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(54) **Title:** SENSOR SYSTEM FOR TOILET FLUSH CONTROL

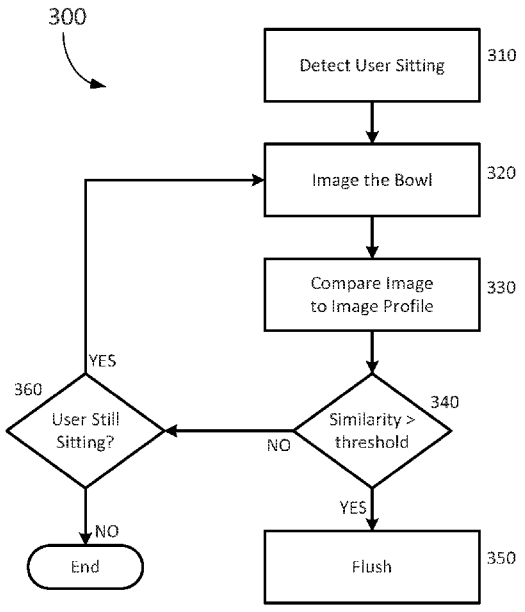


Fig. 3A

(57) **Abstract:** An intelligent sensing system for controlling a flush toilet. One or more sensing devices are disposed proximate to the toilet bowl and coupled to a controller. The sensing devices are configured to image the space in the bowl when the toilet is in use. The controller is configured to analyze the image information in order detect a condition where excessive solid waste is entering the toilet bowl above the static water line. If the sensing devices detect excessive solid waste entering the toilet bowl above the water line, a flush cycle is immediately initiated so that the solid waste has no opportunity to collect and clog the outlet of the toilet.

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SENSOR SYSTEM FOR TOILET FLUSH CONTROL

TECHNICAL FIELD

[0001] This disclosure relates to a system and method for intelligent sensing and control of a toilet flush operation.

BACKGROUND

[0002] The use of flush toilets for sanitary removal of normal human waste, i.e., urine and feces, is well established in developed countries. For example, Figs. 1A and 1B illustrate a conventional flush toilet 100 designed for ordinary residential use. Commercial toilet facilities may have multiple toilets and varying designs, but in general, the principle of operation for any toilet is virtually the same. The main components of the toilet 100 are: a ceramic bowl 110, filled with a small amount of water for collecting the human waste; a water tank 120 coupled to the bowl, and usually positioned above the bowl 110, for delivering a large quantity of water to the bowl during a flush cycle; and an outlet portion or siphon 130, for removing the waste and water to a drain-waste-vent system (not shown).

[0003] In a steady state, i.e., when the toilet is not in use, the water 111 in the bowl 110 is maintained at a predetermined level 112 in equilibrium with the water that remains in the siphon portion 130. Upon initiation of a flush cycle, a flush valve (not shown) inside the tank 120 opens allowing the large quantity of water in the tank to drop by force of gravity into the bowl 110, and the resultant water pressure generates a whirlpool that forces the wastewater through the outlet 130 and down the drain. Upon completion of the flush cycle, the water in the bowl returns to its predetermined equilibrium level.

[0004] However, a significant problem with flush toilets is that a clogged outlet/drain line may be caused by a large amount of solid waste deposited into the bowl. Some individuals may recognize and address this issue by manually starting a flush cycle as they begin to deposit solid waste, thereby initiating the whirlpool action early such that the solid waste does not have a chance to aggregate in the bowl and clog the drain pipe, but instead is carried away in the whirlpool immediately upon hitting the water in the bowl.

[0005] One solution that has been suggested to avoid clogs is to provide a larger volume of water for flushing solid waste (feces) and a smaller volume of water for flushing liquid waste

(urine). However, this method is not always successful, particularly where the quantity of solid waste deposited is large.

[0006] Thus, it would be desirable to provide a flush toilet with an intelligent sensing system that can initiate a flush cycle automatically upon detecting solid waste entering the bowl above the water line. Such a system would enable the whirlpool action to begin before the solid waste hits the water in the bowl and ensure that the waste is removed rather than clog the drain line.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Fig. 1A is a perspective view of a conventional flush toilet.

[0008] Fig. 1B is a cross-sectional side view of the toilet of Fig. 1A.

[0009] Fig. 2A is top plan view of a toilet having an intelligent flush sensor system installed in the bowl.

[0010] Fig. 2B is top plan view of a toilet having an intelligent flush sensor system in the seat.

[0011] Fig. 3A is a flowchart illustrating one process for initiating a flush cycle.

[0012] Fig. 3B is a flowchart illustrating another process for initiating a flush cycle.

[0013] Fig. 4 is a flowchart illustrating an alternative process for initiating or confirming a flush cycle.

[0014] Fig. 5 is a flowchart illustrating another alternative process for initiating or confirming a flush cycle.

DETAILED DESCRIPTION

[0015] An intelligent sensing system for controlling a flush toilet includes one or more sensing devices disposed proximate to the toilet bowl and coupled to a controller. The sensing devices are configured to image the space in the bowl when the toilet is in use. The controller is configured to analyze the image information in order detect a condition where excessive solid waste is entering the toilet bowl above the static water line. If the sensing devices detect excessive solid waste entering the toilet bowl above the water line, a flush cycle is immediately initiated so that the solid waste has no opportunity to collect and clog the outlet of the toilet.

[0016] Other types of information may also be gathered to help analyze and corroborate the image information in a decision process. For example, a variety of techniques are well-known for detecting the presence (or absence) of a user using various types of sensor devices, e.g., to

facilitate automatic flush decisions, and such information could form a step in the decision process for initiating a flush cycle for excessive solid waste. Also, sound and/or odor may be detected using known technologies, and such information also analyzed by the controller in the decision process. In one embodiment, the image information may be compared against stored image information to facilitate condition recognition.

[0017] Fig. 2A illustrates one embodiment of a toilet 200A having a number of sensing devices 250 disposed in several locations around the bowl. Fig. 2B illustrates another embodiment of toilet 200B having a number of sensing devices 251 disposed in several locations on the underside of the toilet seat 201 rather than the bowl. The sensing devices 250 or 251 are coupled to an electronic controller 260. The controller 260 is configured to use data/signals from the sensing devices 250 or 251 to detect and distinguish "active" conditions for human waste collection, namely, when the user actively deposits either liquid waste or solid waste or both into the bowl. In particular, the controller 260 is configured to initiate a flush cycle as soon as solid waste is detected entering the bowl.

[0018] In one embodiment, the sensing devices 250 or 251 are imaging devices, such as digital cameras, that are configured to detect and transmit data comprising moving images or still images to the controller 260. In preferred constructions, four sensing devices are affixed in key locations in order to image the entire space of the bowl. For example, in an original manufacture of the toilet bowl 210, the sensing devices 250 may be embedded within the sidewall of the bowl and electronic connections routed either through passages formed in the bowl or outside the bowl. In an original manufacture of the toilet seat 201, the sensing devices 251 may be embedded into the underside of the seat and electronic connections routed through passages formed in the seat, with a electrical connector provided to connect with the controller260. In a retrofit application for the toilet bowl 210, the sensing devices 250 may be affixed to the sidewall and appropriate electrical wiring for hazardous environments used to connect the devices to the controller. In a retrofit application for the toilet seat 201, the sensing devices 251 may be affixed to the underside of the seat, and appropriate electrical wiring for hazardous environments used to connect the devices to the controller. The number of sensing devices may be different, but it is recommended that at least two sensing devices be used to provide useful imaging information. Also, the sensing devices must be protected from the harsh bowl environment, for example, by having a clear cover that can be cleaned as necessary from time to time.

[0019] The controller 260 is preferably mounted on or near the tank 230 and coupled to

actuate a flush valve (not shown), which is typically contained within the tank. In one embodiment, the controller 260 is a conventional computer processor-based device having an associated memory. The controller 260 may also be implemented as an application specific integrated circuit ("ASIC") or other digital implementations. The interaction between an electronic controller and a flush valve is well known and need not be described in detail herein.

[0020] The controller 260 is programmed using known methods with one or more series of instructions to perform particular computing tasks for initiating a flush cycle when excessive solid waste is detected entering the toilet bowl above the water line. For example, Fig. 3A illustrates a process 300 for initiating a flush cycle. In optional step 310, the process detects that the user has sat down on the toilet. Technology for detecting the user and/or that the user has sat down is well known. As one example, a pressure sensor (not shown) can be incorporated with the toilet seat that is actuated when the user sits down.

[0021] In step 320, the sensing devices image the bowl space. It is preferred that the sensing devices take moving images of the bowl space, but a series of still images could also be effectively processed. In step 330, the image information is compared to a predetermined image profile. For example, a number of different image profiles may be stored in a lookup table and the processor performs a programmed routine to evaluate the similarity between the current bowl image and the stored image profiles. The stored image profiles may initially be best guesses, but over time, the processor can learn from the imaging information and store new image profiles that correspond to actual active conditions that resulted in a flush cycle, or upon review, should have resulted in a flush cycle.

[0022] In step 340, the similarity between the current bowl image and each stored image profile is scored and compared to a threshold score. If the similarity exceeds the threshold, i.e., if the current bowl profile is sufficiently similar to a stored image profile, then a flush cycle is initiated in step 350. If the similarity does not exceed the threshold, the process determines whether the user is still seated in step 360. If so, then the process returns to step 320 and continues to image the bowl. If not, the process ends.

[0023] Fig. 3B illustrates an alternative process 301 for initiating a flush cycle. Steps 311 and 321 are the same as steps 310 and 320 in process 300. In step 331, the image information is analyzed to determine whether one or more objects are exiting the bowels of the user. If the size of any of the objects is larger than a predetermined threshold, then a flush cycle is initiated in step 351. If the size of any of the objects is not larger than a predetermined threshold, the

process determines whether the user is still seated in step 361. If so, then the process returns to step 321 and continues to image the bowl. If not, the process ends.

[0024] In other embodiments, additional sensors may be incorporated to evaluate other types of information that may help the controller make the correct decision regarding initiating a flush cycle.

[0025] For example, one or more microphones may be placed proximate to the bowl to collect sound signals when the toilet is in use and deliver the sound signals to the controller. Fig. 4 illustrates a process 400 for using sounds in the decision process. In step 410, sounds in the toilet bowl are collected by one or more microphones. In step 420, the sound signals are transmitted to the controller. In step 430, the captured sounds are compared to stored sound profiles. For example, a number of different sound profiles may be stored in a lookup table and the processor performs a programmed routine to evaluate the similarity between the current bowl sounds and the stored sound profiles. The stored sound profiles may initially be best guesses, but over time, the processor can learn from the sound information and store new sound profiles that correspond to actual active conditions that resulted in a flush cycle, or upon review, should have resulted in a flush cycle.

[0026] In step 440, the similarity between the current bowl sounds and each stored sound profile is scored and compared to a threshold score. If the similarity exceeds the threshold, i.e., if the current bowl sound profile is sufficiently similar to a stored sound profile, then a flush cycle is initiated in step 450. If the similarity does not exceed the threshold, then the process returns to step 410 and continues to capture sound in the bowl.

[0027] Process 400 may be used a standalone process to determine whether to initiate a flush cycle, or instead it may be used as a corroborating process to confirm the decision to initiate a flush cycle that was reached in step 350 of process 300.

[0028] In another example, odor sensors may be incorporated to help make a flush decision. For example, the Figaro TGS2602 gas sensor is highly sensitive to low concentrations of odorous gases such as ammonia and hydrogen sulfide ("H_2S)", which are generated from human waste.

[0029] Fig. 5 illustrates a process 500 for using odor detection in the decision process. In step 510, odors in the bowl are captured by the odor sensor. In step 520, the odor signals detected by the odor sensor are transmitted to the controller. If H_2S has been detected by the odor sensor in step 530, then the decision to flush is confirmed in step 540. If not, the process

returns to step 510 to continue monitoring odors.

[0030] A gas sensor system for use in a toilet is described in International Patent Publication WO 2016/083405, which is incorporated herein by reference. The gas sensor system is used to detect changes in the concentration of target gases as a means for evaluating the health condition of the user.

[0031] It should be apparent from the foregoing that there are a number of ways to implement the principles described herein, and thus, the description is intended to cover various modifications and similar arrangements as would be apparent to those skilled in the art.

CLAIMS

1. A system for toilet flush control, comprising:

at least one sensor configured to detect solid waste entering a toilet bowl; and

a controller coupled to the sensor and to a toilet flush valve, wherein the flush valve is activated to release water into the toilet bowl to initiate a flush cycle when the sensor detects solid waste entering the toilet bowl above a waterline in the toilet bowl.

2. The system of claim 1, wherein the sensor is affixed within the toilet bowl above the waterline.

3. The system of claim 2, wherein a plurality of sensors are each embedded in different locations around the toilet bowl

4. The system of claim 1, wherein the sensor is affixed to an underside of a toilet seat.

5. The system of claim 4, wherein a plurality of sensors are each embedded in different locations around the toilet seat.

6. The system of claim 1, wherein the sensor is configured to generate an image of the toilet bowl, and the controller is configured to detect solid waste in the generated image entering the toilet bowl above the waterline.

7. The system of claim 6, further comprising a plurality of sensors each disposed in a different location in order to completely image the toilet bowl.

8. The system of claim 6, further comprising a memory accessible by the controller and having a plurality of stored images, wherein the generated image is compared to the stored images and scored, and when the score of the generated image exceeds a threshold value, the flush cycle is initiated.

9. The system of claim 1, wherein the sensor is configured to detect the size of an object entering the toilet bowl, and when the object size exceeds a threshold value, the flush cycle is initiated.

10. The system of claim 1, further comprising

a memory accessible by the controller and having a plurality of stored sound profiles associated with the toilet in use;

a sound sensor configured to detect sounds when the toilet is in use, wherein the detected sounds are compared to the stored sound profiles, and when the detected sounds are sufficiently similar to one of the stored sound profiles, the flush cycle is initiated.

11. The system of claim 1, further comprising

an odor sensor configured to detect odors when the toilet is in use, and when a specific low concentration of odorous gases associated with human waste is detected, the decision to initiate a flush cycle is corroborated.

12. The system of claim 11, wherein the detected odorous gas is hydrogen sulfide.

13. A method for toilet flush control, comprising:

detecting that a user has sat down on a seat of the toilet;

imaging a bowl of the toilet;

comparing the bowl imaging to a plurality of stored images;

scoring a similarity of the bowl imaging to the stored image; and

initiating a flush cycle for the toilet when the score exceeds a threshold;

14. The method of claim 13, further comprising:

detecting sounds when the toilet is in use;

comparing the detected sounds to a plurality of stored sound profiles; and

initiating the flush cycle when the detected sounds are sufficiently similar to one of the stored sound profiles.

15. The method of claim 13, further comprising:

detecting odors when the toilet is in use;

determining that at least one of the odors is a specific low concentration of an odorous gas associated with human waste; and

initiating the flush cycle when the detected odor exceeds the specific low concentration of an odorous gas associated with human waste.

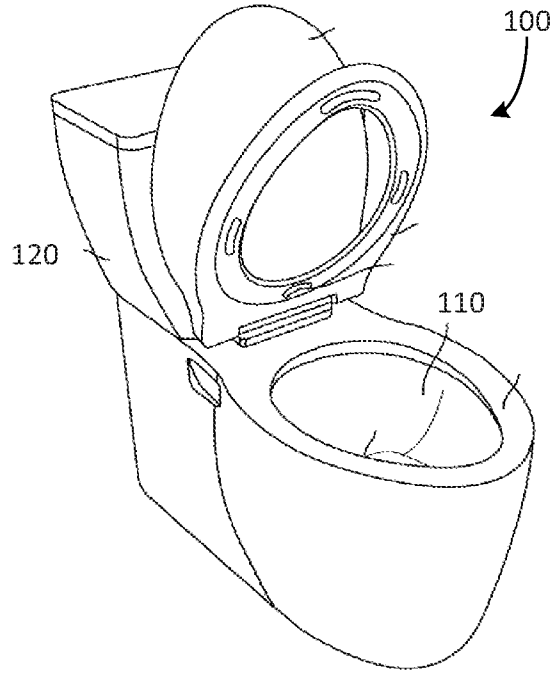


Fig. 1A

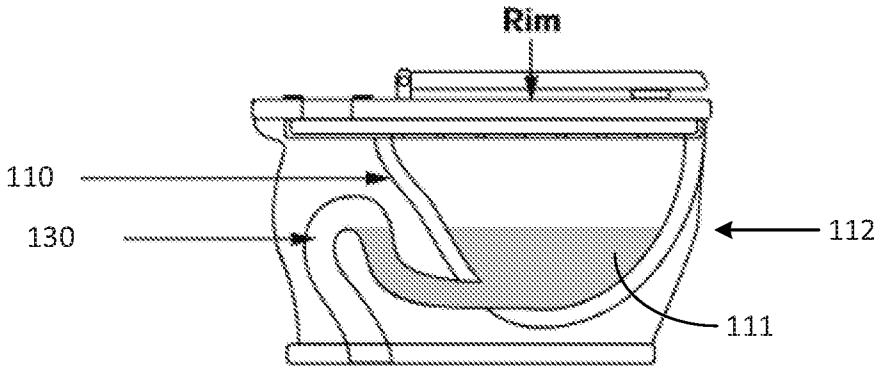


Fig. 1B

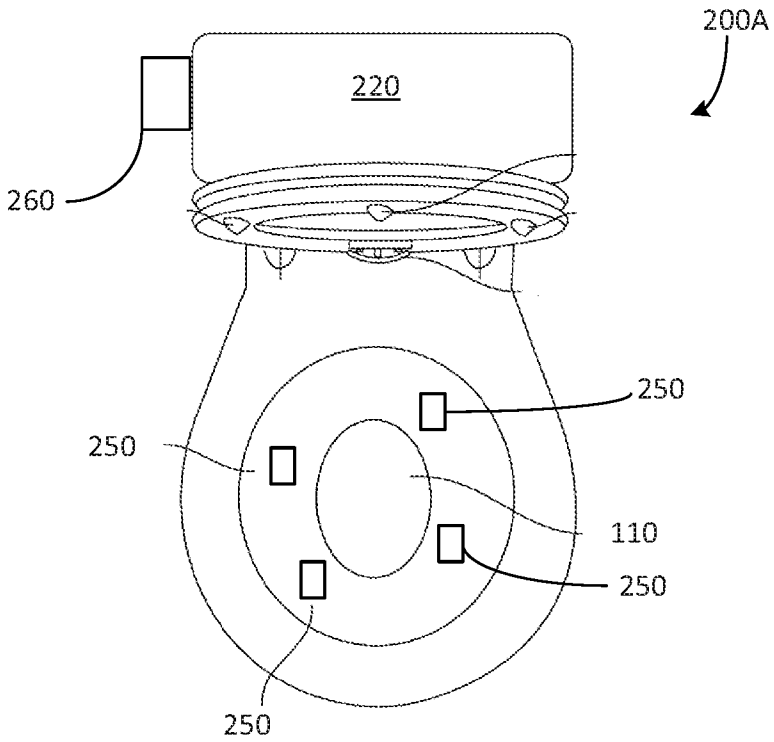


Fig. 2A

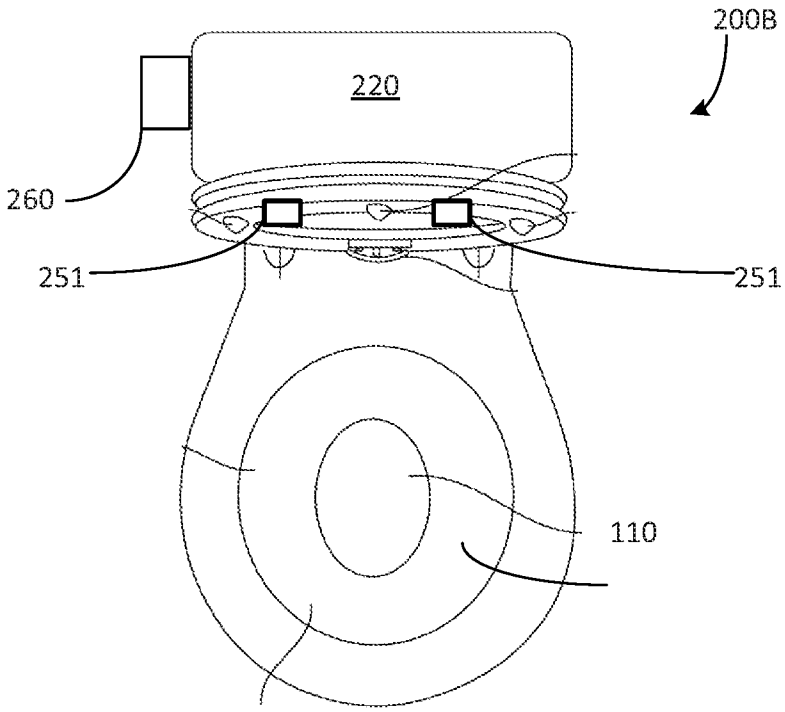


Fig. 2B

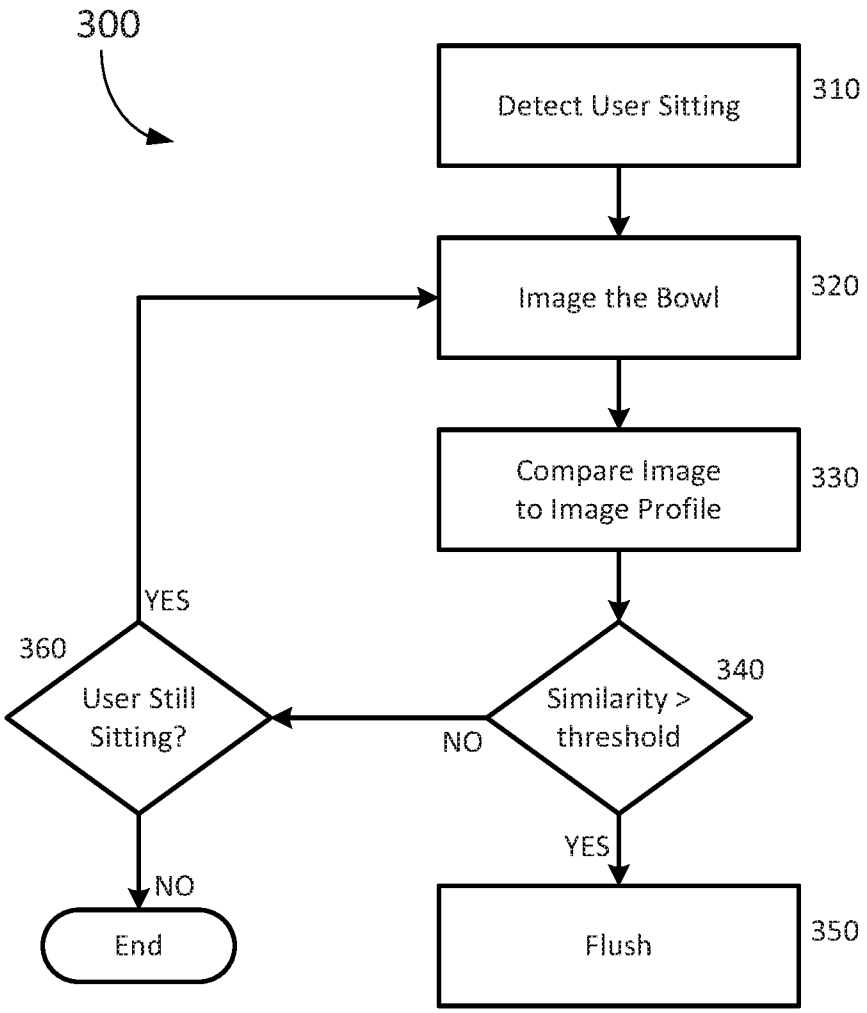

300
Detect User Sitting
310
Image the Bowl
320
Compare Image to Image Profile
330
Similarity > threshold
340
NO
YES
User Still Sitting?
360
YES
NO
End
Flush
350

Fig. 3A

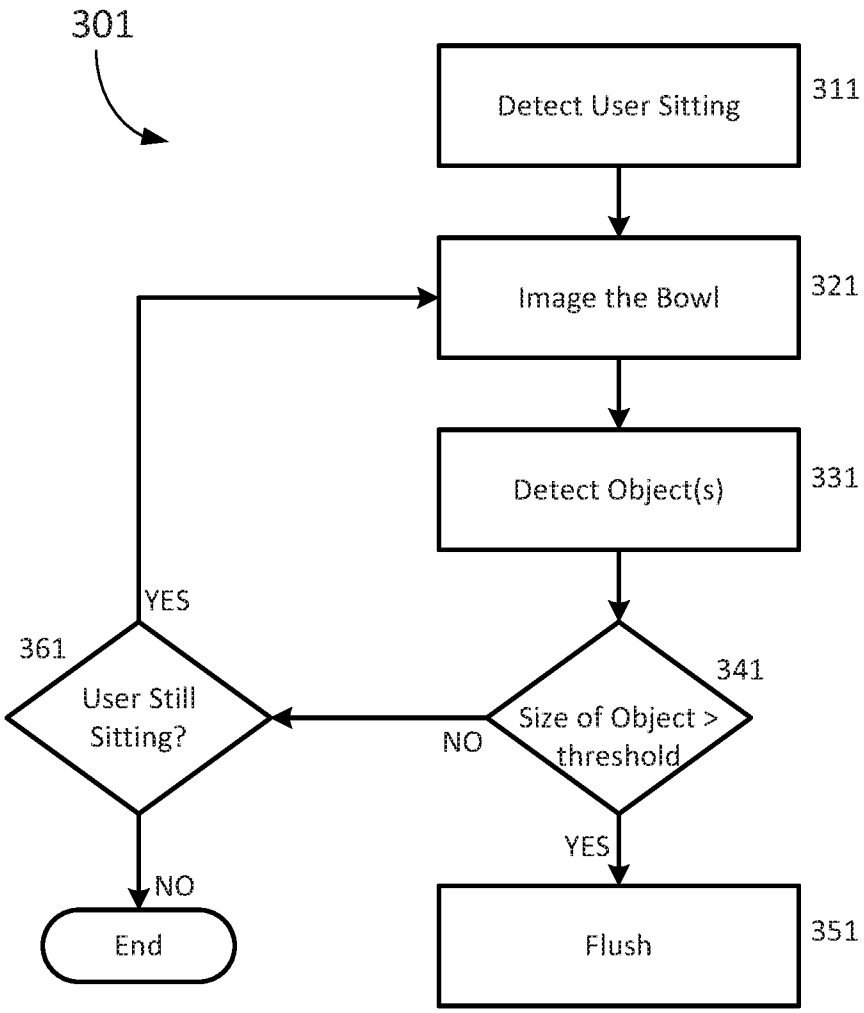

301
Detect User Sitting
311
Image the Bowl
321
Detect Object(s)
331
Size of Object > threshold
341
NO
YES
User Still Sitting?
361
YES
NO
End
Flush
351

Fig. 3B

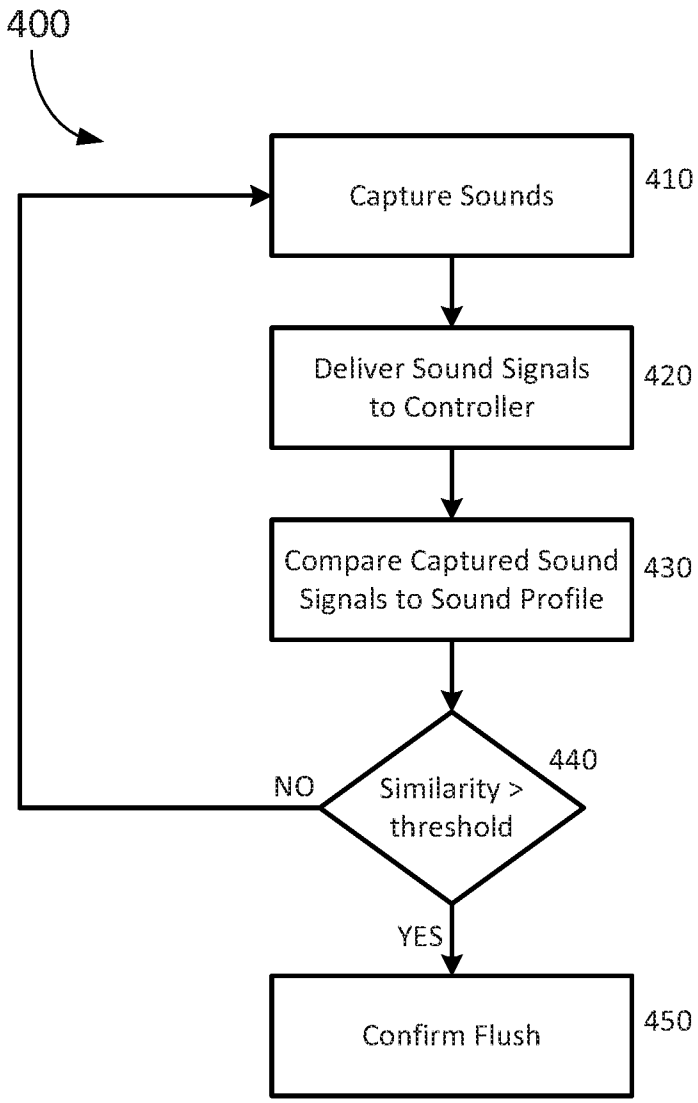

400
Capture Sounds
410
Deliver Sound Signals to Controller
420
Compare Captured Sound Signals to Sound Profile
430
Similarity > threshold
440
NO
YES
Confirm Flush
450

Fig. 4

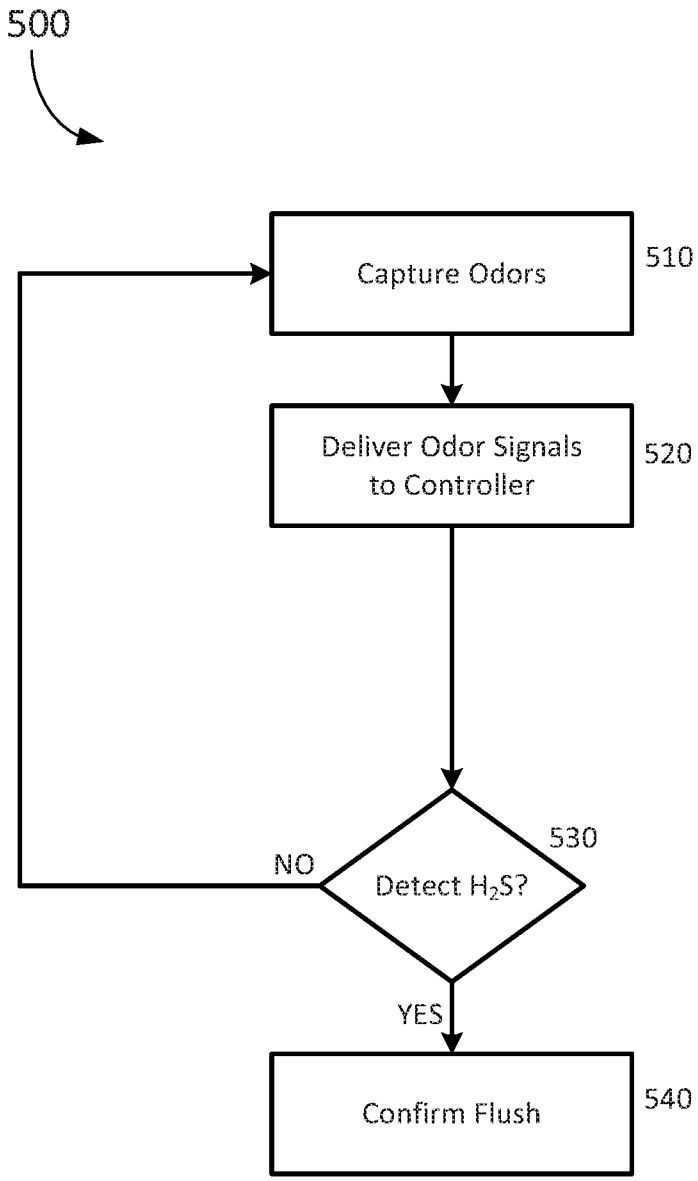

500
Capture Odors
510
Deliver Odor Signals to Controller
520
Detect H_2S?
530
NO
YES
Confirm Flush
540

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 17/69012

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E03D 1/00 (2018.01)
CPC - E03D 5/105, E03D 5/10, E03D 5/04, E03D 5/024, E03C 1/057

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2010/0146691 A1 (CHAN) 17 June 2010 (17.06.2010), entire document, especially abstract and para [0032], [0036]-[0038], [0043]-[0052], [0060]-[0062], Fig. 1B.	1-9, 11, 13, 15 ---------- 10, 12, 14
Y	US 2016/0217670 A1 (DORO AB) 28 July 2016 (28.07.2016), entire document, especially abstract and para [0043]-[0047], [0063], [0075], [0077].	10, 14
Y	US 2015/0330958 A1 (SCA HYGIENE PRODUCTS AB) 19 November 2015 (19.11.2015), entire document, especially abstract and para [0027]-[0028], [0046]-[0053].	12
A	US 2016/0083949 A1 (SIAMP CEDAP) 24 March 2016 (24.03.2016), entire document.	1-15
A	US 2010/0031431 A1 (LEE) 11 February 2010 (11.02.2010), entire document.	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 March 2018 (01.03.2018)	26 MAR 2018
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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