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Hulevesisuodatin, hulevesien käsittelyjärjestely sekä hulevesien käsittelymenetelmä

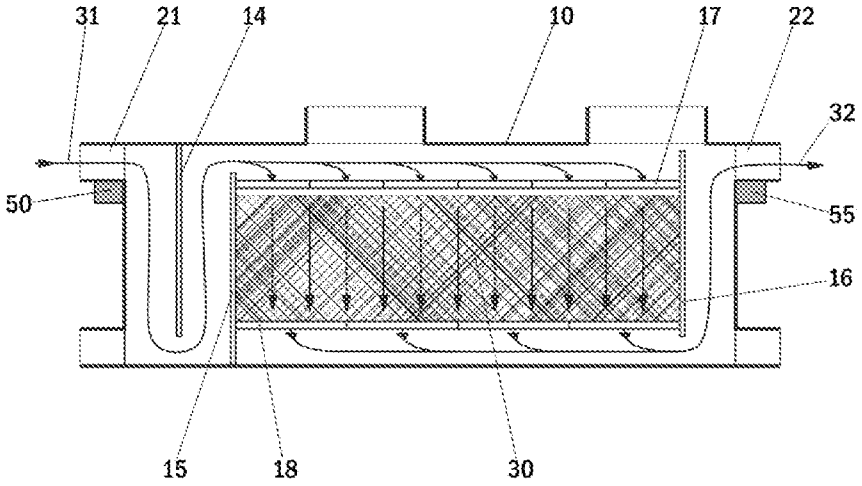
Dagvattenfilter, arrangemang för dagvattenbehandling och förfarande dagvattenbehandling

A STORMWATER FILTER, A STORMWATER TREATMENT ARRANGEMENT AND A METHOD FOR STORMWATER TREATMENT

(57) Tiivistelmä - Sammandrag - Abstract

Keksintö koskee vesien käsittelyn alaa ja erityisesti hulevesisuodatinta, hulevesien käsittelyjärjestelyä sekä hulevesien käsittelymenetelmää, jotka mahdollistavat hulevesien käsittelyn ohjauksen ja valvonnan. Esillä olevan keksinnön mukainen hulevesisuodatin (1, 101-106) käsittää suodatinyksikön (10), ainakin yhden näytteenottoyksikön (51, 53, 56), useita antureita (61-69), ohjausyksikön (70) ja tiedonsiirtoyksikön (75). Suodatinyksikkö (10) on järjestetty vastaanottamaan biohiilisuodatinmateriaalia (30) mainitun suodatinkehyksen (11-13) sisään. Ainakin yksi näytteenottoyksikkö (51, 53, 56) on järjestetty vastaanottamaan ja välittämään näyte tulevasta suodattamattomasta vedestä ja näyte tulevasta suodatetusta vedestä mainittuihin useisiin antureihin (61-69). Ohjausyksikkö (70) on konfiguroitu ohjaamaan mainittua ainakin yhtä näytteenottoyksikköä (51, 53, 56) ja mainittuja useita antureita (61-69). Tiedonsiirtoyksikkö (75) on konfiguroitu vastaanottamaan anturitoimintojen tulokset mainitulta ohjausyksiköltä (70) ja välittämään mainitut tulokset hulevesien käsittelyjärjestelyn palvelimelle.

The invention relates to the field of treatment of water, and more particularly to a stormwater filter, a stormwater treatment arrangement, and a method for stormwater treatment allowing control and monitoring of the stormwater treatment. The stormwater filter (1, 101-106) of the present invention comprises a filtering unit (10), at least one sampling unit (51, 53, 56), several sensors (61-69), a control unit (70) and a communication unit (75). The filtering unit (10) is arranged to receive biochar filter material (30) inside said filter frame (11-13). The at least one sampling unit (51, 53, 56) is arranged to receive and forward a sample of incoming unfiltered water and a sample of outcoming filtered water to said several sensors (61-69). The control unit (70) is configured to control said at least one sampling unit (51, 53, 56) and said several sensors (61-69). The communication unit (75) is configured to receive the results of sensing functions from said control unit (70) and to communicate said results to a server of a stormwater treatment arrangement.



A STORMWATER FILTER, A STORMWATER TREATMENT ARRANGEMENT AND A METHOD FOR STORMWATER TREATMENT

FIELD OF THE INVENTION

[0001] The present invention relates to the field of treatment of water, and more particularly to a stormwater filter, a stormwater treatment arrangement and a method for stormwater treatment allowing control and monitoring of the stormwater treatment.

BACKGROUND OF THE INVENTION

[0002] During rain events, storms and snow melts, stormwater runs on paved and unpaved surfaces, such as through rooftops, asphalt surfaces and concrete surfaces, and carries polluted stormwater to drains, the stormwater network and eventually to nature. Stormwater runoff, also often referred to as urban runoff water or surface runoff rainwater is often left untreated and is in many municipal storm sewer systems discharged untreated to rivers, lakes, or sea and to nature in general.

[0003] Stormwater typically runs different surfaces in urban areas and tends to pick up gasoline, motor oil, heavy metals such as nickel, copper, zinc, cadmium, and lead, trash, microplastics and other pollutants from roadways and parking lots. Stormwater running through rooftops contributes high levels of synthetic organic compounds and zinc from galvanized gutters. Stormwater running through residential lawns and parks tends to pick up nutrients and fertilizers, such as nitrates and phosphorus. Industrial areas and landfills are significant sources of polluted stormwater runoff, and they contain high concentrations of heavy metals and nutrients. In addition, mining industry and agriculture cause pollution to natural surface waters when stormwater runoff passes through mentioned unpaved areas. Stormwater runoff from agriculture contains both nutrients and pesticides while typical pollutants in mining industry are heavy metals.

[0004] In urban stormwater management most stormwater systems are based on basins and pipes to transfer the water outside of the cities and bays. In the recent decades there has also been more focus on stormwater treatment through filtration.

[0005] Today the emphasis on green infrastructure has intensified the need for removing pollutants and contaminants in stormwater that reaches other waterways, this improving the overall water quality.

[0006] In prior art solutions, there has not been developed stormwater filters in which the filtering efficiency and capacity could be constantly controlled and maintained. There has not been developed stormwater treatment arrangements allowing a constant control and monitoring stormwater treatment system as a whole.

[0007] In today's demanding environment, there is a need for a more effective and elegant solution for a stormwater filter and a need for a solution for a stormwater treatment arrangement allowing constant control and monitoring.

[0008] There is a demand in the market for a method for stormwater treatment and for a stormwater treatment arrangement that would provide a better overall management of the stormwater treatment system compared to the current prior art solutions.

BRIEF DESCRIPTION OF THE INVENTION

[0009] The object of the invention is to introduce a stormwater filter and an arrangement and a method for stormwater treatment, which would allow control and monitoring of the stormwater treatment and would provide a better overall management of the stormwater treatment system. Advantageous embodiments are furthermore presented.

[0010] It is brought forward a new stormwater filter comprising a filtering unit, at least one sampling unit, several sensors, a control unit and a communication unit, wherein: said filtering unit comprises a filter frame, said filter frame having

an inlet for incoming water and an outlet for outcoming water, said filtering unit being arranged to receive biochar filter material inside said filter frame, said filter material comprising mostly of biochar material; said at least one sampling unit is arranged to receive and forward a sample of incoming unfiltered water and a sample of outcoming filtered water to said several sensors; said several sensors comprise a conductivity sensor, an oxidation-reduction potential (ORP) sensor and a turbidity sensor, each of said several sensors being arranged to perform sensing function on said sample of incoming unfiltered water and on said sample of outcoming filtered water and for each performed sensing function to forward a signal indicating the result of the sensing function to the control unit; said control unit is configured to control said at least one sampling unit, said several sensors, and said communication unit, said control unit being configured to receive the results of sensing functions from each of said several sensors and to forward said results to said communication unit; and said communication unit is configured to receive the results of sensing functions from said control unit and to communicate said results to a server of a stormwater treatment arrangement.

[0011] In a preferred embodiment, said filtering unit comprises a bed structure with a number of filter material grates, said filter material grates being arranged to receive said filter material.

[0012] In a preferred embodiment, said filtering unit comprises a service layer structure with a number of service grates, said service grates being arranged to distribute the incoming unfiltered water from above to the filter material.

[0013] In a preferred embodiment, said filtering unit comprises two partition walls in the end of the inlet for incoming water, whereby: a first inlet partition wall of said two partition walls is fixed to the top part of said filter frame of the filtering unit for directing the incoming water first to go to a bottom part of the filtering unit; and a second inlet partition wall of said two partition walls is arranged after said a first inlet partition wall and fixed to the bottom part of said filter frame of

the filtering unit for directing the incoming water to go to a top part of the filtering unit before entering the filtration.

[0014] In a preferred embodiment, said filtering unit comprises an outlet partition wall in the end of the outlet for outcoming water, said outlet partition wall being fixed to the center part of said filter frame of the filtering unit.

[0015] In a preferred embodiment, said filtering unit comprises filter material resting on said filter material grates of said bed structure.

[0016] In a preferred embodiment, said filter material has a granularity and consistency suited for filtering out both organic contaminants and inorganic contaminants from the incoming water .

[0017] In a preferred embodiment, said at least one sampling unit is arranged: to receive a sample of incoming unfiltered water and a sample of outcoming filtered water; and to forward said received sample of incoming unfiltered water and said received sample of outcoming filtered water to said several sensors.

[0018] In a preferred embodiment, said several sensors comprise one or more of the following sensors: a pH sensor (pH, the potential of Hydrogen), a dissolved oxygen (DO) sensor, a temperature sensor, a flow sensor and a water level sensor.

[0019] In a preferred embodiment, said control unit and said communication unit are arranged as a one integrated unit.

[0020] Furthermore, it is brought forward a new stormwater treatment arrangement, said stormwater treatment arrangement comprising a server and several stormwater filters of the invention, wherein said server is arranged: to receive and store results of sensing functions performed on samples of incoming unfiltered water and of outcoming filtered water from said several stormwater filters as filter sensor data; to analyse said received and stored results of sensing

functions for producing a filter sensor data analysis; and to determine control and/or maintenance actions based on said filter sensor data analysis.

[0021] In a preferred embodiment of said arrangement, said server is arranged to request filter sensor data from one or more of said several stormwater filters.

[0022] In a preferred embodiment of said arrangement, said server is configured to forward filter sensor data and/or filter sensor data analysis to a mobile device and/or a computer device.

[0023] Furthermore, it is brought forward a new method for stormwater treatment in a server of a stormwater treatment arrangement of the invention, in which method: results of sensing functions performed on samples of incoming unfiltered water and of outcoming filtered water from one or more of several stormwater filters of to the invention are received and stored; said received and stored results of sensing functions are analysed for producing a filter sensor data analysis; and control and/or maintenance actions are determined based on said filter sensor data analysis.

[0024] Furthermore, it is brought forward a new method for stormwater treatment in a stormwater filter of a stormwater treatment arrangement of the invention, in which method: sensing functions are performed on a sample of incoming unfiltered water; said incoming water is filtered by filter material to produce outcoming filtered water; sensing functions are performed on a sample of outcoming filtered water; and results of sensing functions performed on samples of incoming unfiltered water and of outcoming filtered water are communicated to a server of said stormwater treatment arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] In the following, the present invention will be described in more detail by way of example and with reference to the attached drawings, in which:

Figure 1 illustrates a perspective cross-sectional view of an embodiment of a filtering unit of a stormwater filter according to the present invention.

Figure 2 illustrates a cross-sectional view of another embodiment of a filtering unit of a stormwater filter according to the present invention.

Figure 3 illustrates an embodiment of an incoming water sensing arrangement of a stormwater filter according to the present invention.

Figure 4 illustrates an embodiment of an outcoming water sensing arrangement of a stormwater filter according to the present invention.

Figure 5 illustrates another embodiment of a water sensing arrangement of a stormwater filter according to the present invention.

Figure 6 illustrates an embodiment of a control arrangement of a stormwater filter according to the present invention.

Figure 7 illustrates a simplified diagram of an embodiment of a stormwater treatment arrangement according to the present invention.

Figure 8 illustrates a functional block diagram of an embodiment of a stormwater treatment arrangement according to the present invention.

Figure 9 illustrates a flow diagram of an embodiment of a method for stormwater treatment according to the present invention.

Figure 10 illustrates a flow diagram of another embodiment of a method for stormwater treatment according to the present invention.

Figure 11 illustrates a flow diagram of a third embodiment of a method for stormwater treatment according to the present invention.

The foregoing aspects, features and advantages of the invention will be apparent from the drawings and the detailed description related thereto.

In the following, the invention will be described in greater detail by means of preferred embodiments with reference to the accompanying drawings of Figures 1 to 11.

DETAILED DESCRIPTION

[0026] The stormwater filter according to one embodiment of the present invention comprises a filtering unit, at least one sampling unit, several sensors,

a control unit and a communication unit, wherein: said filtering unit comprises a filter frame, said filter frame having an inlet for incoming water and an outlet for outcoming water, said filtering unit being arranged to receive biochar filter material inside said filter frame, said filter material comprising mostly of biochar material; said at least one sampling unit is arranged to receive and forward a sample of incoming unfiltered water and a sample of outcoming filtered water to said several sensors; said several sensors comprise a conductivity sensor, an oxidation-reduction potential (ORP) sensor and a turbidity sensor, each of said several sensors being arranged to perform sensing function on said sample of incoming unfiltered water and on said sample of outcoming filtered water and for each performed sensing function to forward a signal indicating the result of the sensing function to the control unit; said control unit is configured to control said at least one sampling unit, said several sensors, and said communication unit, said control unit being configured to receive the results of sensing functions from each of said several sensors and to forward said results to said communication unit; and said communication unit is configured to receive the results of sensing functions from said control unit and to communicate said results to a server of a stormwater treatment arrangement.

[0027] Figure 1 illustrates a perspective cross-sectional view of an embodiment of a filtering unit of a stormwater filter according to the present invention. The presented embodiment of a filtering unit 10 of a stormwater filter comprises a filter frame 11-13, said filter frame 11-13 having an inlet 21 for incoming water and an outlet 22 for outcoming water. In the presented embodiment the filter frame 11-13 of the filtering unit 10 of a stormwater filter comprises a tubular outer frame 11, a first end plate 12 and a second end plate 13. In the presented embodiment the inlet 21 for incoming water is arranged through the first end plate 12. Respectively, the outlet 22 for outcoming water is arranged through the second end plate 13. In the presented embodiment the first end plate 12 comprises an additional water inlet/outlet 23, and the second end plate 13 comprises an additional water inlet/outlet 24. Said additional water inlets/outlets 23, 24 may be used as alternative water inlets/outlets 23, 24 and

also as water inlets/outlets 23, 24 for cleaning and maintenance purposes. Said additional water inlets/outlets 23, 24 may be sealed off in normal operation.

[0028] The presented embodiment of a filtering unit 10 also comprises a partition walls 14-16 fixed to said tubular outer frame 11. Furthermore, the presented embodiment of a filtering unit 10 also comprises a bed structure 18, 20 being arranged to receive the filter material on said bed structure 18, 20. The filter material is arranged for filtering the stormwater and is not shown in Figure 1. In the presented embodiment the bed structure 18, 20 comprises a number of grate support fixtures 20 fixed to said tubular outer frame 11 and/or to said partition walls 14-16 of said of filtering unit 10. Said bed structure 18, 20 also comprises a number of filter material grates 18 arranged to fit on said grate support fixtures 20. Said grate support fixtures 20 are arranged to receive said filter material grates 18. Said grate support fixtures 20 are also arranged to carry the weight of said filter material grates 18 as well as the weight of said filter material and also the weight of the stormwater being filtrated. Said filter material grates 18 are arranged to receive said filter material. Said filter material grates 18 are also arranged to carry the weight of said filter material and also the weight of the stormwater being filtrated. Said filter material grates 18 have openings allowing the filtered water to go through said openings to the bottom of said tubular outer frame 11 and towards the outlet 22 for outcoming water.

[0029] The presented embodiment of a filtering unit 10 also comprises a service layer structure 17, 19 on top of said filter material, said service layer structure 17, 19 being arranged to distribute the incoming unfiltered water somewhat evenly from above to the filter material resting on said bed structure 18, 20.

[0030] In the presented embodiment the service layer structure 17, 19 comprises a number of grate support rails 19 fixed to said tubular outer frame 11 and/or to said partition walls 14-16 of said of filtering unit 10. Said service layer structure 17, 19 also comprises a number of service grates 17 arranged to fit on said grate support rails 19. Said grate support rails 19 are arranged to

receive said service grates 17. Said grate support rails 19 are also arranged to carry the weight of said service grates 17 as well as the weight of the stormwater being filtrated. Said service grates 17 are arranged to carry the weight of the stormwater being filtrated. Said service grates 17 are arranged to distribute the incoming unfiltered water somewhat evenly from above to the filter material resting on said bed structure 18, 20. Said service grates 17 have openings allowing the unfiltered water to go through said openings to the filter material resting on said bed structure 18, 20.

[0031] The presented embodiment of a filtering unit 10 also comprises service outlets 25, 26 arranged on the top part of the filter frame 11-13. Said service outlets 25, 26 allow the inserting of the filter material inside said a filtering unit 10 and also allow the extracting of the used filter material out from said a filtering unit 10 for example with suction. Said service outlets 25, 26 also allow other service and maintenance activities to be carried out inside said filtering unit 10. A stormwater filter according to the present invention also comprises a sampling unit and several sensors as well as a control unit and a communication unit which are not shown in Figure 1.

[0032] Figure 2 illustrates a cross-sectional view of another embodiment of a filtering unit of a stormwater filter according to the present invention. The presented another embodiment of a filtering unit 10 of a stormwater filter comprises a filter frame having an inlet 21 for incoming water 31 and an outlet 22 for outcoming water 32. Said filter frame may have a tubular shape or another shape, for example a shape of a parallelepiped. The presented another embodiment of a filtering unit 10 comprises additional water inlets/outlets which may be used for cleaning and maintenance purposes, and which can be sealed off in normal operation.

[0033] The presented another embodiment of a filtering unit 10 also comprises a bed structure having a number of filter material grates 18 supported by grate support fixtures. Said filter material grates 18 of said bed structure are arranged to receive the filter material on filter material grates. The grate support

fixtures of said bed structure are not shown in Figure 2. The filter material is arranged for filtering the stormwater and is indicated with reference number 30 in Figure 2. Furthermore, the presented another embodiment of a filtering unit 10 also comprises a service layer structure having a number of service grates 17 supported by grate support rails. Said service grates 17 of said service layer structure are arranged to distribute the incoming unfiltered water 31 somewhat evenly from above to the filter material 30 resting on said filter material grates 18 of said bed structure. The grate support rails of said service layer structure are not shown in Figure 2.

[0034] The presented embodiment of a filtering unit 10 comprises a partition walls 14-16 fixed to said filter frame of the filtering unit 10. In the presented embodiment of a filtering unit 10 there are two partition walls 14, 15 in the end of the inlet 21 for incoming water 31 and one partition wall 16 in the end of the outlet 22 for outcoming water 32. In the end of the inlet 21 for incoming water 31 there is a first inlet partition wall 14 fixed to the top part of said filter frame of the filtering unit 10. Said first inlet partition wall 14 directs the incoming water 31 first to go to a bottom part of the filtering unit 10. This allows bigger solid material to settle and remain at the bottom of the filtering unit 10 and not to go to filtration. In the end of the inlet 21 for incoming water 31 after said first inlet partition wall 14 there is a second inlet partition wall 15 fixed to the bottom part of said filter frame of the filtering unit 10. Said second inlet partition wall 15 directs the incoming water 31 to go to a top part of the filtering unit 10 before entering the filtration. In Figure 2 the flow of the incoming water 31 is indicated with a line and arrows. In the end of the outlet 22 for outcoming water 32 there is an outlet partition wall 16 fixed to the center part of said filter frame of the filtering unit 10. Said outlet partition wall 16 directs the filtered water 32 to go to the top of the filtering unit 10 and towards the outlet 22 for outcoming water 32.

[0035] In the presented embodiment of a filtering unit 10 there is the filter material 30 arranged between said second inlet partition wall 15 and said outlet partition wall 16. Said filter material 30 is arranged to rest on said filter material grates 18 of said bed structure. Said service grates 17 are arranged to distribute

the incoming unfiltered water 31 somewhat evenly from above to the filter material 30. Said service grates 17 have openings allowing the unfiltered water 31 to go through said openings to the filter material 30 resting on said filter material grates 18 of said bed structure.

[0036] In the presented embodiment the filter material 30 comprises mostly of biochar material. In another embodiment the filter material 30 may comprise almost entirely of biochar material. Biochar material is a form of charcoal typically comprising carbon and ashes i.e. lightweight residue remaining after the pyrolysis of biomass. Biochar material can be obtained from a thermochemical conversion of biomass in an oxygen-limited environment. Biochar is a stable solid material that is rich in pyrogenic environment. Biochar is a stable solid material that is rich in pyrogenic carbon. In the presented embodiment said filter material 30 has a granularity and consistency suited for filtering out both organic contaminants and inorganic contaminants from the incoming water 31. The size distribution of the biochar is defined according to the desired water flow, and it can be adjusted by adding suitable organic or inorganic material, such as sand.

[0037] In the presented embodiment of a filtering unit 10 the filter material 30 i.e. biochar filter material 30 effectively filters out many impurities out from the incoming water 31 which impurities remain attached to the biochar filter material 30. Said filter material 30 has granularity and consistency suited for filtering out both organic contaminants and inorganic contaminants from the incoming water 31. The impurities may include both organic contaminants and inorganic contaminants, such as heavy metals, nitrogen, phosphorus, nutrients, solids, microplastics, oil etc. among others.

[0038] In the presented embodiment of a filtering unit 10 the service grates 17 are arranged to distribute the incoming unfiltered water 31 somewhat evenly from above to the filter material 30 resting on said filter material grates 18 of said bed structure. Said service grates 17 have openings allowing the incoming water 31 to go through said openings to the filter material 30. The

incoming water 31 is filtered by the filter material 30. During filtration the water flows through said filter material 30 as indicate with arrows in in Figure 2. On the bottom below said filter material 30 the filter material grates 18 have openings allowing the outcoming filtered water 32 to go through said openings to the bottom of the filtering unit 10 and towards the outlet 22 for outcoming water 32. In Figure 2 the flow of the outcoming water 32 is indicated with a line and arrows.

[0039] The presented embodiment of a filtering unit 10 of a stormwater filter is also accompanied by an incoming water sensing arrangement 50 and an outcoming water sensing arrangement 55, said sensing arrangements 50, 55 comprising at least one sampling unit and several sensors. A stormwater filter according to the present invention also comprises a control unit and a communication unit which are not shown in Figure 2. The presented embodiment of a filtering unit 10 of a stormwater filter may be located below ground. The presented embodiment of a filtering unit 10 of a stormwater filter may also be located above ground, for example inside a freight container.

[0040] Figure 3 illustrates an embodiment of an incoming water sensing arrangement of a stormwater filter according to the present invention. The presented embodiment of an incoming water sensing arrangement 50 of a stormwater filter 1 comprises at least one sampling unit 51 and several sensors 61-63. In the presented embodiment said at least one sampling unit 51 is arranged to receive a sample flow from the incoming unfiltered water before said incoming water enters to a filtering unit 10 of said stormwater filter 1 for filtration. Said at least one sampling unit 51 is also arranged to forward a sample of incoming unfiltered water to said several sensors 61-63.

[0041] In the presented embodiment the stormwater filter 1 also comprises a control unit 70, which control unit 70 is configured to control said at least one sampling unit 51 and to control said several sensors 61-63. The control unit 70 controls the sampling unit 51 at selected time intervals to receive a sample flow from the incoming unfiltered water and to forward a sample of incoming unfiltered water to said several sensors 61-63. The control unit 70

controls said several sensors 61-63 at selected time intervals to perform sensing function on said sample of incoming unfiltered water and to forward a signal indicating the result of the sensing function to the control unit 70. The control unit 70 of the stormwater filter 1 is configured to receive the results of sensing functions from each of said several sensors 61-63.

[0042] In the presented embodiment said several sensors 61-63 comprise a conductivity sensor, an oxidation-reduction potential (ORP) sensor and a turbidity sensor. Each of said several sensors 61-63 is arranged to perform sensing function on a sample of incoming unfiltered water and for each performed sensing function to forward a signal indicating the result of the sensing function to the control unit 70.

[0043] Figure 4 illustrates an embodiment of an outcoming water sensing arrangement of a stormwater filter according to the present invention. The presented embodiment of an outcoming water sensing arrangement 55 of a stormwater filter 1 comprises at least one sampling unit 56 and several sensors 64-66. In the presented embodiment said at least one sampling unit 56 is arranged to receive a sample flow from the outcoming filtered water as said outcoming water exits from a filtering unit 10 of said stormwater filter 1 after filtration. Said at least one sampling unit 56 is also arranged to forward a sample of outcoming filtered water to said several sensors 64-66.

[0044] In the presented embodiment the stormwater filter 1 also comprises a control unit 70, which control unit 70 is configured to control said at least one sampling unit 56 and to control said several sensors 64-66. The control unit 70 controls the sampling unit 51 at selected time intervals to receive a sample flow from the outcoming filtered water and to forward a sample of outcoming filtered water to said several sensors 64-66. The control unit 70 controls said several sensors 64-66 at selected time intervals to perform sensing function on said sample of outcoming filtered water and to forward a signal indicating the result of the sensing function to the control unit 70. The control

unit 70 of the stormwater filter 1 is configured to receive the results of sensing functions from each of said several sensors 64-66.

[0045] In the presented embodiment said several sensors 64-66 comprise a conductivity sensor, an oxidation-reduction potential (ORP) sensor and a turbidity sensor. Each of said several sensors 64-66 is arranged to perform sensing function on a sample of outcoming filtered water and for each performed sensing function to forward a signal indicating the result of the sensing function to the control unit 70.

[0046] Figure 5 illustrates another embodiment of a water sensing arrangement of a stormwater filter according to the present invention. The presented another embodiment of a water sensing arrangement 52 of a stormwater filter 1 comprises at least one sampling unit 53 and several sensors 67-69. In the presented another embodiment said at least one sampling unit 53 is arranged to receive a sample flow from the incoming unfiltered water before said incoming water enters to a filtering unit 10 of said stormwater filter 1 for filtration. In the presented another embodiment said at least one sampling unit 53 is also arranged to receive a sample flow from the outcoming filtered water as said outcoming water exits from a filtering unit 10 of said stormwater filter 1 after filtration. Said at least one sampling unit 53 is also arranged not to mix the samples together and to handle a sample of incoming unfiltered water separate from a sample of outcoming filtered water. Said at least one sampling unit 53 is also arranged to forward said sample of incoming unfiltered water and said sample of outcoming filtered water to said several sensors 67-69.

[0047] In the presented embodiment the stormwater filter 1 also comprises a control unit 70, which control unit 70 is configured to control said at least one sampling unit 53 and to control said several sensors 67-69. The control unit 70 controls the sampling unit 53 at selected time intervals to receive a sample flow from the incoming unfiltered water or to receive a sample flow from the outcoming filtered water and to forward a sample of incoming unfiltered water or to forward a sample of outcoming filtered water to said several sensors 67-

69. The control unit 70 controls said several sensors 67-69 at selected time intervals to perform sensing function on said sample of incoming unfiltered water or to perform sensing function on said sample of outcoming filtered water and to forward a signal indicating the result of the sensing function to the control unit 70. The control unit 70 of the stormwater filter 1 is configured to receive the results of sensing functions from each of said several sensors 67-69.

[0048] In the presented another embodiment said several sensors 67-69 comprise a conductivity sensor, an oxidation-reduction potential (ORP) sensor and a turbidity sensor. Each of said several sensors 67-69 is arranged to perform sensing function on a sample of incoming unfiltered water and on a sample of outcoming filtered water and for each performed sensing function to forward a signal indicating the result of the sensing function to the control unit 70.

[0049] In the presented invention said several sensors 61-69 comprise a conductivity sensor, an oxidation-reduction potential (ORP) sensor and a turbidity sensor. Furthermore, said several sensors 61-69 may also comprise one or more of the following sensors: a pH sensor (pH, the potential of Hydrogen), a dissolved oxygen (DO) sensor, a temperature sensor, a flow sensor and a water level sensor.

[0050] Figure 6 illustrates an embodiment of a control arrangement of a stormwater filter according to the present invention. The presented embodiment of a control arrangement of a stormwater filter 1 comprises at least one sampling unit 53 and several sensors 67-69, a control unit 70 and a communication unit 75. Said at least one sampling unit 53 is arranged to receive and handle samples of water and to forward samples of water to said several sensors 67-69. Said several sensors 67-69 are arranged to receive said samples of water from said at least one sampling unit 53 and to perform sensing functions on said samples of water.

[0051] The control unit 70 of the stormwater filter 1 is configured to control said at least one sampling unit 53 and to control said several sensors 67-69.

Said control unit 70 is configured to receive the results of sensing functions from each of said several sensors 67-69.

[0052] The control unit 70 of the stormwater filter 1 is also configured to control and communicate with said communication unit 75. Said control unit 70 is configured to forward the results of sensing functions from each of said several sensors 67-69 to said communication unit 75. Furthermore, said control unit 70 is configured to forward the results of sensing functions from each of said several sensors 67-69 to said communication unit 75. Said control unit 70 is also configured to control said communication unit 75 to communicate the results of sensing functions to a server of a stormwater treatment arrangement.

[0053] Said communication unit 75 is configured to receive the results of sensing functions from control unit 70. Said communication unit 75 is also configured to receive control instructions from said control unit 70 and also to communicate the results of sensing functions to a server of a stormwater treatment arrangement. In the present invention, said control unit 70 and said communication unit 75 may also be arranged as a one integrated unit.

[0054] Figure 7 illustrates a simplified diagram of an embodiment of a stormwater treatment arrangement according to the present invention. The presented embodiment of stormwater treatment arrangement comprises several stormwater filters 101-106 arranged in several stormwater lines. The uppermost stormwater line in Figure 7 comprises one stormwater filter 101. The two stormwater lines in the middle in Figure 7 each comprise one stormwater filter 102, 103 after which said stormwater lines are combined into an input of a third stormwater filter 104. The lowermost stormwater line in Figure 7 comprises two stormwater filters 105, 106. The functioning of the stormwater treatment arrangement according to the present invention is shown in Figure 8.

[0055] Figure 8 illustrates a functional block diagram of an embodiment of a stormwater treatment arrangement according to the present invention. The presented embodiment of stormwater treatment arrangement comprises a server 80 and several stormwater filters 101-106 arranged in stormwater lines

of said stormwater treatment arrangement. Each of said stormwater filters 101-106 comprises a filtering unit, at least one sampling unit, several sensors, a control unit and a communication unit. Each of said stormwater filters 101-106 is configured to communicate the results of sensing functions to a server of a stormwater treatment arrangement. Said server 80 is configured to receive the results of sensing functions from each of said stormwater filters 101-106 and to store said received results of sensing functions to a data storage 81 as filter sensor data. Said server 80 and said data storage 81 may also be realised as one integrated server unit comprising data storage capacity.

[0056] In said one or more said stormwater filters 101-106 sensing functions are performed on a sample of incoming unfiltered water 31. After this, incoming water 31 is filtered by filter material 30 to produce outcoming filtered water 32. Thereafter, in said one or more said stormwater filters 101-106 sensing functions are performed on a sample of outcoming filtered water 32. Finally, the results of sensing functions performed on samples of incoming unfiltered water 31 and of outcoming filtered water 32 are communicated to said server of the stormwater treatment arrangement.

[0057] In the presented embodiment of a stormwater treatment arrangement said server 80 is also configured to requesting filter sensor data from one or more of said several stormwater filters 101-106. Furthermore, said server 80 is also configured to send control instructions to one or more of said several stormwater filters 101-106.

[0058] In the presented embodiment of a stormwater treatment arrangement said server 80 may be remotely accessed by a mobile device 85 or a computer device 86. Said server 80 is also configured to forward filter sensor data as well as filter sensor data analysis to said mobile device 85 and/or said computer device 86. Furthermore, said server 80 is also configured to receive data and control instructions said mobile device 85 and/or said computer device 86.

[0059] Figure 9 illustrates a flow diagram of an embodiment of a method for stormwater treatment according to the present invention. In the method according to the present third embodiment, in a stormwater filter 1, 101-106 of a stormwater treatment arrangement sensing functions are first performed 91 on a sample of incoming unfiltered water 31. As the next step, said incoming water 31 is filtered 92 by filter material 30 to produce outcoming filtered water 32.

[0060] Thereafter, in the presented an embodiment, sensing functions are performed 93 on a sample of outcoming filtered water 32. As the next step in said stormwater filter 1, 101-106 of a stormwater treatment arrangement, the results of sensing functions performed on samples of incoming unfiltered water 31 and of outcoming filtered water 32 are communicated 94 to a server 80 of a stormwater treatment arrangement as filter sensor data.

[0061] Figure 10 illustrates a flow diagram of another embodiment of a method for stormwater treatment according to the present invention. In the method according to the present another embodiment, results of sensing functions performed on samples of incoming unfiltered water and of outcoming filtered water from one or more of several stormwater filters 1, 101-106 are first received 96 in a server 80 of a stormwater treatment arrangement. Thereafter, said received results of sensing functions are stored 97 to a data storage 81 of said stormwater treatment arrangement as filter sensor data.

[0062] Thereafter, said received and stored filter sensor data is analysed 98 in said server 80 to produce filter sensor data analysis. In the presented another embodiment, as the next step, control actions and/or maintenance actions are determined 99 based on said filter sensor data analysis.

[0063] Figure 11 illustrates a flow diagram of a third embodiment of a method for stormwater treatment according to the present invention. In the method according to the present another embodiment, results of sensing functions performed on samples of incoming unfiltered water and of outcoming filtered water is requested 95 from one or more of said several stormwater filters 1, 101-106 by a server 80 of a stormwater treatment arrangement. As the next

step, the requested results of sensing functions from one or more of several stormwater filters 1, 101-106 are received 96 in said server 80 as filter sensor data.

[0064] Thereafter, said received and stored filter sensor data is analysed 98 in said server 80 to produce filter sensor data analysis. In the presented third embodiment, as the next step, control actions and/or maintenance actions are determined 99 based on said filter sensor data analysis.

[0065] With the help of the stormwater filter according to the present invention many impurities are effectively filtered out from the incoming water 31 said impurities including both organic contaminants and inorganic contaminants, such as heavy metals, nitrogen, phosphorus, nutrients, solids, microplastics, oil etc. among others.

[0066] The method for stormwater treatment and the stormwater treatment arrangement according to the present invention allow constant control and monitoring and provides a better overall management of the stormwater treatment system compared to the current prior art solutions.

[0067] It is to be understood that the above description and the accompanying Figures are only intended to teach the best way known to the inventors to make and use the invention. It will be apparent to a person skilled in the art that the inventive concept can be implemented in various ways. The above-described embodiments of the invention may thus be modified or varied, without departing from the invention, as appreciated by those skilled in the art in light of the above teachings. It is therefore to be understood that the invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims and their equivalents.

CLAIMS

1. A stormwater filter (1, 101-106) comprising a filtering unit (10), at least one sampling unit (51, 53, 56), several sensors (61-69), a control unit (70) and a communication unit (75), wherein:

- said filtering unit (10) comprises a filter frame (11-13), said filter frame (11-13) having an inlet (21) for incoming water (31) and an outlet (22) for outcoming water (32), said filtering unit (10) being arranged to receive biochar filter material (30) inside said filter frame (11-13), said filter material (30) comprising mostly of biochar material;
- said at least one sampling unit (51, 53, 56) is arranged to receive and forward a sample of incoming unfiltered water and a sample of outcoming filtered water to said several sensors (61-69);
- said several sensors (61-69) comprise a conductivity sensor, an oxidation-reduction potential (ORP) sensor and a turbidity sensor, each of said several sensors (61-69) being arranged to perform sensing function on said sample of incoming unfiltered water and on said sample of outcoming filtered water and for each performed sensing function to forward a signal indicating the result of the sensing function to the control unit (70);
- said control unit (70) is configured to control said at least one sampling unit (51, 53, 56), said several sensors (61-69), and said communication unit (75), said control unit (70) being configured to receive the results of sensing functions from each of said several sensors (61-69) and to forward said results to said communication unit (75); and
- said communication unit (75) is configured to receive the results of sensing functions from said control unit (70) and to communicate said results to a server of a stormwater treatment arrangement.

2. A stormwater filter (1, 101-106) according to claim 1, wherein said filtering unit (10) comprises a bed structure (18, 20) with a number of filter

material grates (18), said filter material grates (18) being arranged to receive said filter material (30).

3. A stormwater filter (1, 101-106) according to claim 1 or claim 2, wherein said filtering unit (10) comprises a service layer structure (17, 19) with a number of service grates (17), said service grates (17) being arranged to distribute the incoming unfiltered water from above to the filter material (30).

4. A stormwater filter (1, 101-106) according to any of the claims 1-3, wherein said filtering unit (10) comprises two partition walls (14, 15) in the end of the inlet (21) for incoming water (31), whereby:

- a first inlet partition wall (14) of said two partition walls (14, 15) is fixed to the top part of said filter frame (11-13) of the filtering unit (10) for directing the incoming water (31) first to go to a bottom part of the filtering unit (10); and
- a second inlet partition wall (15) of said two partition walls (14, 15) is arranged after said a first inlet partition wall (14) and fixed to the bottom part of said filter frame (11-13) of the filtering unit (10) for directing the incoming water (31) to go to a top part of the filtering unit (10) before entering the filtration.

5. A stormwater filter (1, 101-106) according to claim 4, wherein said filtering unit (10) comprises an outlet partition wall (16) in the end of the outlet (22) for outcoming water (32), said outlet partition wall (16) being fixed to the center part of said filter frame of the filtering unit (10).

6. A stormwater filter (1, 101-106) according to any of the claims 2-5, wherein said filtering unit (10) comprises filter material (30) resting on said filter material grates (18) of said bed structure (18, 20).

7. A stormwater filter (1, 101-106) according to claim 6, wherein said filter material (30) has a granularity and consistency suited for filtering out both organic contaminants and inorganic contaminants from the incoming water (31).

8. A stormwater filter (1, 101-106) according to any of the claims 1-7, wherein said at least one sampling unit (53) is arranged:

- to receive a sample of incoming unfiltered water and a sample of outcoming filtered water; and
- to forward said received sample of incoming unfiltered water and said received sample of outcoming filtered water to said several sensors (67-69).

9. A stormwater filter (1, 101-106) according to any of the claims 1-8, wherein said several sensors (61-69) comprise one or more of the following sensors: a pH sensor (pH, the potential of Hydrogen), a dissolved oxygen (DO) sensor, a temperature sensor, a flow sensor and a water level sensor.

10. A stormwater filter (1, 101-106) according to any of the claims 1-9, wherein said control unit (70) and said communication unit (75) are arranged as a one integrated unit.

11. A stormwater treatment arrangement, comprising a server (80) and several stormwater filters (1, 101-106) according to any of the claims 1-10, wherein said server (80) is arranged:

- to receive and store results of sensing functions performed on samples of incoming unfiltered water and of outcoming filtered water from said several stormwater filters (1, 101-106) as filter sensor data;
- to analyse said received and stored results of sensing functions for producing a filter sensor data analysis; and

- to determine control and/or maintenance actions based on said filter sensor data analysis.

12. A stormwater treatment arrangement according to claim 11, wherein said server (80) is arranged to request filter sensor data from one or more of said several stormwater filters (1, 101-106).

13. A stormwater treatment arrangement according to claim 11 or to claim 12, wherein said server (80) is configured to forward filter sensor data and/or filter sensor data analysis to a mobile device (85) and/or a computer device (86).

14. A method for stormwater treatment in a server (80) of a stormwater treatment arrangement according to any of the claims 11-13, in which method:

- results of sensing functions performed on samples of incoming unfiltered water and of outcoming filtered water from one or more of several stormwater filters (1, 101-106) according to any of the claims 1-10 are received and stored;
- said received and stored results of sensing functions are analysed for producing a filter sensor data analysis; and
- control and/or maintenance actions are determined based on said filter sensor data analysis.

15. A method for stormwater treatment in a stormwater filter (1, 101-106) of a stormwater treatment arrangement according to any of the claims 11-13, in which method:

- sensing functions are performed on a sample of incoming unfiltered water (31);
- said incoming water (31) is filtered by filter material (30) to produce outcoming filtered water (32);

- sensing functions are performed on a sample of outcoming filtered water (32); and
- results of sensing functions performed on samples of incoming unfiltered water (31) and of outcoming filtered water (32) are communicated to a server (80) of said stormwater treatment arrangement.

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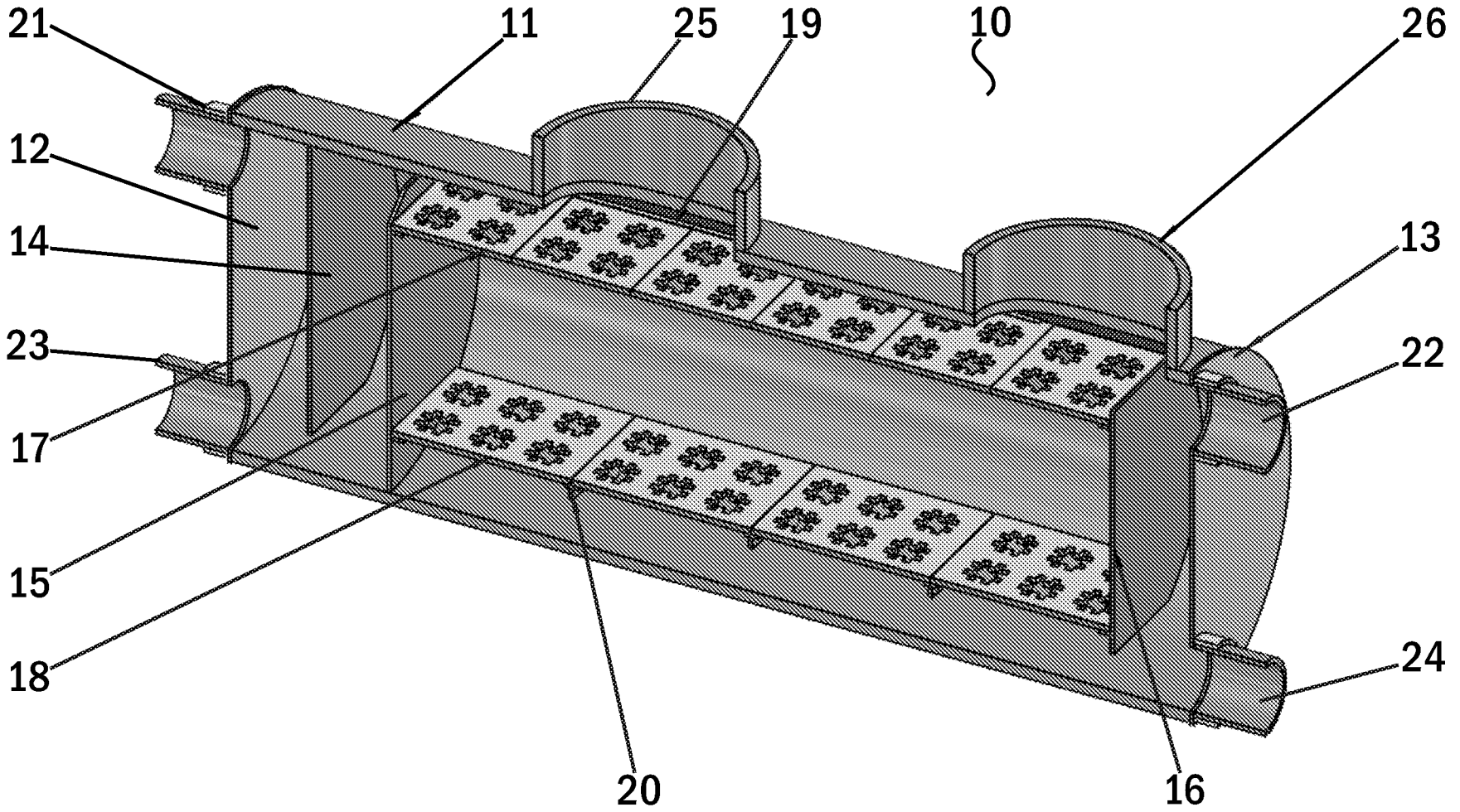

Fig. 1

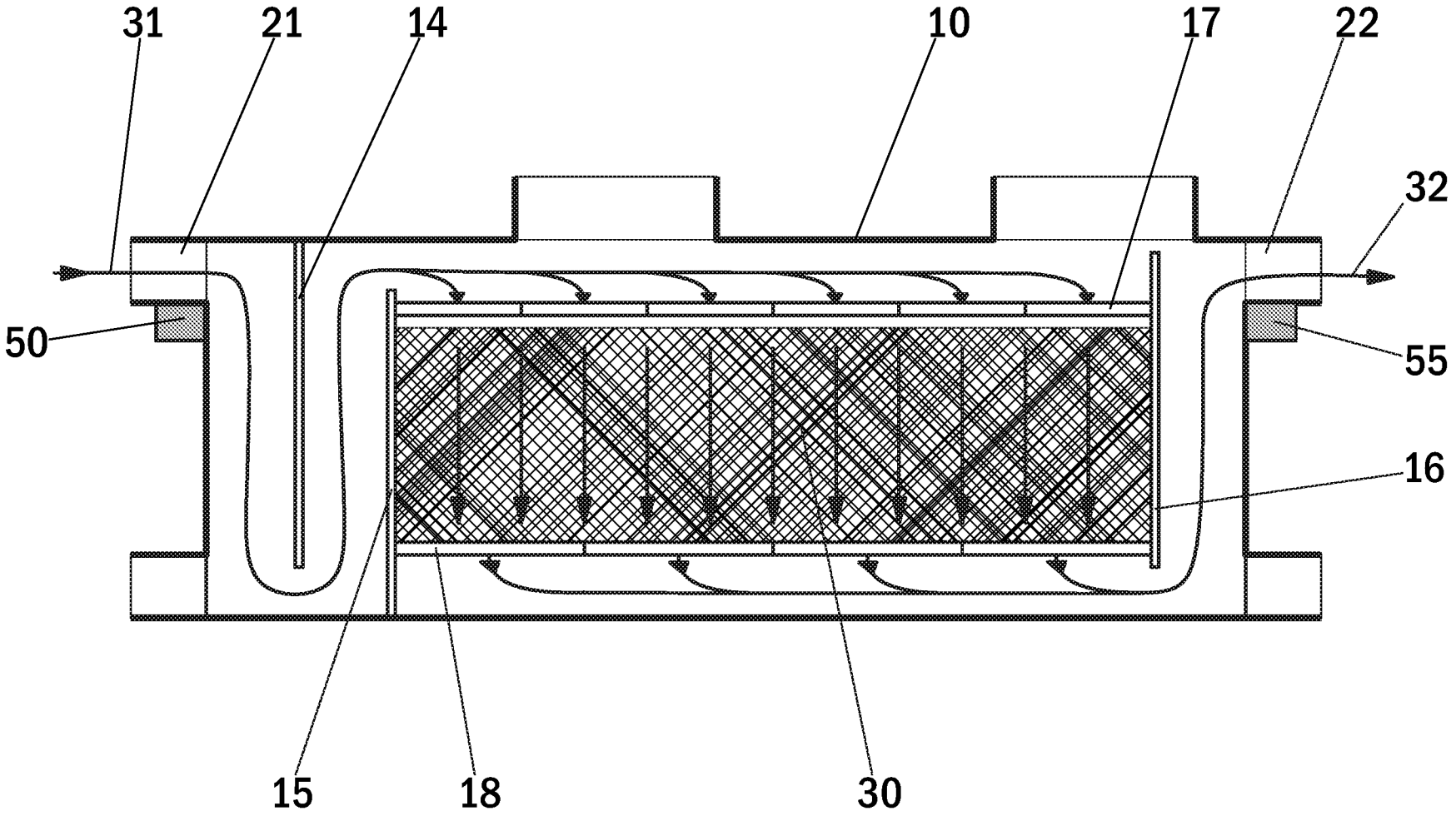

Fig. 2

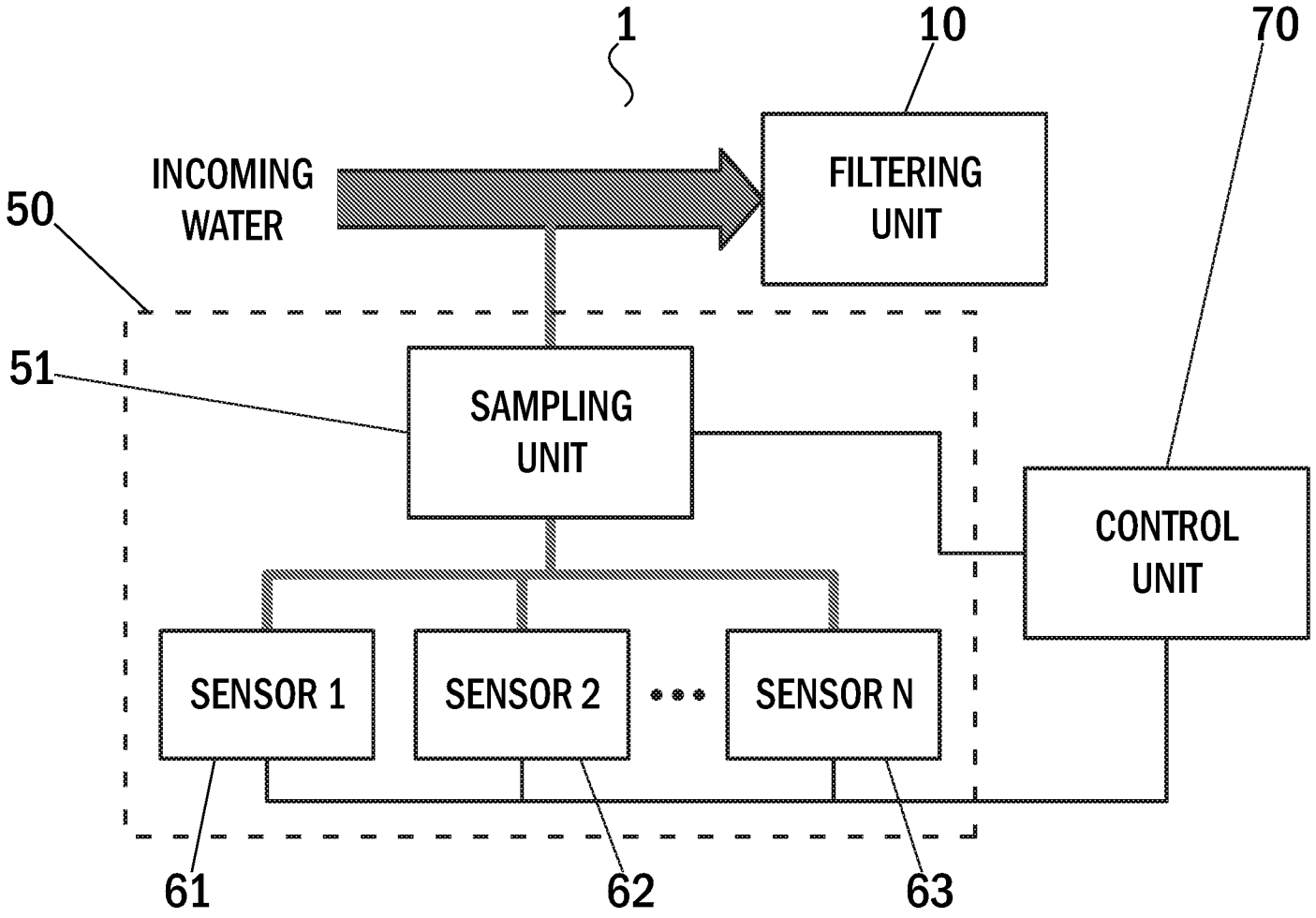

Fig. 3

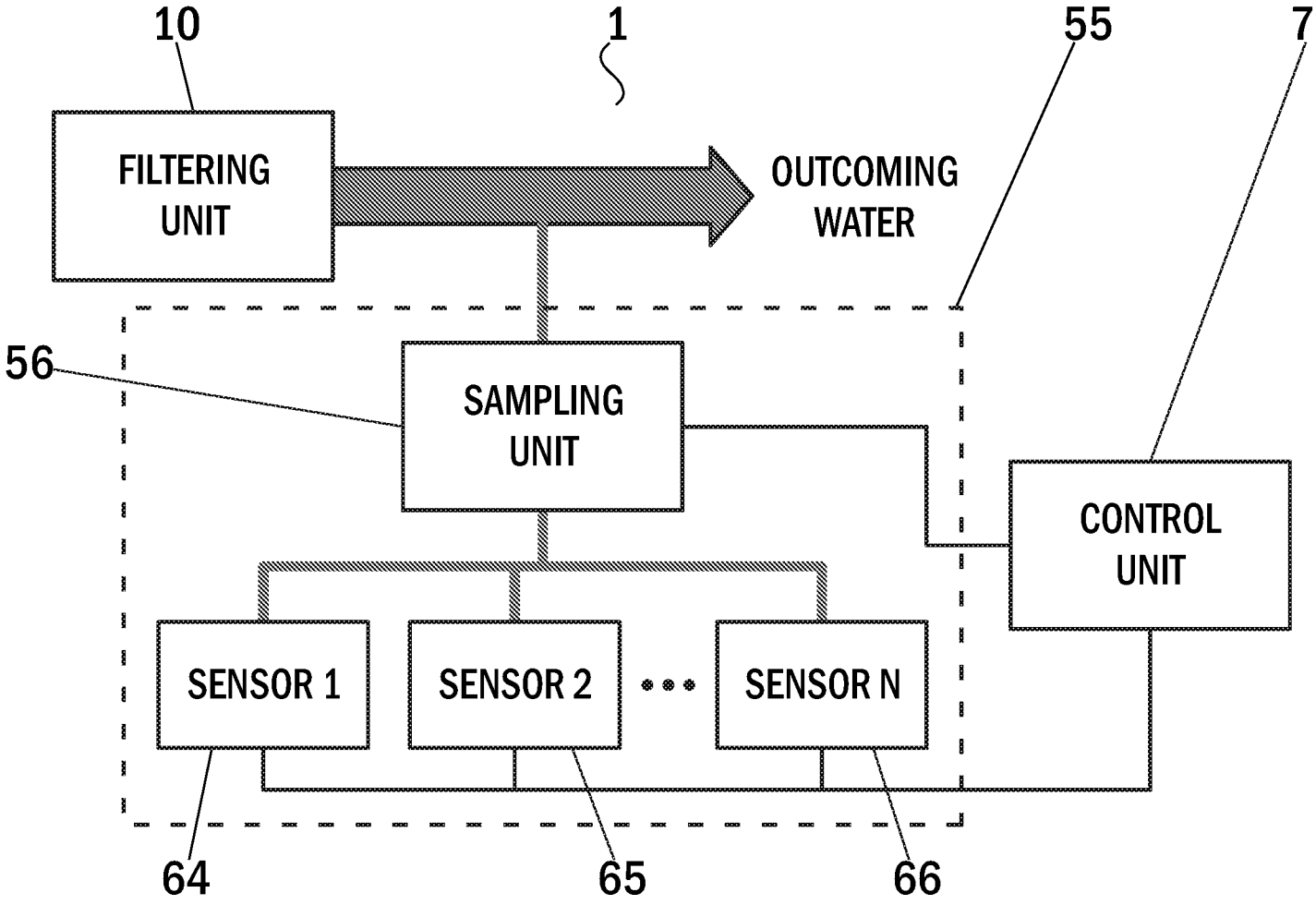

Fig. 4

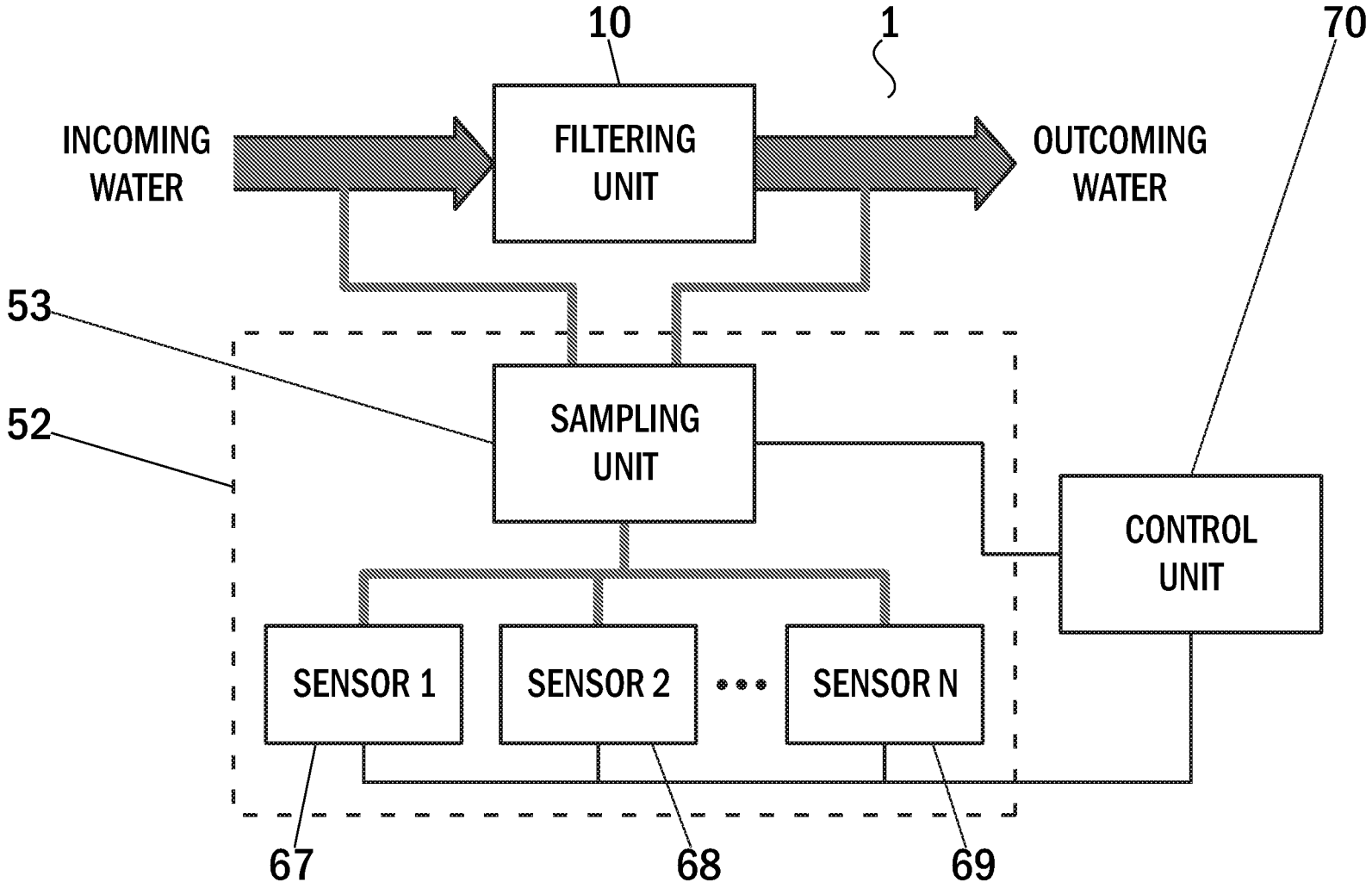

Fig. 5

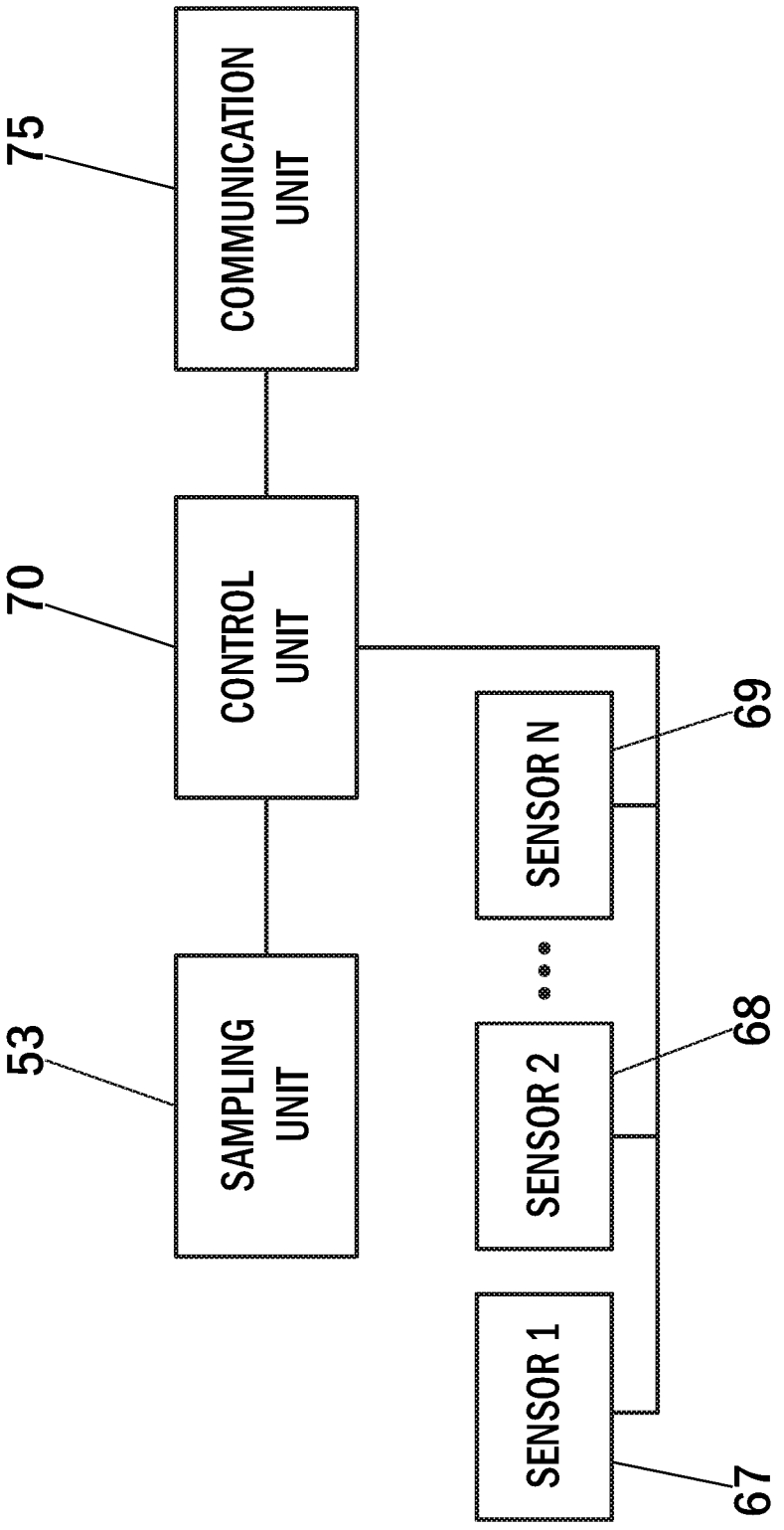
75
COMMUNICATION UNIT
70
CONTROL UNIT
53
SAMPLING UNIT
SENSOR N
69
SENSOR 2
68
SENSOR 1
67

Fig. 6

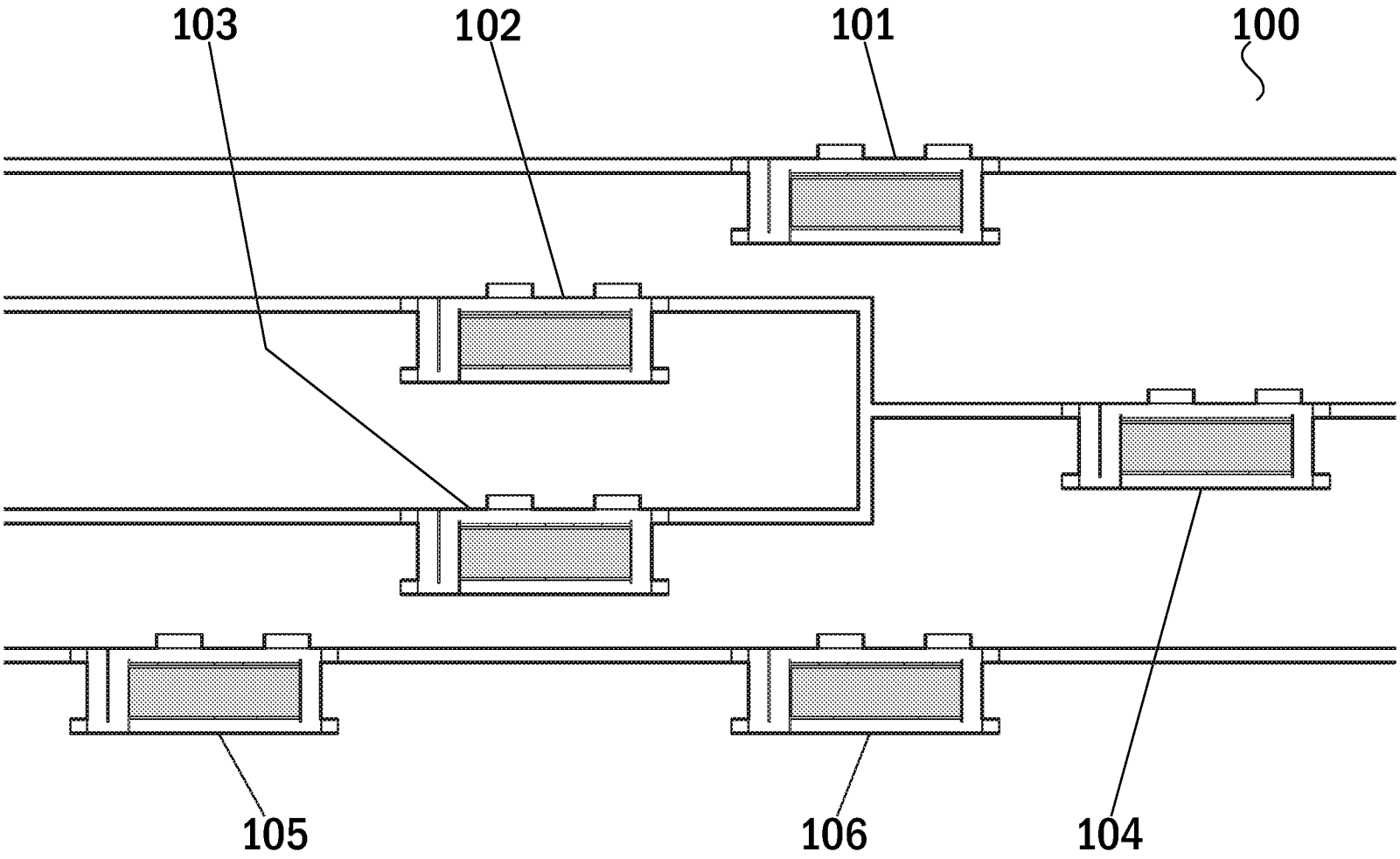

Fig. 7

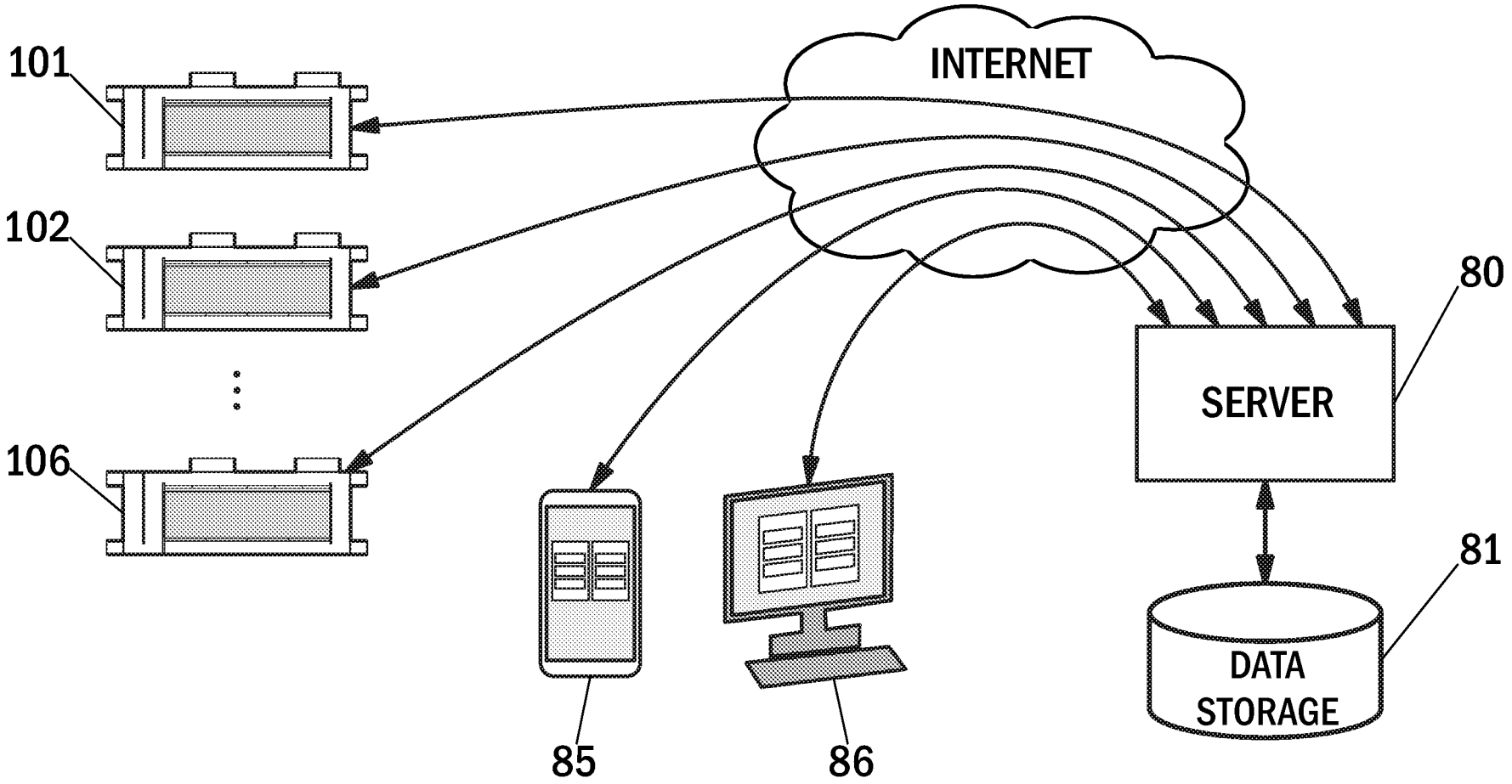

Fig. 8

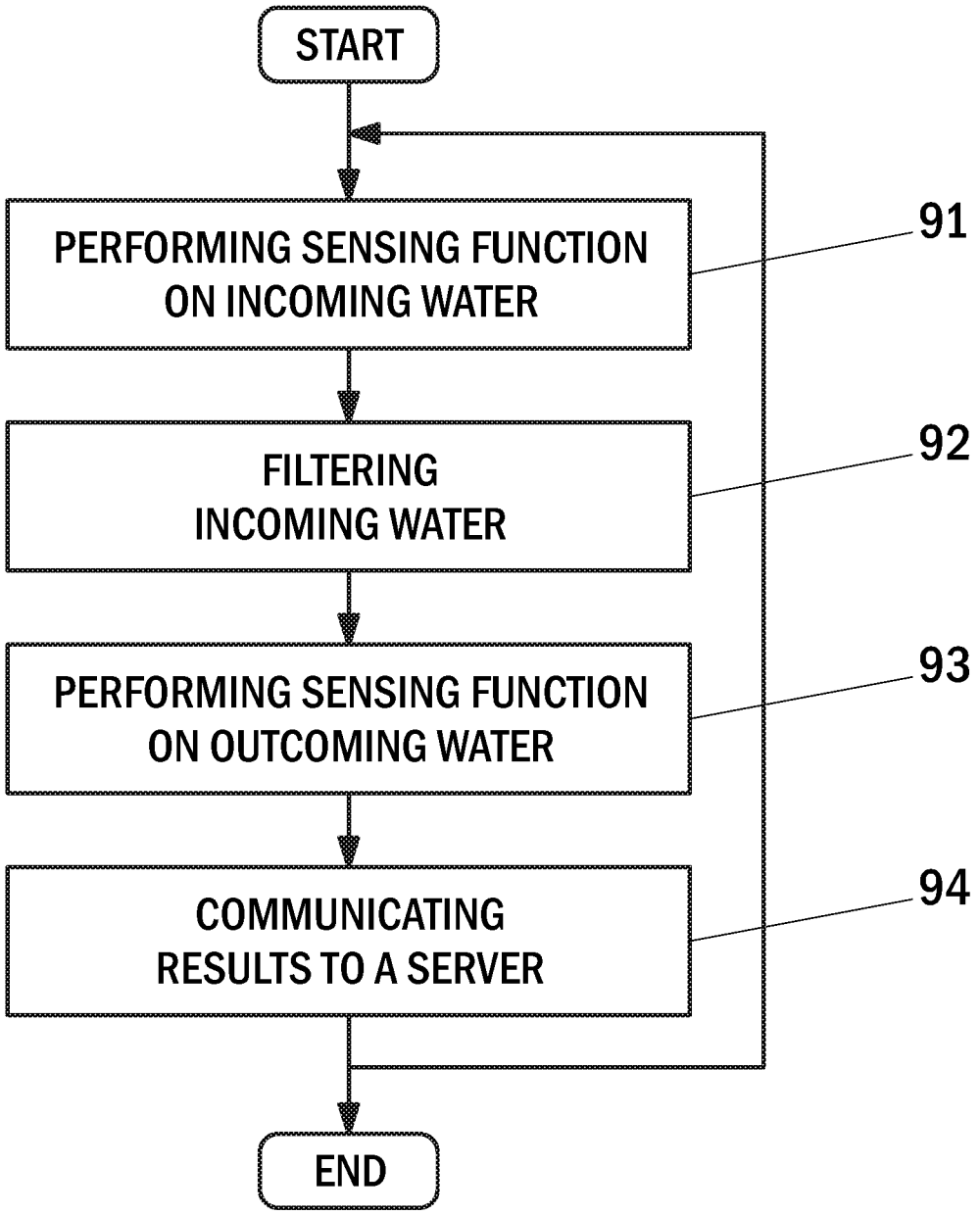

Fig. 9

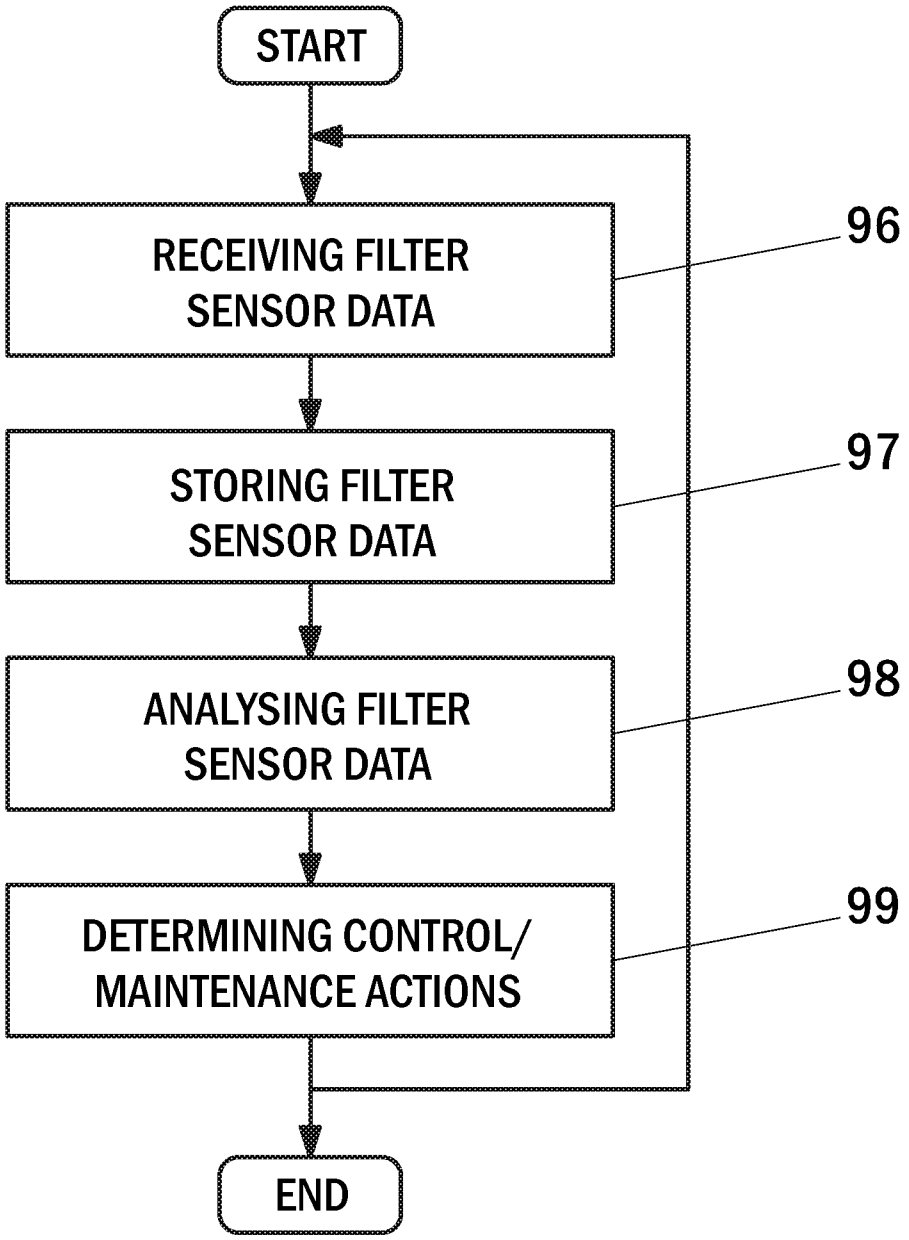

Fig. 10

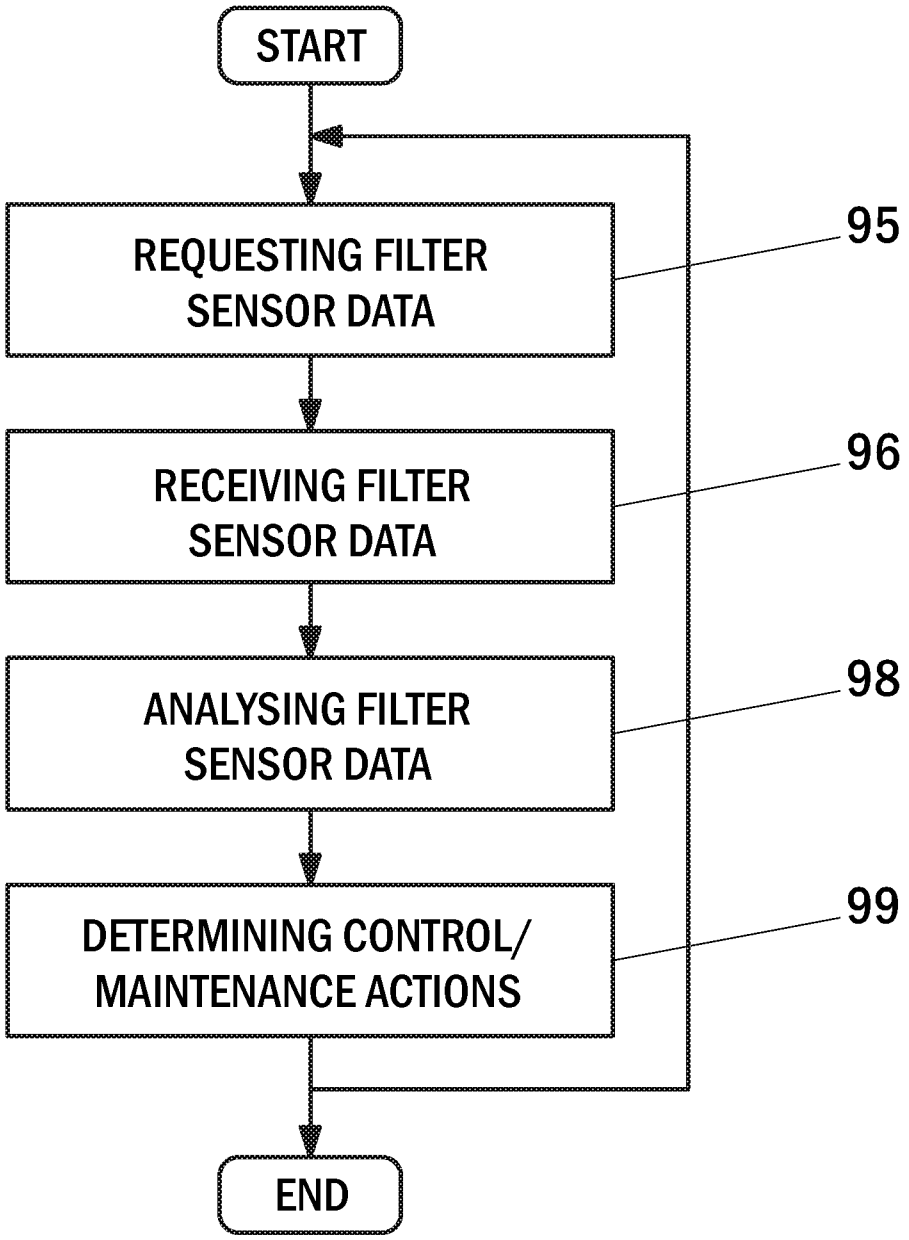

Fig. 11

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SEARCH REPORT

PATENT APPLICATION No.	CLASSIFICATION	
20236013	IPC ***C02F 1/00*** (2023.01) *C02F 103/00* (2006.01)	CPC **C02F 1/001** C02F 2103/001 C02F 2201/002 Y02A 20/108 Y02A 20/152

PATENT CLASSES SEARCHED (classification systems and classes)
IPC: C02F

DATABASES CONSULTED DURING THE SEARCH
EPODOC, EPO-Internal full-text databases, Full-text translation databases from Asian languages, WPIAP, IPRally

DOCUMENTS CONSIDERED TO BE RELEVANT

Category*)	Bibliographic data on the document and relevant passages	Relevant to claims
X Y	CN 111995166 A (UNIV NANJING INFORMATION SCIENCE & TECH) 27 November 2020 (27.11.2020) especially figure 1 & abstracts [online] EPOQUENET EPODOC & WPI & the whole machine translation into English by EPO [online] EPOQUENET TXPMTCEA, particularly page 5, line 29 – page 7, line 23; page 8, lines 9–19	1-3, 6-15 4, 5

Continued on the next sheet ☒

*) X Document indicating that the invention is not novel or does not involve an inventive step with respect to the state of the art.
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O Document referring to disclosure through lecture, use or other non-written means.
P Document published prior to the filing date but not prior to the earliest priority date.
T Document published after the filing date or priority date and illustrating the principle or theory underlying the invention.
E Earlier patent or utility model application that either is Finnish or designates Finland published on or after the filing date (priority date).
D Document that is mentioned in the application.
L Document which may throw doubts on priority claim(s), is cited to establish the publication date of another citation or is referred to for some other reason.

& Document member of the same patent family.

This document has been electronically signed.

Further information given in the annex ☐

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Finnish Patent and Registration Office
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PATENT APPLICATION No.
20236013

DOCUMENTS CONSIDERED TO BE RELEVANT, CONTINUED

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Y	CN 108191098 A (BEIJING ZHONGKE GANHE ENVIRONMENTAL PROTECTION TECH SERVICE CO LTD) 22 June 2018 (22.06.2018) especially figures 1 and 2 & abstracts [online] EPOQUENET EPODOC & WPI & the whole machine translation into English by EPO & Google [online] [retrieved 8.3.2024], particularly page 3, lines 26–36; page 5, lines 1–7; claim 8	4, 5
A	KR 101300070 B1 (NOX KOREA CO LTD [KR]) 30 August 2013 (30.08.2013) especially figure 1 & abstract [online] EPOQUENET EPODOC & the whole machine translation into English by EPO & Google [online] [retrieved 11.3.2024], particularly paragraphs [0052], [0055], [0059], and [0067]–[0069]	1-15
A	CN 114751602 A (PEARL RIVER HYDRAULIC RES INST PEARL RIVER WATER RESOURCES COMMISSION) 15 July 2022 (15.07.2022) especially figure 1 & abstracts [online] EPOQUENET EPODOC & WPI & the whole machine translation into English by EPO [online] EPOQUENET TXPMTCEA, particularly page 5, lines 21–25; page 6, line 34 – page 7, line 4	1-15
A	US 2010292844 A1 (WOLF WAYNE ALLAN [US]) 18 November 2010 (18.11.2010) the whole document, especially paragraphs [0033] and [0055]–[0060]; claims 1 and 3; figures 1 and 4A–4E & abstracts [online] EPOQUENET EPODOC & WPI	1-15
A	US 2005247113 A1 (KAHN MALCOLM R [US] et al.) 10 November 2005 (10.11.2005) the whole document, especially paragraphs [0065]–[0075], [0083], and [0084]; figures 1F and 1L & abstracts [online] EPOQUENET EPODOC & WPI	1-15