Sept. 26, 1967 N. J. PALMER 3,343,178

PUMP AND FILTER APPARATUS FOR A CHEMICAL TOILET

Filed Feb. 1, 1966 2 Sheets-Sheet 1

FIG. 1.

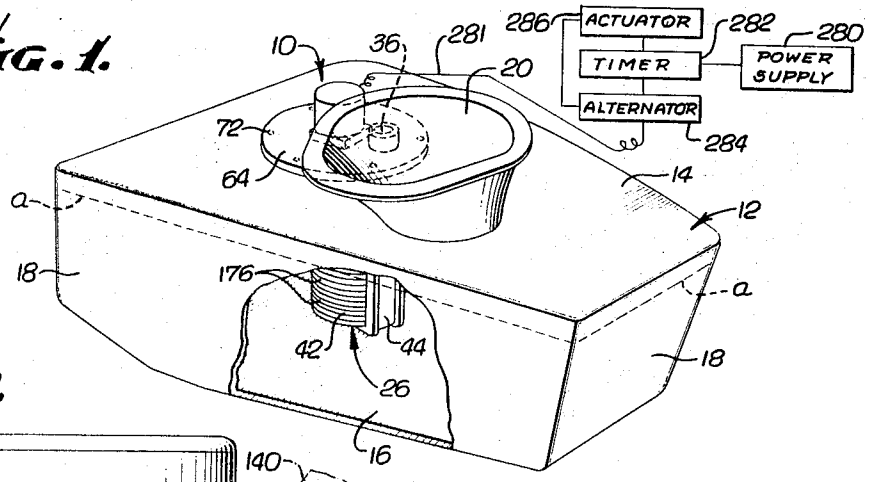


FIG. 2.

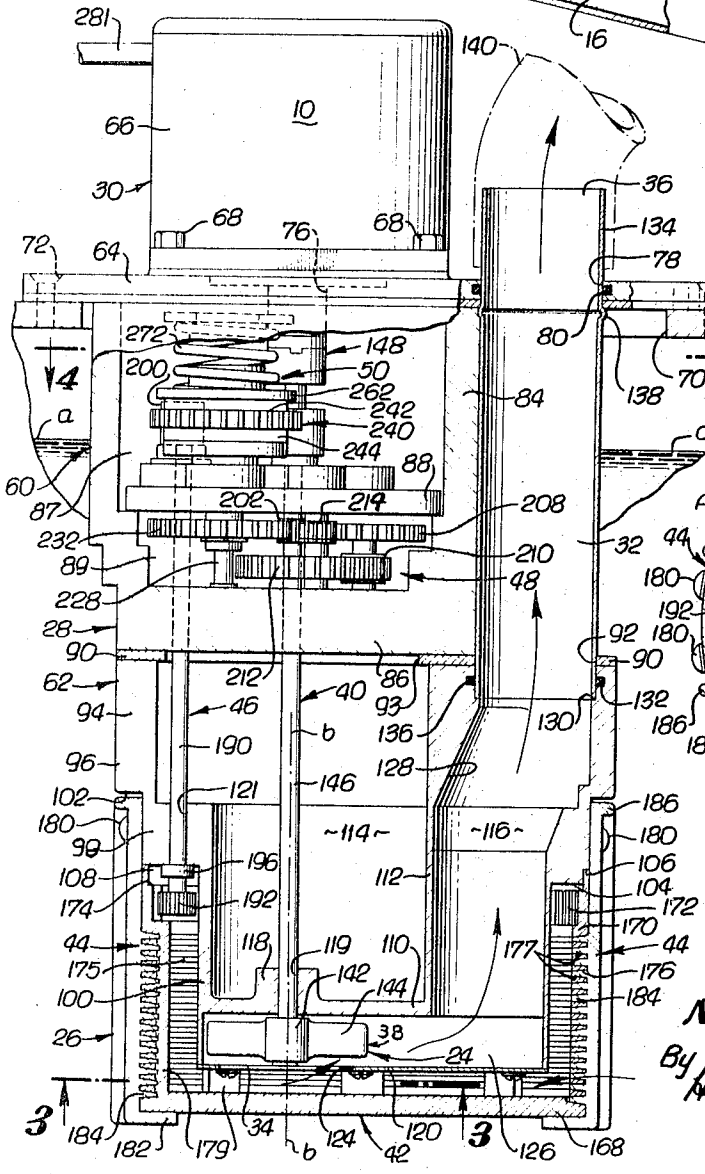
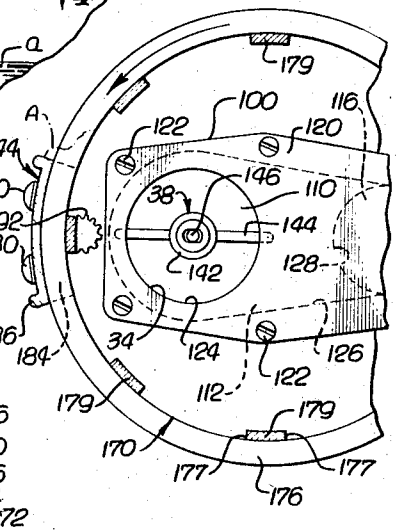


FIG. 3.



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FIG. 4.

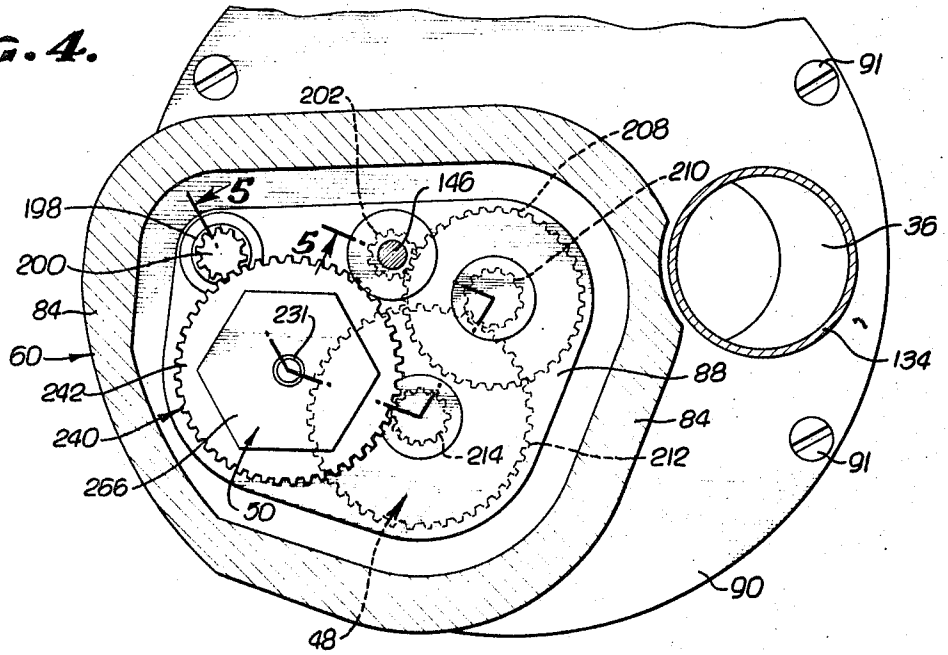
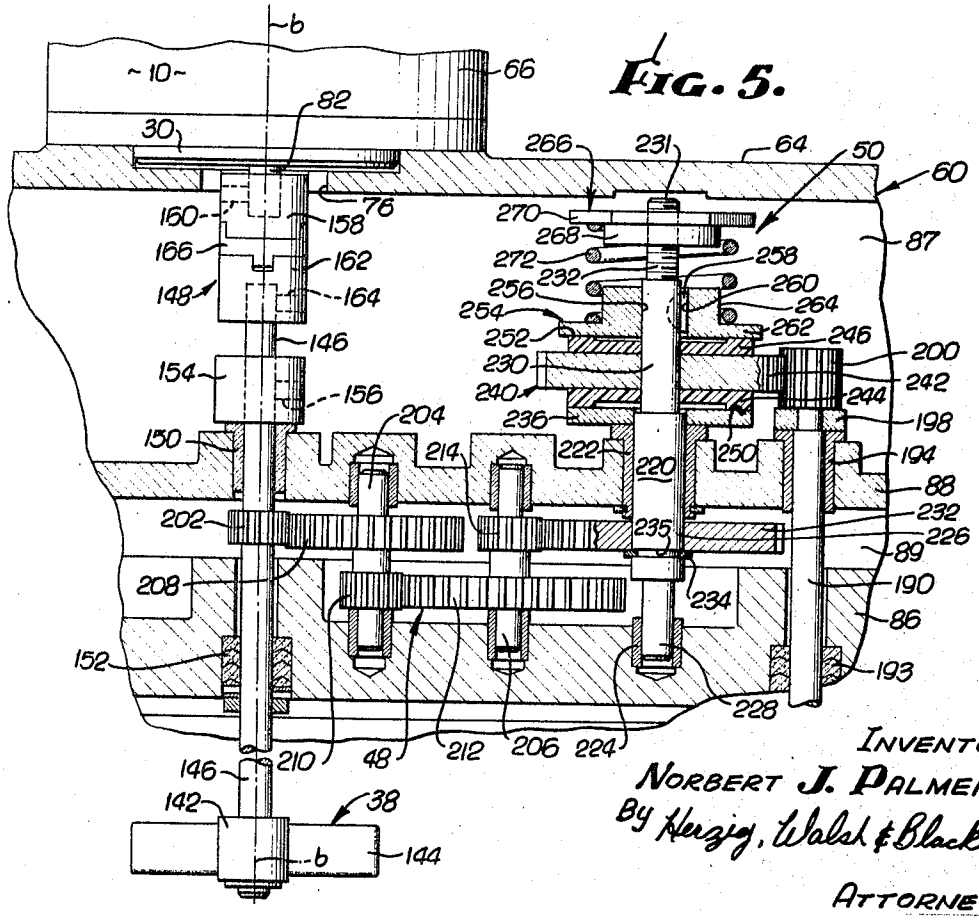


FIG. 5.



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PUMP AND FILTER APPARATUS FOR A CHEMICAL TOILET

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4 Claims. (Cl. 4—115)

ABSTRACT OF THE DISCLOSURE

A toilet system having a rotating pump element in a rotating filter basket with both being rotated by a single motor for recirculating flushing liquid, the motor being of the reversible type having its output shaft connected to a pump impeller which cooperates with a pump housing to produce a flow of such liquid from a tank through the filter element and into said housing, in that order, regardless of the direction of rotation of said motor output shaft, the filter basket being driven through a speed reduction unit and a slip friction clutch to prevent overheating of the motor in the event that the speed of the filter basket is reduced appreciably or stopped.

The present invention relates generally to a recirculating sanitation system. It relates more particularly to pump and filter appparatus for such a system. This application is a continuation-in-part of U.S. Application Ser. No. 438,500, filed Mar. 10, 1965, in the name of the same inventor.

Self-contained recirculating toilet systems have found a wide application in aircraft, marine vessels, trailers and campers and the like. Typically such a system includes a toilet bowl and a tank that is in communication with the bowl and only partially filled with a quantity or batch of a liquid chemical solution. After each use of the toilet, whereby liquid and/or solid waste material is deposited in the bowl, a generally determined amount of liquid is recirculated from the tank to the bowl to flush or wash the waste material into the tank. In addition to the waste material, toilet paper and various other foreign articles, objects or material may be thrown into the toilet, and the liquid also washes this foreign material into the tank. As the toilet is used, more and more liquid waste is added to the liquid in the system. The chemical solution in the liquid acts on the waste or foreign material to break it down, to mask undesired odors, and to generally digest or neutralize the waste material. While the tank itself is periodically emptied and cleaned of such waste material, solids, paper and the like, and the liquid in the system replaced with a fresh batch of solution, the value of such as a system depends to a considerable extent on the ability of the system to operate repeatedly using the same batch of solution and without requiring cleaning of the system or changing of the solution. As a corollary to this, it is necessary that the filter arrangement be capable of effectively functioning for a like long time period during which is provided a sufficient quantity of solution for each flush of the bowl.

One of the problems presented in such a system is effectively filtering the quantity of liquid which is circulated to the bowl so that relatively clear liquid leaves the tank, with solid waste and foreign material being retained in the tank. This is desirable from an esthetic viewpoint, but more importantly is necessary to protect the functioning of the pumping mechanism and to keep the conduits or lines clear. It will, of course, be appreciated that some particels of solid waste and foreign material will be included in the liquid which is recirculated. The terms "liquid" and "solution," as used herein, refer generally to the mixture of liquid waste and liquid chemical solution together with such particles.

Material and particles tend to accumulate at the inlet to the pumping means, and such accumulation tends to limit the amount of liquid which can be circulated or delivered to the bowl when the system is operated or flushed. From the point of view of filtering, one of the most severe problems is caused by toilet or tissue paper which tends to decompose or fragment into small fibers or particles which then tend to accumulate or compact at the inlet to the pumping means to limit its intake.

Certain prior devices have attempted to alleviate such problems by periodically reversing the flow of solution in the system. This approach has not proved particularly satisfactory. A more successful approach to the problem has been the use of a filter arrangement having mechanical wipers or scrapers with relative movement being provided between the wipers and the filter to physically scrape or remove material which tends to accumulate on the filter. While such an arrangement has proved commercially effective, material tends to accumulate at one side of the wipers and to impair the full efficiency of the device.

In addition to such problems from the gradual accumulation of particles, there is some danger that the filer arrangement will become locked or jammed so that it is slowed or even stopped, and inasmuch as it is physically connected to the output of the motor, will cause the motor to burn out. To meet this danger, clutch devices have been utilized between the motor and the filter arrangement to permit the motor to operate freely of a jammed filter arrangement. However, the prior art devices have usually produced a loud sound or noise, such as a clicking, when the filter arrangement becomes jammed. This can be annoying, disturbing and even alarming to nearby people, particularly when the sanitation system is installed in a passenger aircraft and the noise occurs during the flight of the aircraft.

Prior sanitation systems of this type have other disadvantages and deficiencies.

Accordingly, it is an object of the present invention to provide a novel and improved sanitation system construction.

A further object of the present invention is to provide a novel and improved pump and filter apparatus for a recirculating sanitation system.

A more specific object of the present invention is the provision of such a pump and filter apparatus which is self-cleaning.

Another object of the present invention is the provision of means that protect the drive motor should the filter arrangement become jammed or locked, but do not produce an accompanying loud noise or sound to disturb or alarm nearby people.

A further object of the present invention is the provision of a compact, simple and economical pump and filter apparatus of this type which is effective, durable and dependable.

Various other objects and advantages of the present invention will become more apparent from the following description and the accompanying drawings.

Broadly, the present invention contemplates a novel and improved pump and filter apparatus for a recirculating toilet system. The apparatus includes a reversible, mechanical wiper-type filter arrangement which may be reversed incident to the operation of the apparatus to effect self-cleaning of the filter arrangement. The apparatus may be constructed and arranged so that the reversal and accompanying cleaning of the filter arrangement takes place simultaneously with the pumping of liquid through the system.

Very broadly, a presently preferered form of the pump and filter apparatus of the present invention includes a pump means which will move substantially the same volume of liquid material in the same pre-determined di-

rection for either direction of pump rotation. The apparatus also includes a self-cleaning filter arrangement comprising a filter means and wiper means. Relative lateral movement between the filter and wiper means causes the wiper means to scrape away material that tends to accumulate on the filter means. A single reversible motor is operatively connected to the pump means and to the filter arrangement to drive both in forward or reverse direction in accordance with the direction of rotation of the motor. Thus, reversing the motor reverses the relative movement of the filter arrangement so that the arrangement is self-cleaning. The motor reversal also reverses the pump means, but, as noted above, the pump means continues to move liquid in the same direction.

A relatively silent clutch arrangement is interposed between the motor and the filter arrangement. If the latter should become jammed or locked so that it was slowed or stopped, the motor would be free to rotate and would thereby be protected. The silent operation of the clutch arrangement avoids disturbing or alarming people nearby.

In the drawings:

FIGURE 1 is a partially schematic perspective view, with a part broken away to show details of construction, of portions of a self-contained recirculating aircraft toilet system that includes a pump and filter apparatus embodying various features of the present invention;

FIGURE 2 is an enlarged side view, with parts broken away and in section, of the filter and pump apparatus shown in FIGURE 1.

FIGURE 3 is a sectional view taken generally along 3—3 of FIGURE 2;

FIGURE 4 is a further enlarged sectional view taken generally along line 4—4 of FIGURE 2, showing particularly the transmission means of said apparatus; and

FIGURE 5 is a sectional view taken generally along line 5—5 of FIGURE 4, which line 5—5 is arranged to show in elevation the sequence of elements in said transmission means.

The over-all sanitation or toilet system

FIGURE 1 illustrates schematically portions of a self-contained recirculating toilet system for use in a large passenger aircraft. The illustrated system includes the presently preferred form of pump and filter apparatus which is designated generally by the numeral **10**. It will be appreciated that there are various other applications for such a system and apparatus, such as in boats, trailers, campers, trains, or the like.

As shown in FIGURE 1, the system includes a tank or reservoir **12** which is generally rectangular in shape having an upper wall **14**, a lower wall **16** and vertical side walls **18**. Initially, the tank **12** is only partially filled with a quantity or batch of liquid chemical solution. As the system is used, the level rises to a level such as indicated by lines *a—a* in FIGURES 1 and 2 or even higher before the liquid is removed and a fresh batch of solution added. The tank **12** may be constructed of any suitable material which will withstand the corroding, deteriorating and rusting effect of the chemical solution and the waste material which the tank will hold. A generally standard frusto-conical toilet bowl **20** is mounted in the upper wall **14** of the tank, and suitable means (not shown) provide communication from the bowl to the tank.

As noted generally above, after each use of the toilet, the pump and filter apparatus **10** is actuated to deliver a determined quantity of relatively clear liquid from the tank **12** to the bowl **20** to wash the waste material from the bowl and to facilitate its passage into the tank. In the tank, the solution acts on the waste material to generally neutralize it and cause its structural breakdown. The solution will normally include substances to reduce and/or mask the odor from the waste material both initially and during its decomposition and the solution may be colored to visually mask the waste material. The solution also acts on foreign material such as tissue paper.

General description of illustrated pump and filter apparatus

As shown best in FIGURES 1 and 2, the illustrated pump and filter apparatus **10** is a compact, self-contained unit or package mounted on the upper wall **14** of the tank **12** so as to extend downwardly into the interior of the tank and to have its lower end submerged in the liquid within the tank. In general, the apparatus **10** comprises an impeller type pump **24** and a rotary filter arrangement **26**. As shown in FIGURE 2, the apparatus **10** includes a casing or housing **28** that supports a reversible motor **30** above the tank. The housing **28** defines a pump passage **32** that includes an inlet **34** at the lower end of the housing below the level of the liquid and an outlet **36** at the upper end of the housing to connect to the bowl. A pump rotor or impeller **38** is rotatably supported in the passage **32** and directly connected to the motor by pump drive means **40**. Rotation of the impeller in either direction causes liquid to flow through the passage in the same direction from the inlet to the outlet as shown generally by the arrows in the drawings. The filter arrangement **26** includes a filter **42** which is rotatably mounted at the lower end of the housing **28** surrounding the pump inlet **34**. The filter arrangement **26** also includes filter wiper or scraper means in the form of a pair of opposed wiper or scraper blades **44** which are secured to the lower end of the housing for engagement with the filter **42**. The housing supports filter drive means **46** for transmitting power from the motor **30** to the filter arrangement **26**. The filter drive means **46** includes a gear train or transmission **48** and a silent friction-type clutch arrangement **50**.

In general, in the operation of the illustrated apparatus **10**, rotation of the motor in a first direction rotates the pump impeller **38** in the same direction and also rotates the filter **42** in a first direction. Reversing the motor to rotate in a second direction reverses the pump impeller **38**, however the flow continues in the same direction as indicated by the arrows noted above. The reversal of the motor reverses the direction of rotation of the filter, however, to effect cleaning of the filter **42** and the scrapers **44**.

Detail description of pump and filter apparatus

The housing or casing **28** which is constructed of a suitable corrosion-resistant material includes an upper gear box section **60** and a lower pump housing section **62**. A circular mounting plate **64** is secured to the upper end of the gear box section **60** with the gear box section positioned eccentrically with respect to the mounting plate. A motor housing **66** is secured, as by means of bolts **68**, to the mounting plate **64** generally above the gear box section **60**.

The tank upper wall **14** is provided with an aperture **70**, and the apparatus **10** is inserted through the aperture **70** to position the gear box and pump housing sections **60** and **62** within the tank while the mounting plate **64** is supported by the portion of the upper tank wall surrounding the aperture. Suitable screws **72** may be used to secure the mounting plate **64** to the tank wall. The mounting plate **64** is provided with an aperture **76** generally central of the motor housing **66** for providing communication between the motor housing and the gear box section. The mounting plate **64** is recessed around the upper portion of the aperture **76** to receive a portion of the motor **30**, as shown best in FIGURE 5. The mounting plate **64** is also provided with an aperture **78** for the pump outlet, as will be explained in further detail below. The aperture **78** is prvided with an annular groove **80** adapted to receive an O-ring. A suitable sealing gasket **81** is provided between the underside of the mounting plate and the upper tank wall. Suitable openings or cutouts are provided in the gasket **81** in alignment with the apertures **76** and **78**.

The motor **30** is a conventional electric motor capable of reversing direction of rotation of its output shaft **82**

when the direction in which current is delivered to the motor is reversed. The motor **30** is disposed within the motor housing **66** with its output shaft **82** extending vertically downwardly through aperture **76** in the mounting plate into the interior of the gear box section **60**. The axis of the motor output shaft **82** will be used as a main or reference axis *b—b* in describing the apparatus. As noted above, a portion of the motor **30** extends downwardly into the recessed area around the aperture **76**.

The gear box section **60** includes a vertical side wall **84** of irregular cylindrical shape, as shown in horizontal section in FIGURE 4. The wall **84** is secured along its upper edge to the underside of the mounting plate **64** and extends downwardly through the aperture **70** in the upper tank wall. The gear box section **60** includes a horizontal lower or bottom wall **86** which is integral with the side wall **84**. An intermediate horizontal wall or internal plate **88** is supported within the gear box section a short distance above the lower wall **86** to define an upper cavity or compartment **87** and a lower cavity or compartment **89**. The gear box section **60** will be discussed in further detail below in connection with the pump and the filter drive means, the transmission means, and the clutch arrangement.

The lower or pump housing section **62** is generally cylindrical externally and is secured to the lower end of the gear box section **60**. The pump housing section **62** is positioned eccentrically both with regard to the gear box section **60** and to the main axis *b—b*. A suitable spacing plate **90** is disposed between the gear box section **60** and the pump housing section **62**. The spacer **90** is generally circular and coextensive with the upper surface of the pump housing section **62**, to which it is secured by screws **91** (FIGURE 4). The spacer plate **90** is provided with a circular aperture **92** that is below the aperture **78** in the mounting plate **64**. A large aperture **93** is formed in the spacer plate below the gear box section **60** and generally centered about the main axis *b—b*.

The pump housing section **62** includes an annular vertical outer wall **94** formed with an upper portion **96** that is generally circular cylindrical of approximately the same diameter as the spacer plate **90**. The wall **94** has also a circular cylindrical intermediate portion **98** of a smaller diameter than the upper portion. A downwardly facing annular shoulder or lip **102** is formed at the lower edge of the upper portion **96**. The wall **94** is further formed with a lower portion **100** of irregular elongated shape in horizontal section as shown in FIGURE 3. There is a main downwardly facing generally annular shoulder **104** at the lower edge of the intermediate portion **98**. The lower edge of the intermediate portion **98** is also formed with a second generally annular shoulder **106**. Further, at the side of the vertical wall **94**, adjacent the main axis *b—b*, the lower portion of the intermediate portion **98** is provided with a recess **108** to accommodate a portion of the filter drive means, as will be described below.

The pump housing section **62** is integrally formed with an internal or intermediate horizontal wall **110**, spaced upwardly a short distance from the lower edge of the exterior wall **94**, and with an internal or intermediate vertical wall **112**. The intermediate walls **110** and **112**, in general, separate the interior of the pump housing section **62** into two cavities or compartments: a drive means cavity or compartment **114** and a pump cavity or compartment **116**. The drive means cavity **114** is open at its upper end to the aperture **93** in the spacer plate **90** and to the underside of the gear box section **60**. The intermediate horizontal wall **110** is integrally formed with a hub **118** that provides a bearing **119** extending along the main vertical axis *b—b*. The external wall **94** is formed adjacent its intermediate portion **98** to provide a bearing **121**. The bearing **121** extends vertically from shoulder **106** at recess **108** upwardly into cavity **114**.

A cover plate **120** having the irregular shape of the lower outer wall portion **100** (FIGURE 3) is secured by means of screws **122** to the lower edge of the exterior wall **94**. The cover plate **120** is provided with a circular opening or aperture **124** that is positioned directly below the main vertical axis *b—b* and provides the pump inlet **34**.

The cover plate **120**, the intermediate horizontal wall **110**, and the lower edges of the exterior wall **94** define an elongated horizontally extending section **126** of the pump cavity **116**. The exterior wall **94** and the intermediate vertical wall **112** define a generally circular, vertically extending outlet section **128** of the pump cavity **116**. The vertical section **128** extends generally adjacent the drive means cavity **114**, extending from the end of the horizontal section **126** furthest from the main axis *b—b* upwardly to the aperture **92** in the spacer plate **90**. As shown in FIGURE 2, the lower portion of the vertical section **128** is spaced inwardly or closer to the main axis *b—b* than is the upper portion of the section **128**. The upper and lower portions of the section **128** are connected by a generally inclined intermediate portion. The upper portion of the vertical section **128** is counterbored to provide an annular upwardly-facing shoulder **130**. An annular groove **132** is formed in the section **128** above the shoulder **130** for receiving an O-ring. The counterbored upper end of the section **128** corresponds in size and alignment with the aperture **92** of the spacer plate **90**.

A generally cylindrical, vertically extending discharge tube or conduit **134** has its lower end received in the counterbore at the upper end of the vertical section **128**. The lower edge of the tube **134** is supported on the shoulder **130** and an O-ring **136** is provided in the groove **132**. The discharge tube **134** extends upwardly adjacent the gear box section **60** through the aperture **78** in the mounting plate **64**, and through the associated hole in the gasket **81**. The discharge tube **134** is formed with an annular outwardly extending rib **138** positioned immediately below the undersurface of the gasket **81**. The upper end of the tube **134** extends above the mounting plate **64** and it is adapted to receive one end of a flexible hose or conduit **140** which leads to the flushing means (not shown) of the toilet bowl. The discharge tube **134** is thus in communication with the pump cavity **116** and together they comprise the pump passage **32**.

The pump **24** also comprises the pump rotor or impeller **38** and the pump drive means **40**. As shown in FIGURES 2 and 3, the impeller **38** includes a central hub **142** and a pair of flat, oppositely extending, generally rectangular blades **144**. As shown in those figures, the impeller **38** is supported at one end of the horizontal cavity section **126** for rotation about the main axis *b—b*. The tips of the blades **144** extend in generally close proximity to the adjacent cavity inner wall. It will be readily apparent that rotation of the impeller in either direction will tend to draw solution upwardly through the inlet aperture **124** and to direct it along the horizontal cavity section **126** toward the vertical cavity section **128** and thence upwardly through that vertical cavity section.

The pump is driven directly by the motor **30**. The impeller **38** is fixed on the lower end of a vertical pump drive shaft **146** and the upper end of the shaft is connected to the motor output shaft **82** by a self-aligning coupling assembly **148**.

The pump drive shaft **146** is rotatably supported along main axis *b—b*. The lower end of the shaft **146** is journalled in the bearing in the hub **118** and extends downwardly into the cavity section **126** where it supports the impeller **38**. As shown best in FIGURE 5, the upper end of the shaft is supported in a bearing **150** that is mounted in the intermediate wall **88** of the gear box section **60**. The shaft **146** passes through the lower wall **86** of the gear box section where a suitable seal assembly or means **152** is provided. The upper end of the shaft **146** extends above the bearing **150** and has a cylindrical sleeve or retaining collar **154** releasably secured around it by means such as a set screw **156**. The collar **154** rests upon the upper edge

of the bearing **150** to provide vertical support for the shaft **146**. The upper end of the shaft extends upwardly above the collar **154** and is secured to the coupling assembly **148**.

The assembly **148** includes an upper section **158** connected to the lower end of the motor shaft **82** by a set screw **160**. The assembly **148** also includes a lower section **162** which is connected to the upper end of the pump drive shaft **146** as by means of a set screw **164**. The sections **158** and **162** are pivotally connected together for generally universal movement by an intermediate section **166**. The assembly **148** serves to compensate for minor variations in the positioning and alignment of the motor shaft and the pump drive shaft from the main vertical axis *b—b*.

As noted above, the filter arrangement **26** includes a filter **42** which is rotatably mounted on the lower end of the housing **28** surrounding the pump inlet **34**. As shown in FIGURES 2 and 3, the filter **42** is a generally cylindrical upwardly open, cup-shaped solid stack filter member or basket having slotted walls: a circular horizontal lower wall **168** and a generally cylindrical vertical side wall **170**. The filter **42** is a solid integral part of a suitable material such as various plastics and is formed with an internal integral ring gear **172** spaced from its upper edge of the side wall **170**. The inside of the upper edge of the wall **170** above the ring gear **172** is cut back to provide an annular recess **174**. As shown at best in FIGURE 2, the filter **42** is mounted on the housing so that the lower portion of the side wall **170** and the lower wall **168** are spaced from the respective adjacent walls of the housing to provide a space or cavity **175** for the circulation and flow of liquid. The side wall **170** is formed to define a plurality of vertically stacked horizontally-extending interrupted annular slots **177**. Each slot **177** forms a circular peripheral outer groove **176** extending around the outside of the filter. The outer grooves **176** expand somewhat toward the outside of the filter. Also, periodically spaced around the internal circumference of the filter, the side wall **170** is formed so as to provide vertical posts or ribs **179**, which interrupt the slots **177** but not the outer grooves **176**. The slots **177** and grooves **176** start adjacent the lower edge of the filter and are provided up to adjacent the upper edge of the filter, terminating just below where the filter is formed internally to provide the ring gear **172**. Some slots (not shown) are also provided in the lower bottom wall **168** of the filter. The filter **42** is normally submerged below the level *a—a* of the liquid in the tank when the system is operative. Operation of the pump draws liquid from the cavity **175** through the opening **124**. The liquid in the tank is drawn through the slots in the walls **170** and **168** into the cavity **175**. Flow of liquid from the tank is illustrated generally by arrows in FIGURE 2.

The filter **42** is held in place by a pair of the wiper or scraper blades **44** that are secured to the pump housing section **62** as by means of screws **180**. Each wiper blade **44** is a generally elongated, vertically-extending structure mounted at its upper end to the outside of the intermediate wall portion **98**. Each blade **44** is provided at its lower end with an inwardly extending support flange **182**. Each blade **44** is generally arcuate in horizontal section, as seen best in FIGURE 3, generally conforming to the contour of the outside of the filter side wall **170**. A plurality of horizontally-extending vertically-spaced teeth or ribs **184** are provided on the inside of each blade to intermesh with the filter grooves **176**. Each of the ribs **184** is generally arcuate in horizontal section to mate with the filter **42**. A reinforcing flange **186** extends along the upper edge, down the two opposite sides of its blade, and inwardly on the opposite sides of the support flange **182**. These wiper blades, which are relatively heavy-duty to minimize their flexing or deformation and are referred to as solid-stack type blades, have proven quite effective in operation in comparison to lighter-duty more flexible structures.

The blades **44** provide the scraper or wiper means for the illustrated device. Relative movement between the filter **42** and the blades **44** serves to scrape or wipe away material accumulating on the outside of the filter and on the blades incident to the flow of liquid through the filter. Continuous rotation in one direction would tend to accumulate material at one side of the blades. For example, with the filter **42** rotating in the direction shown by the arrow in FIGURE 3, material would tend to accumulate on the filter at one edge of the blade **44** as indicated generally by the letter "A." By periodically reversing the rotation of the filter relative to the blades, such accumulation can be minimized and the self-cleaning feature effectuated.

The filter drive means **46** which transmits power from the motor **30** to the filter arrangement **26** includes, as noted above, the gear train or transmission **48** and the clutch arrangement **50**. Filter drive means **46** also includes a vertically extending filter drive shaft **190** which is rotatably mounted adjacent one side of the housing **28**. The shaft **190** is positioned so that a filter drive pinion **192** secured at the lower end of the shaft is in driving mesh with the internal ring gear **172** of the filter **42**. The lower end of the shaft **190** is journalled through bearing **121** in pump housing wall **94**. As shown best in FIGURE 5, the shaft **190** passes upwardly through the lower wall **86** of the gear box section **60**, where a suitable seal assembly **193** is provided, and through a bearing **194** in the intermediate wall **88** of the gear box section. A thrust washer **196** is secured on the shaft **190** below the bearing **121** and a thrust washer **198** is mounted on the shaft above the bearing **194** to support the shaft in position. The upper end of the shaft **190** extends into the upper cavity **87** of the gear box section and has secured thereon a small gear **200**.

A small driving pinion **202** is secured on the pump drive shaft **146** intermediate the walls **86** and **88**. As shown best in FIGURES 4 and 5, power is delivered from the pinion **202** through the gear train or transmission **48** and through the clutch arrangement **50** to the small gear **200**.

The gear train or transmission **48** is mounted on a pair of vertical shafts **204** and **206** that are rotatably supported between the intermediate wall **88** and the lower wall **86**. The driving pinion **202** drives a large gear **208** secured to shaft **204**. A small pinion **210**, also on the shaft **204**, drives a large gear **212** on the shaft **206**. A small pinion **214**, also secured on the shaft **206**, imparts rotation to the clutch arrangement **50** which ordinarily transmits that rotation to the small gear **200** of the filter drive means.

The clutch arrangement **50** includes a vertical shaft **220** that is journalled in bearings **222** and **224** in the respective intermediate and lower walls **88** and **86** of the gear box housing **60**. The shaft **220** includes a large cylindrical center portion **226** which is received in the bearing **222**, and a lower reduced diameter portion **228** which is received in the bearing **224**. The shaft **220** further includes an upper portion **230** which extends upwardly into the upper cavity **87** of the gear box and has a threaded upper end **231**. An idler gear **232** is fixed on the shaft **220** within the lower cavity **89** in meshing engagement with the last pinion **214** of the gear train. The idler gear **232** is supported on the center or intermediate portion **226** of the shaft by a thrust washer **234** received in an annular groove **235** adjacent the lower end of the shaft center portion **226**.

A cylindrical support plate **236** in the shape of a ring is disposed on the shaft at the upper end of the center portion **226** where it extends upwardly above the bearing **222**.

A clutch assembly **240** is rotatably mounted on the upper portion **230** of the shaft **220** immediately above

the support plate **236**. The clutch assembly **240** includes a clutch gear **242** which is of generally the same size as the idler gear **232** so that there is no change in speed of rotation between these two gears when they rotate together on the shaft **220**. The clutch assembly **240** further includes a pair of generally cylindrical discs: a lower disc **244** and an upper disc **246**. The discs **244** and **246** are made from a suitable high frictional material, such as clutch or brake composition. One disc is secured on each side of the clutch gear **242**. The face of each disc **244** and **246** away from the clutch gear **242** has a recessed center portion so as to form an annular or ring-shaped contact surface **250** and **252**, respectively.

A pressure plate **254** is positioned on the upper portion **230** of the shaft above the disc **244**. The pressure plate **254** is mounted for axial movement relative to the shaft **220** but for common rotation with the shaft. More particularly, the shaft **220** extends through a central bore **256** in the pressure plate **254**. A Woodruff-type key **258** is secured to the shaft **220** so as to extend into a vertical slot **260** opening radially outwardly from the bore **256**. The pressure plate **254** comprises a lower generally-flat disc-shaped section **262** and an upper hub section **264** of reduced diameter.

A torque nut **266** is threaded on the upper end **231** of the shaft **220**. The nut **266** includes a lower cylindrical hub section **268** of approximately the same diameter as the hub section **264** of the pressure plate. The torque nut **266** also includes an upper hexagonal-shaped plate section **270**. A coil compression spring **272** is disposed coaxially with the shaft on the hub sections **268** and **264**. The spring **272** tends to urge the pressure plate **254** downwardly against the upper disc **246** of the clutch assembly **240**. In turn, the clutch assembly **240** is urged downwardly so that the lower disc **244** is urged against the support plate **236** that is supported by the upper end of the bearing **222**. Thus, the ring-shaped contact surfaces **250** and **252** are urged or biased against adjacent surfaces of the support plate **236** and the pressure plate **254**, respectively. This serves to resiliently hold or lock the clutch assembly **240** relative to the shaft **220**. Therefore, rotation imparted to the idler gear **232** rotates the shaft **220** and, in turn, the clutch gear **242** to, in turn, rotate the input pinion **200** of the filter drive means.

Should the filter arrangement become totally or partially jammed so that the gear **200** will not rotate or will be slowed, the clutch gear **242** and the entire clutch assembly **240** will also become stationary or be slowed while the shaft **220**, the pressure plate **254**, the idler gear **232**, the gear train **48**, the pinion **202** and the pump drive shaft **146**, and the motor output shaft **82** all continue to rotate. Thus, the motor is protected from burning itself out due to a jammed or locked filter. The pressure exerted by the spring **272** is such that the clutch assembly **240** will normally rotate with the shaft **220**, but relative movement is permitted between the disc **244** and **246** of the clutch assembly and the adjacent surfaces should the clutch assembly be slowed or stopped. The spring force exerted by coil spring **272** may be adjusted by adjusting the torque nut **266**.

FIGURE 1 diagrammatically illustrates the control means for the illustrated toilet system. A power supply **280** provides electrical current to the motor **30** through suitable electrical conductors **281** (FIGURE 2). An electro-mechanical arrangement that includes timing means **282** and alternating means **284** is provided between the motor and the power supply. The timing means and the alternating means are controlled by a manually operated actuator **286**. To flush the toilet, the actuator **286** is operated, which starts the timing means **282** to provide power from the supply **280** to the motor **30** for a controlled time increment. Further, the actuator **286** operates the alternating means **284** to provide current flow to the motor **30** in opposite directions for each subsequent operation of the actuator **286**. Thus, the actuator **286** is operated and the reversible motor **30** is run for the predetermined time increment in a first direction. The next time the actuator **286** is operated, the motor is run in the opposite direction for that time increment. This cycling is continuously repeated. If preferred, the motor need not reverse for each alternate operation, but might be provided with means causing reversal of the motor only after a predetermined number of operations of the motor in a single direction.

The illustrated motor **30** has a capacity of over ten hours continuous running under load. Although the operation of the motor is normally intermittent rather than continuous, should the control means malfunction so that the motor did operate continuously, it is sufficiently durable to survive an extended time period until the problem is discovered. Also, the motor **30** is so designed and constructed that it will withstand a locked rotor or impeller condition for approximately four minutes.

The illustrated motor **30** has a 0.25 horsepower rating and operates at approximately 7200 r.p.m. The pump impeller is rotated at the same speed to deliver approximately 16 gallons per minute at 0.7 p.s.i. This speed is reduced in two stages: first to about 2168 r.p.m. at shaft **204** and then to about 498 r.p.m. at shaft **206**. The clutch arrangement (idler gear **232** and clutch gear **242**) is rotated at about 115 r.p.m. The filter drive means (shaft **190**) is rotated at about 498 r.p.m. and the filter **42** is rotated at about 40.4 r.p.m.

The capacity of the illustrated structure to continue to pump liquid in one direction while the operation of the motor and thus the direction of relative movement of the filter arrangement is reversed, provides a highly novel and effective self-cleaning pump and filter apparatus for such a system. Also, as noted above, the construction of the clutch arrangement protects the motor should the operation of the filter become slowed or stopped, but does not create noises such as would disturb or alarm nearby people.

Various modifications and changes may be made in the illustrated structure without departing from the spirit and scope of the present invention.

Various features of the present invention are set forth in the following claims.

What is claimed is:

1. In a self-contained toilet system that includes a toilet bowl and a tank for holding the liquid of the system, self-cleaning pump-and-filter apparatus for circulating a quantity of relatively clear liquid from the tank to the bowl for return to the tank, said apparatus comprising:

(a) reversible pump means having an inlet, said pump means being positioned, constructed and arranged to draw liquid into said inlet and to deliver the liquid in the same predetermined direction from the tank to the bowl for either direction of its operation.

(b) a reversible filter arrangement including a filter means disposed outwardly of said pump inlet and filter wiper means disposed immediately outwardly of said filter means, said filter arrangement including means supporting said filter means and said wiper means for relative movement therebetween to remove material deposited on said filter means, said direction of relative movement being changed by reversal of the direction of operation of said filter arrangement to effect self-cleaning of said filter arrangement, and

(c) operating means operatively associated with said pump means and with said filter arrangement for operating both said pump means and said filter arrangement in either one direction or the other, said operating means comprising a single reversible motor means for operating both said pump means and said filter arrangement in either one direction or the other, a clutch arrangement between said motor means and said filter arrangement, said clutch arrangement being constructed and arranged to permit said motor means to continue to operate should operation of

said filter arrangement be stopped or slowed, said clutch arrangement being of the silent friction-type and including a shaft assembly, a clutch assembly rotatably supported on the shaft assembly, and friction means frictionally connecting said clutch assembly to said shaft assembly for common rotation under normal conditions, one of said assemblies being movable with said motor means and the other of said assemblies being movable with said filter arrangement, said friction means permitting relative rotation between said shaft assembly and said clutch assembly should the relative rotation between said filter means and said filter wiper means be stopped or slowed to stop or slow the operation of said filter arrangement.

2. A toilet system as set forth in claim 1 in which said pump means includes a rotor, said rotor being coupled to the output shaft of said reversible motor means and functioning to produce a flow of liquid from said tank, through said filter arrangement and to said rotor, in that order, regardless of the direction of rotation of said reversible motor.

3. A toilet system as set forth in claim 2 in which said motor output shaft has a gear thereon, a speed reduction unit coupled to said gear and driving said shaft assembly.

4. In a self-contained toilet system that includes a toilet bowl and a tank for holding the liquid of the system, self-cleaning pump-and-filter apparatus for circulating a quantity of relatively clear liquid from the tank to the bowl for return to the tank, said apparatus comprising:

reversible pump means having an inlet, said pump means being positoned, constructed and arranged to draw liquid into said inlet and to deliver the liquid

in the same predetermined direction from the tank to the bowl for either direction of its operation,

a reversible filter arrangement including a filter means disposed outwardly of said pump inlet and filter wiper means disposed immediately outwardly of said filter means, said filter arrangement including means supporting said filter means and said wiper means for relative movement therebetween to remove material deposited on said filter means, said direction of relative movement being changed by reversal of the direction of operation of said filter arrangement to effect self-cleaning of said filter arrangement, and

operating means operatively associated with said pump means and with said filter arrangement for operating both said pump means and said filter arrangement in either one direction or the other, said operating means comprising a single reversible motor means for operating both said pump means and said filter arrangement in either one direction or the other, said pump means including a rotor connected to the output shaft of said reversible motor and cooperating with the housing of said pump means to produce liquid flow from said tank through said filter means and into said pump housing, in that order, regardless of the direction of rotation of said motor output shaft.

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