said purpose. Furthermore, said ideal system directs the removed malodorous gasses into the toilet's sewer direct drain connection, confidently sealed from said sewerage by an appropriate water trap and backed up by a normally-closed mains water solenoid valve for water replenishment, all using low-cost market-available components housed in a non-obtrusive damp-proof container. Said system should be directed by a reality-based control system, operating under fail-to-seal conditions, be tamper and theft-proof- in the case of public toilets-, be easy to manufacture and install and can be retrofitted onto pre-existing toilet installations.

Summary of the invention

[0025] The invention describes an electronically-controlled toilet bowl direct-venting device attached - geometry- and space-permitting - to the horizontal space between the rear side of the toilet seat and toilet flush water

tank. Upon installation, the device's rear face is directed towards the toilet flush tank, while its front faces the direction of the toilet seat.

[0026] Housed within a solid damp-proof container, said device sucks in toilet bowl gases directly via an intake port protruding from the lower front of the device and deployed underneath the rear end of the toilet seat at a level above the bowl's overflow line. The sucked gases, driven by an electric fan within the device's container, bypasses the toilet's main water trap and is communicated, via a relatively-smaller secondary water trap, with the toilet's sewerage drain, and hence ejected safely out of the toilet room space.

[0027] Said venting unit container, when closed, has three openings of differing dimensions: the smallest to accommodate an electric power supply wire, another for a mains water supply pipe and a third (and largest) for a vented air exit pipe. Said water and vented air pipes are positioned at opposite lateral ends of the container, at a distance prescribed by limitations imposed by the available space within the container, whose shape and size is dictated by ergonomic and aesthetic design parameters related to the toilet commode. All openings seal around their respective conduits to prevent water entering said container.

[0028] Also housed within said container are low voltage electromechanical components: an electric venting fan blower and two normally-closed solenoid valves. One of said solenoid valves is deployed onto the vented bowl gases pipe and the other onto the water supply line.

[0029] Externally, a proximity sensor switch's tip protrudes from the front face of said container.

[0030] All aforementioned components are connected, via appropriate wiring, to a control unit also housed within said container.

[0031] The invention's toilet venting unit can-geometry and space allowing-either be incorporated into a prepared toilet commode or retrofitted onto an existing standard toilet commode.

[0032] In the case of a prepared toilet commode, the venting unit's case has its aforementioned mains water entry pipe and vented air exit pipe located at the case's bottom face.

[0033] Said aforementioned prepared commode is a standard toilet commode, albeit with a secondary water trap as well as two vertical thru-holes on the horizontal surface between the back of toilet seat and the flush water tank on either side of the commode's flush water supply duct that match said venting unit's dedicated pipe locations at its bottom face.

[0034] Said thru-holes and secondary water trap can be produced during the toilet commode's manufacturing stages via a minor alteration of the mould in the case of ceramic-based toilets. Furthermore, many existing toilet commodes allow for the aforementioned thru-holes to be drilled into them without negatively affecting said commode's performance or integrity, thus rendering the commode suitable for the standard aforementioned attachment method for the venting unit's mains water and vented air pipes. While said secondary water trap can be attached to the toilet commode.

[0035] Said thru-holes and secondary water trap must not interfere with the commode's function or penetrate or expose any internal cavities within the commode that will adversely affect the commode's function and sanitary conditions as well as user safety.

[0036] In the case of a prepared commode, if the owner opts not to have the venting feature installed, said thru-holes can be sealed with specially-provided tight fitting plugs of suitable matching colour and material.

[0037] An ancillary pipe communicates the venting device's vented air exit pipe, through its matching aforementioned thru-hole (at the exit point at the lower side, past said thru-hole), with said secondary water trap of appropriate seal height, which prevents sewerage gasses, bacteria and insects from moving upstream from sewerage into the toilet venting device, and hence into toilet room space. Water seal height inside said secondary water trap is dictated by local relevant dwelling's buildings and sanitary codes.

[0038] In turn, said secondary water trap communicates with the sewerage drain at a point downstream of the toilet's primary water trap. Communication between venting device's vented air exit pipe and toilet sewerage drain allows the sucked toilet bowl air to safely bypass the toilet's primary water trap and evacuate into the sewerage system, eliminating the spread of malodour and contamination within the toilet room space.

[0039] Said secondary water trap can be any of various possible permissible trapping methods, such as U-, S-, J-, P-shaped pipe or bottle-type, or any suitable form of plumbing trap, according to the relevant buildings and sanitary codes. Said secondary water trap is produced as part of the toilet in the case of a specifically-manufactured toilet commode.

[0040] Said venting device is connected to a mains water supply to replenish the secondary water trap's seal (preferably via a tee junction shared with the toilet's flush tank water supply valve), via piping that passes through the lower part of the commode's second vertical thru-hole to communicate with the device's inlet water pipe. Said inlet water pipe connects with the aforementioned normally-closed water solenoid valve deployed within the venting device, furthermore to a point along the air exit point downstream from the air fan.

[0041] Said device's lower front is secured onto the commode via two slots flanking the device's inlet air port, whose locations are adjacent to the toilet commode's seat attachment bolts. Said slots receive the toilet seat's bolts and hence will become fastened between the commode's surface and the toilet seat hinge.

[0042] Installation location of venting unit onto a non-prepared toilet commode is similar to the aforementioned prepared commode method except for the following: the venting device will have its mains water inlet pipe and vented air exit pipe both laterally extending from opposite

side faces of the device's casing, as opposed to from below said casing. Due to the lack of thru-holes, as in the case of the aforementioned prepared commode, said inlet and exit pipes will communicate with their respective connections (mains water pipe in the case of the former and the secondary water trap in the case of the latter) via piping circumnavigating the commode's torso lying between the toilet bowl and flush tank, to reach the lower end of the horizontal surface between the toilet bowl and flush tank, i.e. to reach the same piping locations below toilet commode unit attachment surface as in the case of the prepared toilet commode detailed above.

[0043] In the case of a prepared commode, apart from said two thru-holes, said secondary water trap is manufactured as part of the commode in the most compact and concealed way possible so as to prevent any accidental damage due to handling as well as to be aesthetically pleasing. This also applies to "smart"/"intelligent" toilets whereby the whole venting device, along with said secondary water trap, are concealed within the toilet's casing.

[0044] In the case of a retrofit venting device, an appropriately-sized third hole is deployed downstream of the toilet's primary water trap to attach, and hence communicate, the toilet's vented malodour exiting a retrofit secondary water trap with the toilet's sewerage waste pipe downstream.

[0045] Said secondary water trap hole downstream of the toilet's primary water trap is carefully drilled in, using a drilling method appropriate to the commode's material of construction, to assure commode's integrity and to ensure a suitable connection seal via an appropriate internally-sealed joint.

[0046] For said retrofit venting device, said casing's pipe holes are positioned in the lateral sides - as opposed to the bottom - of the casing so as to allow for opening and closing of unit without undue obstruction that will result from the pipes passing through said unit's casing.

[0047] Said pipes extending from the device unit's lateral sides are threaded pipe ends protruding just enough to connect with flexible pipe attachments outside the container that communicate each pipe with its relevant component: secondary water trap (in the case of the vented air outlet) and mains water (in the case of the mains water inlet).

[0048] To prevent tampering with the venting device's container and its contents, said container is fastened shut via screws penetrating from the bottom surface of the case bottom part and connects with the cover via adjacent screw sockets. Once the unit is installed onto the toilet commode and its piping secured, access to the unit's components is only possible by dismantling the plumbing accordingly. This applies to both prepared and non-prepared toilet configurations.

[0049] Said venting unit houses a suitably-sized fan, a normally-closed solenoid air valve, a normally-closed water valve, a proximity sensor switch and a control unit, all connected with suitable piping and wiring to allow for the unit to function according to the invention's purpose.

[0050] Malodorous air is sucked from the toilet bowl via the device's air inlet port by an electric fan, and is vented through a normally-closed air solenoid valve (which is switched open simultaneously with the activation of the air fan) to the vented air exit pipe passing through the base of the container (in the case of the prepared toilet configuration, otherwise, it will pass through the side of the container), where it communicates with the similarly-dimensioned secondary water trap.

[0051] Mains water connected to the device's container passes from the opening below the container through an appropriate pipe connection (in the case of the prepared toilet, otherwise it will pass from the side of the container) and is piped to flow through the water solenoid valve (which opens up for a sufficient pre-set time interval) and into the relatively-larger vented air exit pipe via a connection downstream of the vented air solenoid valve to replenish the secondary water trap's seal downstream of the air exit pipe at the end of the venting operation. Any excess water will safely flow downstream into the sewerage drain. Due to the small amount of water needed to complete the water seal, the diameter of the mains water piping is minimal.

[0052] Both normally-closed solenoid valves ensure the device faulting into a safe mode: In the case of the water valve, the closed valve will prevent mains water inadvertently flowing through the device during the venting operation, while the closed air valve will act as a back-up seal to the secondary water trap from the sewerage in case the secondary water trap seal is compromised, such as due to prolonged power loss, the device's complete failure, or the device being left unused over a long period that allows for the drying up of its water seal.

[0053] Low voltage electric power, sufficient to power the venting unit's electromechanical components, is supplied to the venting unit via an external power supply connected to the mains in a suitable manner to ensure safety according to the relevant buildings and sanitary codes. An On/OFF switch can be part of said power supply. Instances where electric mains power is not available in a toilet room, batteries can be used (but not favoured in view of environmental considerations). Said batteries can be placed in a suitably-sized separate container, concealed in available space behind or under the toilet torso. Space-permitting, said batteries may also be accommodated within the venting unit's damp-proof container. In this case, the power supply wire conduit in the device's container can be excluded.

[0054] A proximity sensor switch protrudes from the venting unit's front face that is directed towards the front part of the toilet seat. Its location is such that its field of view is not restricted by the raised or lowered positions of both toilet seat cover and toilet seat, allowing for said field of view to register the presence of a seated toilet user.

[0055] In cases where toilet seat and/or cover obstructs said proximity sensor's field of view, said sensor

may be placed in any suitable location that has its field of view directed towards seated toilet user.

[0056] Infrared proximity switch sensors are most suited for the job as they are commercially-available, reliable and relatively cheap. Ultrasonic proximity switch sensors are also suitable, but are usually more costly.

[0057] A control unit housed within the venting device casing oversees the venting cycle. Said venting cycle is comprised of: 1) control unit confirming the presence of a seated toilet user based on proof-positive signal/s from proximity sensor switch, 2) opening of normally-closed air solenoid valve in tandem with momentary operation of fan unit at high pressure to evacuate secondary water trap seal into sewerage and hence communicating device's exiting vented air with sewerage drain pipe, 3) air solenoid valve remains open while fan unit operates at low pressure for toilet bowl malodorous air continuous ventilation, 4) control box confirming proximity sensor switch's signal that user has dismounted the toilet seat, 5) a timer commences, maintaining ventilation for a set period of time, 6) air solenoid valve closes and fan unit turns off in tandem, 7) water solenoid valve opens momentarily to allow mains water to flow into and through vented air exit pipe so as to replenish the ejected secondary water trap's seal for a pre-set period of time to ensure complete sealing, 8) water solenoid valve closes to end the venting cycle.

[0058] The venting fan blower is programmed to operate at two speeds. Upon a relatively higher pressure ejection of secondary water trap's seal, pressure head will decrease to a sufficient value that allows for toilet bowl malodorous air to freely flow into sewerage yet within a suitable air flow rate that produces noise below buildings and sanitary codes standards, as well as at an optimum pressure comfortable to toilet user seated on the toilet commode, and sufficient for efficient toilet bowl venting without excess that may cause excessive burden on the drain's vent under simultaneous use of multiple toilet commodes connected to the same sewer.

[0059] Variable speed centrifugal fans are generally more suited for this duty as they provide greater head in comparison with axial fans, therefore taking up relatively less space within the venting unit to ensure said unit's compact design. Centrifugal fans are also more suited to providing multiple airflow-pressure combinations, as well as being able to process several airflow conditions, including clean, dry and wet air.

[0060] The control system can be "read only" or programmable. In the case of a programmable logic circuit (PLC), which is more costly for production, the user may be able to modify the control system's timers' durations to suit specific needs and requirements, such as in installations in dwellings with high pressure mains water that will require opening the mains water solenoid valve for a shorter time period to seal the secondary water trap.

[0061] Depending on type of proximity sensor, the raising and/or lowering of toilet seat cover and/or toilet seat may provide a false signal to the control unit. In such a case, said control unit compares two or more proximity sensor's readings separated by a brief time interval to differentiate between the time period the sensor's field of view is momentarily obstructed upon raising/lowering of toilet seat/cover and that of a user mounting the toilet. For greater accuracy, further timed proximity sensor sweeps can be programmed into the control unit, reducing the chance of unwanted activation of venting system's venting cycle.

[0062] The invention can also be integrated into an "intelligent" toilet seat or "smart" toilet systems, whereby said system will provide the signal for user's presence. In this case, the invention's venting system can do away with the proximity sensor switch. Also, In this case, the venting unit can be integrated within the "intelligent" toilet seat/"smart" toilet casing for ergonomic and aesthetic purposes.

Brief description of the drawings

[0063] The figures of the drawings are briefly described as follows:

Fig 1a is a conceptual perspective view illustration of an assembled and closed toilet venting device case having an automatic venting system according to the present invention that can be attached to a prepared toilet commode to receive said device's water inlet and ventilation outlet within said modified toilet commode's horizontal plane between toilet seat rear and water flush tank

Fig 1b is a front view illustration of an assembled and closed toilet venting device case having an automatic venting system according to the present invention that can be retrofitted onto a non-prepared toilet commode's horizontal plane surface between toilet seat rear and water flush tank

Fig 2a is a perspective view illustration of the present invention's toilet venting device case for a prepared toilet commode with top cover removed to show components housed within said casing for a prepared toilet commode

Fig 2b is a top view of the present invention's toilet venting device for a prepared toilet commode with case cover removed to reveal its components, indicating cross sectional view **A-A** location of mains water replenishment pipe supply in communication with vented air pipe

Fig 2c is section view along **A-A** in **Fig 2b** of the present invention's toilet venting device's vented air pipe communicating with the water replenishment pipe that feeds the device's secondary water trap downstream of the device upon completion of a venting cycle

Fig 3 is a perspective view of a prepared toilet commode with vertical thru-holes to accommodate the present invention's water and vented air pipes

Fig 4a is a perspective view of toilet venting device attached to a modified toilet commode without an assembled toilet seat or cover to illustrate the invention's location and the relevant connections

Fig 4b is similar to **Fig 4a** but with attached toilet seat in the lowered position and the cover in the raised position to illustrate the installation's appearance during use relative to the invention and indicating proximity sensor's direction of field of view

Fig 4c is a perspective view of the device retrofitted onto a generic toilet commode with assembled toilet seat and cover in the lowered position to illustrate the invention's location and the relevant connections

Fig 5a is a perspective view of the device attached to a modified toilet commode with an assembled seat cover in the raised position and seat in the lowered position to illustrate the invention's position during its operation

Fig 5b is a right perspective view of the device retrofitted onto a generic toilet commode with an assembled toilet seat cover in the lowered position to illustrate the invention's location and connection with the secondary water trap

Fig 6a is a top view of the present invention attached to a modified toilet commode illustrating the venting unit's position and indicating cross section line **B-B**

Fig 6b is a section cut along **B-B** to illustrate the flow of malodorous air from toilet bowl to sewerage drain, bypassing the toilet's primary water trap via the invention and its associated attachments

Detailed description of the preferred embodiments

[0064] Referring to the figures, in which like numerals and letters indicate like parts, and particularly to **Fig 1a,** which is a diagrammatic perspective view of the present invention for a prepared toilet commode, and is the reference design unless otherwise specified.

[0065] Toilet venting unit in **Fig 1a** is attached to a toilet commode **301**- made of ceramic, coated-porcelain, plastic, metal, or any suitable solid material - that contains a water trap (siphon) **313**, bowl **302** and flush tank **309** (illustrated in **Fig 4a**). Said toilet is either a prepared toilet that communicates with the water supply line **318** and the toilet's sewerage conduit **315** downstream of said venting unit, or a generic toilet that has sufficient space and geometric configuration to cater for the retrofit unit in **Fig 1b.**

[0066] Said venting unit (**Fig 1a**) is housed within a solid damp-proof container **101** of suitable dimensions so as to fit onto the horizontal space **305** between the toilet seat **311** and flush tank **309**, with sufficient dimensional allowances for the venting unit's intake port **110** to fit under said toilet seat **311** and to protrude just above the toilet bowl **302** rim **303** to enable toilet bowl's air intake but to prevent water intake in the case of said toilet bowl water overflow (**Fig. 4a**).

[0067] Said unit's container **101** is designed so as to ensure proper closure of both cover **102** and bottom piece **103**, such as a securing male-female perimeter lip **122** that also prevents water/humidity entering said container.

[0068] Said venting unit container **101**, when closed, has three openings of differing dimensions: the smallest **105** to accommodate an electric power supply wire **123**, another for a mains water supply pipe **107** and a third (and largest) for a vented air exit pipe **108**. Said water and vented air pipes are positioned at opposite lateral ends of the container, at a distance prescribed by limitations imposed by the available space within the container, whose shape and size is dictated by ergonomic and aesthetic design parameters related to the toilet commode **301**. All openings seal around their respective conduits to prevent water entering said container.

[0069] Said container's cover **102** is fastened onto the bottom piece **103** via screws driven through said bottom's base **103** vertically upwards into adjacent equally-spaced screw sockets in the top cover **102** around the case's perimeter.

[0070] The front area of the device is secured onto the commode **301** via two slots **104** flanking the device's inlet air port, whose locations are placed adjacent to the toilet commode's seat attachment bolts holes **306**. Said slots **104** receive the toilet seat's bolts and hence will become fastened between the commode's surface **305** and the toilet seat hinge anchor **320**.

[0071] Said venting unit (**Fig 1a**) is powered by an external power supply **125** plugged into an available socket **126** that provides suitably-conditioned electric supply to the electric and electro-mechanical components within the venting unit via a wire **124** extending from said unit's casing's power conduit **105,** which is an extension of wire **123** connected to the unit's control unit **113**. For the sake of safety, commonly-available 12VDC or 24VDC electric and electro-mechanical components are suitable.

[0072] In the case of battery operation, said venting unit may either house a suitably-sized battery pack or such a pack can be concealed in a suitable location on the commode.

[0073] Said venting unit has a mains-water inlet pipe **107** connected to the toilet's water mains pipe **316,** ideally via a "tee" fitting **319** that connects both the toilet's flush water tank **309** (via line **317**) and said water inlet pipe **107** (via line **318**) to said mains water **316**. Said mains water will replenish the secondary water trap's **321** seal during the operation of the venting unit.

[0074] Said venting unit (**Fig 1a**) contains a vented-air outlet pipe **108** that is a conduit for the toilet bowl's extracted malodorous air, directing said air to the toilet's sewerage conduit **315** via the aforementioned secondary water trap **321**. Within said container **101**, said vented-air outlet pipe **108** contains a smaller mains water pipe **115** (downstream of water solenoid valve **114**) described by **Fig. 2c A-A** cross section of vented air pipe, thus resulting in a mains water-fed vented air pipe **120**.

[0075] At the end of the venting operation, said water mains-fed vented air pipe **120,** connected to vented air pipe **118** at point lower in elevation to fan blower **112** outlet, supplies water to the secondary water trap **321** under the force of gravity.

[0076] In **Fig 2a,** said venting unit houses a suitably-sized air fan blower **112,** a normally-closed solenoid air valve **117,** a normally-closed water valve **114,** a proximity sensor switch **105** and a control unit **113,** all connected with suitable piping and wiring to allow for the unit to function according to the invention's purpose. Therefore, air fan blower **112** is connected to control unit **113** via wire **113a,** normally-closed solenoid air valve **117** is connected **to** control unit **113** via wire **113b,** normally-closed water valve **114** is connected to control unit **113** via wire **113c** and proximity sensor switch **105** is connected to control unit **113** via wire **113d**.

[0077] The aforementioned components are assembled in a way such that gases sucked from toilet bowl via venting unit's air intake port **110** enters the venting unit and passes through a suitably-sized air fan blower unit **112** via a sufficiently-sized reducer **111**. Said air fan blower **112** would ideally be a variable-speed fan that can provide two pressure heads, one for the initial stage of venting secondary water trap's **321** water seal - to provide direct communication of venting unit's exit air with sewerage conduit **315 -** and another for the venting of toilet bowl's malodorous air, as shown in **Fig. 6b.**

[0078] A proximity sensor switch **105** is disposed on the front face of venting unit's either upper or lower part (cover or bottom), depending on the casing's ergonomically-based design (seen here to be on the cover **102**) such that it is activated when a toilet user is seated on toilet seat, yet does not activate when toilet seat and/or cover is raised. This is achieved by locating the active face of the proximity sensor **109** at a height that is above toilet seat **311** and seat cover **312** when in the lowered position, yet has a clear unobstructed direction of field of view **124** when toilet seat cover **312** is raised. Therefore, both toilet seat **311** and cover **312** should be of suitable geometry to allow for proximity sensor's field of view **124** to be unobstructed when in the raised or lowered positions (see **Fig. 4b**).

[0079] In cases where said proximity sensor's **109** field of view is obstructed, said proximity sensor switch may be placed in a suitable location such that said field of view is directed towards toilet user.

[0080] Sensing can also be carried out by toilet seat skin inductance sensors, as present on commercially-available "intelligent" or "smart" toilets. If used, it will forego the proximity sensor switch **105** (and relevant casing **101** holes) directly send a signal indicating user presence to control box **113**, which will carry out all control operations as in the complete ventilating cycle for this invention.

[0081] To ensure that proximity sensor switch is not triggered by simply raising toilet seat cover **312**, control unit **113** is programmed to register at least two active signals from said proximity sensor's range separated by a suitable duration to differentiate accordingly.

[0082] Malodorous gases exit fan unit **112** and travels through a normally-closed air solenoid valve **117**. Both air fan blower unit **112** and normally-closed air solenoid valve **117** work in tandem such that the air solenoid valve is open when the fan is operational and closed when the fan is off.

[0083] Upon malodorous air exiting the normally-closed air solenoid valve **117**, said air flows through the vented air outlet pipe **118**, past mains-fed pipe **120** and out of venting unit via **108** towards the secondary water trap **321**. Said secondary water trap **321** (of suitable geometry such as U-, S-, J-, P-shaped pipe, bottle-type, etc., that satisfies required sanitary standards dictating specific minimum water seal height) separating said venting unit and the building's sewerage.

[0084] Said secondary water trap **321** has its water seal content discharged down the sewer at a sufficient pressure head by air fan blower **112** upon initial operation of said fan, ejecting said trap's water content downstream into sewerage conduit **315**. Upon evacuation of secondary water trap **321** water seal, fan unit **112** pressure head is reduced - upon signal from control box **113 -** to a sufficient value that allows for toilet bowl malodorous air to freely flow into sewerage yet within a suitable air flow rate that produces noise below buildings and sanitary codes standards as well as at a pressure comfortable to toilet user seated on the toilet commode **301** and the lowest discharge rate sufficient for an efficient toilet bowl **302** venting operation.

[0085] Once toilet user dismounts toilet seat **311**, as signalled by venting unit's proximity switch sensor **105**, a pre-programmed timer within control unit **113** dictates the duration for which the fan unit **112** resumes its venting operation in tandem with the air solenoid valve **117** open state. Upon culmination of said timer's countdown, a signal from control box **113** turns off fan unit **112** and releases air solenoid valve **117** into its normally-closed position. Immediately thereafter, the secondary water trap **321** is sealed by the control box **113** signalling the normally-closed water solenoid valve **114** to open up briefly to replenish the secondary water trap **321.**

[0086] Upon a predetermined duration of time, a signal is sent from said control unit **113** to said water solenoid valve **114** to return to its normally-closed position. This ends the operational cycle of the invention.

[0087] Installation of the invention onto a toilet is described for two types of toilets: a prepared toilet and a non-prepared toilet. In the case of a prepared toilet, two

thru-holes **307** and **308** are present in the area **305** on either side of the flush tank duct **304** between toilet seat anchor holes **306** and water flush tank **309**. Said thru-holes are of diameters suitable to receive a mains water inlet pipe **107** and a vented air outlet pipe **108** respectively and allow for secure sealing around said pipes to ensure a sanitary environment on the toilet's surface. Locations of said thru-holes are such that the invention's venting device can be centred behind the toilet seat in a neat fashion. Said holes do not interfere with the function of the toilet's other components.

[0088] Said thru holes **307** and **308**, can either be manufactured as part of the toilet or are safely and suitably drilled onto the horizontal surface **305** between toilet seat and flush tank without harming the integrity of the commode or any of its components.

[0089] Said specifically-manufactured toilet commode can be used as a regular toilet without the venting unit by sealing the two thru-holes **307** and **308** disposed behind the seat **311** at either side of the flush water duct **304** with the use of suitably-dimensioned seal caps.

[0090] Mains water is supplied to the device by connecting toilet mains water outlet point **316** with the venting unit's connecting pipe **107** (via pipe connection **318)** protruding from the lower point of the toilet commode's thru-hole **308**. Sharing mains water with toilet flush tank inlet pipe **317** via a tee junction **319** is the most convenient method.

[0091] At the opposite side of the commode, at the device's vented air exit point **108** side, a suitably-sized secondary water trap **321** is communicated to the vented air exit point **108** through the thru-hole **308** directly beneath it. The other end of said secondary water trap is attached to a suitable point **322** downstream of the toilet's primary water trap **313**. This safely communicates device's vented air with the sewerage conduit **315**. Figures **4a** and **5a** illustrate an assembled venting device onto a prepared toilet commode. Said secondary water trap **321** is manufactured as part of the prepared commode (**Fig 3**) in the most compact way possible, with communication point **322** connecting drainage pipe **314** to the closest possible point to the primary water trap **313** upstream without affecting said secondary water trap's **321** function.

[0092] All pipe connections must be sealed in a way so as to meet sanitary codes and standards.

[0093] In the case of retrofitting the device to an unprepared toilet commode, since thru-holes **307** and **308** as well as secondary water trap **321** are not present, the venting unit's mains water inlet **207** and vented air outlet **208** pipes circumnavigate the commode's torso **310** and attach to their relevant attachment points (mains water inlet pipe **207** and retrofit secondary water trap **323** respectively) beneath the commode's horizontal surface **305** that lies between toilet seat anchor bolt holes **306** and flush tank **309** in a manner similar to the aforementioned prepared commode.

[0094] In the case of said retrofit device, all components and their relevant connections within the venting unit are the same as described for the prepared toilet version apart from retrofitted device's casing **201** protruding mains water inlet **207** and vented air outlet **208** pipes, which are positioned laterally on the case's **203** bottom so as to allow for assembly and for opening and closing of unit without undue obstruction that will result from the pipes passing through them.

[0095] To allow for various geometric and dimensional configurations pertaining to different commode models, as well as the relevant in-situ toilet room connections and fittings (wall positioning, mains water pipes, primary water trap shape and location, etc.), said case's protruding pipe connections **207** and **208** are made so that they minimally-protrude from said casing **201** and hence allow for flexible pipe connections to communicate with their relevant links (secondary water trap **323** in the case of the vented air pipe **208** and mains water pipe **318** in the case of the mains water inlet pipe **207**), as in **Fig 4c**.

[0096] Said retrofit secondary water trap **323** is of suitable material so as to maintain its integrity throughout its operational lifetime and is of minimal possible size and obtrusiveness so as to remain inconspicuous and out of harm's way.

[0097] Similar to the prepared commode's device in **Fig 1a**, retrofit venting device's proximity sensor tip **209** will protrude from the casing's front face, albeit from the bottom casing **203**, so as to allow unobstructed opening and closing of said casing **201**.

[0098] Thus, the only difference between the piping of an unprepared toilet commode and a prepared commode is that in the prepared commode, the two pipes **107** and **108** connected to the device pass through the commode's horizontal surface **305**, while in the retrofitted version they circumnavigate the commode's structure to achieve the same goal.

[0099] For said retrofit assembly, a third hole **324** is disposed downstream of the toilet's primary water trap **313** on sewerage channel **314**, at a location upstream of toilet's sewerage drain **315** and to communicate with secondary water trap **323**. Said third hole **324** is appropriately-drilled into the toilet's sewerage channel at **314**.

[0100] The representative version of the invented device (for prepared toilet commodes) presents an orientation whereby the mains water inlet **107** is located on the left side and the vented air outlet **108** is on the right side when the device is viewed from the front face, as in **Fig 1a** (or **207** and **208** respectively for the retrofit version in **Fig 1b**). All illustrations in this description of the invention describe such a version. The device can be mirrored, which will in turn require all connections to the device to be mirrored as well, and hence, all illustrations related to this description will correspondingly be mirror images of themselves.

[0101] In the case the type of said proximity sensor requires for the differentiation between the rising/lowering toilet seat cover **312** and/or toilet seat **311** and the presence of a user sitting on the toilet **301 -** and hence limit the operation cycle of the venting unit to instances

when a user sits on the toilet seat-, the control unit **113** can be programmed such that the proximity sensor switch **105** takes readings at pre-set intervals and compares two simultaneous readings. Therefore, in the case that both of the sensor's readings register the presence of an object within the pre-set range of said sensor's field of view, it would be with a higher degree of confidence that a user is sitting on the toilet seat, as opposed to a fleeting movement in the sensor's field of view.

[0102] Fastening of venting unit's closure can be either easy-access or not. In the case of easy access, the cover can be easily removed by removing screws or releasing latches that are easy to access while the venting unit is attached to toilet. In the case of application in public toilets, removal of cover is achieved via screws at the base of the bottom unit's cover, which can only be accessed by releasing venting said unit from the toilet, a step that requires the disconnection of mains water pipe **107** and vented air pipe **108**, making it much harder for unwanted access and/or removal.

[0103] The control is summarised according to the following, using the configuration of the prepared toilet's venting unit in **Fig 2a** as well as **Fig 4c and Fig 5a** as a reference: 1) control unit **113** confirming the presence of a seated toilet user based on proof-positive signal/s from proximity sensor switch **105**, 2) opening of normally-closed air solenoid valve **117** in tandem with momentary operation of fan unit **112** at high pressure to evacuate secondary water trap's **321** seal downstream into sewerage via sewerage conduit **315** and hence communicate device's exiting vented air with sewerage conduit **315**, 3) air solenoid valve **117** remains open while fan unit **112** operates at low pressure for toilet bowl **302** malodorous gases continuous ventilation, 4) control unit **113** confirming proximity sensor switch's **105** signal that user has dismounted the toilet seat, 5) control unit's **113** timer commences, maintaining venting for a set period of time, 6) air solenoid valve **117** closes and fan unit **112** turns off in tandem, 7) water solenoid valve **114** opens to allow mains water to flow into (at a point in elevation below fan blower **112** outlet to prevent flow of water into said fan) and through vented air exit pipe **120** so as to replenish the ejected secondary water trap's **321** seal for a pre-set period of time to ensure complete sealing, 8) water solenoid valve **114** closes to end the venting cycle.

[0104] The control unit's **113** is either read only printed circuit board (PCB) or a programmable logic device (PLD). A PLD is more versatile to accommodate specific toilet needs, such as timers' durations - off signal to fan **112** after user gets off of toilet seat as well as water solenoid valve **114** opening duration to replenish secondary water trap **321** seal - requirements, but is relatively larger in size and more costly. As read-only PCBs are cheaper, yet do not allow for program alterations, selection relies on market segment as well as product range.

[0105] In the case of wall-fitted toilets, the venting unit may be placed in the wall cavity behind the toilet commode, which will require extra wall space to accommodate it. All connections and operation methods remain the same, save for some dimensional variations.

[0106] As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be constructed in accordance with the substance defined by the following claims.

Claims

1. A ventilating toilet device attached to a prepared toilet commode that includes a tank and a bowl. Said toilet assembly material of construction can be of ceramic, plastic, metal or any other solid material acceptable for attachment of said ventilating device according to the relevant buildings and sanitary codes and standards.
   Said prepared toilet commode provides sufficient space and geometry to accept the invention's ventilating device and its associated parts on the horizontal surface lying between toilet seat and flush water tank behind it.
   Aforementioned prepared commode is a typical toilet commode, albeit with two vertical thru-holes on the horizontal surface between the back of toilet seat and the flush water tank on either side of the commode's flush water supply duct, that match said venting device's dedicated pipe locations at said device's bottom face.
   Said vertical thru-holes may be part of the toilet commode's manufacturing stages or said thru-holes may be, if technically possible and without negatively affecting commode's integrity and performance, be drilled into a suitable commode.
   Said container is fastened shut via screws penetrating from the case's bottom surface that connect with the cover via adjacent screw sockets to prevent tampering with said unit's contents.
   Said ventilating unit's air inlet port protrudes from the front of the device and is deployed underneath the rear end of the toilet seat at a level above the bowl's overflow line.
   Attachment means for said ventilation device casing onto toilet commode is achieved via the toilet's seat fastening anchor bolts passing through said venting unit's two fastening slots flanking said venting unit's air inlet port. Furthermore, the vent unit's mains water inlet and air outlet pipes run vertically downwards through the commode's adjacent vertical thru-holes to connect (and securely fit) with their respective piping emanating from the venting device's bottom face.
   Access to said device's components entails the dismantling of the connected plumbing accordingly.

2. The device according to claim 1 made of matching

top and bottom waterproof container covers, resulting in a damp proof container once closed.
Said venting unit container, when closed, has three openings of differing dimensions:

the smallest to accommodate an electric power supply wire (present at one side of the casing, near the bottom) another for a mains water supply pipe and a third (and largest) for a vented air exit pipe.
Said device's water and vented air pipes are positioned at opposite lateral ends of the container, at a distance prescribed by limitations imposed by the available space within the container, whose shape and size is dictated by ergonomic and aesthetic design parameters related to the toilet commode.
All openings seal around their respective conduits to prevent water/humidity entering said container.

3. The device installation according to claim 2 with an ancillary pipe communicating the venting device's vented air exit pipe - passing through commode's matching thru-hole (at the exit point at the lower side past said thru-hole) - with a secondary water trap of appropriate seal height dictated by relevant dwelling's buildings and sanitary codes.
Said secondary water trap securely bypasses said toilet's primary water trap and communicates in a unidirectional manner the venting device's vented air outlet pipe that runs vertically down through the commode's thru-hole to a connection point with the toilet's drain pipe downstream of toilet's primary water trap, irrespective of said primary water trap's type.
In the case of a prepared toilet commode, said secondary water trap is manufactured as part of said commode using suitable material and space-saving methods.

4. The device installation according to claim 3 where communication between said secondary water trap and toilet drain outlet, downstream of toilet's primary water trap, is achieved via an appropriately-sized hole present in said toilet drain pipe. Said hole may be drilled using a suitable method that is compatible with said drain pipe material and is fastened appropriately to ensure no leakage of sewerage gas or contamination into the toilet room space.

5. The device installation according to claim 4 wherein said toilet ventilating device houses a low voltage fan air blower.
Said ventilation unit's fan blower provides for at least two pressure head and flow rate requirements: one to evacuate said secondary water trap's seal and the other for proper, yet comfortable, ventilation of toilet bowl malodorous gasses, as dictated by local relevant dwelling's buildings and sanitary codes.

6. The device installation according to claim 5 whereby mains water feeds the venting device via a water inlet pipe passing through one of the commode's thru-holes and vertically upward through said venting device case's bottom. Said mains water replenishes the secondary water trap's seal upon culmination of fan blower's ventilation.
Said mains water flow is controlled by a normally-closed solenoid valve.

7. The device installation according to claim 6 whereby mains electricity (via an appropriate power supply) or a battery supply provides low voltage power sufficient for the safe operation of the ventilating unit's electric components.

8. Toilet ventilation unit assembled as in claim 7 with a normally-closed solenoid air valve, contained within the ventilation unit's casing.
Said normally-closed solenoid air valve lies between said fan unit outlet and said secondary water trap, ensuring unidirectional air flow from said fan unit towards said secondary water trap.

9. The device installation according to claim 8 with a proximity sensor switch located on the front outside surface of said ventilation unit to sense, and hence signal the venting device's control unit, the presence of a seated toilet user.
Position of said proximity sensor switch is such that its field of view registers the presence of a seated toilet user and is not obstructed by the toilet seat cover and/or toilet seat in both the raised and lowered positions.
Proximity sensor switch must be suitable to register the presence and departure of a human.
Said proximity sensor switch's sensing range covers the distance between said sensor's tip and the front tip of the toilet bowl rim.

10. The device installation according to claim 9 with a control unit housed within said unit's container that orchestrates the electromechanical components' operations so as to achieve the ventilation unit's venting cycle.
Said venting cycle is comprised of: 1) control unit confirming the presence of a seated toilet user based on proof-positive signal/s from proximity sensor switch, 2) opening of normally-closed air solenoid valve in tandem with momentary operation of fan unit at high pressure to evacuate secondary water trap seal downstream to sewerage and hence communicate device's exiting vented air with sewerage drain pipe, 3) air solenoid valve remains open while fan unit operates at low pressure for toilet bowl malodorous air continuous ventilation, 4) control box con-

firming proximity sensor switch's signal that user has dismounted the toilet seat, 5) a timer commences, maintaining venting for a set period of time, 6) air solenoid valve closes and fan unit turn off in tandem, 7) water solenoid valve opens to allow mains water to flow into and through vented air exit pipe so as to replenish the ejected secondary water trap's seal for a pre-set period of time to ensure complete sealing, 8) water solenoid valve closes to end the venting cycle.

11. The device installation according to claim 10 whose secondary water trap's water seal is replenished at the end of said unit's venting procedure via a normally-closed water solenoid valve enclosed within said ventilation unit. Said solenoid water valve is connected to mains water supply.
Said water valve is controlled by said venting unit's control unit such that the necessary amount of water is replenished to satisfy the necessary depth of said trap's water seal by controlling the duration of said water valve's.
Said water valve's outlet communicates with blower fan's outlet pipe within the ventilation unit's casing downstream of the ventilating fan unit at point lower in elevation than said blower fan's outlet point.

12. The device installation according to claim 11 retrofitted onto a non-prepared toilet by attaching the venting unit case onto any available surface on the toilet.
Said venting device has its mains water inlet pipe and vented air exit pipes both laterally extending from opposite side faces of the device's casing via threaded pipe ends.
Said protruding threaded pipe ends extend via holes present on the sides of said case so as to allow for unobstructed opening and closing of the top part of said unit's casing. All openings seal around their respective conduits to prevent water/humidity entering said container.
Said protruding pipes extend laterally just enough to connect with flexible pipe attachments outside the venting device's container, thus communicating with their respective connections (mains water pipe and secondary water trap) via piping circumnavigating the commode's torso lying between the toilet bowl and flush tank, to reach the lower end of the horizontal surface between the toilet bowl and flush tank, i.e. to reach the same connection locations as in the case of the prepared toilet commode detailed in the claims above.

13. The device installation according to claims 11 and 12 with a control unit that compares two or more proximity sensor's readings separated by a brief time interval to differentiate between the time period the sensor's field of view is momentarily obstructed upon raising/lowering of toilet seat/cover and that of a user mounting the toilet. For greater accuracy, further timed proximity sensor sweeps can be programmed into the control unit, reducing the chance of unwanted activation of venting system's venting cycle.

14. The device installation according to claims 11, 12 and 13 whose venting system is installed for wall-mounted toilets, whereby said venting unit is placed within the wall cavity behind toilet seat, having its proximity sensors protruding from the surface of the enclosed wall cavity.

15. The device installation according to claims 11, 12, 13 and 14 whereby the invention is integrated into an "intelligent" electromechanical toilet seat system, or "smart" toilet, whereby said system will provide the signal for user's presence. In this case, the invention's venting system can do away with the proximity sensor switch.
Said venting unit is integrated within the "intelligent" toilet/"smart" toilet casing for ergonomic and aesthetic purposes.

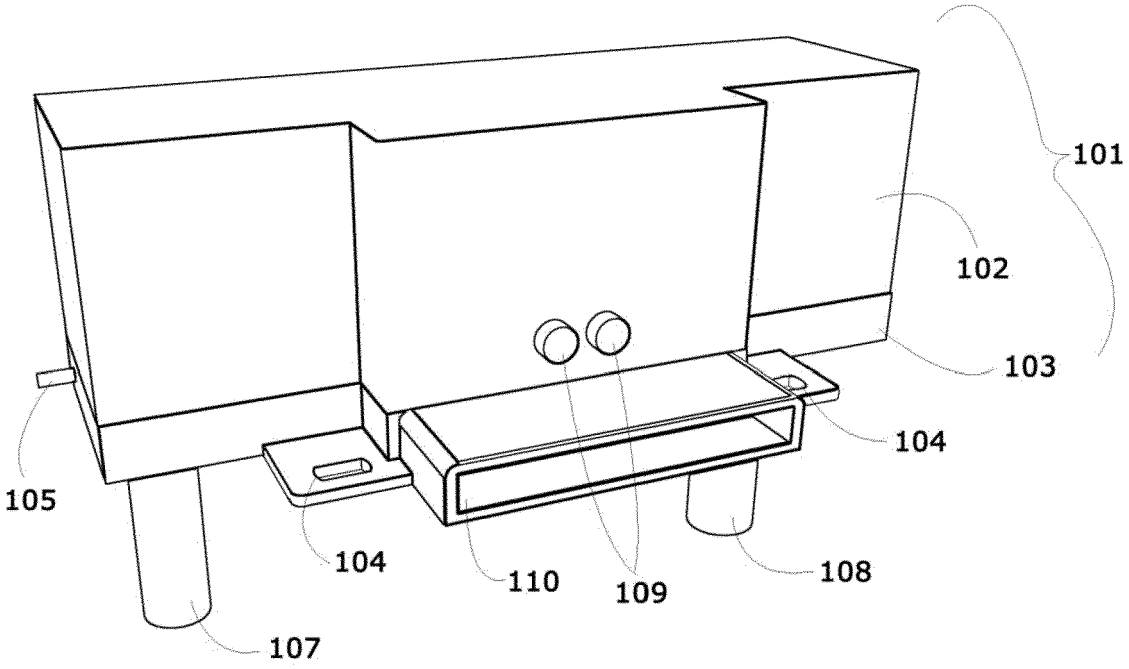

Fig 1a

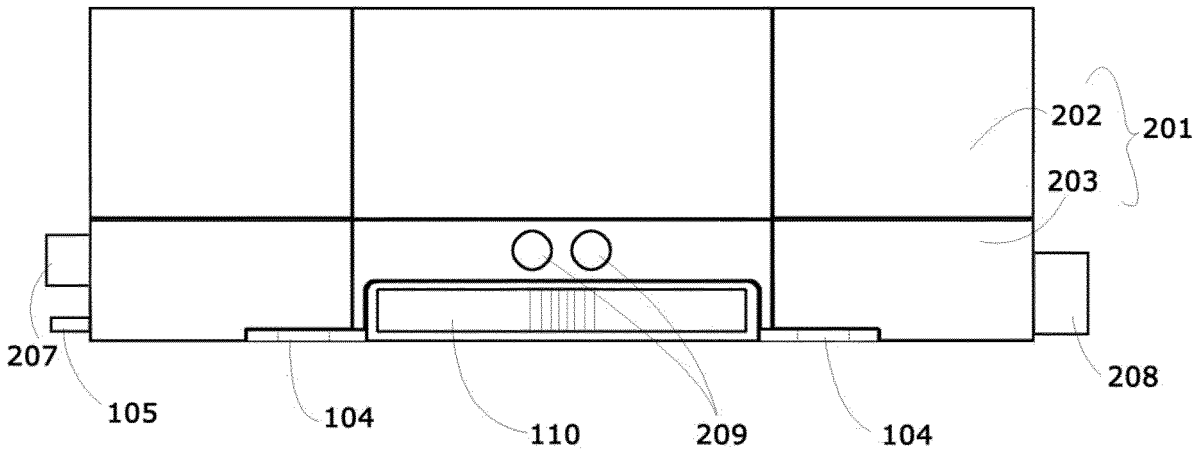

Fig 1b

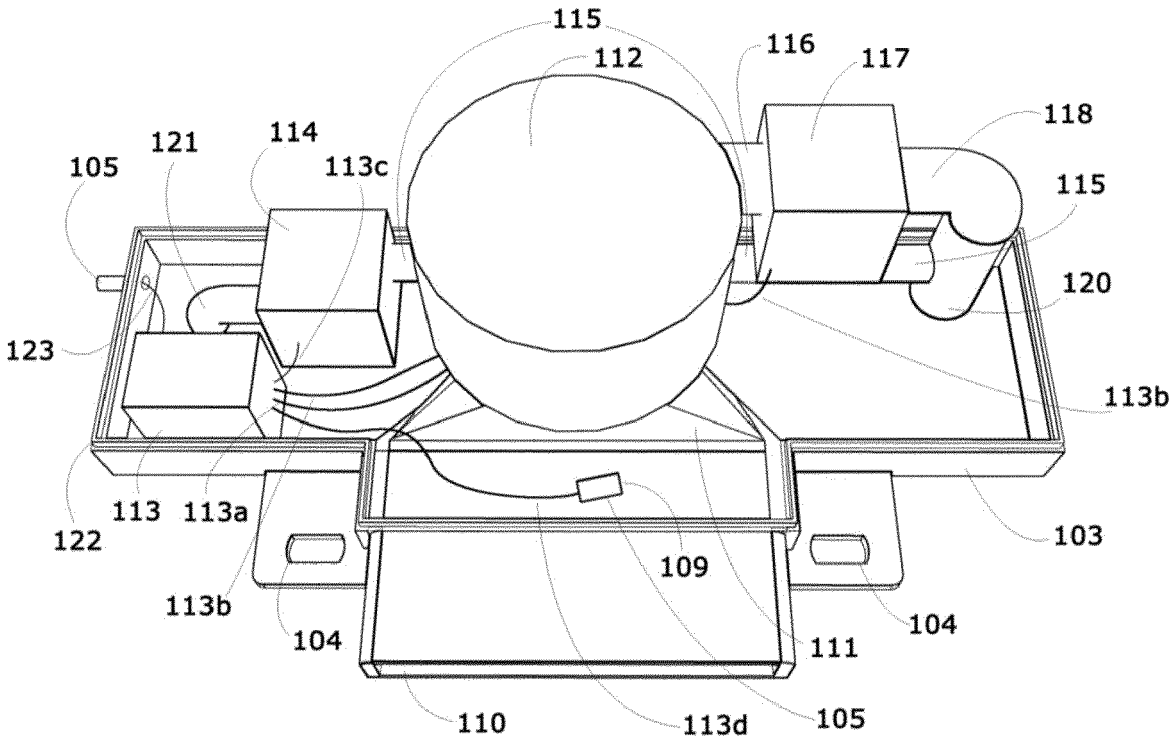
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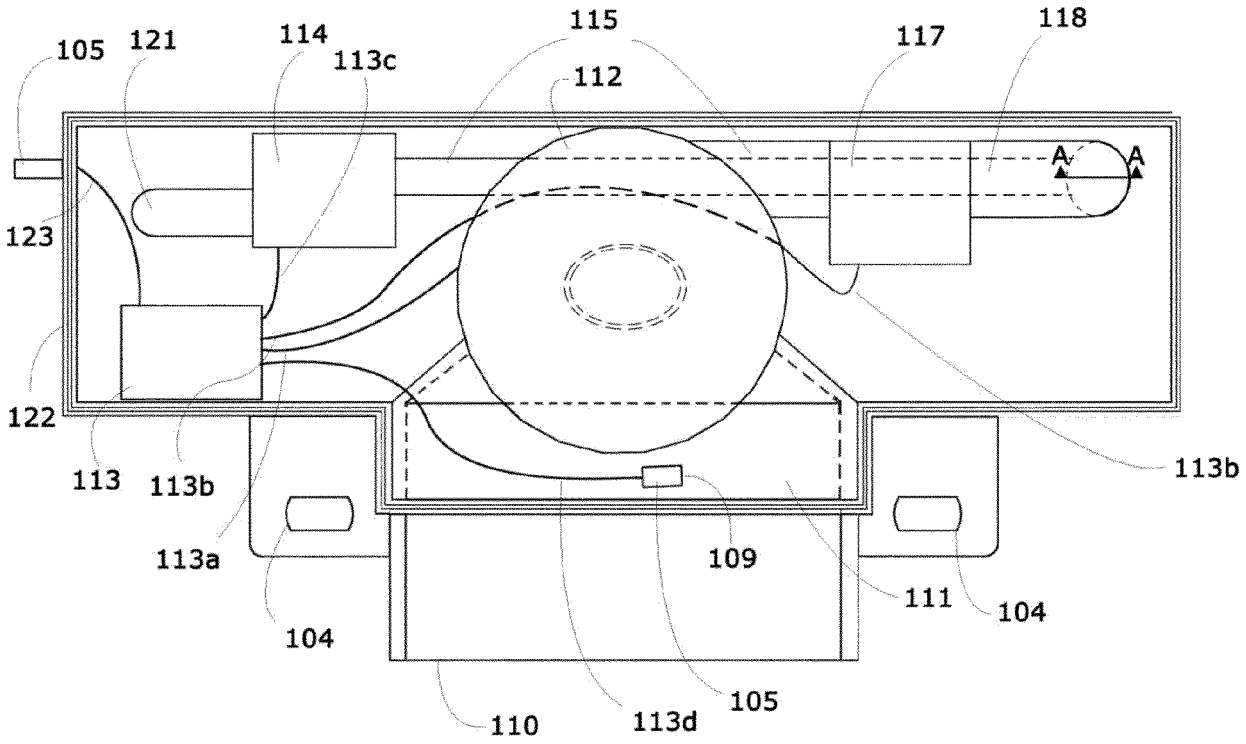
Fig 2a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113d
105

Fig 2b

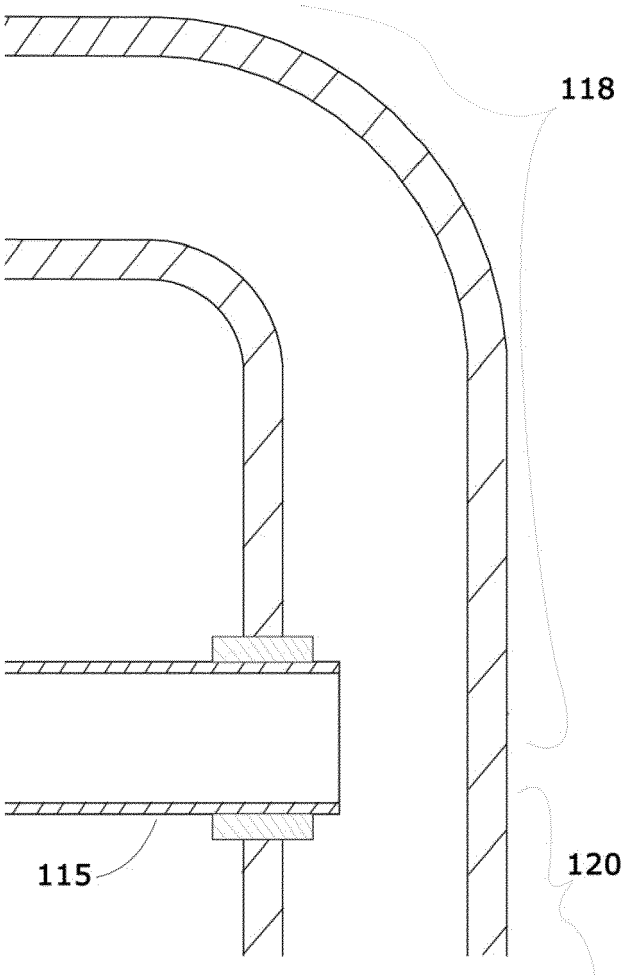

Fig 2c (section A-A)

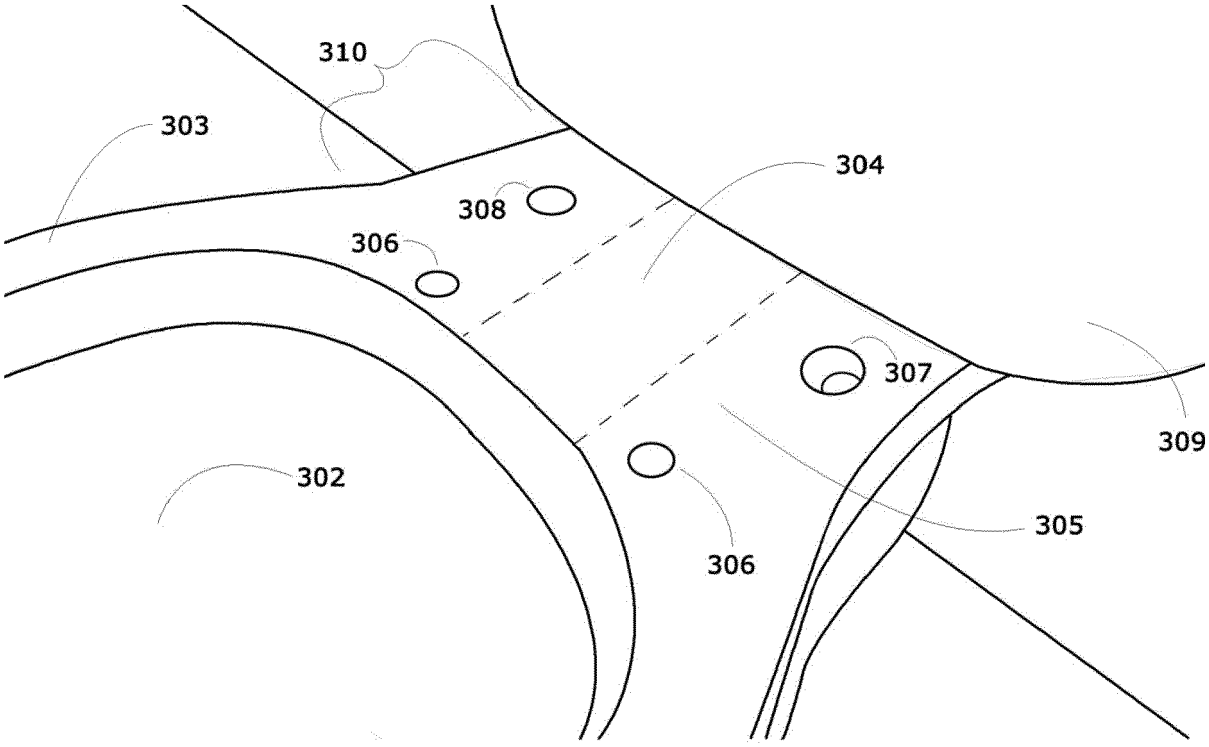

Fig 3

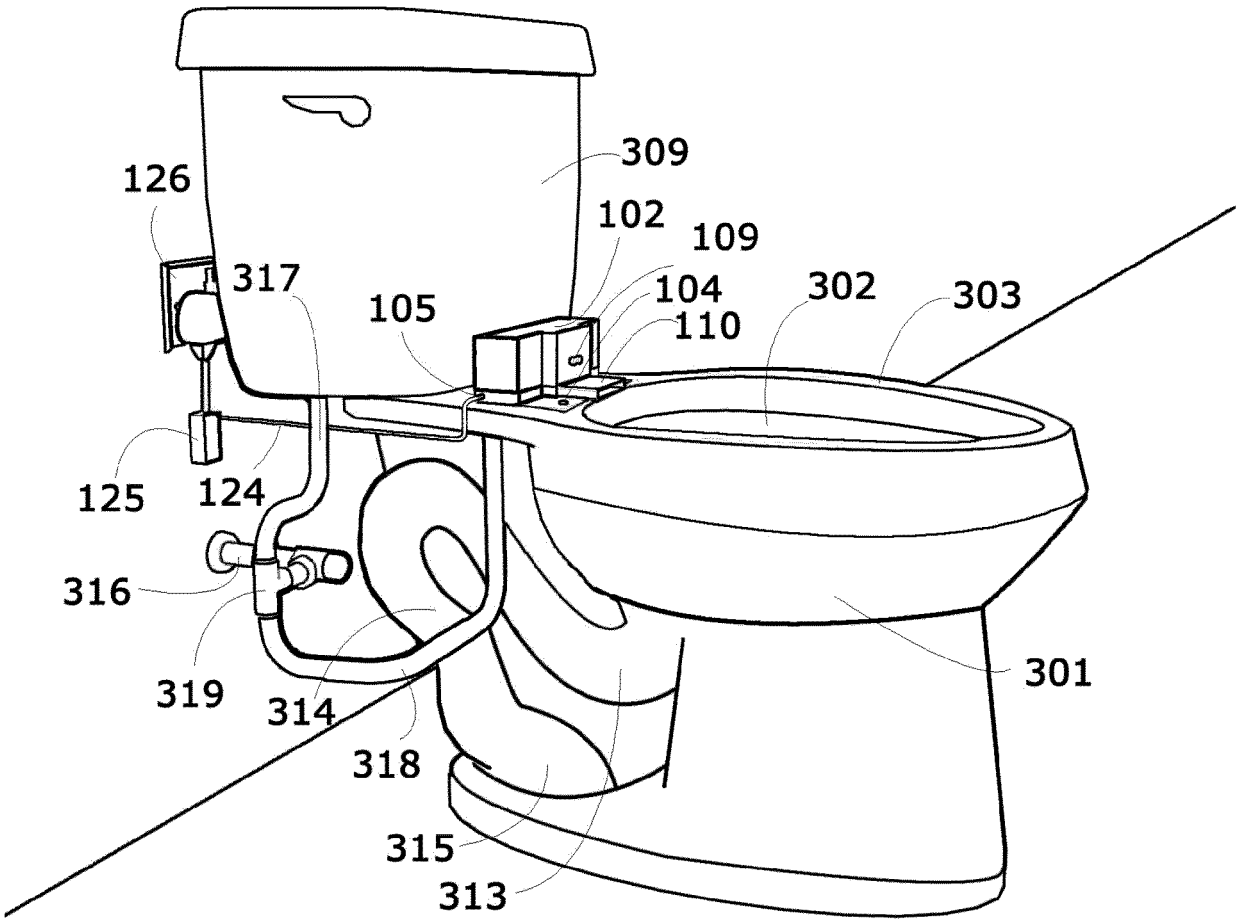
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Fig 4a

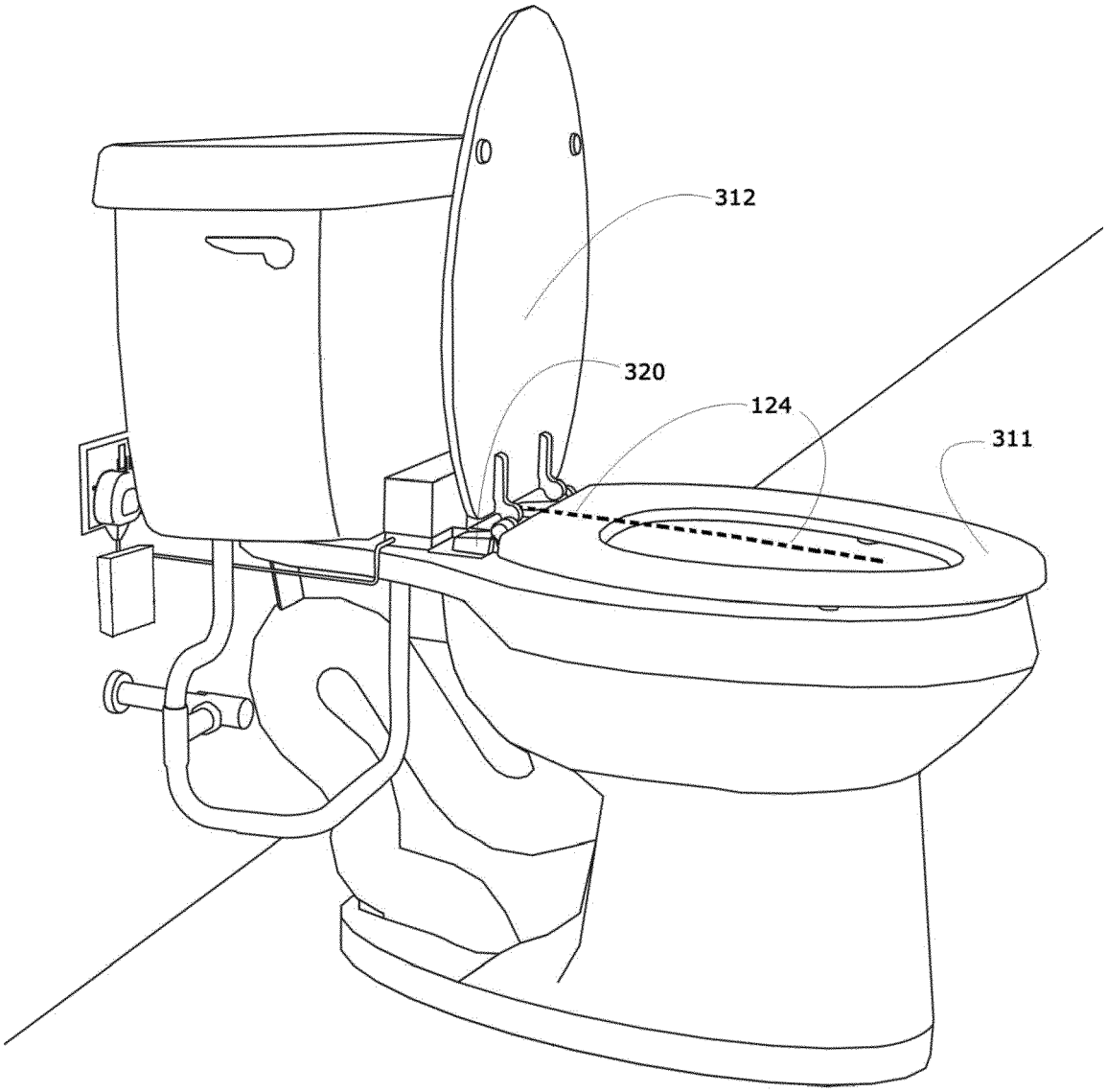

Fig 4b

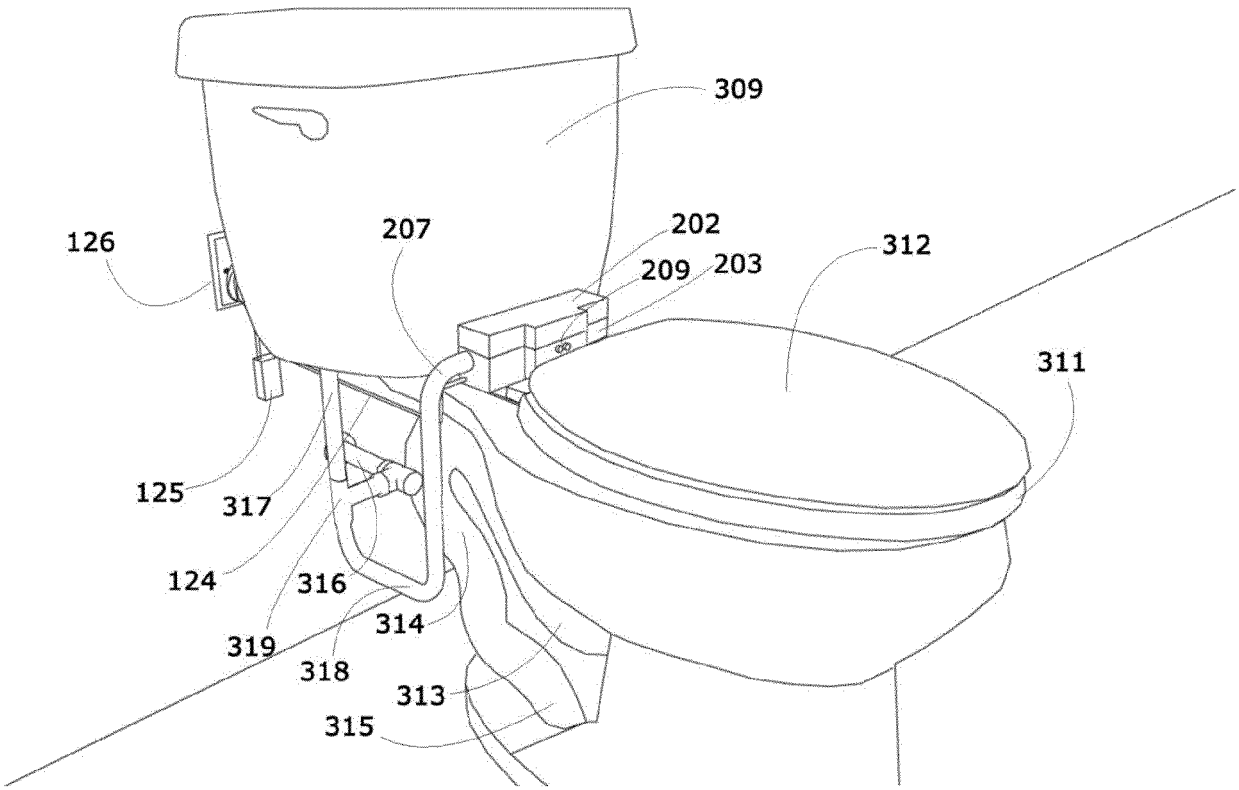
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Fig 4c

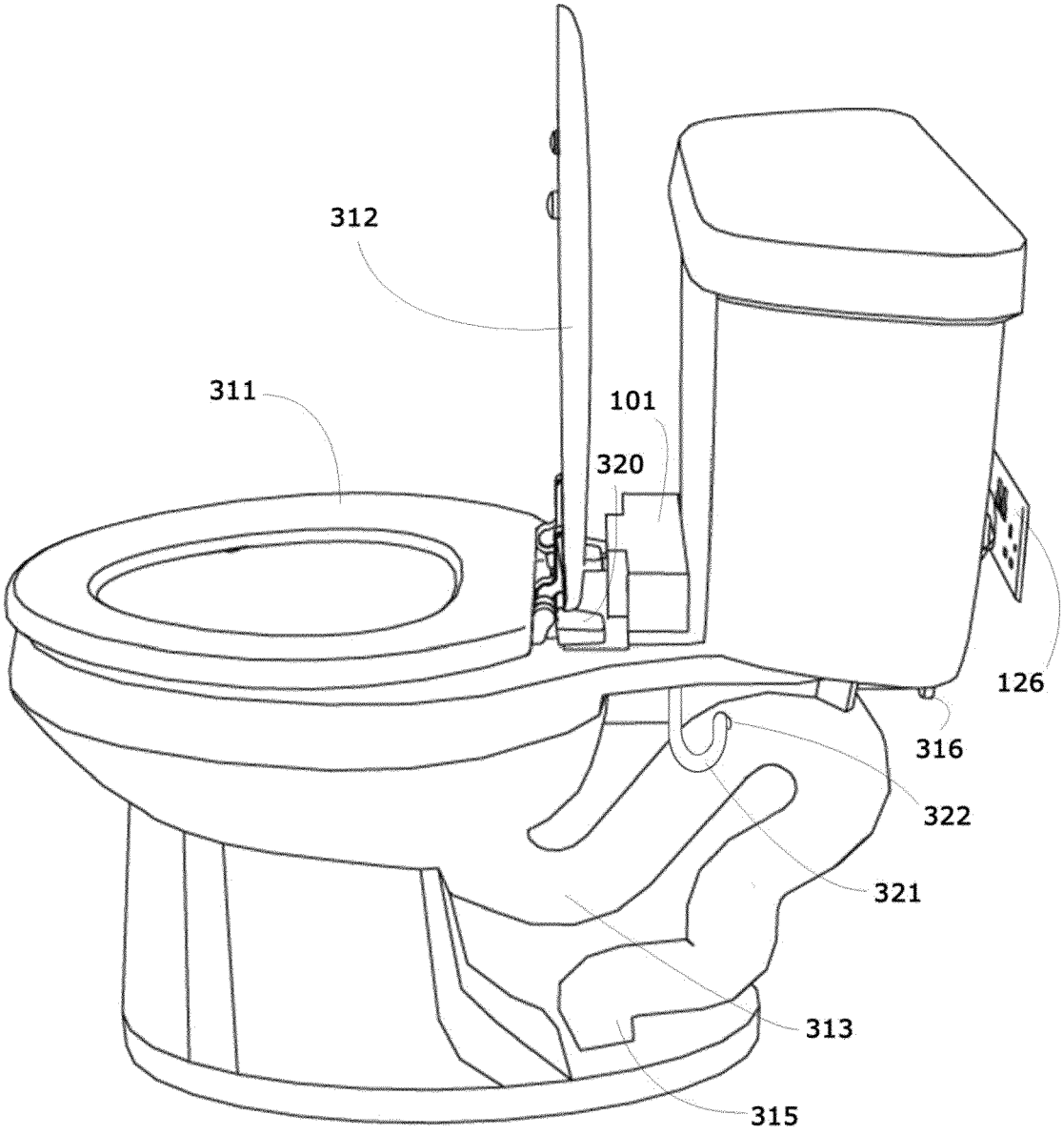

Fig 5a

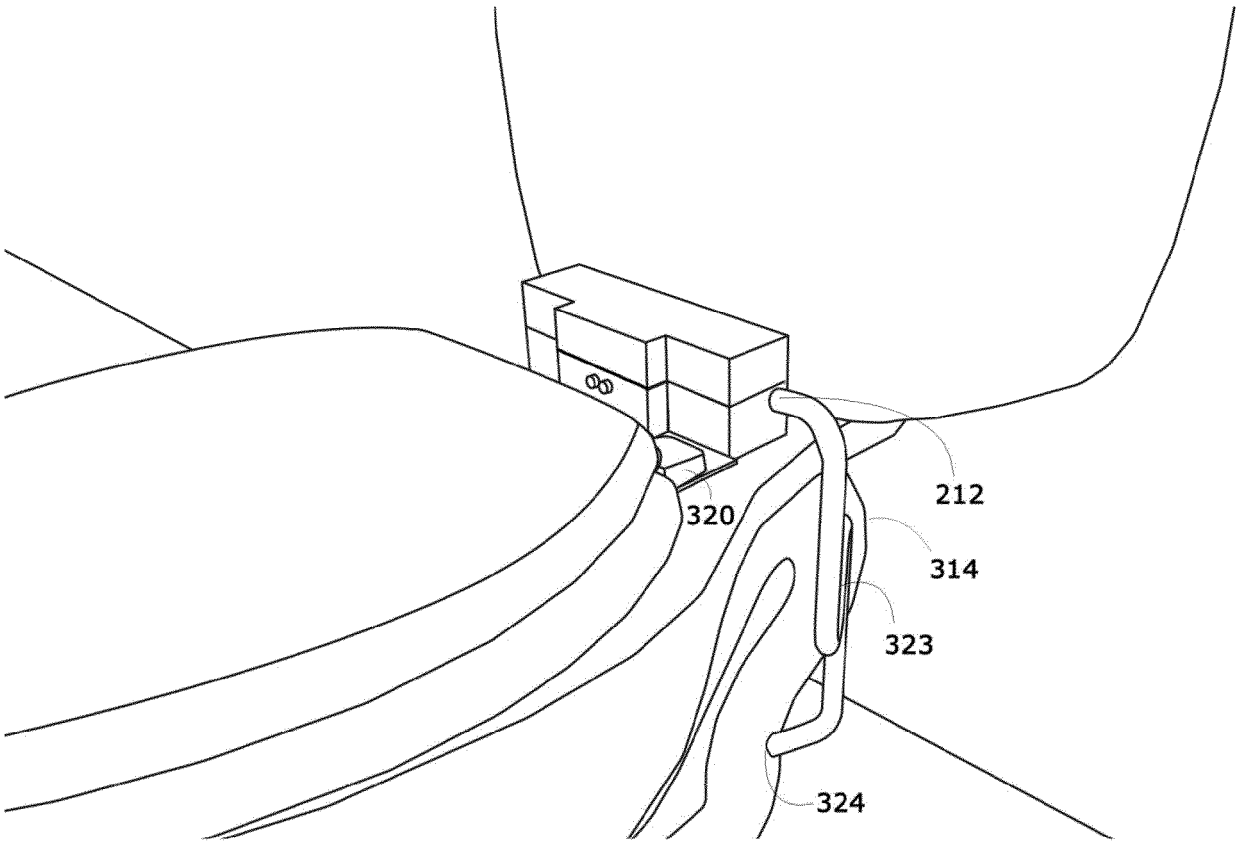

Fig 5b

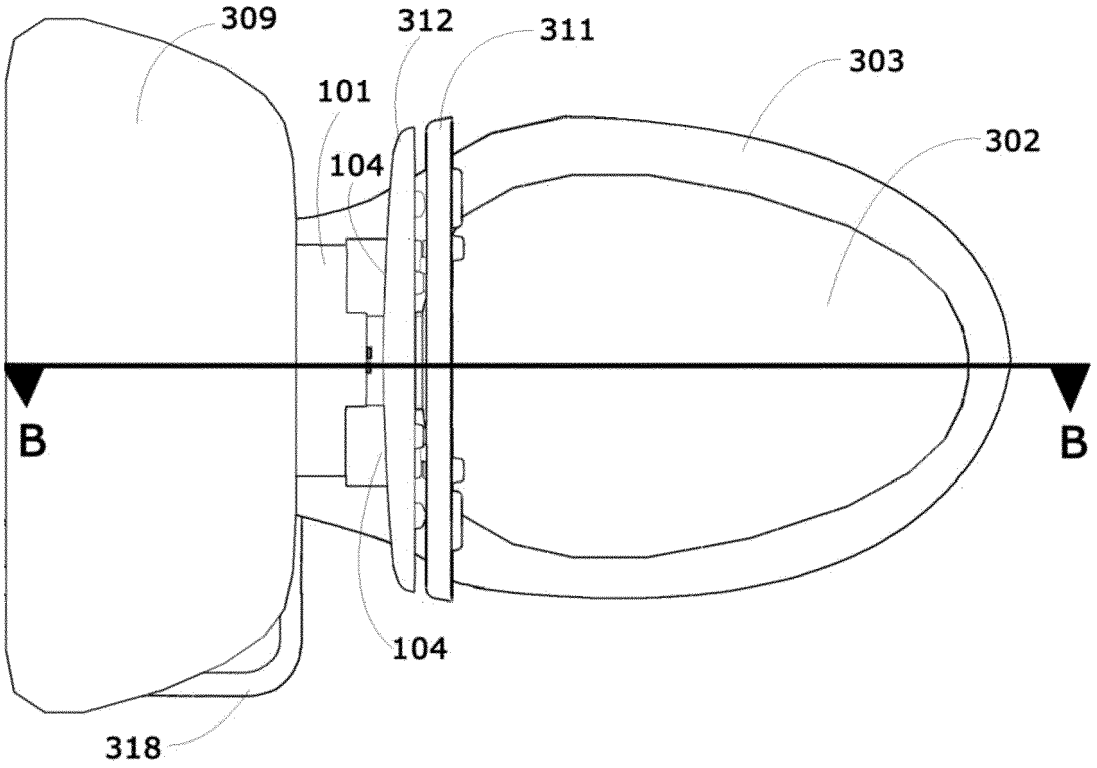

Fig 6a

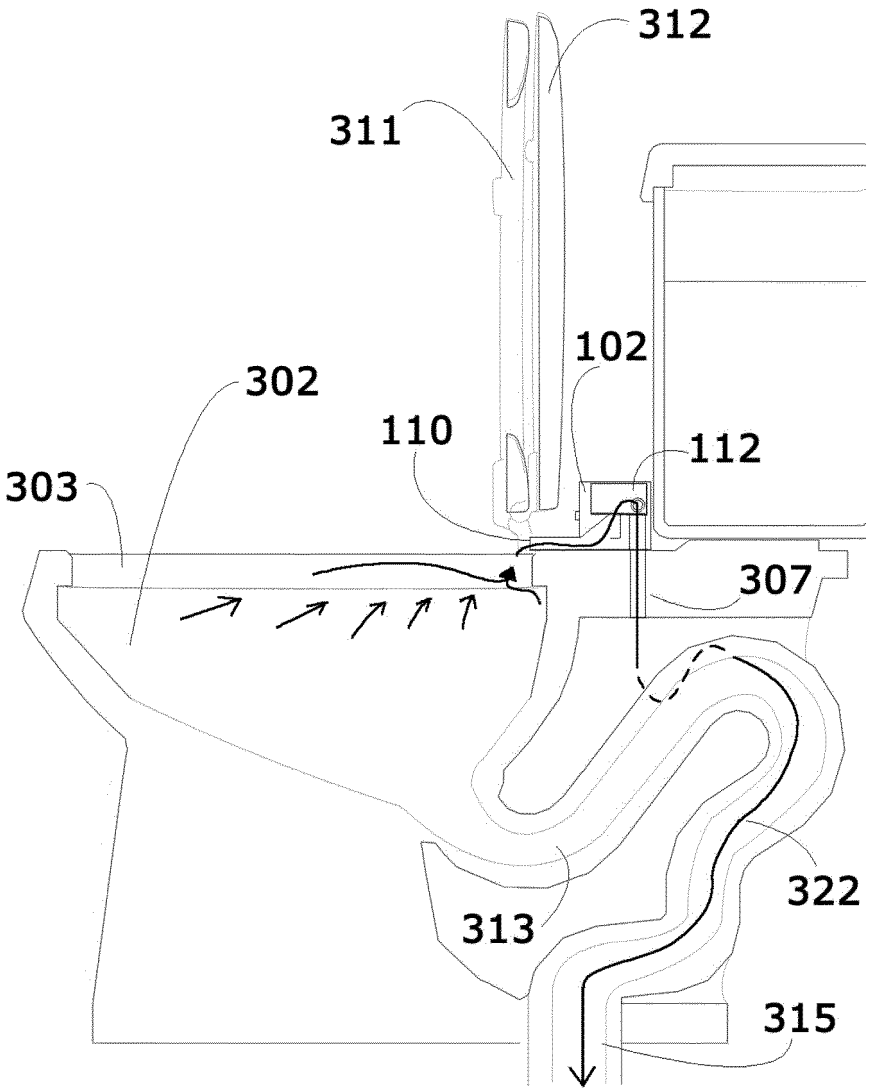

Fig 6b

REFERENCES CITED IN THE DESCRIPTION

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