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[Continued on next page]

(54) Title: OZONE-BASED DISINFECTING DEVICE AND MIXER THEREFOR

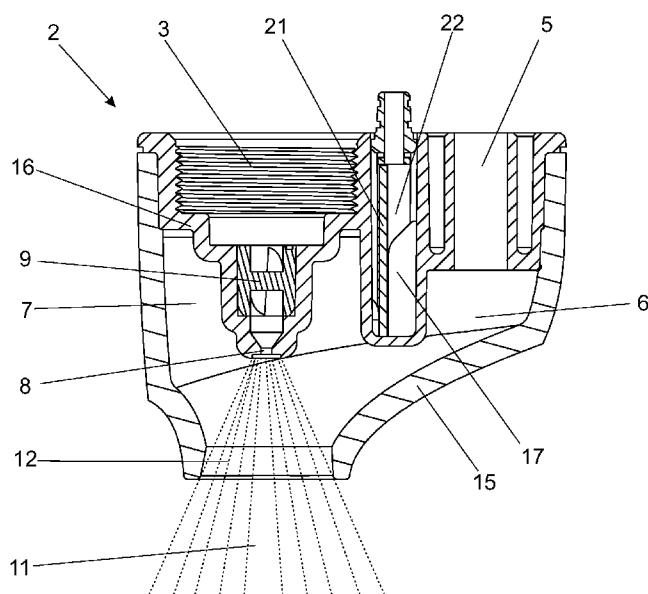


Figure 5

(57) Abstract: An ozone-based disinfecting device is provided comprising a mixer having a generally hollow body with a water inlet for water under pressure, a spray nozzle for generating a generally conical spray of water introduced by way of the water inlet, a contact chamber communicating with a gas inlet for ozone rich gases, and an outlet aperture from the contact chamber. The outlet aperture is coaxial with the spray nozzle and axially spaced apart therefrom. The diameter of the outlet aperture corresponds substantially to the diameter of the conical spray at that position so that substantially no free space exists between the outside of the conical spray and the periphery of the outlet, in use. The contact chamber generally has a larger cross-sectional size than the diameter of the outlet aperture.

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OZONE-BASED DISINFECTING DEVICE AND MIXER THEREFOR

5 FIELD OF THE INVENTION

This invention relates to an ozone-based disinfecting device of the general nature in which the device, in use, generates a water spray having an effective and appropriate quantity of ozone embodied therein. More
10 particularly, the invention relates to an ozone-based disinfecting device that is suitable for use in relation to food, although it may be used in many other applications.

Still more particularly, the invention relates to a disinfecting device of the
15 general nature described in our earlier published international patent application WO 2010/001279.

BACKGROUND TO THE INVENTION

20 Microbial outgrowth is a primary concern amongst the food processing industry and consumers. The presence of pathogenic microorganisms on food products can potentially lead to food-borne outbreaks of disease.

Chlorine-based chemicals such as sodium hypochlorite, calcium
25 hypochlorite, sodium dichloroisocyanurate and quaternary ammonium compounds have been employed for disinfecting food products in the past. However, chlorine is most effective at a pH of 6 to 8, and becomes less effective outside of this pH range. Also, chlorine can produce toxic byproducts that are harmful to human health, such as chloramines and
30 trihalomethanes.

As a result of this, the European Union has imposed a bar against the use of chlorine compounds for disinfecting food produce, as specified by the EU Directive 2092/91. There has consequently been a concerted effort to improve technology employing non-chlorine based products for the decontamination of food products. This has resulted in an increased interest in the disinfecting properties of ozone. The use of ozone for disinfecting food has been approved by the United States Food and Drug Administration (FDA).

It is noted that ozone is reported to have about 1.5 times the oxidizing potential of chlorine with contact times for the anti-microbial action of ozone being typically four to five times less than that of chlorine.

Ozone has been shown to be a highly reactive oxidant that is capable of killing microorganisms such as bacteria as well as reacting with other chemicals such as pesticides and herbicides. Of course, a major advantage of ozone is its natural decomposition into oxygen and thus its use in disinfecting food products is highly beneficial as it decomposes into a non-toxic gas. It therefore does not impart odour to, or taint, food products, and no residual compounds or toxic residue remains. Rinse water can be discharged to the environment or used for other applications without additional treatment or decontamination.

In prior art disinfecting processes using ozone that are known to applicant, venturi injection systems and bubble diffusers have been used to mix ozone into water. In the case of venturi injectors, water is forced through a convergent conical body, initiating a pressure differential between the inlet and the outlet of the system. This creates a vacuum inside the body of the injector, thereby initiating a flow of ozone rich air through a suction port.

30

As regards bubble diffusers, ozone is emitted in bubbles beneath the surface of the water. Irrespective of the problems further identified below, bubble

diffusers suffer from an inherent disadvantage in that diffuser holes frequently become fouled over time thereby decreasing the efficiency of the system.

5 In both instances, ozone is dissolved into the water, typically from an ozone rich air, and an appreciable proportion of the sterilizing ability of the ozone may be spent on sterilizing the water itself. This leaves a reduced amount of ozone available for effective disinfecting of the ultimate target that may be fresh produce, for example.

10 Furthermore, these prior art systems appear to allow free gaseous ozone to be released into the atmosphere in higher concentrations than is permitted by regulatory standards. It is to be noted that free ozone in the air is harmful when it exceeds predetermined concentrations.

15 In this regard it is to be noted that in the European Union, the current target value for ozone concentrations is reported to be 120 $\mu\text{g}/\text{m}^3$ which is about 60 nmol/mol. This target applies to all member states in accordance with Directive 2008/50/EC although there is no date set for formalizing this as a requirement and it is treated as a long-term objective. In the USA, in May
20 2008, the Environmental Protection Agency (EPA) lowered its ozone standard from 80 nmol/mol to 75 nmol/mol. This was done in spite of the fact that the Agency's own scientists and advisory board had recommended lowering the standard to 60 nmol/mol. The EPA has developed an Air Quality Index to help explain air pollution levels to the general public and
25 presently the current standards describe an eight-hour average ozone mole fraction of 85 to 104 nmol/mol as "unhealthy for sensitive groups"; 105 nmol/mol to 124 nmol/mol as "unhealthy"; and 125 nmol/mol to 404 nmol/mol as "very unhealthy". The World Health Organization recommends 51 nmol/mol.

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Excess ozone in the air is therefore quite undesirable and it is important that any disinfecting device using ozone as its active disinfecting medium should

not release any appreciable quantities of ozone into the atmosphere, whilst providing an effective concentration to destroy target bacteria etc.

There is a need for an ozone-based disinfecting device that overcomes, at least to some extent, the difficulties perceived with the prior art devices outlined above.

SUMMARY OF THE INVENTION

10 In accordance with a first aspect of this invention there is provided an ozone-based disinfecting device comprising a mixer having a generally hollow body with a water inlet for water under pressure; a spray nozzle for generating a generally conical spray of water introduced by way of the water inlet; a contact chamber communicating with a gas inlet for ozone rich gases; and an
15 outlet aperture from the contact chamber with the outlet aperture being coaxial with the spray nozzle and spaced apart therefrom, wherein the diameter of the outlet aperture corresponds substantially to the diameter of the conical spray at that position so that substantially no free space exists between the outside of the conical spray and the periphery of the outlet, in
20 use.

Further features of the first aspect of the invention provide for the contact chamber to have a larger cross-sectional size than the diameter of the outlet aperture; for the gas inlet for ozone rich gases to have an axis parallel to, but
25 laterally offset from, that of the water inlet with a gas inlet chamber merging laterally with the contact chamber; for the mixer body to be composed of a first part in the form of a shroud defining the outlet aperture that receives, in an open end thereof opposite the outlet aperture, a second part defining the water inlet, gas inlet and a pocket for receiving an electronic flow sensing
30 device for sensing the extent of flow of water through the spray nozzle with the second part of the body being received in the open end of the shroud part of the body in plug-like manner; and for both the first and second parts of the

mixer body to be injection moulded or die cast from suitable ozone resistant material.

Still further features of the first aspect of the invention provide for the flow sensing device to include a piezoelectric sensor and associated circuit, typically in the form of a printed circuit board housed within the mixer body, conveniently in the aforesaid pocket where same is present; for the flow sensing device and associated circuit to be arranged to activate and deactivate an ozone generator operatively connected to the gas inlet for ozone rich gases; for a signal outputted by the flow sensing device and associated circuit to activate and deactivate a fan supplying air to the ozone generator and capable of running at different speeds dependent on the flow rate of water through the spray nozzle with the activation of the fan being effected before activation of the ozone generator takes place and deactivation of the fan being effected after deactivation of the ozone generator takes place; and for the water inlet to be configured as a screw threaded socket for application directly to a complementarily screw threaded spout of a tap or other tubular water dispensing item.

In accordance with a second aspect of the invention there is provided an ozone-based disinfecting device comprising a mixer as defined above; an ozone generator operatively connected to the gas inlet for ozone rich gases in the mixer; and a control circuit connected to the flow sensing device and any associated circuit, wherein the control circuit is configured to activate the ozone generator once a signal is received from the flow sensing device and any associated circuit corresponding to a minimum flow rate of water through the mixer that is required to develop a suitable spray cone of water occupying the outlet aperture from the contact chamber and to deactivate the ozone generator once the signal received corresponds to less than said minimum flow rate.

Further features of the second aspect of the invention provides for a variable speed fan to be included for blowing air through the ozone generator and into the contact chamber of the mixer with the variable speed fan being controlled by the control circuit in response to signals received from the flow sensing device; for the control circuit to activate and deactivate the fan dependent on the flow rate of water through the spray nozzle with activation of the fan being effected before activation of the ozone generator takes place and deactivation of the fan being effected after deactivation of the ozone generator takes place; for the fan to be driven by a DC electric motor wherein the speed of the DC motor is controlled by the control circuit; for the electric fan to be a centrifugal fan; and for the ozone generator to be a corona discharge type of ozone generator.

In accordance with a third aspect of the invention there is provided a method of producing a disinfecting spray of water carrying ozone as an active disinfectant, the method being characterized in that it comprises generating a conical spray of water that is sprayed into a contact chamber in which ozone rich gases are introduced so that the spray passes through the contact chamber and out of an outlet aperture that is coaxial with the spray generating nozzle so that ozone is carried with the spray out of the outlet.

It is to be noted that practice of the present invention results in ozone rich gases becoming entrained with multitudinous water droplets of the spray and it is believed that the ozone adheres itself in some way, possibly electromagnetically or electro-statically, to the surface of the water droplets without any appreciable proportion of the ozone becoming dissolved in the water. This theory explains the practical measurements taken to date that indicate that more ozone is carried by the water than would normally be soluble in it. Tests conducted to date have also revealed that there is substantially no free ozone in the air surrounding the disinfecting spray and there is little or no ozone remaining in the spent water. Practice of the

invention apparently approaches optimal use of ozone and enables it to be highly effective in its disinfecting activity.

5 It is to be mentioned that the tests conducted were fairly rudimentary but clearly indicated that limited ozone became dissolved in the water droplets as a result of the fact that a blue dye was included in the water and whilst the dye did oxidise to a colourless state at the time, only very limited oxidation was observed at the time of spraying.

10 Whilst the mechanism of the attachment or otherwise of ozone molecules to the water droplets of the spray is not yet fully understood, or fully researched technically, tests conducted to date indicate that the droplet size developed by the spray is preferably between 10 and 50 μm and the water spray cone preferably has a cone angle of between 35° and 45°.

15 Also, the flow developed by the fan and the reduction in pressure created by the flow of the conical spray out of the outlet aperture, is such that a slightly negative pressure, of the order of 10 mm of water (100 Pa), is maintained within the contact chamber. In this regard, further tests will be directed at
20 establishing whether or not it is practical to do away with the fan completely and this will depend largely on the negative pressure that is generated within the contact chamber and the nature of the flow path through the ozone generator to the mixer.

25 Also, the flow developed by the fan and the reduction in pressure created by the flow of the conical spray out of the outlet aperture, is believed to be generally balanced so that a slightly negative pressure, of the order of 10 mm of water (100 Pa), is maintained within the contact chamber.

30 In order that the above and other features of the invention may become more apparent, one embodiment embracing all of the different aspects of the

invention will now be described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

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In the drawings:-

- Figure 1 is a schematic illustration of the various components of an ozone-based disinfecting device according to the invention;
- 10 Figure 2 is an illustration of the ozone generator used in the device illustrated in Figure 1 with its cover removed;
- Figure 3 is a similar illustration of the ozone generator with certain components removed in order to reveal others;
- 15 Figure 4 is an exploded perspective view of the mixer according to this invention;
- Figure 5 is a sectional elevation of the mixer according to the invention;
- 20 Figure 6 is a plan view of the mixer;
- 25 Figure 7 and,
- Figure 8 is a graph showing the variation of output from the piezoelectric sensor and associated circuit and to the water pressure as against flow rate through the mixer.

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DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS

In the embodiment of the invention illustrated in the drawings, an ozone-based disinfecting device comprises a mixer (2) having a generally hollow body with a screw threaded socket (3) as a water inlet for water under pressure with the socket being adapted for direct connection to a screw threaded outlet from a water supply tap (4) or some other water supply device having a tubular outlet.

A gas inlet (5) for ozone rich gases has its axis parallel to, but laterally offset from, that of the water inlet with a gas inlet chamber (6) merging laterally with an otherwise generally cylindrical contact chamber (7) surrounding the water inlet. The mixer has a spray nozzle (8) that embodies a swirler (9) (see Figure 4) for generating a generally conical spray (11) of water introduced by way of the water inlet (see Figure 5) such that the conical spray is directed into the contact chamber and towards a coaxial reduced diameter outlet aperture (12) spaced apart therefrom. The contact chamber itself has a larger cross-sectional size than the diameter of the outlet aperture. The spray nozzle is coaxial with the water inlet and the nozzle itself is located generally centrally in the contact chamber.

The diameter of the outlet aperture corresponds substantially to the outer diameter of the conical spray at that distance from the nozzle so that substantially no free space exists between the outside of the conical spray and the periphery of the outlet. In fact, in use, the outer perimeter of the conical spray may be cut off slightly by the periphery of the outlet aperture although care should be taken that the extent of this should not cause larger droplets to coalesce on the perimeter of the outlet.

As regards the construction of the mixer body, it is conveniently composed of a first part (15) in the form of a shroud defining the outlet aperture and an open end opposite the outlet aperture that receives a second part (16) defining the water inlet, gas inlet, as well as a pocket (17) between the water inlet and gas inlet. The lateral merging of the gas inlet chamber and contact

chamber, in this instance, takes place on the sides and beneath the outer walls of the pocket.

5 The second part of the body is received in the open end of the shroud part of the body in plug-like manner, as will be most apparent from Figure 4 of the accompanying drawings. Both the first and second parts of the mixer body may be injection moulded or die cast from suitable ozone resistant material and the two parts may be permanently sealed together in any suitable manner including ultrasonic welding, solvent welding and adhesive.

10

The mixer includes a flow sensing device in the form of a piezoelectric sensor (21) that is connected to an associated circuit in the form of an electronic signal generating printed circuit board (22) that serves to amplify signals generated by the piezoelectric sensor and provide an output appropriate for
15 operating a control circuit that is described further below.

In order to ensure that the piezoelectric sensor is activated adequately by the vibration created by water passing through the mixer, the piezoelectric sensor itself, as well as its associated circuit in the form of the printed circuit
20 board (22), are received in the pocket (17) in the mixer body and the remaining space within the pocket is filled with a suitable settable material. The settable material will thus ensure that vibrations generated are properly transferred to the piezoelectric sensor.

25 Of course, the piezoelectric sensor is sensitive to vibration set up by water as it passes through the nozzle and the vibration will vary, typically in frequency, with the flow rate of water. Figure 7 is a graph illustrating the variation of flow rate with pressure and the output from the piezoelectric sensor and associated circuit.

30

A separate ozone generator (25) of generally known construction and of the corona discharge type is operatively connected by way of a suitable tube (26)

to the gas inlet (5) for ozone rich gases to the mixer. The ozone generator is, however, modified to operate in terms of this invention and houses a control circuit on a printed circuit board (27) (see Figure 3) within the ozone generator housing.

5

The ozone generator is also connected to the mixer by way of a communications cable (28) that serves to supply the printed circuit board (22) and piezoelectric sensor (21) in the pocket within the mixer with electrical energy at a low DC voltage and to convey signals generated in response to the piezoelectric sensor to the control circuit in the ozone generator housing.

10

The control circuit incorporates a suitable transformer and rectifier for connection by way of a suitable cable (31) to an electrical mains power outlet supply. The control circuit is configured to activate a corona discharge ozone generator unit (32) once a signal is received from the mixer corresponding to a minimum predetermined flow rate of water through the mixer that will correspond to the development of a spray cone of water occupying the outlet aperture from the contact chamber. The control circuit similarly deactivates the ozone generator unit once the signal received from the mixer corresponds to less than said minimum flow rate. It will be understood that, in this manner, the generation of ozone in the absence of an adequate flow of water through the mixer is avoided and ozone cannot be liberated into the atmosphere in consequence.

15

20

The ozone generator, in this embodiment of the invention, also includes a variable speed centrifugal fan (33) for blowing air through the ozone generator and thence into the contact chamber of the mixer by way of the gas inlet (5) and gas inlet chamber (6). The centrifugal fan has a substantially conventional centrifugal impeller (34) that is driven by a variable speed DC electric motor (35). The variable speed electric motor is controlled by the control circuit in response to signals received from the piezoelectric sensor such that the fan is activated before activation of the ozone generator

30

takes place and is deactivated after deactivation of the ozone generator takes place.

5 In use a disinfecting spray of water carrying ozone as an active disinfectant is generated with the spray passing through the contact chamber and out of the outlet aperture so that ozone is carried with the spray out of the outlet, as described above.

10 Operation of the disinfecting device is initiated by opening the tap to cause water to flow through the mixer and once the flow rate reaches a minimum level of, in this instance about 2 litres per minute, and preferably between 3.5 and 4 litres per minute, the control circuit will firstly switch on the DC motor that drives the fan to establish an airflow over the corona discharge unit (32) and, shortly afterwards, the high-voltage circuit of the corona discharge unit
15 is energized to start generating ozone. This routine is followed to make sure that all of the ozone that is generated is carried through to the mixer. The control circuit may also switch on an indicator light such as a blue LED to indicate that the air is flowing and that ozone is being generated.

20 As the tap is opened further the piezoelectric sensor in the nozzle causes a signal of increased flow to be sent to the control circuit which adjusts the fan speed to increase the airflow in response to the increased water flow. The disinfecting device thus has the ability to sense the rate of water flow and to supply an increased amount of ozone to the mixer when the water flow rate
25 increases.

The mixed ozone and water leave the nozzle in fine droplet / spray form and hit the target which is placed or handled in the water spray where it is cleaned.

30

Thus the air is blown by the fan through the corona discharge unit at a speed that is variable according to the signal received from the piezoelectric sensor

and its associated circuit. In this regard, it is to be noted that the piezoelectric sensor senses vibration created by the passage of water through the swirler and nozzle of the mixer and the properties of the vibrations will vary with the flow rate of water through the mixer.

5

Simply by way of example, in test equipment employed, the following pressures resulted in the stated flow rates of water and fan speeds with the stated ozone content of the water:-

10

15

20

Pressure Bar	Flow Rate litres / min	Fan Speed RPM	Ozone Content ppm
2	1.3	2000	26
		2500	29
		3000	29
2.5	1.5	2000	26
		2500	28
		3000	28
3	1.7	2000	22

25

30

			2500	25
			3000	25
	3.5	1.8	2000	22
			2500	25
5			3000	25
	4	1.9	2000	22
			2500	23
			3000	24

- 10 In spite of the foregoing, it is to be noted that it is also envisaged that the slightly reduced pressure created in the mixing chamber by virtue of the spray moving through it, may be enough to induce a satisfactory flow of air through the ozone generator thereby rendering the fan and its associated controls not necessary with a consequent saving in cost. However, in such
- 15 an instance, the pressure of the water supply should be relatively consistent within a predetermined practical range available from water mains.

Numerous variations and applications exist for the invention. Thus, for example, a portable unit could be produced as a self contained shoulder

20 slung unit with a water reservoir, a battery pack and an atomizing lance. A user could walk around an area sanitizing equipment for gyms or other large areas that cannot tolerate large volumes of water.

The nozzle could be attached to a dishwasher in order to supply a constant

25 sanitizing spray during a wash cycle. This arrangement may allow a dishwasher to have its operating temperature reduced so as to save electricity.

The nozzle could be attached to an overhead misting type of system to

30 create a gentle cooling mist over fresh produce to cool and sanitize in many situations such as a market, a transport vehicle, or any other appropriate environment.

The device could be used in a tunnel with a conveyor and multiple nozzles could be spaced apart along the length of the tunnel for large volume items that need to be sanitized. Such an arrangement could be used to sanitize
5 fish packing crates or any other fresh produce packing crates. This system could also be used to sanitize and remove pesticides on high volumes of fresh produce in packing houses.

The disinfecting device could be connected to a urinal so as to spray ozone
10 enriched water into the urinal upon flushing. In this way bacteria and odours could be reduced.

The unit may be an under-counter or wall mounted unit associated with a dedicated wash basin, for example.

15 Numerous variations of the invention exist without departing from the scope hereof.

20

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CLAIMS:

1. An ozone-based disinfecting device comprising a mixer having a generally hollow body with a water inlet for water under pressure; a
5 spray nozzle for generating a generally conical spray of water introduced by way of the water inlet; a contact chamber communicating with a gas inlet for ozone rich gases; and an outlet aperture from the contact chamber with the outlet aperture being coaxial with the spray nozzle and spaced apart therefrom, wherein the
10 diameter of the outlet aperture corresponds substantially to the diameter of the conical spray at that position so that substantially no free space exists between the outside of the conical spray and the periphery of the outlet, in use.
- 15 2. An ozone-based disinfecting device as claimed in claim 1 in which the contact chamber has a larger cross-sectional size than the diameter of the outlet aperture.
- 20 3. An ozone-based disinfecting device as claimed in either one of claims 1 or 2 in which the gas inlet for ozone rich gases has an axis parallel to, but laterally offset from, that of the water inlet with a gas inlet chamber merging laterally with the contact chamber.
- 25 4. An ozone-based disinfecting device as claimed in any one of the preceding claims in which the mixer body is composed of a first part in the form of a shroud defining the outlet aperture that receives, in an open end thereof opposite the outlet aperture, a second part defining the water inlet, gas inlet and a pocket for receiving an electronic flow
30 sensing device for sensing the extent of flow of water through the spray nozzle with the second part of the body being received in the open end of the shroud part of the body in plug-like manner.

5. An ozone-based disinfecting device as claimed in any one of the preceding claims in which the flow sensing device includes a piezoelectric sensor and associated circuit.
- 5 6. An ozone-based disinfecting device as claimed in claim 5 in which the piezoelectric sensor and associated circuit are in the form of a printed circuit board housed within the mixer body.
7. An ozone-based disinfecting device as claimed in any one of the
10 preceding claims in which the flow sensing device and associated circuit are arranged to activate and deactivate an ozone generator operatively connected to the gas inlet for ozone rich gases.
8. An ozone-based disinfecting device as claimed in any one of the
15 preceding claims in which a signal outputted by the flow sensing device and associated circuit activates and deactivates a fan supplying air to an ozone generator with the activation of the fan being effected before activation of the ozone generator takes place and deactivation of the fan being effected after deactivation of the ozone
20 generator takes place.
9. An ozone-based disinfecting device as claimed in any one of the preceding claims in which the water inlet is configured as a screw threaded socket for application directly to a complementarily screw
25 threaded spout of a tap or other tubular water dispensing item.
10. An ozone-based disinfecting device as claimed in any one of the preceding claims in which an ozone generator is operatively connected to the gas inlet for ozone rich gases in the mixer and a
30 control circuit is connected to the flow sensing device and any associated circuit to activate the ozone generator once a signal is received from the flow sensing device and any associated circuit

corresponding to a minimum flow rate of water through the mixer that is required to develop a suitable spray cone of water occupying the outlet aperture from the contact chamber and to deactivate the ozone generator once the signal received corresponds to less than said minimum flow rate.

5

11. An ozone-based disinfecting device as claimed in claim 10 in which the ozone generator is a corona discharge type of ozone generator.

10 12. A method of producing a disinfecting spray of water carrying ozone as an active disinfectant, the method being characterized in that it comprises generating a conical spray of water that is sprayed into a contact chamber in which ozone rich gases are introduced so that the spray passes through the contact chamber and out of an outlet aperture that is coaxial with the spray generating nozzle such that

15 ozone is carried with the spray out of the outlet.

15

13. An ozone-based disinfecting device as claimed in any one of claims 1 to 11 in which the droplet size developed by the spray is between 10 and 50 μm .

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14. An ozone-based disinfecting device as claimed in any one of claims 1 to 11 or 13 in which and the water spray cone has a cone angle of between 35° and 45°.

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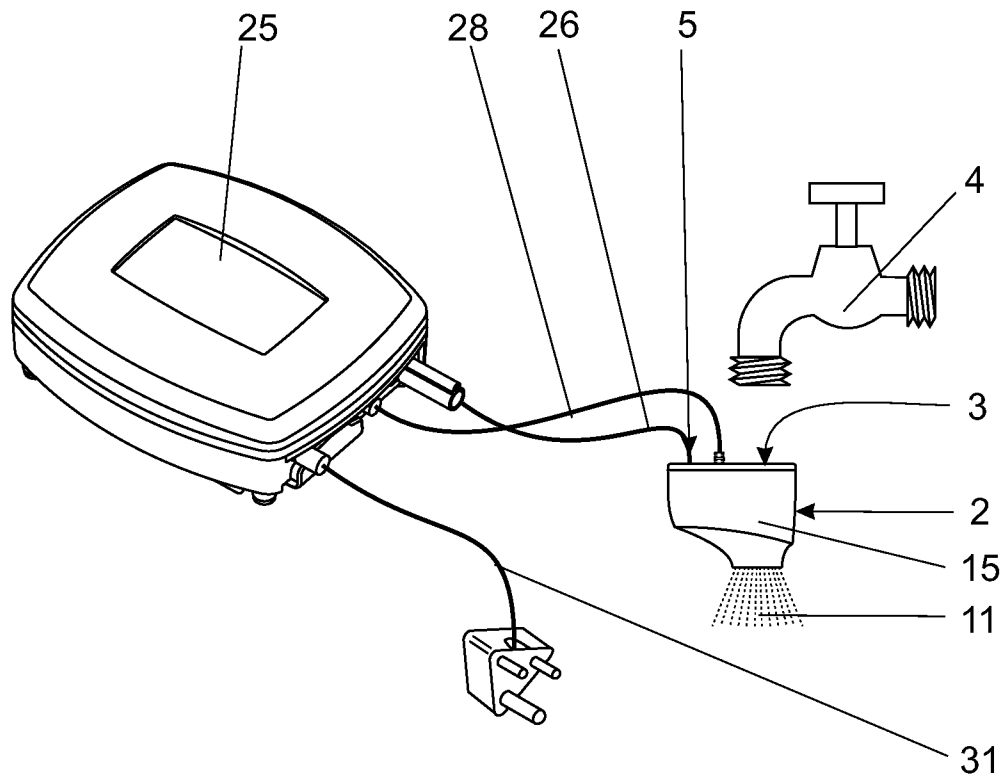


Figure 1

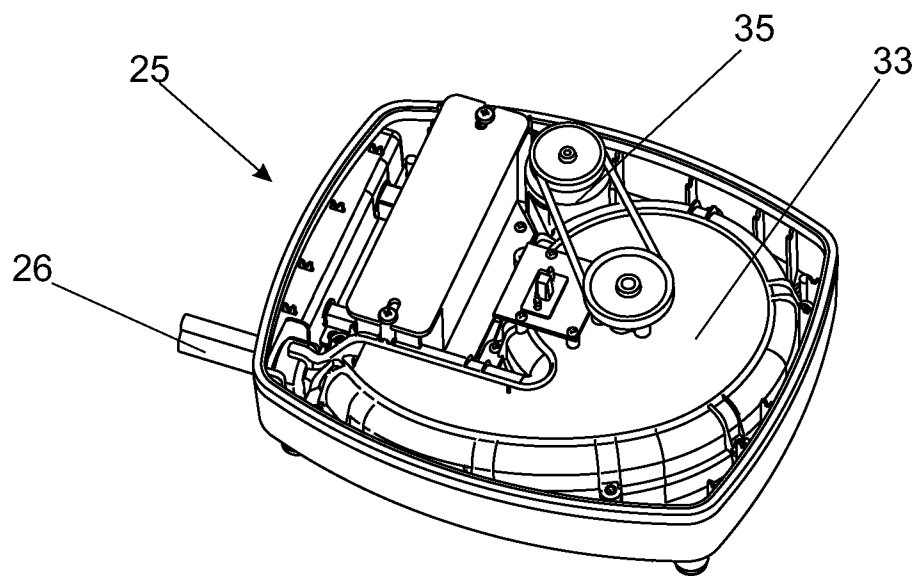


Figure 2

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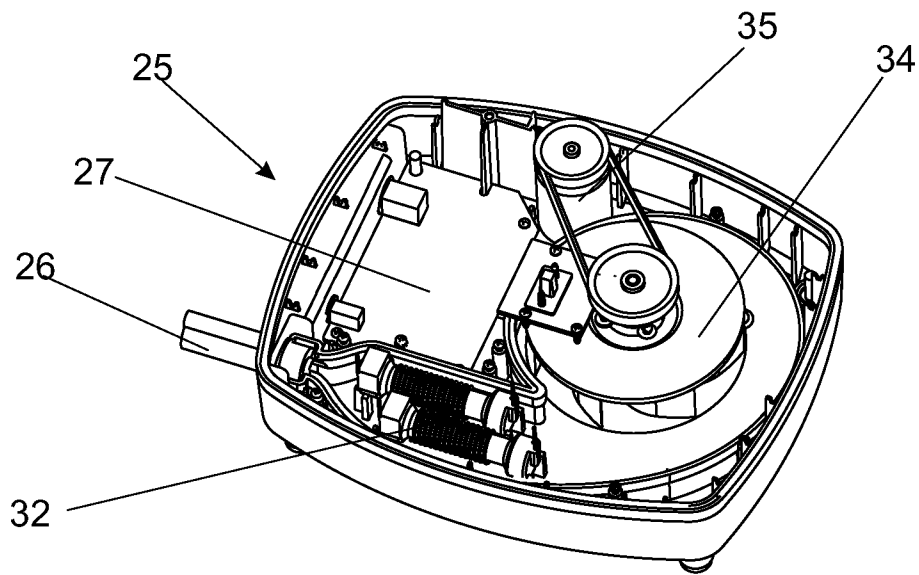


Figure 3

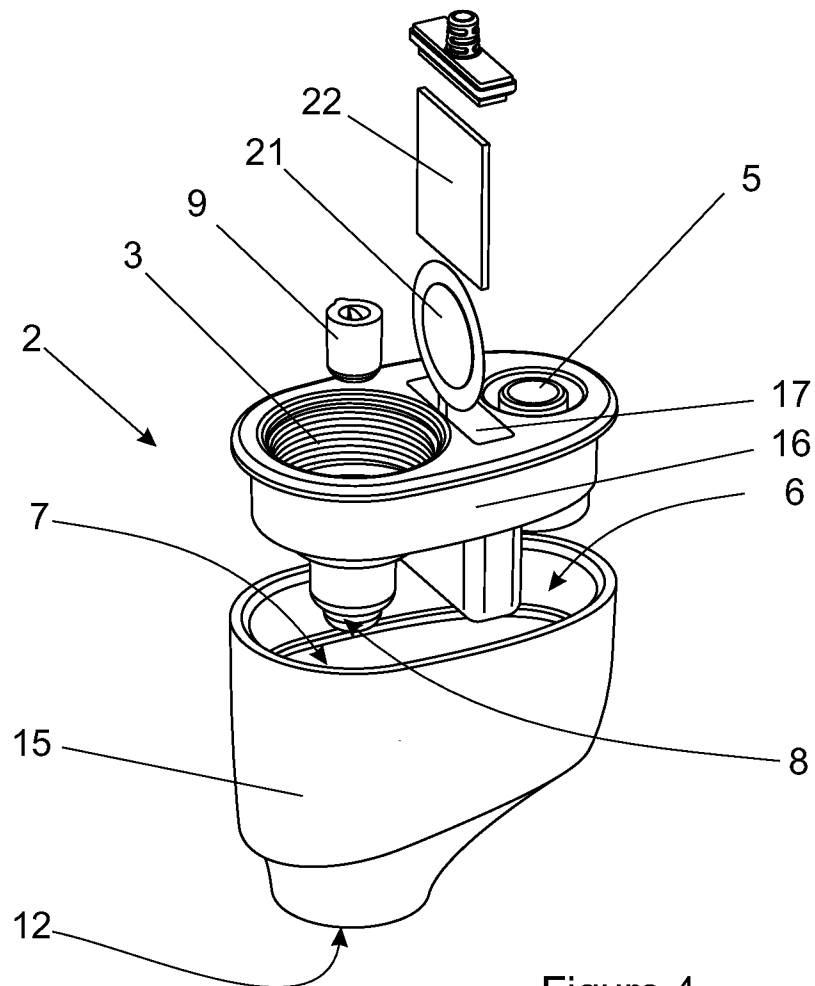


Figure 4

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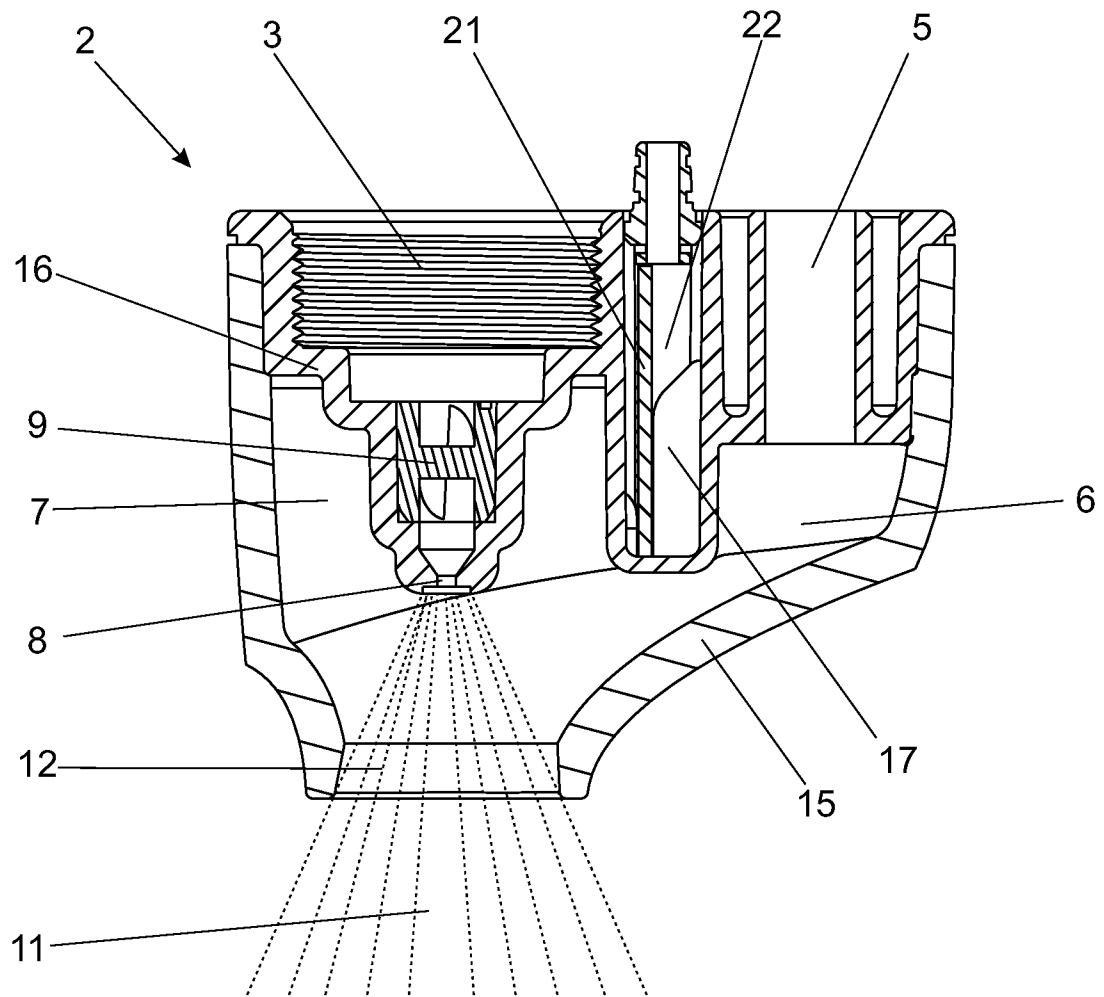


Figure 5

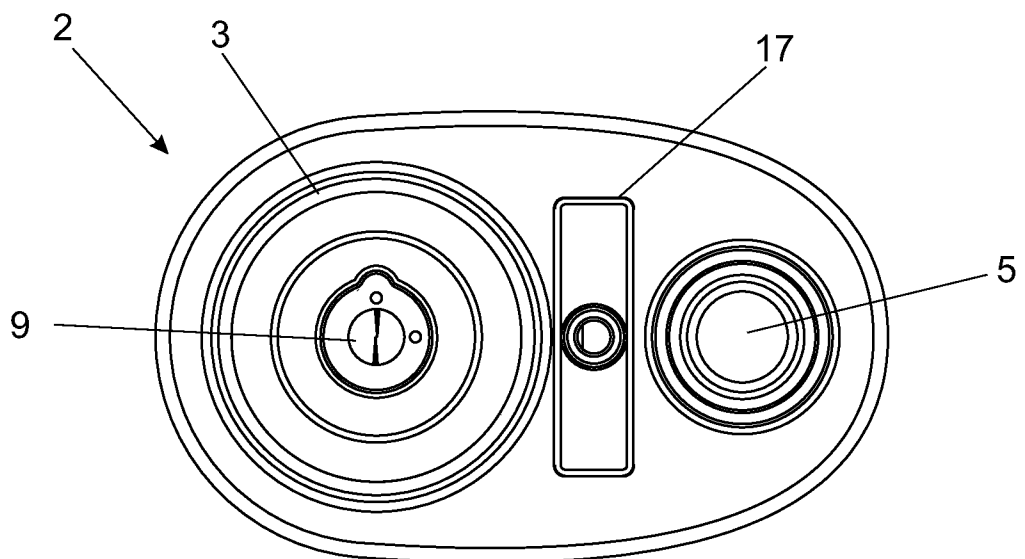


Figure 6

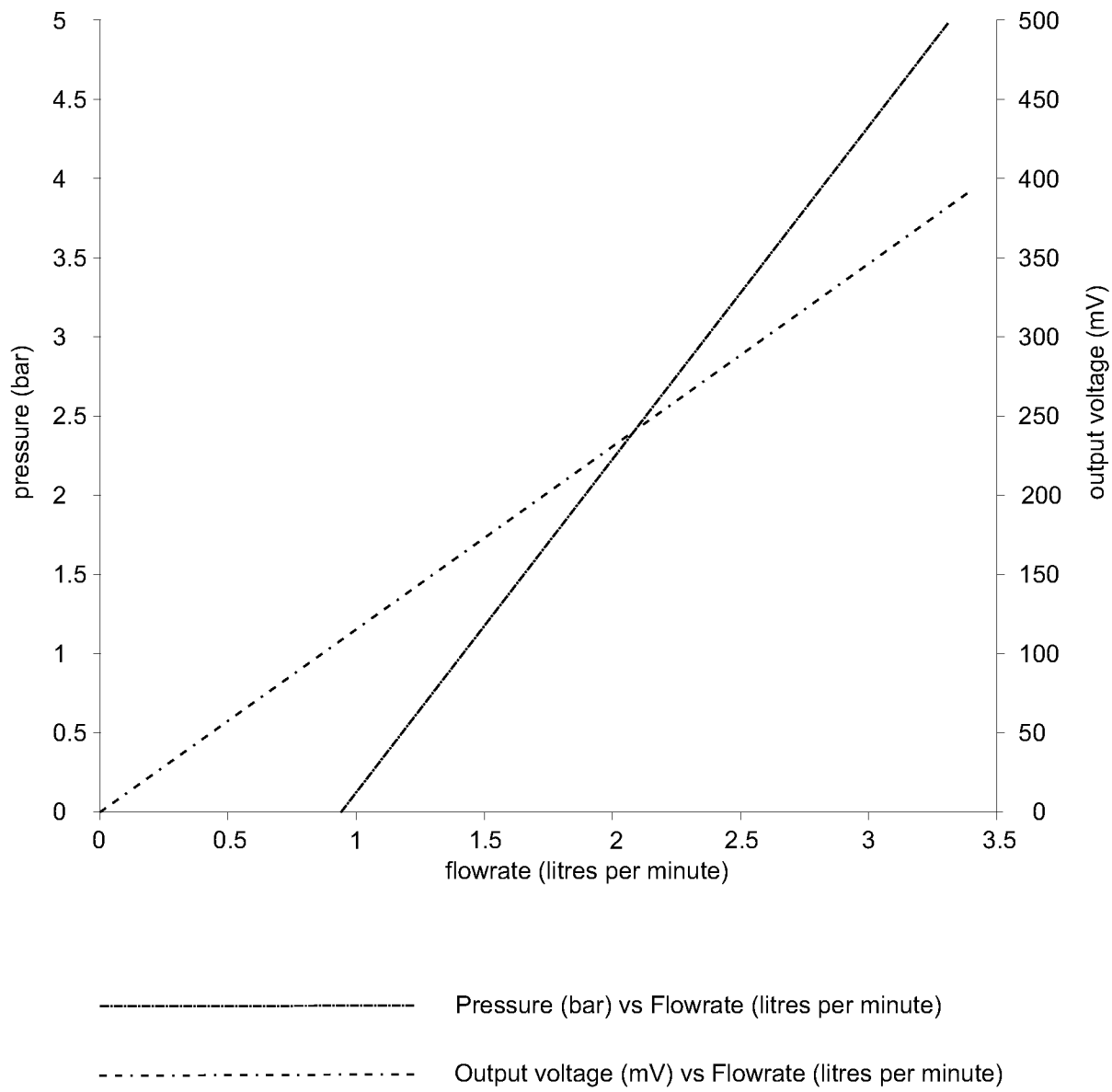


Figure 7