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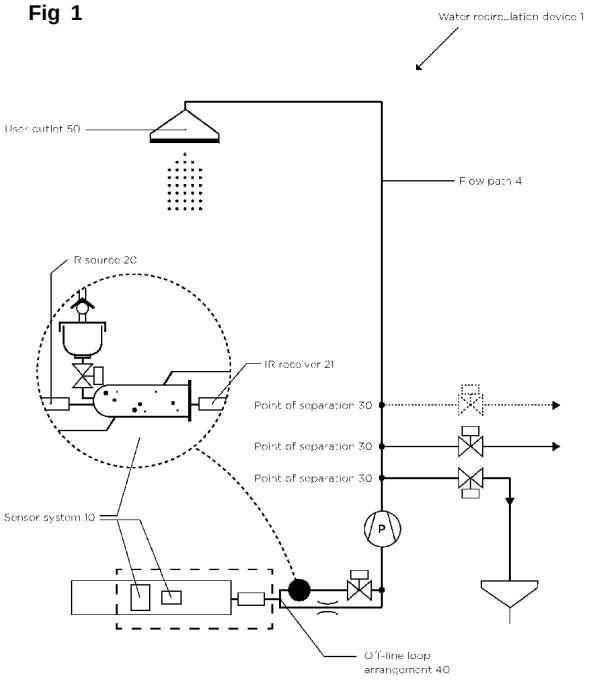
Fig 1



(57) Abstract: The present invention describes a device 1 intended for recycling of water or discarding of water not suitable to recycle, said device 1 comprising a flow path 4 for recycled water, a fresh water inlet and a point of separation 30, wherein the device also comprises a sensor system 10 for measurement of water quality, wherein the sensor system 10 comprises a IR source 20 and a IR receiver 21, and wherein the sensor system 10 is connected to a control unit which decides if water should be recycled or discarded in the point of separation 30 based on the measurement of the water quality.

A DEVICE INTENDED FOR RECYCLING OF WATER OR DISCARDING OF WATER NOT SUITABLE TO RECYCLE

Field of a first aspect of the invention

The present invention relates to a device intended for recycling of water or discarding of water not suitable to recycle and wherein the device comprises a sensor system for measurement of water quality so that a decision of recycling or discarding can be performed by a control unit.

Technical background relating to a first aspect of the invention

The water recirculation systems of interest in relation to the present invention are those measuring water quality known and using this data information as a basis for a decision if to recirculate or discard the water given the specific water quality at that specific time. One example is disclosed in WO2013/095278, which describes a hybrid device for a recirculation shower allowing purification and either recycling of water or discarding of water. The hybrid device comprises a water quality sensor which measures the water quality, and said water quality sensor may be a TOC sensor (Total Organic Carbon), a biosensor, a pH meter (measuring acidity or alkalinity) or an optical sensor. Furthermore, in WO 2015/094107 there is disclosed a hybrid device allowing purification and either recycling of water or discarding of water, where said hybrid device comprises a recirculation loop, a filter system and multiple sensors which are conductivity sensors. Yet another device is disclosed in US 9,074,355 B2 which describes a domestic water recycling system using a combination of an optical detector to detect certain smaller sized (non-filtered) contaminants and a filter to remove larger sized (filtered) contaminants.

The present invention is directed to the provision of a water recycling device with a sensor system implying several advantages in comparison to the known systems today.

Summary of a first aspect of the invention

The stated purpose above is achieved by a device intended for recycling of water or discarding of water not suitable to recycle, said device comprising a flow path for recycled water, a fresh water inlet and a point of

separation, wherein the device also comprises a sensor system for measurement of water quality, wherein the sensor system comprises a IR source and a IR receiver, and wherein the sensor system is connected to a control unit which decides if water should be recycled or discarded in the point of separation based on the measurement of the water quality.

As notable above, the sensor system comprises a IR source and a IR receiver. Generally, IR is said to have a wavelength range of from 700 nm to 1 mm, i.e. just above the visible light. According to one specific embodiment of the present invention, the sensor system is directed to the area called NIR (near-infrared), with a wavelength area normally defined in the range of from 750 nm to 1.4 pm. Therefore, according to one specific embodiment of the present invention, the IR source and IR receiver are a NIR source and NIR receiver, respectively. According to yet another specific embodiment of the present invention, the wavelengths used in the IR source is in the whole range of from 700 nm to 1.7 pm. According to yet another specific embodiment, the wavelengths used in the IR / NIR source is from 900 nm to 1.2 pm.

One great advantage provided by the present invention is the fact that the sensor system may now also provide data on the content in the water and not only the actual quality as one measurement. As such, content levels of substances, such as lime, hydrocarbon substances, e.g. fatty substances, polymers etc., and many other substances in the water may be measured and sent as data to a control unit, user interface or the like. Furthermore, different water types may be labelled by use of a sensor system according to the present invention, when comparing the content data to collected data in the past. Furthermore, also other parameters, such as the water hardness, which is a measure on the levels of minerals in the water, may also be set by use of the present invention.

Another advantage of the sensor systems according to the present invention is related to that the measurement may be performed on both emitted and absorbed light (wavelengths).

Moreover, it should be mentioned that there are existing systems where IR or NIR is used to measure water quality in general. For instance, in

US 2015/0369787 there is disclosed a system for monitoring quality of ballast water, and where one or more ballast water quality parameters may be measured using a measurement technology comprising at least one of fluorescence, light scattering, or Near Infrared (NIR). Moreover, in JP2016107235A there is disclosed an analysis method for water quality meaurement in a method involving membrane filtration separation, where the water quality measurement inviolves either or both of fluorescent spectroscopy and near-infrared spectroscopy.

None of these documents relates to the combination of an optimal sensor system for a water recirculation system, such as according to the present invention where the water quality measurement is used to drive a decision if water should be recirculated or separated off in a point of separation.

Specific embodiments of a first aspect of the present invention

Below, different embodiments of the present invention according to a first aspect are described.

First of all, it should be noted that the sensor system according to the present invention may comprise other sensor features than the IR or NIR source/detector. According to one specific embodiment, the sensor system also comprises a conductivity sensor and/or a turbidity sensor. A conductivity sensor is of interest to measure the conductivity which also may be used as one water quality indicator to show salinity, total dissolved solids and also as an indicator to a change in the water quality. To measure the turbidity may also function to measure the water quality, in this case to show turbidity (often measured in the NTU (Nephelometric Turbidity Units), which is a value of the level of the concentration of suspended particles in the water sample being measured.

Furthermore, it should also be said that the sensor system according to the present invention may comprise only one sensor, i.e. a IR or NIR sensor, or several sensors. If several sensors are provided, these may be of one type or different types. The sensor system, regardless of comprising one or more sensors, is connected to a data collecting unit, such as a control unit or the like. Moreover, the sensor system may have one or several purposes. One

purpose is of course directed to measurement of water quality. Another additional possible purpose may be to measure or indicate the functionality of a unit in the water recirculation device, such as discussed below.

Also other sensors may be implemented in the sensor system according to the present invention. According to one embodiment of the present invention, the sensor system also comprises a UV sensor. This UV sensor then detects wavelengths from 10 nm up to 400 nm. In such a case, the detector or receiver in one or several units then detects both UV wavelengths as well as IR / NIR wavelengths. This type of UV sensor provides the feature of detecting UV light. This should not be confused with a UV sensor which may be incorporated in the device as a quality measurement of a UV light intended as a water treatment unit by killing bacteria or the like. This type of UV sensor is incorporated to detect light from e.g. a UV lamp and thereby ensuring the functionality of the UV lamp. This is further disclosed below in reference to the functionality sensor mentioned below.

According to one specific embodiment of the present invention, according to a first aspect, the device also comprises a UV light or other type of light source. As hinted above, this UV light or other type of light source acts as a water treatment unit to neutralize organisms, such as bacteria or the like, in the water flow. Also other types of water treatment units than UV or other lights are possible to implement according to the present invention.

According to yet another embodiment, the device comprises a functionality sensor for the UV light or other type of light source. In the case of a UV light or UV lamp, the functionality sensor is a UV sensor which detects if the UV lights works as intended or not.

As may be understood from above, the sensor system according to the present invention may comprise one or several UV sensors. If several are provided then these may have different purposes.

According to yet another specific embodiment of the present invention, the sensor system comprises an energy sensor. This energy sensor detects energy which implies that it detects emission when atom or molecule performs a transition from a higher energy state to a lower energy state. To

give one possible example for a water recirculation system according to the present invention, if e.g. an enzyme is added into an intended measurement space, this enzyme may function as an activator to perform such energy transition. If such an enzyme is used it may also be mentioned that suitably the IR measurement is performed in one step and the addition of an enzyme or the like and energy state transition is detected in another step according to the present invention. Such an enzyme may then be used for bacteriological measurement in the water recirculation system according to the present invention.

Furthermore, according to yet another specific embodiment, the sensor system also comprises a micro-spectrometer, e.g. in the form of a NIR-UV-micro-spectrometer or a unit also comprising several other features such as according to above. There are many different types of micro-spectrometers available on the market today, intended for different types of wavelengths ranges. The present invention could incorporate almost any type as long as it supports the intended features discussed above.

It should be noted, as is evident from above, that several sensors may be comprised in the sensor system according to the present invention, even if a micro-spectrometer or similar sensor / receiver unit may in itself comprise several sensor features disclosed above.

Furthermore, according to yet another specific embodiment of the present invention, the sensor system comprises a camera module and an image sensor. In relation to this feature, please also see the second aspect of the present invention. This camera module and image sensor may be intended for the detection of particles, e.g. as a particle counter. The camera module sends a flash light into a transparent measurement space and the image sensor then takes an image when the space is illuminated. For particle counting or the like there are software possible to use when doing calculations from the image data sent from the image sensor to a control unit or computer unit.

According to yet another specific embodiment of the present invention, the IR source and the IR receiver are positioned on each sides of a transparent portion of the flow path for recycled water and before the point of

separation. This transparent portion is also suitable to include when a camera module and an image sensor are implemented in a system according to the present invention.

Furthermore, according to yet another embodiment of the present invention, the device comprises an off-line loop arrangement which comprises a liquid-stagnant space, wherein the IR source and the IR receiver are arranged to perform the measurement in the liquid-stagnant space. The off-line loop arrangement may e.g. be in the form of a transparent glass tube. The off-line loop arrangement is of interest to ensure that the water sample being measured is arranged in a liquid-stagnant space. At the moment, a IR measurement sequence or sweep over for instance a wavelength range of 700 - 1000 nm needs around 1 second to be performed. This further implies that at the moment with reference to the general IR and NIR technology development it is of interest to ensure to perform the IR or NIR water quality measurement in a space where the water is stagnant as it is not suitable to perform in flowing water.

Moreover, the loop arrangement according to the present invention may have different type of design and arrangement. According to one specific embodiment the loop arrangement is driven by use of throttling design and possibly also an ejector pump which has a sucking effect for filling up the loop arrangement with a new water sample to measure. With this type of arrangement, e.g. an enzyme or the like may also be sucked into the loop arrangement by use of the ejector pump.

Furthermore, the present invention also provides a device according to the present invention, where the sensor system is arranged for measurement of at least water quality, wherein the sensor system is connected to a control unit, and wherein the device also comprises at least two separation points, wherein one first separation point is positioned within the device to allow for recirculation of clean water or separation of a first separated stream of water not intended to be recirculated in the device, and wherein one second separation point is arranged for fractionation of the first separated stream of water in at least one high quality water stream and in one low quality water

stream, and wherein a decision of recirculation or separation is made by the control unit based on the measurement of water quality.

Moreover, according to yet another specific embodiment of the present invention there is provided a device according to the present invention, where the sensor system is arranged for measurement of at least water quality and where the sensor system is connected to a control unit, and wherein the device also comprises a separation point within the device to allow for recirculation of clean water or separation of at least two separated streams of water not intended to be recirculated in the device, wherein the at least two separated streams of water differ in water quality, and wherein a decision of recirculation or separation is made by the control unit based on the measurement of water quality.

Both of the embodiments according to the present invention disclosed above relate to multiple fractionation or separation of water based on water quality. In the first embodiment, at least two points of separation are used to fractionation the water at least two times. This may imply to have two similar points of separation, but most of all is intended to fractionate a stream separated off in the first point of separation into yet two streams where one first stream may be seen as a high quality stream and a second stream may be seen as a low quality stream. The high quality stream may either be recirculated back to the main flow path, if the quality is high enough, or may be used for a purpose where at least a certain quality is needed, e.g. to be used as water in a dishwasher or washing machine, or the like.

The latter alternative of the embodiments also implies providing possible fractionation of the water into at least three fractions being one first which is recirculated back and two other ones having different quality levels and may be used accordingly.

The device according to the present invention may of course also comprise other units. According to one specific embodiment of the present invention, the device also comprises a user outlet, a heater and a filter system. The user outlet differs depending on the type of device. To give some examples it may be a shower head in a shower device, or other types of nozzles, e.g. in a hair shower, or outlets in a washing machine or dishwasher.

The heater may any type suitable for heating the water flow, however for instance a combined UV unit and heater for water treatment may be one possible alternative according to the present invention.

Regarding the filter system, this may comprise one or several units. According to one specific embodiment, then the filter system only comprises a rough filter, which is intended to collect larger particles or the like, e.g. hair and so in a shower device. Such a rough filter may e.g. be positioned in the drain of a device according to the present invention. According to another specific embodiment of the present invention, then the filter system comprises also a finer filter, such as a micro-filter, which is intended to collect much smaller particles in the water flow.

According to yet another specific embodiment of the present invention there is provided a method for measurement of water quality in a device according to the present invention, wherein the method comprises measurement of water quality by using a sensor system comprising a IR source and a IR receiver, e.g. a NIR source and NIR receiver, and sending data of the water quality to a control unit which decides if water should be recycled or discarded in a point of separation based on the measurement of the water quality and/or to a computer unit collecting data about water quality and/or water content. It should be noted that the data sent to a computer unit or control unit may carry not only direct data on water quality but also other information, some of course relating to the water quality, such as concentration or level of different substances, a measure on water hardness, concentration of solids or particles, turbidity, conductivity, etc. etc.

As said above, according to one embodiment, the method also comprises measurement of content of substances in the water and sending data on the content of substances to the control unit and/or to a computer unit. The data may either be used in the control unit to allow for decision making on recirculation or not, but can also be sent to a computer unit for collection and storing or for visualization on a user interface or the like.

The present invention provides a device and method where it is not only to measure the water quality in a water recirculation device which is possible, but where also the chemical and biological content of the water as well as

certain other water parameters may be measured. Furthermore, by use of a IR source and a IR receiver, such as a NIR source and NIR receiver, it is possible to measure both on emitted and absorbed light (wavelengths).

Detailed description of the drawings relating to a first aspect of the present invention

In fig. 1 there is shown one specific embodiment according to the present invention. The water recirculation device 1, in this case a shower, comprises a flow path 4, a fresh water inlet and at least one point of separation 30. In this case there are three points of separations, which is further discussed below.

Furthermore, the device 1 also comprises a user outlet 50, in this case a shower nozzle as the device 1 is a recirculation shower. It is important to understand that many other industrial applications are possible according to the present invention, such as washing machines, dishwashers, hair showers etc. where the recirculation of water may be of interest.

Moreover, the water recirculation device 1 also comprises a sensor system 10 for measurement of water quality, said sensor system 10 comprising at least a IR source 20 and a IR receiver 21. Furthermore, as shown in fig. 1, according to this embodiment the IR/NIR source 20 and receiver 21 are positioned in an off-line loop arrangement 40. A throttling on the main tube of the flow path 4 enables water to be sucked into the off-line loop 40. This arrangement enables to measure a water volume which is not in movement. Moreover, and as shown in the enlargement of the black circle, the measurement portion may also comprise an addition unit enabling adding other substances, such as an enzyme or cleaning agents etc. Valves are provided at suitable positions for the processing of the system. Furthermore, a pump is used to enable recirculation in the system. Moreover, also an ejector pump may be provided to enable water to be flown into the off-line loop arrangement 40.

The senor system 10 may also comprise other components, such as electrical conductivity (EC) sensor(s) and a turbidity sensor, which in this embodiment are arranged in a water receiving unit (shower drain) in the shower, which is schematically depicted as a square with a dashed line.

Moreover, the sensor system 10 according to the present invention may also comprise other types of sensors or units. Examples are a UV sensor for also detecting UV light and not only IR or NIR, an energy sensor, a micro-spectrometer, and/or a camera module with an image sensor. Moreover, the system may also comprise a water treatment unit 75, e.g. in the form of a UV light 75 and/or heater, also a combined UV and heater. As such, the sensor system 10 may also comprise a functionality sensor for the UV light 75. Furthermore, the sensor system 10 is connected to a control unit which decides if water should be recycled or discarded in the point of separation(s) 30 based on the measurement of the water quality.

The first point of separation 30 is provided so that low quality water or contaminated water may be sent to waste (to a waste drain). If the quality of the water is high enough, then the flow is recirculated and sent further in the flow path 4. A second point of separation 30 may be arranged so that a higher quality water fraction may be sent to a recovery and second usage of that water fraction, such as in a washing machine, for irrigation purposes, or for flushing in a toilet. Furthermore, if the water quality is even higher than, water may be recirculated further in the flow path 4, either passing another point of separation 30 for another type of application or totally recycled in the water recirculation device 1. As shown in fig. 1, the water recirculation device 1 is a shower, and the water fraction having a quality high enough for reuse in the shower is totally recycled in the shower. Moreover, it is important to understand that also part of a flow may be separated off in different points of separations 30. Another way to describe the above possibility is that the present invention enables to separate suitable fractions as high quality water, another fraction for grey water use and also low quality water to intended waste.

In fig. 2 there is shown yet another embodiment of the present invention. Also in this case three points of separation 30 are provided. Furthermore, the device 1, also in the form of a shower, comprises a first shower drain unit. In this drain unit two sensors are provided which are also part of the sensor system 10. In this case, these sensors may be a level sensor and a water quality sensor, such as e.g. a turbidity sensor or the like.

This embodiment is very similar to the embodiment shown in fig. 1, however in this case the system also comprises a filter system 70. This filter system 70 comprises a pre-filter being a rough filter and also a main filter which is intended to filter off smaller particles, e.g. of micro-size or even smaller. It should be noted that the filter system 70 may also only comprise a pre-filter and no further filters.

Furthermore, in this case, the system also comprises a water treatment unit 75, in this case a UV light or lamp 75. Moreover, the senor system 10 also comprises a functionality sensor for the UV light 75. As seen, a control unit may be arranged which is in connected to different sensor units.

A second aspect of the invention

Field of a second aspect of the invention

According to a second aspect, the present invention relates to a device intended for recycling of water or discarding of water not suitable to recycle, said device comprising a sensor system involved in the decision for discarding or allowing for recirculation of water.

Technical background to this second aspect

As mentioned above, today there are existing water recirculation devices. As said, one such, in the form of a shower, is disclosed in WO 2013/095278 which describes a hybrid device for a recirculation shower, allowing purification and either recycling of water or discarding of water, where said hybrid device comprises a recirculation loop, a filter system with a nano-filter, and at least one filter quality sensor, and wherein the hybrid device is arranged to redirect the water from recirculation to drainage when the at least one filter quality sensor indicates the need thereof. The solution in WO 2013/095278 also comprises sensors, such as a filter quality sensor, e.g. in the form of a pressure meter, and also a water quality sensor, e.g. a TOC (Total Organic Carbon) sensor, a biosensor, a pH meter (measuring acidity or alkalinity), an optical sensor, or a conductive sensor, such as an electrical conductive sensor. Furthermore, in WO 2015/094107 there is disclosed a hybrid device allowing for purification and either recycling of water or discarding of water, wherein said hybrid device comprises multiple conductivity sensors.

One aim of a second aspect of the present invention is to further simplify the decision for either discarding of contaminated water or recirculation of clean water. According to this aspect, the present invention aims on increasing the accuracy of the measurement and the provision of a simple and fast detection measure if water should be discarded or recirculated.

Summary of the second aspect of the invention

The stated purpose above is achieved by a device intended for recycling of water or discarding of water not suitable to recycle, said device comprising a flow path for recycled water, a fresh water inlet and a point of separation, wherein the device also comprises a sensor system for measuring of water quality, wherein the sensor system comprises a camera module arranged to take one or more images of water in the device in an image space, and wherein the sensor system is connected to a control unit which decides if water should be recycled or discarded in the point of separation based on the measurement of the water quality.

The expression “image space” should be seen as the flow space inside of the device into which the camera is taking the images.

As should be understood from above, the present invention, according to this second aspect, is directed to a water recirculation system comprising a sensor system, which sensor system comprises a camera module. As said, the camera module is arranged to take one or more images of water in the so called image space of the water flow space in the device. Furthermore, the sensor system is used to detect one or more parameters enabling for a control system to decide if water should be recirculated in the device or discarded and separated off from the device based on the water quality. The device may have one or more separation points as is further discussed below.

The camera module may be arranged at different positions in a device according to the present invention. As a first alternative, the camera module and thus detection point is positioned before but in proximity to a separation point so that when detection of bubbles, particles or contamination in a water fraction is detected then this water fraction may be separated off directly. This may have the advantage that the delay between detection and action is

diminished. As one example, the camera module may be positioned in connection to a drain in a recirculation shower. This alternative is further discussed in relation to the figures.

The actual camera module according to the present invention may be a standard camera, e.g. with a 8 megapixel resolution. The camera module is connected to a chip, micro-processor or any type of computer unit or control unit to detect image data, save the same and also process the same. It should be noted that a device according to the present invention may comprise additional micro-processors intended for other reasons than for the camera module. Furthermore, the camera module may be directly connected also to other sensors, e.g. by implementing LED units which may provide different colors when the sensors indicate something specific, e.g. when measuring conductivity as explained below.

Specific embodiments of the second aspect of the present invention

Below some specific embodiments of the second aspect of the present invention are disclosed and discussed further.

The camera module according to the second aspect of the present invention comprises different components. The camera module comprises a flash. As the camera detects colour, it is of interest to avoid disturbing light for the surrounding. Therefore, keeping the camera module in a dark surrounding and using a flash to take the images is preferred in some set-up modes.

Besides the colour question it is of interest to ensure to keep the lens of the camera module free from any contamination or water. Any type of deposit onto the camera lens may disturb the images so this is of importance to avoid. To keep the lens free from any contamination risk may be provided by different means. According to one specific embodiment of the present invention, the camera module is arranged to provide an air gap to water. This is one way of ensuring this. Furthermore, according to another embodiment, the camera module is arranged outside of a transparent portion of the device. So, to ensure that the camera module may take controlled images of a water flow in an environment without interference from surrounding light or interference from contamination on the lens or in or on a water enclosing transparent tube is a key feature of the present invention. It should be noted

that also other alternatives are possible according to the present invention. For instance, according to one specific embodiment the camera is embedded in a transparent material, such as in a silicone material or the like.

Moreover, also water proof camera modules may be used in a device according to the present invention. In such cases, the placing of the camera module may be inside of a tube where water flows. Therefore, the present invention embodies both the case where a camera module is free from direct contact with water and also the case where there a risk of contact with water.

The camera module may also comprise other components. As one example, the camera module may comprise a macro lens. This may be of interest to enable a magnification. Furthermore, the camera module is intended to be in connection with the control unit of the device, e.g. a microprocessor of that control unit. Image data may be sent to the microprocessor in which it is processed to provide a response to the question if water should be discarded or recycled so that the control unit can act based on the obtained image data. Furthermore, the control unit may of course also receive data from other sensors in the device, and also use this as either data to act upon or data to store or send further, and this is further discussed below.

There are of course existing techniques today for the analysis of particles and the like in samples and flows. Also cameras and images are used in such analysis today. The present invention is, however, directed to the incorporation of a camera module in a water recirculation device to enable to perform a decision of either discarding water or recirculation of the same. Moreover, the present invention also provides the incorporation of a camera module in a way so that the risk of interference from either outside light or lens disturbance is diminished.

The device according to this second aspect of the present invention suitably also has the ability to treat water. Therefore, according to one specific embodiment of the present invention, the device also comprises one or more water treatment units. Such water treatment units may be of different types and several different ones may be combined in a system according to the present invention. According to one specific embodiment of the present

invention, said one or more water treatment units is one or more filters, a heater or a UV unit, or a combined UV and heater unit. Also combinations of several of these are possible. To give an example, a pre-filter may be positioned in connection to the drain to enable to separate off larger pieces in the water flow, e.g. hair in a recirculation shower, and which is combined with a UV unit and a heater, possible in one and the same combined UV and heater unit. Furthermore, the device may also comprise another filter which is intended to separate off smaller particles, such as particles or the like down to micro sizes.

Furthermore, the device according to the present invention may also comprise several other units and components. Examples are the actual drain unit, a fresh water inlet, and a user outlet, etc. Furthermore, one or more pumps are also part of the device according to the present invention. These different components are further discussed below in relation to the figures and one example of a combination system is shown in fig. 4.

In addition to the camera module, the sensor system may comprise also other sensors. According to one specific embodiment of the present invention, the sensor system comprises a water quality sensor. This water quality sensor may be an additional sensor to the camera module. Examples are conductivity sensors, such as electrical conductivity sensors, a pH sensor, turbidity sensor, or a sensor measuring ultrasound or microbiological activity. Moreover, according to yet another embodiment of the present invention, the sensor system also comprises a water composition sensor, e.g. in line with the first aspect of the present invention. One possible example is a IR (infrared) source and IR receiver, e.g. a NIR (near infrared) source and NIR receiver, i.e. in line with the first aspect of the present invention. As an example, a IR source and a IR receiver may be positioned on each sides of a transparent portion of the flow path for recycled water and before the point of separation. Furthermore, according to yet another specific embodiment of the present invention, the sensor system comprises a UV sensor. A UV sensor may work as a functionality sensor for a possible UV light / UV lamp, but can also act as direct water quality sensor.

Furthermore, according to yet another specific embodiment of the present invention, the device also comprises an off-line loop arrangement and wherein the camera module is arranged to generate images inside of the off-line loop arrangement. An off-line loop is only one alternative according to the present invention, and it is optional. One possible advantage of an off-line loop is that water may be directed to this single loop with controlled conditions. Moreover, it may be simple to apply a loop arrangement connected to a camera module to a water recirculation system according to the present invention. The opposite, a so called inline solution, implies that a section of the tubing has to be transparent, such as being made of glass, e.g. plexiglass.

Furthermore, it should be noted that the off-line loop arrangement may comprise also other sensors, such as mentioned above. Moreover, it should be stated that the present invention also embodies a water recirculation system where the camera module is provided in connection to the main tubing. Furthermore, also in such a case an off-line loop may be provided to include other sensors.

The off-line loop arrangement may be connected to a pump to ensure to be able to pressurize the loop. Furthermore, the off-line loop arrangement may comprise a liquid-stagnant space where water is ensured to be kept without any movement. This may be of interest for some sources to ensure that one and the same water fraction is measured on. To give one example, IR measurements may be in need of such an arrangement. In this regard it should be noted that a camera module according to the present invention does not have to take images in a liquid-stagnant space, however it is one possibility according to the present invention. As understood from above, according to one specific embodiment of the present invention, the off-line loop arrangement comprises one or more sensors enabling measuring in the off-line loop arrangement. Furthermore, according to yet another specific embodiment of the present invention, said one or more sensors in the off-line loop arrangement is arranged to measure at least one of the parameters conductivity, pH value, energy, ultrasound or microbiological activity, or a combination of these. Another possible component to use is a micro-

spectrometer. Moreover, and as said above, a IR source and a IR receiver may be arranged in the off-line loop arrangement.

Furthermore, the water recirculation device according to the present invention may comprise other components and features. To mention one examples, the device may provide the possibility to multi-separate och fractionate in several points. Therefore, according to one specific embodiment of the present invention, the sensor system is arranged for measurement of at least water quality and where the sensor system is connected to a control unit, and where the device also comprises at least two separation points, wherein one first separation point is positioned within the device to allow for recirculation of clean water or separation of a first separated stream of water not intended to be recirculated in the device, and wherein one second separation point is arranged for fractionation of the first separated stream of water in at least one high quality water stream and in one low quality water stream, and wherein a decision of recirculation or separation is made by the control unit based on the measurement of water quality. Moreover, according to yet another specific emboidment of the present invention, the sensor system is arranged for measurement of at least water quality and wherein the sensor system is connected to a control unit, and where the device also comprises a separation point within the device to allow for recirculation of clean water or separation of at least two separated streams of water not intended to be recirculated in the device, wherein the at least two separated streams of water differ in water quality, and wherein a decision of recirculation or separation is made by the control unit based on the measurement of water quality.

Moreover, the present invention according to this second aspect also refers to a method. According to one specific embodiment of the present invention, there is provided a method for measurement of water quality in a device according to the present invention, wherein the method comprises using a sensor system comprising a camera module to take one or more images in flashes and in a dark environment around the camera module, and sending image data to a control unit which decides if water should be recycled or discarded in a point of separation based on the image data and/or

to a computer unit collecting data about water quality and/or water content. By use of a flash and taking images one by one, instantaneous images are obtained. One can say that the flash “freezes” the image and makes it possible to analyze it in the right way, i.e. with distinct particles / bubbles.

According to yet another specific embodiment of the present invention, the method involves calculating one or more water quality parameters from the one or more images. This implies that the control unit may evaluate a measured level against a set limit value, said limit value being obtained as an absolute value or as limit value which is set continuously based on a reference value which may change based on the measurements in the device (“the water recirculation AI device with learning capabilities”). This feature may be suitable for some parameters, while absolute limits are more suited for other parameters.

The method according to the present invention provides the capability of detecting different events. According to one specific embodiment of the present invention, the method involves analyzing images with respect to colour and/or size of bubbles, if present. By using colour as a parameter, then it should be mentioned that the method may evaluate the colour in a white to dark range. A very white result may indicate foam formation and a lot of bubbles in the water, such as for instance if a shampoo or conditioner has been used in a water recirculation shower. Another possible example is if a sun lotion is washed off from a user’s body in such a shower. It may be said that a shampoo may provide the “whitest” result when comparing the above mentioned. Furthermore, the method according to the present invention may also comprise detecting particles. Here the method may involve to detect particles as such, further evaluate these or only calculate the particles (see below). By using the method according to the present invention, it is not only possible to measure clean vs contaminated water, but also what the water contains, like particles, shampoo, conditioner or foam etc.

Moreover, according to yet another specific embodiment of the present invention, the method also comprises measurement of content of substances in the water and sending data on the content of substances to the control unit and/or the computer unit. This further step implies that the composition of the

water, or at least the composition referring to some components, are set and data are used either in the decision step or as data to collect and present. Furthermore, the method may also comprise measuring at least one other parameter in one or more sensors in the sensor system and sending data thereof to the control unit and/or the computer unit. This combination may refer to both taking images and sending this data as well as measuring and saving data on a conductivity sensor or UV sensor or some other sensor.

Moreover, the device may comprise an off-line loop arrangement, as mentioned above. Therefore, according to one specific example, the method may comprise directing part of a water flow to an off-line loop arrangement where the one or more images are taken. As mentioned above, the device may also comprise the off-line loop for other reasons. As one example, the method may involve measuring at least one other parameter in the water in one or more sensors in the off-line loop arrangement and sending this data to the control unit and/or the computer unit. Furthermore, the step of directing part of the water flow to an off-line loop arrangement may be performed cyclically. This may be of interest to continuously measure some parameters, or taking images, in the water, e.g. after some events that trigger an increased need for measurement. As an example, in a water recirculation shower the cyclical behavior may be triggered by normal use times during a day and night, real use or other events taking place.

Description of the drawings relating to the second aspect of the present invention

In fig. 3 there is shown one possible part of a device 1 according to one specific embodiment of the present invention. In this case the camera module 80, which is part of a sensor system 10, is arranged to be connected to an off-line loop arrangement 3. In fig. 3 a pump drives water into the off-line loop arrangement 3 and then a camera module 80 takes images of a water beam. In this regard different arrangements are possible. It is important to keep the lens free from any contamination risk, also to ensure that water is not in contact with the lens. As shown in fig. 3, this may be accomplished by providing a water beam. Another alternative is to use a transparent glass, however also in this case it is important that the glass is free from

contamination or bubble formation etc. If bubbles are there is should be there because of bubbles being present in the water from a shampoo or the like and not bubbles being formed in the flowing into the off-line loop arrangement 3.

Other possible parts of one system example is provided in fig. 4. In fig. 4 there is shown one “total” device system according to one embodiment of the present invention. It should be noted that this examples provides a variety of different sensors, however only the camera module 80 is a mandatory component of a sensor system 10 according to the present invention. In this example, where a recirculation shower 1 is shown, there may be arranged several other sensors 11, or only one of them, in the sensor system 10. This sensor system 10 is connected to a computer unit or control unit to enable saving or processing the obtained data. It should also be mentioned that any of the mentioned sensors may be provided in the main tubing, e.g. in the flow path 4. It is however suitable that the sensor providing direct input to the decision if water should be recirculated or discarded, i.e. in this case the camera module 80, is arranged before the decision point / separation point 30 which in this case is arranged in a so called selection tank. This selection tank is arranged directly after the user drain in the shower floor so that water flown out from the shower head and onto the user may then directly be measured and either recirculated or discarded.

As may be seen, the device in this case comprises two off-line loop arrangements 3, however it should be noted that a device 1 according to the present invention may comprise none or only one such loop 3. Furthermore, the actual arrangement of an off-line loop 3 may vary. In the second case a restriction and ejector pump are provided. Furthermore, there is a valve provided to enable water to be flown into the second off-line loop 3. Furthermore, a connection to the waste may be provided to enable to send a measurement fraction to the waste. Again, and as said, suggested sensors 11, and also the camera module 80, of the sensor system 10, may also be arranged directly on the main tubing.

The device 1 comprises a fresh water inlet 5 with a mixing valve for hot and cold water. This is of course also valid for the alternatives shown in figs.

1-3, even if this is not shown. Furthermore, pumps may be arranged at different places in the device 1, but also one single pump may be used. This is also dependent on the number of off-line loop arrangements provided in the system. Moreover, the device 1 also comprises one or more water treatment units 500, e.g. one or more filters, a heater or a UV unit, or a combined UV and heater unit. Furthermore, the device 1 may also be provided with an inlet to provide other components into the water, e.g. components intended for measuring purposes, such as reference agents or energy carriers, e.g. enzymes, or treatment agents, e.g. citric acid.

In fig. 5, the results are shown of a test performed in a device according to the present invention. In this case, a hose is placed in a drain of a recirculation shower 1 according to the present invention. A pump flows water into the hose and out from the hose as a continuous beam. This continuous beam is flown out in front of a camera module 80 arranged in a dark surrounding. The camera registers all items giving some kind of light or colour in the water flow, such as particles and bubbles during the micro second when the flash of the camera module 80 is activated. In this case the number of particles per image are counted. The value of the number of particles per image is presented every 10 seconds in the graph shown in fig. 3. As notable, the test was run for 10 minutes. Two different peaks are clearly seen in the graph. In the first peak shampoo used in the shower 1 was clearly detected and in the second peak conditioner used was also clearly detected.

In fig. 6 one image provided according to the present invention is shown. In this case it is clearly seen that bubbles are seen in the flow. According to the present invention, the number of these or the colour provided, in this case very white, may be detected. In this case it is clearly seen that a shampoo or a conditioner is detected in the flow. If a clean water flow is detected, then a clear dark flow is seen instead. From this figure it should be clear that the device and method according to the present invention provides a mode for a clear and simple detection of clean water and contaminated water, respectively.

In fig. 7 a corresponding figure is shown with two enlargements provided beneath (see the marked square). In this case, the device and

method visualizes particles in the flow. As seen in the enlargements there are several particles shown as white dots. These are marked with rings in the enlargement to the right. It should be noted that the method according to the present invention is founded on the same basis independently if bubbles or found or particles. The only difference is in the images created. Colour is however one important indicator with reference to finding these objects in the water flow.

It should be noted that a solution in accordance with the first aspect of the present invention may be combined with a solution according to a second aspect of the present invention, as is hinted above. This combination may be made in many different ways, however the starting point being to combine a camera unit with an IR unit, e.g. a NIR unit, in a device intended for recirculation or recycling of water. It should be said that specific features disclosed in relation to a first aspect of the present invention may be combined with the second aspect of the present invention, also in its broadest sense, and vice versa.

Clauses - some embodiments relating to a second aspect of the present invention

1. Device (1) intended for recycling of water or discarding of water not suitable to recycle, said device (1) comprising a flow path (4) for recycled water, a fresh water inlet (5) and a point of separation (30), wherein the device also comprises a sensor system (10) for measuring of water quality, wherein the sensor system (10) comprises a camera module (80) arranged to take one or more images of water in the device (1) in an image space, and wherein the sensor system (10) is connected to a control unit which decides if water should be recycled or discarded in the point of separation (30) based on the measurement of the water quality.

2. Device according to claim 1, wherein the camera module (80) is arranged to provide an air gap to water.

3. Device according to claim 1 or 2, wherein the camera module (80) is arranged outside of a transparent portion of the device (1).

4. Device according to any of claims 1-3, wherein the camera module (80) comprises a macro lens.

5. Device (1) according to any of claims 1-4, wherein the device (1) also comprises one or more water treatment units (500).

6. Device (1) according to claim 5, wherein said one or more water treatment units (500) is one or more filters, a heater or a UV unit, or a combined UV and heater unit.

7. Device (1) according to any of the preceding claims, wherein the sensor system (10) comprises a water quality sensor.

8. Device (1) according to any of the preceding claims, wherein the sensor system (10) comprises a water composition sensor.

9. Device (1) according to any of claims 2-8, wherein the sensor system (10) comprises a UV sensor.

10. Device (1) according to any of claims 1-9, wherein the device (1) also comprises an off-line loop arrangement (3) and wherein the camera module (80) is arranged to generate images inside of the off-line loop arrangement (3).

11. Device (1) according to claim 10, wherein the off-line loop arrangement (3) is connected to a pump.

12. Device (1) according to claim 10 or 11, wherein the off-line loop arrangement (3) comprises one or more sensors (11) enabling measuring in the off-line loop arrangement (3).

13. Device (1) according to claim 12, wherein said one or more sensors (11) is arranged to measure at least one of the parameters conductivity, pH value, energy, ultrasound or microbiological activity, or a combination of these.

14. Device (1) according to claim 12 or 13, wherein a IR source and a IR receiver is arranged in the off-line loop arrangement (3).

15. Device (1) according to any of claims 1-14, wherein the sensor system (10) is arranged for measurement of at least water quality and wherein the sensor system (10) is connected to a control unit, and wherein the device (1) also comprises at least two separation points (30), wherein one first separation point (30) is positioned within the device (1) to allow for recirculation of clean water or separation of a first separated stream of water not intended to be recirculated in the device (1), and wherein one second separation point (30) is arranged for fractionation of the first separated stream

of water in at least one high quality water stream and in one low quality water stream, and wherein a decision of recirculation or separation is made by the control unit based on the measurement of water quality.

16. Device (1) according to any of claims 1-14, wherein the sensor system (10) is arranged for measurement of at least water quality and wherein the sensor system (10) is connected to a control unit, and wherein the device (1) also comprises a separation point (30) within the device (1) to allow for recirculation of clean water or separation of at least two separated streams of water not intended to be recirculated in the device (1), wherein the at least two separated streams of water differ in water quality, and wherein a decision of recirculation or separation is made by the control unit based on the measurement of water quality.

17. Method for measurement of water quality in a device (1) according to any of claims 1-16, wherein the method comprises using a sensor system (10) comprising a camera module (80) to take one or more images in flashes and in a dark environment around the camera module (80), and sending image data to a control unit which decides if water should be recycled or discarded in a point of separation (30) based on the image data and/or to a computer unit collecting data about water quality and/or water content.

18. Method according to claim 17, wherein the method involves calculating one or more water quality parameters from the one or more images.

19. Method according to claim 17 or 18, wherein the method involves analyzing images with respect to colour and/or size of bubbles, if present.

20. Method according to any of claims 17-19, wherein the method also involves detecting particles.

21. Method according to any of claims 17-20, wherein the method also comprises measurement of content of substances in the water and sending data on the content of substances to the control unit and/or the computer unit.

22. Method according to any of claims 17-21, wherein the method comprises measuring at least one other parameter in one or more sensors in the sensor system (10) and sending data thereof to the control unit and/or the computer unit.

23. Method according to any of claims 17-22, wherein the method comprises directing part of a water flow to an off-line loop arrangement (3) where the one or more images are taken.

24. Method according to claim 23, wherein the method also comprises measuring at least one other parameter in the water in one or more sensors in the off-line loop arrangement (3) and sending this data to the control unit and/or the computer unit.

25. Method according to claim 23 or 24, wherein the step of directing part of the water flow to an off-line loop arrangement (3) is performed cyclically.

Claims

1. Device (1) intended for recycling of water or discarding of water not suitable to recycle, said device (1) comprising a flow path (4) for recycled water, a fresh water inlet and a point of separation (30), wherein the device also comprises a sensor system (10) for measurement of water quality, wherein the sensor system (10) comprises a IR source (20) and a IR receiver (21), and wherein the sensor system (10) is connected to a control unit which decides if water should be recycled or discarded in the point of separation (30) based on the measurement of the water quality.

2. Device (1) according to claim 1, wherein the IR source (20) and IR receiver (21) are a NIR source and NIR receiver, respectively.

3. Device (1) according to claim 1 or 2, wherein the sensor system (10) also comprises a conductivity sensor and/or a turbidity sensor.

4. Device (1) according to any of claims 1-3, wherein the device (1) also comprises a UV light (75) or other type of light source.

5. Device according to claim 4, wherein the device (1) comprises a functionality sensor for the UV light (75) or other type of light source.

6. Device (1) according to any of claims 1 or 2, wherein the sensor system (10) also comprises at least one UV sensor.

7. Device (1) according to any of claims 1-6, wherein the sensor system (10) comprises an energy sensor.

8. Device (1) according to any of claims 1-7, wherein the sensor system (10) also comprises a micro-spectrometer.

9. Device (1) according to any of claims 1-8, wherein the sensor system (10) comprises a camera module and an image sensor.

10. Device (1) according to any of claims 1-9, wherein the IR source (20) and the IR receiver (21) are positioned on each sides of a transparent portion of the flow path (4) for recycled water and before the point of separation (30).

11. Device (1) according to any of claims 1-10, wherein the device comprises an off-line loop arrangement (40) which comprises a liquid-stagnant space (2), wherein the IR source (20) and the IR receiver (21) are arranged to perform the measurement in the liquid-stagnant space (2).

12. Device (1) according to any of claims 1-11, wherein the sensor system (10) is arranged for measurement of at least water quality and wherein the sensor system (10) is connected to a control unit, and wherein the device (1) also comprises at least two separation points (30), wherein one first separation point (30) is positioned within the device (1) to allow for recirculation of clean water or separation of a first separated stream of water not intended to be recirculated in the device (1), and wherein one second separation point (30) is arranged for fractionation of the first separated stream of water in at least one high quality water stream and in one low quality water stream, and wherein a decision of recirculation or separation is made by the control unit based on the measurement of water quality.

13. Device (1) according to any of claims 1-11, wherein the sensor system (10) is arranged for measurement of at least water quality and wherein the sensor system (10) is connected to a control unit, and wherein the device (1) also comprises a separation point (30) within the device (1) to allow for recirculation of clean water or separation of at least two separated streams of water not intended to be recirculated in the device (1), wherein the at least two separated streams of water differ in water quality, and wherein a decision

of recirculation or separation is made by the control unit based on the measurement of water quality.

14. Device (1) according to any of the preceding claims, wherein the device (1) also comprises a user outlet (50), a heater and a filter system (70).

15. Method for measurement of water quality in a device (1) according to any of claims 1-14, wherein the method comprises measurement of water quality by using a sensor system (10) comprising a IR source (20) and a IR receiver (21), and sending data of the water quality to a control unit which decides if water should be recycled or discarded in a point of separation (30) based on the measurement of the water quality and/or to a computer unit collecting data about water quality and/or water content.

16. Method according to claim 15, wherein the method also comprises measurement of content of substances in the water and sending data on the content of substances to the control unit and/or computer unit.

Fig 1

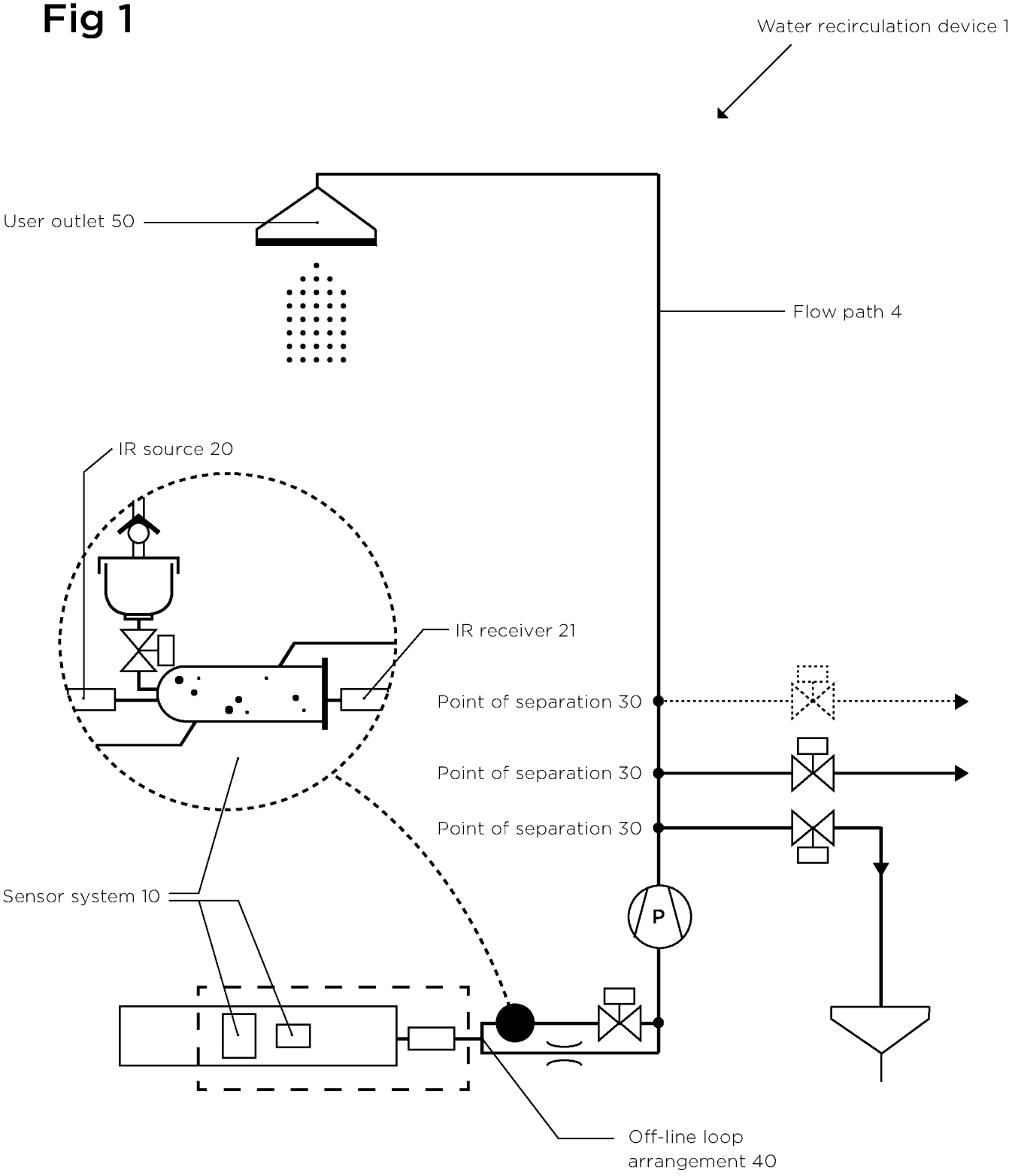

Water recirculation device 1
User outlet 50
Flow path 4
IR source 20
IR receiver 21
Point of separation 30
Point of separation 30
Point of separation 30
Sensor system 10
P
Off-line loop arrangement 40

Fig 2

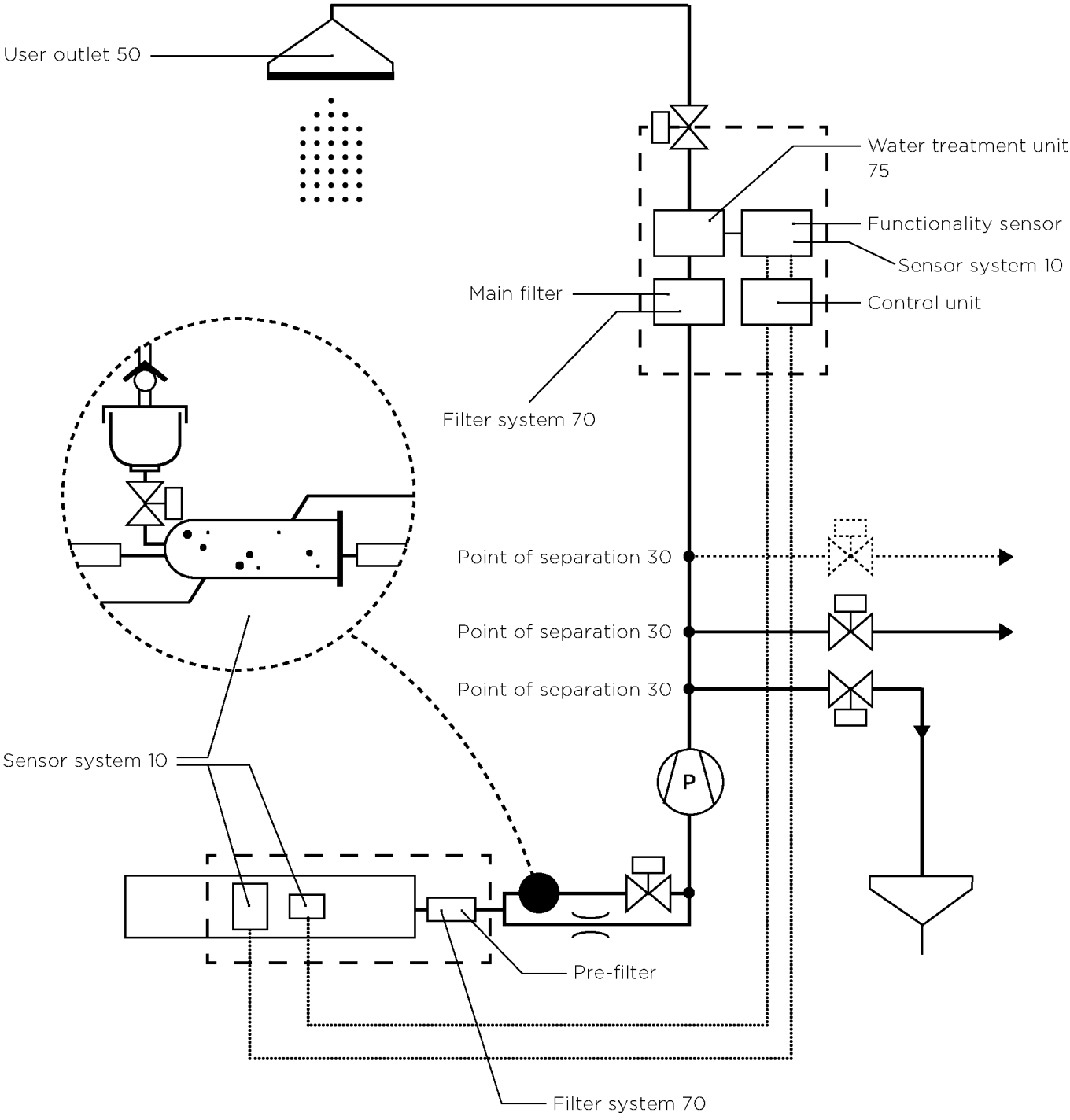

User outlet 50
Water treatment unit 75
Functionality sensor
Sensor system 10
Main filter
Control unit
Filter system 70
Point of separation 30
Point of separation 30
Point of separation 30
P
Sensor system 10
Pre-filter
Filter system 70

Fig 3

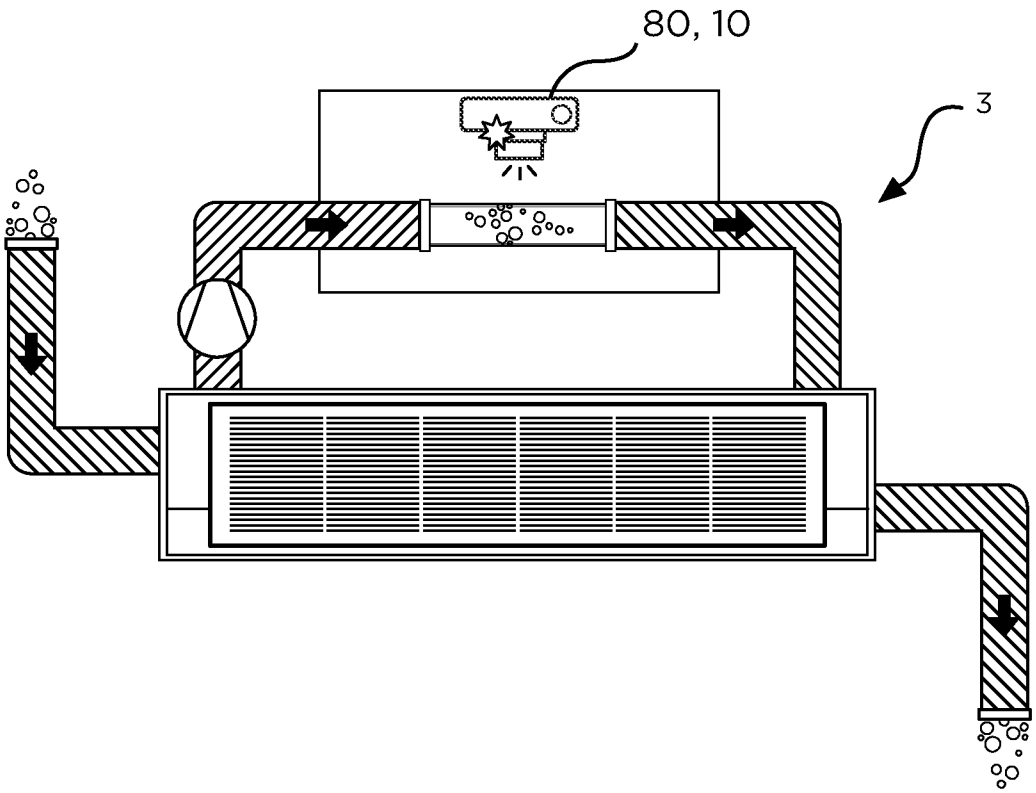


Fig 4

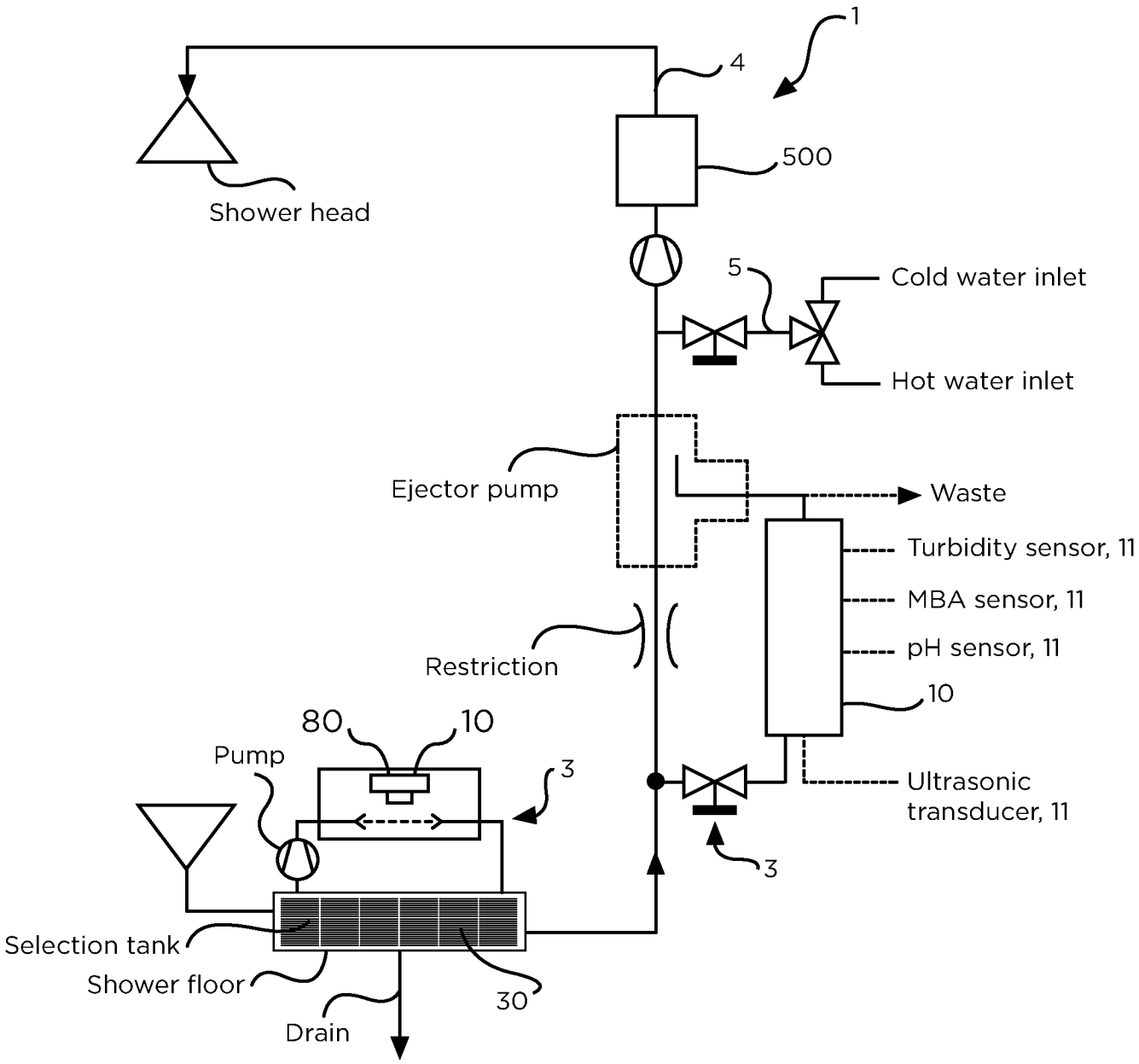
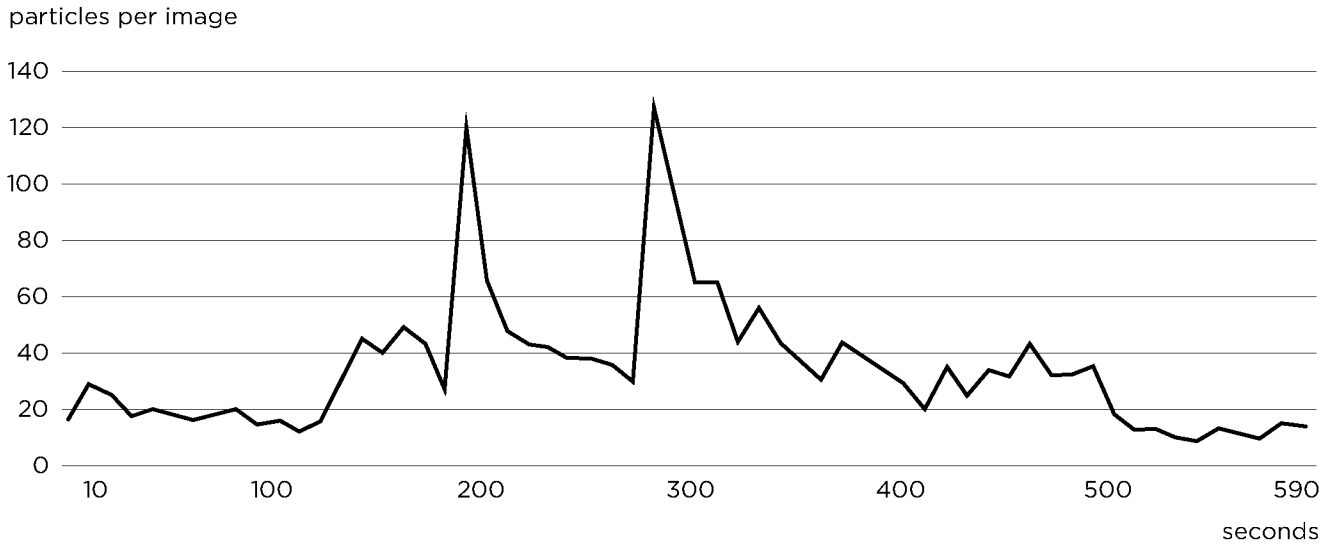

1
4
500
Shower head
5
Cold water inlet
Hot water inlet
Ejector pump
Waste
Turbidity sensor, 11
MBA sensor, 11
pH sensor, 11
10
Restriction
80
10
Pump
3
Ultrasonic transducer, 11
3
Selection tank
Shower floor
30
Drain

Fig 5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100
80
60
40
20
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10
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400
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590
seconds

Fig 6

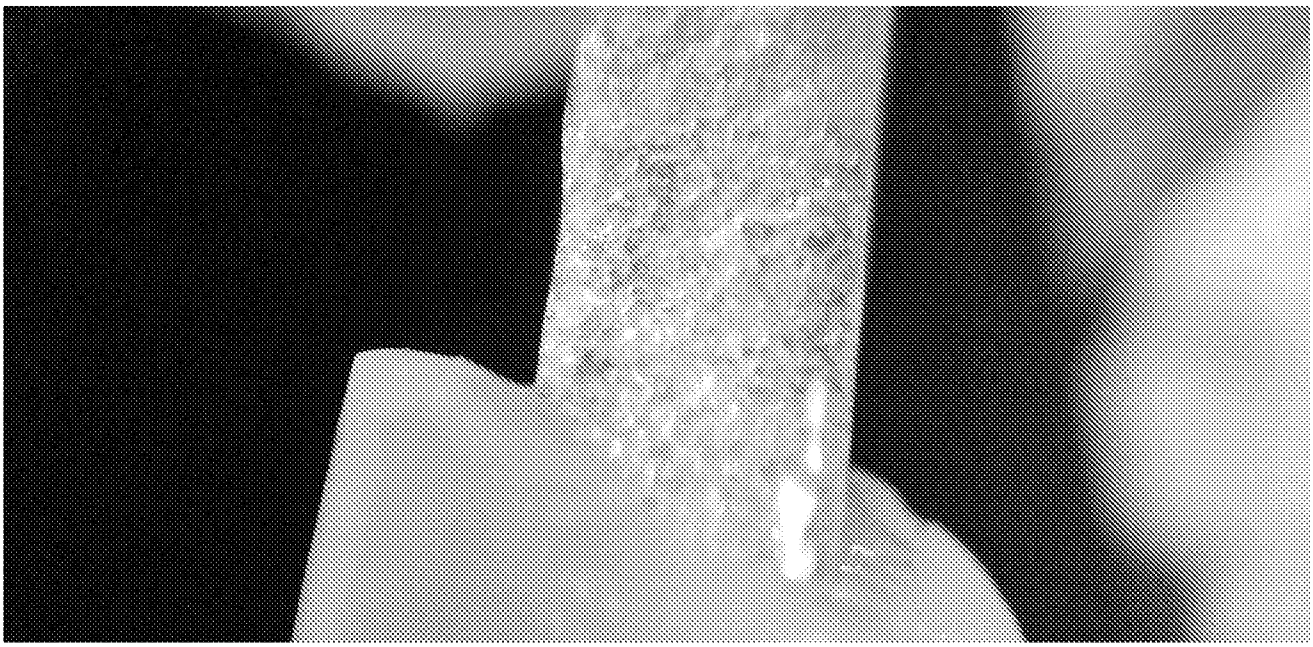
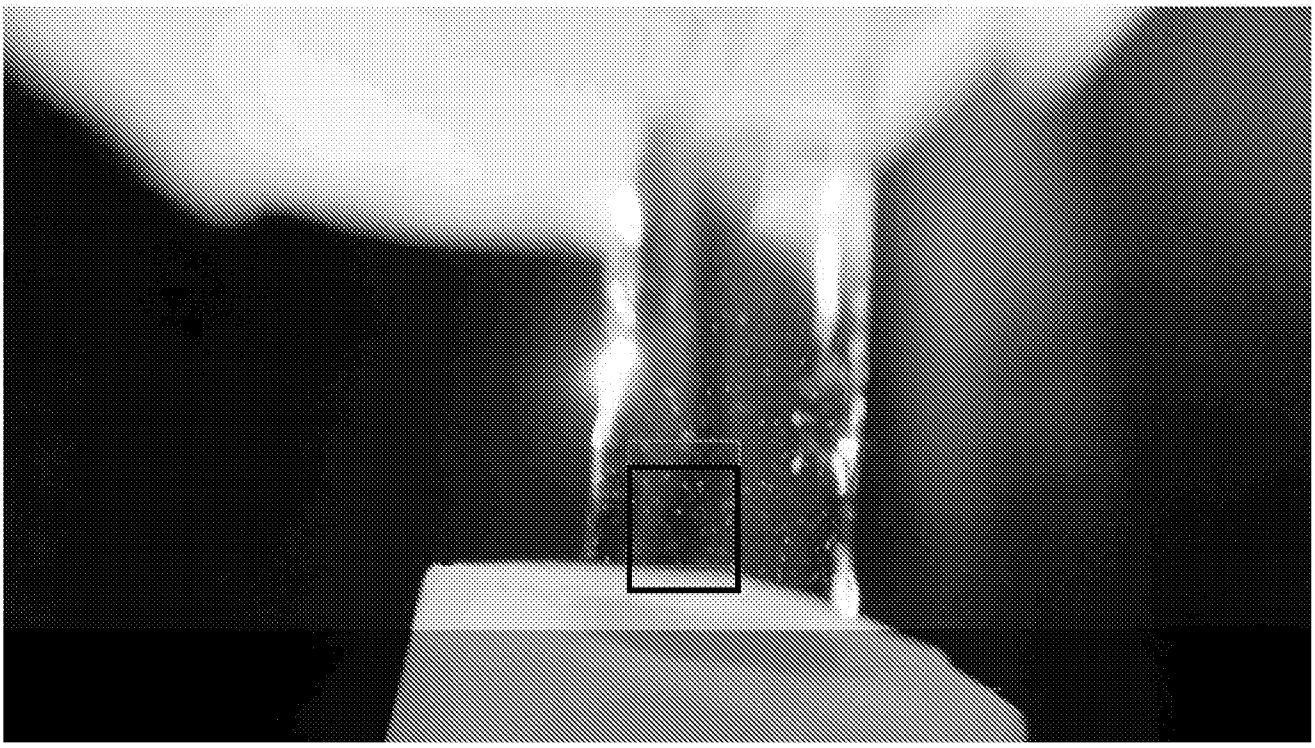
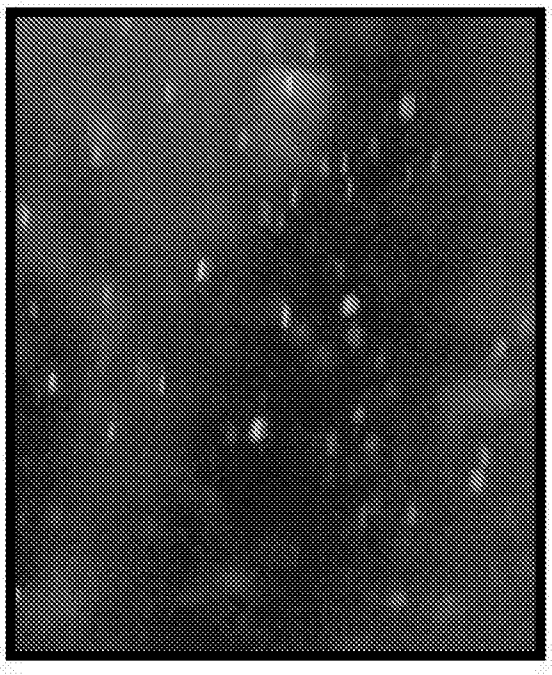
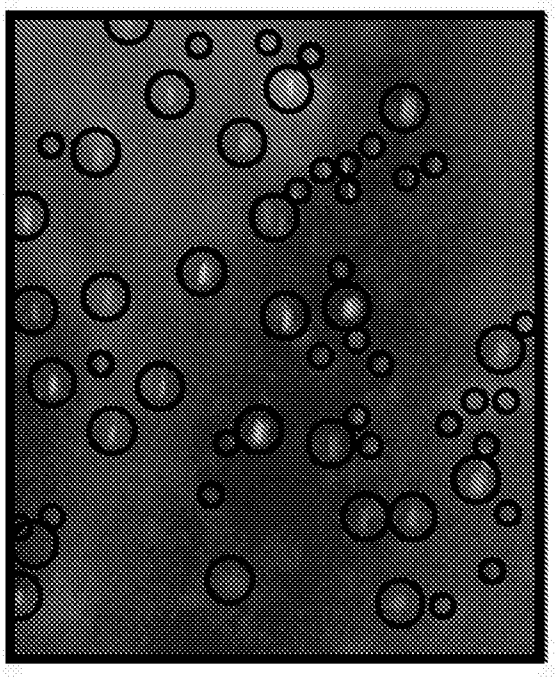


Fig 7



Particle search





INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 9/0501 05

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: A47K, E03B, E03C

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

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013095278 A1 (ORBITAL SYSTEMS AB), 27 June 2013 (2013-06-27); abstract; page 10, line 26 - page 11, line 16; page 12, line 1 - page 12, line 6; figures --	1-16
Y	Mizaikoff, Boris. (2003). Infrared optical sensors for water quality monitoring. Water science and technology : a journal of the International Association on Water Pollution Research. 47. 35-42. 10.2166/wst.2003.0079.; abstract; figures --	1-16
Y	JP 2016107235 A (SWING CORP.), 20 June 2016 (2016-06-20); abstract; claim 1 --	1-16

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"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)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"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
25-04-2019	25-04-2019
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Yvonne Grebäck Telephone No. + 46 8 782 28 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2019/050105

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2014076171 A1 (LITEHAUZ APS), 22 May 2014 (2014-05-22); page 6, line 6 - page 6, line 11; claim 6 --	1-16
A	US 20180022618 A1 (BERTRAND GUILLAUME ET AL), 25 January 2018 (2018-01-25); abstract; figures --	1-16
A	CN 101579198 A (YUTONG CHEN ET AL), 18 November 2009 (2009-11-18); abstract; figures -- --------	1-16

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International Patent Classification (IPC)

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