ineffective, have been developed. Such devices are described for example in US 4,681,677; US 5,997,734 and 6,491,811; as well the above-indicated International publication WO 08/044230.

GENERAL DESCRIPTION

Provided, by an aspect of the disclosure herein, is a liquid filter device configured with an ability to be automatically shut/blocked (without a need for user intervention) when a filtering media has become ineffective. Provided by another aspect of the disclosure herein is a liquid filter device that is configured to enable to maintain a filtering medium in the filter under optimal conditions.

The present invention provides a novel filter device, which according to one aspect of the invention, is configured for maintaining at least a part of the filtering medium therein in a liquid environment. This is important so that the porousivity will not be lost which may occur if the filter medium dries.

Thus, there is provided a filter device for filtering a liquid portion by passing it through at least one filtering medium. The filter device comprises at least one cartridge comprising a treatment region filled with the at least one filtering medium, an inlet for liquid ingress into the treatment region, and a liquid outlet, the cartridge comprising: a first array of walls arranged in the treatment region in a spaced-apart relationship in a liquid path from the inlet towards the outlet, defining an array of vessel-like spaces in between the walls for the liquid successively flowing through the vessel-like spaces into a tubular vessel at the liquid outlet, dimensions of the tubular vessel being selected to create an effect of communicating vessels within the array of vessel-like spaces to thereby maintain at least a part of the at least one filtering medium in liquid environment.

The arrangement of walls of the first array of walls is such as to define alternating upward and downward flows of the liquid through each two adjacent vessel-

like spaces. In some embodiments of the invention, each of the walls of the first array of walls has closed-loop geometry, and the walls are concentrically arranged. The tubular vessel may be located at a center of the concentric arrangement. The liquid may thus flow from the inlet to the outlet in two opposite general flow directions from the periphery towards the center of the cartridge. In some other embodiments, the walls of the first array of walls are configured as spaced-apart plates (planar or not). The liquid may flow from the inlet to the outlet in a general flow direction from one side of cartridge to the other, where the tubular vessel is located.

The filter device may include a pretreatment region accommodated in a liquid path towards the inlet so as to apply an additional treatment to the liquid on its way to the treatment region. For example, the cartridge may include a cover, and the pretreatment region is located in at least a part of the inner region of the cover. The pretreatment may, for example, be release of a substance of nutritional or disinfecting value. An example, of pretreatment is the release of iodine from an iodine containing matrix included in the pretreatment region.

Preferably, the treatment region is divided into a plurality of compartments arranged successively along the liquid path, such that liquid while flowing along the vessel-like space passes through two or more such compartments. The compartments contain different filtering media and are coupled to one another in a manner allowing the liquid passage in between them while substantially preventing mixing of the different filtering media. For example, an interface between the adjacent compartments has an array of perforations or membrane regions of appropriate dimensions. The filtering media suitable to be used in the filter device of the invention include for example a carbonaceous material, chitosan, ion exchanger, metal oxide, metal hydroxide, etc.

According to another aspect of the invention, which may or may not be combined with the above described technique of maintaining at least a part of the

filtering medium (media) in the liquid environment, the invention provides a filter device capable of being automatically shut/blocked when the filtering medium has become ineffective. Thus, according to this broad aspect of the invention, there is provided a filter device for filtering liquid by passing it through one or more filtering media, the filter device comprising a cartridge defining a treatment region filled with one or more filtering media; a liquid inlet; a liquid outlet; and a locking mechanism located within a liquid flow through the cartridge and configured to lock at least one of the liquid inlet and the liquid outlet upon expiration of life time of at least one filtering medium.

The locking mechanism includes an erodible member formed by a composition selected to be erodible (continuously or gradually) during its interaction (direct or not) with the liquid and thereby reducing its volume, and includes a mechanical assembly coupled to the erodable member and shiftable from its unlocking positions into its locking position, the shift being caused by a decrease in the volume of the composition, such that the mechanical mechanism when shifted into its locking position blocks at least one of the liquid inlet and outlet.

The unlocking positions of the mechanical assembly correspond to the volumes of the erodible member above a certain threshold value, and the locking position of the mechanical assembly corresponds to the volume substantially equal to the threshold value.

In some embodiments, the erodible member is located outside the treatment region.

In some embodiments, the blocking member is displaceable from its retracted positions being disengaged with the outlet into its released position in which it engages with the outlet and thereby blocks the liquid path away from the cartridge.

Such mechanical assembly may comprise a connector which at its one end is attached to the erodible member and at its opposite end is engaged with a blocking

member. The volume reduction of the composition drags the connector away from the blocking member until disengaging from the blocking member, thus releasing the blocking member into a released position. The mechanical assembly preferably includes a spring-like member associated with the connector to control its movement during the reduction of volume of the erodible member.

In some other embodiments, the mechanical assembly is associated with the liquid inlet and may include at least two plates arranged in a parallel relationship one above the other, each having a plurality of perforations or membrane regions for the liquid passage therethrough. The arrangement of plates is shiftable between its normally open unlocking position, in which the plates are either spaced from one another or are positioned with alignment between their perforations or membrane regions, thus allowing the liquid flow into the cartridge, and its closed locking position in which the plates are in contact with one another and oriented with a misalignment between their perforations or membrane regions thus blocking the liquid flow into the cartridge.

One of the plates is coupled, by the connector, to the erodible member, and driven for movement(s) with respect to the other plate(s), by the change of the erodible member position due to the change of volume of the composition. Thus, for example the upper plate is held by the connector in a position, corresponding to the normally open unlocking position of the plates, in which the upper plate is spaced from at least one other plate, and during the continuous or gradual volume reduction of the erodible member the upper plate falls towards a position of contact with at least one other plate and is rotated, resulting in the closed locking position of the plates. The rotational movement may be achieved by using a torsion spring. According to another example, the plates in their normally open unlocking position are arranged in contact with one another, and at least one of the plates is rotatable with respect to at least one other plate (by torsion spring), the rotation bringing the plates from the normally open position corresponding to the alignment between their perforations or membrane regions, into

the closed locking position in which their perforations or membrane regions are in misalignment.

In some other embodiments of the invention, the blocking member is downwardly biased and the connector is upwardly biased by respective springs. The blocking member is blocked from downward displacement, e.g. by bearings associated with a tubular structure stationary included in the cartridge, where the bearings are blocked from lateral movement by a rod of the connector. The reduction in volume of the erodible member causes upward displacement of the connector by the spring up to a point where the rod of the connector moves out of a space in between the bearings thus allowing the lateral movement of the bearings and accordingly permitting downward movement of the blocking member. Preferably, the blocking member carries at its distal end a flexible diaphragm facilitating a sealing engagement with a nozzle of the outlet.

The filter device may include an indicator responsive to a condition of the locking mechanism and generating output data for presentation to user.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a schematic illustration of an example of a filter device of the present invention;

Figs. 2A and **2B** show two examples, respectively, of the arrangement of walls inside a cartridge of the filter device;

Fig. 3 shows an example of a locking mechanism inside the cartridge;

Figs. 4A and **4B** show another example of the configuration of a locking mechanism inside the cartridge; and

Figs. 5A to **5D** exemplify the filter device of the present in its successive positions before and during the operation.

Figs. 6A and **6B** show another example of a locking mechanism inside the cartridge.

DETAILED DESCRIPTION OF EMBODIMENTS

Referring to **Fig. 1**, there is schematically illustrated a filter device **10** constructed and operated according to aspects of the invention for filtering a liquid (e.g. water) by passing the liquid through one or more filtering media. Filter device **10** may be appropriately designed to be installed into a portable potable water container or a tabletop water filtration device, as well as to be mountable on a water supply valve. Filter device **10** has a cartridge **11** defining a treatment region **12** filled with filtering medium/media, a liquid inlet **14**, and a liquid outlet **16**.

Preferably provided in the cartridge **11** is a locking mechanism **40**, the purpose and configuration of which will be described further below.

As further shown in **Fig. 1**, cartridge **11** includes a plurality of walls **W** arranged in treatment region **12** in a spaced-apart substantially parallel relationship in the liquid path from inlet **14** towards outlet **16**, and preferably also includes another arrangement of walls, generally at **L**, extending substantially perpendicular to walls **W**. Walls **W** define vertical flow paths with spaces between them. Walls **W** and **L** divide the treatment region **12** into compartments, the purpose of which will be described further below. Walls **C** are formed with liquid flow apertures (perforations or membrane regions) to allow the liquid flow in between compartments.

It should be understood that generally the inlet **14** as well as the outlet **16** may include one or more windows (openings or membrane regions) for liquid passage therethrough in and out of the cartridge **11**. For example, the inlet may be

circumferentially distributed with respect to the cartridge. The cartridge is configured as gravity fed filter; accordingly, the inlet and outlet are located at the upper and bottom sides of the treatment region respectively. It should also be understood that the filter device may include more than one cartridge arranged in a cascade-like manner thus creating a multi-stage filter device.

Reference is made to **Figs. 2A** and **2B** showing two specific, not limiting examples of the configuration of the cartridge of **Fig. 1**, namely its treatment region **12**. To facilitate understanding, the same reference numbers are used for identifying components that are common for all the examples of the invention.

As shown in both examples of **Figs. 2A** and **2B**, cartridge **11** includes a plurality of walls **W** arranged in the treatment region in a spaced-apart relationship in the liquid path from the inlet **14** towards the outlet **16**. This arrangement defines an array of vessel-like spaces **A, B, C, D** in between walls **W**. The liquid successively flows through these vessel-like spaces into a tubular vessel **18** at the liquid outlet. Dimensions of tubular vessel **18** (its height) are selected to create an effect of communicating vessels in the arrangement of vessels **A, B, C, D** and **18** such that at least a part of the filtering medium/media is always maintained in the liquid environment. More specifically, considering the portion-by-portion feeding of liquid into the filter device, certain amount of filtered liquid will remain in the vessels until a next portion is fed into the treatment region. Also, the diameter of the tubular vessel **18** defines the flow rate of liquid through the filter device. For example, the flow rate of liquid through the filter device may be selected to be about 6 minutes/liter.

Also, as shown in both examples, walls **W** are arranged such as to define alternating upward and downward flows of the liquid through each two adjacent U-shaped interconnected vessel-like spaces. This results in a turbulent flow of the liquid being filtered thus increasing interaction between the liquid and particles of the filtering medium/media, and improving the quality of the filtered liquid.

As shown in the example of **Fig. 2A**, the configuration is such that liquid flows through the spaces between plate-like walls **W** in a general flow direction **d** from liquid inlet **14** to liquid outlet **16**. The latter is made in tubular vessel **18**.

In the example of **Fig. 2B**, each wall **W** has closed-loop geometry (e.g. circular or polygonal), and walls **W** and arranged in a concentric manner. Tubular vessel **18** is located in the central vessel **D**. Liquid flows in opposite, general flow directions **d1** and **d2** from a periphery (vessels **A**) to a center (vessel **D**) of the treatment region **12**.

As further shown in the example of **Fig. 2B**, filter device **10** may define a pretreatment region **22** within a liquid path towards inlet **16** of the treatment region **12**. For example, the cartridge may have a cover **24** and pretreatment region **22** is located within an inner region (at least a part thereof) of the cover **24**.

Reference is made to **Fig. 3** showing an example of the configuration of a locking mechanism located within the liquid flow through the cartridge **11**. Locking mechanism, generally at **40**, is configured to be associated with either the liquid inlet or the liquid outlet or both of them upon expiration of life time of the filtering medium/media. In the present example of **Fig. 3**, locking mechanism is associated with liquid output **16**.

Locking mechanism **40** includes an erodible member **42** formed by a certain composition of a kind being continuously/gradually erodible during its interaction with the liquid. The volume of this composition therefore reduces during the operation of the filter device from its maximal value at the beginning of operation, after installing erodible member **42** into the cartridge, until its minimal value as a result of interaction with the liquid. This minimal value presents a threshold value for the amount of the erodible member corresponding to a condition of the filtering medium/media in the treatment region that does not allow its use for further filtering. It should be understood that the material(s) in said composition comprising the erodible member and the maximal volume are selected in accordance with the filtering requirements (e.g. filtering medium/media, liquid to be filtered, cartridge volume, etc.). Further provided in the

locking mechanism **40** is a mechanical assembly **44** coupled to erodible member **42** such as to be shiftable, by a decrease in the volume of the erodible member **42**, from unlocking positions of the mechanical assembly into a locking position. The configuration is such that mechanical assembly **44** when shifted into the locking position blocks the liquid outlet **16**. Thus, unlocking positions of mechanical assembly **44** correspond to value of the volume of erodible member **42** above the certain threshold value, and the locking position of mechanical assembly **44** corresponds to the volume substantially equal to the threshold value.

It should be noted that erodible materials suitable to be used in erodible member **42** may be of any known type, for example for the filtration of water the erodible composition may include polymeric or non-polymeric materials. Typically, these may include materials that slowly dissolve into the filtering medium without being degraded, materials that degrade into soluble fragments or materials that gradually disintegrate into small insoluble particles or fragments. These materials are either entrapped by the filter before reaching the filtered liquid or are safe for human consumption and do not add unwanted taste or odor. Various examples of suitable materials are described for example in WO 08/044230 assigned to the assignee of the present application.

Generally, selection of the erodible composition is defined by the specific liquid to be filtered as well as the filter conditions, such as temperature, pressure, presence of additives, etc. The erodible composition is erodible by the liquid or by an element within the liquid. The extent of exposure of the erodible member to the liquid correlates with the extent of erosion of said composition.

Erodible member **42** may be of any suitable shape and size. Erodible member **42** may be a substantially solid rigid body, or solid flexible body or a hollow member; may be made of one or multiple materials, e.g. a multi-layer structure. Different materials may have different erosion rates, thus providing a gradual change in the volume of the composition, while the materials erode layer by layer.

Turning back to **Fig. 3**, mechanical assembly **44** comprises a blocking member **46** aligned with tubular vessel **18** and displaceable with respect to tubular vessel **18** from retracted positions of blocking member **46** into a released position thereof. The configuration is such that blocking member **46**, when in either one of the unlocking (retracted) positions, is disengaged from outlet **16** (is located above the outlet as shown in the figure), and when in the locking (released) position, engages the outlet **16** (moves downwards along tubular vessel **18**).

Displacement of blocking member **46** through retracted positions towards the released position is driven by the change of volume of the erodible member. This is implemented by coupling mechanical assembly **44**, namely its blocking member **46**, to erodible member **42** via a connector **48**. As shown, connector **48** is at its one end **48A** coupled to erodible member **42** and at its opposite end **48B** is engaged with blocking member **46**. Continuous volume reduction of the erodible member "drags" connector **48** in a direction **d3** away from blocking member **46** until a position of disengagement between connector and blocking member **48**, thus releasing blocking member **48** into its locking position. In the present specific but not limiting example, engagement between connector **48** and blocking member **46** is achieved by providing a hook-like member **49** and coupling upper end of blocking member **46** thereto (e.g. hook-like member **49** may be integral with blocking member **46**). Connector **48** by its end **48B** is mounted inside the hook-like member **49** with the ability for sliding therein. Change of volume of erodible member **42** from its initial maximal value until the minimal one (corresponding to the threshold value) results in a sliding movement of connector **48** in direction **d3** until it becomes released from hook-like assembly **49** and thus disengaged from blocking member **46** causing the latter to "fall" into tubular vessel **18** blocking the liquid outlet **16**.

Preferably, mechanical assembly **44** includes a spring member **52** interconnected between connector **48** and erodible member **42**. Movement of connector **48** in direction

d3 (during the reduction of volume of the erodible member) is thus controlled by tension of spring 52.

As further shown in Fig. 3, in the present example, blockage of the liquid outlet is achieved by engagement between blocking member 46 and tubular vessel 18. More specifically, blocking member 46 at its distal end, by which it is insertable into tubular vessel 18. Also, mechanical assembly 44 includes a restriction mechanism 54 which limits the movement of blocking member 46 with respect to tubular vessel 18. Restriction mechanism 54 is formed by two support elements 54A and 54B supporting blocking member 46 at two spaced-apart locations. In the present example, these are ring-like elements 54A and 54B mounted on the blocking member 54A such that elements 54A is attached to blocking member 46 and element 54B is attached to the cartridge (to the walls of vessel-like space D in which tubular vessel 46 is located or to the tubular vessel). Thus, sliding movement of blocking member 46 in a direction towards the tubular vessel 18 is limited by a distance between ring-like elements 54A and 54B.

Elements 54A and 54B may be magnetic elements attractable to one another by magnetic forces.

Reference is now made to Figs. 4A and 4B illustrating another example of the configuration of locking mechanism 40. In this example, locking mechanism is associated with liquid inlet 14. Similar to the above described example, locking mechanism 40 includes an erodible member 42 and a mechanical assembly 44 coupled to erodible member 42 and driven by said member 42 (i.e. reduction in the volume of the erodible member) from normally open unlocking position of the liquid inlet into a closed, locked position thereof. Mechanical assembly 44 includes an arrangement 56 of plates (at least two plates 56A and 56B arranged in a parallel relationship one above the other). These plates 56A and 56B may be associated with a cover (24 in Fig. 2B) of the cartridge. Each plate has a plurality of perforations or membrane regions, generally at 58, for the liquid passage therethrough. When these perforations in the two plates are at

least partially aligned water flow is enabled; and when there is no alignment water flow is blocked. One of the plates **56** is coupled to erodible member **42** the erosion-mediated movement of which causes a relative displacement of the plates, one with respect to the other, from their positions corresponding to the normally open positions of the locking mechanism to that of the closed locking position.

Generally, the normally open positions of the locking mechanism may correspond to the arrangements of plates when they are spaced from one another thus allowing the liquid flow into the cartridge. Alternatively (or additionally), the normally open positions may correspond to the plates being in contact with one another and oriented one with respect to the other with an alignment between their perforations or membrane regions, thus allowing the liquid flow into the cartridge. The closed locking position corresponds to the position of plates when they are in contact with one another and oriented with a misalignment between their perforations or membrane regions, thus blocking the liquid flow into the cartridge.

In the example of **Figs. 4A** and **4B**, plates **56A** and **56B** are also in contact with one another, and one of the plates, e.g. upper plate **56A**, can be rotated with respect to the other plate **56B**. Plates **56A** and **56B** are kept in the position of alignment between their perforations/membranes **58** and driven (via rotation of plate **56A**) into the position of misalignment by erodible member **42**. More specifically, erodible member **42** is coupled to a blocking member **46** and is coupled, via a connector **48** (seen in **Fig. 4B**), to plate **56A**. Connector **48** may be associated with a torsion spring (not shown). Blocking member **46** is connectable to the other plate **56B**. This is implemented by installing blocking member **46** in a slot **62** formed in a support **60** rigidly connected to plate **56B** (not specifically shown in the figure) with ability for sliding movement of blocking member **46** along the slot. A spring **52** is provided to control upward movement of blocking member **46**. In the open positions of the locking mechanism, blocking member **46** is engaged with support **60** (is located inside slot **62**) thus keeping connection between plates **56A** and **56B** (via support **60** and connector **48**). A reduction

in the volume of the erodible member results in a change in the vertical position of blocking member **46** pushing it upwards until it disengages from slot **62**. This results in a disconnection between support **60** (plate **56B**) and connector **48** (plate **56A**), thus causing rotation of plate **56A** with respect to plate **56B** towards the position of misalignment between the perforations/membranes, blocking the liquid inlet into the treatment region.

The filter device of the invention thus provides for automatic prevention of further use of the device, i.e. automatically blocking the liquid inlet and/or liquid outlet upon expiration of the lifetime of the filtering medium. This technique does not require the user intervention, i.e. does not require any user input in order to block the filter device. The filter device, however, may include an indicator to advise the user about inoperative state of the filter device.

Reference is made to **Figs. 5A** to **5D** exemplifying fours sequential positions of the filter device, namely of its locking mechanism and indicator. In this example, the locking mechanism is configured similar to the example described above with reference to **Figs. 4A-4B**. Filter device **10** has a cartridge formed with a cover **24**, incorporating a locking mechanism (not specifically shown), and is equipped with an indicator unit **70**. The latter is mounted on cover **24** and is in communication with either one of erodible member (**42** in **Figs. 4A-4B**) or locking mechanism **40** or both of them, and is configured to be responsive to a reduction in the volume of the erodible member and/or in the positions of the locking mechanism to provide an indication as to the filter status, and particularly when a filter reaches the end of its useful life. For example, indicator **70** has a ruler or scale **74** and a slider **72** mounted for movement along the ruler; slider **74** is in communication with the blocking member and is calibrated such that movement of the blocking member is correlated with the movement of slider **72**.

As further shown in the figures, filter device **10** may also include an external locking mechanism **76** removably mounted on the cartridge so as to be keep it in its locking position preventing the undesired exposure of the erodible member inside the

cartridge to liquid environment. **Fig. 5A** shows the filter device before being put in operation: locking mechanism **76** is in operative position being attached to a corresponding opening **78** made in the cover **24** to screen the erodible member from the surroundings of the filter device. In order to put the filter device into operation, locking mechanism **76** is removed from the cover (**Fig. 5B**). In this initial operating position of the filter device, plates **56A** and **56B** are oriented with vertical alignment between their perforations/membranes **58**, and slider **72** of indicator **70** is in its lower position corresponding to the maximal volume of the erodible member. During the device operation, the erodible member interacts with liquid being filtered resulting in reduction in the volume of erodible member and a corresponding upward movement of slider **72** (**Fig. 5C**), until its uppermost position corresponding to the minimal, threshold value of the volume of the erodible member and thus the closed, blocked position of the liquid inlet, i.e. inoperative position of the filter device (**Fig. 5D**).

As indicated above, the cartridge is preferable configured to enable filtering of the liquid with various (generally at least two) different filtering media. This can be implemented by dividing the treatment region into an array of compartments. This is better seen in **Figs. 4A** and **4B**. As also mentioned above, adjacent compartments **C** are in liquid communication with one another in a manner substantially preventing mixing between the different filtering media in said compartments respectively. This can be achieved by providing perforations/membranes in wall **L** between compartments **C** of a dimension allowing the liquid passage therethrough and preventing the passage of particles of the respective filtering medium.

Referring now to **Figs. 6A** and **6B** shown is another embodiment of a filter device **10**. Elements with the same functions to those described above are indicated by the same reference numeral and the reader is referred to the above description for an explanation of the function. In this embodiment the locking mechanism **40** is associated with the tubular member **18** of liquid outlet **16**.

Locking mechanism **40** of this embodiment includes a mechanical assembly **44** with a blocking member **46** and a connector **48**, the former being downwardly biased and the latter upwardly biased by respective springs **52A** and **52B**. Member **46** is blocked from downward displacement by bearings **80** which are held in annular recess **82** formed on the inner face of tubular structure **84** which is stationary included in the cartridge **11**, e.g. integral with its cover **24**. Bearings **80** are blocked from lateral movement by rod **86** of connector **48**.

With the erosion of the erodible member (i.e. reduction of volume), the connector **48** becomes upwardly displaced by the spring **52B** up to the point where rod **86** moves out of the space in between bearings **80** and consequently bearing **80** can move laterally thus permitting downward movement of blocking member **46** as shown in **Fig. 6B**. Blocking member **46** carries at its distal end a flexible (e.g. made of rubber) diaphragm **88** that in the state shown in **Fig. 6B** provides a sealing engagement with outlet nozzle **90**.

ineffective, have been developed. Such devices are described for example in US 4,681,677; US 5,997,734 and 6,491,811; as well the above-indicated International publication WO 08/044230.

GENERAL DESCRIPTION

Provided, by an aspect of the disclosure herein, is a liquid filter device configured with an ability to be automatically shut/blocked (without a need for user intervention) when a filtering media has become ineffective. Provided by another aspect of the disclosure herein is a liquid filter device that is configured to enable to maintain a filtering medium in the filter under optimal conditions.

The present invention provides a novel filter device, which according to one aspect of the invention, is configured for maintaining at least a part of the filtering medium therein in a liquid environment. This is important so that the porousivity will not be lost which may occur if the filter medium dries.

Thus, there is provided a filter device for filtering a liquid portion by passing it through at least one filtering medium. The filter device comprises at least one cartridge comprising a treatment region filled with the at least one filtering medium, an inlet for inputting the portion of liquid into the treatment region, and a liquid outlet, the cartridge comprising: a first array of walls arranged in the treatment region in a spaced-apart relationship in a liquid path from the inlet towards the outlet, defining an array of vessel-like spaces in between the walls for the liquid successively flowing through the vessel-like spaces into a tubular vessel at the liquid outlet, dimensions of the tubular vessel being selected to create an effect of communicating vessels within the array of vessel-like spaces to thereby maintain at least a part of the at least one filtering medium in liquid environment.

The arrangement of walls of the first array of walls is such as to define alternating upward and downward flows of the liquid through each two adjacent

vessel-like spaces. In some embodiments of the invention, each of the walls of the first array of walls has closed-loop geometry, and the walls and concentrically arranged. The tubular vessel may be located at a center of the concentric arrangement. The liquid may thus flow from the inlet to the outlet in two opposite general flow directions from the periphery towards the center of the cartridge. In some other embodiments, the walls of the first array of walls are configured as spaced-apart plates (planar or not). The liquid may flow from the inlet to the outlet in a general flow direction from one side of cartridge to the other, where the tubular vessel is located.

The filter device may include a pretreatment region accommodated in a liquid path towards the inlet so as to apply an additional treatment to the liquid on its way to the treatment region. For example, the cartridge may include a cover, and the pretreatment region is located in at least a part of the inner region of the cover. The pretreatment may, for example, be release of a substance of nutritional or disinfecting value. An example, of pretreatment is the release of iodine from an iodine containing matrix included in the pretreatment region.

Preferably, the treatment region is divided into a plurality of compartments arranged successively along the liquid path, such that liquid while flowing along the vessel-like space passes through two or more such compartments. The compartments contain different filtering media and are coupled to one another in a manner allowing the liquid passage in between them while substantially preventing mixing of the different filtering media. For example, an interface between the adjacent compartments has an array of perforations or membrane regions of appropriate dimensions. The filtering media suitable to be used in the filter device of the invention include for example a carbonaceous material, chitosan, ion exchanger, metal oxide, metal hydroxide, etc.

According to another aspect of the invention, which may or may not be combined with the above described technique of maintaining at least a part of the filtering medium (media) in the liquid environment, the invention provides a

filter device capable of being automatically shut/blocked when the filtering medium has become ineffective. Thus, according to this broad aspect of the invention, there is provided a filter device for filtering liquid by passing it through one or more filtering media, the filter device comprising a cartridge defining a treatment region filled with one or more filtering media; a liquid inlet; a liquid outlet; and a locking mechanism located within a liquid flow through the cartridge and configured to lock at least one of the liquid inlet and the liquid outlet upon expiration of life time of at least one filtering medium.

The locking mechanism includes an erodable member formed by a composition selected to be continuously or gradually erasable during its interaction (direct or not) with the liquid and thereby having a variable volume, and includes a mechanical assembly coupled to the erodable member and shiftable from its unlocking positions into its locking position, the shift being caused by a decrease in the volume of the composition, such that the mechanical mechanism when shifted into its locking position blocks at least one of the liquid inlet and outlet.

The unlocking positions of the mechanical assembly correspond to the volumes of the composition above a certain threshold value, and the locking position of the mechanical assembly corresponds to the volume substantially equal to the threshold value.

In some embodiments, the erodable member is located outside the treatment region.

In some embodiments, the mechanical assembly includes a blocking member displaceable from its retracted positions being disengaged with the outlet into its released position in which it engages with the outlet and thereby blocks the liquid path away from the cartridge.

Such mechanical assembly may comprise a connector which at its one end is attached to the erodable member and at its opposite end is engaged with the blocking member. The volume reduction of the composition drags the connector

away from the blocking member until disengaging from the blocking member, thus releasing the blocking member into its released position. The mechanical assembly preferably includes a spring-like member associated with the connector to control its movement during the reduction of volume of the composition.

In some other embodiments, the mechanical assembly is associated with the liquid inlet and may include at least two plates arranged in a parallel relationship one above the other, each having a plurality of perforations or membrane regions for the liquid passage therethrough. The arrangement of plates is shiftable between its normally open position, in which the plates are either spaced from one another or are positioned with alignment between their perforations or membrane regions, thus allowing the liquid flow into the cartridge, and its closed locking position in which the plates are in contact with one another and oriented with a misalignment between their perforations or membrane regions thus blocking the liquid flow into the cartridge.

One of the plates is coupled, by a connector, to the erodable member, and driven for movement(s) with respect to the other plate(s), by the change of the erodable member position due to the change of volume of the composition. Thus, for example the upper plate is hold by the connector in a position, corresponding to the normally open position of the plates, in which the upper plate is spaced from at least one other plate, and during the continuous or gradual volume reduction of the composition the upper plate falls towards a position of contact with at least one other plate and is rotated, resulting in the closed locking position of the plates. The rotational movement may be achieved by using a torsion spring. According to another example, the plates in their normally open position are arranged in contact with one another, and at least one of the plates is rotatable with respect to at least one other plate (by torsion spring), the rotation bringing the plates from the normally open position corresponding to the alignment between their perforations or membrane regions, into the closed locking position in which their perforations or membrane regions are in misalignment.

In some other embodiments of the invention, the locking mechanism comprises a mechanical assembly comprising a blocking member and a coupling member. The blocking member is downwardly biased and the coupling member is upwardly biased by respective springs. The blocking member is blocked from downward displacement, e.g. by bearings associated with a tubular structure stationary included in the cartridge, where the bearings are blocked from lateral movement by a rod of the coupling member. The change of volume of the erodable member causes upward displacement of the coupling member by the spring up to a point where the rod of the coupling member moves out of a space in between the bearings thus allowing the lateral movement of the bearings and accordingly permitting downward movement of the blocking member. Preferably, the blocking member carries at its distal end a flexible diaphragm facilitating a sealing engagement with a nozzle of the outlet.

The filter device may include an indicator responsive to a condition of the locking mechanism and generating output data for presentation to user.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a schematic illustration of an example of a filter device of the present invention;

Figs. 2A and **2B** show two examples, respectively, of the arrangement of walls inside a cartridge of the filter device;

Fig. 3 shows an example of a locking mechanism inside the cartridge;

Figs. 4A and **4B** show another example of the configuration of a locking mechanism inside the cartridge; and

Figs. 5A to **5D** exemplify the filter device of the present in its successive positions before and during the operation.

Figs. 6A and **6B** show another example pf a locking mechanism inside the cartridge.

DETAILED DESCRIPTION OF EMBODIMENTS

Referring to **Fig. 1**, there is schematically illustrated a filter device **10** constructed and operated according to aspects of the invention for filtering a liquid (e.g. water) by passing the liquid through one or more filtering media. Filter device **10** may be appropriately designed to be installed into a portable potable water container or a tabletop water filtration device, as well as to be mountable on a water supply valve. Filter device **10** has a cartridge **11** defining a treatment region **12** filled with filtering medium/media, a liquid inlet **14**, and a liquid outlet **16**.

Preferably provided in the cartridge **11** is a locking mechanism **40**, the purpose and configuration of which will be described further below.

As further shown in **Fig. 1**, cartridge **11** includes a plurality of walls **W** arranged in treatment region **12** in a spaced-apart substantially parallel relationship in the liquid path from inlet **14** towards outlet **16**, and preferably also includes another arrangement of walls, generally at **L**, extending substantially perpendicular to walls **W**. Walls **W** define vertical flow paths with spaces between them. Walls **W** and **L** divide the treatment region **12** into compartments, the purpose of which will be described further below. Walls **C** are formed with liquid flow apertures (perforations or membrane regions) to allow the liquid flow in between compartments.

It should be understood that generally the inlet **14** as well as the outlet **16** may include one or more windows (openings or membrane regions) for liquid passage therethrough in and out of the cartridge **11**. For example, the inlet may

be circumferentially distributed with respect to the cartridge. The cartridge is configured as gravity fed filter; accordingly, the inlet and outlet are located at the upper and bottom sides of the treatment region respectively. It should also be understood that the filter device may include more than one cartridge arranged in a cascade-like manner thus creating a multi-stage filter device.

Reference is made to **Figs. 2A and 2B** showing two specific, not limiting examples of the configuration of the cartridge of **Fig. 1**, namely its treatment region **12**. To facilitate understanding, the same reference numbers are used for identifying components that are common for all the examples of the invention.

As shown in both examples of **Figs. 2A** and **2B**, cartridge **11** includes a plurality of walls **W** arranged in the treatment region in a spaced-apart relationship in the liquid path from the inlet **14** towards the outlet **16**. This arrangement defines an array of vessel-like spaces **A, B, C, D** in between walls **W**. The liquid successively flows through these vessel-like spaces into a tubular vessel **18** at the liquid outlet. Dimensions of tubular vessel **18** (its height) are selected to create an effect of communicating vessels in the arrangement of vessels **A, B, C, D** and **18** such that at least a part of the filtering medium/media is always maintained in the liquid environment. More specifically, considering the portion-by-portion feeding of liquid into the filter device, certain amount of filtered liquid will remain in the vessels until a next portion is fed into the treatment region. Also, the diameter of the tubular vessel **18** defines the flow rate of liquid through the filter device. For example, the flow rate of liquid through the filter device may be selected to be about 6 minutes/liter.

Also, as shown in both examples, walls **W** are arranged such as to define alternating upward and downward flows of the liquid through each two adjacent U-shaped interconnected vessel-like spaces. This results in a turbulent flow of the liquid being filtered thus increasing interaction between the liquid and particles of the filtering medium/media, and improving the quality of the filtered liquid.

As shown in the example of **Fig. 2A**, the configuration is such that liquid flows through the spaces between plate-like walls **W** in a general flow direction ***d*** from liquid inlet **14** to liquid outlet **16**. The latter is made in tubular vessel **18**.

In the example of **Fig. 2B**, each wall **W** has closed-loop geometry (e.g. circular or polygonal), and walls **W** and arranged in a concentric manner. Tubular vessel **18** is located in the central vessel **D**. Liquid flows in opposite, general flow directions d_1 and d_2 from a periphery (vessels **A**) to a center (vessel **D**) of the treatment region **12**.

As further shown in the example of **Fig. 2B**, filter device **10** may define a pretreatment region **22** within a liquid path towards inlet **16** of the treatment region **12**. For example, the cartridge may have a cover **24** and pretreatment region **22** is located within an inner region (at least a part thereof) of the cover **24**.

Reference is made to **Fig. 3** showing an example of the configuration of a locking mechanism located within the liquid flow through the cartridge **11**. Locking mechanism, generally at **40**, is configured to be associated with either the liquid inlet or the liquid outlet or both of them upon expiration of life time of the filtering medium/media. In the present example of **Fig. 3**, locking mechanism is associated with liquid output **16**.

Locking mechanism **40** includes an erodable member **42** formed by a certain composition of a kind being continuously/gradually erasable during its interaction with the liquid. The volume of this composition therefore varies during the operation of the filter device from its maximal value at the beginning of operation, after installing erodable member **42** into the cartridge, until its minimal value as a result of interaction with the liquid. This minimal value presents a threshold value for the amount of the composition corresponding to a condition of the filtering medium/media in the treatment region that does not allow its use for further filtering. It should be understood that the material(s) in said composition and the maximal volume are selected in accordance with the

filtering requirements (e.g. filtering medium/media, liquid to be filtered, cartridge volume, etc.). Further provided in the locking mechanism **40** is a mechanical assembly **44** coupled to erodable member **42** such as to be shiftable, by a decrease in the volume of the composition of the erodable member **42**, from unlocking positions of the mechanical assembly into a locking position. The configuration is such that mechanical assembly **44** when shifted into the locking position blocks the liquid outlet **16**. Thus, unlocking positions of mechanical assembly **44** correspond to value of the volume of composition **42** above the certain threshold value, and the locking position of mechanical assembly **44** corresponds to the volume substantially equal to the threshold value.

It should be noted that erodable materials suitable to be used in erodable member **42** may be of any known type, for example for the filtration of water the erodable composition may include polymeric or non-polymeric materials. Typically, these may include materials that slowly dissolve into the filtering medium without being degraded, materials that degrade into soluble fragments or materials that gradually disintegrate into small insoluble particles or fragments. These materials are either entrapped by the filter before reaching the filtered liquid or are safe for human consumption and do not add unwanted taste or odor. Various example of suitable materials are described for example in WO 08/044230 assigned to the assignee of the present application.

Generally, selection of the erodable composition is defined by the specific liquid to be filtered as well as the filter conditions, such as temperature, pressure, presence of additives, etc. The erodable composition is erodable by the liquid or by an element within the liquid. The extent of exposure of the erodable composition to the liquid correlates with the extent of erosion of said composition.

Erodable member **42** may be of any suitable shape and size. Erodable member **42** may be a substantially solid rigid body, or solid flexible body or a hollow member; may be made of one or multiple materials, e.g. a multi-layer structure. Different materials may have different erosion rates, thus providing a

gradual change in the volume of the composition, while the materials erode layer by layer.

Turning back to **Fig. 3**, mechanical assembly **44** comprises a blocking member **46** aligned with tubular vessel **18** and displaceable with respect to tubular vessel **18** from retracted positions of blocking member **46** into a released position thereof. The configuration is such that blocking member **46**, when in either one of the retracted positions, is disengaged from outlet **16** (is located above the outlet as shown in the figure), and when in the released position, engages the outlet **16** (moves downwards along tubular vessel **18**).

Displacement of blocking member **46** through retracted positions towards the released position is driven by the change of volume of the erodable/erasable composition. This is implemented by coupling mechanical assembly **44**, namely its blocking member **46**, to erodable member **42** via a connector **48**. As shown, connector **48** is at its one end **48A** attached to erodable member **42** and at its opposite end **48B** is engaged with blocking member **46**. Continuous volume reduction of the composition "drags" connector **48** in a direction d_3 away from blocking member **46** until a position of disengagement between connector and blocking member **48**, thus releasing blocking member **48** into its released position. In the present specific but not limiting example, engagement between connector **48** and blocking member **46** is achieved by providing a hook-like member **49** and coupling upper end of blocking member **46** thereto (e.g. hook-like member **49** may be integral with blocking member **46**). Connector **48** by its end **48B** is mounted inside the hook-like member **49** with the ability for sliding therein. Change of volume of composition **42** from its initial maximal value until the minimal one (corresponding to the threshold value) results in a sliding movement of connector **48** in direction d_3 until it becomes released from hook-like assembly **49** and thus disengaged from blocking member **46** causing the latter to "fall" into tubular vessel **18** blocking the liquid outlet **16**.

Preferably, mechanical assembly **44** includes a spring member **52** interconnected between connector **48** and erodable member **42**. Movement of

connector **48** in direction $\mathbf{d_3}$ (during the reduction of volume of the composition) is thus controlled by tension of spring **52**.

As further shown in **Fig. 3**, in the present example, blockage of the liquid outlet is achieved by engagement between blocking member **46** and tubular vessel **18**. More specifically, blocking member **46** at its distal end, by which it is insertable into tubular vessel **18**. Also, mechanical assembly **44** includes a restriction mechanism **54** which limits the movement of blocking member **46** with respect to tubular vessel **18**. Restriction mechanism **54** is formed by two support elements **54A** and **54B** supporting blocking member **46** at two spaced-apart locations. In the present example, these are ring-like elements **54A** and **54B** mounted on the blocking member **54A** such that elements **54A** is attached to blocking member **46** and element **54B** is attached to the cartridge (to the walls of vessel-like space **D** in which tubular vessel **46** is located or to the tubular vessel). Thus, sliding movement of blocking member **46** in a direction towards the tubular vessel **18** is limited by a distance between ring-like elements **54A** and **54B**.

Elements **54A** and **54B** may be magnetic elements attractable to one another by magnetic forces. In the initial retracted position of the blocking member **46** (corresponding to the maximal volume of the erasable composition), elements

Reference is now made to **Figs. 4A and 4B** illustrating another example of the configuration of locking mechanism **40**. In this example, locking mechanism is associated with liquid inlet **14**. Similar to the above described example, locking mechanism **40** includes an erodable member **42** and a mechanical assembly **44** coupled to erodable member **42** and driven by said member **42** (i.e. change in the volume of composition) from normally open positions of the liquid inlet into a closed, blocked position thereof. Mechanical assembly **44** includes an arrangement **56** of plates (at least two plates **56A** and **56B** arranged in a parallel relationship one above the other). These plates **56A** and **56B** may be associated with a cover (**24** in **Fig. 2B**) of the cartridge. Each

plate has a plurality of perforations or membrane regions, generally at **58**, for the liquid passage therethrough. When these perforations in the two plats are at least partially aligned water flow is enabled; and when there is no alignment water flow is blocked. One of the plates **56** is coupled to erodable member **42** the erosion-mediated movement of which causes a relative displacement of the plates, one with respect to the other, from their positions corresponding to the normally open positions of the locking mechanism to that of the closed locking position.

Generally, the normally open positions of the locking mechanism may correspond to the arrangements of plates when they are spaced from one another thus allowing the liquid flow into the cartridge. Alternatively (or additionally), the normally open positions may correspond to the plates being in contact with one another and oriented one with respect to the other with an alignment between their perforations or membrane regions, thus allowing the liquid flow into the cartridge. The closed locking position corresponds to the position of plates when they are in contact with one another and oriented with a misalignment between their perforations or membrane regions, thus blocking the liquid flow into the cartridge.

In the example of **Figs. 4A and 4B**, plates **56A** and **56B** are also in contact with one another, and one of the plates, e.g. upper plate **56A**, can be rotated with respect to the other plate **56B**. Plates **56A** and **56B** are kept in the position of alignment between their perforations/membranes **58** and driven (via rotation of plate **56A**) into the position of misalignment by erodable member **42**. More specifically, erodable member **42** is coupled to a blocking member **46** and is coupled, via a connector **48** (seen in Fig. 4B), to plate **56A**. Connector **48** may be associated with a torsion spring (not shown). Blocking member **46** is connectable to the other plate **56B**. This is implemented by installing blocking member **46** in a slot **62** formed in a support **60** rigidly connected to plate **56B** (not specifically shown in the figure) with ability for sliding movement of blocking member **46** along the slot. A spring **52** is provided to control upward

movement of blocking member **46**. In the open positions of the locking mechanism, blocking member **46** is engaged with support **60** (is located inside slot **62**) thus keeping connection between plates **56A** and **56B** (via support **60** and connector **48**). Change in the volume of erasable composition results in a change in the vertical position of blocking member **46** pushing it upwards until it disengages from slot **62**. This results in a disconnection between support **60** (plate **56B**) and connector **48** (plate **56A**), thus causing rotation of plate **56A** with respect to plate **56B** towards the position of misalignment between the perforations/membranes, blocking the liquid inlet into the treatment region.

The filter device of the invention thus provides for automatic prevention of further use of the device, i.e. automatically blocking the liquid inlet and/or liquid outlet upon expiration of the lifetime of the filtering medium. This technique does not require the user intervention, i.e. does not require any user input in order to block the filter device. The filter device, however, may include an indicator to advise the user about inoperative state of the filter device.

Reference is made to **Figs. 5A to 5D** exemplifying fours sequential positions of the filter device, namely of its locking mechanism and indicator. In this example, the locking mechanism is configured similar to the example described above with reference to Figs. 4A-4B. Filter device **10** has a cartridge formed with a cover **24**, incorporating a locking mechanism (not specifically shown), and is equipped with an indicator unit **70**. The latter is mounted on cover **24** and is in communication with either one of erodable member (**42** in Figs. 4A-4B) or locking mechanism **40** or both of them, and is configured to be responsive to a change in the volume of erasable composition and/or in the positions of the locking mechanism to provide an indication as to the filter status, and particularly when a filter reaches the end of its useful life. For example, indicator **70** has a ruler or scale **74** and a slider **72** mounted for movement along the ruler; slider **74** is in communication with the blocking member and is calibrated such that movement of the blocking member is correlated with the movement of slider **72**.

As further shown in the figures, filter device **10** may also include an external locking mechanism **76** removably mounted on the cartridge so as to be keep it in its locking position preventing the undesired exposure of the erodable member inside the cartridge to liquid environment. **Fig. 5A** shows the filter device before being put in operation: locking mechanism **76** is in operative position being attached to a corresponding opening **78** made in the cover **24** to screen the erodable member from the surroundings of the filter device. In order to put the filter device into operation, locking mechanism **76** is removed from the cover (Fig. 5B). In this initial operating position of the filter device, plates **56A** and **56B** are oriented with vertical alignment between their perforations/membranes **58**, and slider **72** of indicator **70** is in its lower position corresponding to the maximal volume of the erasable composition. During the device operation, the erodable member interacts with liquid being filtered resulting in reduction in the volume of erasable composition and a corresponding upward movement of slider **72** (Fig. 5C), until its uppermost position corresponding to the minimal, threshold value of the volume of the erasable composition and thus the closed, blocked position of the liquid inlet, i.e. inoperative position of the filter device (Fig. 5D).

As indicated above, the cartridge is preferable configured to enable filtering of the liquid with various (generally at least two) different filtering media. This can be implemented by dividing the treatment region into an array of compartments. This is better seen in Figs. 4A and 4B. As also mentioned above, adjacent compartments **C** are in liquid communication with one another in a manner substantially preventing mixing between the different filtering media in said compartments respectively. This can be achieved by providing perforations/membranes in wall **L** between compartments **C** of a dimension allowing the liquid passage therethrough and preventing the passage of particles of the respective filtering medium.

Referring now to **Figs. 6A and 6B** shown is another embodiment of a filter device **10**. Elements with the same functions to those described above are

indicated by the same reference numeral and the reader is referred to the above description for an explanation of the function. In this embodiment the locking mechanism **40** is associated with the tubular member **18** of liquid outlet **16**.

Locking mechanism **40** of this embodiment includes a mechanical assembly **44** with a blocking member **46** and a coupling member **48**, the former being downwardly biased and the latter upwardly biased by respective springs **52A** and **52B**. Member **46** is blocked from downward displacement by bearings **80** which are held in annular recess **82** formed on the inner face of tubular structure **84** which is stationary included in the cartridge **11**, e.g. integral with its cover **24**. Bearings **80** are blocked from lateral movement by rod **86** of coupling member **48**.

With the erosion of the erodable member (i.e. change of volume), the coupling member **48** becomes upwardly displaced by the spring **52B** up to the point where rod **86** moves out of the space in between bearings **80** and consequently bearing **80** can move laterally thus permitting downward movement of blocking member **46** as shown in **Fig. 6B**. Blocking member **46** carries at its distal end a flexible (e.g. made of rubber) diaphragm **88** that in the state shown in **Fig. 6B** provides a sealing engagement with outlet nozzle **90**.