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(54) [UNDERWATER VACUUM AND STERILIZATION SYSTEM]

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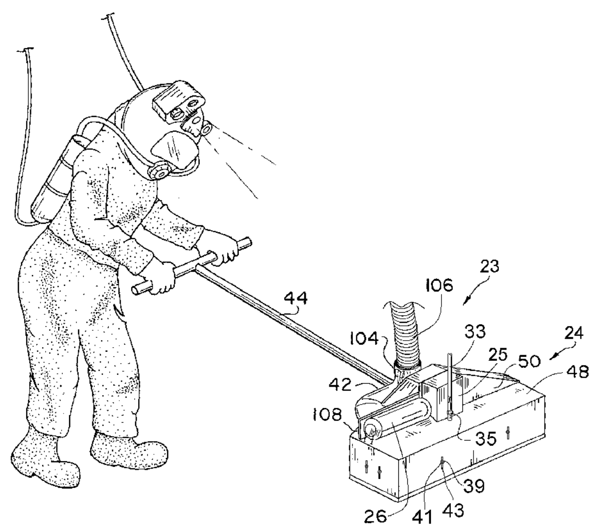
(57) ABSTRACT

An underwater vacuum, cleaning, removal, and sterilization system that allows for the submersible cleaning and sterilization of interior surfaces of drinking water storage, treatment, and distribution facilities. The system allows for the cleaning and chemical sterilization of surfaces in an underwater environment while simultaneously removing the sterilization chemical to prevent the said sterilization chemical from impacting or increasing the optimum sterilization chemical concentration in the surrounding water. The underwater vacuum, cleaning, and sterilization system includes a housing **24** having an opening **46** which is positioned adjacent the surface to be cleaned and sterilized. The system also includes a containment chamber **55** inside said housing. The containment chamber is open on the top and bottom and more than one flexible member, seal or plurality of bristles or brushes thereby defining a circumferential seal **63** on the bottom which is fluidly connected to both the interior cavity and the interior of the vacuum housing for assuring that all of the cleaning and sterilization fluids and any other matter are removed from the cavity and do not leak therefrom. The system also includes a variable-pressure-fluid mechanism inside the housing and containment chamber for providing a variable-pressure fluid flow against the surface to be cleaned and sterilized. The mechanism includes pressure jets **53** or spray portals from which variable pressure water and sterilization chemical flow to remove debris or material from the surface being cleaned and sterilized. A turbine energized by water flow through the vacuum powers the rear wheels inside the housing. In addition the system includes vacuum or water suction for removing all of the cleaning fluid and sterilization chemical and coatings, debris, or any other matter from the cavity. The housing has a water outlet **42** which communicates with a pump or siphon at the surface of the water. The vacuum has two rear wheels that are adjustably attached to the interior of the housing with a rotable axle between each wheel and with a sprocket attached to a chain drive powered by said turbine motor, and two front wheels that are adjustably attached to the interior of the housing. The underwater vacuum, cleaning, removal, and sterilization system can remove sediment and other debris from a water storage reservoir while simultaneously sterilizing the surfaces without causing turbidity in or allowing the sterilization chemical to enter the water column. In one of the embodiments a rotable brush 32 is supported inside the housing, which is also powered by the turbine motor, which may assist the cleaning process for some applications. In some of the embodiments the system includes hand held water suction and variable pressure fluid jet tools that are not powered by a turbine and are held by hand against smaller surfaces, roof support column bases, in corners, wall to floor joints, or any other area not reachable by the large turbine powered embodiment for cleaning and sterilization of said surfaces. The hand held embodiments may or may not have wheels or brushes. In some additional embodiments air lift or fluid pressure driven water suction and variable pressure fluid flow tools are designed to clean and sterilize the exterior surfaces of roof support columns or pipes and the interior surfaces of pipes.



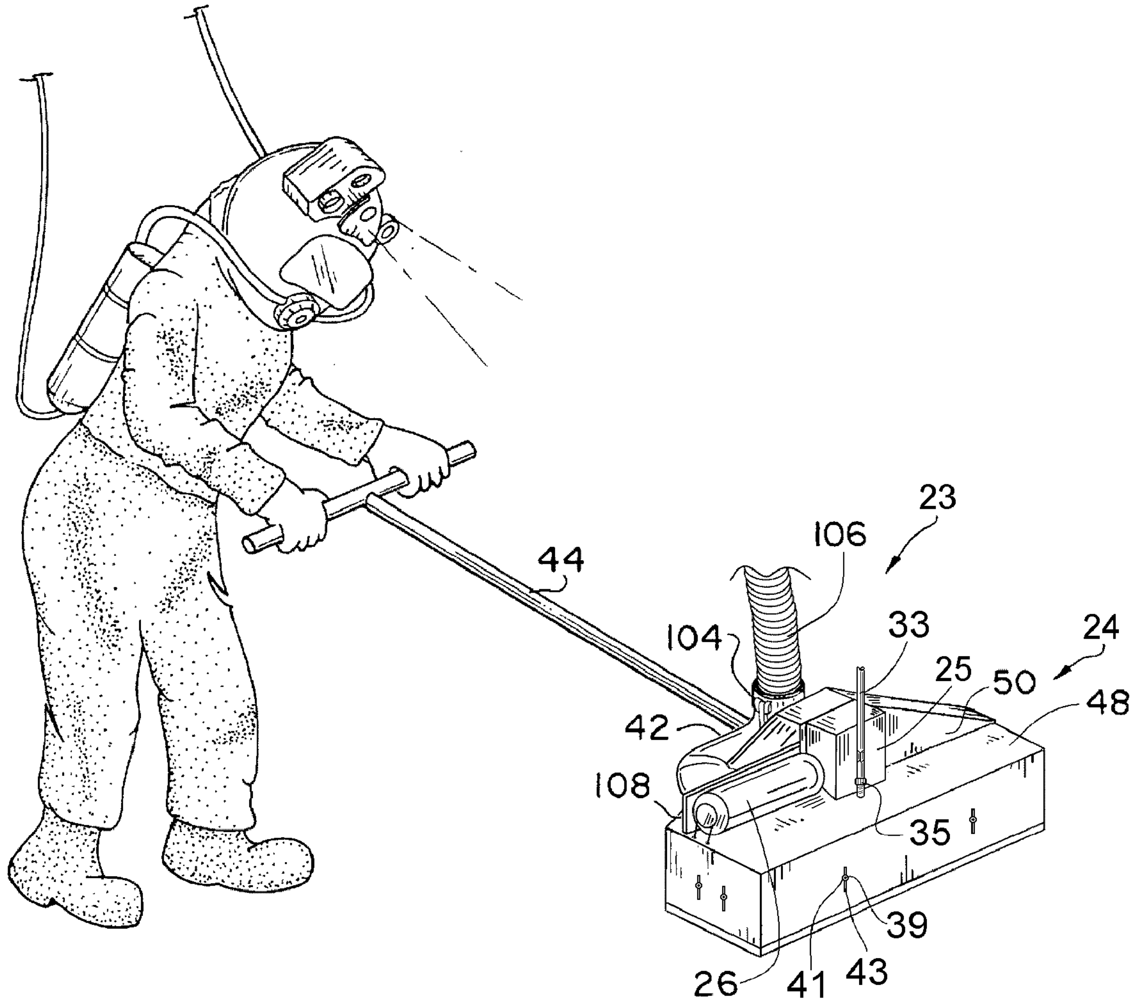


FIG. 1

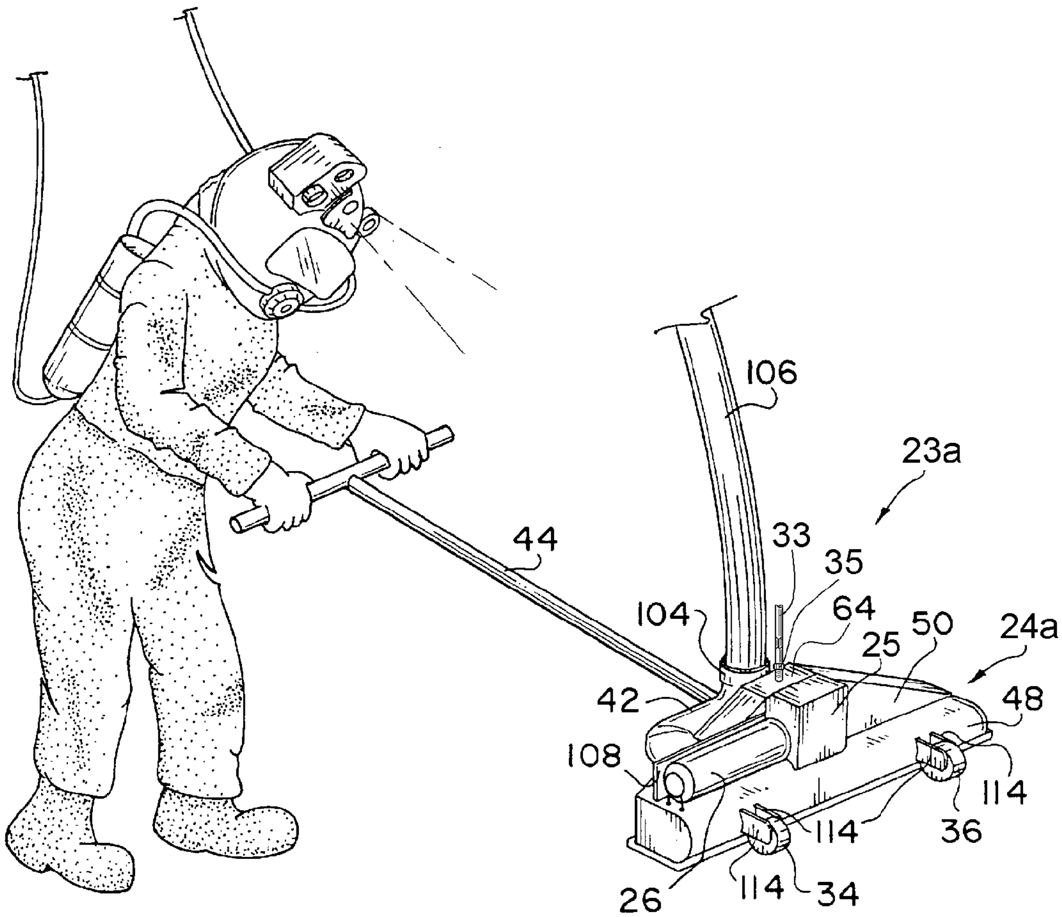


FIG. 1a

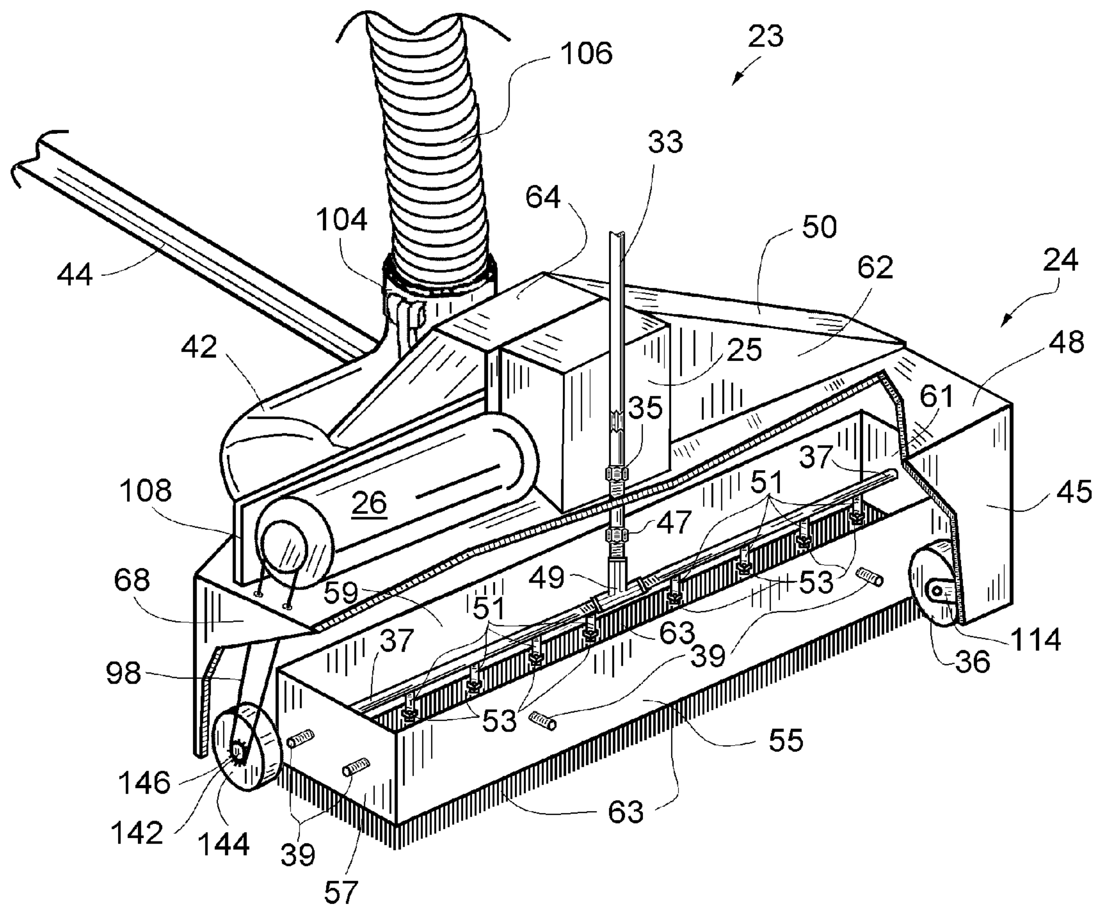

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FIG. 2

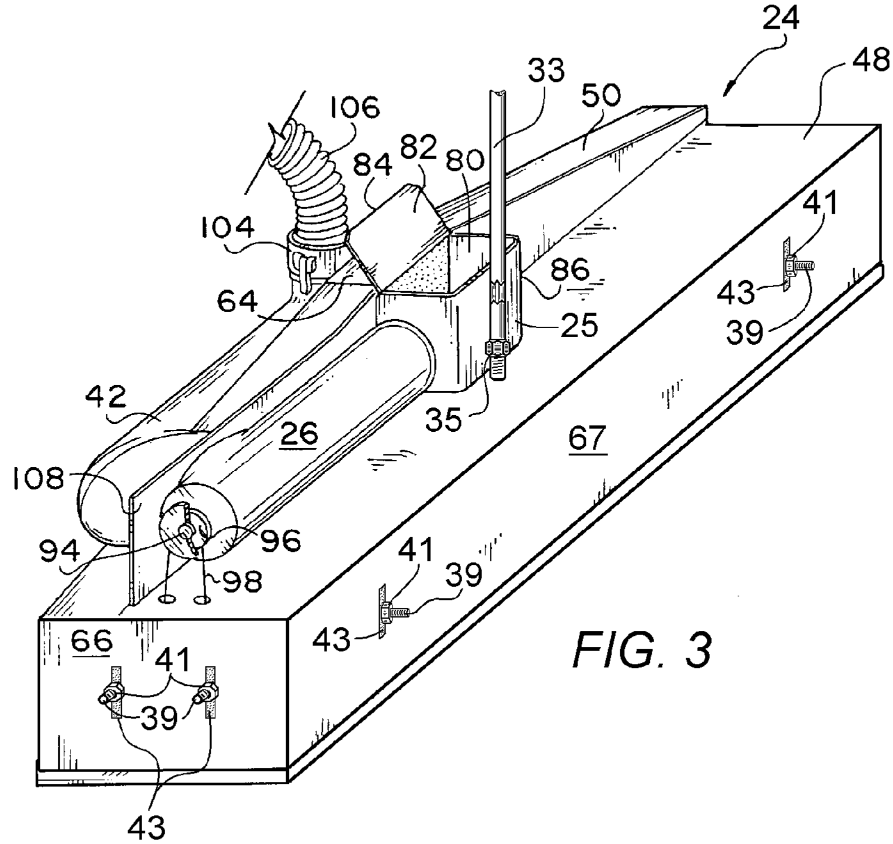
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FIG. 3

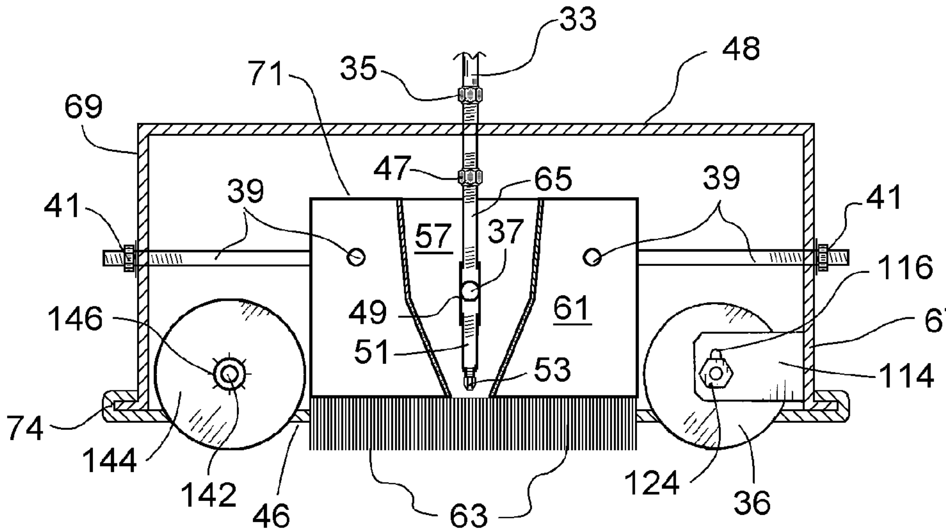
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FIG. 4

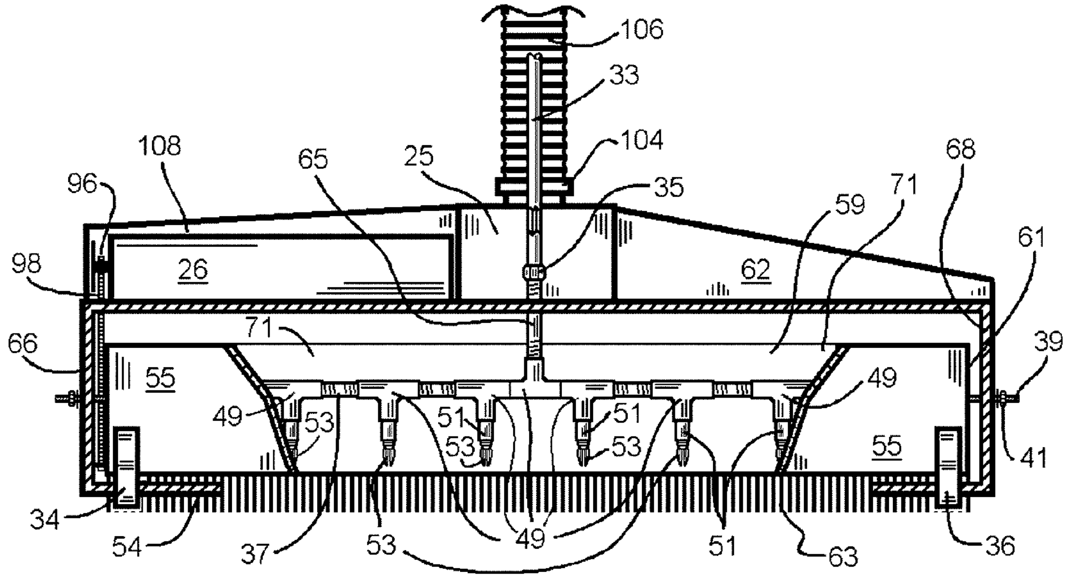
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FIG. 5

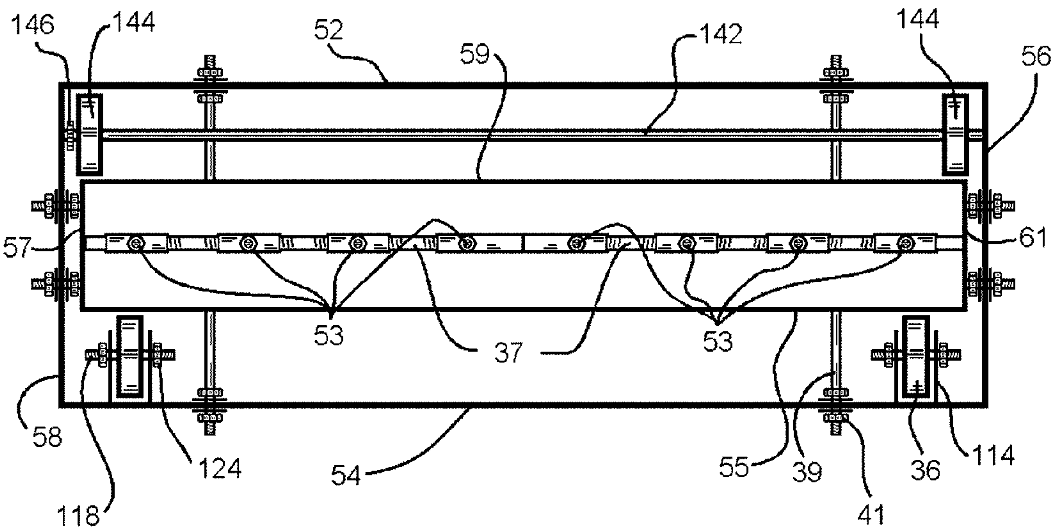
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FIG. 6

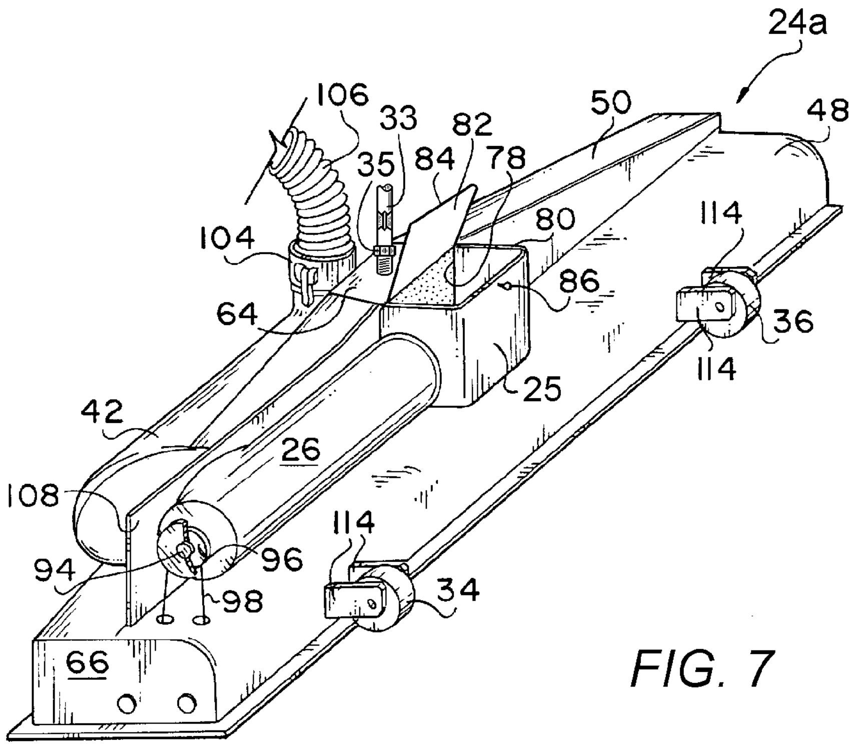
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FIG. 7

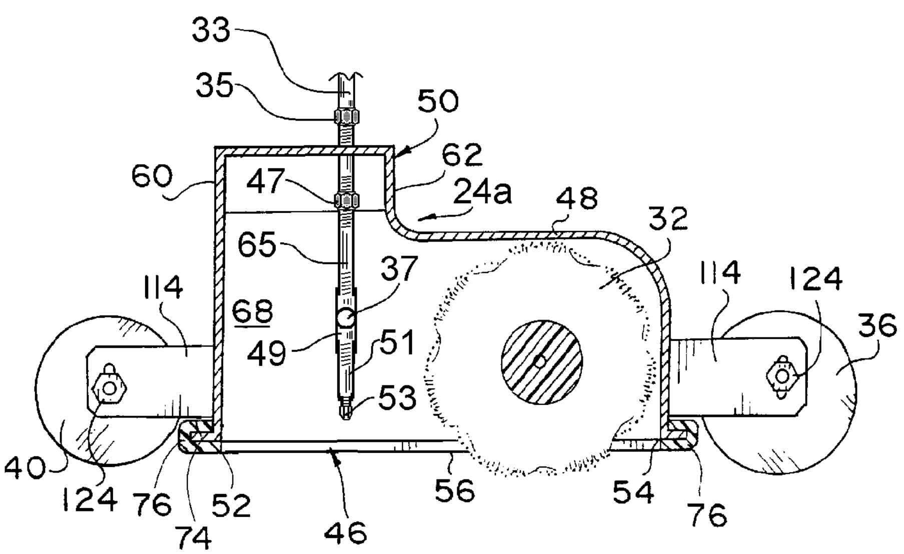
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FIG. 8

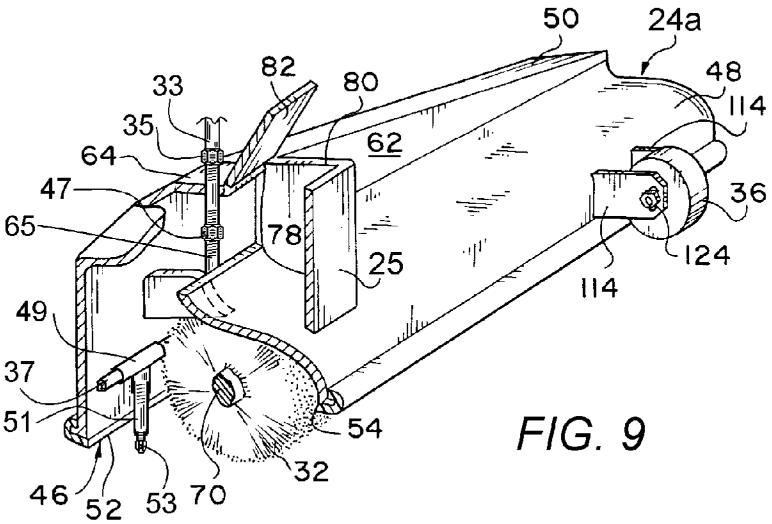
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FIG. 9

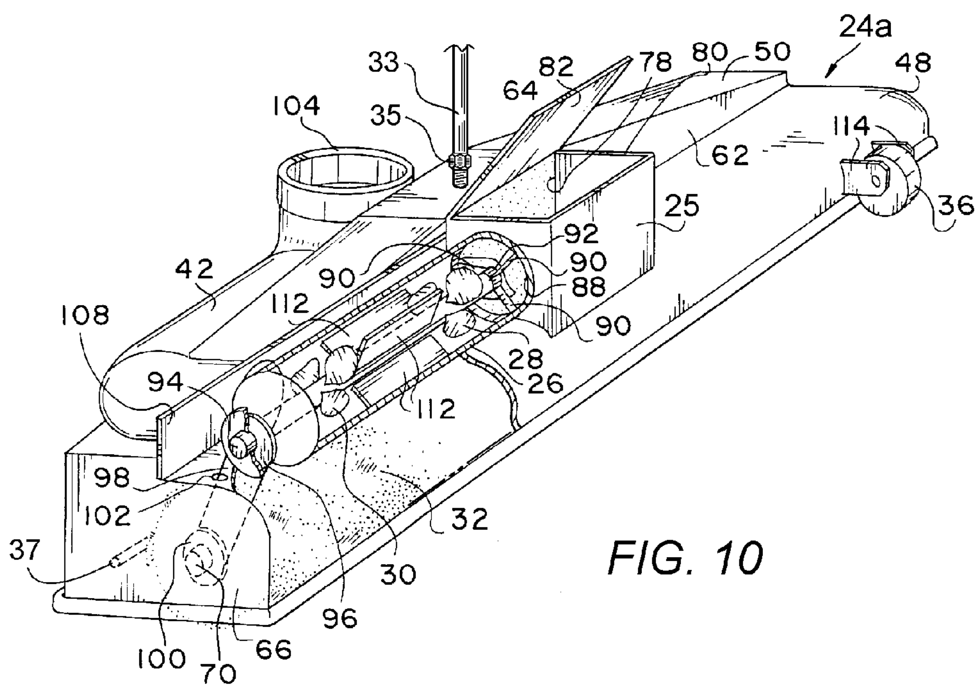
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FIG. 10

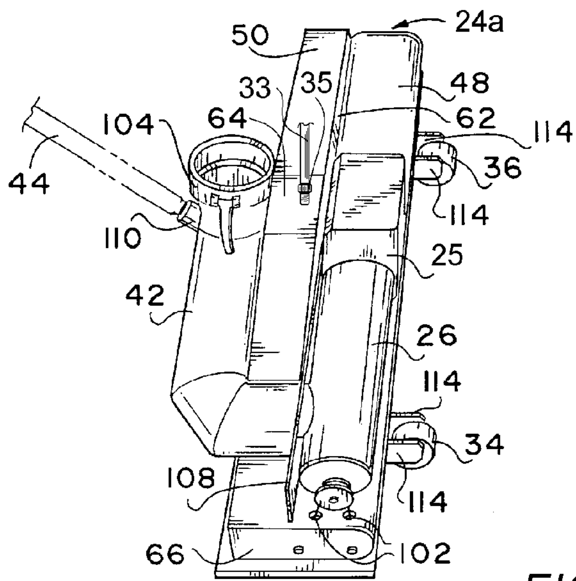
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FIG. 11

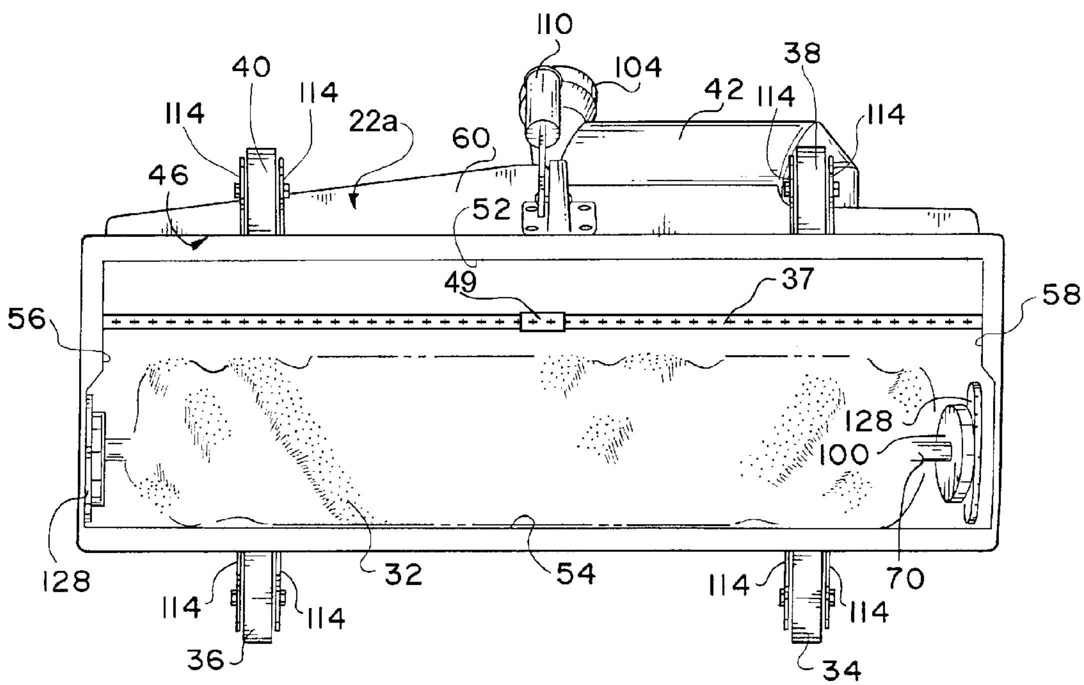
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FIG. 12

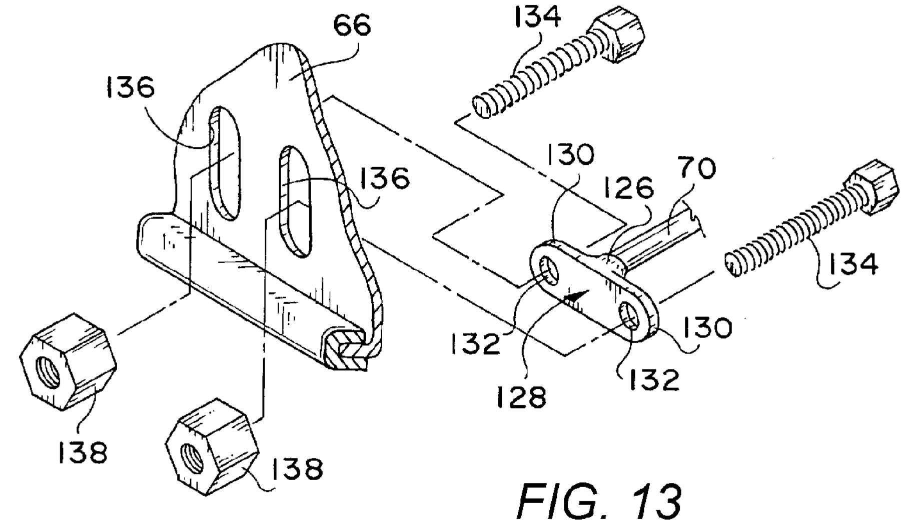
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FIG. 13

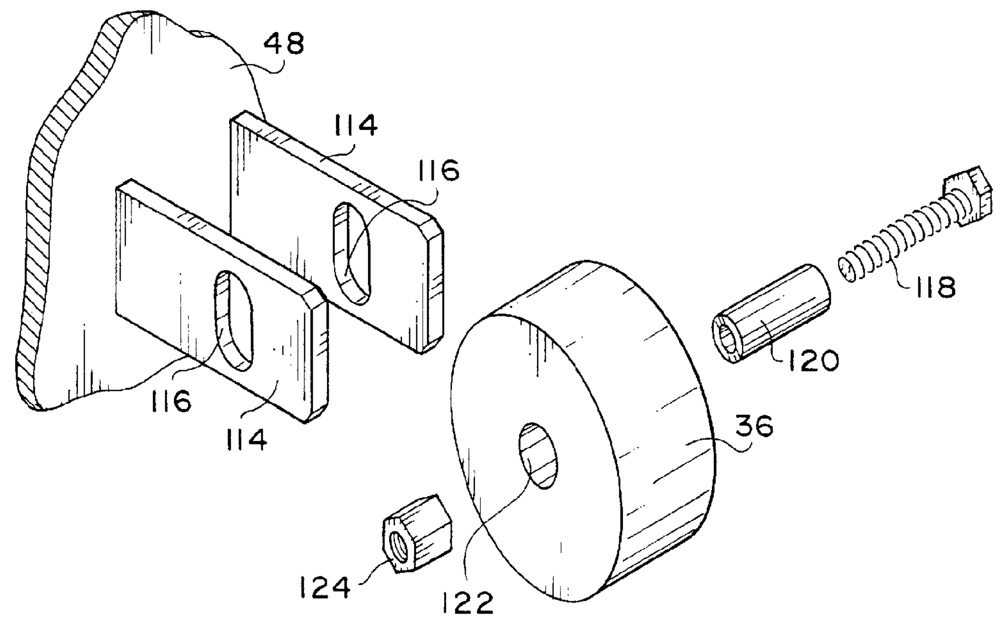
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FIG. 14

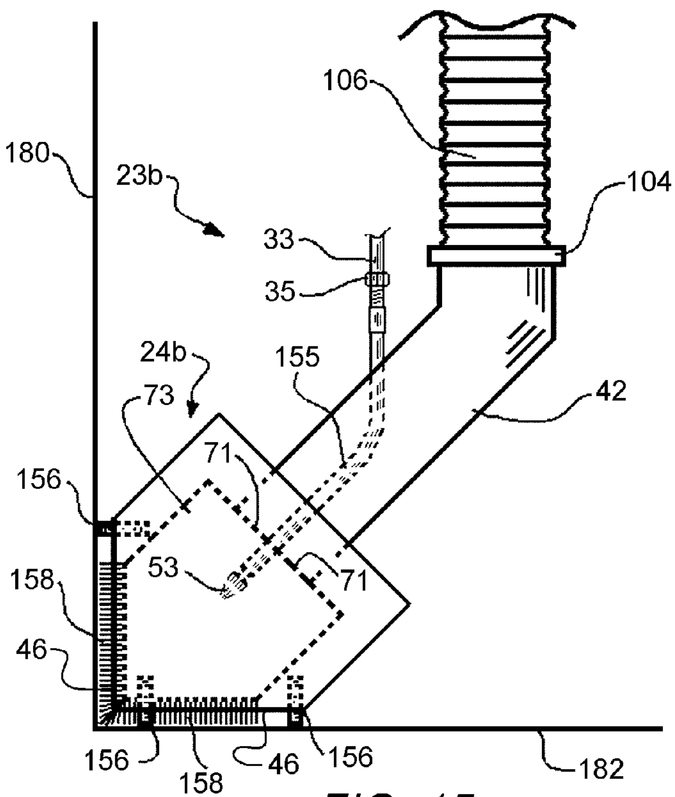
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FIG. 15

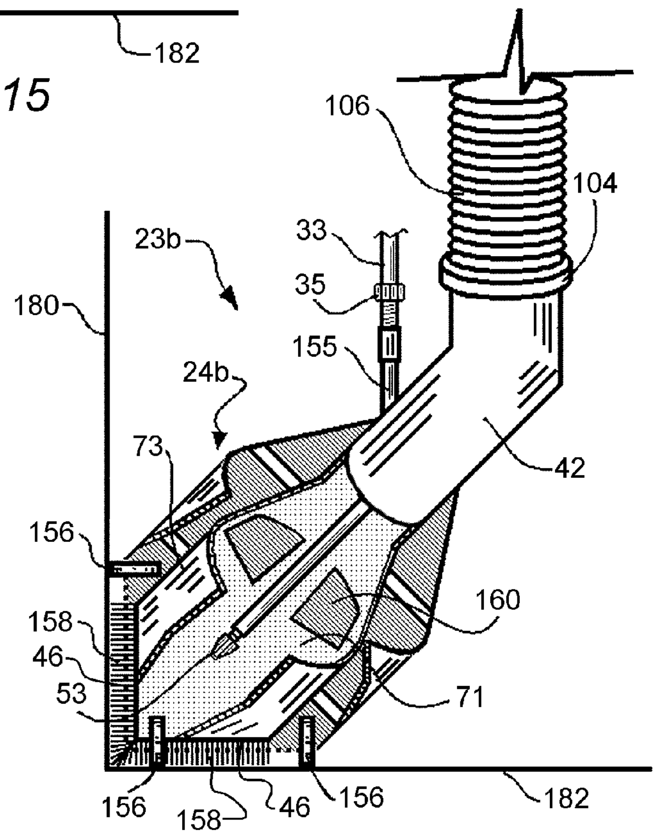
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FIG. 16

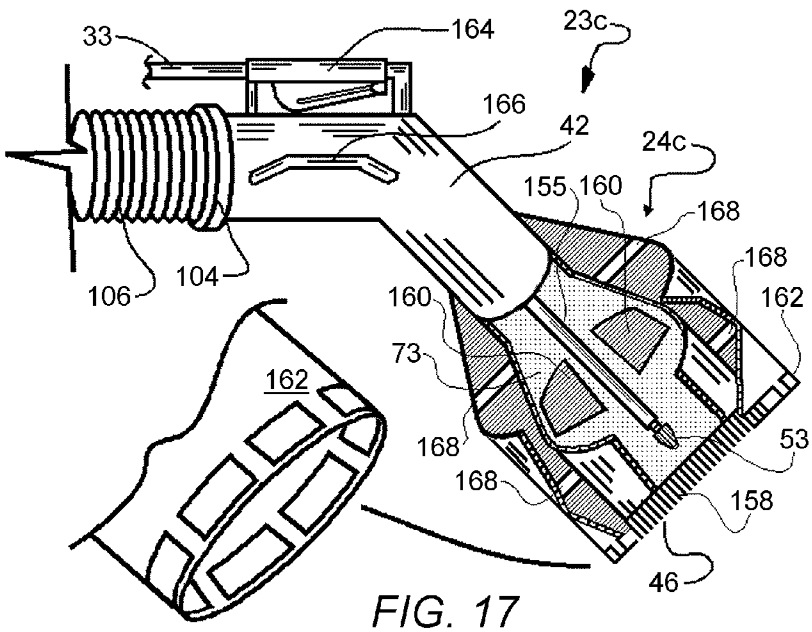
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FIG. 17

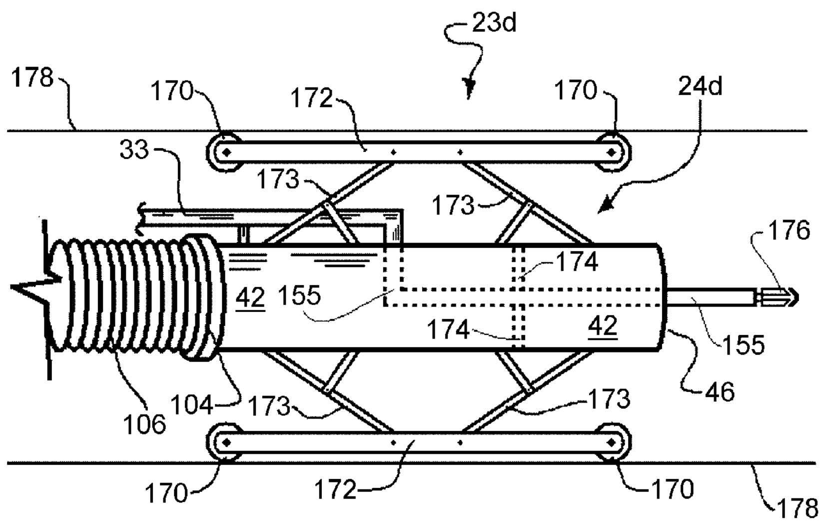
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FIG. 18

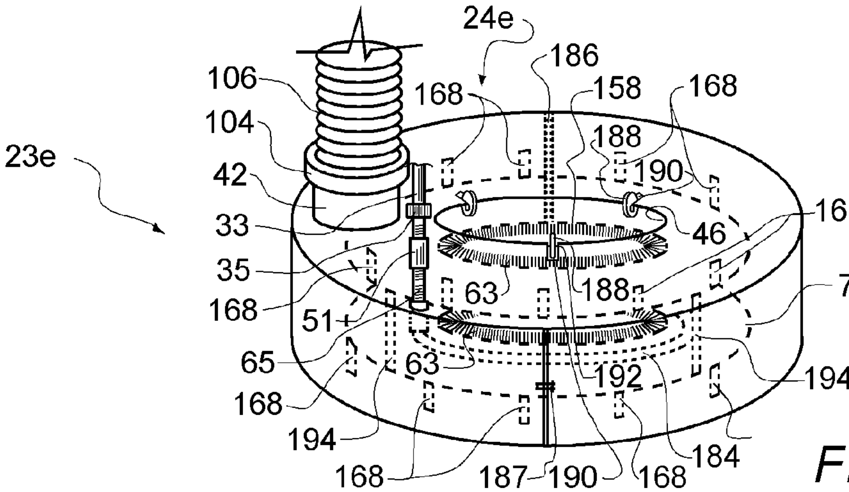

FIG. 19

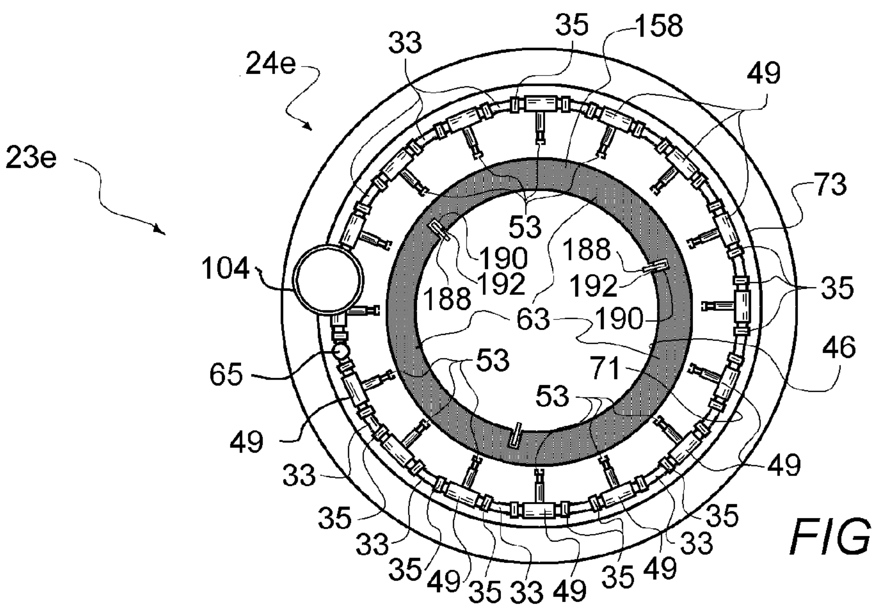

FIG. 20

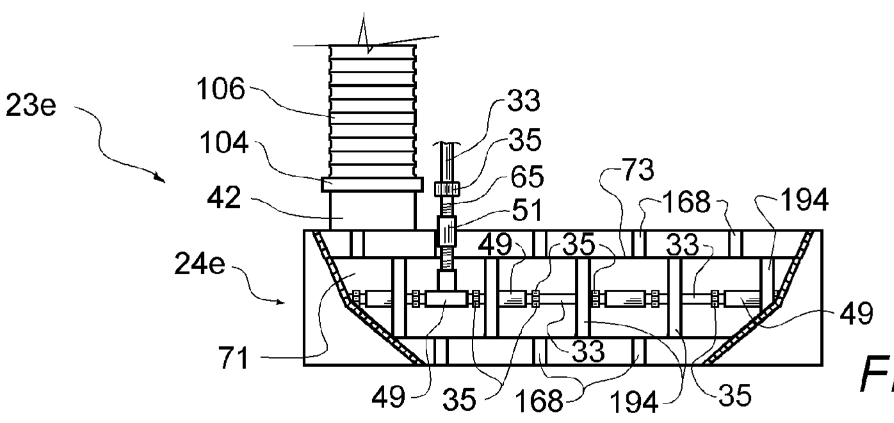

FIG. 21

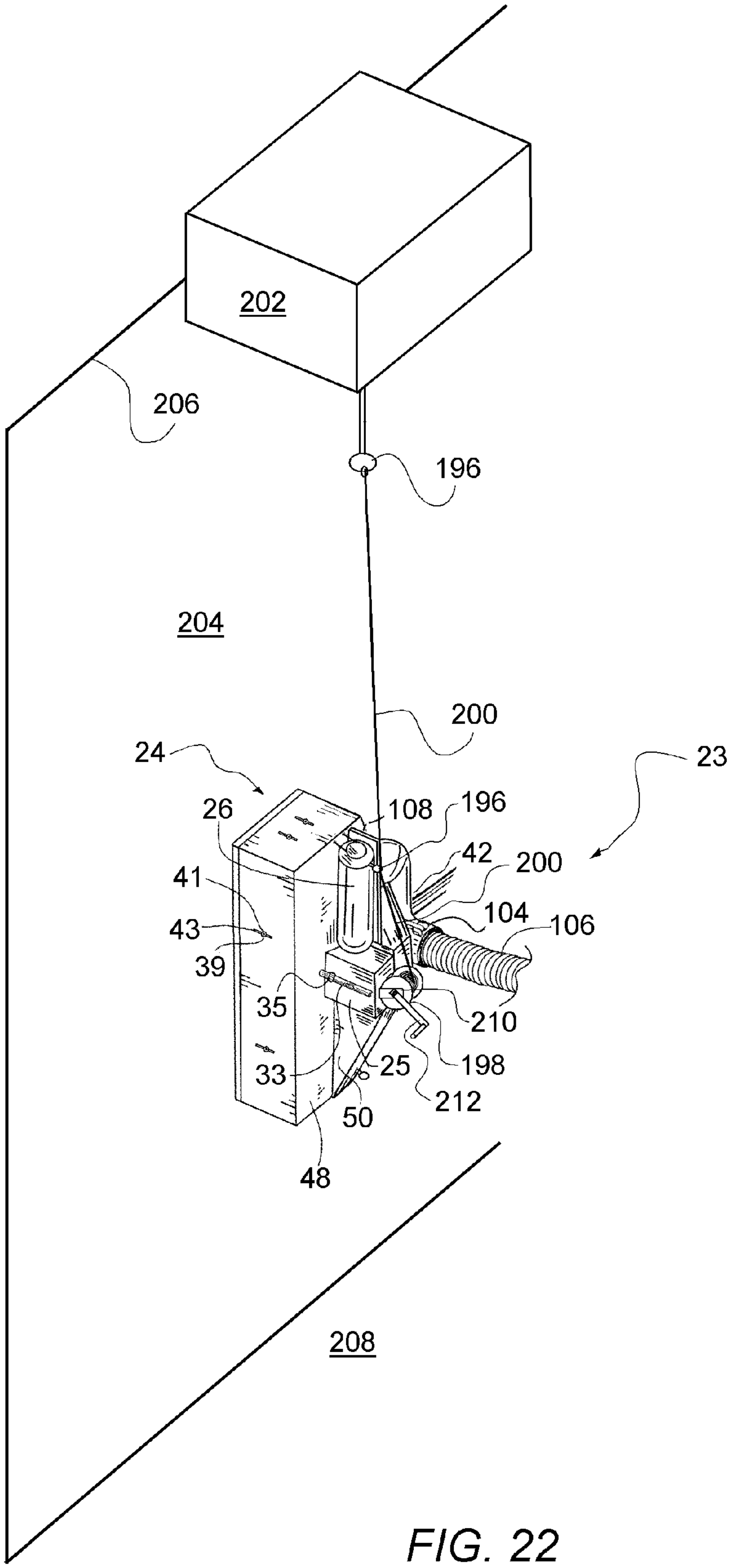
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FIG. 22

[UNDERWATER VACUUM AND STERILIZATION SYSTEM]

BACKGROUND OF INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an underwater vacuum and sterilization system. More particularly, the invention relates to an underwater vacuum specifically designed for sterilizing and removing debris and potential bacterial film from large drinking water reservoirs, treatment and distribution facilities.

[0003] 2. Background and Description of the Related Art

[0004] Protection of the public's health requires that potable water supplies be free of microorganisms that can cause health effects in humans. Also, supplies of potable water must be free from other contaminants that may taint the water and/or negatively impact its acceptability by the consumer, i.e. the members of the public. To ensure consistent and acceptable water quality, rules and regulations regarding testing, maintenance, and maximum tolerable levels of contaminants for potable water reservoirs have been established. Disinfectant chemicals are used to destroy microorganisms in the water. However, it has been shown that sediment, which characteristically accumulates at the bottom of potable water reservoirs, insulates biological contaminants from the disinfection chemicals. Inspection of water storage tanks is recommended at least every five years. Many municipalities, which are charged with ensuring the quality of the water, opt to clean and inspect their reservoirs every year. This annual cleaning and inspection has traditionally been done by first draining the reservoir and then having teams of men physically enter the reservoir to clean and inspect it. This approach has many drawbacks, and some examples of these drawbacks are listed below. First, the procedure is wasteful of natural resources and is very costly. Second, the draining and filling of the reservoir can disturb the sediment, releasing biological contaminants into the pipes in the water distribution area served by that reservoir. Third, draining and filling a reservoir causes mechanical stress to the structure of the reservoir, which can lead to cracks in the reservoir structure. Fourth, the men entering the reservoir with their tools can cause damage to the protective finish on the walls of the reservoir. Fifth, when a reservoir is drained there will usually not be an adequate supply of water to fight a major fire in the water distribution area served by the reservoir. To avoid the aforementioned drawbacks, the underwater vacuum and sterilization system of the present invention has been proposed. The underwater vacuum and sterilization system of the present is particularly adapted to ensure that the vacuum can sterilize all surfaces of a reservoir and remove sediment from the reservoir without causing turbidity in the water and thus avoiding the attendant introduction of biological contaminants into the water. Additionally the system is designed to sterilize all surfaces of a potable water reservoir without allowing any of the sterilization chemicals to enter the surrounding water column. The underwater vacuum of the present invention allows a team of divers to accomplish the cleaning and sterilization of a potable water reservoir without the drawbacks associated with the periodic emptying and filling of the reservoir. Although many underwater vacuum systems have been proposed in the art, none are seen to be specially adapted for the chemical sterilization and removal of sediment from potable water reservoirs while keeping any sterilization chemicals, turbidity or biological contamination from being introduced into the water within the exacting requirements for potable water reservoirs. The following patents and other documents illustrate some examples of underwater vacuums that have been proposed in the underwater vacuum art.

[0005] U.S. Pat. No. 3,795,027, issued to Albert W. Lindberg, Jr. on Mar. 5, 1974, and U.S. Pat. No. 4,498,206, issued to Heinz W. Braukmann on Feb. 12, 1985, shows underwater vacuums having fixed brush bristles for cleaning swimming pools.

[0006] U.S. Pat. No. 5,404,607, issued to Pavel Sebor on Apr. 11, 1995, shows a self-propelled underwater vacuum for cleaning swimming pools. The Sebor device uses one or more pivotally mounted oscillators that are caused to oscillate by the flow of water through the vacuum, to cause the vacuum to move in a random path along the bottom of the swimming pool.

[0007] U.S. Pat. No. 5,412,826, issued to Dennis A. Raubenheimer on May 9, 1995, shows a self-propelled underwater vacuum for cleaning swimming pools. The Raubenheimer device uses a turbine driven by the flow of water through the suction cleaner to power a pair of wheels that propel the vacuum.

[0008] U.S. Pat. No. 5,456,412, issued to Christopher J. Agee on Oct. 10, 1995, shows a high-pressure surface-washing device. The Agee device is designed to be used in an air environment and will not work in an underwater environment. The Agee device does not have a vacuum system for removal of debris or fluid.

[0009] U.S. Pat. No. 5,617,600, issued to Ercole Frattini on Apr. 8, 1997, shows a self-propelled underwater vacuum for cleaning swimming pools. The Frattini device uses a submersible electric motor to drive a pump impeller to create suction and to drive a set of rollers to propel the underwater vacuum.

[0010] U.S. Pat. No. 6,081,960, issued to Forrest A. Shook, et al on Jul. 4, 2000, shows a high pressure cleaning and removal system for cleaning and removing coatings from building walls and floors or driveways, sidewalks, etc. The system works in an air environment and utilizes high-pressure fluid flow for cleaning and a high volume air vacuum to remove fluid and debris from inside a housing. The Shook system is designed for use in an air environment and will not work underwater on submerged surfaces.

[0011] U.S. Pat. No. 6,199,237, issued to Brent Budden on Mar. 13, 2001, shows an underwater vacuum with a turbine powered brush having an axis of rotation parallel to the surface being cleaned and having a unique structure of the suction head of the invention which allows vacuuming sediment without introducing turbidity, and the attendant biological contaminants, into potable water supplies. The Budden device does not sterilize surfaces cleaned. The Budden device does not use variable pressure fluid flow against surfaces for a cleaning method. The Budden device does not use a sterilization chemical or fluid flow of any kind. The Budden underwater vacuum uses only a rotating brush and water suction to clean reservoirs and claims that said rotating brush removes biofilm from potable water reservoir interior surfaces. It is my belief that a rotating brush and water suction alone will not remove all biofilm or bacterial contamination from potable water reservoir interior surfaces.

[0012] U.S. Pat. No. 6,378,163, issued to Frank J. Moll on Apr. 30, 2003, shows a high pressure cleaning and removal system for cleaning and removing coatings from building walls and floors or driveways, sidewalks, etc. The system works in an air environment and utilizes high-pressure fluid flow for cleaning and a high volume air vacuum to remove fluid and debris from inside a housing. The Moll system is designed for use in an air environment and will not work underwater on submerged surfaces.

[0013] U.S. Pat. No. 6,413.323, issued to Forrest A. Shook, et al on Jul. 2, 2002, shows a high pressure cleaning and removal system for cleaning and removing coatings from building walls and floors or driveways, sidewalks, etc. The system works in an air environment and utilizes high-pressure fluid flow for cleaning and a high volume air vacuum to remove fluid and debris from inside a housing. The Shook system is designed for use in an air environment and will not work underwater on submerged surfaces.

[0014] U.S. Pat. No. 6,647,585, issued to Robert S. Robinson on Mar. 18, 2003 shows a high pressure cleaning and vacuum system for use on carpets. The system works in an air environment and is not designed for use underwater.

[0015] United Kingdom Complete Patent Specification Number 1,092,133, By Russell Edward Winn, published on Nov. 22, 1967, shows an underwater vacuum for cleaning the hulls of ships or inside storage tanks. The Winn device is a self-propelled vacuum with a steerable wheel and a pump for creating suction. The Winn device also has two rotating brushes that rotate about axes perpendicular to the surface being cleaned. The Winn device is not concerned with the introduction of contaminants into the surrounding water column.

[0016] European Patent Application Number 468,876, By Michael John Chandler et al., published on Jan. 29, 1992, shows a self-propelled underwater vacuum which uses a turbine to power the drive wheels of the vacuum. The device of Chandler et al. has fixed brush bristles.

[0017] None of the above inventions and patents, taken either singularly or in combination, is seen to describe the instant invention as claimed. In particular, none of the above inventions and patents disclose a means for sterilizing the surface being cleaned or the use of variable pressure fluid flow for removing debris or other matter from surfaces such as the present invention which allows vacuuming sediment without introducing turbidity, and the attendant biological contaminants, or sterilization chemicals, into potable water supplies.

SUMMARY OF INVENTION

[0018] The present invention is directed to an underwater or submersible vacuum and sterilization system including a housing having an opening which, in use, is positioned adjacent the surface to be cleaned. The housing also supports a variable pressure sterilization and cleaning fluid flow mechanism, containment chamber, and a turbine. The housing has a water outlet which communicates with a pump at the surface of the water. The fluid flow mechanism communicates with a variable pressure pump at the surface of the water. The variable pressure pump is fluidly connected to a sterilization chemical and fluid source. There are many different types of sediment and materials that build up on potable water storage reservoir floors or other potable water treatment or distribution facilities. These materials may vary from easy to remove to sticky and difficult to remove. The amount of fluid pressure needed and the type of jet nozzle is dependent on the job being done at the moment. Therefore the amount of fluid pressure may vary from a few hundred p.s.i. all the way up to 50,000 p.s.i. or more. The type of fluid jet nozzles used are also variable to the job at hand at the moment. None of the fluid pressure pumps or jet nozzles will be discussed in this patent due to the fact that they are readily available on the open market for purchase and are not the subject of this patent.

[0019] Water flowing through the vacuum is routed through the turbine. The inlet to the turbine has a trap which collects large debris that can damage the turbine blades. The flow of water through the turbine powers the rotation of the rear wheels so the vacuum is self-propelled over the surfaces being cleaned and sterilized. The vacuum has four wheels that support the vacuum and sterilization system adjacent the surface being cleaned while allowing free movement of the underwater vacuum over the surface. The two rear wheels are adjustably attached to the interior of the housing and connected by a shaft or axle, while the two front wheels are adjustably attached to the interior of the housing and are not connected by a shaft or axle. The particular arrangement and attachment of the wheels contributes to the capability of the underwater vacuum and sterilization system of the present invention to remove sediment from the bottom of a water storage reservoir without causing turbidity in the water column and propelling the vacuum over the surface being cleaned and sterilized. The structure and particular arrangement of the interior containment chamber effectively prevents any of the sterilization chemical fluid flow from entering and impacting the surrounding water column on the outside of the vacuum housing.

[0020] A second embodiment has a rotable brush that is powered by the turbine powering the wheels. The rotable brush embodiment is used for cleaning water reservoirs with matter which is stubbornly attached to the surface being cleaned. This embodiment employs the rotable brush in combination with the variable pressure fluid flow mechanism for cleaning and sterilization.

[0021] A third embodiment is a hand held vacuum head with an enclosed variable pressure fluid flow mechanism. The hand held embodiment is used for cleaning and sterilizing surfaces that cannot be reached by the large powered embodiments.

[0022] Accordingly, it is a principal object of the invention to provide an underwater vacuum that can sterilize the interior surfaces of a water storage reservoir without causing turbidity or allowing sterilization chemicals in the water column.

[0023] It is another object of the invention to provide an underwater vacuum and sterilization system that can remove sediment from the bottom of a water storage reservoir without causing turbidity in the water column. It is another object of the invention to provide an underwater vacuum and sterilization system having a variable pressure fluid flow mechanism to loosen sediment on the bottom of a water storage reservoir prior to the removal of the sediment by the suction of the vacuum.

[0024] It is a further object of the invention to provide an underwater vacuum and sterilization system having a turbine in the path of water flow through the vacuum such that the turbine can power the rotation of the wheels of the vacuum thereby causing it to be self-propelled.

[0025] It is a further object of the invention to provide an underwater vacuum and sterilization system having a turbine in the path of water flow through the vacuum such that the turbine can power the rotation of a brush used to loosen sediment, in combination with a variable pressure fluid flow mechanism, on the bottom of a water storage reservoir. Still another object of the invention is to provide an underwater vacuum and sterilization system having an internal containment chamber to prevent escape of any of the sterilization chemical into the surrounding water column on the exterior of the vacuum housing.

[0026] Still another object of the invention is to provide an adjustable means of supporting the internal containment chamber so the bottom opening is supported at the right height and at the right angle above the surface to be cleaned so as to allow the surface to be sterilized without the generation of sterilization chemicals into the water column.

[0027] Still another object of the invention is to provide an underwater vacuum and sterilization system having wheels that are specially configured to support the vacuum above the surface to be cleaned such that the vacuum opening is supported at the right height and at the right angle above the surface to be cleaned so as to allow the surface to be cleaned without the generation of turbidity in the water column.

[0028] It is an object of the invention to provide improved elements and arrangements thereof for the purposes described which is inexpensive, dependable and fully effective in accomplishing its intended purposes. These and other objects of the present invention will become readily apparent upon further review of the following specification and drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0029] **FIG. 1** is an environmental view of an underwater vacuum and sterilization system according to the present invention being used by a diver.

[0030] **FIG. 1***a* is an environmental view of an underwater vacuum and sterilization system according to the present invention (second embodiment with housing **23***a*) being used by a diver.

[0031] **FIG. 2** is a cutaway perspective view of an underwater vacuum according to the present invention showing a variable pressure fluid flow mechanism with a plurality of pressure jets and a mechanism for providing power to the rear wheels.

[0032] **FIG. 3** is a perspective view of an underwater vacuum according to the present invention.

[0033] **FIG. 4** is a section view showing through the left side of the vacuum housing.

[0034] **FIG. 5** is a cutaway section view showing through the front of the vacuum housing.

[0035] **FIG. 6** is a bottom plan view of an underwater vacuum and sterilization system according to the present invention.

[0036] **FIG. 7** is a perspective view of a second embodiment of an underwater vacuum and sterilization system.

[0037] **FIG. 8** is a cutaway section view showing both a rotable brush and variable pressure fluid flow mechanism of a second embodiment of an underwater vacuum and sterilization system according to the present invention.

[0038] **FIG. 9** is a cutaway perspective view of a second embodiment an underwater vacuum and sterilization system showing the opening to the debris trap, the rotable brush, and the variable pressure fluid flow mechanism according to the present invention.

[0039] **FIG. 10** is a cutaway perspective view of a second embodiment of an underwater vacuum and sterilization system showing the interior of the turbine and the drive linkage to the rotating brush, and the variable pressure fluid flow mechanism according to the present invention.

[0040] **FIG. 11** is a top perspective of a second embodiment of an underwater vacuum and sterilization system showing the placement of exterior front wheels, placement of variable pressure fluid flow hose and different arrangement of vacuum housing front lower portion according to the present invention.

[0041] **FIG. 12** is a bottom plan view of a second embodiment of an underwater vacuum and sterilization system showing the positioning of a rotable brush in combination with a variable pressure fluid flow mechanism according to the present invention. This variation of the underwater vacuum and sterilization system shows a low-pressure spray tube and would be used in situations where only sterilization is required from the variable pressure fluid flow mechanism due to the rotable brush being sufficient to remove the type of sediment in question.

[0042] **FIG. 13** is a fragmentary view showing the height adjustment mechanism for the rear wheel shaft or axle or for the rotable brush of the underwater vacuum and sterilization system according to the present invention.

[0043] **FIG. 14** is a fragmentary view showing the height adjustment mechanism for the non-powered wheels of the underwater vacuum and sterilization system according to the present invention.

[0044] **FIG. 15** is an rear see-through plan view with phantom lines of a third embodiment of the underwater vacuum and sterilization system according to the present invention designed for use in cleaning the seam or joint where a wall meets the floor inside a potable water reservoir.

[0045] **FIG. 16** is an side cut-away perspective view of a third embodiment of the underwater vacuum and sterilization system according to the present invention designed for use in cleaning the seam or joint where a wall meets the floor inside a potable water reservoir.

[0046] **FIG. 17** is an rear cut-away perspective view of a fourth hand-held embodiment of the underwater vacuum and sterilization system according to the present invention designed for use in cleaning small flat areas inside a potable water reservoir where the larger embodiments will not fit.

[0047] **FIG. 18** is a side see-through plan view with phantom lines showing a fifth embodiment of the underwater vacuum and sterilization system according to the present invention designed and used for cleaning and sterilizing the inside of pipes connected to a potable water reservoir.

[0048] **FIG. 19** is a see-through perspective view of a fifth embodiment of the underwater vacuum and sterilization system with phantom lines inside the vacuum housing to reveal the variable pressure fluid flow mechanism and containment chamber for cleaning the outside of exposed pipes or roof support columns inside potable water reservoirs according to the present invention.

[0049] **FIG. 20** is a top see-through plan view of a fifth embodiment of the underwater vacuum and sterilization system with the vacuum housing shown as transparent to reveal the internal variable pressure fluid flow mechanism and containment chamber for cleaning the outside of exposed pipes or roof support columns inside potable water reservoirs according to the present invention.

[0050] **FIG. 21** is a side cut-away plan view of a fifth embodiment of the underwater vacuum and sterilization system to reveal the internal variable pressure fluid flow mechanism and containment chamber for cleaning the outside of exposed pipes or roof support columns inside potable water reservoirs according to the present invention.

[0051] **FIG. 22** is an environmental perspective view of the main embodiment of the underwater vacuum and sterilization system to show how it is connected to a float on the surface of the water for the horizontal cleaning of potable reservoir walls according to the present invention.

[0052] Similar reference characters denote corresponding features consistently throughout the attached drawings.

DETAILED DESCRIPTION

[0053] Referring to **FIGS. 1-12**, the present invention is an underwater vacuum **23** which includes a housing **24**, a debris trap **25**, a cylindrical turbine housing **26**, turbines **28** and **30**, a variable pressure fluid supply hose **33**, a variable pressure fluid flow mechanism consisting of a fluid hose connector **35**, vertical fluid flow delivery pipe **65**, fluid flow system vertical height adjustment mechanism **47**, vertical to horizontal fluid supply "T" fitting **49**, horizontal fluid supply pipe **37**, horizontal pipe to vertical fluid supply threaded connectors **51**, variable pressure fluid flow nozzles **53**, an internal containment chamber consisting of a front wall **55**, a right wall **57**, a back wall **59**, a left wall **61**, the bottom of each wall having more than one flexible member, seal or plurality of bristles or brushes thereby defining a circumferential seal on the bottom edges, an open top **71**, containment chamber adjustable vacuum housing attachment bolts or studs **39**, vacuum housing adjustable attachment slots **43**, containment chamber to vacuum housing attachment nuts **41**, an optional rotating brush **32**, front wheels **34** and **36**, rear wheels **144**, an outlet pipe **42**, and a T-shaped handle **44**. The housing **24** has a suction opening **46**, a base portion **48**, and a cap portion **50**. The suction opening **46** is substantially rectangular. By substantially rectangular it is intended to convey that the opening **46** is generally rectangular and the perimeter may deviate from a perfect rectangle in that the opening **46** may have rounded corners or fillets at corners, or the opening **46** may have clearance channels (shown in **FIG. 12**) for the mounting hardware of the shaft of the rotating brush **32**. The substantially rectangular perimeter of the suction opening **46** defines the plane of the suction opening. The suction opening **46** has a rear edge **52**, a front edge **54**, a left edge **56**, and a right edge **58**.

[0054] There are two variations of the main embodiment vacuum. **FIG. 1, 2, 3, 4, 5, 6,** and **22** show vacuum **23** with vacuum housing **24**. This embodiment employs the combination of water suction and variable pressure fluid flow for cleaning and sterilization. This embodiment does not utilize a rotable brush **32**. The function of the vacuum housing **24** is the same as vacuum housing **24*a*,** however the shape of the housing base portion **48** is different whereas the front wall is not curved where it extends from the suction opening front edge **54** to the front wall **62** of the cap portion **50**.

[0055] The second embodiment shown in **FIG. 1*a*, 7, 8, 9, 10, 11,** and **12** show vacuum **23*a*** with vacuum housing **24*a***. This embodiment employs the combination of water suction, variable pressure fluid flow, and a rotable brush for cleaning and sterilization. There are many types of sediment and/or matter that accumulate on the interior surfaces of potable water reservoirs. Depending on the type of material will vary the need of a rotable brush, the amount of fluid pressure utilized, or the sterilization needs. Due to the variety of needs for this process the vacuum **23** and **23*a*** may need a combination of pressure fluid flow and a rotable brush or the use of pressure fluid flow without a rotable brush. The combinations of fluid flow and rotable brush may also have a varying need for the amount of pressure utilized in the fluid flow. The fluid flow has two purposes; one is to sterilize the surface being cleaned and the other is to use the pressure fluid flow to remove material from the surface being cleaned. On the extreme high pressure end of the spectrum the fluid flow may be utilized to even remove paint, epoxy, or other coatings from steel surfaces. On the low end of the pressure spectrum the fluid flow may only be a low-pressure spray (as shown in **FIG. 12** lateral water pipe **37**). The latter embodiment only needs low-pressure spray to sterilize the surface, which has been adequately cleaned by the rotable brush **32**. Another difference between vacuum **23** and **23*a*** is that vacuum housing **24*a*** does not need power to drive the rear wheels due to the fact that the rotable brush **32** propels the vacuum.

[0056] Referring to vacuum **23*a*** and vacuum housing **24*a*,** the cap portion **50** has a rear wall **60** and a front wall **62**, which is spaced apart from the rear wall **60**. The cross sectional area, in a plane parallel to the plane of the suction opening **46**, of the cap portion **50** tapers from a maximum where the cap portion **50** joins the base portion **48** to a minimum at the cap portion top **64**. The front wall of the base portion **48** is curved or rounded and it extends from the suction opening front edge **54** to the front wall **62** of the cap portion **50**. The front wall of the base portion **48**, or a portion thereof, follows or parallels the contour of a cylindrical surface defined by the tips of the bristles of the brush **32**. The rear wall of the base portion **48** extends, perpendicular to the plane of the suction opening **46**, from the suction opening rear edge **52** to the rear wall **60** of the cap portion **50**. The base portion **48** has a right sidewall **66** and a left sidewall **68**.

[0057] The right sidewall **66** is joined to the rear wall of the base portion **48** along substantially the entire length of the right edge of the rear wall of the base portion **48**. The top edge of the right sidewall **66** is joined to the cap portion **50** along substantially the entire length of the right edge of the widest portion of the cap portion **50**. The right sidewall **66** is joined to the front wall of the base portion **48** along substantially the entire length of the curved right edge of the front wall of the base portion **48**. The bottom edge of the right sidewall **66** essentially forms the right edge **58** of the suction opening **46**.

[0058] The left sidewall **68** is joined to the rear wall of the base portion **48** along substantially the entire length of the left edge of the rear wall of the base portion **48**. The top edge of the left sidewall **68** is joined to the cap portion **50** along substantially the entire length of the left edge of the widest portion of the cap portion **50**. The left sidewall **68** is joined to the front wall of the base portion **48** along substantially the entire length of the curved left edge of the front wall of the base portion **48**. The bottom edge of the left sidewall **68** essentially forms the left edge **56** of the suction opening **46**. The front and rear walls of the base portion **48**, the left sidewall **68**, the right sidewall **66**, and the cap portion **50** cooperatively form an enclosure or concavity which opens to the suction opening **46**.

[0059] The brush **32** is rotatably supported intermediate the left sidewall **68** and the right sidewall **66**. The brush **32** is oriented such that it axis of rotation is parallel to the plane of the suction opening **46**. The brush **32** has a central shaft **70** each end of which is journaled in mounting hardware attached to a respective one of the left and right sidewalls **68** and **66**. The details of the mounting hardware will be discussed later. The bristles of the brush **32** may have their roots embedded directly in the shaft **70** or, alternatively, the roots of the sleeves may be embedded in a cylindrical sleeve which is keyed or otherwise fixed to the shaft **70**. Most preferably, the roots of the bristles of each half of the brush **32** are embedded over a helical strip into either the sleeve or the shaft **70**. The helical strips over which the bristles are embedded are angled in opposite directions for each half of the brush **32** such that the bristles on each half of the brush **32** act as screw conveyors moving the sediment toward the center of the suction opening **46** where it can be vacuumed up more readily and with a lesser chance of escaping to the outside of the housing **24***a*.

[0060] Referring to **FIG. 8**, the brush **32** is powered to rotate such that the bristles of the brush **32** move toward the rear of the housing **24***a* as the bristles pass under the axis of rotation of the brush **32**. This means that with the underwater vacuum **23***a* oriented as illustrated in **FIG. 8**, the brush **32** is powered to rotate in the clockwise direction. For the helically arranged bristles to push sediment toward the center of the housing **24***a*, the bristles on the right half of the brush **32** are arranged along a helical strip having an acute helix angle when measured from the inside surface of the right sidewall **66** in a clockwise direction. Also, the bristles on the left half of the brush **32** are arranged along a helical strip having an acute helix angle when measured from the inside surface of the left sidewall **68** in a counter clockwise direction, as illustrated in **FIG. 12**.

[0061] The brush **32** is positioned within the housing **24***a* such that the bristles of the brush project for a user determined distance beyond the plane of the suction opening **46**. The brush **32** has soft bristles so as not to damage the surface coatings of the water reservoir being cleaned. In addition, a flange **74** projects from about the suction opening **46**. A soft bumper **76** made of a rubber or plastic material covers the flange **74**. The bumper **76** provides further protection against damage to the surfaces of the reservoir being cleaned due to being bumped by the housing **24***a*.

[0062] The front wheels **34** and **36** are attached to the outer surface of the front most portion of the front wall of the base portion **48** of the housing **24***a*. The rear wheels **38** and **40** are attached to the outer surface of the rear wall of the base portion **48** of the housing **24***a* (as shown in **FIG. 8**). The wheels **34**, **36**, **38**, and **40** are attached at their respective locations in such a way that they can all rotate freely. The wheels **34**, **36**, **38**, and **40** support the housing **24**A at a user selected height above the surface of the reservoir that is being cleaned, and these wheels allow the underwater vacuum **23***a* to be pushed along the surface being cleaned. The details of the attachment of the wheels **34**, **36**, **38**, and **40** are discussed later.

[0063] An opening **78** is provided in the front wall **62** of the cap portion **50** of the housing **24** and **24***a*. A reinforcing bar **77** extends between the front and rear walls of the base portion **48**. The reinforcing bar **77** helps keep the rear wall, formed by the rear walls of the base portion **48** and the cap portion **50**, of the housing **22** from collapsing under the pressure differential between the exterior and the interior of the housing **22**. The opening **78** communicates with the debris trap **24**. The debris trap **24** is formed by three walls, two of which project perpendicularly from the front wall **62** on either side of the opening **78**. The third wall forming the debris trap **24** extends between the edges, located distal from the front wall **62**, of the two walls, which project from the front wall **62**. The walls forming the debris trap **24** also join the top surface of the curved front wall of the base portion **48**. Thus, the top surface of the curved front wall of the base portion **48** forms the bottom of the debris trap **24**. The open top **80** of the debris trap **24** is provided with a hinged closure **82** which can be secured in the closed position by the latch **84**.

[0064] In the illustrated example, the latch **84** is in the form of a hook that is engageable with an eye **86**; however, the latch **84** may be of any known type. A sealing strip or gasket (not shown) may be provided about the perimeter of the closure **82** to provide a watertight seal about the open top **80** of the debris trap **24**. To maximize water flow through the housing **24** and **24***a*, an essential feature for eliminating turbidity, the opening **78** should be made as large as possible. Most preferably, the opening **78** has a width approximately equal to the distance between the interior surfaces of the right and left walls of the debris trap **24** and a height approximately equal to the distance between the top **64** of the cap portion **50** and the top edge of the front wall of the base portion **48**.

[0065] The cylindrical turbine housing **26** is fixed to the right wall of the debris trap **24**. The right wall of the debris trap **24** has a hole **88** with a diameter essentially equal to the inside diameter of the cylindrical turbine housing **26**. The hole **88** allows fluid communication between the interior of the debris trap **24** and the interior of the turbine housing **26**. Spokes **90** concentrically support a bearing **92**, which rotatably supports an end of the turbine shaft **94**. The turbine shaft **94** extends through the closed end of the turbine housing **26** such that the end of the shaft **94** distal from the bearing **92** lies outside the turbine housing **26**. The portion of the shaft **94** passing through the closed end of the turbine housing **26** is journaled within a bearing surface formed in the closed end of the turbine housing **26**, such that the shaft **94** can rotate freely.

[**0066**] Spokes **90**, in addition to supporting the bearing **92**, act as a screen to keep debris that may damage the blades of turbines **28** and **30** from entering the turbine housing **26**. Where relatively smaller particles or debris cause concern relating to possible damage to the blades of the turbines **28** and **30**, a wire mesh screen may be provided at the opening **88**. Debris trapped in the debris trap **24** can be removed through the hinged closure **82**.

[**0067**] A sprocket **96** is fixedly attached to the end of the shaft **94**, which is outside the turbine housing **26**. A chain **98** engages the sprocket **96** and a sprocket **100** which is fixedly attached to the shaft **70** (vacuum **23***a* and vacuum housing **24***a*) or a sprocket **146**, which is fixedly attached to the rear wheel shaft **142** (vacuum **23** and vacuum housing **24**). Thus, rotation of the turbine shaft **94** causes the rotation of the brush shaft **70** in vacuum **23***a* or the rear wheel shaft **142** in vacuum **23**. The chain **98** passes through holes **102** formed in the upper portion of the front wall of the base portion **48**. The chain **98** is in the form of an endless loop.

[**0068**] Any suitable power transmission mechanism may be substituted for the chain **98** and the sprockets **96** and **100** without departing from the spirit and scope of the present invention. For example, a belt and pulley can be used in place of the chain **98** and the sprockets **96**, **100**, and **146**, or the shaft **70** or shaft **142** can be extended to the exterior of the housing **24** or **24***a* and a fully enclosed gear train used transmit power from an extended shaft **94** to the shaft **70** or **142**.

[**0069**] The turbines **28** and **30** are of the axial flow type and are positioned in tandem within the turbine housing **26**. The blades of each of the turbines **28** and **30** are fixed to the common turbine shaft **94** such that the turbine blades and the shaft **94** rotate together. Thus, water flow past the blades of the turbines **28** and **30** powers the rotation of the shaft **94** and in turn, through the use of the belt **98**, the rotation of the brush **32**.

[**0070**] As water passes through the upstream turbine **28** and rotating current is generated in the water flowing through the turbine housing **26**. This rotating current causes the downstream turbine **30** to lose effectiveness. To remedy this problem, re-directional baffles **112** are provided intermediate the turbines **28** and **30**. The baffles **112** are fixed to the inside surface of the cylindrical wall of the turbine housing **26** and extend radially inward toward the shaft **94**, but the baffles **112** do not touch the shaft **94** so as not to interfere with the rotation of the shaft **94**. The baffles **112** straighten out the flow of the water, i.e. restore the flow to purely axial flow as much as possible, before the water impinges upon the blades of the downstream turbine **30** to thereby restore efficiency to the downstream turbine **30** and thus increase the combined power output from the turbines **28** and **30**.

[**0071**] Any motor mechanism may be substituted for turbine housing **26** and turbines **28** and **30** without departing from the spirit and scope of the present invention. For example a water powered vane type side driving motor, submersible electric motor or air pressure motor can be substituted in place of turbine housing **26** and turbines **28** and **30**. The motor mechanism only supplies power to drive the rear wheels and/or rotable brush of the present invention and does not deviate from the principle of a combination variable pressure fluid flow, water suction and/or rotable brush for the cleaning and sterilization of underwater surfaces.

[**0072**] The outlet of the turbine housing **26** is positioned intermediate the downstream turbine **30** and the closed end of the turbine housing **26**. The outlet of the turbine housing **26** communicates with the outlet pipe **42**. The inlet of the outlet pipe **42** is rigidly fixed about the outlet of the turbine housing **26**. The outlet pipe **42** extends directly rearward from the turbine housing **26** until the outlet pipe **42** clears the rear wall of the cap portion **50** of the vacuum housing **24** or **24***a*. Once clear of the rear wall of the cap portion **50** of the vacuum housing **24** or **24***a*, the outlet pipe **42** makes a first bend. The outlet pipe **42** extends, parallel to the plane of the suction opening **46**, from the first bend toward the middle of the housing **24** or **24***a*. Once near the middle portion of the housing **24** or **24***a*, i.e. near the portion of the rear wall **60** extending downward from the top **64** of the cap portion **50**, the outlet pipe **42** makes a second bend and extends upward perpendicular to the plane of the suction opening **46**. The outlet pipe **42** terminates in a coupling **104** that allows the outlet pipe **104** to be connected to a flexible pipe **106** which is in turn connected to a pump (not shown) at the surface. A support plate **108** is rigidly fixed to the front wall **62** of the cap portion **50**. The outlet pipe **42** passes through the support plate **108** near the joint between the turbine housing **26** and the outlet pipe **42**. Thus the support plate **108** supports the inlet to the outlet pipe **42**, and the support plate **108** also supports the closed end of the turbine housing **26** via the inlet to the outlet pipe **42**.

[**0073**] A socket **110** is pivotally attached to the rear wall, formed by the rear walls of the base portion **48** and of the cap portion **50**, of the housing **24** or **24***a*. The socket **110** allows the attachment of the T-shaped handle **44**. The user can fix the angle of the socket **110** relative to the rear wall of the base portion **48** at any desired angle. The fixing of the socket angle can, for example, be accomplished frictionally by tightening a nut and bolt passing through the pivot point of the socket **110**.

[**0074**] In use, the underwater vacuum **23** or **23***a* is placed on the bottom surface of a potable water reservoir such that it is supported over the bottom of the reservoir by the four wheels **34**, **36**, **144** and **144** (underwater vacuum **23**) or four wheels **34**, **36**, **38**, and **40** (underwater vacuum **23***a*). When the vacuum **23** or **23***a* is thus positioned, the suction opening will be positioned adjacent the surface to be cleaned. The flexible pipe **106** connects the outlet pipe **42** to a pump located above the surface of the water in the reservoir. Such pumps are well known and are therefore not described here. A diver then stands behind the vacuum **23** or **23***a* and grasps the T-shaped handle **44**. The pump is now turned on, causing water to be drawn through the suction opening **46**, through the housing **24** or **24***a*, and up the flexible pipe **106**. The diver then walks behind the vacuum **23** or **23***a*, and the vacuum **23** or **23***a* moves self-propelled along the bottom of the reservoir, to apply the cleaning and sterilization action of the vacuum **23** or **23***a* to an increasingly wider area of the reservoir bottom.

[0075] Due to the suction created by the pump, water rushes into the housing **24** or **24***a* through the suction opening **46**. The water moves at a high flow rate up the cap portion **50** of the housing **22**. The water then passes through the opening **78** and into the debris trap **24**. From the debris trap **24** the water rushes through the turbine housing **26**, through the outlet pipe **42**, and up the hose **106** to the surface. As the water rushes through the turbine housing **26**, the axial flow turbines **28** and **30** and the shaft **94** are caused to rotate or spin. The rotating shaft **94** causes the rotation of the shaft **70** or shaft **142** via the sprockets **96**, **100** and/or **146** and the chain **98**. The brush **32**, being fixed to the shaft **70**, or the rear wheels **144**, being fixed to the shaft **142**, are set in motion rotating about the longitudinal axis of the shaft **70** (vacuum **23***a*) or the shaft **142** (vacuum **23**). The rotating brush **32** scrubs the reservoir bottom dislodging the sediment film coating the reservoir bottom. The dislodged sediment and the biological contaminants contained in it are carried, by the water rushing through the housing **24***a*, up the hose **106** and to the surface where the water containing the sediment is discarded in accordance with applicable regulations. This process continues as long as the pump is turned on. Thus, the removal of the sediment and associated biofilm, from the bottom of the reservoir is effected without introducing turbidity into the reservoir water. Simultaneously the variable fluid flow mechanism via vertical fluid flow pipe **65** and connectors **51** and **49** and horizontal fluid flow pipe **37** to fluid flow nozzles **53** introduces fluid sterilization chemical against the surface of the bottom of the reservoir behind the rotable brush **32** to remove any additional stubborn biofilm and sterilize said surface.

[0076] Note the sterilization chemicals used are 200 ppm chlorine solution or of a type similar to 200 ppm chlorine solution which is accepted as "instant kill" for microorganisms and need only touch the surface momentarily for effective sterilization. In vacuum **23** the fluid flow may be of high pressure and the fluid chemical sterilization solution is from entering the surrounding water column outside of vacuum housing **24** by means of the bottom sealed internal containment chamber walls **55**, **57**, **59**, and **61** and bottom circumferential seal **63**. The volume of fluid flow via the fluid flow mechanism is significantly less (between 6 and 60 gpm) than the water suction exiting the vacuum housing **24** or **24***a* via the outlet pipe **42** and flexible suction pipe **106** (which normally ranges between 150 and 300 gpm). Thus the open top of the containment chamber **71** allows for the greater suction through outlet pipe **42** and flexible suction pipe **106** to effectively and instantly remove all variable pressure fluid flow and sterilization chemical from the vacuum housing **24** or **24***a* and therefore avoid any introduction of the sterilization chemical into the water column on the outside of vacuum housing **24** or **24***a*. Simultaneously the variable pressure fluid flow cannot exit the suction opening **46** and cause turbidity on the outside of vacuum housing **24** or **24***a*.

[0077] It is important to note that the internal containment chamber is a necessary and integral part of the present invention. If the circumferential seal were placed around the suction opening **46** it would provide the same function of preventing turbidity from the variable pressure fluid flow and would prevent the escape of sterilization chemical into the surrounding water column. However, if the circumferential seal were placed around the suction opening **46** the vacuum housing **24** or **24***a* would suck down against the reservoir surface and would not be movable along the surface being cleaned and sterilized.

[0078] Referring to **FIG. 14**, a height adjustable attachment for the wheels **34**, **36**, **38**, and **40** can be seen. Wheel **36** is being used as representative of all the wheels **34**, **36**, **38**, and **40**. A pair of parallel plates **114** are fixedly attached to the housing **24** or **24***a*. In the case of the wheels **34** and **36** the plates **114** would be attached to the front wall of the base portion **48**, while in the case of the wheels **38** and **40** the plates **114** would be attached to the rear wall of the base portion **48**. Each plate **114** has an elongated slot **116**. The slots **116** are in registry with one another. The slots **116** are just wide enough for the threaded shaft of the bolt **118** to pass through the slots **116**. The length of the slots **116** provides the range of adjustment of the position of the wheel **36** in a direction perpendicular to the plane of the suction opening **46**.

[0079] The wheel **36** is rotatably supported by the bushing **120** which is slightly longer than the wheel **36** is wide. The plates **114** are spaced apart to allow the bushing **120** to fit therebetween. When the bushing **120** is placed between the plates **114**, the central bore of the bushing **120** can be brought into registry with the slots **116**. The inside diameter of the bushing **120** is about the same as the width of the slots **116**. The outside diameter of the bushing **120** is greater than the width of the slots **116**. With the bushing **120** placed through the central hole **122** of the wheel **36**, the bushing **120** is then placed between the plates **114** with the central bore of the bushing **120** in registry with the slots **116**. The bolt **118** is then passed through the slots **116** and the bushing **120**, and the nut **124** is threadedly engaged to the end, distal from the bolt head, of the bolt **118**. The wheel **36** is then moved to the desired position along the slots **116** and the nut **124** is tightened to frictionally secure the wheel **36** in place while allowing free rotation of the wheel **36**.

[0080] Referring to **FIG. 13**, a height adjustable attachment for the shaft **70** or shaft **142** can be seen. Each end of the shaft **70** or shaft **142** is journaled within the central boss or cylindrical portion **126** of the mounting attachments **128**. The mounting attachments **128** have lateral extensions **130** which are provided with bolt holes **132**. The bolt holes **132** are in registry with elongated slots **136**. A pair of slots **132** is formed in each of the side walls **66** and **68** for the shaft **70** or shaft **142**. Only the attachment of the right end of the shaft **70** or shaft **142** is shown in detail, the attachment of the left end of the shaft **70** or shaft **142** being a mirror image of the right end. Each one of a pair of bolts **134** pass s through a respective bolt hole **132** and a respective slot **136**. The slots **136** are just wide enough for the threaded shaft of the bolt **134** to pass through the slots **136**. The length of the slots **136** provides the range of adjustment of the position of the shaft **70** or shaft **142** in a direction perpendicular to the plane of the suction opening **46**.

[0081] Each one of a pair of nuts **138** is threadedly engaged to the end, distal from the bolt head, of a respective one of the bolts **134**. The ends of the shaft **70** or shaft **142** are then moved to the desired position along the slots **136** and the nuts **138** are tightened to friction ally secure the shaft **70** or shaft **142** in place. The chain **98** is sized to remain under tension, and in frictional engagement with sprockets **96**, **100**, and **146**, over the entire adjustment range of the shaft **70** or shaft **142**. The adjustable attachments of the wheels **34**, **36**, **38**, and **40** and of the shaft **70** or shaft **142** allow the underwater vacuum to be adjusted for sediment accumulations having varying depths.

[**0082**] Referring to **FIGS. 15 and 16**, a third hand held or manually pushed embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. The manual underwater vacuum **23***b* is designed for cleaning and sterilizing the area where reservoir walls meet the floor. The larger vacuum's **23** or **23***a* cannot reach this wall to floor joint or seam. The vacuum **23***b* differs from the vacuum **23** and **23***a* in the fact that it is not self-propelled and it does not have a rotable brush. The vacuum is smaller in size and has a variable pressure fluid flow mechanism in combination with water suction. The vacuum **23***b* also has an internal containment chamber similar to vacuum **23**. Vacuum **23***b* has two suction openings **46** and two containment chamber seal areas **158**. Each of the respective two openings has a specific purpose of adjacent plane contact with the wall on the vertical side and the floor on the horizontal side for cleaning and sterilizing the area near and where the wall and floor meet. There are four wheels **156** attached to the bottom of the vacuum housing **24***b* which make contact with the reservoir floor **182**. The height of the wheels is adjustable to allow for the optimum water flow between the floor and housing. There are two wheels **156** adjustably attached to the vertical portion of the vacuum housing **24***b* which maintain the proper horizontal distance between the vacuum housing and the wall **180**. The fluid hose **33** is attached to the fluid flow internal tube **155** by means of attachment **35**. The fluid flow nozzle or jet **53** is threadedly attached to the end of fluid flow tube **155**. The fluid flow nozzle shown in this figure is a rotating pressure turbo jet nozzle that spins in order for the fluid jet to spray all surfaces exposed under the vacuum housing **24***b*. The variable pressure fluid flow nozzle can be of a variety of types such as a fan spray nozzle or multiple low-pressure spray nozzles. The internal containment chamber **73** is open on the upper portion **71** to allow for water flow to travel from the inside of the containment chamber **73** as well as around the exterior space between the containment chamber **73** and the vacuum housing **24***b*. The bottom of the containment chamber has a circumferential flexible seal **158**, which prevents the variable pressure fluid flow from escaping to the exterior of the vacuum housing **24***b*. As in other embodiments this device has a water suction flexible pipe **106**, which is connected to a water pump on the exterior of the reservoir which is connected to the outlet pipe **42** by means of attachment **104**. The variable pressure fluid hose **33** is connected to a variable pressure fluid pump on the exterior of the reservoir.

[**0083**] Referring to **FIG. 17**, a fourth hand held embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. The hand held underwater vacuum **23***c* is designed for cleaning smaller flat areas where the vacuums **23**, **23***a,* or **23***b* cannot reach. The vacuum **23***c* differs from the vacuum **23**, **23***a* and **23***b* in the fact that it is not self-propelled and it does not have a rotable brush. The vacuum is smaller in size and has a variable pressure fluid flow mechanism in combination with water suction. The vacuum **23***c* also has an internal containment chamber similar to vacuum **23**. Vacuum **23***c* only has one suction opening **46** whereas vacuum **23***b* has two suction openings **46**, one for the wall and one for the floor. The vacuum **23***c* has a manual trigger **164** for operating the variable pressure fluid flow mechanism, which is an optional element of vacuums **23**, **23***a,* and **23***b*. This device has two handles **166** for manual operation. Like the other embodiments a water suction flexible pipe **106** is attached to an outlet pipe **42** by means of an attachment collar **104**. This flexible pipe **106** is connected to a water pump on the exterior of the reservoir. The variable pressure fluid flow mechanism is connected to a variable pressure fluid pump on the exterior of the reservoir by means of a water hose **33**. The water hose is connected to an internal fluid transmission pipe **155**, which is connected to a variable pressure fluid nozzle **53**. As in other embodiments the type of fluid flow nozzles can vary from a high pressure rotating nozzle to a fan spray nozzle of multiple low-pressure nozzles. The internal containment chamber **73** is attached to the vacuum housing **24***c* by means of attachment bars **168**. The containment chamber has openings **160** that allow the water to flow from the inside of the containment chamber as well as from the space between the containment chamber **73** and the vacuum housing **24***c*. The water flows by way of suction out through outlet pipe **42** to the flexible pipe **106**. The lower circumference of the internal containment chamber **73** has a flexible seal **158** to prevent the variable pressure fluid flow from escaping to the exterior of vacuum housing **24***c*. The lower circumference of the vacuum housing **24***c* has openings as shown in expanded view **162**. These openings allow for water flow to the inside of the vacuum housing to prevent the opening **46** from sucking down and sticking to the surface being cleaned and sterilized.

[**0084**] Referring to **FIG. 18**, a fifth self-propelled embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. The self-propelled underwater vacuum **23***d* is designed for cleaning the interior portions of pipes connected to potable water reservoirs where the vacuums **23**, **23***a,* **23***b* or **23***c* cannot reach. The vacuum **23***d* differs from the vacuum **23**, **23***a,* **23***b* and **23***c* in the fact that it is not self-propelled by wheels or a rotable brush and it does not have a rotable brush. The vacuum is smaller in size and has a variable pressure fluid flow mechanism in combination with water suction. The vacuum **23***d* does not have an internal containment chamber similar to vacuum **23**, **23***b,* or **23***c*. Vacuum **23***d* only has one suction opening **46** whereas vacuum **23***b* has two suction openings **46**, one for the wall and one for the floor. The vacuum **23***d* is self-propelled by the backward direction of the variable pressure fluid flow against the interior surface of the pipe. The fluid flow mechanism turbojet nozzle spins to clean all interior surface of pipes and by virtue of a backward direction of the fluid flow the device is self-propelled. The technology of this type of turbo rotating jet nozzle is not the subject of this invention and is available on the open market from a variety of manufacturers. The prior art of this fluid flow pressure nozzle system is widely used for cleaning sewer pipes in the utility industry. The difference between the present invention and prior art sewer cleaning technology is that this invention combines water suction to remove debris loosened by the fluid flow jet nozzle. There is no need for a internal containment chamber due to the fact that all sterilization chemical and debris loosened by the fluid flow jet is directed back towards the vacuum suction opening **46** and all materials are rapidly removed from the confined enclosed space between the vacuum housing **24***d* and the interior walls of the pipe. The device has six wheels **170** that are attached to a bar **172** that is adjustably attached to the vacuum housing **24***d* by means of movable arms **173**. The three adjustable wheel assemblies (only two are shown) maintain the vacuum **23***d* in a center position inside the pipe equal distant from the interior pipe surface **178**. The vacuum housing **24***d* and outlet pipe **42**, in this embodiment, serve the same purpose. The outlet pipe **42** is attached to the flexible suction pipe **106** by means of attachment collar **104**. The flexible suction pipe **106** is connected to a water pump on the exterior of the reservoir. This embodiment can be used for cleaning and sterilizing the interior of any pipe whether attached to a water reservoir or not.

[**0085**] Referring to **FIGS. 19, 20** and **21**, a sixth float driven embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. The circular underwater vacuum **23***e* is designed for cleaning the exterior surfaces of roof support columns and/or exposed internal pipes where the vacuums **23**, **23***a*, **23***b*, **23***c* or **23***d* can not reach. This embodiment can also be fabricated in a rectangular, square or other design for square, rectangular, or other shaped roof support columns. The vacuum **23***e* differs from the vacuum **23**, **23***a*, **23***b*, **23***c* or **23***d* in the fact that it is not self-propelled and it does not have a rotable brush. The vacuum is smaller in size and has a variable pressure fluid flow mechanism in combination with water suction. The vacuum **23***e* also has an internal containment chamber **73** with an open top **71** similar to vacuum **23**. Vacuum **23***e* only has one suction opening **46** whereas vacuum **23***b* has two suction openings **46**, one for the wall and one for the floor. The vacuum **23***e* has a circumferential suction opening **46** that surrounds a cylindrical column or pipe. The vacuum **23***e* can also be adapted to surround a rectangular or other shaped column. The vacuum **23***e* is propelled in an upward direction by means of air-activated floats (not shown in drawings). The internal containment chamber **73** has an internal circumferential flexible seal **158** similar to the other embodiments to prevent escape of the variable pressure fluid flow to the exterior of vacuum housing **24***e*. The variable pressure fluid flow mechanism has a plurality of variable pressure fluid flow nozzles **53** arranged in around the interior circumference of the containment chamber **73**. The fluid flow nozzles are connected by means of threaded attachments **35** to short sections of high-pressure fluid hose **33**. The fluid hose **33** is flexible allowing for the circular arrangement of the fluid flow nozzles **53**. The vacuum housing **24***e* and internal containment chamber **73** are flexibly attached by means of hinge **186** to allow for the device to open so it can be placed around the internal column. The hinged portions of the housing and internal chamber are held closed by means of a latch **187**. In order to open the circular arrangement of fluid nozzles and fluid hose to place the device around a column the fluid hose attachment **35** nearest the latch **187** is detached and then re-attached prior to closing the latch **187**. A plurality of wheels **192** have a shaft **188** that is adjustably attached to the internal circumference of the vacuum housing **24***e*. Each wheel is place and attached inside a slot **190** on the internal circumference of the vacuum housing **24***e*. As in the other embodiments the flexible water suction pipe **106** is connected to a water pump on the exterior of the reservoir. The water pipe is attached to the outlet pipe **42** by means of attachment collar **104**. The outlet pipe **42** is fixedly attached to the vacuum housing **24***e*. The internal containment chamber **731** is fixedly attached to the inside of the vacuum housing **24***e* by means of a plurality of attachment bars **168**. The high-pressure fluid hose **33** is attached to the fluid flow mechanism by means of attachment **35** and fluid pipe **65** and housing attachment **51**. The fluid flow pipe is attached to the fluid flow mechanism by means of a "T" fitting **49**. The outside perimeter of the internal containment chamber **73** is open **71**. The outside perimeter of the internal containment chamber has bars **194** that connect the top and bottom walls of the chamber together. The open outside perimeter **71** of the internal containment chamber **73** allows for water flow to the outlet pipe **42** from the inside of the internal containment chamber **73** as well as from the space surrounding the internal containment chamber between it's top and bottom walls and the walls of the vacuum housing **24***e*.

[**0086**] Referring to **FIG. 22**, a seventh float controlled embodiment of the underwater vacuum and sterilization system made in accordance with the present invention can be seen. This embodiment utilizes vacuum **23** or **23***a* for cleaning and sterilizing walls or other vertical flat surfaces inside water reservoirs or other water facilities. The only difference between this embodiment and vacuums **23** and **23***a* is the fact that it's vertical position relative to the floor **208** or surface of the water **206** is maintained by a cable **200** attached to a float **202** at the water surface **206**. The vacuum is held to the wall **204** surface by water suction and is self-propelled in a horizontal direction by it's motor and drive mechanism as previously described. After the vacuum makes a complete circumference of the reservoir it is turned in the opposite direction and raised a distance equal to one width of the vacuum suction opening **46**. The vacuum is raised by turning a small winch **198** by hand which is fixedly attached to the vacuum housing cap **50** by a winch attachment **210**. This process is repeated successively cleaning and sterilizing a complete circumference or perimeter of the reservoir until the entire vertical surface is cleaned and sterilized.

[**0087**] It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims. The basis of this invention is to cover any combination of water suction, variable pressure fluid flow, and rotable brush for the cleaning and sterilization of underwater surfaces.

I claim:

1. An underwater system for cleaning and chemically sterilizing interior surfaces of drinking water storage, treatment, or distribution facilities comprising:

a vacuum housing having a suction opening at the bottom thereof and a vacuum housing outlet opening, and said vacuum housing having an exterior and an interior;

a variable-pressure-fluid mechanism fixed to the interior of said vacuum housing for providing a variable-pressure fluid flow against the surface to be cleaned and sterilized, said variable-pressure fluid mechanism being in communication with an exterior fluid supply line extending through the vacuum housing and connected to a fluid pump at the water surface,

a sterilization chemical and fluid source above the water fluidly connected to said variable pressure pump at the water surface, an interior containment chamber adjustably fixed to the interior of said vacuum housing with four walls parallel to each wall of said vacuum housing having an opening on the top and bottom and having more than one flexible member, seal or plurality of bristles or brushes thereby defining a circumferential seal on the bottom edges of said four walls which is fluidly connected to both the interior cavity and the interior of the housing for containing said variable-pressure fluid flow from entering water on the exterior of said vacuum housing,

a turbine housing fixed to said exterior of said vacuum housing, said turbine housing having a turbine housing inlet and a turbine housing outlet, said turbine housing inlet being in fluid communication with said vacuum housing outlet opening;

a turbine rotatably supported within said turbine housing;

an outlet pipe supported by said vacuum housing, said outlet pipe having an outlet pipe inlet and an outlet pipe outlet, said outlet pipe inlet being in fluid communication with said turbine housing outlet;

a pair of front wheels rotatably supported by said vacuum housing proximate said suction opening, said plurality of wheels supporting said suction opening adjacent a surface to be cleaned, and allowing the underwater vacuum to be moved about the surface to be cleaned;

a pair of rear wheels and axle rotatably supported within said vacuum housing;

a means for transmitting rotational motion to said plurality of rear wheels from said turbine, whereby the underwater vacuum is self-propelled over the surface being cleaned;

whereby, when said underwater vacuum and sterilization system is supported adjacent a submerged surface to be cleaned by said plurality of wheels and when said outlet pipe outlet is connected to a pump via a hose and the pump is turned on, water being drawn through said vacuum housing will cause rotation of said turbine, which in turn causes rotation of said rear wheels;

whereby, when said variable pressure fluid pump is turned on said variable pressure fluid jets cause variable pressure fluid and sterilization chemical flow against said submerged surface to thereby dislodge matter from and sterilize the submerged surface, the water, fluid and chemical and the dislodged matter becoming entrained in water being drawn through said vacuum housing, the water and the dislodged matter being removed from proximity of the submerged surface via said outlet pipe.

2. The underwater vacuum and sterilization system according to claim 1, wherein said suction opening has a rear edge, a right edge, a left edge, and a front edge, and wherein said plurality of wheels includes a plurality of rear wheels and a plurality of front wheels, said plurality of front wheels being rotatably supported on said interior of said vacuum housing proximate said front edge, and said plurality of rear wheels rotatably supported on said interior of said vacuum housing and being connected by a connecting shaft or axle proximate said rear edge.

3. The underwater vacuum and sterilization system according to claim 2, further comprising means for transmitting rotational motion to said plurality of rear wheels from said turbine, whereby the underwater vacuum is self-propelled over the surface being cleaned.

4. The underwater vacuum and sterilization system according to claim 2, wherein:

said suction opening has a perimeter and said perimeter of said suction opening defines a plane, wherein each of said plurality of front wheels is attached to said vacuum housing by a respective one of a first plurality of adjustable attachment means such that the position of each of said plurality of front wheels can be adjusted in a direction approximately perpendicular to said plane of said suction opening;

and wherein said plurality of rear wheels are coaxially fixed to a common shaft rotatably supported by said vacuum housing, there further being a second pair of adjustable attachment means, each end of said common shaft being attached to said vacuum housing by a respective one of said second pair of adjustable attachment means, such that the position of all of said plurality of rear wheels can be adjusted in a direction approximately perpendicular to said plane of said suction opening simultaneously.

5. The underwater vacuum and sterilization system according to claim 1, further comprising a debris trap provided intermediate said vacuum housing outlet and said turbine housing inlet, fluid communication between said vacuum housing outlet and said turbine housing inlet provided via said debris trap.

6. The underwater vacuum and sterilization system according to claim 1, wherein said turbine is a first turbine, the underwater vacuum further comprising:

a second turbine;

and a common turbine shaft rotatably supported within said turbine housing, said first turbine and said second turbine being fixed in tandem to said common turbine shaft, whereby water rushing through said first turbine and said second turbine causes rotation of said common turbine shaft.

7. The underwater vacuum and sterilization system according to claim 6, further comprising a plurality of re-directional baffles provided intermediate said first turbine and said second turbine, said plurality of re-directional baffles straightening water flow from said first turbine before the water flow from said first turbine impinges upon said second turbine.

8. The underwater vacuum and sterilization system according to claim 1, wherein the vacuum housing has a rear wall, the underwater vacuum further comprising:

a socket attached to said rear wall;

and a T-shaped handle having a gripping portion and a distal end distal from said gripping portion, said distal end of said T-shaped handle being inserted into said socket.

9. The underwater vacuum and sterilization system according to claim 1, wherein said suction opening has a perimeter and said perimeter of said suction opening defines a plane, and wherein each of said plurality of wheels is attached to said vacuum housing by adjustable attachment means such that the position of each of said plurality of wheels can be adjusted in a direction approximately perpendicular to said plane of said suction opening.

10. The underwater vacuum and sterilization system according to claim 1, there further being a variable pressure sterilization chemical and fluid flow mechanism that said fluid flows against said surface with enough pressure to completely clean and sterilize all surfaces under said vacuum housing.

11. The underwater vacuum and sterilization system according to claim 1, there further being an interior containment chamber within said vacuum housing, said chamber having more than one flexible member, seal or plurality of bristles or brushes thereby defining a circumferential seal on the bottom edges, that said fluid flow is contained inside said chamber and removed by suction through open top of said chamber, such that said variable pressure fluid flow can flow against said surface with enough pressure to remove all matter and sterilize said surface, such that none of the fluid can escape under said containment chamber and enter the water on the exterior of said vacuum housing.

12. The underwater vacuum and sterilization system according to claim 1, there further being adjustable attachment means, said suction opening having a perimeter and said perimeter of said suction opening defining a plane, said containment chamber being attached to interior of said vacuum housing by said adjustable attachment means, such that the position of said containment chamber can be adjusted in a direction approximately perpendicular to said plane of said suction opening.

13. An underwater vacuum and sterilization system comprising:

a vacuum housing having a suction opening at the bottom thereof and a vacuum housing outlet opening, said suction opening being substantially rectangular and having a rear edge, a right edge, a left edge, and a front edge, said suction opening having a perimeter and said perimeter of said suction opening defining a plane, said vacuum housing having an exterior and an interior, said vacuum housing having a base portion and a cap portion, said cap portion having a rear wall and a front wall spaced apart from said rear wall, said cap portion having a closed top and an open bottom, said open bottom being smaller in area than said suction opening, said cap portion being joined to said base portion at said open bottom of said cap portion, said cap portion having lateral walls that extend between said front and rear wall, said cap portion having a decreasing cross sectional area in sections parallel to said plane of said suction opening, said cross sectional area of said cap portion decreasing from a maximum where said cap portion joins said base portion to a minimum at said closed top of said cap portion;

said base portion having a curved front wall extending from said front edge of said suction opening to said front wall of said cap portion, a rear wall extending perpendicular to said plane of said suction opening from said suction opening rear edge to said rear wall of said cap portion, a right sidewall extending from said curved front wall of said base portion to said rear wall of said base portion and from said right edge of said suction opening to said cap portion, and a left sidewall extending from said curved front wall of said base portion to said rear wall of said base portion and from said left edge of said suction opening to said cap portion, said front and rear walls of said base portion, said left sidewall, said right sidewall, and said cap portion cooperatively forming a concavity which opens to said suction opening;

said vacuum housing outlet opening being formed in said front wall of said cap portion, said vacuum housing outlet opening being as wide as said closed top of said cap portion and extending from said closed top of said cap portion to said curved front wall of said base portion;

a turbine housing fixed to said exterior of said vacuum housing said turbine housing having a turbine housing inlet and a turbine housing outlet, said turbine housing inlet being in fluid communication with said vacuum housing outlet opening;

a turbine rotatably supported within said turbine housing;

an outlet pipe supported by said vacuum housing, said outlet pipe having an outlet pipe inlet and an outlet pipe outlet, said outlet pipe inlet being in fluid communication with said turbine housing outlet; a brush rotatably supported within said vacuum housing, said brush having a plurality of bristles, said brush being positioned within said vacuum housing such that a predetermined number of said plurality of bristles project beyond said suction opening to the outside of said vacuum housing and contact the surface to be cleaned;

a plurality of front wheels rotatably supported on said exterior of said vacuum housing proximate said front edge of said suction opening;

a plurality of rear wheels rotatably supported by said interior of said vacuum housing intermediate said rear edge of said suction opening and said brush, said front and rear plurality of wheels supporting said suction opening adjacent a surface to be cleaned and allowing the underwater vacuum to be moved about the surface to be cleaned;

and means for transmitting rotational motion from said turbine to said brush;

a variable pressure fluid mechanism fluidly connected to variable pressure pump at water surface for transmitting chemical sterilization chemical and fluid to the interior of the vacuum housing to sterilize and additionally clean surface;

whereby, when said underwater vacuum is supported adjacent a submerged surface to be cleaned by said plurality of wheels and when said outlet pipe outlet is connected to a pump via a hose and the pump is turned on, water being drawn through said vacuum housing will cause rotation of said turbine which in turn causes rotation of said brush to thereby dislodge matter from the submerged surface, the dislodged matter becoming entrained in water being drawn through said vacuum housing, the water and the dislodged matter being removed from proximity of the submerged surface via the outlet pipe;

whereby, when said variable pressure pump is turned on the sterilization chemical and fluid will flow against the submerged surface behind said brush, the said chemical and fluid sterilizing said submerged surface, the water, dislodged matter, sterilization chemical and fluid becoming entrained in water being drawn through said vacuum housing the water and the dislodged matter being removed from proximity of the submerged surface via the outlet pipe.

14. The underwater vacuum according to claim 13, further comprising a debris trap provided intermediate said vacuum housing outlet and said turbine housing inlet, fluid communication between said vacuum housing outlet and said turbine housing inlet provided via said debris trap.

15. The underwater vacuum according to claim 13, wherein said turbine is a first turbine, the underwater vacuum further comprising:

a second turbine;

and a common turbine shaft rotatably supported within said turbine housing, said first turbine and said second turbine being fixed in tandem to said common turbine shaft, whereby water rushing through said first turbine and said second turbine causes rotation of said common turbine shaft.

16. The underwater vacuum according to claim 15, further comprising a plurality of re-directional baffles provided intermediate said first turbine and said second turbine, said plurality of re-directional baffles straightening water flow from said first turbine before the water flow from said first turbine impinges upon said second turbine.

17. The underwater vacuum according to claim 13, wherein said vacuum housing has a rear wall formed by said rear wall of said base portion and said rear wall of said cap portion, the underwater vacuum further comprising:

a socket attached to said rear wall of said vacuum housing;

and a T-shaped handle having a gripping portion and a distal end distal from said gripping portion, said distal end of said T-shaped handle being inserted into said socket.

18. The underwater vacuum according to claim 13, there further being adjustable attachment means, each of said plurality of front and rear wheels being attached to said vacuum housing by said adjustable attachment means, such that the position of each of said plurality of front and rear wheels can be adjusted in a direction approximately perpendicular to said plane of said suction opening.

19. The underwater vacuum according to claim 13, wherein:

each of said plurality of front wheels is attached to said vacuum housing by a respective one of a first plurality of adjustable attachment means, such that the position of each of said plurality of front wheels can be adjusted in a direction approximately perpendicular to said plane of said suction opening;

and wherein said plurality of rear wheels are coaxially fixed to a common shaft rotatably supported by said vacuum housing, there further being a second pair of adjustable attachment means, each end of said common shaft being attached to said vacuum housing by a respective one of said second pair of adjustable attachment means, such that the position of all of said plurality of rear wheels can be adjusted in a direction approximately perpendicular to said plane of said suction opening simultaneously.

20. A hand held underwater vacuum and sterilization system comprising:

a water suction pipe connected to a hand held tubular vacuum head;

a variable pressure fluid mechanism fluidly connected to variable pressure pump at water surface for transmitting chemical sterilization chemical and fluid to the interior of the vacuum head, and supported to the interior of said vacuum head, to sterilize and clean the surface;

a flexible member, seal or plurality of bristles or brushes thereby defining a circumferential seal on around the inlet edge of the vacuum head;

whereby when the hand held vacuum and sterilization system is placed adjacent to a submerged surface the variable pressure fluid flow from the interior of the vacuum head dislodges matter from the surface and sterilizes the surface. The water suction from inside the vacuum head removes all dislodged matter and sterilization chemical immediately from the area being cleaned and sterilized thereby preventing turbidity or sterilization chemical from entering the surrounding water column.

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