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# DESCRIPTION

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention:

**[0001]** This invention relates generally to municipal sewage treatment facilities and methods, and particularly to a sewage plant adapted for short-term service at temporary locations to mitigate interim short-falls of sewage treatment capacity. More particularly, this invention relates to a portable, unitary, non-biological sewage treatment system adapted to be moved without disassembly on national and state highways between temporary sites, and the apparatus and methods employed to make such sewage treatment facilities portable.

### 2. Description of Related Art:

**[0002]** The majority of wastewater treatment plants in use today for treatment of municipal sewage are of the biological type. It is well known that the liquid waste from such plants is not suitable for re-use without advanced or tertiary treatment which requires additional equipment and land space. The solid waste also requires considerable handling and space, either for disposal or processing for re-use as fertilizer or fuel. Land requirements and equipment size for such plants thus are quite large, resulting in significant capital investment when building or expanding this type of plant. A need exists for a compact, unitary, portable wastewater treatment plant that does not require extensive pretreatment or materials handling space.

**[0003]** It is widely known that sulfur dioxide is an effective and rapid disinfecting agent for both liquids and solids, and it is an economically acceptable choice. Previous designs for chemical disinfection and dewatering systems have failed to gain wide acceptance, mostly due to insufficient reduction in equipment size, or limitations imposed by systems designed for batch operation. There exists a need for a Wastewater Treatment System that will continuously disinfect both the liquid and the solids in a rapid manner in limited space.

**[0004]** Temporary construction sites can develop very large camps occupied by workers and sometimes their families for months and even years at a time. Often located in remote, rural settings or near small, existing settlements, sewage treatment requirements of such camps can easily overwhelm local treatment capacity, if it exists at all. This could require such municipalities to add far more capacity than they'll need once the camp is disbanded after construction. A need exists for temporary wastewater treatment facilities that easily can be set up for interim capacity increases and efficiently and quickly removed and relocated when no longer needed. Further, a need exists for a sewage treatment plant that can be moved on national and local roadways from one such site to the other with little or no disassembly.

**[0005]** US 4 687 574 A describes a mobile water treatment plant capable of handling sewage confined within the dimensions of a conventional truck-hauled container. The mobile water treatment plant comprises a screen to separate gross solids from liquids, a holding chamber in which the liquid is aerated, a flocculating chamber for the liquid, and a lamellar separator. The water is treated from the lamellar separator with activated oxygen.

**[0006]** US 4 340 489 A describes that wastewater is continuously disinfected by combining the wastewater with sufficient acid to reduce the pH of the wastewater to less than about 4.

**SUMMARY OF THE INVENTION**

**[0007]** A portable sewage water treatment system according to the invention is defined in Claim 1. An improved method of non-biological treatment of untreated sewage water performed in the portable sewage water treatment system is defined in Claim 8. Use of an acid compound in the portable sewage water treatment system is defined in Claim 9. Use of an alkaline compound in the portable sewage water treatment system is defined in Claim 10. Use of a flocculant compound in the portable sewage water treatment system is defined in Claim 14. The respective dependent claims relate to advantageous embodiments.

**[0008]** Generally it holds also for the invention that a mobile sewage treatment and water reclamation system for rapid deployment to augment existing wastewater systems and/or provide interim service in lieu of permanent facilities, may include: (a) a denaturing stage wherein raw sewage is first ground into suspendable grit, its pH first lowered to kill acid-sensitive bio-organisms, then raised to kill base-sensitive bio-organisms, and then neutralized; (b) a clarifying stage employing an inverted-cone tank to circulate the solution after injection with chemicals to flocculate small particles for collection in a layer for siphoning off; and (c) a disposal stage wherein clarified water passes through media filters to remove remaining solids and odors, the effluent water being clean enough for irrigation, aquatic life and discharge into waterways; and wherein sterile sludge is pressed into semi-dry solids, then dried, crushed, powdered and bagged for use as high-nitrate biomass fertilizer or for fossil-fuel power co-generation applications.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0009]** The invention as well as a preferred mode of use and further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure **1** shows a schematic of the wastewater treatment system of the present invention.

Figures **2** details the reaction vessel of the wastewater treatment system of Figure 1.

Figure **3** shows a bottom plan view of the reaction vessel of Figure 2.

Figures **4A - 4B** depict perspective and front elevational views, respectively, of the reaction vessel of Figure 2.

Figures **5A** - **7** details alternate embodiments of the header shown in Figure 4A.

Figures **8A** - **8B** show a physical layout of a portable version of the wastewater treatment system of Figure 1.

Figure **9** depicts elevated side perspective view the reactor vessel trailer of the wastewater treatment system of Figures 1 and 8B.

Figure **10** shows the pretreatment vessel trailer of the treatment system of Figure 1.

Figures **11A** - **11H** depict displays for the control module for the system of Figure 1.

## DESCRIPTION OF A PREFERRED EMBODIMENT

**[0010]** Referring now to the figures, and particularly to Figures **1 - 7**, the portable wastewater treatment system of the present invention comprises both method and apparatus adapted to provide a portable, unitary, rapidly deployable system on two trailers which can be set up for providing sewage and wastewater treatment on a temporary or permanent basis. The system first will be discussed as a method, or process, and then a discussion follows of the physical layout which enables quick deployment and mobility.

### Process

**[0011]** The method employed by the present invention comprises chemically treating wastewater first with an acid such as sulfur dioxide ($S0_2$), and then with an alkaline such as lime (calcium hydroxide ($Ca(OH)_2$), to disinfect the liquid and solids of both high and low pH tolerant organisms, then neutralizing the pH of the resulting fluid and processing it to precipitate and separate solids from liquid water, both of which then can be returned to the environment.

**[0012]** Figure 1 is a schematic representation of the process. Raw wastewater is introduced into the system via conduit 1 where it enters a macerating stage, represented in Figure 1 by macerating pump 20, which reduces suspended solids in the wastewater to a size range of 30-200 µm (30- 200 microns). In a preferred embodiment discussed in detail below, separate pretreatment stage 130 buffers influent wastewater flow and feeds it steadily into the treatment system at conduit 1. Pretreatment stage 130 includes screens (not shown) for straining out large, solid objects and a macerating system 20A that reduces remaining solids to the ranges specified above. One having ordinary skill in the art will recognize that various means for processing raw sewage into satisfactory influent waste water for feeding into the system at conduit 1 may be employed without departing from the scope of the present invention.

**[0013]** Pretreated wastewater flows into the system through check valve 22 and proceeds directly into influent surge tank 7, where it is partially disinfected. Just upstream of influent surge tank 7, the wastewater is injected with a acid such as sulfur dioxide ($S0_2$) which lowers its pH to kill acid-intolerant microorganisms. Preferably, the acid is injected in an amount sufficient to reduce the pH of the wastewater to between 2 and 2.5, resulting in a residual sulfur dioxide content of at least 20 ppm up to 100 ppm, preferably around 75 ppm.

**[0014]** One having ordinary skill in the art will recognize that other inorganic acids, such as compounds of bromine and chlorine, halogen compounds, chloramines and ozone can serve the purpose of lowering the pH of influent wastewater. Likewise, the wastewater can be treated with ultraviolet light equipment, though UV disinfecting with current technology is quite expensive. Sulphur dioxide thus is preferred, because it is plentiful, inexpensive, comparatively safe to handle, non-carcinogenic and easily can be provided in a variety of ways, depending upon the preference of operators of the system.

**Acid injection system**

**[0015]** Liquid sulfurous acid ($H_2SO_3$), when mixed with water, ionizes into sulfur dioxide and water. A preferred embodiment of the acid injection system would include on-board storage tank **50** containing liquid sulfurous acid which, when fed by chemical forwarding pump **52** through feed conduits **15, 15A, 15B,** is injected directly into the stream of wastewater both upstream (through chemical feed valve **54**) and downstream (through chemical feed valve **55**) of influent surge tank **7.** This arrangement allows an operator (not shown) to select a desired sulfur dioxide injection point based on system operation and the nature of the influent wastewater.

**[0016]** An alternate embodiment for the sulfur dioxide injection system comprises using gaseous sulfur dioxide in commercial cylinders. These replace chemical storage tank **50**, chemical storage tank valve **51**, and chemical pump **52** with a gas cylinder and injection valve (neither shown), flowing through the remaining chemical feed conduits **15, 15A, 15B,** and chemical feed valves **54, 55** for the on-board chemical storage tank arrangement discussed above.

**[0017]** Another alternate embodiment for the sulfur dioxide injection system comprises a sulfur dioxide generator (not shown) installed downstream of influent check valve **22,** so that the influent wastewater flows through a chamber in the presence of burning sulfur and oxygen, thereby absorbing the necessary sulfur dioxide produced in the combustion process. In this arrangement, chemical storage tank **50,** chemical storage tank valve **51,** chemical feed pump **52,** chemical feed valve **53,** chemical feed conduits **15, 15A, 15B** and chemical feed valves **54, 55** could be eliminated.

**[0018]** After spending less than two (2) minutes in the low-pH disinfection step within influent surge tank **7,** the wastewater exits surge tank **7** via exit conduit **2,** urged by pressurizing pump **23** toward branch point **2A,** where a first portion recycles back to influent surge tank **7** through recycle **conduit** 3. Recycling of a portion of the wastewater results in an average contact time of at least five (5) minutes with the acidic environment and allows the sulfur dioxide to complete the disinfection process. A second portion of the wastewater proceeds toward static mixer **27** through clarifier feed conduit **4.** Static mixer **27** is discussed in more detail below.

**High pH disinfection**

**[0019]** Downstream of branch point **2A** but upstream of static mixer **27,** the wastewater is injected with an alkaline solution such to raise its pH above neutral and to disinfect it of organisms that may thrive on low pH but for which high pH is lethal. The alkaline injection system comprises alkaline storage tank **61** from which alkaline forwarding pump **63** feeds the chemical through alkaline feed conduit **17** to the alkaline injection point just downstream of branch pont **2A.** Preferably, the alkaline solution is a strong hydroxide compound such as lime (calcium hydroxide ($Ca(OH)_2$), sodium hydroxide (NaOH) or potassium hydroxide (KOH), depending on the wastewater to be treated. One having ordinary skill in the art will recognize that any suitable base solution may be chosen to elevate the pH of the wastewater without departing from the scope of the present invention.

**Flocculent injection**

**[0020]** Downstream of the alkaline injection point but still upstream of static mixer **27,** the wastewater is injected with a flocculent to promote clumping and precipitation of solid particles within the clarifier stage. The flocculent injection system comprises flocculent storage tank **56** from which flocculent forwarding pump **58** feeds the chemical through flocculent conduit 16 to the injection point into the wastewater stream just upstream of static mixer **27.**

**[0021]** Different wastewater compositions require different flocculent treatments. Municipal waste, though surprisingly consistent, even including septic systems such as portable toilets which contain high concentrations of biocides, is high in organic compounds and microorganisms that feed upon them. Agricultural waste also can be high in bio-organisms but also includes high concentrations of nitrates and nitrites from fertilizer runoff. Industrial waste can vary radically, but often contains both bioorganisms and nitrates. All three may require different flocculent compounds.

**[0022]** Metal based flocculents such as iron compounds readily attract such particles and cause them to clump for better precipitation and removal as sludge Preferably, for the typical municipal wastewater influent, the flocculent is a liquid, iron-based, inorganic chemical such as ferric chloride (FeCL), ferrous sulfate ($FeSO_4$) or aluminum sulfate ($AlSO_4$), depending on the wastewater being treated.

**Polymer injection**

**[0023]** Also provided for injection just upstream of static mixer **27** as needed, based upon the actual wastewater being treated, is a high pH tolerant polymer. Polymers can assist in the clumping process triggered by the flocculents, and can deter sticking of sludge to side walls of the clarifier stage, discussed in more detail below. A polymer injection system comprises polymer storage tank **66** from which polymer forwarding pump **68** feeds the chemical through polymer feed conduit **18** to be injected into the wastewater stream immediately upstream of static mixer **27.**

**[0024]** Differing types of influent wastewater may require use of different types of polymers. The correct polymer for each application is determined by testing the influent wastewater. Some polymers that may be used with the system include, but are not limited to: CAT FLOC, CAT FLOC+HI, CAT FLOC+LO, CAT CO HI, AN FLOC HI, AN FLOC MED, and AN CO. All are manufactured and distributed by PFP Technology of Houston, Texas.

**Static Mixer**

**[0025]** Static mixer **27** comprises a small, one (1 ft.) foot diameter tank for mixing the chemicals injected into the wastewater just upstream thereof. As a static device, it is preferable to blenders and impellers which may clog and break down over time. As the wastewater enters static mixer **27,** the device buffers and creates turbulence in the wastewater flow, causing the injected chemicals to become thoroughly mixed. Static mixer **27** contains no moving parts, and accomplishes the mixing by directing the flow tangentially into and out of a small tank. The tangential entry and exit causes the solution to move in a circular motion inside the small tank, thereby causing the necessary turbulence for mixing. The wastewater then exits static mixer 27, and proceeds via clarifier feed conduit 4 to reaction vessel 28, where solids are removed.

**Solids precipitation and removal**

**[0026]** As best seen in Figures 2 - 4B, clarifier, or reaction vessel, 28 comprises an inverted, cone-shaped chamber having a cylindrical top section where disinfected liquid water accumulates awaiting filtering. Wastewater enters at reaction vessel 28's lowest point 82

(Figures 2-3) and flows radially upwards in a swirling, rotating path to exit through header 85 disposed at the top of the cylindrical tank portion of reaction vessel 28. The significance of this flow pattern is discussed in more detail herein below.

**[0027]** Reaction vessel 28 is designed so that wastewater enters reaction vessel 28 on a tangent at the bottom through injection port 82. This causes the wastewater to flow in a circular motion (counterclockwise in the northern hemisphere and clockwise in the southern hemisphere) while rising upwards through the vessel. This unique arrangement aids in the settling of the solids by using the effect of gravity in combination with the radially outward centrifugal force imparted by the circular motion.

**[0028]** Cone-shaped lower portion of reaction vessel 28 has walls that slope on an angle no greater than 29 degrees from vertical. At such slope, clumps of flocculated, suspended solid materials are prevented by gravity from sticking to the interior faces of reaction vessel 28. This aids in the settling of the solids, and results in a floating blanket of sludge (not shown) disposed in the lower third of reaction vessel 28. This blanket of sludge is maintained at a thickness of 0.91 to 1.21 m (three to four feet) by periodically removing sludge from reaction vessel 28 through sludge exit valve 41 and sludge conduit 12 to sludge storage tank 42. The sludge processing system is described in more detail below.

**Headers**

**[0029]** At the top of reaction vessel **28,** header means for siphoning off the disinfected and deflocculated wastewater directs it toward finishing filters **35, 36.** The header means allows sufficient fluid to pass out of clarifier **28** so that there is no pressure differential created. The header means allows for collection of the liquid across the entire upper surface of reaction vessel **28,** thereby promoting smooth, laminar flow toward filters **35, 36,** which are discussed in more detail below.

**[0030]** In a preferred embodiment, the header means comprises header **85** depicted in Figure **4A.** Header **85** is a tree-like, lateral structure having a central manifold **86** with parallel collector arms **87** disposed parallel to and spanning the water's surface in the top of reaction vessel **28.** See Figures **5A** - **5C.** Alternate embodiments to header **85** for the header means include hub radial design **185** (Figures **6A** - **6B)** and upper collector design **285** (Figure **7)**. One having ordinary skill in the art will recognize that all variations of header design are considered to be within the scope of the present invention.

**[0031]** The disinfected wastewater exits reaction vessel **28** through water conduit **5** and proceeds to stilling well **30.** Stilling well **30** comprises a simple, columnar accumulator that reduces turbulence and flow, thereby allowing additional time for any remaining, minute, unsettled particles to settle out of suspension. The wastewater then exits stilling **well 30** via conduits **6, 7A** where it is re-pressurized by pressurizing pump **33** to a conduit pressure of between 2,76 and 4,14 bar (40 and 60 PSI (pounds per square inch)).

**Finishing filtering**

**[0032]** From pump **33,** the wastewater enters depth filter **35,** a conventional multi-media filter utilizing filter media consisting of alternating layers of sand, garnet and anthracite. As the wastewater travels in a downward path through depth filter **35,** it removes any remaining particles larger than approximately 15 to 20 microns. As the removed particles accrete in the filter, occasional backwashing is required. This is accomplished using water from the finished water storage tank **37,** utilizing backwash conduit **10,** and pressurizing pump **33.**

**[0033]** As the disinfected, filtered wastewater exits depth filter **35,** it may still retain residual amounts of sulfur dioxide. Sulfur dioxide itself deodorizes the wastewater stream, but it has its own odor which might be noticeable in the discharged water effluent. So, the wastewater is directed via filter conduit **8A** to finishing filter **36.** Finishing filter **36** is a conventional carbon filter utilizing granular active carbon media. As the disinfected, filtered wastewater travels in a downward path through finishing filter **36,** any residual color and odor that may be present (though unlikely) is removed.

**[0034]** For both pressure filters **35, 36,** an underdrain system allows sufficient liquid to pass out of the filters while maintaining a differential pressure of between 0,03 and 0,21 bar (0.5 psi to 3 psi). This creates a back pressure in filters **35, 36** which keeps the liquid flowing evenly and throughout the square area of the vessel.

**[0035]** The wastewater treatment system of the present invention controls the disinfection process by automatically regulating the amount of $H_2S0_3$ (sulfurous acid), or $S0_2$ (sulfur dioxide), based on the output of a residual sulfite analyzer (not shown). The analyzer is positioned at the output of the finishing filters and provides a feedback loop to the system's control modules, discussed below. A suitable residual sulfite analyzer would be Model number A15/66-2-1, manufactured by Analytical Technology Incorporated.

**[0036]** From finishing filter **36,** the disinfected, filtered wastewater is transported via finished water conduit **9** to finished water storage tank **37.** From finished water storage tank **37,** the treated wastewater can be discharged to the desired reuse via discharge pump **38** and discharge conduit 11, though some of it periodically will be utilized for filter backwashing via backwash conduit **10,** as discussed herein above. The finished water can be used directly for irrigation, discharged into a waterway, or further processed for drinking water.

**Sludge storage and processing**

**[0037]** The sludge storage system receives settled particulates, or sludge, from reaction vessel **28** via sludge exit valve **41** and sludge conduit **12.** The sludge storage section consists of sludge storage tank **42** and sludge mixer **43.** Sludge mixer **43** keeps particulates in the sludge in suspension pending processing through filter press **48.**

**[0038]** The sludge exits sludge storage tank **42** via air operated diaphragm pump **44** and is directed to sludge tank **42.** The sludge then is pumped through filter press conduit **13** and into filter press **48** for de-watering. Filter press **48** accumulates sludge and compresses it, extracting liquid material from the sludge and returning it to influent surge tank **7** through liquid return conduit **14.** A suitable filter press **48** module for the purpose is available as Model FP00456-FP630G32L-22-7AXC, from M.W. Watermark, LLC, of Holland, Michigan.

**[0039]** Once filter press **48** has been filled, the flow of sludge is halted and filter press **48** is allowed to drain for approximately 5 minutes. Filter press **48** is then opened, and the pressed solids are removed for drying and other processing for re-use. These solids may be used as soil amendments, additives for animal feed stock, or burned as fuel to generate heat or possibly electricity.

**Power consumption, capacity and controls**

**[0040]** The above described wastewater system may be of various sizes, but for the transportability feature described below, it is limited in size to treating between 54,509 to 218,039 liters (14,400 gallons and 57,600 gallons) of wastewater during a 24 hour period, This is ample for most temporary applications, and can serve a municipal system with hundreds of typical houses connected. If larger volumes are required, multiple units can be staged in parallel in sufficient numbers to handle the required flow.

**[0041]** In this preferred size embodiment, power consumption requires only a 240 volt supply, either single phase or three phase, with a capacity of fifteen (15 kw) kilowatts or less.

**[0042]** Figures **11A - 11H** depict screen prints of various control modules for an operator to control the wastewater treatment of the present invention. In a preferred embodiment, images on Figures **11A - 11F** represent real-time control buttons for operating the depicted equipment.

**Transportability**

**[0043]** Turning now also to Figures 8A - 10, the portable wastewater treatment system of the present invention is shown completely contained on two elongate trailers 100, 200 adapted to be towed by tractor 91 along on national and local highways from one site to another. The entire system remains on trailers 100, 200 and operates without having first to be assembled nor disassembled for transportation. To achieve this remarkable feat, careful arrangement of the various pieces of equipment discussed individually herein above must be performed.

**[0044]** Trailer 100 comprises elongate deck 101 surrounded by side rails 105 and having a longitudinal axis extending between front tongue 103 and rear truck 110. Tuck 110 comprises a transverse axle coupled to trailer 100 by conventional means and fitted with dual wheels and tires of proper size and strength to support the weight of trailer 100 with all the equipment installed onto deck 101. Tongue 103 includes conventional towing hitch equipment (not shown) adapted to mate with tractor 91's "fifth wheel" trailer rigging for safe transportation on highways. As best seen in Figure 8A, when trailer 100 is in transportation mode, to be towed by tractor 91, tongue 103 is elevated above the rear wheels of tractor 91 with trailer 100's rear wheels engaging the ground 93.

**[0045]** As best seen in Figure 8B, when trailer 100 is installed and prepared for operation of the waste treatment system of the present invention, tongue 103 is in a much lower position than shown in Figure 8A, and base rails 106 engage ground 93 to support trailer 100. Wheels 111 of truck 110 are lifted off of ground 93 and no longer bear the weight of trailer 100. One having ordinary skill in the art will recognize, of course, that ground 93 preferably comprises a level concrete pad at least the length and width of trailer 100 so that the waste treatment system of the present invention is leveled and stabilized against shifting soil conditions, Given the known weight of the waste treatment system and its equipment, chemical and sewage water loads, such a slab preferably is at least 30,48 cm (twelve (12 in.) inches) thick and reinforced with sufficient steel reinforcing rods to withstand moment forces tending to bend and crack it.

**[0046]** As best seen in Figure **9**, the heaviest equipment borne by trailer **100** is reaction vessels **28,** which are disposed at the rear of deck **101** nearest to truck **110**. Reaction vessels **28** also are the largest components, and stand the tallest of all the equipment on trailer **100**. By placing them at the rear of trailer **100**, nearest truck **100**, they must move the least amount in the vertical direction when tongue **103** is lifted onto tractor **91** for towing. Further, by lifting reaction vessels **28** the least necessary for roadway clearance under base rails **106**, the lowest height of trailer **100** in transportation mode is achieved. This can be vitally important when trailer **100** must pass under low clearances like roadway underpasses or the like. If necessary, **well 102** may be provided as a recess for the bottom of reaction vessels **28** to extend below deck **101** to achieve low enough clearance for transporting trailer **100** on national and local highways with the least amount of regulatory licensing and oversight. Wells **102** can be as deep as the height of base rails **106**.

**[0047]** Disposed on deck **101** approximately at the longitudinal middle of trailer **100** and immediately forward of reaction vessels **28**, influent surge tank **7** represents the entry point to trailer **100** of influent wastwater, as discussed herein above in conjunction with Figure **1**. Immediately forward of influent surge tank **7** are filters **35, 36** which are the last stage of treatment of disinfected and flocculated water before it is discharged from the system through finished water storage tank **37**, also disposed immediately forward of reaction vessels **28**. The lightest and most easily lifted equipment on trailer **100** are chemical tanks **50, 56, 61, 71** containing the acid, alkali, flocculant and polymer additives introduced into the wastewater stream as discussed above. Conveniently disposed between reaction vessels **28,** sludge storage tank **42** is positioned to collect sludge from both vessels **28.** Filter press **48** (not shown) may be installed atop truck deck **120** rearward from reaction vessels **28** and above truck **110.**

**[0048]** One having ordinary skill in the art will recognize that appropriate piping, conduits and valves (not shown) are required to be in place to interconnect the equipment into the sequence of stages discussed herein above in conjunction with Figure **1.** Such piping, conduits and valves are contained completely within the confines of rails **105** surrounding deck **101.**

**[0049]** Turning now also to Figure **10,** pretreatment reservoir **130** is disposed on second trailer **200** and adapted to be towed by its tongue **203,** supported by its truck **210,** and installed on a second concrete slab **93** as discussed above for the wastewater treatment system of the present invention. Pretreatment reservoir **130** comprises a large, water- and sewer gas- tight tank **131** adapted to receive raw sewage from municipal sanitary sewer systems, septic tank trucks and other sources of wastewater intended to be processed by the present invention. Pretreatment reservoir **130** also provides a buffering system whereby a steady flow of influent wastewater is fed into influent surge tank **7,** keeping the wastewater treatment system of the present invention operating smoothly and at maximum capacity despite potentially erratic arrival of raw sewage, especially from septic truck arrivals.

**[0050]** The incoming wastewater first passes through a grinder (not shown) to reduce the size of the solids to particles in the range of 200 μm (200 microns) (nominal). When tank **130** is loaded with wastewater being stored in anticipation of treatment, the wastewater is continuously circulated through the grinder using a pair of booster pumps **20A** operating in parallel. As the wastewater recirculates into tank **131,** it passes through a pair of educator/mixers which cause enough turbulence in tank **131** to keep solids in the wastewater suspended in solution. As illustrated in Figure **10,** tongue deck **204** provides a platform for the above equipment, including macerating pump 20 and other devices adapted to cany out such preparatory work, so that it need not be housed on wastewater treatment system trailer **100.** Valve **22** couples to conduit **1** to feed wastewater from pretreatment reservoir **130** into influent surge tank **7** located on trailer 100.

**[0051]** A suitable grinder for the above describe application is the "Muffin Monster" model 30004T-1204-D1, available from JWC Environmental of Costa Mesa, California, USA. The grinder must be supplied with a compatible "Rock Trap" to prevent very dense material such as rocks, bolts, nuts, etc. from reaching the grinder. Suitable pumps for the above described pretreatment application are available as Model AC8SJS1V800B012104 from Finish Thompson, Inc., of Erie, Pennsylvania, USA. Suitable valves for the pretreatment system can be manually or automatically actuated, stainless steel butterfly valves available as Model 4-396-967-000 from ABZ, Inc., of Chantilly, Virginia, USA. Suitable check valves required in the above pretreatment system are available as Center Line Valve Company Model 04R1644D1X from MCC HOLDINGS, Inc., of Stamford, Connecticuit, USA.

**[0052]** Fully loaded with the wastewater treatment system described above and depicted in

Figure **8A,** trailer **100** weighs approximately 11,340 kg (25,000 pounds). Trailer **100** preferably is approximately 2.59 m (eight and one-half (8 *Vi* ft.) feet) wide, 13.72 m (forty-five (45 ft.) feet) long, and with the equipment depicted in Figure **8A** aboard, no more than 4.11 m (thirteen and one-half (13 'A ft.) feet) high. Trailer **200,** though having substantially the same horizontal dimensions, need not be nearly as tall, preferably being approximately 3.05 m (ten (10 ft.)) high.

**[0053]** Thus, trailers **100, 200** as depicted and described are sufficiently small and light weight that the entire system can travel on the highways and local roads of most if not all states of the United States without obtaining wide-load and heavy equipment permits and without escorts and clearance supervision for overpasses, bridges and the like. This makes the present invention readily transportable from one site to another with only the cost and time required to connect and disconnect it and to travel between sites.

**[0054]** While the invention has been particularly shown and described with reference to preferred and alternate embodiments, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the scope of the invention.

# REFERENCES CITED IN THE DESCRIPTION



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- US4340489A [0006]

## Bærbart, ikke-biologisk, cyklisk spildevandbehandlingsanlæg

**Patentkrav:**

**1.** Bærbart spildevandbehandlingssystem omfattende:

spildevandindtagsanordninger indrettet til at modtage ubehandlet spildevand og til at lede det ind i behandlingssystemet i en spildevandstrøm,

en klaringsanordning (28) koblet til spildevandindtagsanordningerne, hvilken klaringsanordning (28) har:

en tank med:

en lodret akse, der strækker sig mellem en top og en bund,

tankvægge (81, 83, 84), der omgiver den lodrette akse og afgrænser et indre af klaringsanordningen (28), hvilke tankvægge (81, 83, 84) endvidere afgrænser:

et opbevaringskammer anbragt tilstødende toppen, hvilket opbevaringskammer har i det væsentlige lodrette, cylindriske sider (84), der strækker med en indbyrdes afstand under toppen, og

et cirkulationskammer, der er anbragt under opbevaringskammeret og strækker sig til bunden, hvilket cirkulationskammer har i det væsentlige koniske vægge (83), der konvergerer i en udvalgt vinkel i forhold til den lodrette akse fra tilstødende opbevaringskammeret til tilstødende bunden,

en spildevandstrøminjektionsport (82), der er koblet til cirkulationskammeret tilstødende bunden og i væskeforbindelse med det indre af klaringsanordningen (28), og

hovedanordninger (85), der er anbragt i opbevaringskammeret og indrettet til at bortlede en behandlet spildevandstrøm med behandlet spildevand fra klaringsanordningen (28),

en desinfektionsanordning, der er tilkoblet mellem spildevandindtagsanordningerne og klaringsanordningen (28) og indrettet til ikke-biologisk at desinficere spildevandet, hvilken desinfektionsanordning har:

syreinjektionsanordninger (50-55, 15, 15A, 15B), der er tilkoblet nedstrøms spildevandindtagsanordningerne og indrettet til at injicere en syreforbindelse udvalgt fra en gruppe af syreforbindelser i spildevandstrømmen,

baseinjektionsanordninger (61, 63, 17), der er tilkoblet nedstrøms syreinjektionsanordningerne (50-55, 15, 15A, 15B) og indrettet til at injicere en baseforbindelse udvalgt fra en gruppe af baseforbindelser i spildevandstrømmen, og

neutraliseringsmiddelinjektionsanordninger, der er tilkoblet nedstrøms baseinjektionsanordningerne (61, 63, 17) og indrettet til at injicere et pH-neutraliseringsmiddel i spildevandstrømmen,

flokkuleringsanordninger (56, 58, 16), der er tilkoblet nedstrøms desinfektionsanordningen og mellem desinfektionsanordningen og klaringsanordningen (28) og indrettet til at forårsage, at faststoffer, der er opslæmmet i spildevandet, bundfældes ud af opløsningen som klumper, der kan fjernes,

polymerbehandlingsanordninger (66, 68, 18), der er indrettet til at behandle spildevandet for at modvirke, at flokkulerede faststoffer klæber til tankvæggene (81, 83, 84) i det indre af klaringsanordningen (28), og

filtreringsanordninger (30, 35, 36), der er koblet til hovedanordningerne (85) og indrettet til at filtrere det behandlede spildevand fra klaringsanordningen (28).

**2.** Bærbart spildevandbehandlingssystem ifølge krav 1, hvor spildevandindtagsanordningerne omfatter:

et reservoir (130, 131), der er indrettet til at akkumulere indstrømmende spildevand fra forskellige spildevandkilder,

en cirkulationspumpe, der er indrettet til at skabe en spildevandstrøm, der cirkulerer i reservoiret (130, 131),

et tætstoffilter, der er tilkoblet nedstrøms cirkulationspumpen i spildevandstrømmen,

mindst en kværn, der er tilkoblet nedstrøms tætstoffilteret og indrettet til at kværne faststoffer af ubestemmelig størrelse i spildevandstrømmen til faststofpartikler af i det væsentlige samme størrelse, mindst én macerationspumpe (20A), der er indrettet til yderligere at reducere størrelsen af faststoffet til partikler af i det væsentlige samme størrelse,

en fremføringspumpe, der er tilkoblet nedstrøms macerationspumpen (20A) og indrettet til at fremføre spildevandstrømmen i det bærbare spildevandbehandlingssystem, og

en udligningstank (7), der er tilkoblet nedstrøms fremføringspumpen og indrettet til at udligne spildevandstrømtrykket i det bærbare spildevandbehandlingssystem.

**3.** Bærbart spildevandbehandlingssystem ifølge krav 1, hvor:

spildevandstrøminjektionsporten (82) er indrettet til at injicere spildevandstrømmen i klaringsanordningen (28) i en retning tangerende de koniske vægge (83).

**4.** Bærbart spildevandbehandlingssystem ifølge krav 1, hvor:

den udvalgte vinkel ikke er mere end 29° (29 grader).

**5.** Bærbart spildevandbehandlingssystem ifølge krav 2, hvor syreinjektionsanordningerne (50-55, 15, 15A, 15B) omfatter en svovldioxidgenerator (50-53, 15, 15A, 54), der er tilkoblet i spildevandstrømmen opstrøms udligningstanken (7) og har:

et spildevandopbevaringskammer,

en oxygenkilde og

en svovlforbrændingsanordning koblet til kammeret,

hvorved svovlforbrændingsanordningen er indrettet til at forårsage, at svovl reagerer med oxygen fra oxygenkilden til frembringelse af svovldioxid ($SO_2$)-gas i spildevandopbevaringskammeret og i nærvær af spildevandet, og

hvorved spildevandet absorberer en udvalgt mængde af svovldioxidgassen.

**6.** Bærbart spildevandbehandlingssystem ifølge krav 1 endvidere omfattende:

et slamhåndteringssystem, der er koblet til klaringsanordningen (28) og har:

en slamudgangsport anbragt i de koniske vægge (83),

en slamudgangsventil (41) koblet til slamudgangsporten, en slamtank (42) koblet til slamudgangsventilen (41),

en slammikser (43) tilkoblet i slamtanken og

en slamfilterpresse (48) koblet til slamopbevaringstanken.

**7.** Bærbart spildevandbehandlingssystem ifølge krav 1 endvidere omfattende:

mindst én anhænger (100), der er indrettet til at bære det bærbare spildevandbehandlingssystem på offentlig vej, hvilken anhænger (100) har:

et i det væsentlige plant dæk (101) med:

en langsgående akse, der strækker sig mellem en tungeende (103) og en truckende,

en topflade, der i det væsentlige strækker sig sammen med den langsgående akse og en modstående bundflade,

en flerhed af skinner (106), der er anbragt på bundfladen parallelt med og med en indbyrdes afstand til hinanden på modstående sider af den langsgående akse, hvilke skinner er indrettet til at gå i indgreb med en bæreflade (93) for at understøtte det bærbare spildevandbehandlingssystem, når det bærbare spildevandsystem er i drift,

tungeanordninger (103), der er koblet til tungeenden (103) og indrettet til kobling til en traktor (91) for at trække mindst én anhænger (100) på offentlig vej, og

en truck (111), der er anbragt i truckenden (111) og har en flerhed af truckhjul, der er indrettet til at:

gå i indgreb med vejen og understøtte anhængeren (100), når tungeanordningen (103) er koblet til traktoren (91), og

hænge over bærefladen (93), når det bærbare spildevandbehandlingssystem er i drift.

**8.** Fremgangsmåde til ikke-biologisk behandling af ubehandlet spildevand udført i systemet ifølge ét af kravene 1 til 7, hvilken fremgangsmåde omfatter følgende på hinanden følgende trin:

- at lede det ubehandlede spildevand ind i spildevandindtagsanordningerne,

- at desinficere det ubehandlede spildevand ved at udføre følgende trin:

    - at injicere en udvalgt mængde syre ind i spildevandet ved anvendelse af syreinjektionsanordningerne (50-55, 15, 15A, 15B) for at sænke pH-værdien af spildevandstrømmen til en værdi under 7,0, derefter

    - at injicere en udvalgt mængde base ind i spildevandet ved anvendelse af baseinjektionsanordningerne (61, 63, 17) for at hæve pH-værdien af spildevandstrømmen til en værdi over 7,0, derefter

    - at injicere en udvalgt mængde neutraliseringsmiddel i spildevandstrømmen for at bringe pH-værdien af spildevandstrømmen tilbage til en værdi, der i det væsentlige er lig med 7,0,

- at drive flokkuleringsanordningerne (56, 58, 16) til at forårsage, at faststoffer, der er opslæmmet i spildevandet, bundfældes ud af opløsningen som klumper,

- at tilføre polymer fra polymerbehandlingsanordningerne (66, 68, 18) til spildevandet for at modvirke, at flokkulerede faststoffer klæber til tankvæggene i det indre af klaringsanordningen, og

- at klare spildevandet ved at anvende klaringsanordningen (28) til at fjerne faststofferne fra spildevandet ved at udføre følgende på hinanden følgende trin:

    - at injicere spildevandet i en kontinuerlig spildevandstrøm i spildevandstrøminjektionsporten (82),

    - at bortlede det behandlede spildevand i en kontinuerlig behandlet spildevandstrøm fra opbevaringskammeret ved anvendelse af hovedanordningerne (85),

    - at lede den behandlede spildevandstrøm til filtreringsanordningerne (30, 35, 36), derefter

- at filtrere det behandlede spildevand med filtreringsanordningerne (30, 35, 36), og

- udlede det behandlede spildevand fra spildevandbehandlingssystemet.

**9.** Anvendelse af en syreforbindelse i det bærbare spildevandbehandlingssystem ifølge krav 1, hvilken syreforbindelse er udvalgt fra gruppen af syreforbindelser omfattende svovl, brom, chlor, halogen, chloraminer og ozon ($0_3$).

**10.** Anvendelse af en baseforbindelse i det bærbare spildevandbehandlingssystem ifølge krav 1, hvilken baseforbindelse er udvalgt fra gruppen af baseforbindelser omfattende calciumhydroxid ($Ca(OH)_2$), natriumhydroxid (NaOH) og kaliumhydroxid (KOH).

**11.** Anvendelse af syreforbindelsen ifølge krav 9, hvor den udvalgte syreforbindelse er svovl, der ioniserer i spildevandstrømmen til frembringelse af opløst svovldioxid ($SO_2$).

**12.** Anvendelse af syreforbindelsen ifølge krav 11, hvor den udvalgte syreforbindelse er indrettet til at ionisere til frembringelse af en koncentration af svovldioxid, der er opslæmmet i spildevandstrømmen, med en volumen mellem 20 ppm (milliontedele) og 100 ppm.

**13.** Anvendelse af syreforbindelsen ifølge krav 12, hvor koncentrationen af svovldioxid er 75 ppm.

**14.** Anvendelse af en flokkuleringsmiddelforbindelse i det bærbare spildevandbehandlingssystem ifølge krav 1, hvilken flokkuleringsmiddelforbindelse er udvalgt fra en gruppe af jernforbindelser omfattende jernchlorid (FeCL), jernsulfat ($FeSO_4$) og aluminiumsulfat ($AlSO_4$).

# DRAWINGS

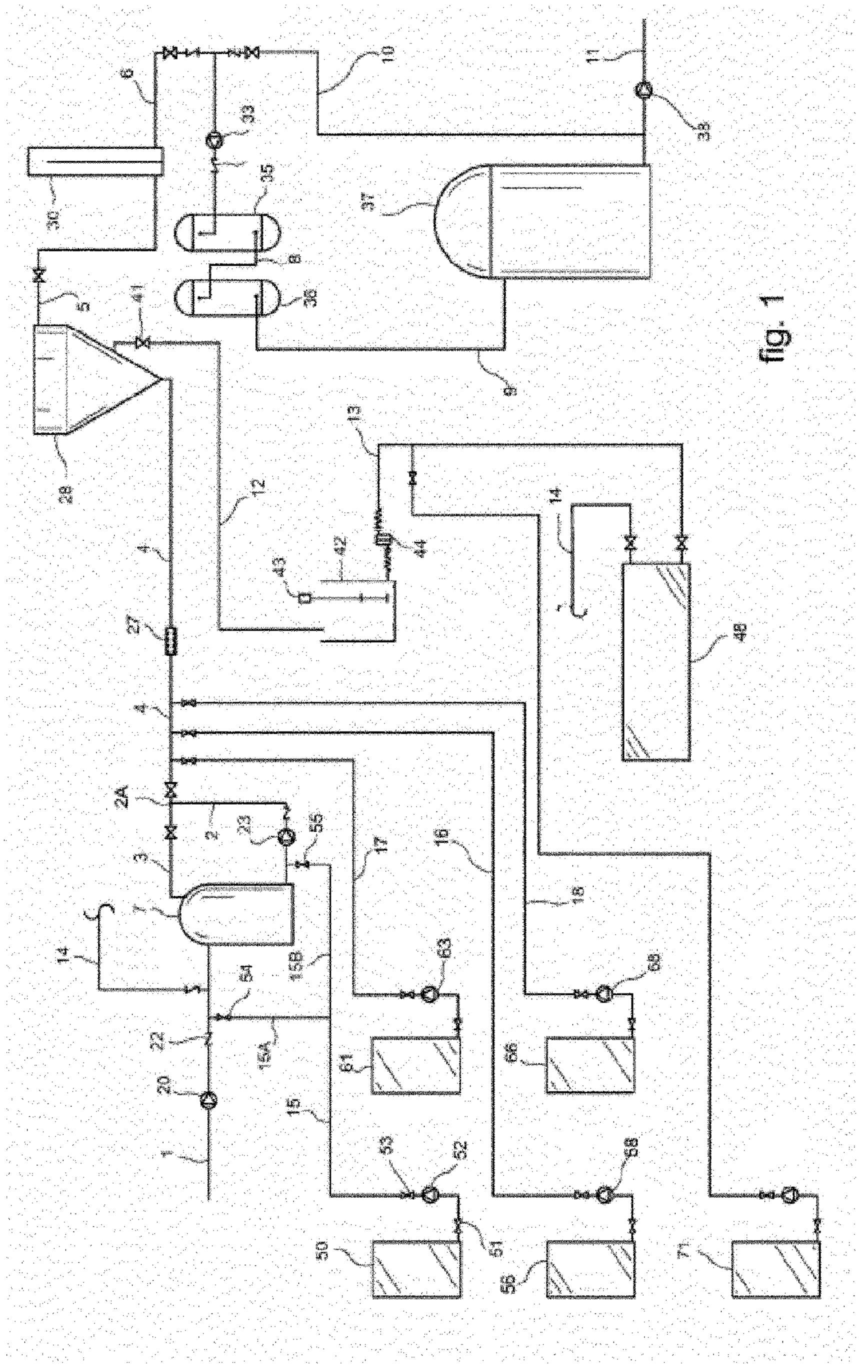



fig. 1

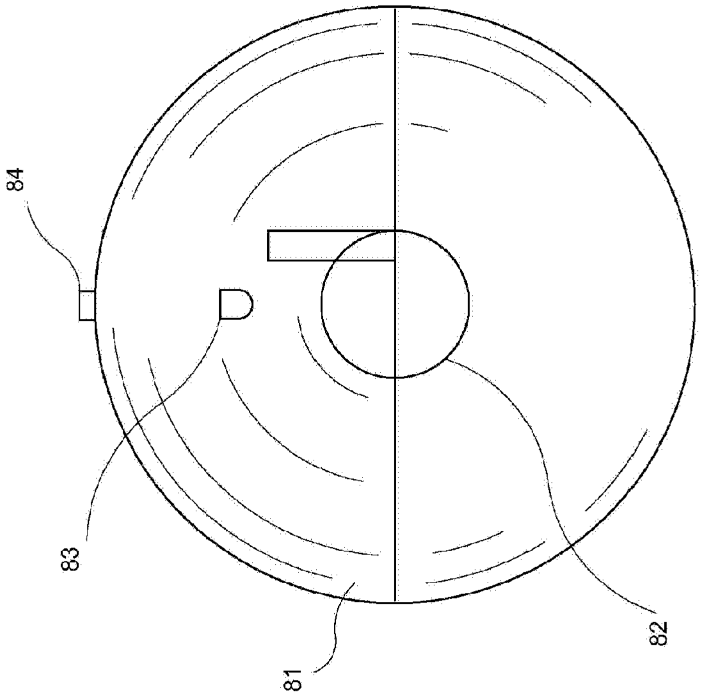



fig. 3

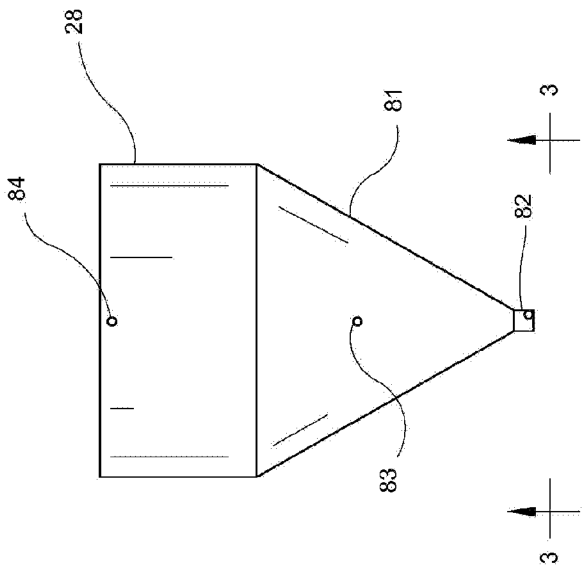



fig. 2

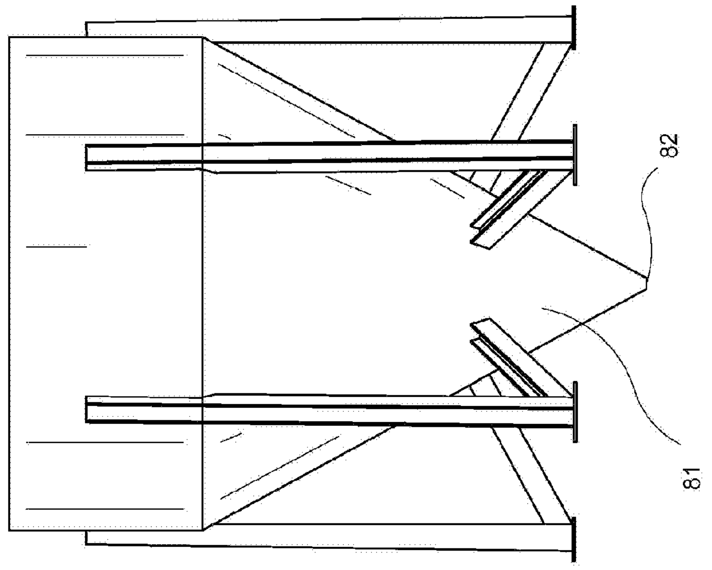



fig. 4B

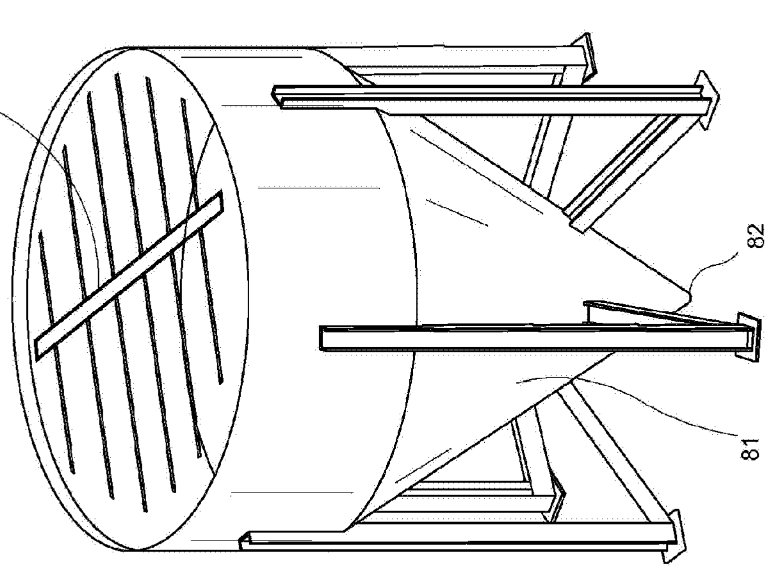



fig. 4A

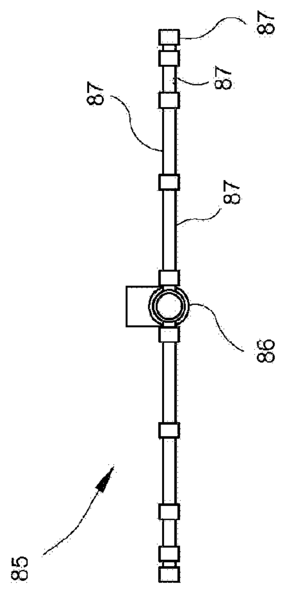


fig. 5B

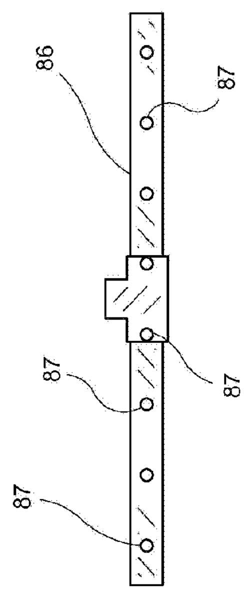


fig. 5C

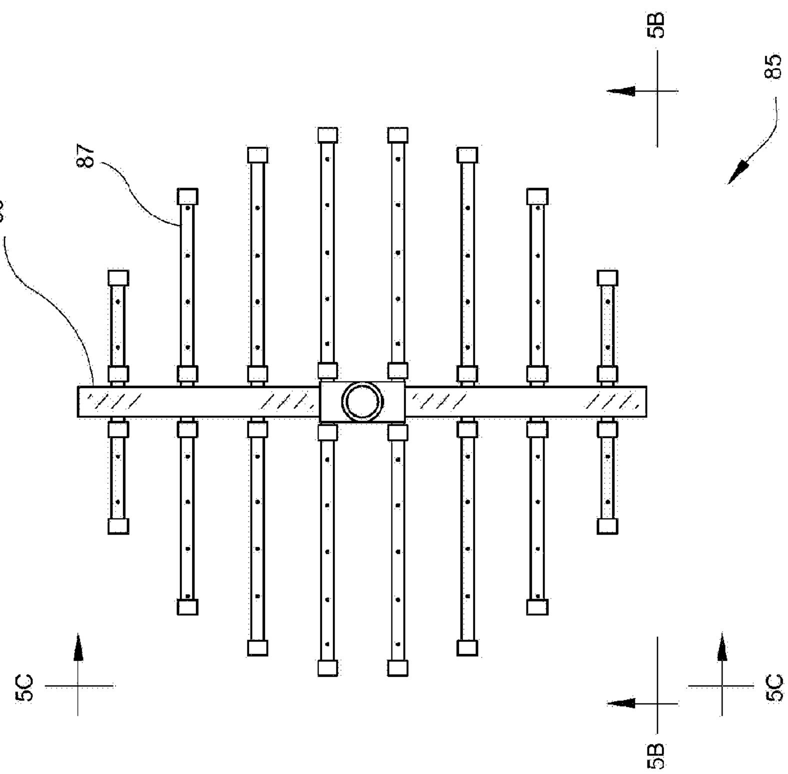


fig. 5A

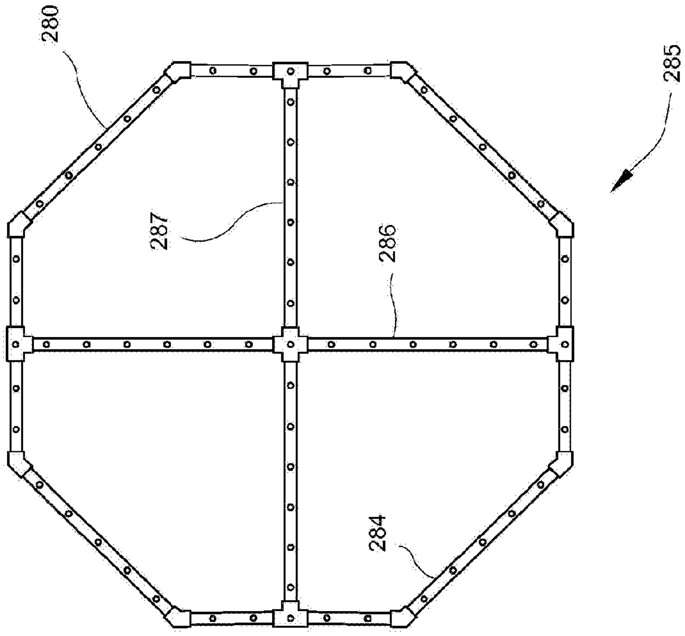



fig. 7

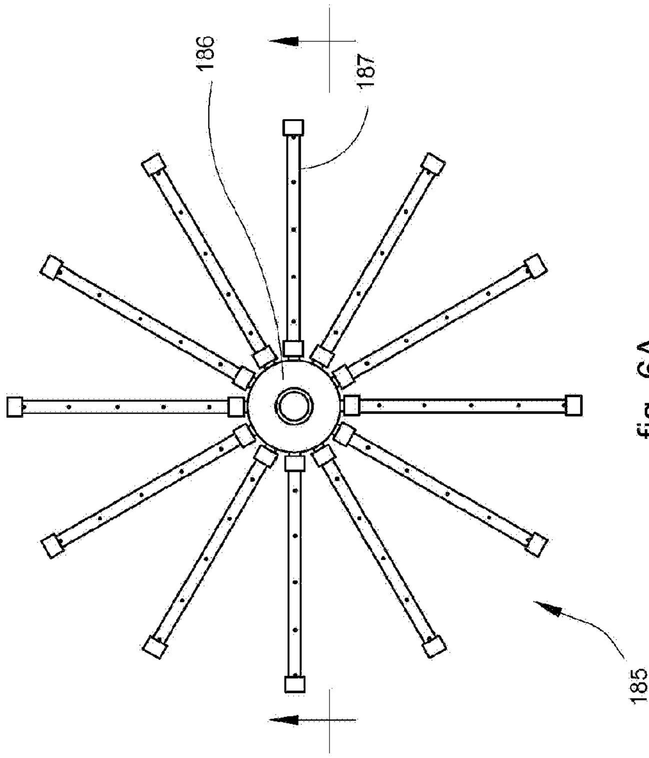



fig. 6A

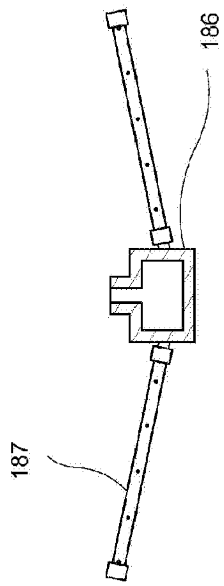



fig. 6B

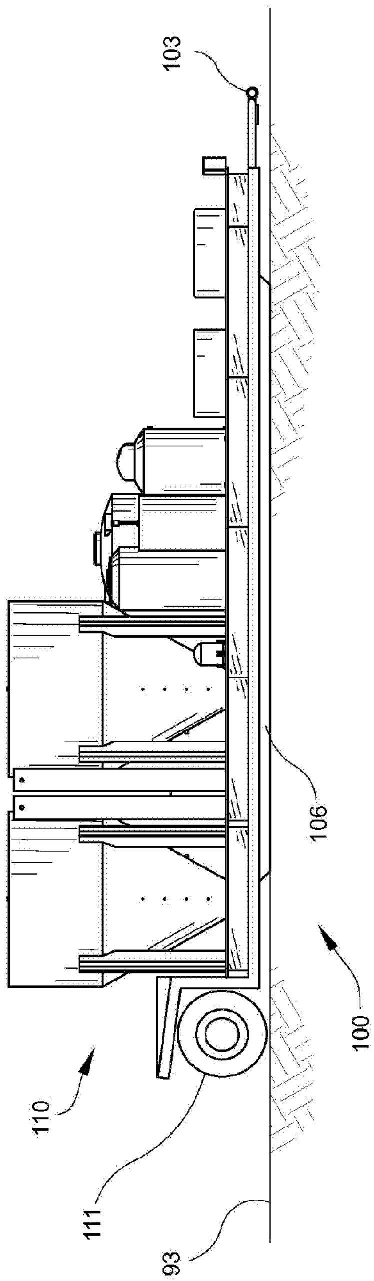



fig. 8B

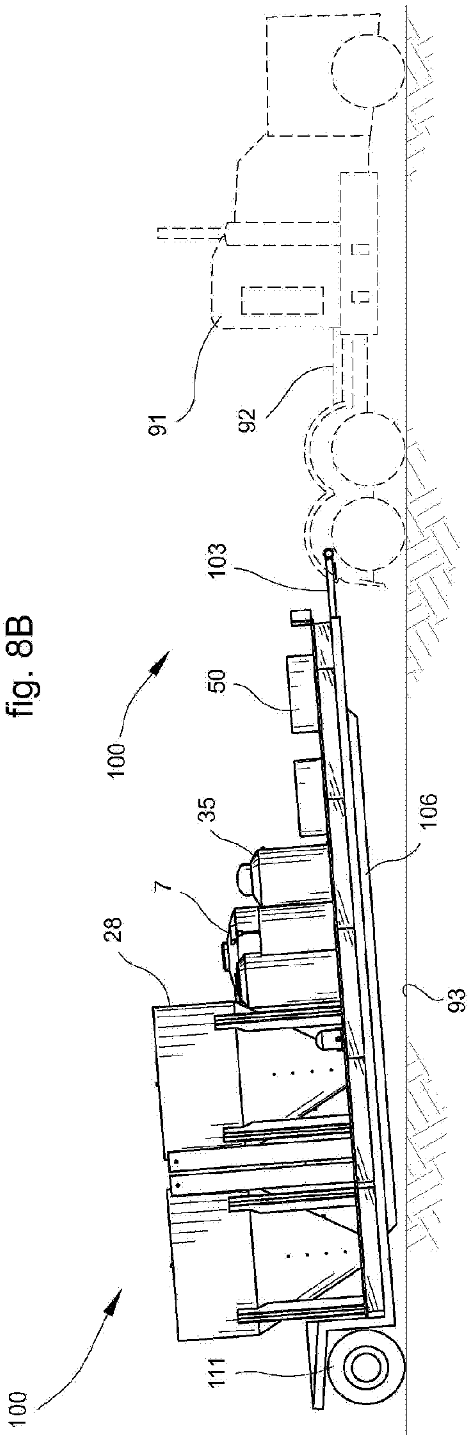
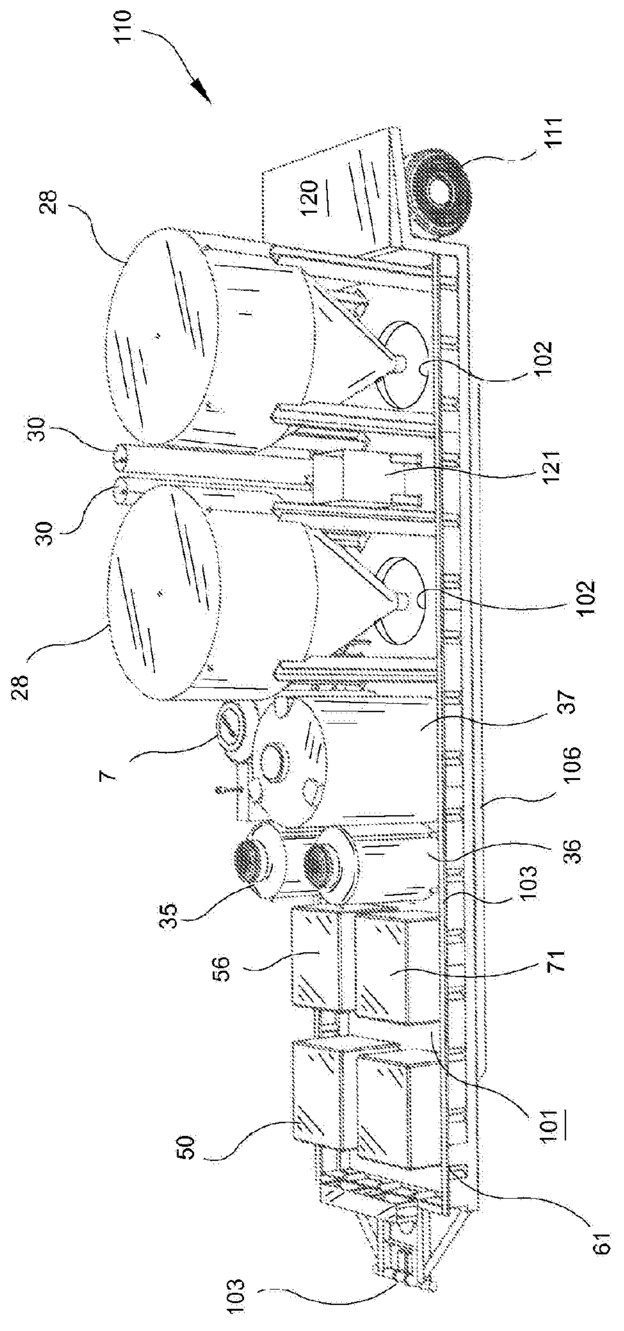



fig. 8A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111
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61
103

fig. 9

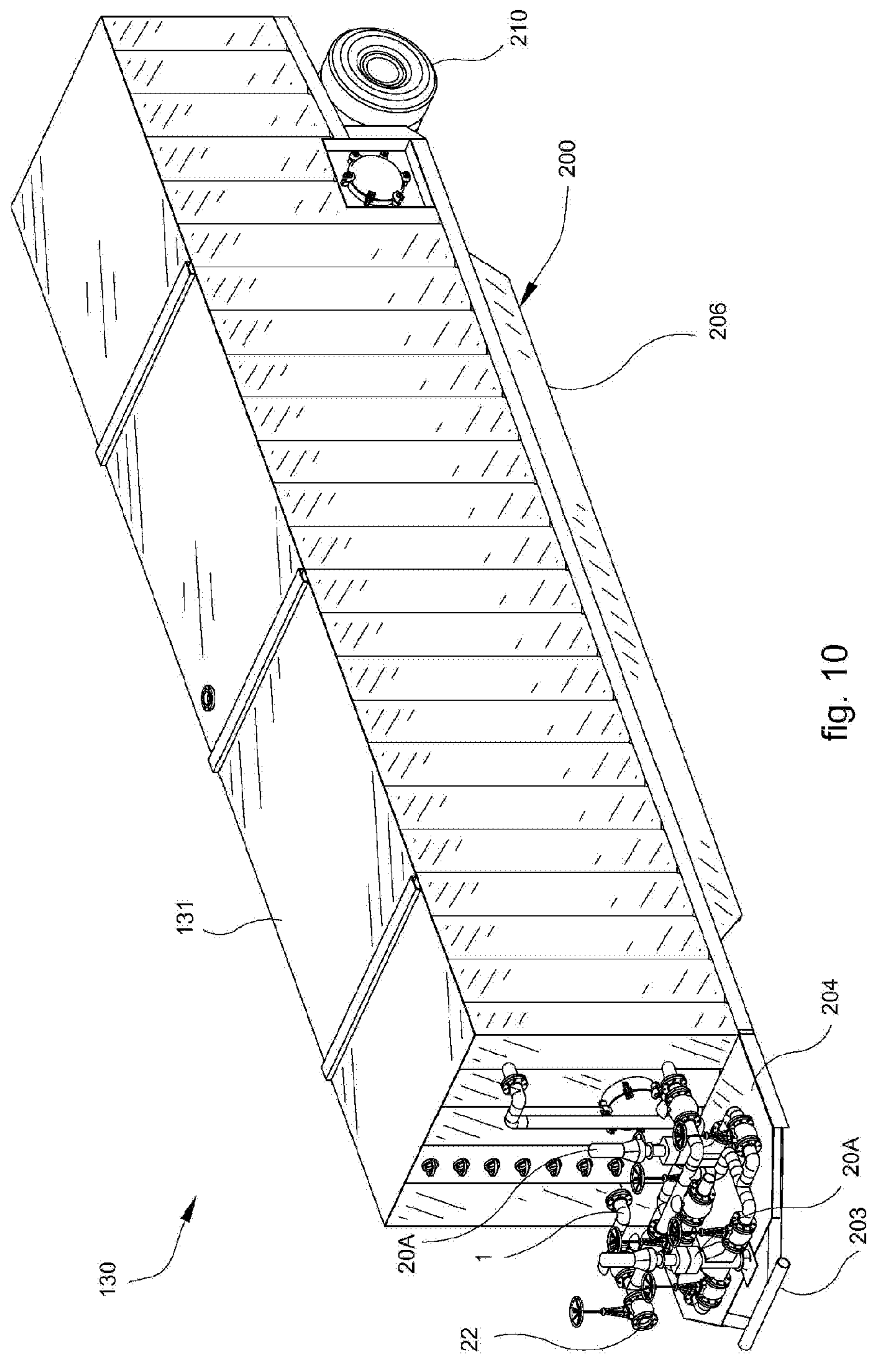



fig. 10

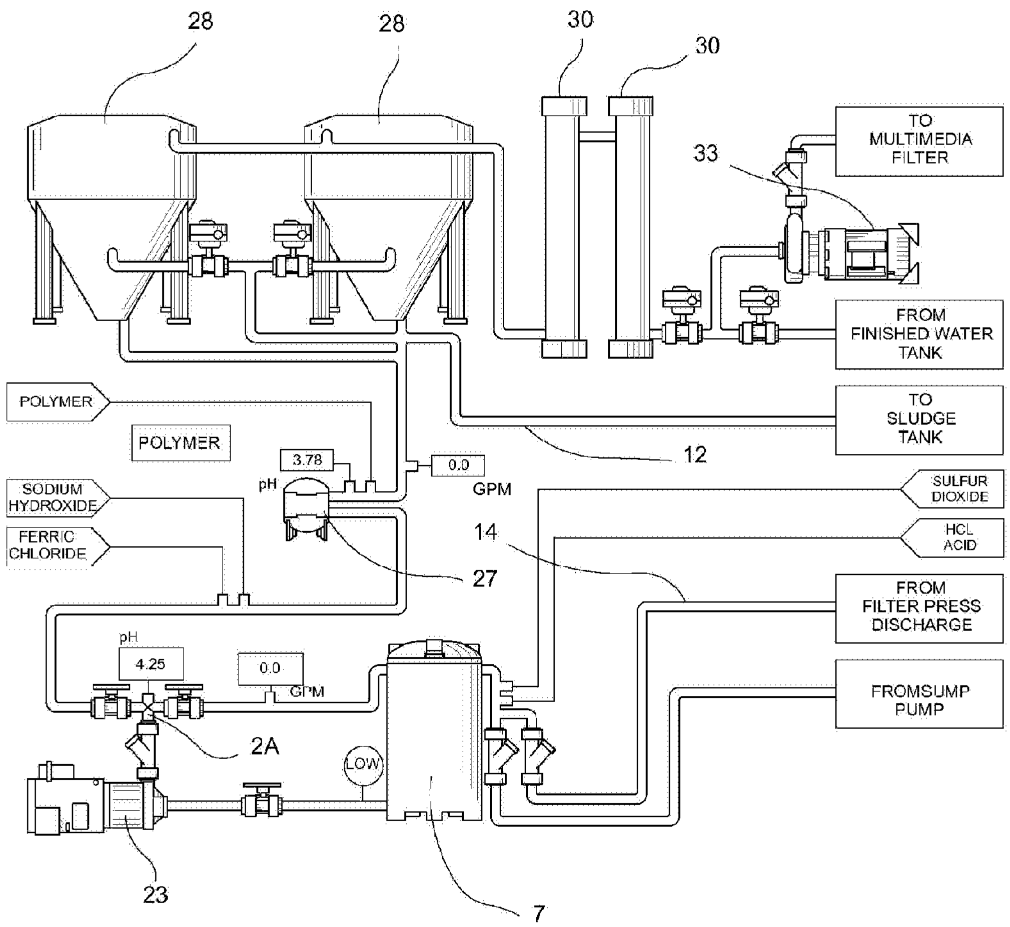

28
28
30
30
TO MULTIMEDIA FILTER
33
FROM FINISHED WATER TANK
POLYMER
POLYMER
TO SLUDGE TANK
3.78
pH
0.0
GPM
12
SODIUM HYDROXIDE
SULFUR DIOXIDE
FERRIC CHLORIDE
14
HCL ACID
27
FROM FILTER PRESS DISCHARGE
pH
4.25
0.0
GPM
FROMSUMP PUMP
2A
LOW
23
7

fig. 11A

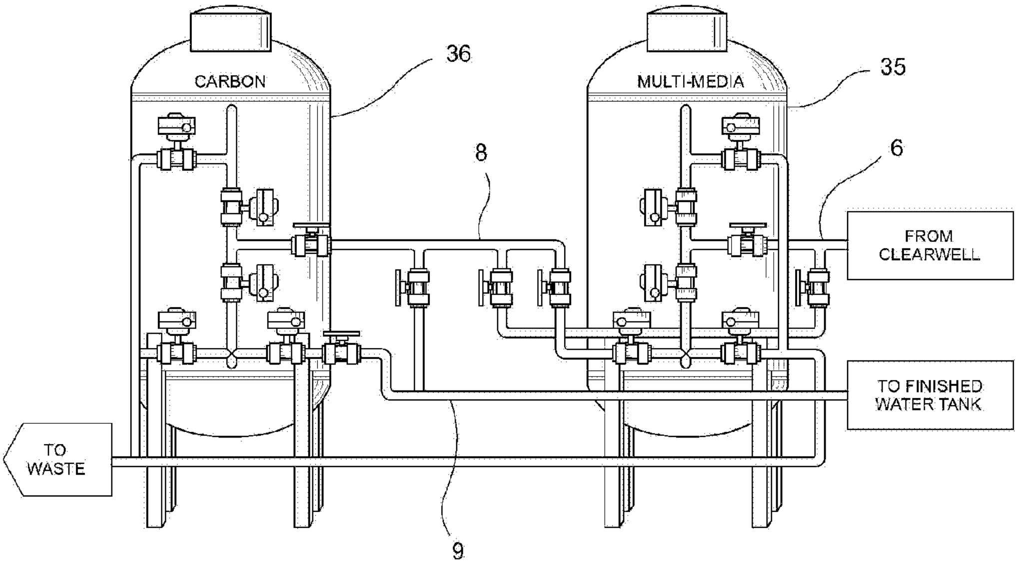



fig. 11B

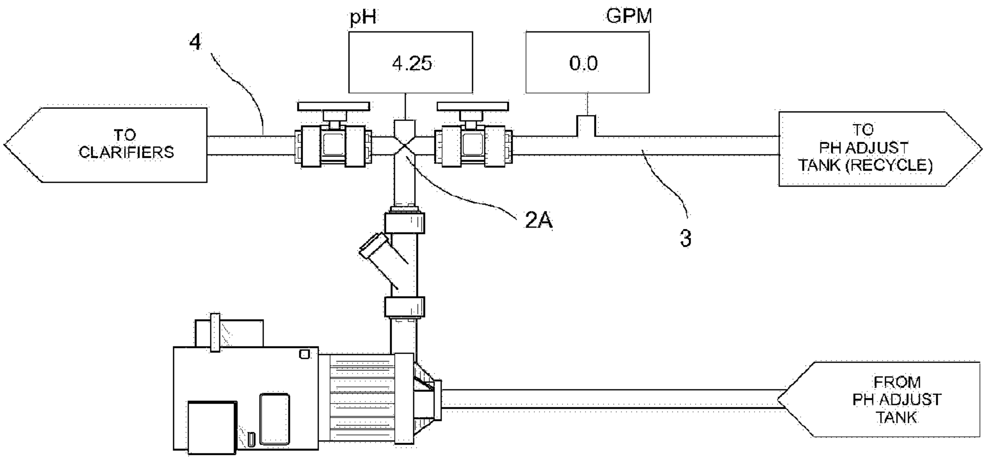



fig. 11C

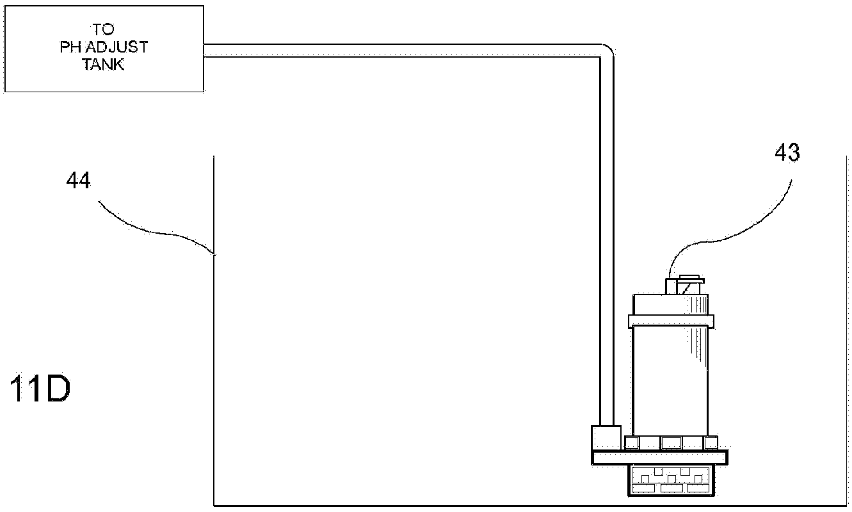



fig. 11D

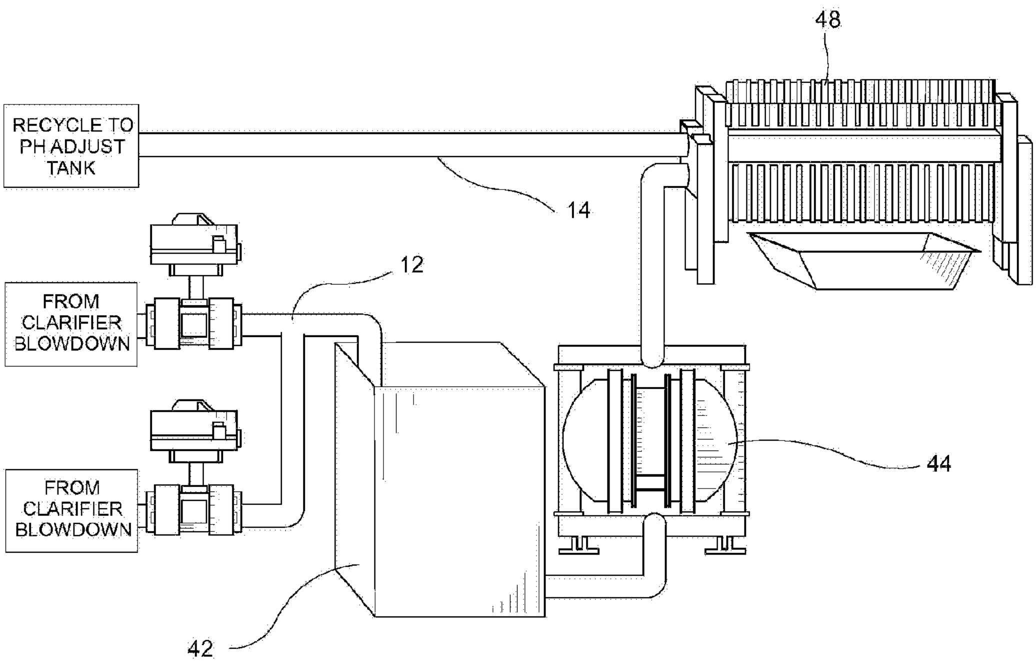
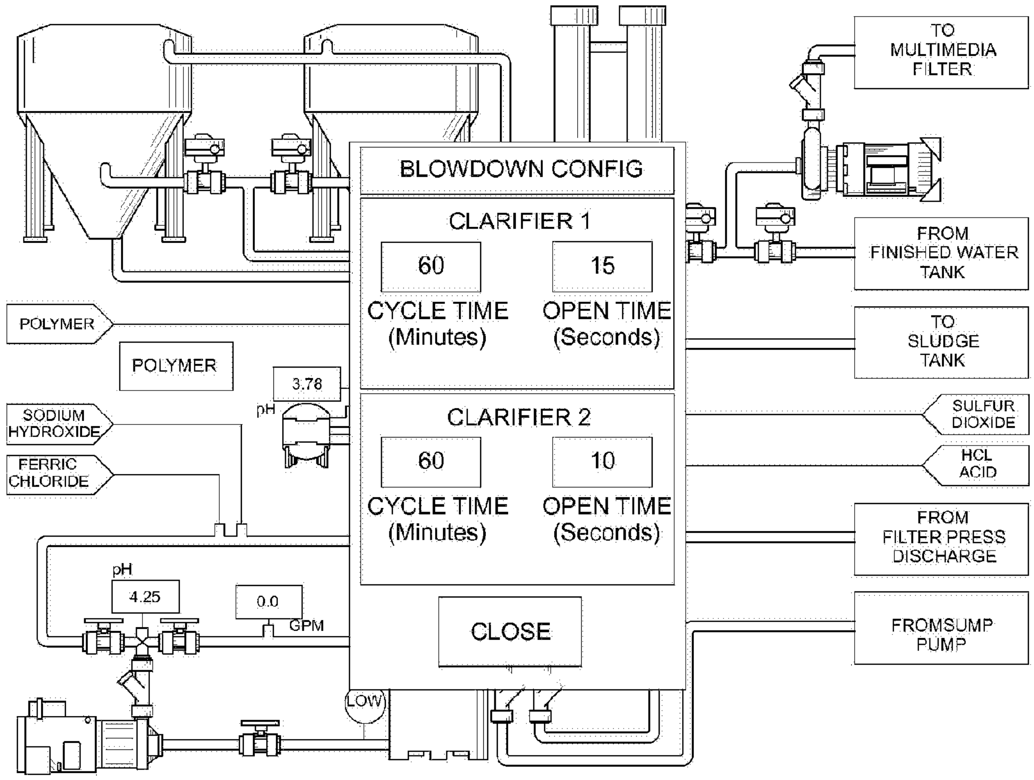



fig. 11E


BLOWDOWN CONFIG
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15
CYCLE TIME (Minutes)
OPEN TIME (Seconds)
CLARIFIER 2
60
10
CYCLE TIME (Minutes)
OPEN TIME (Seconds)
CLOSE
TO MULTIMEDIA FILTER
FROM FINISHED WATER TANK
TO SLUDGE TANK
SULFUR DIOXIDE
HCL ACID
FROM FILTER PRESS DISCHARGE
FROMSUMP PUMP
POLYMER
POLYMER
3.78
pH
SODIUM HYDROXIDE
FERRIC CHLORIDE
pH
4.25
0.0
GPM
LOW

fig. 11F

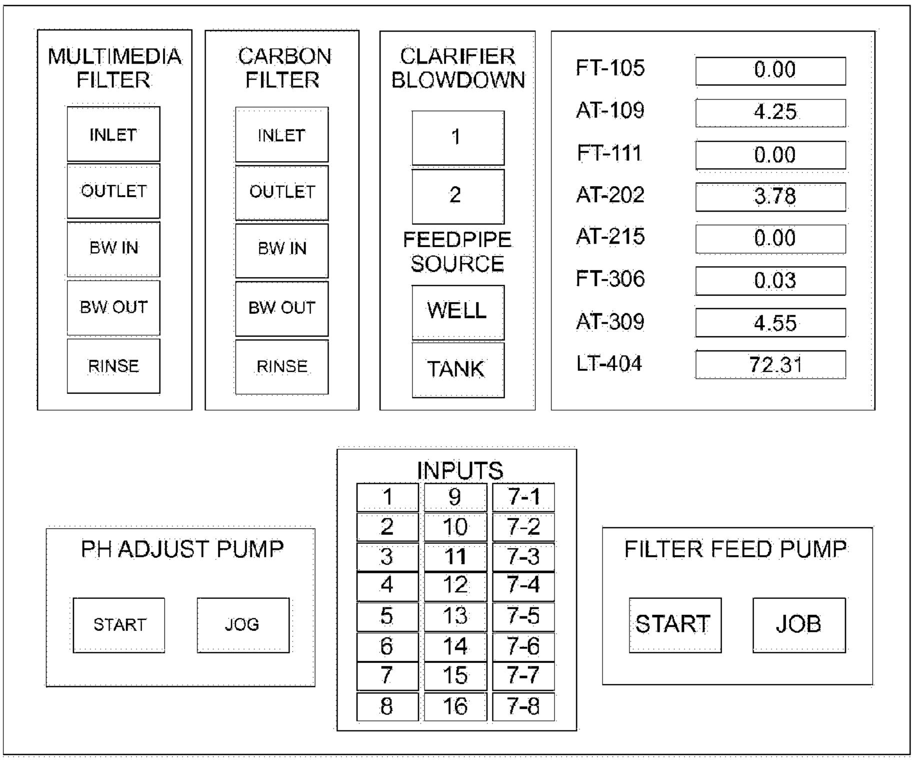


fig. 11G

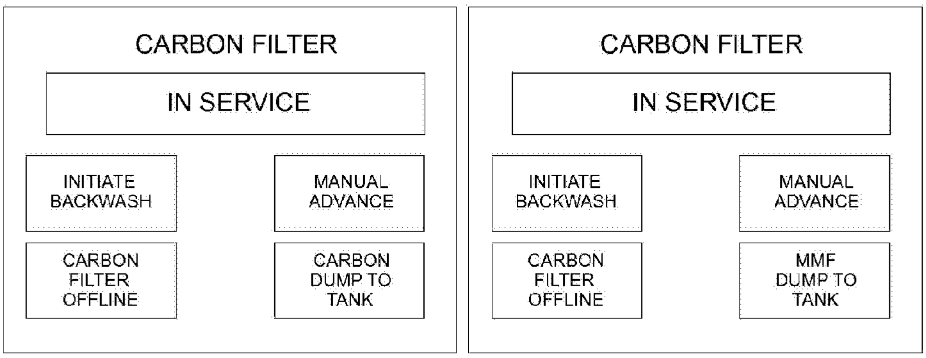


fig. 11H