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(54) Title: FLUID TREATMENT APPARATUS

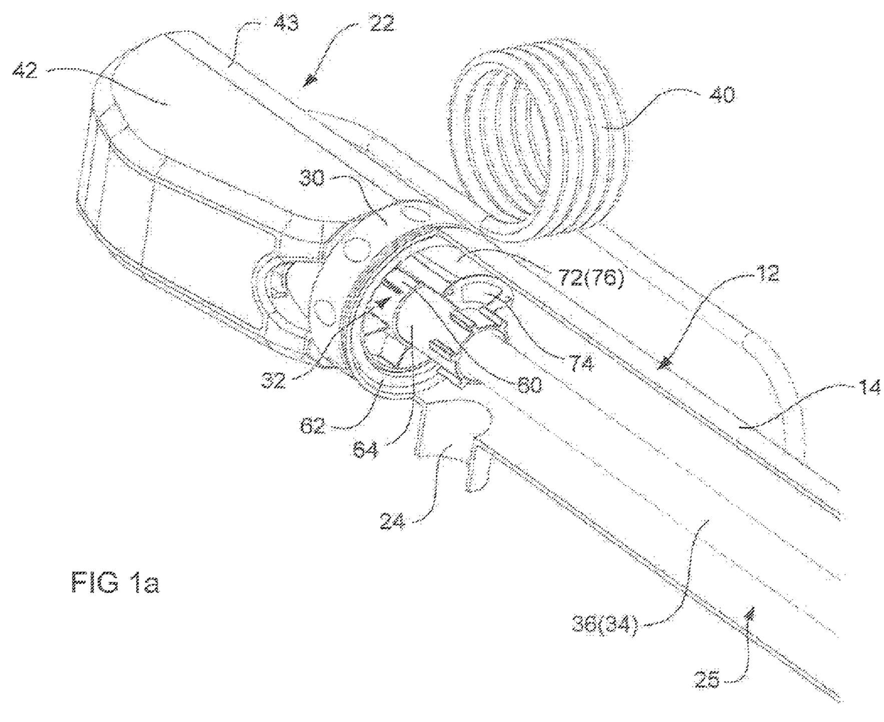

FIG 1a

(57) Abstract: A UV fluid treatment apparatus includes a housing, a treatment chamber defined within the housing, an inlet to and an outlet from the treatment chamber by which fluid is able to flow through the treatment chamber, and a UV lamp within the treatment chamber. A flow sensor located externally of the treatment chamber is operable to sense, and generate a signal indicative of, the flow rate through the treatment chamber. A power supply system and a control system enables and controls operation of the apparatus whereby fluid in, and flowing through, the treatment chamber is disinfected by exposure to UV light generated by the UV lamp.

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FLUID TREATMENT APPARATUS

Field of the Invention

This invention relates to a fluid treatment apparatus by which a fluid is able to be treated by exposure to ultraviolet (UV) light. The invention has particular application in the disinfection of liquids, such as water from a water supply, in particular a drinking water supply, to eliminate harmful bacteria and viruses. However, while the invention generally will be described with reference to the disinfection of water, it is to be understood that this need not necessarily be drinking water, and that the invention can be used for the treatment of liquids other than water and for the treatment of gases.

Background of the Invention

The advantages of UV light for eliminating micro-organisms in water over chemical treatments is well established, and the same principals apply to other fluids. UV light is commonly used for disinfection of water from a wide range of water sources by many local councils, as well as by the food, dairy and brewing industries and by thousands of private consumers to ensure their water is safe to drink or use. One form of apparatus is disclosed in US patent 6972415, to Schaible et al. Alternative apparatus is that sold under the trade mark STERIFLO (a registered trade mark of Davey Water Products Limited of North Harbour, New Zealand). The STERIFLO apparatus is available in various forms for water treatment under the model numbers UV40-20, UV75-25 and UV130-40, having maximum effective water flow rates of 40, 75 and 130 litres per minute, respectively, when operating at close to the maximum strength (such as about 95%) of UV light output from the UV lamps. However, as indicated by Schaible et al, the flow rate can be as low as about 0.5 US gallons per minute (about 1.9 lpm) up to several thousand gallons per minute.

Schaible et al records that the use of UV as a means to inactivate micro-organisms in water has been shown to be effective and advantageous over chemical disinfection, as UV does not require handling of dangerous chemicals and does not lead to the formation of undesirable disinfection by-products. In the UV treatment of Schaible et al, a housing defines a fluid treatment zone, and has a fluid inlet and a fluid outlet. A

UV emitter is mounted within the treatment zone. Also within the treatment zone, a sensor unit includes fluid flow sensing means to sense the flow of fluid within the treatment zone and UV sensing means to sense UV light levels. Additionally, an intelligent ballast, driver or controller has the capability for receiving, processing, responding to and displaying one or more parameters based on one or more input signals.

Each of the STERIFLO models provides a UV treatment apparatus with a stainless steel chamber, a UV lamp within the chamber and an external control box. The apparatus is designed for continuous operation, treating water at a temperature up to 45°C at any flow rate from zero up to the respective indicated design flow rate for each model. Extended periods of zero flow may not be harmful to achieving water disinfection as the chamber is full of water exposed to UV light. However, a period of zero flow can result in electronic components being damaged by heat accumulated in the absence of the cooling effect of flowing water.

The present invention provides an alternative form of fluid treatment apparatus which, at least in preferred embodiments, provides advantages over the apparatus of Schaible et al and/or the STERIFLO apparatus of models UV40-20, UV75-25 and UV130-40.

Summary of the Invention

A UV fluid treatment apparatus according to the present invention has a housing which defines a treatment chamber and which has an inlet to and an outlet from the treatment chamber by which fluid is able to flow through the treatment chamber. The apparatus also has a UV lamp within the treatment chamber and, located externally of the treatment chamber, a flow sensor system operable to sense fluid flow rate through the treatment chamber and generate a signal indicative of that flow rate. The apparatus further includes a power supply and a control system for enabling and controlling operation of the apparatus in response to the signal generated by the flow sensor whereby fluid in, and flowing through, the treatment chamber is disinfected by UV light generated by the UV lamp.

The power supply and the control systems preferably are operable to maximise the operating life of the UV lamp, to reduce operating power costs and to avoid the passage of the fluid insufficiently exposed to UV radiation.

UV lamps have a designated minimum operating life, such as of about 12 months continuous operation at maximum designed output. In the past, safety systems have been operable to terminate fluid flow, such as by cutting power to a pump by which the fluid is supplied, at the end of the minimum designed life. A manual over-ride can enable operation for a further period, such as from 24 to 48 hours, sufficient to enable a replacement lamp to be obtained and fitted. However, safety systems which restrict lamp use to the minimum designed life are wasteful. This is because the minimum designated life is based on data averaged over a large number of lamps. In many instances, individual lamps are capable of operating for considerably longer periods. This is particularly so for lamps which are not used in continuous operation, and possibly also with lamps not used at maximum output intensity for at least some of the time of use.

The present invention may include a UV sensor which is adapted to monitor the output intensity of the UV lamp and to generate an output signal which varies in accordance with the UV light output intensity from the UV lamp. The output signal from the UV sensor is received by the control system in which a determination is able to be made on degradation of the UV lamp, cleanliness of the quartz sleeve in which the lamp is contained to isolate it from fluid flowing through the treatment chamber, or turbidity of the fluid. An alarm output signal can enable a check by a user to determine which of these factors is involved. Where a UV sensor is provided, it may be mounted in a cover provided on or in the housing. The cover may be mounted on the exterior surface of the housing, with the UV sensor exposed to UV light generated within the treatment chamber through a small opening in the housing, with the transparent window of quartz, or suitable plastics material of the UV sensor covering the opening and sealed around the periphery of the opening to prevent leakage of water from the treatment chamber. Alternatively, the cover may be mounted inside the housing, with the UV sensor exposed to the UV light in the treatment chamber by the window of the UV sensor covering an opening in the cover. In each case, the UV sensor preferably is oriented so that its window is perpendicular to UV light received radially from the UV lamp, most preferably at a location intermediate of the ends of the lamp.

The control system may be operable to vary the operating strength or output intensity of the UV lamp when the flow rate of fluid through the treatment chamber falls below or rises above a threshold level. A flow rate below that level, even zero flow, may cause the flow sensor to generate and pass to the control system a signal indicative of such flow, or the flow sensor may cease to generate a signal. In either case, the control system preferably is operable to adjust the strength or intensity of UV light output of the UV lamp to a reduced level sufficient to ensure a static volume of fluid held in the treatment chamber. That is, the content of the chamber at zero flow rate, is and remains disinfected. Similarly, with an increase in flow velocity above the threshold level, such as when returning to a designed operating flow rate for the apparatus, the flow sensor preferably is operable to generate and pass to the control system a sign causing the control system to adjust the UV lamp to full UV light strength or output intensity.

The housing may be of elongate form, having a water inlet at a first end and water outlet adjacent to the second end. A respective connector at the inlet and outlet preferably enables the apparatus to be connected in-line in a water supply system, such as a water reticulation system providing drinking water.

With such elongate housing, a sub-housing may be provided at the second end. The sub-housing preferably is isolated from water in the treatment chamber by suitable seals which act to prevent water in the treatment chamber from passing into the sub-housing. In one form, the sub-housing has a partition which divides the sub-housing to provide a first compartment containing electrical and electronic components of the power supply and control systems, and a second compartment between the first compartment and the treatment chamber. The second compartment may be provided with drainage openings such that, in the event that any water does leak past seals between the second compartment and the treatment chamber, the leaked water can drain from the apparatus to prevent it passing to the first compartment.

The sub-housing preferably contains the power supply system, with a power supply cable extending from the sub-housing to enable connection to an external source of electric power. The sub-housing preferably also contains an electronic ballast for adapting the UV lamp to the external source of electric power. Additionally, the sub-housing may contain a microprocessor, comprising the control system, for monitoring and controlling operation of the UV lamp, the flow sensor and, if provided, the UV sensor.

The sub-housing may be separable from the housing. This may be enabled by a screw threaded coupling, but preferably one which does not necessitate rotation of the sub-housing relative to the housing. One of the sub-housing and the housing may have a rotatable, but captively held threaded collar which is able to engage a threaded portion of the other one of the sub-housing and the housing, to secure the housing and the sub-housing together.

The sub-housing may include a lamp holder by which the UV lamp is electrically connectable to the power supply system. The holder may enable the UV lamp to be so connectable at one end, such as by provision within the lamp holder of a suitable socket in which the one end of the UV lamp is engageable. This arrangement facilitates removal of the UV lamp from the housing, when cleaning or UV lamp replacement is required, particularly where sub-housing and housing are releasably secured together by a threaded collar, as described above.

As indicated, the flow sensor is external to the treatment chamber. It therefore provides an indirect determination of water flow rate in the treatment chamber. The flow sensor may be, and preferably is, in the sub-housing containing the power supply and control system. To enable the determination of the flow rate of water in the treatment chamber, a part of the overall surfaces defining the treatment chamber may be provided by a metal plate and the flow sensor is operable through the plate to determine the water flow rate across the metal plate and thereby obtain a measure related to the water flow rate through the treatment chamber. It will be appreciated that flow rate through the treatment chamber as so determined is volumetric flow rate.

Alternatively, rather than a metal plate, the flow sensor may be operable through a plate or wall of plastics material. In each case the plate or wall may be formed integrally with a housing, sub-housing or other component of the apparatus, or the plate or wall may be secured over an opening in a housing, sub-housing or other component, with a fluid-tight seal provided around the periphery of the plate or wall. A practical benefit of having the flow sensor external to the flow chamber is to ensure isolation of the flow sensor from the fluid in the treatment chamber. Such isolation is more readily able to be ensured with an integral plate or wall, as seals can fail or be improperly fitted. In the following, reference is made to a metal wall or plate, but it is to be understood that a plastics wall or plate can be used.

For determining the flow rate in the treatment chamber, the flow sensor may be operable to monitor a characteristic which varies with the rate at which water passes across the metal plate. The sensor preferably measures changes in power input, to a location on the metal plate, that are required to provide heating and maintain a temperature at that location. More preferably the sensor measures changes in power input required to maintain a temperature differential between the heated location and a second unheated location on the plate. In each case, a variation in flow rate is due to increasing or decreasing dissipation of heat energy through the metal plate to the water with increasing or decreasing water flow rate across the metal plate. The power to provide a temperature differential is preferred, but is not required if the temperature of the fluid is constant or separately determined. However, measurement of the temperature of the water generally is desirable, and it is preferable that this is achieved by the flow sensor, rather than at the cost of providing a separate temperature sensor.

The apparatus may have a printed circuit board which includes the flow sensor and is mounted on the plate or wall through which the flow sensor is operable. The flow sensor may be of the type that operates on thermal techniques and includes at least one source of heat, such as a resistive heater element, and at least one temperature sensor, such as a thermistor. In one preferred arrangement, the flow sensor includes two thermistors of which a first one is heated by one or two heaters, and a second one is situated away from the or each heater. Control of heating the first thermistor endeavours to maintain the first thermistor at a constant temperature above the water temperature, while the second thermistor is exposed to the water temperature through the metal plate. The power required to maintain the temperature differential is proportional to the dissipation of heat energy through the metal plate, from the first thermistor to the water. The power therefore is proportional to the flow rate of the water across the metal plate. When there is no water flow, the heater or heaters can maintain a specified temperature offset between the first and second thermistors. With water flow, heat is removed from the metal plate by passing water and the power required increases.

When there is no flow/demand, disinfection is not required beyond that necessary to ensure a static volume of water remains disinfected. However, continuing operation of the UV lamp at full output can result in: nuisance heating of the fluid within the chamber, overheating of the lamp/electronic components, a reduction in UV output and/or wasted energy. To prevent the aforementioned, the apparatus is able to enter a power-saving standby state, for example by reducing current to the lamp, thereby reducing the output light strength or intensity. The UV lamp cannot be switched off completely, as 100% UV output is not achieved instantaneously from a ‘cold start’ and repeated switching on and off shortens the life of the UV lamp. While in standby mode, the apparatus is able to continuously monitor ongoing lack of flow/demand via the flow sensor, which is also capable of monitoring absolute water temperature. There is a delay between provision of full power to the lamp and full UV output. At warm ambient temperatures the delay is insignificant and substantially immediate 100% output ensures complete sterilisation. However, if lamp intensity is reduced excessively when ambient temperatures are low, the lamp may take too long to return to full intensity and, at higher flows, some water may not receive a ‘safe’ UV dose. At 100% output, the lamp heats the water around it. The apparatus senses the water temperature and adjusts the lamp intensity to an output level at which the lamp can return substantially instantaneously to full output in any temperature. At very low temperatures, it is necessary to operate the UV lamp at 100% output and not reduce the lamp output. An algorithm preferably is applied to adjust operation of the UV lamp to an appropriate output level which decreases below 100% as the temperature increases.

The flow sensor may be housed in an extension, such as from the sub-housing, which projects into the housing. The metal plate may be disposed across the free end of the extension, with the flow sensor being mounted on the metal plate, within the extension, and thereby able to be isolated from water in the treatment chamber.

Detailed Description of the Invention

In order that the invention may be understood more readily, description now is directed to the accompanying drawings, in which:

Figure 1 is a perspective view of a fluid flow apparatus according to the invention;

Figure 1A is a first part sectional view of a first end of the apparatus of Figure 1;

Figure 2 is a second part sectional view of the first end of the apparatus of Figure 1;

Figure 3 is a perspective view of the first end of the apparatus, showing components partially disassembled;

Figure 4 is a perspective view of the one end of the apparatus when in a disassembled condition;

Figure 5 is a perspective view of a component of the apparatus of Figure 1, shown partly sectioned;

Figure 6 is an inverted perspective view of the component shown in Figure 5, showing different sectioning;

Figure 7 is a perspective view of further components of the apparatus of Figure 1;

Figure 8 is a sectional view of the components of Figure 7, taken on line A-A;

Figure 9 shows a read-out panel of the apparatus of Figure 1;

Figure 10 is a state transition diagram for the apparatus of Figure 1; and

Figure 11 is a graph illustrating variation in stand-by voltage with temperature for a given start-up delay before full power.

Figure 1 shows fluid treatment apparatus 10 which is of elongate form. The apparatus includes a housing 12, preferably of stainless steel, which has a peripheral cylindrical wall 14, an annular wall 16 at one end of housing 12 and an axially in-line inlet connector 18 opening through wall 16. At the other end of housing 12, wall 14 has an externally threaded, reduced diameter end portion 20 (see Figures 2 and 3) which is received in and is closed by a sub-housing assembly 22 mounted on housing 12. Adjacent to end portion 20, a lateral, outlet connector 24 projects from wall 14.

The arrangement is such that, with inlet connector 18 coupled to a water supply, water from the supply is able to flow through a treatment chamber 25 defined by housing 12 and an end of assembly 22 adjacent to outlet connector 24. Water discharging from chamber 25 through connector 24 is able to be directed as required by a conduit (not shown) coupled to connector 24. Thus, apparatus 10 is able to be connected in-line in a water supply system.

The assembly 22 includes a sub-housing 26 which, as shown in Figure 2, defines a fluid tight compartment 28. Assembly 22 is mounted on end portion 20 of housing 12 by screw threaded engagement between an internally threaded collar 30 and the external thread of portion 20. Within collar 30, assembly 22 includes a lamp holder 32 shown in more detail in Figures 5 and 6. One end of an elongate UV lamp 34 and of a protective quartz sleeve 36 are engaged with the holder 32 so that the lamp 34 and sleeve 36 extend substantially centrally within and along housing 12. A system 38, shown in Figure 2 and comprising a power supply system integrated with a control system, is mounted in compartment 28. System 38 receives electric power from a source via an external lead 40, and is operable to provide required operating power to UV lamp 34. The system 38 is able to supply power to UV lamp 34 by means of electric leads (not shown) which pass through a resilient sealing block 41.

In the arrangement shown, the part of sub-housing 26 which defines compartment 28 is formed in two parts 42 and 43 which abut on a plane substantially parallel with the axis of housing 12. A resilient water-tight seal 44 is provided between mating edges of parts 42 and 43. The seal 44 extends not only along peripheral edges of parts 42 and 43, but also along the edge of a respective transverse partition wall 46 of each of sub-housing 42 and 43. The edge of each wall 46 has a centrally recessed region such that, when parts 42 and 43 are secured together, the resilient block 41 is located between the recessed regions and compressed radially, with the main part of block 41 outside compartment 28. This results in completion of the seal between parts 42 and 43 to prevent fluid from treatment chamber 25 from being able to enter compartment 28. Compression of block 41 also ensures a seal is provided between block 41 and electric power leads (not shown) for UV lamp 34 which extend from power supply and control system 38 and through block 41 to the lamp holder 32, for the supply of electric power to lamp 34. Retention of such sealing is ensured by threaded fasteners (not shown) extending through locating spacer posts 48 shown in one part of parts 42 and 43 for threaded engagement in similar posts in the other of parts 42 and 43.

Each of parts 42 and 43 has a semi-circular continuation 46 which has an inturned flange 49 spaced from the respective partition wall 46. The inner edge of each flange 49 is located in one half of a peripheral groove 50 (shown in Figure 5) around the lamp holder 32. With parts 42 and 43 of sub-housing 26 secured together, the lamp holder 32 therefore is secured in relation to sub-housing 26 by each flange 49 being held in a respective half of groove 50. Similarly, collar 30 has an inwardly extending peripheral flange 52 by which collar 30 is rotatably secured on lamp holder 32. As shown, the flange 52 is secured between the respective flange 49 of each of parts 42 and 43 and an outwardly extending peripheral flange 54 (shown in Figure 5) of lamp holder 32.

As shown in Figures 5 and 6, the lamp holder 32 has an annular overall form, with an outer, cylindrical peripheral wall 56 which defines groove 50 and on which flange 54 is provided. Holder 32 also has transverse partition wall 58 which is located intermediate of the ends of peripheral wall 56 and which effectively defines an end of treatment chamber 25. Extending into treatment chamber 25 from wall 58, concentrically within one end of peripheral wall 56, lamp holder 32 also includes an internally threaded boss 60. A number of circumferentially spaced, radial webs 61 extend between the outer surface of boss 60 and the inner surface of wall 56 to strengthen and increase the rigidity of lamp holder 32.

With the lamp holder 32 secured in relation to sub-housing 26, the partition wall 58 is spaced from the respective transverse partition wall 46 of each of sub-housings 42 and 43 by a distance resulting in resilient sealing block 41 being compressed in a direction longitudinally of housing 12. This enhances the sealing action of block 41 and ensures that it provides a fluid-tight seal over and around a central opening 58a through partition wall 58 and around leads from power supply and control system 38 which pass through opening 58a and provide operating electric power to UV lamp 34.

The outer surface 56a of peripheral wall 56 is closely adjacent to the inner surface 20a of reduced diameter portion 20 of housing 12. A resilient O-ring 62 is provided between surfaces 56a and 20a. The O-ring 62 is contained between a step 20b which is provided in surface 20a and faces towards assembly 22, and a peripheral bead 56b formed around surface 56a. The O-ring 62 provides a further fluid-tight seal preventing water in treatment chamber 25 from passing around and beyond lamp holder 32, to assist in isolating the contents of compartment 28 from the water. A still further fluid-tight seal is provided between boss 60 and the outer surface of the silica sleeve 36 in which UV lamp 34 extends.

As shown in Figure 2, a cylindrical sealing sleeve 64 projects from boss 60 of lamp holder 32, around an end portion of the quartz sleeve 36. An end portion of sealing sleeve 64 is externally threaded and in threaded engagement in boss 60. This engagement is to cause a resilient O-ring 66 around quartz sleeve 36 to be compressed between the end of sealing sleeve 64 and a shoulder 60a which is formed in the inner surface of boss 60 and faces away from partition wall 58. The end of sealing sleeve 64 further from lamp holder 32 is reduced in thickness so that an annular recess 68 is defined between sealing sleeve 64 and silica sleeve 36. A resilient O-ring 70 provided with a tight fit in recess 68 is thereby compressed to provide a fluid-tight seal between sleeves 64 and 36. Thus, water in treatment chamber 25 is prevented from passing between sleeves 64 and 36 by O-ring 70 and through the threaded engagement between sleeve 64 and boss 60 by O-ring 66.

To one side of opening 58a of wall 58 of lamp holder 32, holder 32 has a tubular extension 72 which projects beyond wall 56 and boss 60. The end of extension 72 remote from wall 56 is closed by a metal plate 74 secured by screws 75 extending into threaded bores 75a in the peripheral wall defining extension 72. In Figure 7, a part of plate 74 and the end of extension 72 is cut away to show the hollow interior 72a of extension 72. A groove formed in and around the end of that wall across which plate 74 is secured houses a resilient O-ring 76 which is compressed by securement of plate 74 to provide a fluid-tight seal. Thus, again, water in treatment chamber 25 is prevented from leaking, in this instance from leaking by passing between plate 74 and the end of extension 72. The arrangement is such that, as with other parts of lamp holder 32, the external surface of tubular extension 72 and plate 74 define part of the treatment chamber 25. The extension 72 and plate 74 provide part of surfaces which define chamber 25 across the end of chamber 25 adjacent to outlet connector 24. The length of extension 72 and its location on lamp holder 32 is such that the end of extension 72 and plate 74 are positioned in line with and close to the bore of outlet connector 24. Thus, water discharging from treatment chamber 25 passes across the surface of plate 74.

The extension 72 houses a fluid flow sensor 76 which, although not in treatment chamber 25, is operable to sense the flow of fluid through chamber 25. The flow sensor 76 has its active sensing components mounted on the surface of plate 74 which faces along extension 72, back towards partition wall 58. Control of operation of the flow sensor 76 is provided by the power supply and control system 38. For this, further electric leads (not shown) extend from system 38, and through resilient block

41, to pass laterally across partition wall 58 and along extension 72 to components of flow sensor 76.

In one preferred arrangement the flow sensor 76 includes a heater 77a comprising resistors and two thermistors 77b and 77c mounted on a printed circuit board 76d secured on plate 74. A first one 77b of the thermistors 77b, 77c is located close to and is heated by the heater 77a, while the second thermistor 77c is located away from the influence of the heater 77a. The second thermistor 77c is held at the temperature of water in chamber 25 which passes over plate 74 and serves as a reference relative to which the temperature of the first thermistor 77b can be assessed by system 38.

In use, the heater 77a is operated to heat the first thermistor 77b in an endeavour to maintain that thermistor at a selected temperature higher than the temperature of the second thermistor 77c. The temperature of water in treatment chamber 25 sets the temperature of the second thermistor 77c while, with heat energy conducted from the first thermistor 77b through plate 74, the water functions as a heat sink against which the heater 77a acts in heating the first thermistor 77b. The power required to maintain the temperature difference between the first and second thermistors 77b, 77c is proportional to the rate of heat energy transfer from the first thermistor to the water in treatment chamber 25 and, hence, to the flow rate of water in chamber 25. The power supply and control system 38 provides electric power for operation of the flow sensor 76, and monitors signals indicative of the relative temperatures of the first and second thermistors 77b, 77c.

The system 38 is operable to reduce the power supply to the UV lamp 34 when performance of flow sensor 76 indicates that water flow rate in treatment chamber 25 has stopped, or at least fallen below a threshold level. This occurs when a minimum current supply to the heater 77a for the first thermistor 77b is required to maintain a maximum temperature differential between the first and second thermistors 77b, 77c. Thus, when water flow rate in chamber 25 stops or is below the threshold level, the UV lamp 34 may enter a power-saving standby mode in which UV output is at a substantially reduced level sufficient to keep disinfected a static volume of water remaining in chamber 25.

The sensitivity of the flow sensor 75 may be such that system 38 is unable to distinguish between zero water flow and minimal flow rate below a low level threshold, such as less than 3 litres per minute. Due to this, the UV output when the lamp is in the standby mode needs to be sufficient to ensure water discharging from treatment chamber 25 at that low level is disinfected to an extent substantially the same as is achieved with the lamp operating at maximum output for the apparatus 10 operating at its designed water flow rate. In this regard it will be appreciated that UV radiation can not ensure 100% effective disinfection. However, it usually is possible to attain greater than a 99% reduction in the bacteria count under all water flow velocities from zero up to the designed, maximum flow rate for the apparatus. At zero or such minimal flow rate, such a level of reduction in bacteria can be achieved with the UV lamp in a power-saving standby mode at which the lamp operates at a reduced UV output light strength or intensity of normal output at full supply power input. This can both significantly reduce operating costs, reduce unnecessary heating and possibly increase the useful operating life of the UV lamp. However, at low water temperatures, a lesser reduction is necessary in order to avoid a delay in switching to full operating UV light strength or intensity, as detailed earlier herein.

Even if attainment of zero flow could be distinguished from minimal flow of less than about 3 litres per minute, this would not enable further reduction of operating costs. That is, depending on the lamp model, it may not be acceptable to reduce UV intensity to less than for example about 20% to 50% of normal output for a UV lamp which operates cost effectively at normal output for the designed water flow rate of the apparatus. Also, it is not acceptable to turn off power to the UV lamp. As low as about 20% of normal power can be required to keep disinfected water remaining in the treatment chamber, while turning a UV lamp on and off reduces its operating life. Also, depending on temperature, a UV lamp operating at reduced output is able to ramp up to normal output to ensure full effective disinfection as the apparatus returns to its designed flow rate. That is, the apparatus is able to operate effectively as an on demand system.

The apparatus illustrated includes a UV sensor 80. The UV sensor 80 is housed in a dished cover 82 which is mounted on housing 12 at a location intermediate of the ends of UV lamp 34. The cover 82 is secured against the exterior of housing 12 by fasteners threaded through the bosses 83 and threaded in the wall of housing 12. The edges 82a of opposite end walls 82b of cover 82 are contoured so as to fit neatly against housing 12. The UV sensor 80 is oriented so that its axis extends radially through the axis of UV lamp 34, with its window 80a perpendicular to UV light through a small opening (not shown) in housing 12 and received along the axis of sensor 80. Thus, UV light is able to pass through window 80a and axially along body 80b of sensor 80 to a standard UV sensing element 80c behind window 80a.

The UV sensor 80 may be a UV-transmittance sensor, such as an AlGaN photodiode, with amplification and filtration circuits (not shown). Suitable UV-C radiation sensitive sensors are the KPDU27HQ2 and UVD280 photodiodes available, respectively, from Kyosemi Corporation of Japan and IL Metronic Sensortechnik GmbH of Germany. Power for operation of the UV sensor 80 is provided by the power supply and control system 38. Output from the UV sensor 80 passes back to the system 38, and enables variations in the intensity of UV light to be monitored. This enables the effective life of the UV lamp to be progressively measured and, in the short term, it enables the need for cleaning to be assessed.

Figure 9 shows a form of visual display keypad 90 suitable for the front face of sub-housing 26. This includes a standby mode LED indicator lamp 91 and, below lamp 91, a UV lamp timer reset button 92. The keypad 90 also includes an LED power on/off indicator lamp 93 and an alarm mute button 94 allowing a 24 hour muting of an alarm indicating expiry of the nominal or measured life of the UV lamp. A lamp life indicator bar 95 provides a progressive read-out, such as with successive LEDs transitioning from green to red, to give a progressive indication of the expired part of the UV lamp life.

Figure 10 illustrates overall control able to be exercised over operation of the apparatus 10, with the chart below the state transition diagram showing visual read-out provided by keypad 90 under various conditions.

Figure 11 illustrates the variation in standby voltage with temperature for one apparatus 10. The voltage at each temperature is that required to ensure a delay of not more than 0.9 seconds in switching from standby to full UV light output. This was based on conceptual testing using a low-output lamp with a Vossloh-Schwabbe ballast and need not be representative of what will occur in the final products.

Finally, it is to be understood that various alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the spirit or ambit of the invention.

CLAIMS:

1. A UV fluid treatment apparatus, wherein the apparatus includes a housing, a treatment chamber defined within the housing, an inlet to and an outlet from the treatment chamber by which fluid is able to flow through the treatment chamber, a UV lamp within the treatment chamber, a flow sensor located externally of the treatment chamber and operable to sense, and generate a signal indicative of, the flow rate through the treatment chamber, and a power supply system and a control system for enabling and controlling operation of the apparatus whereby fluid in, and flowing through, the treatment chamber is disinfected by exposure to UV light generated by the UV lamp.

2. The apparatus of claim 1, wherein the power supply and control systems are operable to reduce or increase UV output from the UV lamp when the flow sensor located externally of the treatment chamber, detects fluid flow rate through the treatment chamber is below or above a threshold flow rate.

3. The apparatus of claim 1 or claim 2, wherein the housing is of elongate form, with the inlet and outlet at first and second respective ends of the housing, the power supply system and the control system are in a compartment defined by a sub-housing mounted at the second end of the housing, and the UV lamp extends longitudinally from the sub-housing within the treatment chamber.

4. The apparatus of claim 3, wherein the compartment housing the power supply and control systems is separated from the treatment chamber defined within the housing by a second compartment defined by the sub-housing, and the second housing is provided with drainage ports by which any fluid which leaks from the treatment chamber is able to drain from the apparatus.

5. The apparatus of any one of claims 1 to 4, wherein the flow sensor is separated from the treatment chamber by a metal plate which defines part of surfaces defining the treatment chamber, and the flow sensor is operable through the plate to

determine the fluid flow rate across the plate and thereby generate said signal indicative of fluid flow rate through the treatment chamber.

6. The apparatus of claim 5, wherein the flow sensor is operable to monitor a characteristic which varies with the flow rate of the fluid across the metal plate.

7. The apparatus of claim 6, wherein the flow sensor is operable to measure an increase or decrease in power input, to a location on the metal plate, required to maintain a temperature at the location with an increase or decrease in fluid flow rate across the metal plate.

8. The apparatus of claim 7, wherein the flow sensor includes on the plate a heater and, at respective locations on the plate, first and second thermistors, with the first thermistor close to and heatable by the heater, with the power supply system operable to power the heater to heat the first thermistor to establish and maintain a temperature differential between the first and second thermistors.

9. The apparatus of any one of claims 1 to 8, further including a UV sensor mounted in relation to the housing to enable measurement of UV light intensity in the treatment chamber, and to generate a signal received by the control system.

10. The apparatus of claim 9, wherein the UV sensor is mounted externally on the housing at a location intermediate of the ends of the UV lamp.

1/11

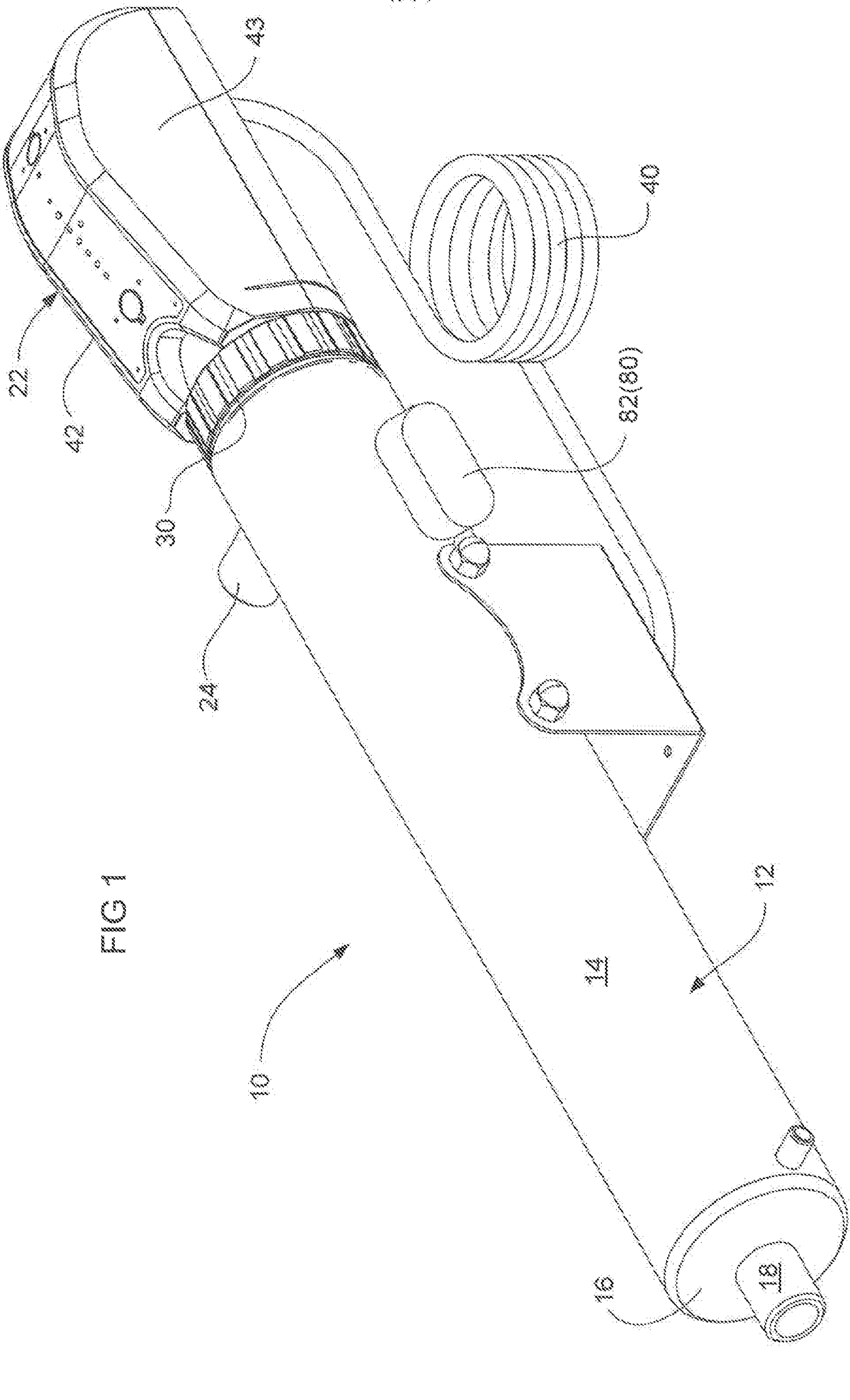


FIG 1

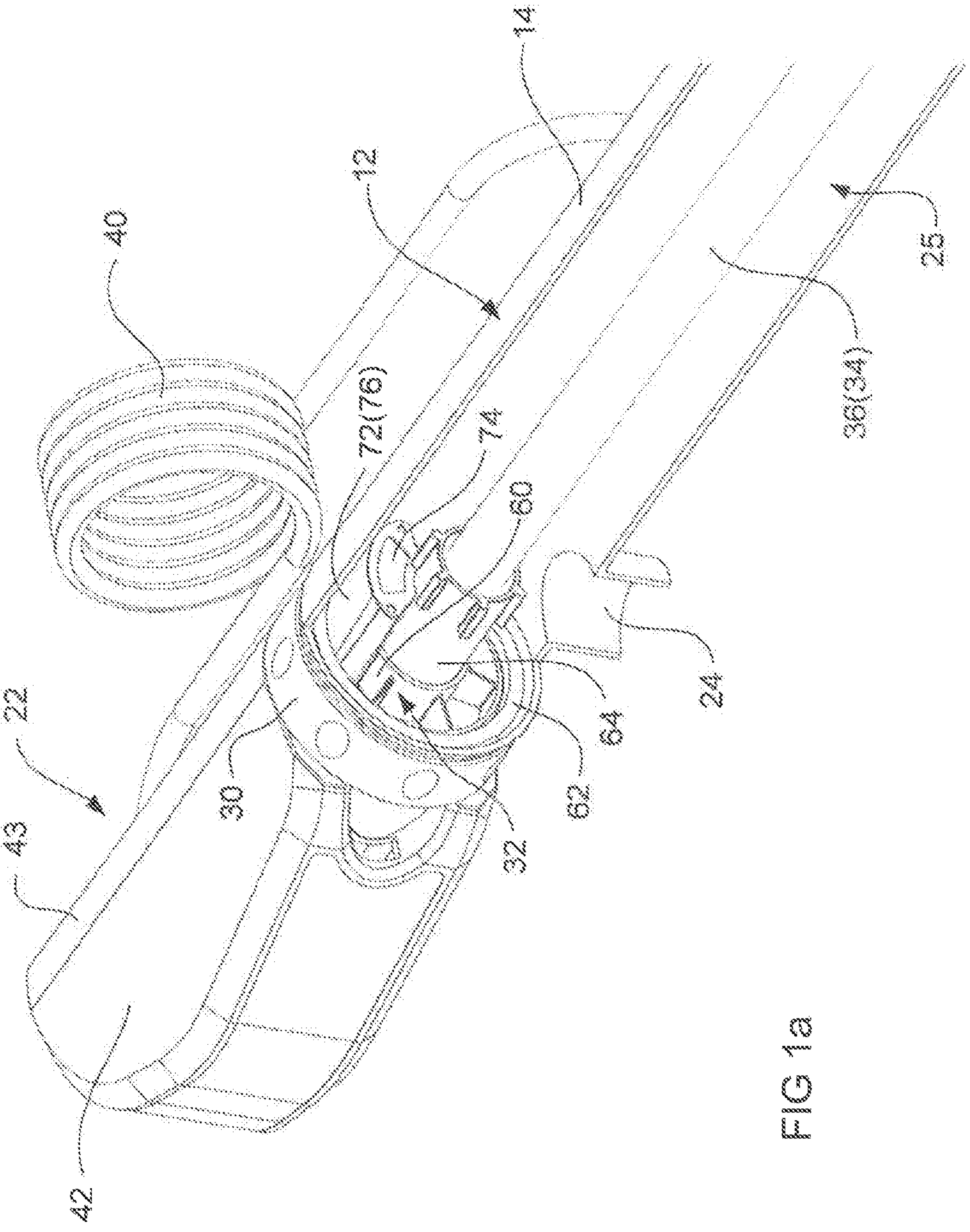


FIG 1a

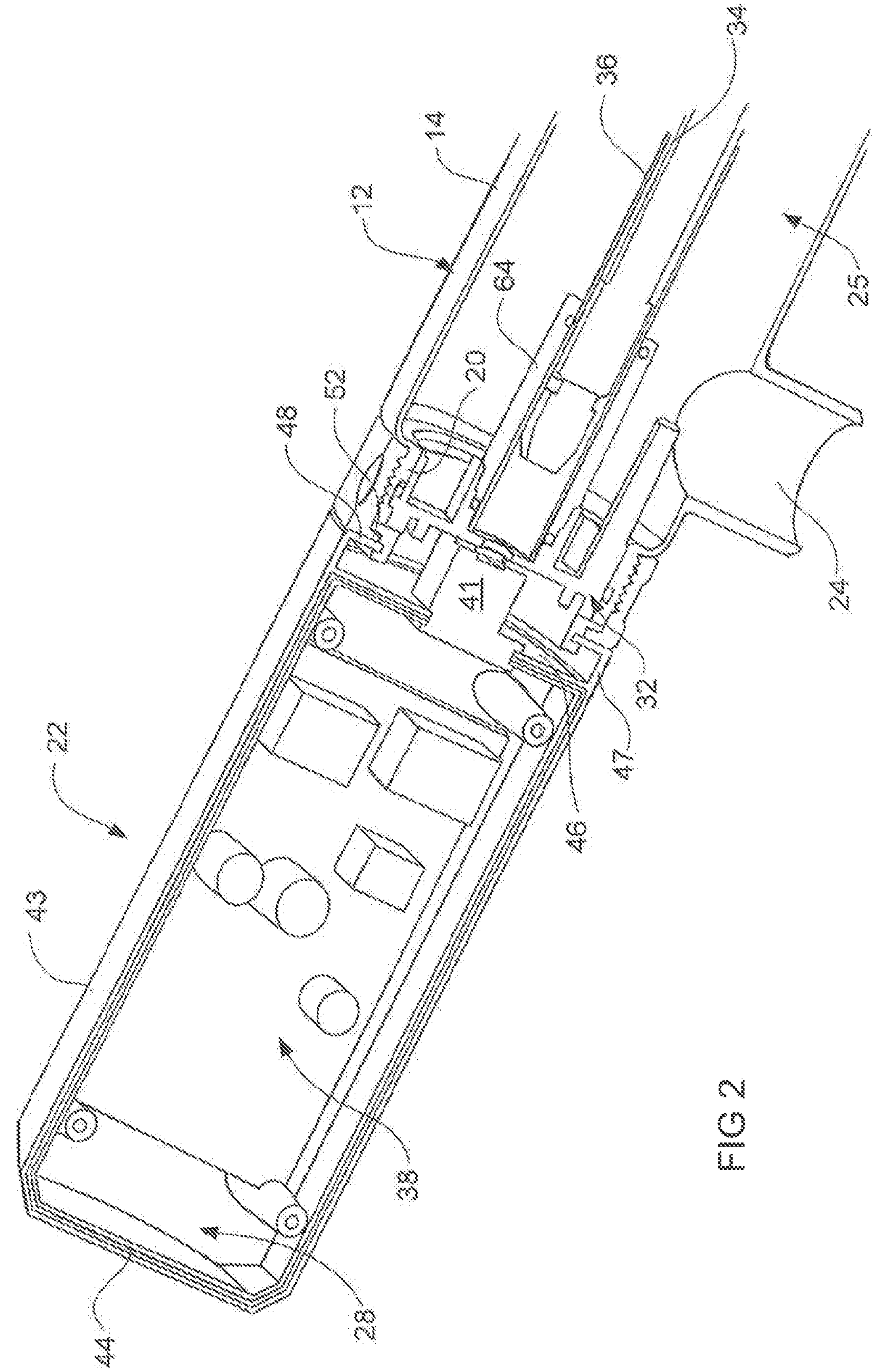


FIG 2

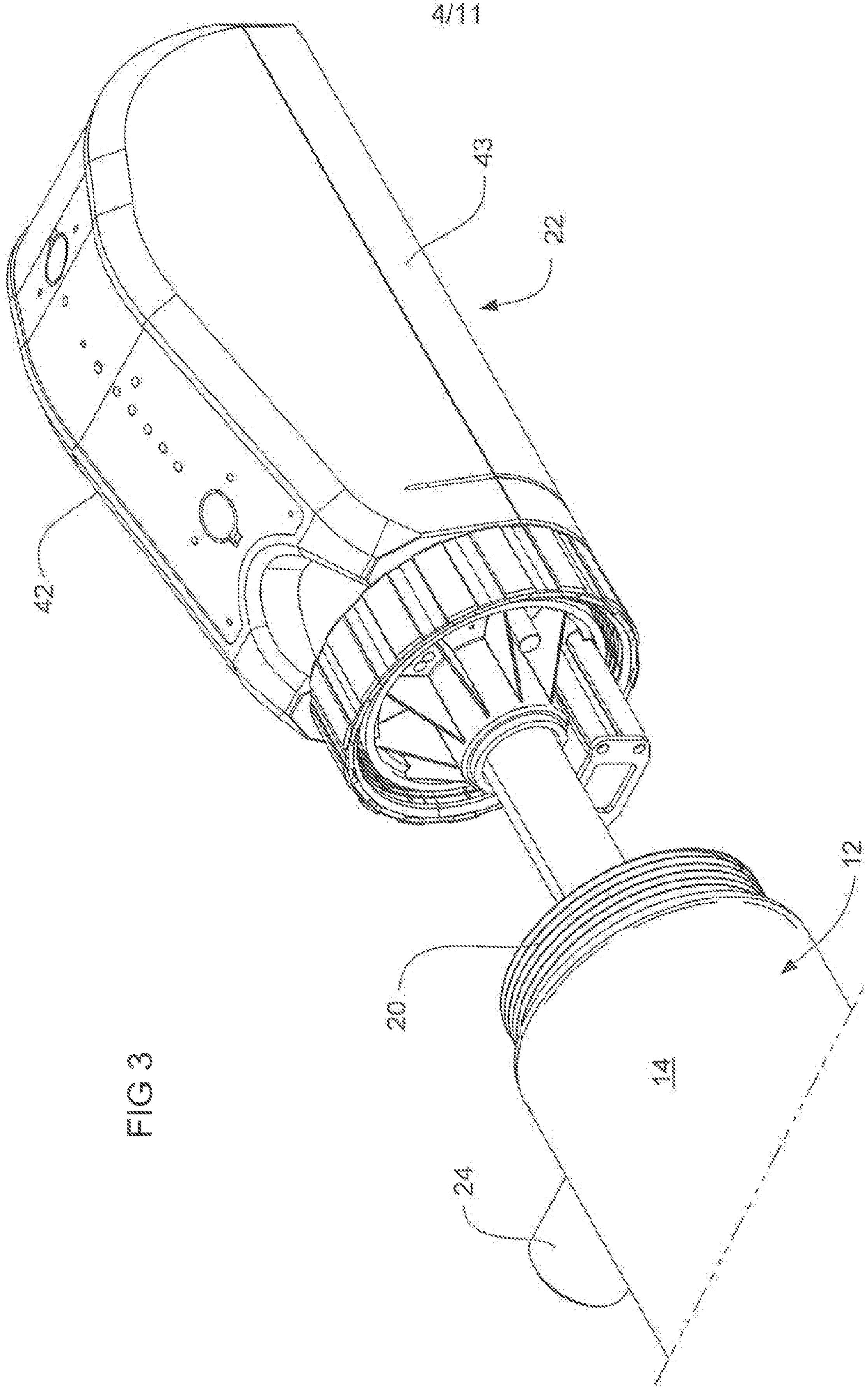
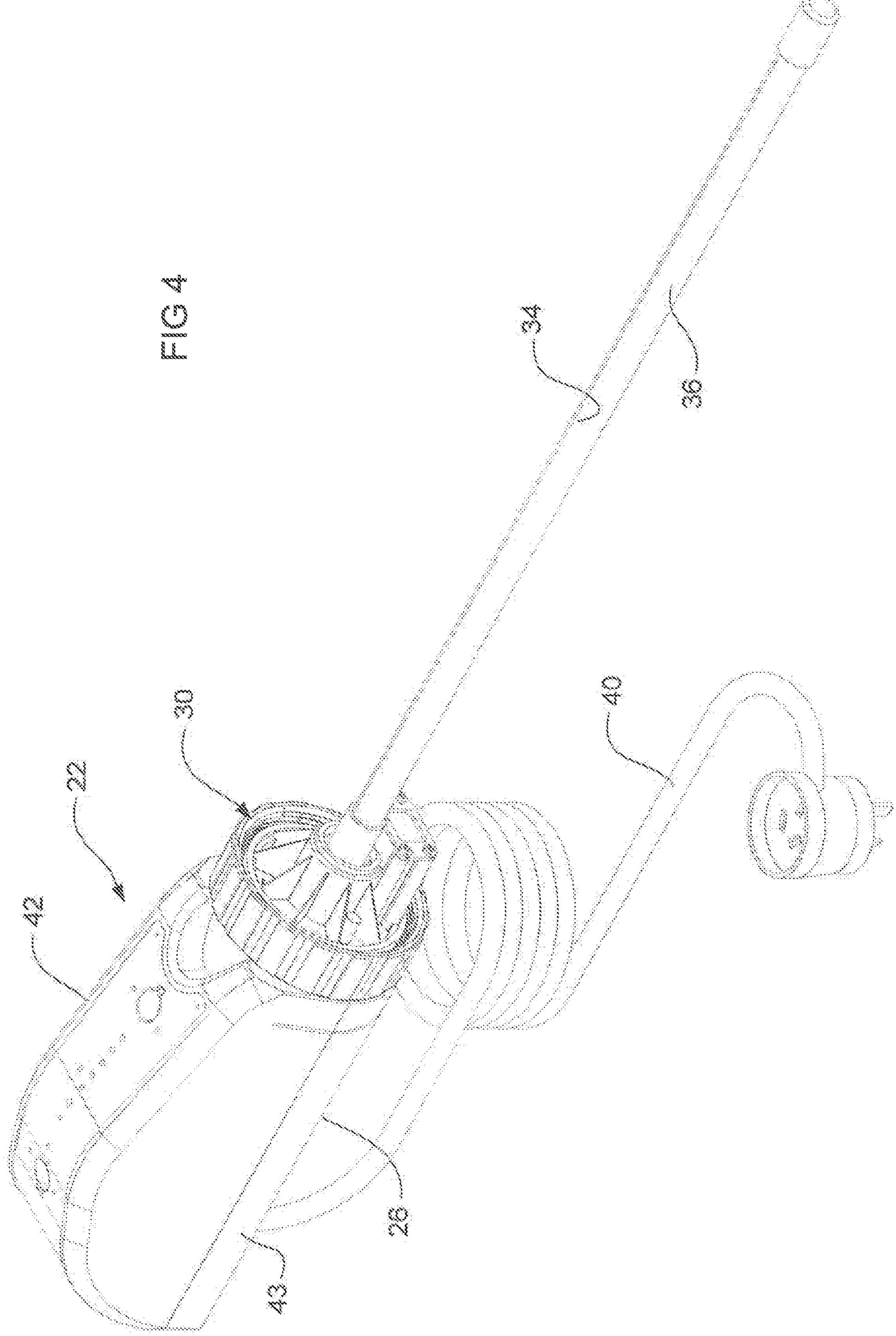


FIG 3

FIG 4



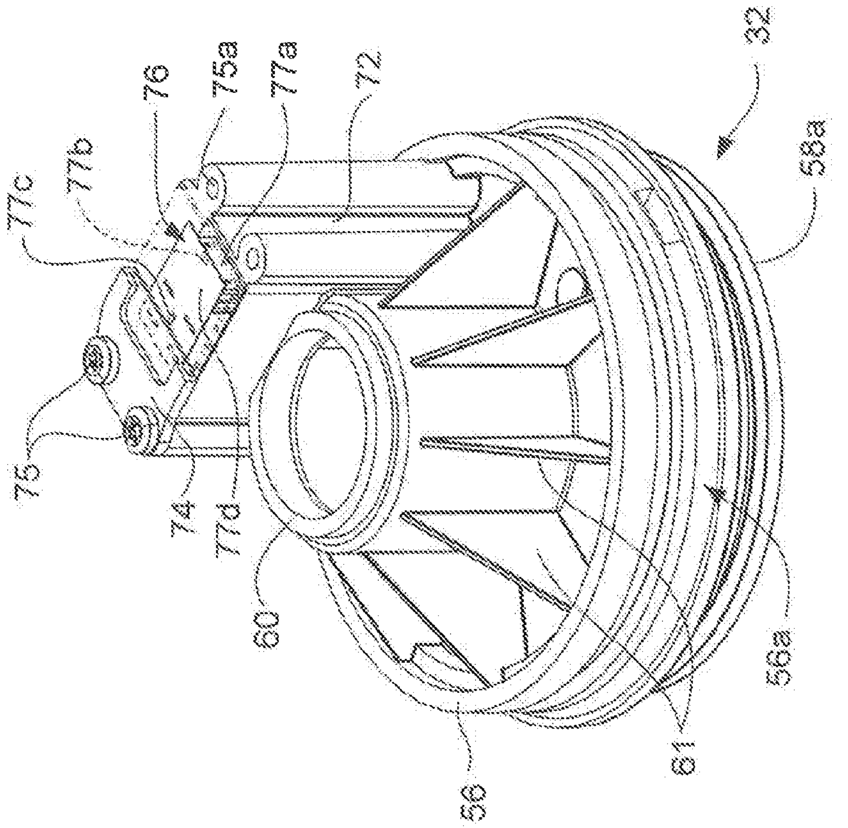

32
72
77a
75a
76
77b
77c
75
74
77d
60
56
61
56a
58a

FIG 6

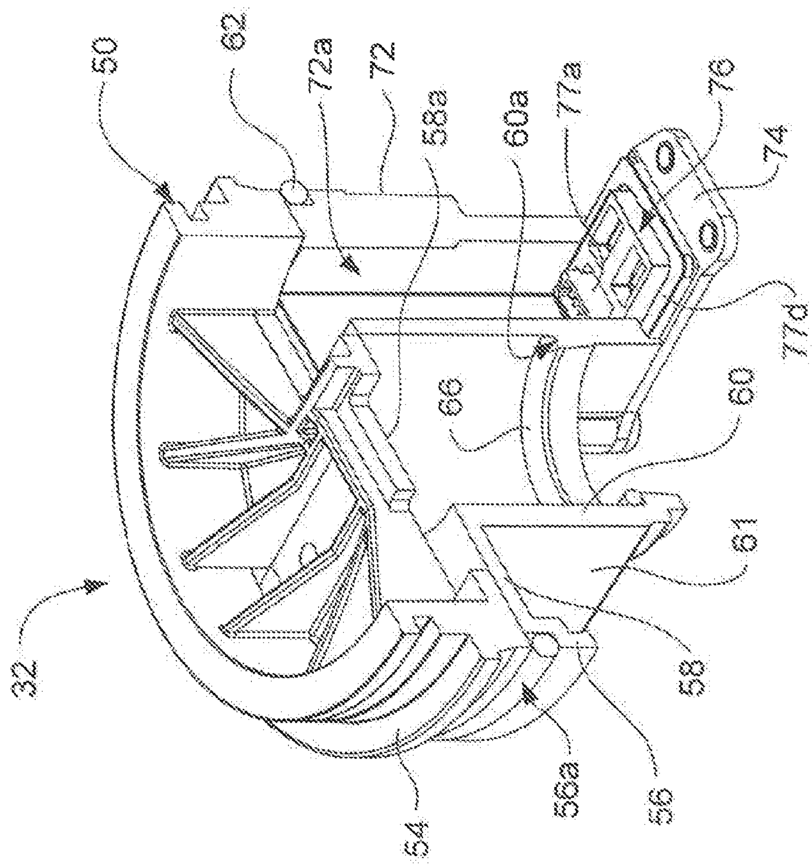

50
62
72a
72
58a
60a
77a
76
74
77d
66
60
61
58
56
56a
54
32

FIG 5

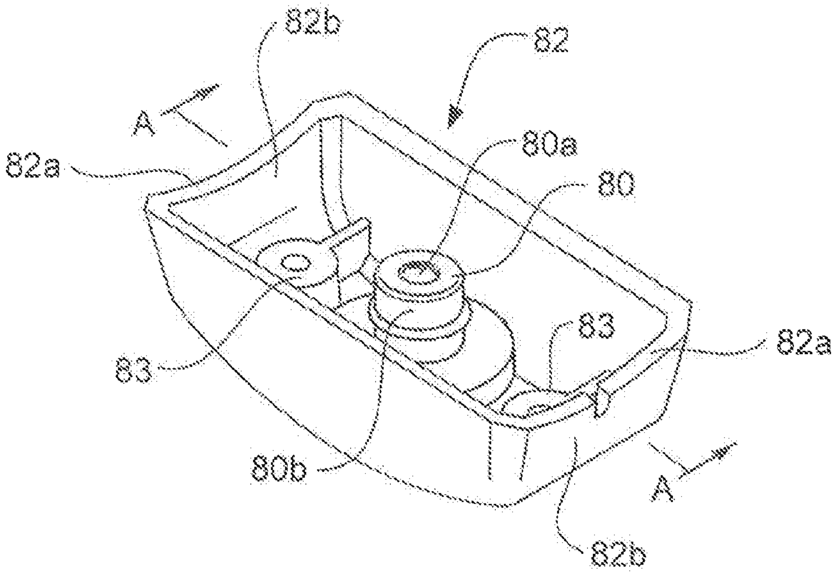

82b
82
A
80a
82a
80
83
82a
83
80b
A
82b

FIG 7

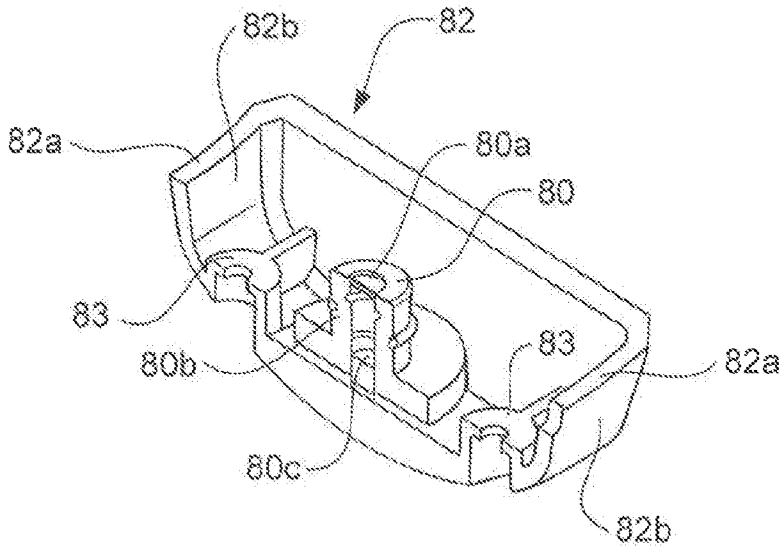

82b
82
82a
80a
80
83
80b
83
82a
80c
82b

FIG 8

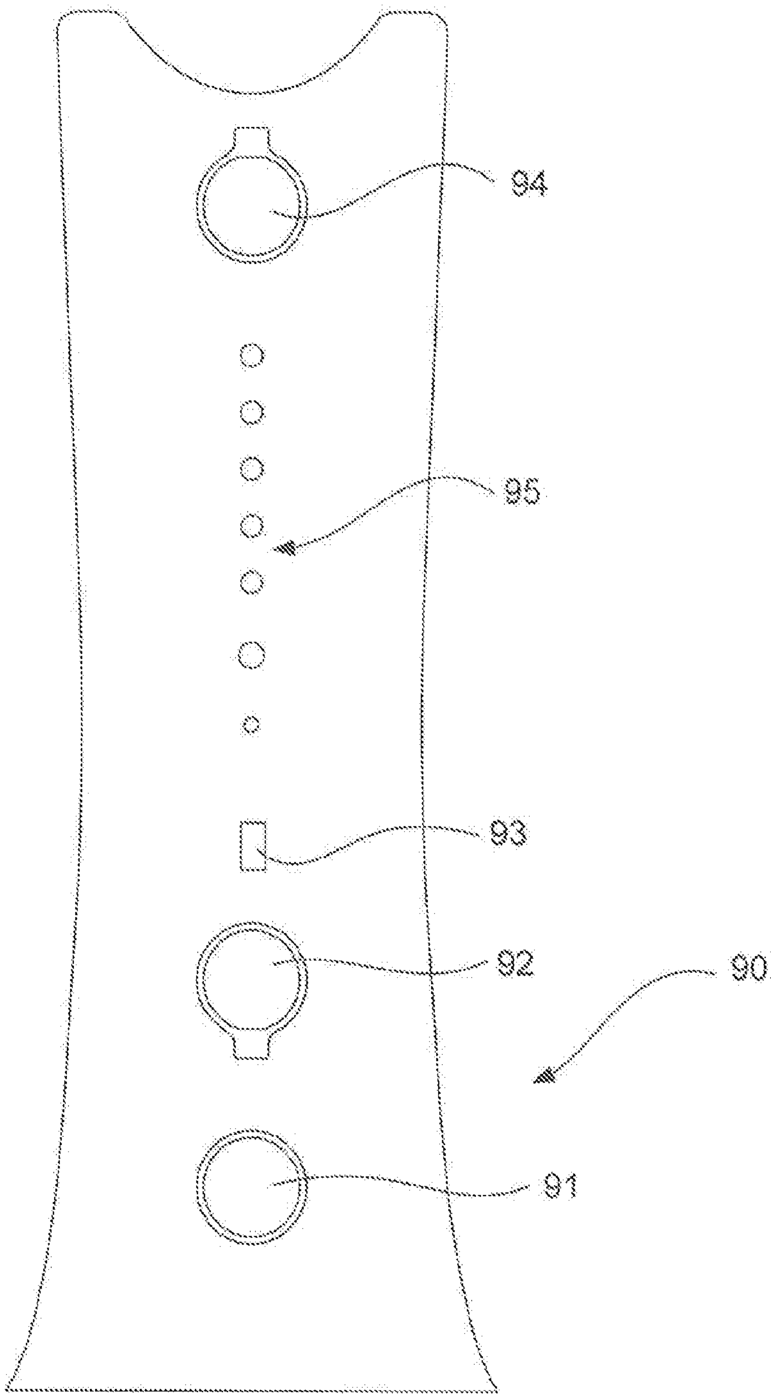


FIG 9

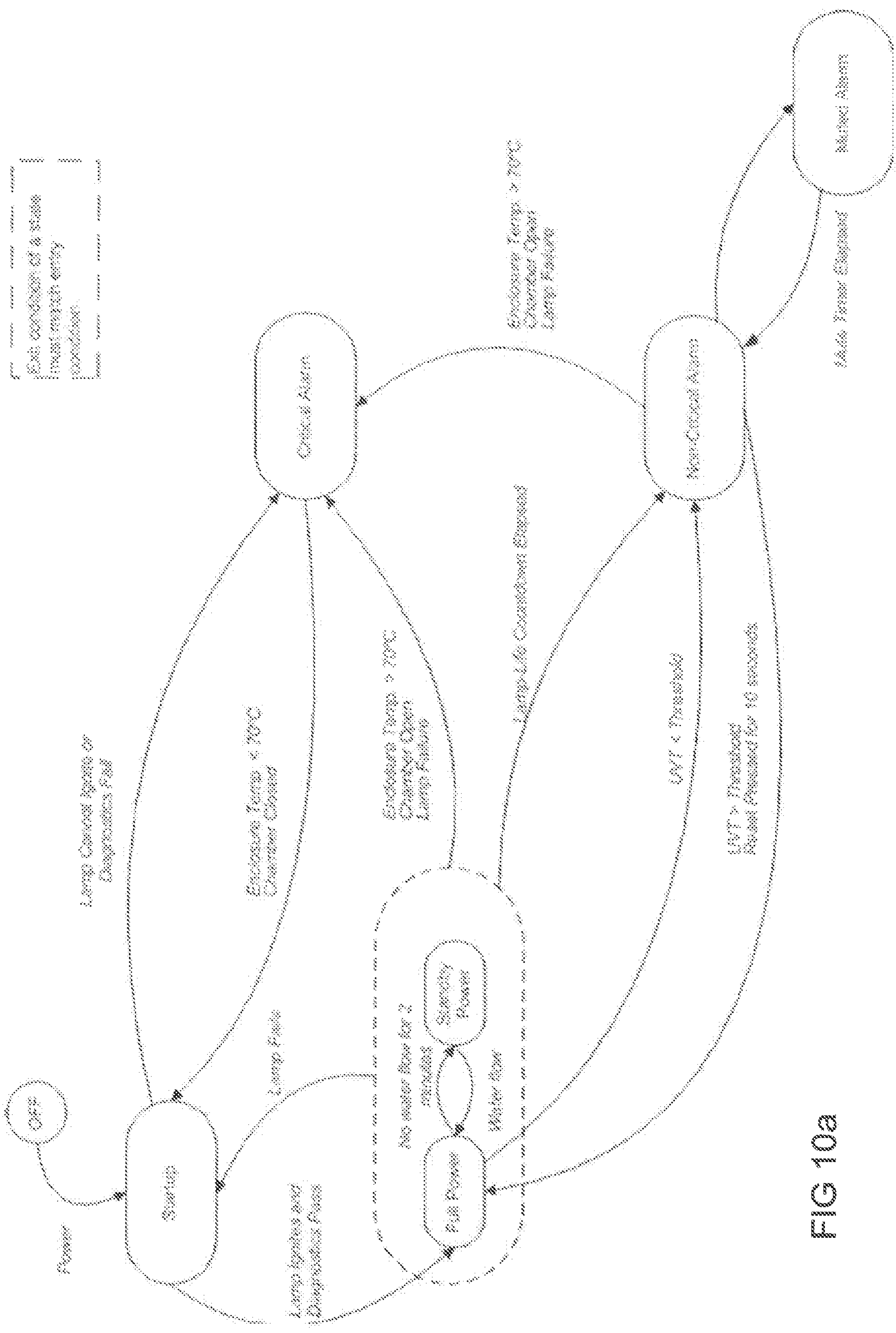
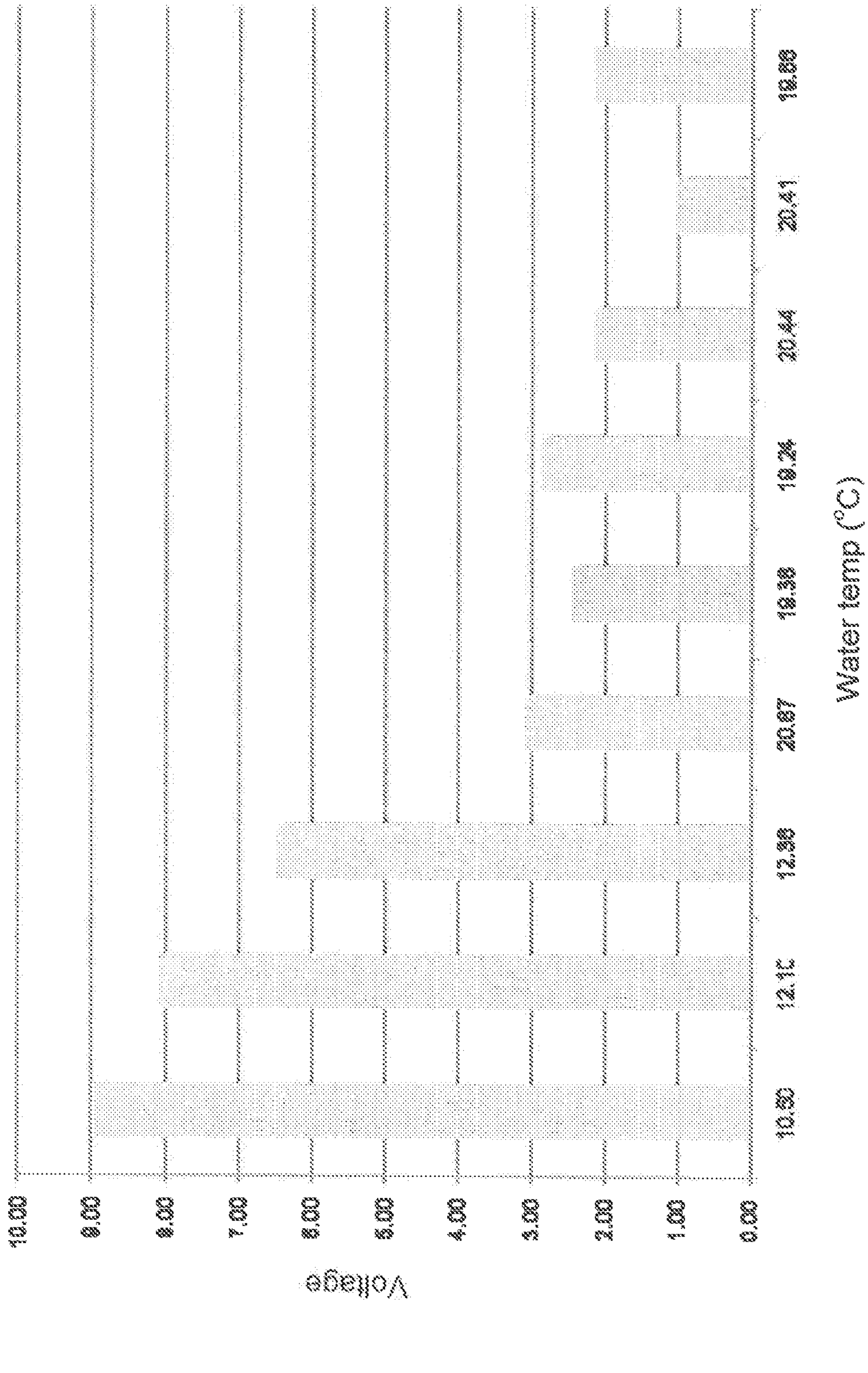

OFF
Power
Startup
Lamp Cannot Ignite or
Diagnostics Fail
Exit condition of a state
must match entry
condition.
Enclosure Temp < 70°C
Chamber Closed
Lamp Fails
Lamp Ignites and
Diagnostics Pass
Critical Alarm
No water flow for 2
minutes
Full Power
Standby
Power
Water flow
Enclosure Temp > 70°C
Chamber Open
Lamp Failure
Lamp Life Countdown Elapsed
Enclosure Temp > 70°C
Chamber Open
Lamp Failure
UVT < Threshold
Non-Critical Alarm
UVT > Threshold
Reset Pressed for 10 seconds
Muted Alarm

FIG 10a

	Lamp Power	Pump Relay	Alarm Relay	Audible Alarm	Power LED	Standby LED	Lamp Life Bar LED	Alarm Muted LED	UVT LED
Off	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
Startup	Starting	OFF	ON	ON	RED	OFF	RED (ALL)	RED (ALL)	RED
Full Power	100%	ON	OFF	OFF	GREEN	OFF	GREEN (LIFE)	GREEN (LIFE)	GREEN
Standby Power	Dimmed (20-90%)	ON	OFF	OFF	GREEN	GREEN	GREEN (LIFE)	GREEN (LIFE)	GREEN
Critical Alarm	OFF	OFF	ON	ON	RED FLASHING	OFF	RED FLASHING	RED FLASHING	OFF
Non-Critical Alarm	100%	OFF	ON	ON	GREEN	OFF	RED (BOTTOM ONLY)	RED (BOTTOM ONLY)	RED
Muted Alarm	100%	ON	OFF	OFF	GREEN	OFF	RED	RED	RED

FIG 10b

FIG 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/001112

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

C02F 1/32 (2006.01) ***A61L 2/10*** (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI, EPODOC: IPC marks-(/IC/EC C02F1/32, C02F1/32D, A61L2/10, A61L9/20, A61L2/00P2R6, G01N21/01) & keywords: ultra violet, UV lamp, water treatment, housing, vessel, chamber, storage, flow sensor, control, thermistor and like terms; Esp@cenet, Google Patents, Patent Lens, ScienceDirect & Google Scholar (including NPL) using similar keywords.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4017734 A (ROSS) 12 April 1977 Abstract; col. 1, lines 57-64; col. 2, lines 20-67; col. 3, lines 1-26; claims 1-5; Fig. 3; claim 7	1-10
A	US 6057917 A (PETERSEN et al.) 2 May 2000 Abstract; col. 3, lines 1-60; Fig. 1; claim 1	
A	US 2005/0247614 A1 (WIEMER et al.) 10 November 2005 Abstract; claims 1-23	

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

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 October 2011	19 OCTOBER 2011

Name and mailing address of the ISA/AU	Authorized officer
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Patent Document Cited in Search Report		Patent Family Member					
US	4017734	NONE					
US	6057917	CA	2298151	CA	2323333	US	6541777
US	2005247614	NONE					

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX