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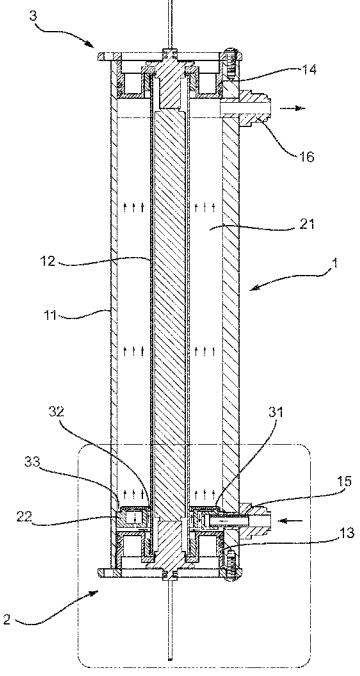
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(54) Title: DEVICE FOR UV-TREATMENT OF AQUEOUS FLUID

Fig. 1



(57) Abstract: The invention relates to a device (1) for disinfecting aqueous fluid by exposing the fluid to ultraviolet (UV) light, said device (1) comprising: • a tubular UV-lamp; • a treatment chamber (21) comprising a cylindrical outer wall (11), said treatment chamber (21) providing a passage for conveying aqueous fluid and providing exposure to UV-light emitted by the UV-lamp; • a top cover (14) and a bottom cover (13); • an inlet chamber (22) located at one end of the treatment chamber (21), • an outlet (16) for discharging aqueous fluid located at the other end of the treatment chamber (21); wherein the inlet chamber (22) comprises: - an inlet (15) for receiving aqueous fluid; - an annular diffuser passage that is in fluid communication with the inlet (15) for receiving aqueous fluid and that is in fluid communication with the treatment chamber (21) through an inner annular slit opening (32) and an outer annular slit opening (33), said outer annular slit opening (33) being located adjacent the outer wall of the treatment chamber (21) and said inner annular slit opening (32) being located concentrically within the outer annular slit opening (33); and - a cover plate (31), which separates the annular diffuser passage from the treatment chamber (21) and defines the inner annular slit opening (32) and the outer annular slit opening (33). The UV-treatment device (1) of the present invention is extremely efficient at disinfecting aqueous fluid, even at very high throughput.

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DEVICE FOR UV-TREATMENT OF AQUEOUS FLUID

TECHNICAL FIELD OF THE INVENTION

The invention relates to a device for disinfecting aqueous fluid by exposing the fluid to ultraviolet (UV) light. More particularly, the invention concerns to such a device comprising:

- a tubular UV-lamp;
- a treatment chamber comprising a cylindrical outer wall, said treatment chamber providing a passage for conveying aqueous fluid and providing exposure to UV-light emitted by the UV-lamp;
- a top cover and a bottom cover;
- an inlet for receiving aqueous fluid located at one end of the treatment chamber; and
- an outlet for discharging aqueous fluid located at the other end of the treatment chamber.

The invention further provides a method for disinfecting aqueous in a UV-treatment device.

BACKGROUND OF THE INVENTION

UV treatment of water is a quick, reliable and cost effective method of disinfecting water for both point of use and point of entry. UV water treatment uses ultraviolet light to kill micro-organisms that may be present in water. It is a proven technology that has no significant drawbacks. In some applications, its initial cost is a bit more than chlorination, but because of its low operating cost, it quickly pays for itself. It is environmentally friendly and essentially trouble-free. Most ultraviolet water treatment systems require only an annual change of lamp and a periodic change of the filter cartridge.

Devices for point-of-use UV-water treatment are commercially available. These devices have in common that water flows through a UV tank assembly past a source of UV-light. Depending on how the water is directed through the UV tank assembly, portions of the water flow may receive different UV-exposure. That is, portions of water that pass most quickly through the UV tank assembly tend to receive less UV light exposure than portions of water that take a slower path and have a longer residence time.

Ideally, all the water would receive the same predetermined minimum dosage of UV light to ensure a desired kill or destruction rate without unnecessarily overexposing certain portions of the water flow. Without steady or plug flow through the UV tank assembly, this objective cannot be optimally met. Plug flow refers to a “plug” or mass of water moving together through the system. Plug flow avoids uneven flow rate of water through the system.

WO 00/06499 describes a point-of-use water treatment system comprising:

- a base;
- a filter housing assembly mounted relative to the base;
- a filter disposed within the filter housing for filtering water passing through the filter housing assembly;
- a UV tank assembly mounted relative to the base;
- a UV bulb assembly disposed within the tank assembly for irradiating water passing therethrough; and
- a housing generally enclosing the filter housing assembly and the tank assembly.

The treatment system may comprise a wedge shaped entrance chamber to cause incoming water to travel circumferentially. The tank comprises a lower baffle plate and an upper vaned baffle plate. A plurality of circular openings are located in the lower baffle plate to allow water to travel toward upper baffle plate in a spiral manner.

EP-A 0616 975 describes a point-of-use water treatment system for home use comprising:

- a filter for removing contaminants from water;
- a source of radiant energy for killing microorganisms in the water;
- a filter monitor for monitoring the amount of water flowing through said filter and providing an indication when said filter has reached end-of-life;
- a radiant energy monitor for monitoring the performance of said source of radiant energy and providing an indication when said source has reached end-of-life;
- a filter quick-disconnect for providing a user with the ability to change said filter in response to an indication from said filter monitor; and

- a source quick-disconnect for providing a user with the ability to change said source of radiant energy in response to an indication from said radiant energy monitor.

The source of radiant energy comprises an ultraviolet discharge lamp having an elongate central axis and a diverter for providing a spiral plug flow of water about the discharge lamp.

WO 2011/014717 describes a reactor for treating a fluid, comprising:

- a vessel having an inlet for receiving fluid and an outlet for discharging fluid;
- an ultraviolet light source located within said vessel; and
- first, second and third baffle plates located within said vessel for forming first, second and third chambers, respectively wherein said first, second and third baffle plates include holes arranged in a predetermined pattern for controlling fluid flow in said vessel to provide plug flow.

WO 2012/014108 describes a device for subjecting a fluid to a disinfecting treatment by exposing the fluid to UV light, said device comprising a reactor having an inner space in which means for emitting ultraviolet light are arranged, an inlet for letting fluid into the inner space, and an outlet for letting out fluid from the inner space, wherein the light emission means comprise a single electrode, wherein a wall encompassing the inner space is adapted to function as an electrode and comprises electrically conductive material, and wherein the device further comprises means which also comprise electrically conductive material, and which are arranged for locally enhancing the electrical conductivity in a space between the reactor wall and the light emission means. An element is arranged on an inlet side of the reactor, the closed central portion having the function of reducing the jet of water from the inlet, whereas the holes play a role in forming the flow of water. The element can have a central hole for allowing the element to be positioned on an end portion of the lamp. When such an element is used, the element serves as a divider plate which has a role in avoiding that the water finds the fastest way toward the outlet.

US 2005/0056597 describes a system for treating a fluid comprising:

- a treatment chamber;

- a light source for emitting light, such that at least a portion of the light travels within the treatment chamber; and
- a treatment area within the treatment chamber;

wherein a flow profile of the fluid in the treatment area matches the fluence profile of the light that travels within the treatment area. The system may comprise a plurality of baffles coupled to the treatment chamber, wherein the plurality of baffles provide for substantially uniform treatment of the fluid.

SUMMARY OF THE INVENTION

The present inventors have designed a device for UV-treatment of aqueous fluid that is extremely efficient in disinfecting said aqueous fluid, even at very high throughput.

The UV-treatment of aqueous fluid in the present device is very effective because the geometry of the devices ensure that exposure time to UV radiation is constant throughout the stream of aqueous fluid that is treated in the device.

The UV-treatment device of the present invention comprises:

- a tubular UV-lamp;
- a treatment chamber comprising a cylindrical outer wall, said treatment chamber providing a passage for conveying aqueous fluid and providing exposure to UV-light emitted by the UV-lamp;
- a top cover and a bottom cover;
- an inlet chamber located at one end of the treatment chamber; and
- an outlet for discharging aqueous fluid located at the other end of the treatment chamber.

Aqueous liquid passing through the treatment chamber is exposed to UV-light that is emitted by the tubular UV-lamp, resulting in disinfection of the aqueous fluid. In one embodiment, the cylindrical treatment chamber of the UV-treatment device is positioned around the UV-lamp, providing an annular passage to the aqueous fluid. In an alternative embodiment, the cylindrical treatment chamber is positioned parallel to the tubular UV-light.

The inlet chamber comprises an inlet for aqueous fluid and is designed to transfer the incoming linear stream of aqueous fluid as an annular plug flow stream into the treatment chamber. To this end the inlet chamber comprises:

- an inlet for receiving aqueous fluid;
- an annular diffuser passage that is in fluid communication with the inlet for receiving aqueous fluid and that is in fluid communication with the treatment chamber through an inner annular slit opening and an outer annular slit opening;
- a cover plate, which separates the annular diffuser passage from the treatment chamber and defines the inner annular slit opening and the outer annular slit opening , said outer annular slit opening being located adjacent the outer wall of the treatment chamber and said inner annular slit opening being located concentrically within the outer annular slit opening ;

  said annular diffuser passage comprising an annular diffuser chamber which receives a stream of aqueous fluid from the inlet and an annular nozzle section, said annular diffuser chamber and said annular nozzle section being coaxially positioned, the annular diffuser chamber being separated from the annular nozzle section by a separating plate comprising a plurality of equidistant openings through which the stream of aqueous fluid enters the annular nozzle section in a direction away from the treatment chamber, following which the stream is split up in the annular nozzle section into a first stream of aqueous fluid that proceeds in a radially inward direction before being directed towards the inner annular slit opening and the treatment chamber and a second stream of aqueous fluid that proceeds in a radially outward direction before being directed towards the outer annular slit opening and the treatment chamber.

The plug flow achieved in the treatment chamber of the present device ensures that the aqueous fluid receives uniform UV-treatment so that maximum disinfecting efficiency can be achieved.

The invention further provides a method of disinfecting aqueous fluid in a UV-treatment device comprising (a) a tubular UV-lamp; (b) a treatment chamber comprising a cylindrical outer wall, said treatment chamber providing a passage for conveying aqueous fluid and providing exposure to UV-light emitted by the UV-lamp; (c) an inlet for

aqueous fluid located at one end of the treatment chamber; and (d) an outlet for discharging aqueous fluid located at the other end of the treatment chamber, said method comprising the steps of:

- introducing a linear stream of aqueous fluid through the inlet for aqueous fluid into an annular diffuser to reduce the flow rate of the aqueous fluid and to convert the linear stream into an annular stream that is directed away from the treatment chamber;
- splitting up the annular stream into a first stream of aqueous fluid that proceeds in a radially inward direction before being directed towards the treatment chamber and a second stream of aqueous fluid that proceeds in a radially outward direction before being directed towards the treatment chamber;
- introducing the first stream of aqueous fluid into the treatment chamber through an outer annular slit opening located adjacent the outer wall of the treatment chamber;
- introducing the second stream of aqueous fluid into the treatment chamber through an inner annular slit opening located concentrically within the outer annular split opening;
- exposing the stream of aqueous fluid to UV-light from the UV lamp as it flows through the treatment chamber; and
- discharging the disinfected aqueous fluid from the device.

DRAWINGS

Figure 1 is cross-sectional side view of a UV-treatment device according to the present invention.
Figure 2 is a cross-sectional side view of the inlet chamber of the UV-treatment device
Figure 3 is a perspective view of the inlet chamber of the UV-treatment device
Figure 4 is a top view of the inlet chamber of the UV-treatment device.

DETAILED DESCRIPTION OF THE INVENTION

Accordingly, one aspect of the present invention relates to a device for disinfecting aqueous fluid by exposing the fluid to ultraviolet (UV) light, said device comprising:

- a tubular UV-lamp;

- a treatment chamber comprising a cylindrical outer wall, said treatment chamber providing a passage for conveying aqueous fluid and providing exposure to UV-light emitted by the UV-lamp;
- a top cover and a bottom cover;
- an inlet chamber located at one end of the treatment chamber,
- an outlet for discharging aqueous fluid located at the other end of the treatment chamber;
- wherein the UV-lamp is located inside a cylindrical sleeve means, said cylindrical sleeve means (12) being located inside the cylindrical outer wall of the treatment chamber (21), said sleeve means (12) and said outer wall forming a treatment chamber (21) providing an annular passage for conveying aqueous fluid;

wherein the inlet chamber comprises:

- an inlet for receiving aqueous fluid;
- an annular diffuser passage that is in fluid communication with the inlet for receiving aqueous fluid and that is in fluid communication with the treatment chamber through an inner annular slit opening and an outer annular slit opening;
- a cover plate, which separates the annular diffuser passage from the treatment chamber and defines the inner annular slit opening and the outer annular slit opening , said outer annular slit opening being located adjacent the outer wall of the treatment chamber and said inner annular slit opening being located concentrically within the outer annular slit opening ;

  said annular diffuser passage comprising an annular diffuser chamber which receives a stream of aqueous fluid from the inlet and an annular nozzle section, said annular diffuser chamber and said annular nozzle section being coaxially positioned, the annular diffuser chamber being separated from the annular nozzle section by a separating plate comprising a plurality of equidistant openings through which the stream of aqueous fluid enters the annular nozzle section in a direction away from the treatment chamber, following which the stream is split up in the annular nozzle section into a first stream of aqueous fluid that proceeds in a radially inward direction before being directed towards the inner annular slit opening and the treatment chamber and a second stream of aqueous fluid that

proceeds in a radially outward direction before being directed towards the outer annular slit opening and the treatment chamber.

It should be understood that the present invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being implemented in various ways.

The terms “including”, “comprising”, “containing” or “having” and variations thereof as used herein are meant to encompass the items listed thereafter as well as additional items. Unless specified or limited otherwise, the terms “mounted,” “connected,” “supported,” and “coupled” and variations thereof are used broadly and encompass direct and indirect mountings, connections, supports, and couplings.

The inner and outer annular slit openings through which aqueous fluid can enter the treatment chamber of the UV-treatment device typically are relatively narrow in comparison to the distance between these annular slit openings. Accordingly, in a preferred embodiment, the inner annular slit opening has an inner radius R_1 and a width W_1; the outer annular slit opening has an outer radius R_2 and a width W_2;; and $(W_1+W_2) / (R_2-R_1) \leq 0.3$. Even more preferably the following condition is met: $0.05 \leq (W_1+W_2) / (R_2-R_1) \leq 0.25$.

In accordance with another preferred embodiment, the width of the inner annular slit opening (W_1) and the width of the outer annular slit opening (W_2) are not very different. Preferably, the ration W_1/ W_1 is in the range of 0.25 to 4, more preferably in the range of 0.33 to 3.

The annular diffuser chamber has an internal volume (V_d) that typically exceeds the internal volume of the annular nozzle section (V_n); by at least a factor 1.2, more preferably by at least a factor 1.3. Most preferably, $1.4 \leq V_d / V_n \leq 4$.

The inlet chamber of UV-treatment device typically has an internal volume V_{ic} ($V_{ic} = V_d + V_n$) that is at least 15 times smaller than the internal volume of the treatment chamber (V_{tc}). In other words, in a preferred embodiment $V_{tc} / V_{ic} \geq 15$. Even more preferably $25 \leq V_{tc} / V_{ic} \leq 150$.

The treatment chamber of the UV-treatment device typically has a volume of 200-5,000 ml, more preferably of 300-2,000 ml.

The length of the treatment chamber typically is in the range of 10 to 80 cm, more preferably in the range of 12 to 60 cm and most preferably in the range of 15 to 40 cm.

According to a particularly preferred embodiment, the cylindrical treatment chamber of the UV-treatment device is positioned around the UV-lamp, providing an annular passage to the aqueous fluid. More particularly, in this advantageous embodiment the UV-lamp is located inside UV-transparent cylindrical sleeve means, said cylindrical sleeve means being located inside the cylindrical outer wall of the treatment chamber, said sleeve means and said outer wall forming a treatment chamber providing an annular passage for conveying aqueous fluid. In this embodiment, the inner annular slit opening is preferably located adjacent the sleeve means.

In the embodiment in which the treatment chamber provides an annular passage for the aqueous fluid, the width of the annular passage ('Y'), i.e. the difference between the inner radius R_1 and the an outer radius R_2 of the annular treatment chamber, is substantially larger than the combined width of the inner annular slit opening (W_1) and the width of the outer annular slit opening (W_2). Accordingly, in a particularly preferred embodiment the dimensions of the present device are such that the following condition is met: $(W_1+W_2) / Y \leq 0.3$. Even more preferably, $0.05 \leq (W_1+W_2) / Y \leq 0.25$.

In the aforementioned embodiment, the annular treatment chamber typically has an inner diameter of 20-120 mm, more preferably of 30-100 mm and most preferably of 40-80 mm.

The outer diameter of the sleeve means typically is in the range of 10-50 mm, more preferably in the range of 12-40 mm and most preferably in the range of 15-30 mm.

The width of the annular treatment chamber, defined as the difference between the inner radius of the treatment chamber and the outer radius of the sleeve means typically is in the range of 5-50 mm, more preferably in the range of 10-35 mm, most preferably in the range of 14-25 mm.

The UV-lamp is preferably mounted mechanically and electrically in sockets that are connected to a driving circuit so that an alternating voltage can be applied. The driving circuit draws its input power from a power source such as a mains voltage or a battery.

As explained herein before, the present UV-treatment device offers the important advantage that it achieves plug flow in the treatment chamber, thanks to the special design of the inlet chamber. Accordingly, in a particularly preferred embodiment, the inlet chamber provides plug flow to the aqueous fluid entering the treatment chamber.

Another aspect of the present invention relates to a method of disinfecting aqueous fluid in a UV-treatment device comprising (a) a tubular UV-lamp; (b) a treatment chamber comprising a cylindrical outer wall, said treatment chamber providing a passage for conveying aqueous fluid and providing exposure to UV-light emitted by the UV-lamp; (c) an inlet for aqueous fluid located at one end of the treatment chamber; and (d) an outlet for discharging aqueous fluid located at the other end of the treatment chamber, said method comprising the steps of:

- introducing a linear stream of aqueous fluid through the inlet for aqueous fluid into an annular diffuser to reduce the flow rate of the aqueous fluid and to convert the linear stream into an annular stream that is directed away from the treatment chamber;
- splitting up the annular stream into a first stream of aqueous fluid that proceeds in a radially inward direction before being directed towards the treatment chamber and a second stream of aqueous fluid that proceeds in a radially outward direction before being directed towards the treatment chamber;
- introducing the first stream of aqueous fluid into the treatment chamber through an outer annular slit opening located adjacent the outer wall of the treatment chamber;
- introducing the second stream of aqueous fluid into the treatment chamber through an inner annular slit opening located concentrically within the outer annular slit opening;
- exposing the stream of aqueous fluid to UV-light from the UV lamp as it flows through the treatment chamber; and
- discharging the disinfected aqueous fluid from the device.

This method of disinfecting aqueous fluid may suitably be carried out in UV-treatment device as described herein.

In a particularly preferred embodiment of the present method the aqueous fluid flows through the treatment chamber in plug flow.

The present method offers the advantage that it is possible to effectively disinfect aqueous fluid at high throughput. Accordingly, in a preferred embodiment of the present method disinfected aqueous fluid is discharged from the device at a rate of at least 1 L/min, more preferably at a rate of 1.8-2.5 L/min. These flow rates are typically achieved using a UV-lamp of 8-16 W, more preferably of 11-14 W.

Figure 1 shows a UV-treatment device 1 according to the present invention. The UV-treatment device 1 includes a barrel 11 and an UV-transparent sleeve 12. The sleeve 12 is adapted to hold a tubular UV-lamp. The annular treatment chamber 21 between the barrel 11 and the sleeve 12 is closed off at the bottom end 2 by a bottom cover (bottom gable) 13 and at the top end 3 by a top cover (top gable) 14.

The UV-treatment device further comprises an inlet chamber 22, positioned directly above the bottom cover 13. The inlet chamber 22 is connected to an inlet pipe 15 for receiving water under pressure and comprises a cover plate 31, an inner annular slit opening 32 and an outer annular slit opening 33. An outlet pipe 16 for discharging water is located near the top cover 14.

In operation, water enters the device 1 via inlet chamber 22 through inlet pipe 15. From the inlet chamber 22 water enters the annular treatment chamber 21 through annular slit openings 32 and 33 and travels upwards through annular treatment chamber 21 towards the top end 3 where it is discharged from outlet pipe 16. Whilst the water flows through the annular treatment chamber 21 it is exposed to UV light that is emitted by a UV lamp (not shown) that it is positioned inside the sleeve 12.

Figure 2 shows a cross-sectional side view of the bottom end 2 of the UV-treatment device 1. The inlet pipe 15 feeds into the annular diffuser chamber 41 of inlet chamber 22. The inlet chamber 22 comprises a separating plate 42 that contains a plurality of equidistant openings 43 that connect the interior of the annular diffuser chamber 41 with the interior of the annular nozzle section 44. The interior of the annular nozzle section 44

is connected with the annular treatment chamber 21 through inner annular slit opening 32 and outer annular slit opening 33.

Figure 3 shows a perspective view of the inlet chamber 22 with the cover plate 31 removed. The inlet pipe 15 introduces water into the annular diffuser chamber 41 in such a way that water flows from the inlet pipe 15 through the annular diffuser chamber 41 in both circumferential directions. Water entering the annular diffuser chamber 41 under pressure is pressed through the plurality of equidistant openings 43 in separating plate 42 into the nozzle section 44 of which the inner annular slit opening 32 and the outer annular slit opening 33 are shown. The cover plate 31, when in place, closes off the annular space of the annular diffuser chamber 41, but does leaves open the annular slit openings 32 and 33.

In operation, water enters the annular diffuser chamber 41 of inlet chamber 22 through inlet pipe 15. Water flows from the inlet pipe 15 in both circumferential directions and through equidistant openings 43 in separating plate 42 into the annular nozzle section 44 and leaves the annular nozzle section 44 through the inner annular slit opening 32 and the outer annular slit opening 33. Due to the special geometry of the inlet chamber 22 the linear flow of water from inlet pipe 15 is converted into two steady annular flows that leave the inlet chamber 22 through the inner annular slit opening 32 and the outer annular slit opening 33. Together these two steady annular flows create a plug flow in the annular treatment chamber 21 of the UV-treatment device 1 (see Fig. 1).

Figure 4 shows a top view of the inlet chamber 22 without the cover plate 31. The inlet pipe 15 enters annular diffuser chamber 41. The separating plate 42 comprises equidistant openings 43. Further shown are the slit openings 32 and 33.

The invention is further illustrated by means of the following non-limiting examples.

EXAMPLES

Example 1

An UV treatment device according to the present invention as shown in Figures 1-4 was used to treat water that had been infected with bacteria (*K. terrigena*) and virus (MS2 bacteriophage). The device was fitted with a pre-filter (pleated fabric + carbon block) and

a UV lamp (11 W, ex Osram). The performance of the device was compared with that of an identical device that lacked an inlet chamber.

Characteristics of the UV-treatment device containing an inlet chamber are summarized in Table 1.

Table 1

Volume of treatment chamber	492 ml
Length of treatment chamber	21 cm
Inner diameter of treatment chamber	56 mm
Outer diameter of quartz sleeve	20 mm
Volume of annular diffuser chamber	7.0 ml
Volume of annular nozzle section	3.9 ml
Width of inner annular slit opening	1.7 mm
Width of outer annular slit opening	1.0 mm

Tests were conducted using different flow rates, different concentrations of contaminants and different spike points. The results are shown in Table 2.

Table 2

	K. terrigena Log(cfu/100 ml)			MS2 bacteriophage Log(pfu/ml)			Flow rate (L/min.)	Spike Point (in L)
	Input	Output	Δ	Input	Output	Δ		
Without inlet chamber	7.3	0.0	7.3	5.3	0.0	5.3	2.0	0
	8.2	0.0	8.2	4.9	1.1	3.8	2.0	1500
	7.3	0.0	7.3	5.0	1.8	3.2	1.8	2700
	7.3	0.0	7.3	5.0	1.3	3.7	1.5	3200
With inlet chamber	7.2	0.0	7.2	5.1	0.0	5.1	2.0	0
	7.4	0.0	7.4	4.9	0.0	4.9	2.0	1630
	7.3	0.0	7.3	5.1	0.0	5.1	1.5	2600
	7.2	0.0	7.2	5.0	0.0	5.0	1.5	3537
	7.3	0.0	7.3	5.1	0.0	5.1	1.5	4010

Example 2

An UV treatment device according to the present invention as described in Example 1 was used to treat water that had been infected with bacteria (*K. terrigena*) and virus (MS2 bacteriophage). The performance of the device was compared to that of two devices described in WO 00/06499 (WO'499) and WO 2011/014717 (WO'717).

All devices were fitted with a pre-filter (pleated fabric + carbon block) and a UV lamp (11 W, ex Osram).

The results of the tests are shown in Table 3.

Table 3

	K. terrigena Log(cfu/100 ml)			MS2 bacteriophage Log(pfu/ml)			Flow rate (L/min.)	Spike Point (in L)
	Input	Output	Δ	Input	Output	Δ		
Device according to invention	7.0	0.0	7.0	5.0	0.0	5.0	2.2	0
	6.9	0.0	6.9	5.3	0.6	4.7	2.0	1000
	7.0	0.0	7.0	4.8	0.0	4.8	1.5	2000
	6.0	0.0	6.0	4.2	0.2	4.0	2.1	3500
Device According WO'499	7.0	0.0	7.0	5.0	0.0	5.0	2.2	0
	6.9	0.0	6.9	5.3	0.6	4.7	2.0	1000
	7.0	0.0	7.0	4.8	0.3	4.5	1.5	2000
	6.0	0.0	6.0	4.2	1.2	3.0	2.1	3500
Device According WO'717	7.0	0.0	7.0	4.4	0.0	4.4	2.2	0
	7.0	0.0	7.0	4.0	0.7	3.3	2.0	1000
	7.3	0.0	7.3	4.5	0.0	4.5	1.8	2000

CLAIMS:

1. A device (1) for disinfecting aqueous fluid by exposing the fluid to ultraviolet (UV) light, said device (1) comprising:

- a tubular UV-lamp ;
- a treatment chamber (21) comprising a cylindrical outer wall, said treatment chamber (21) providing a passage for conveying aqueous fluid and providing exposure to UV-light emitted by the UV-lamp;
- a top cover (14) and a bottom cover (13);
- an inlet chamber (22) located at one end of the treatment chamber (21),
- an outlet (16) for discharging aqueous fluid located at the other end of the treatment chamber (21);

wherein the UV-lamp is located inside a cylindrical sleeve means (12), said cylindrical sleeve means (12) being located inside the cylindrical outer wall of the treatment chamber (21), said sleeve means (12) and said outer wall forming a treatment chamber (21) providing an annular passage for conveying aqueous fluid;

wherein the inlet chamber (22) comprises:

- an inlet (15) for receiving aqueous fluid;
- an annular diffuser passage that is in fluid communication with the inlet (15) for receiving aqueous fluid and that is in fluid communication with the treatment chamber (21) through an inner annular slit opening (32) and an outer annular slit opening (33);
- a cover plate (31), which separates the annular diffuser passage from the treatment chamber (21) and defines the inner annular slit opening (32) and the outer annular slit opening (33), said outer annular slit opening (33) being located adjacent the outer wall of the treatment chamber (21) and said inner annular slit opening (32) being located concentrically within the outer annular slit opening (33);

  said annular diffuser passage comprising an annular diffuser chamber (41) which receives a stream of aqueous fluid from the inlet (15) and an annular nozzle section (44), said annular diffuser chamber (41) and said annular nozzle section (44) being coaxially positioned, the annular diffuser chamber (41) being

separated from the annular nozzle section (44) by a separating plate (42) comprising a plurality of equidistant openings through which the stream of aqueous fluid enters the annular nozzle section (44) in a direction away from the treatment chamber (21), following which the stream is split up in the annular nozzle section (44) into a first stream of aqueous fluid that proceeds in a radially inward direction before being directed towards the inner annular slit opening (32) and the treatment chamber (21) and a second stream of aqueous fluid that proceeds in a radially outward direction before being directed towards the outer annular slit opening (33) and the treatment chamber (21).

2. A device according to claim 1, wherein , the inner annular slit opening (32) has an inner radius R_1 and a width W_1; the outer annular slit opening (33) has an outer radius R_2 and a width W_2; and $(W_1+W_2) / (R_2-R_1) \leq 0.3$.

3. A device according to claim 2, wherein $0.05 \leq (W_1+W_2) / (R_2-R_1) \leq 0.25$.

4. A device according to claim 2 or 3, wherein $0.25 \leq W_1/W_2 \leq 4$.

5. A device according to any one of the preceding claims, wherein the annular diffuser chamber (41) has an the internal volume V_d the annular nozzle section (44) has an internal volume V_n; and wherein V_d/V_n exceeds 1.2.

6. A device according to any one the preceding claims, wherein the inlet chamber (22) has an internal volume V_{ic} and the treatment chamber (21) has a volume V_{tc}; and wherein $V_{tc} / V_{ic} \geq 15$.

7. A device according to any one of the preceding claims, wherein the treatment chamber (21) has an internal volume of 200-5,000 ml.

8. A device according to any one of the preceding claims, wherein the treatment chamber (21) has a length of 10-80 cm.

9. A device according to claim 9, wherein width of the treatment chamber (21), defined as the difference between the inner radius of the treatment chamber (21) and the outer radius of the sleeve means (12), is in the range of 5-50 mm.

10. Device according to any one of the preceding claims, wherein the inlet chamber (22) provides plug flow to the aqueous fluid entering the treatment chamber (21).

11. A method of disinfecting aqueous fluid in a UV-treatment device according to any of the preceding claims from 1 to 10, said method comprising the steps of:

- introducing a linear stream of aqueous fluid through the inlet (15) for aqueous fluid into an annular diffuser chamber (41) to reduce the flow rate of the aqueous fluid and to convert the linear stream into an annular stream that is directed away from the treatment chamber (21);
- splitting up the annular stream into a first stream of aqueous fluid that proceeds in a radially inward direction before being directed towards the treatment chamber (21) and a second stream of aqueous fluid that proceeds in a radially outward direction before being directed towards the treatment chamber (21);
- introducing the first stream of aqueous fluid into the treatment chamber (21) through an outer annular slit opening (33) located adjacent the outer wall of the treatment chamber (21);
- introducing the second stream of aqueous fluid into the treatment chamber (21) through an inner annular slit opening (32) located concentrically within the outer annular slit opening (33);
- exposing the stream of aqueous fluid to UV-light from the UV lamp as it flows through the treatment chamber (21); and
- discharging the disinfected aqueous fluid from the device (1).

12. Method according to claim 11, wherein the aqueous fluid flows through the treatment chamber (21) in plug flow.

13. Method according to claim 11 or 12, wherein disinfected aqueous fluid is discharged from the device (1) at a rate of at least 1 L/min.

14. Use of the device according to any of claims 1 to 10 for providing purified water.

Fig. 1

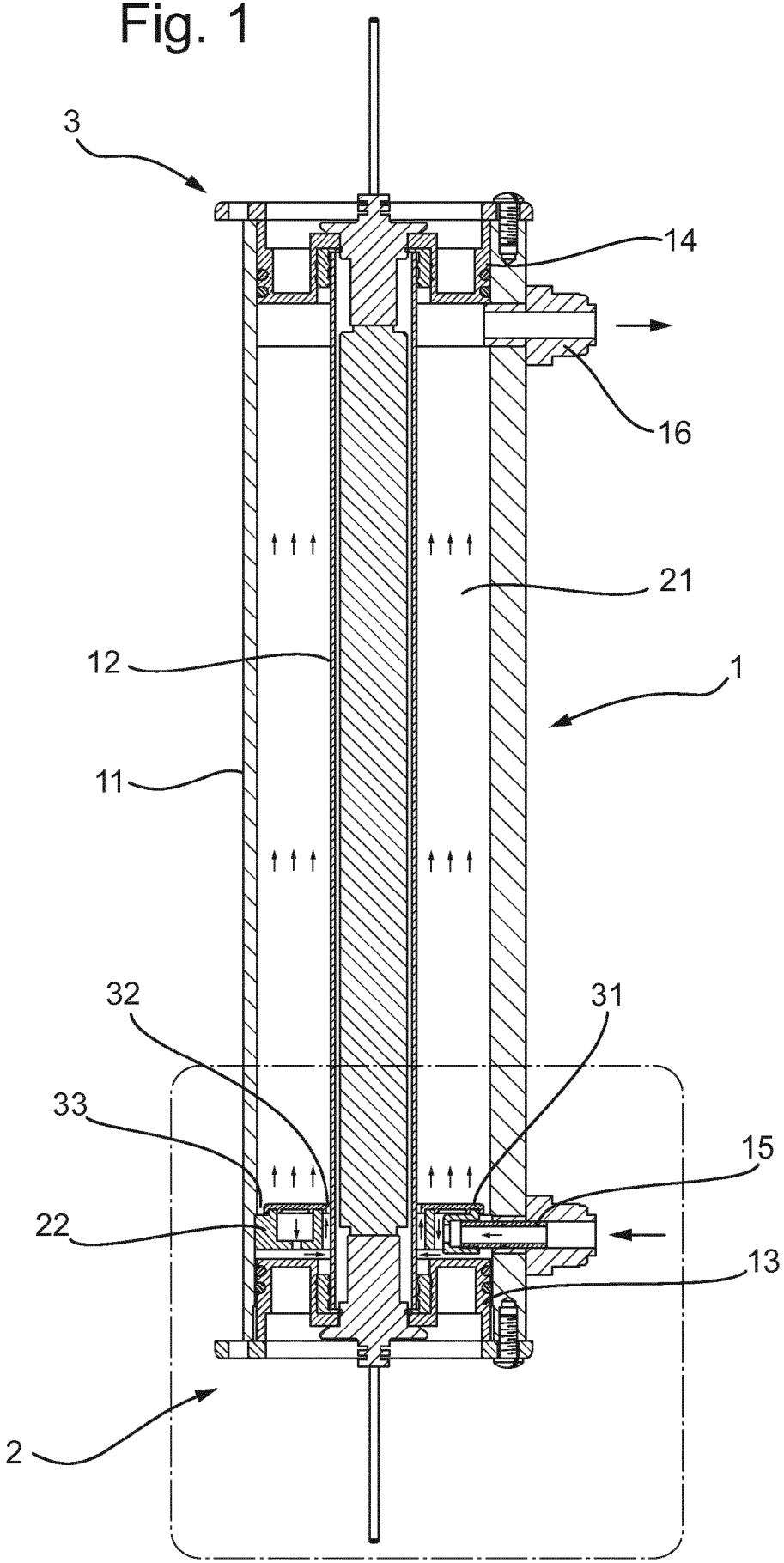


Fig. 2

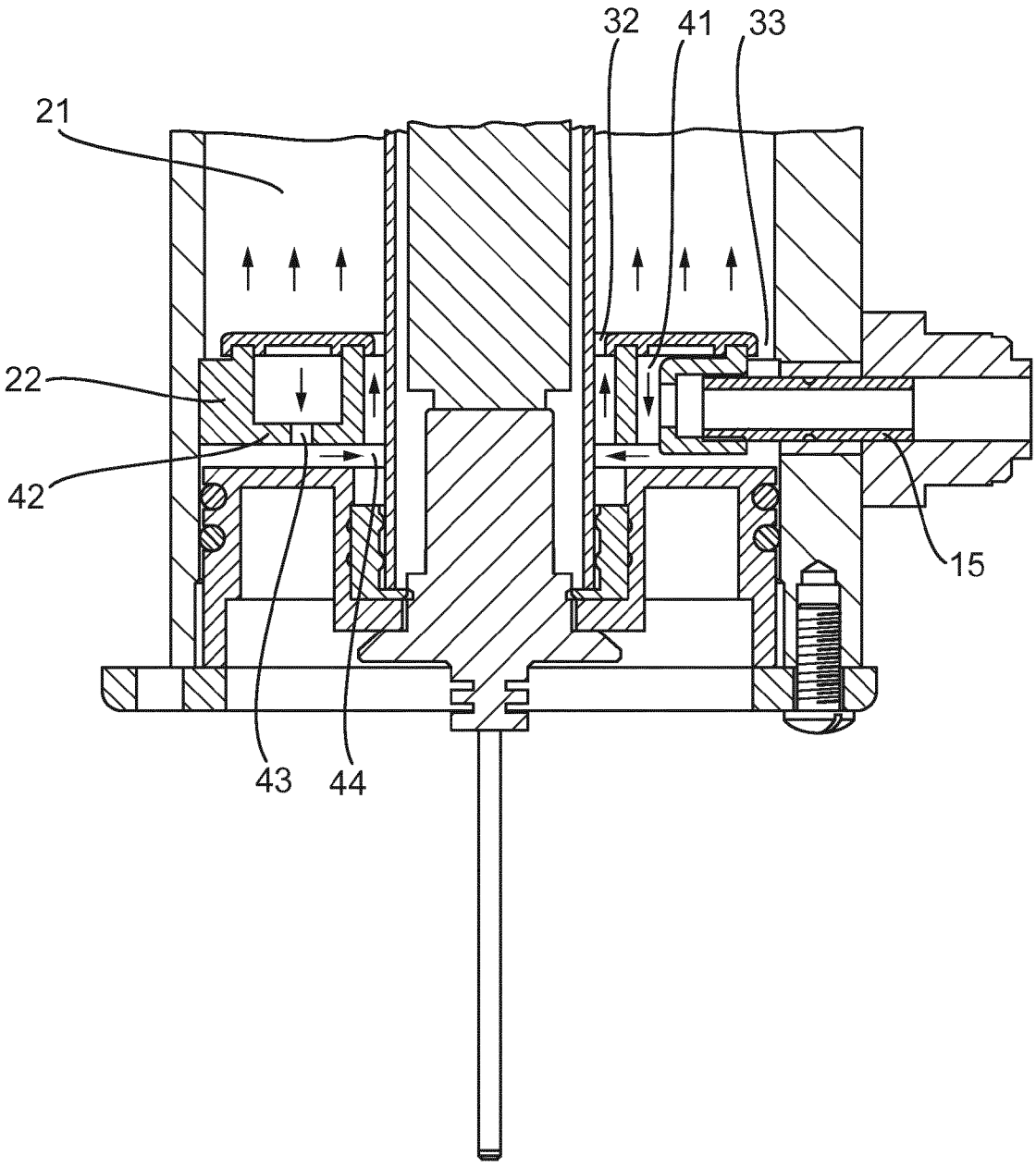


Fig. 3

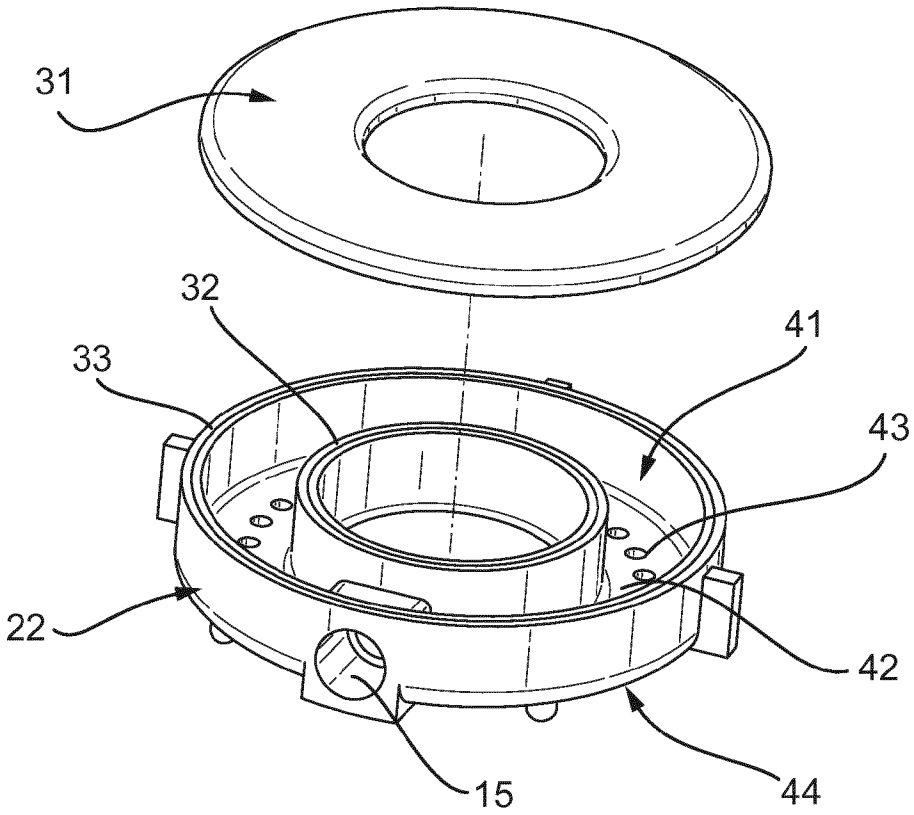
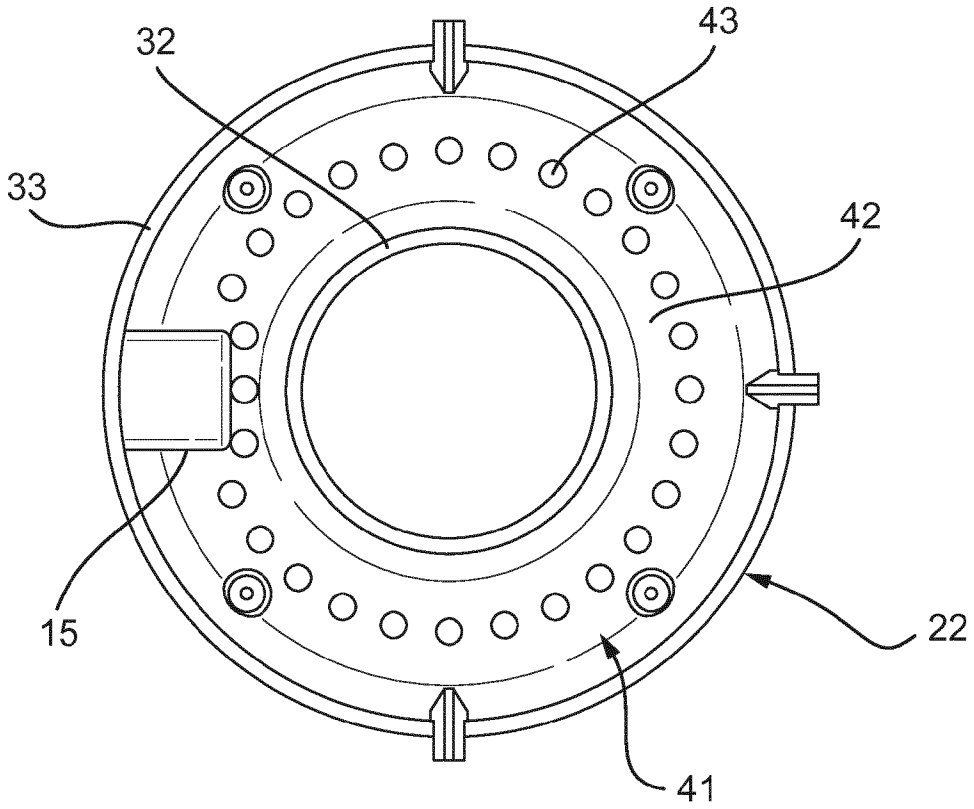


Fig. 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/058942

A. CLASSIFICATION OF SUBJECT MATTER
INV. C02F1/32
ADD.

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)
C02F

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2011/014717 A2 (SIEMENS PTE LTD [SG]; YONG ZHEE MIN JIMMY [SG]; STIBITZ DAVID [US]; CO) 3 February 2011 (2011-02-03) cited in the application the whole document	1-14
A	US 2005/056597 A1 (FRIES WILLIAM M [US] ET AL) 17 March 2005 (2005-03-17) cited in the application the whole document	1-14

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" 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 July 2017	24/07/2017

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/058942

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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