



(51) International Patent Classification:

C02F 5/02 (2006.01) *F22B 37/56* (2006.01)
F22B 37/38 (2006.01) *C23F 14/02* (2006.01)
F22B 37/42 (2006.01) *G01N 27/27* (2006.01)

(21) International Application Number:

PCT/US2015/060500

(22) International Filing Date:

13 November 2015 (13.11.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1421845.7 9 December 2014 (09.12.2014) GB

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

- with international search report (Art. 21(3))

(54) Title: FLUID TREATMENT SYSTEM

(57) Abstract: A boiler feed water treatment system (1, 100, 200) that includes two or more water softeners (20, 21), a totalizer (4) for measuring a quantity of water treated by each softener (20, 21) between regeneration cycles, a hardness analyzer (5) for measuring the hardness of water treated by the softeners (20, 21), a chemical doser (7, 107) for introducing a scale inhibitor into the feed water and a controller (9, 209a, 209b) for controlling the operation of the system (1, 100, 200). The controller (9, 209a, 209b) controls the chemical doser (7, 107) to introduce into or increase the concentration of a scale inhibitor introduced into the feed water if a hardness measured by the hardness analyzer (5) exceeds a first threshold and a water quantity measured by the totalizer (4) is below a second threshold. The controller (9, 209a, 209b) also shifts between the softeners (20, 21) if the measured hardness exceeds the first threshold and the measured water quantity exceeds the second threshold or if the measured hardness is less than the first threshold and the measured water quantity exceeds a third threshold. The second and third thresholds correspond respectively to a fraction and a multiple of the estimated treatment capacity of each of the softeners (20, 21).



FLUID TREATMENT SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

- 5 This application claims priority to Great Britain Patent Application Serial No. 1421845.7 filed on December 9, 2014, the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

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This invention relates generally to a fluid treatment system and more particularly to fluid treatment control systems for controlling such a system to treat a heat transfer fluid. More specifically, although not exclusively, this invention relates to water treatment control systems and associated treatment systems for treating feed water in heating and cooling systems, such as boilers, water heaters, radiators and air conditioners.

15

BACKGROUND OF THE INVENTION

- 20 Heating and cooling systems such as boilers, water heaters, radiators and air conditioners are generally fed by water that requires some treatment to avoid build up of contaminants. Industrial heating systems in particular will normally incorporate a treatment means for removing impurities, dissolved and suspended solids and hardness elements in the feed water in order to prevent scaling within the system. Such treatment can generally be split
- 25 into two categories, namely external treatment focused on removal of impurities and internal treatment, which is focused on limiting the tendency of water impurities to collect within the heating system.

- One example of an external treatment device is a water softener, which typically utilises
- 30 an ion exchange process, whereby hardness is reduced by replacing magnesium and calcium ions (Mg^{2+} and Ca^{2+}) with, for example, sodium ions (Na^{+}) using ion exchange resins. When the ion exchange resin is saturated, rendering it ineffective, regeneration of the resin is performed by reaction with brine.

In many cases, the point at which regeneration is required is determined based on the total flow volume of feed water that has passed through the softener, particularly in small scale operations. This approach typically involves measuring the hardness of the feed water prior to installing the softener and calculating an estimated volume of water that can be treated by the softener before requiring regeneration based on the measured value.
5 However, the set point for regeneration is adjusted down from this estimated volume in order to avoid hardness leakage, since the actual hardness of the feed water is likely to vary. This will often result in premature regeneration, which can cause a reduction in efficiency and/or unnecessary downtime.

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Moreover, feed water treatment for industrial heating systems can be particularly challenging in some industries, such as the palm oil processing industry, due to the level of contaminants and the general quality of the feed water. In such industries, it is common to use small scale steam-generating boiler systems, typically operating at relatively low pressures, e.g. below 40 bar, and relatively low temperatures, for example in the region of
15 200°C to 300°C.

The present invention is particularly, although not exclusively, concerned with small scale boilers and treatment systems for feed water of such boilers. Feed water treatment systems for small scale steam-generating boilers can vary, but typically they include two
20 or more water softeners arranged in parallel to enable continuous use when one of the softeners is in a regeneration mode. It is also known for such installations to include a deaerator and/or some form of internal treatment, for example by dosing reactant chemicals such as sulfite, sodium phosphate, chelates, polymers, and/or caustic, when
25 water quality is particularly challenging.

In some installations, shifting from one softener to the other is carried out automatically based on the total flow volume of feed water measured by a totalizer as outlined above. However, regeneration of the spent softener is normally initiated and controlled manually,
30 requiring an operative to be alerted of the need to do so. It would be desirable to extend the time between softener shift to reduce the burden on manpower.

It is therefore a first non-exclusive object of the invention to provide a fluid treatment system that mitigates the above issues associated with prior art water treatment systems,

particularly but not exclusively those for small scale steam-generating boilers. It is a further non-exclusive object of the invention to provide a fluid treatment solution that can be retrofitted to existing fluid treatment systems to improve performance. It is a yet further, more general non-exclusive object of the invention to provide an alternative fluid
5 treatment system that provides one or more advantages over known systems.

SUMMARY OF THE INVENTION

10 In accordance with a first aspect of the invention, there is provided a feed water treatment system and/or control system, e.g. a boiler feed water treatment system and/or control system, the system comprising a hardness measurement means for measuring the hardness of water treated by a softener, a water flow and/or quantity measurement means for determining a quantity of water treated by the softener and a chemical dosing means for
15 introducing one or more treatment chemicals into the feed water, wherein the system is configured to cause the chemical dosing means to introduce, in use, one or more treatment chemicals, or to increase a quantity or concentration thereof, into the feed water if a hardness measured by the hardness measurement means reaches or exceeds a first predetermined threshold and a water quantity determined by the water quantity
20 measurement means reaches or is below a second predetermined threshold.

The system may further comprise a control means, which may be operable or configured or programmed to control one or more features of the introduction of the one or more treatment chemicals into the feed water. The control means may be operatively connected
25 to the hardness measurement means and/or the water flow and/or quantity measurement means and/or the chemical dosing means. At least one of the operative connections may comprise a wired connection, e.g. a cable or wire. Additionally or alternatively, at least one of the operative connections may comprise a wireless connection means, such as a radio frequency or optical or sonic or ultrasonic transmission means, e.g. a transmitter
30 and/or receiver, or any other suitable transmission means. The system or control means may be programmable with the first and/or second predetermined thresholds. For example, the system or control means may comprise an input means, e.g. for selecting or setting or entering at least one or each threshold. The input means may comprise an interface, such as a connection for communicating with a computer or other device, or a

human machine interface, for example in the form of a keyboard and/or display and/or touchscreen.

5 The first predetermined threshold may comprise a threshold value, which may correspond to a measured or determined or calculated or estimated hardness value or concentration of ions, for example multivalent ions or cations, e.g. magnesium and calcium ions. Additionally or alternatively, the first predetermined threshold may comprise or be indicative of a change or rate of change of a measured or estimated hardness value or concentration of ions. Additionally or alternatively, the first predetermined threshold may
10 comprise any other parameter indicative of hardness leakage and/or a fault or issue or problem with the softener and/or an unacceptable hardness or value or degree thereof. By way of example only, the first predetermined threshold may comprise about 1 ppm, for example between 0.5 and 2 ppm, e.g. between 0.8 and 1.2 ppm or any value therebetween or any other value.

15 The second predetermined threshold may comprise a threshold value, which may correspond to a measured or determined or calculated or estimated flow or total flow or volume, e.g. of feed water treated or treatable by the softener. In some embodiments, the second predetermined threshold comprises a predetermined or precalculated design
20 volume or flow or total flow that may correspond to an estimated capacity, e.g. treatment capacity, of the softener, or a percentage or fraction or multiple thereof.

The one or more treatment chemicals preferably comprises one or more scale inhibiting chemicals or scale inhibitors, for example a scale inhibitor sold under the Nalco® brand,
25 for example whose chemistry and/or concentration is selected to suit the feed water to be treated. The system or control means may be configured to cause the chemical dosing means to introduce or increase the concentration of one or more scale inhibiting chemicals or scale inhibitors into the feed water if a hardness measured by the hardness measurement means reaches or exceeds the first predetermined threshold and a water quantity
30 determined by the water quantity measurement means reaches or is below the second predetermined threshold.

The system or control means may be configured to generate a softener signal, for example a shift and/or regeneration signal, which may be an alarm and/or command signal, for

example if a water quantity determined by the water quantity measurement means reaches or exceeds the second or a third predetermined threshold and/or if a hardness measured by the hardness measurement means reaches or exceeds the first predetermined threshold. Preferably, system or control means is configured to generate the softener signal if a water
5 quantity determined by the water quantity measurement means reaches or exceeds the or a third predetermined threshold and a hardness measured by the hardness measurement means reaches or exceeds the first predetermined threshold. More preferably, the second predetermined threshold corresponds to a first percentage or proportion of an estimated capacity, e.g. treatment capacity, of the softener and/or the third predetermined threshold
10 corresponds to a second percentage or proportion of the estimated capacity. By way of example, the first proportion or percentage may comprise about four fifths or 80%, for example between 50% and 100%, e.g. between 60% and 95%, such as between 70% and 90% or between 75% and 85% or their equivalent fractions. Additionally or alternatively, the second proportion or percentage may comprise about six fifths 120%, for example
15 between 100% and 150%, e.g. between 105% and 140%, such as between 110% and 130% or between 115% and 125% or any value therebetween or any other value or their equivalent multiples.

The system or control means may be configured to generate an alarm signal, e.g. a first
20 alarm signal, for example if a hardness measured by the hardness measurement means reaches or exceeds the first predetermined threshold. Additionally or alternatively, the system or control means may be configured to generate an alarm signal, e.g. a second alarm signal, for example if a water quantity determined by the water quantity measurement means reaches or exceeds the second predetermined threshold. Additionally
25 or alternatively, the system or control means may be configured to generate an alarm signal, e.g. a third alarm signal, for example if a water quantity determined by the water quantity measurement means reaches or exceeds the third predetermined threshold. Additionally or alternatively, the system or control means may be configured to generate an alarm signal, e.g. a hardness alarm signal or fourth alarm signal, for example if a
30 hardness measured by the hardness measurement means reaches or exceeds the first predetermined threshold for a predetermined period of time or if a predetermined number of first alarm signals are generated, e.g. within a predetermined period of time, and/or if the first alarm signal remains active for a predetermined period of time. In embodiments, the system is configured such that the hardness measurement means draws and/or analyzes

a sample at predetermined intervals, for example wherein the hardness alarm signal is generated if a hardness of each of a predetermined number of feed water samples drawn and analyzed reaches or exceeds the first predetermined threshold. The predetermined number may comprise about 10, for example between 5 and 15, e.g. between 8 and 12, 5 such as between 9 and 11. Additionally or alternatively, the predetermined period may comprise about 5 hours, for example between 2 and 8 hours, e.g. between 3 and 7 hours, such as between 4 and 6 hours.

The system or control means may be configured to introduce or increase the introduced 10 quantity or concentration of the one or more treatment chemicals if the first alarm signal is active or generated and the second and third alarms are inactive or have not been generated. Additionally or alternatively, the system or control means may be configured to generate the softener signal if the third alarm signal is active or generated, e.g. irrespective of whether the first and/or second alarm signals are active or generated. 15 Additionally or alternatively, the system or control means may be configured to generate the softener signal if the first and second alarm signals are active or generated, e.g. irrespective of whether the third alarm signal is active or generated.

In some embodiments, the system or control means comprises, or is configured to activate, 20 an alert or alarm means, for example an audible and/or visible alert or alarm means and/or an alert signal, e.g. to alert an operator, for example when any one or more of the alarm signals is generated. Additionally or alternatively, the system or control means is configured to send the or an alert signal to a remote system, for example a remote monitoring system, for example when any one or more of the alarm signals is generated.

25 The system may further comprise one or more softeners, e.g. water softeners and/or the system or control means may be operable to control one or more softeners, for example not forming part of the system. The system or control means may be configured to send or transmit the softener signal to the one or more softeners or a control means thereof.

30 At least one, for example each, softener may comprise a regeneration means or circuit, for example a brine regeneration means or circuit, which may be operable manually or automatically at least in part, e.g. to initiate a regeneration cycle or process or operation. In some embodiments, the system or control means is configured to operate and/or control

and/or initiate the regeneration means or circuit and/or to alert an operative or remote system of the need to manually operate the or a regeneration means, for example when the softener signal is active or generated. The system may further comprise one or more inlets or inlet lines, for example water inlets or inlet lines, and/or one or more outlets or outlet lines, for example that feed or configured to feed a heating or cooling system, such as a boiler, e.g. for connection directly or indirectly or via one or more further components, to a heating or cooling system, such as a boiler. The further components which may, but need not, form part of the system may comprise one or more reservoirs or storage tanks and/or one or more deaerators for removing oxygen and/or other dissolved gases from the feed water.

The one or more softeners may comprise two or more softeners, which may be configured or plumbed or piped in parallel and/or operable independently. In some embodiments, one of the softeners, for example a first softener, may be operable or configured to operate while or as another softener, e.g. a second softener, is in a regeneration mode or is being regenerated, for example by the regeneration means. The system or control means may be operable or configured to cause a change or shift in softener operation, for example between the two or more softeners, e.g. from the first to the second softener and/or vice versa. For example, the system or control means may be operable or configured to activate or enable initiate or cause the activation or enablement or initiation of the second softener and/or to deactivate or disable or de-initialise or cause the deactivation or disablement or de-initiation of the first softener.

The system or the two or more softeners may comprise a valve means or assembly, such as one or more valves, configured to connect or fluidly connect, for example selectively connect or fluidly connect, each of the two or more softeners to the one or more inlets or inlet lines and/or to the one or more outlets or outlet lines and/or to the one or more reservoirs or storage tanks and/or to the one or more deaerators. The valve means or assembly may comprise a feed valve or valve means, for example a respective feed valve or valve means, e.g. for selectively connecting the or each of the softeners, e.g. an inlet thereof, to at least one of the inlets or inlet lines. Additionally or alternatively, the valve means or assembly may comprise an outlet valve or valve means, for example a respective outlet valve or valve means, e.g. for selectively connecting the or each of the softeners, e.g. an outlet thereof, to the one or more outlets or outlet lines and/or to the one or more

reservoirs or storage tanks and/or to the one or more deaerators. For the avoidance of doubt, the terms “valve” and “valve means” are intended to encompass valve assemblies that incorporate more than a single valve to carry out the required operation.

- 5 The system may further comprise a temperature measurement means, e.g. for measuring the feed water temperature, for example downstream of the deaerator. The temperature measurement means may comprise a temperature sensor or thermocouple or thermistor and for the avoidance of doubt any reference to temperature measurement means herein can be replaced with such terms. The temperature measurement means may be
10 operatively connected to the one or more outlets or outlet lines. The system or control means may be configured to detect a deaerator fault or upset, for example based on one or more temperatures measured or detected by the temperature measurement means.

In accordance with another aspect of the invention, there is provided a feed water
15 treatment system and/or control system, e.g. a boiler feed water treatment system and/or control system, the system comprising a temperature measurement means for measuring the temperature of water treated by a deaerator and a chemical dosing means for introducing one or more treatment chemicals into the feed water, wherein the system is configured to cause the chemical dosing means to introduce, in use, one or more treatment
20 chemicals, or to increase a quantity or concentration thereof, into the feed water if a temperature measured by the temperature measurement means reaches or is below or exceeds a predetermined threshold.

The system or control means may be configured to generate an alarm signal, e.g. a fifth
25 alarm signal, for example if a deaerator fault is detected and/or if the temperature measurement means reaches or is below a predetermined threshold or a predetermined temperature threshold, for example a fourth predetermined threshold or temperature threshold. The system or control means may be configured to operate and/or control and/or cause the dosing means to introduce one or more treatment chemicals and/or
30 increase the concentration thereof, for example if the fifth alarm signal is active or generated and/or on detection of a deaerator fault and/or if the temperature measurement means reaches or exceeds or is below the, or the fourth, predetermined threshold or temperature threshold. The one or more treatment chemicals introduced in such circumstances may comprise an oxygen scavenging chemical or an oxygen scavenger,

which may but need not comprise a sulphide based chemistry. Additionally or alternatively system or control means may be configured to alert an operative or a remote system if the fifth alarm signal is active or generated. By way of example only, the predetermined temperature threshold may comprise about 95°C, for example between
5 70°C and 120°C, e.g. between 85°C and 105°C such as between 90°C and 100°C or any value therebetween or any other value.

The chemical dosing means may comprise a doser or pump, for example a dosing and/or metering pump, which may comprise a diaphragm pump, a gear pump, a peristaltic pump,
10 a piston pump, a syringe pump or any other suitable pumping means and for the avoidance of doubt any reference to chemical dosing means herein can be replaced with such terms. The pump may comprise an on/off pump or a variable pump, for example a proportional integral derivative (PID) pump. Additionally or alternatively, the chemical dosing means may comprise any other suitable and/or known means for introducing the requisite
15 chemicals into the feed water where, for example the treatment chemical is not in a pumpable or fluid or liquid form. Additionally or alternatively, the one or more chemicals may comprise an oxygen scavenging chemicals or an oxygen scavenger, which may comprise a sulphide based chemical.

20 In some embodiments, the chemical dosing means comprises two or more dosers or pumps, for example that may be enabled or initialised in sequence to introduce the one or more treatment chemicals into the feed water and/or to increase the concentration of one or more treatment chemicals introduced into the feed water. The system or control means may be configured to enable or initialise a first doser or pump, for example to introduce
25 one or more treatment chemicals, e.g. a first quantity or concentration thereof, into the feed water. The system or control means may be configured to enable or initialise a second doser or pump, for example to introduce one or more treatment chemicals, at least one of which may be the same or different to the one or more treatment chemicals introduced by the first doser or pump. In some embodiments, the system or control means
30 is configured to enable or initialise a second doser or pump to introduce a second quantity or concentration of the same or at least one of the same treatment chemicals as the first doser or pump. The first doser or pump may be configured to operate constantly and/or continuously or intermittently and/or the second doser or pump may be configured to operate on demand and/or continuously or intermittently.

The system may comprise a further one or more, e.g. a third and optionally a fourth and/or further, dosers or pumps that may comprise any one or more of the features of the first and/or second dosers or pumps. One or more of the further dosers or pumps may be
5 arranged to introduce one or more treatment chemicals, which may be different from the dosing chemicals introduced by the first and/or second dosers or pumps. In some embodiments, the first and/or second and/or one or more further dosers or pumps are operable to introduce one or more scale inhibiting chemicals or scale inhibitors into the feed water, while the third and/or fourth and/or one or more further dosers or pumps are
10 operable to introduce one or more oxygen scavenging chemicals or oxygen scavengers into the feed water. Other arrangements are also envisaged, for example more or less dosers or pumps.

The control means may comprise a controller and/or control circuitry and/or a processor and/or a memory means or memory and for the avoidance of doubt any reference to
15 control means herein can be replaced with such terms. Furthermore, the term controller should not be interpreted as being limited to a single component as it may comprise two or more separate elements, which may but need not be connected together either physically or even operatively. In some embodiments, the control means comprises two or more
20 controllers, each of which may, but need not, communicate with one another, and/or control a respective and/or different aspect of the system. For example, a first controller may be provided that controls

The hardness measurement means may comprise a hardness monitor and/or analyzer and
25 for the avoidance of doubt any reference to hardness measurement means herein can be replaced with such terms. Preferably, the hardness measurement means comprises an automatic or semi-automatic monitoring system, which may be configured to operate continuously or discontinuously. More preferably, the hardness measurement means is configured to operate, e.g. the system or control means may be configured to cause the
30 hardness measurement means to operate, at regular and/or predetermined intervals. By way of example, the hardness measurement means may be configured to operate at regular and/or predetermined intervals of, e.g. every or once every, about 30 minutes, for example the intervals may be between 10 and 50 minutes, e.g. between 15 and 45 minutes, such as between 20 and 40 minutes or between 25 and 35 minutes. The hardness measurement

means may be operable to collect sample water and/or inject a chemical reagent and/or mix and/or analyze or evaluate the sample water, e.g. the mixed sample water and chemical reagent. The reagent may be selected to react with one or more elements of the feed water, for example to create a color indicator or indication that may provide an indication of hardness. The hardness measurement means may be configured to measure or monitor the transmissivity of the feed water or color indicator or indication and/or to determine or conclude a hardness value, e.g. from the measured or monitored transmissivity.

10 The water quantity measurement means may be configured to determine the quantity of water treated by a softener from a predetermined point in time and/or within a predetermined time period or interval. In some embodiments, the water quantity measurement means is configured to determine the quantity of water treated by a softener after regeneration or from the completion of a regeneration cycle.

15 The water quantity measurement means may comprise a flow sensor or flow meter or a totalizer and for the avoidance of doubt any reference to water quantity measurement means herein can be replaced with such terms. In some embodiments, the system may comprise a processing means or processor and/or a control means or controller, which may be at least partially remote from or adjacent and/or mounted to the flow sensor or flow meter or totalizer, for determining a quantity of water treated by the softener, for example from one or more signals or a continuous signal received by the flow sensor. The processing means or processor and/or control means or controller may be operable to determine or calculate the quantity of water treated by the softener. In some
20 embodiments, the water quantity measurement means comprises a totalizer or flow meter, which may comprises a flow sensor, that is operable or configured or programmed to determine, e.g. to measure and/or calculate, a quantity of water treated by the softener. The flow sensor may comprise an open-core rotor with blades and/or an arrangement of magnets that may generate a frequency output proportional to flow velocity. Other flow
25 sensors would also be suitable.

The system may further comprise a boiler water withdrawal or blow down means and/or valve and/or circuit and/or assembly, hereinafter referred to as blow down means. The blow down means may comprise a blow down valve and/or a drain and/or a sampler, e.g.

operatively connected to, and/or for sampling and/or analyzing water from, the or a boiler, e.g. a steam chamber or drum thereof. The blow down means or sampler may comprise any one or more of the features described in US5041386, the entire contents are incorporated herein by reference.

5

The dosing means may be operable or configured to introduce, in use, for example continuously or regularly or intermittently, a tracer, e.g. an inert tracer, which tracer may be configured to reach, in use, a final concentration in the or a boiler or in a steam chamber or drum thereof, for example at a steady state therein, and/or which may exhibit a
10 blow down concentration at one or more different points in time. The system or controller or sampler may be configured to sample continuously or regularly or intermittently water samples and/or to measure the pH and/or conductivity and/or blowdown concentration of the tracer, e.g. within the blow down sample. The system or controller or sampler may be operable or configured to generate a signal, e.g. an alarm or blow down signal, which may
15 comprise an alarm signal and/or a command signal, for example when one or more of the parameters measured reaches or exceeds or is below a predetermined set point. The system or controller or sampler may further be configured to cause or initiate or generate, e.g. when the blow down signal is active or generated, an audible and/or visible alarm, and/or to send the blow down signal to the or a remote monitoring system and/or to cause
20 a blow down valve to open and/or to initiate a blow down procedure or cycle.

A further aspect of the invention provides a method of treating feed water, e.g. boiler feed water, the method comprising measuring the hardness of water treated by a softener, determining a quantity of water treated by the softener and introducing one or more
25 treatment chemicals that may include a scale inhibitor, or increasing a quantity or concentration thereof, into the feed water if the hardness measured reaches or exceeds a first predetermined threshold and the water quantity reaches or is below a second predetermined threshold.

30 The method may further comprise disabling the softener and/or enabling a further softener, for example if the measured hardness reaches or exceeds the first predetermined threshold and/or if the determined water quantity reaches or is below a third predetermined threshold. The method may comprise measuring the hardness of water treated by the softener at predetermined intervals and/or generating a hardness alarm signal, for example

if the measured hardness of one or more or each thereof or of a predetermined number of feed water samples, e.g. drawn and analyzed, reaches and/or exceeds the first predetermined threshold.

- 5 Additionally or alternatively, the method may further comprise measuring a temperature of the feed water, for example downstream of a deaerator, and/or introducing or increasing a quantity or concentration of one or more treatment chemicals, e.g. an oxygen scavenger, for example into the feed water, e.g. if the measured temperature reaches or is below or above a predetermined threshold.

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Another aspect of the invention provides a method of treating feed water, e.g. boiler feed water, the method comprising measuring the temperature of water treated by a deaerator and introducing one or more treatment chemicals that may include an oxygen scavenger, or increasing a quantity or concentration thereof, into the feed water if a temperature measured reaches or is below or exceeds a predetermined threshold.

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Moreover, the method may further comprise introducing a tracer, for example an inert tracer, into the feed water, and/or drawing and/or analyzing a water sample from the boiler. The method may comprise measuring the conductivity of the drawn water sample and/or the concentration of the inert tracer therein. In embodiments, the method may comprise generating an audible and/or visible alarm and/or sending a signal, e.g. to a remote monitoring system, and/or initiating a blow down cycle, for example if either the measured conductivity or concentration reaches a respective predetermined set point.

20

- 25 A further aspect of the invention provides a computer program element comprising computer readable program code means for causing a processor to execute a procedure to implement the aforementioned method. A yet further aspect of the invention provides the computer program element embodied on a computer readable medium.

- 30 A yet further aspect of the invention provides a computer readable medium having a program stored thereon, where the program is arranged to make a computer execute a procedure to implement the aforementioned method.

A yet further aspect of the invention provides a control means or control system or controller comprising the aforementioned computer program element or computer readable medium.

5 For the avoidance of doubt, any of the features described herein apply equally to any aspect of the invention, whether they be features or operations of the system or features or steps of the method or any other features that would be understood to apply to each of the various aspects described above.

10 Within the scope of this application it is expressly envisaged that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. Features described in connection with one aspect or embodiment of the invention are applicable to all aspects or
15 embodiments, unless such features are incompatible.

BRIEF DESCRIPTION OF THE DRAWINGS

20 Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic of a water treatment system according to one embodiment of the invention;

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Figure 2 is a logic diagram illustrating the circumstances in which softener shift, regeneration and treatment chemical dosing is controlled in the water treatment system of Figure 1;

30 Figure 3 is a schematic of a water treatment system according to another embodiment of the invention; and

Figure 4 is a schematic of a water treatment system according to yet another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figure 1, there is shown a water treatment system 1 for feeding a steam-generating boiler 10 according to one embodiment. It will be appreciated by those skilled
5 in the art that the water treatment system 1 according to this embodiment may be used to treat feed water to any heating or cooling system in which the elements of the present invention are useful and that the components thereof may be replaced or altered with substantially equivalent features adapted for such a system.

10 The water treatment system 1 according to this embodiment includes a supply line 11 feeding supply water to a water softener assembly 2 that treats the supply water and feeds treated supply water through a first feed line 12 to a storage tank 3 via a totalizer 4.

The water softener assembly 2 includes first and second softeners 20, 21 each with a
15 respective supply valve 22, 23 and outlet valve 24, 25. The water softener assembly 2 also includes a regeneration circuit (not shown) that is operated manually in this embodiment. The totalizer 4 in this exemplary embodiment incorporates a flow sensor having an open-core rotor with blades and an arrangement of magnets that generates a frequency output proportional to flow velocity, but other flow sensors are also envisaged. The totalizer 4
20 includes control logic that is operable to determine based on the measured flow a quantity of water treated by the softener.

A hardness analyzer 5 is also connected to the first feed line 12 between the totalizer 4 and the storage tank 3. The storage tank 3 includes two outlets 30, 31, a first outlet 30
25 supplying a deaerator 6 via a second feed line 13 with a first pump 13a and a second outlet 31 fluidly connected via a third feed line 14 to a fourth feed line 15 that connects the deaerator 6 to the boiler 10 via a second pump 15a and temperature sensor 15b. The third feed line 14 enables the deaerator 6 to be bypassed and includes a valve 14a for isolating the second outlet 31 from the fourth feed line 15. The system also includes a valve 60 in
30 the fourth feed line 15 upstream of the connection with the third feed line 14 for isolating the deaerator 6 in the event that bypass is required. The bypass valve 14a and the deaerator isolation valve 60 are both operated manually in this embodiment.

The hardness analyzer 5 is fluidly connected to the first feed line 12 via a valve 50 that is wired to and controlled by the hardness analyzer 5 in this embodiment. The hardness analyzer 5 is configured to sample the feed water treated by the water softener assembly 2 at predetermined intervals, for example every 20 minutes. The hardness analyzer 5 then
5 injects a chemical reagent into the water sample, mixes and analyzes the mixed sample water and chemical reagent. The reagent is selected to react with elements of the feed water to create a color indication of hardness. The analysis involves measuring the transmissivity of the color indication and determining a hardness value therefrom. Other harness analyzers 5 are also envisaged and may present advantages in circumstances as
10 would be appreciated by the skilled person.

The water treatment system 1 also includes a first treatment chemical doser 7 for dosing a scale inhibitor into the fourth feed line 15 via a first dosing line 16 and a second treatment chemical doser 8 for dosing an oxygen scavenger into the fourth feed line 15 via a second
15 dosing line 17. The connection between the second dosing line 17 and the fourth feed line 15 is downstream of the connection between the first dosing line 16 and the fourth feed line 15. Each doser 7, 8 includes a doser tank 70, 80 containing treatment chemicals and a dosing pump 71, 81 that feeds the treatment chemicals to a respective one of the dosing lines 16, 17 via a respective non-return valve 72, 82 and doser valve 73, 83.

20 The system also includes a controller 9 for controlling the system 1 and a blow down line 18 incorporating a blow down valve 18a for selectively initiating a blow down cycle to withdraw boiler water and discharge it to a common drain 18b. Each of the temperature sensor 15b, water softener valves 22, 23, 24, 25, totalizer 4, hardness analyzer 5, dosing
25 pumps 71, 81 and doser valves 73, 83 is operatively connected to the controller 9 by a respective cable in this embodiment, although one or more such cables may be replaced with wireless connections. The blow down valve 18a is operated manually in this embodiment, but it is envisaged that it could also be operatively connected to and controlled automatically by the controller 9 via a cable or wireless connection. Similarly,
30 the hardness analyzer valve 50 may also be operatively connected to and controlled directly by the controller 9 via a cable or wireless connection instead of being controlled by the hardness analyzer 5.

As explained above, the totalizer 4 includes control logic that is operable to determine based on the measured flow a quantity of water treated by the softener. However, it is also envisaged that the totalizer 4 may be replaced with a simple flow sensor that communicates with a controller 9 of the system, for example wherein the controller 9 is
5 configured to determine the quantity of water treated by the softener.

In use, the supply and outlet valves 22, 24 of the first softener 20 are open and water is fed from the supply line 11 through the first softener 20, where it is treated to replace magnesium and calcium ions (Mg^{2+} and Ca^{2+}) with sodium ions (Na^{+}) using ion exchange
10 resins. The softener treated feed water then passes through the first feed line 12 to the storage tank 3 via the totalizer 4. Softener treated water from the storage tank 3 is then pumped through the second feed line 13 by the first pump 13a from the first outlet 30 of the storage tank 3 to the deaerator 6, where it is treated further to remove oxygen and/or other dissolved gases. The deaerator isolation valve 60 is also open and the treated feed
15 water is pumped through the fourth feed line 15 by the second pump 15a to the boiler 10 via the temperature sensor 15b.

As explained above, the hardness analyzer 5 draws a sample of the softener treated feed water at regular intervals, every 20 minutes in this embodiment. This is achieved by
20 opening the hardness analyzer valve 50 to draw the sample, into which the chemical reagent is injected, the sample is mixed and analyzed as explained above to determine a hardness value. The controller 9 then carries out a procedure as outlined in Figure 2, where HA represents the reading from the hardness analyzer 5, SP represents the excessive hardness set point, which is 1 ppm in this embodiment, and T represents the
25 total flow measured by the totalizer 4. DF represents the design flow for each softener 20, 21, that is to say the estimated volume of water that can be treated by the softener 20, 21 before requiring regeneration as measured by the procedure described above. SP_n represents the normal set point for the totalizer 4, which is set at 80% of the design flow in this embodiment. SP_c represents the critical set point for the totalizer 4, which is set at
30 120% of the design flow in this embodiment. Shift represents a signal generated by the controller 9 to initiate a shift between the softeners 20, 21.

Regeneration Alarm represents a signal generated by the controller 9 that is sent to a remote monitoring system (not shown) and that initiates an audible and visible alarm at the

relevant softener 20, 21 to indicate to an operative that the regeneration circuit must be activated. Similarly, Hardness Alarm represents a signal generated by the controller 9 that is also sent to a remote monitoring system (not shown) and that initiates an audible and visible alarm at the hardness analyzer 5 to indicate to an operative that there is a fault with the hardness analyzer 5 or somewhere else in the system 1. Dosing Pump represents a signal generated by the controller 9 to initiate the first treatment chemical doser 7 by opening the first doser valve 73 and causing the first dosing pump 71 to dose a scale inhibitor into the fourth feed line 15. It is also envisaged that the first dosing pump 71 may be operable to dose continuously a scale inhibitor into the fourth feed line 15 at a first rate or concentration, for example wherein the signal generated by the controller 9 causes an increase from the first rate or concentration to a second rate or concentration. In such embodiments, the first dosing pump 71 may comprise two speeds or may be continuously variable with the controller 9 being configured to operate it at one of two set points. Other arrangements are also envisaged and would be appreciated by the skilled addressee.

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As illustrated in Figure 2, a reading HA is taken from the hardness analyzer 5 at step 51 and a comparison with the set point SP is carried out at step 52. If the reading HA is less than the set point SP, then the controller 9 proceeds to step 53, where the total flow T from the totalizer 4 is compared with the critical set point SP_c . If the total flow T is less than the critical set point SP_c , then the controller 9 proceeds to step 53a and no alarms or signals are generated and no softener shift is carried out.

20

Accordingly, by monitoring the hardness of the softener treated feed water at regular intervals, operation of the softener can be extended by up to 20% of its normal design flow DF, thereby improving the efficiency of the system 1.

25

If the total flow T is more than the critical set point SP_c , then the controller 9 proceeds to step 53b, where a Shift signal is generated and then to step 53c where a Regeneration Alarm signal is also generated. The Shift signal results in the controller 9 initiating a shift between the softeners. This is achieved in the configuration outlined above, in which the first softener 20 is in operation, by opening the supply and outlet valves 23, 25 of the second softener 21 and closing the supply and outlet valves 22, 24 of the first softener 20. The Regeneration Alarm signal alerts the operative that regeneration of the first softener 20 must be carried out.

30

Turning back to step 52, if the reading HA is more than the set point SP, then the controller 9 proceeds to step 54, where the total flow T from the totalizer 4 is compared with the normal set point SP_n. If the total flow T is less than the normal set point SP_n, then
5 the controller 9 proceeds to step 54a, such that no softener shift is carried out, and then to step 55 such that a Dosing Pump signal is generated, thereby causing the first dosing pump 71 to dose, or increase the dosage of, a scale inhibitor into the fourth feed line 15. If the total flow T is more than the normal set point SP_n, then the controller 9 proceeds to step 54b, where a Shift signal is generated and then to step 54c where a Regeneration Alarm
10 signal is also generated. The Shift and Regeneration Alarm signals result in the same procedures described above in relation to steps 53b and 53c.

As a result of this arrangement, in situations where the softener 20 is unable to cope with the quality of the feed water, for example due to seasonal fluctuations, its operation before
15 softener shift may be extended up to at least 80% of its design flow DF whilst mitigating the risk of excessive scale deposits accumulating in the boiler 10.

In this embodiment, the temperature sensor 15b is configured to measure continuously the temperature of the treated feed water passing through the fourth feed line 15. If the
20 measured temperature drops below a predetermined threshold value, which is indicative of a fault in the deaerator 6, the controller 9 is configured to generate a deaerator fault alarm signal, which initiates the second treatment chemical doser 8 to introduce into the fourth feed line 15 an oxygen scavenger by opening the second doser valve 83 and initiating the second doser pump 81. It will be appreciated that the temperature threshold value is
25 selected based on the environmental conditions, the characteristics and settings of the deaerator 6 and features of the feed water supply. By way of example, the temperature threshold value may be approximately 95°C.

As with the first treatment chemical doser 7, it is envisaged that the second dosing pump
30 81 may be operable to dose continuously an oxygen scavenger into the fourth feed line 15 at a first rate or concentration, for example wherein the signal generated by the controller 9 causes an increase from the first rate or concentration to a second rate or concentration. In such embodiments, the second dosing pump 71 may also comprise two speeds or may be continuously variable with the controller 9 being configured to operate it at one of two

set points. Other arrangements are also envisaged and would be appreciated by the skilled addressee.

5 In this embodiment, a blow down operation is carried out at regular intervals according to a predetermined schedule or where the efficiency of the boiler 10 indicates that this is required. Blow down is achieved by opening the blow down valve 18a to withdraw boiler water and discharge it to a common drain 18b. As indicated above, it is also envisaged that the blow down valve 18a could be operatively connected to and controlled by the controller 9 to carry out the blow down cycle at regular intervals.

10

Turning now to Figure 3, there is shown a water treatment system 100 according to a second embodiment, which is similar to the system 1 according to the first embodiment wherein like references depict like features and the system 100 operates in a similar manner that will not be described further. The water treatment system 100 according to this embodiment differs from that of the first embodiment in that the system 100 includes a blow down sampler 118 and the first treatment chemical doser 107 in this embodiment includes a further doser tank 170 with a further dosing pump 171 that feeds the treatment chemicals from the tank to the first dosing line 16 via a further non-return valve 172 and further doser valve 173. Each of the further dosing pump 171 and the further doser valve 173 is operatively connected to the controller 9 by a cable in this embodiment, although the cable may be replaced with a wireless connection.

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In this embodiment, the first treatment chemical doser 107 is configured such that the first dosing pump 71 doses continuously a formulation that includes a scale inhibitor and an inert tracer into the fourth feed line 15. The system 100 follows a similar procedure to that shown in Figure 2. When the Dosing Pump signal is generated by the controller 9, the further doser valve 173 is opened and the further dosing pump 171 is initiated to dose additional scale inhibitor into the fourth feed line 15, thereby increasing the concentration of scale inhibitor to mitigate the higher hardness value determined by the hardness analyzer 5.

30

In this embodiment, the tracer introduced into the fourth feed line 15 reaches a final concentration at steady state in the boiler, which exhibits a blow down concentration at different points in time, as explained in US5041386, the entire contents are incorporated

herein by reference. The blow down sampler 118 is configured to sample continuously water samples from the steam drum of the boiler 10 and to measure the pH, conductivity and the blowdown concentration of the inert tracer within the blow down sample.

5 The blow down sampler 118 is operatively connected to the controller 9 by a cable in this embodiment, although the cable may be replaced with a wireless connection. The blow down sampler 118 is configured to generate a blow down alarm signal when one of the parameters measured reaches or exceeds or is below a predetermined set point. The set point is determined based on the characteristics of the feed water and the configuration of
10 the system 100. When the controller 9 receives a blow down alarm signal, an audible and visible alarm is initiated at or adjacent the manual blow down valve 18a to indicate to an operative that the blow down cycle should be initiated.

Turning now to Figure 4, there is shown a water treatment system 200 according to a third
15 embodiment, which is similar to the systems 1, 100 according to the first and second embodiments wherein like references depict like features and the system 200 operates in a similar manner that will not be described further. The water treatment system 200 according to this embodiment differs from that of the second embodiment in that the system 200 includes an automated blow down circuit with a second blow down valve 218a
20 and a non-return valve 218b, the controller 209a, 209b is incorporated in part 209b into the blow down sampler 218 and the second treatment chemical doser 208 includes a further doser tank 280 with a further dosing pump 281 that feeds the treatment chemicals from the tank to the second dosing line 17 via a further non-return valve 282 and further doser valve 283.

25 The valves 22, 23, 24, 25, totalizer 4 and hardness analyzer 5 are each connected to and controlled by a first controller 209a. The blow down sampler 218 in this embodiment functions in a similar manner to the blow down sampler 118 of the first embodiment, but it also includes a second controller 209b. The second blow down valve 218a and each of the dosing pumps 71, 171, 81, 281, dosing valves 73, 173, 83, 283 and the temperature sensor
30 15b is operatively connected to and controlled by the second controller 209b by a cable, although the cable may be replaced with a wireless connection. The first and second controllers 209a, 209b are also operatively connected to one another by a cable in this embodiment, although the cable may be replaced with a wireless connection.

In this embodiment, the second treatment chemical doser 208 is configured such that the second dosing pump 81 doses continuously an oxygen scavenger into the fourth feed line 15. If the measured temperature drops below the predetermined threshold value described
5 above and a deaerator fault alarm signal is generated, the further doser valve 283 is opened and the further doser pump 281 is initiated to dose additional oxygen scavenger into the fourth feed line 15, thereby increasing the concentration of oxygen scavenger to mitigate the fault in the deaerator 6.

10 In addition, when a blow down alarm signal is generated as outlined above in relation to the system 100 according to the second embodiment the controller 209b is configured to open the second blow down valve 218a automatically in order to initiate the blow down cycle.

15 Whilst embodiments of the present invention have been described and illustrated above, it will be appreciated by those skilled in the art that several variations to the aforementioned embodiments are envisaged without departing from the scope of the invention. Specifically, although not exclusively, one or more of the features and the arrangements described in the summary section above may be included or implemented or embodied
20 within any one of the specific embodiments described.

It will also be appreciated by those skilled in the art that any number of combinations of the aforementioned features and/or those shown in the appended drawings provide clear advantages over the prior art and are therefore within the scope of the invention described
25 herein.

CLAIMS

1. A boiler feed water treatment system comprising a water softener, a controller, a hardness analyzer operatively connected to the controller for measuring the hardness of water treated by the softener, a water flow meter operatively connected to the controller for determining a quantity of water treated by the softener and a chemical doser operatively connected to the controller for introducing one or more treatment chemicals into the feed water, wherein the controller is configured to cause the chemical doser to introduce or increase, in use, a quantity or concentration of one or more treatment chemicals into the feed water if a hardness measured by the hardness analyzer reaches or exceeds a first predetermined threshold and a water quantity determined by or from the water flow meter reaches or is below a second predetermined threshold.
2. A system according to claim 1 further comprising two or more water softeners, wherein the controller is further configured to generate a softener alarm signal if a hardness measured by the hardness analyzer reaches or exceeds the first predetermined threshold and a water quantity determined by or from the water flow meter reaches or is below a third predetermined threshold.
3. A system according to claim 2, wherein the controller is configured to activate or cause the activation of one of the two or more water softeners and to deactivate or cause the deactivation of another of the two or more water softeners when the softener alarm signal is generated.
4. A system according to claim 2, wherein the controller is configured to generate an audible or visible alarm when the softener alarm signal is generated.
5. A system according to claim 2, wherein the controller is configured to activate or cause the activation of a regeneration cycle when the softener alarm signal is generated.
6. A system according to claim 2, wherein the second predetermined threshold comprises a fraction of an estimated treatment capacity of one or each water softener

and the third predetermined threshold comprises a multiple of the estimated treatment capacity.

7. A system according to claim 1, wherein the controller is further configured to generate a hardness alarm signal if a hardness measured by the hardness analyzer reaches or exceeds the first predetermined threshold for a predetermined period of time.
8. A system according to claim 7, wherein the system is configured such that the hardness analyzer draws and analyzes a feed water sample at predetermined intervals and the hardness alarm signal is generated if a hardness of each of a predetermined number of feed water samples drawn and analyzed reaches or exceeds the first predetermined threshold.
9. A system according to claim 1, wherein the one or more treatment chemicals comprises a scale inhibitor.
10. A system according to claim 1 further comprising a deaerator for removing one or more dissolved gases from the feed water and a temperature sensor downstream of the deaerator for measuring the feed water temperature, wherein the system is configured to cause the or a further chemical doser to introduce or increase, in use, a quantity or concentration of an oxygen scavenger into the feed water if a temperature measured by the hardness measurement means reaches or is below a predetermined threshold.
11. A system according to claim 1, wherein the system further comprises a blow down sampler for drawing and analysing a water sample from a boiler to which the system is connected in use, the blow down sampler being operable to measure the conductivity of a drawn water sample, the controller or blow down sampler being configured to generate a blow down signal if a measured conductivity reaches a predetermined set point.
12. A system according to claim 11, wherein the or a further chemical doser is configured to introduce, in use, an inert tracer into the feed water, the blow down

sampler being operable to measure the concentration of the tracer within the drawn water sample, the controller or blow down sampler being configured to generate a blow down signal if a measured concentration reaches or is above a predetermined set point.

13. A system according to claim 12, wherein the system or controller or blow down sampler is configured to generate an audible or visible alarm in response to the blow down signal or to send the blow down signal to a remote monitoring system or to initiate a blow down cycle.
14. A method of treating boiler feed water, the method comprising measuring the hardness of water treated by a softener, determining a quantity of water treated by the softener and introducing or increasing a quantity or concentration of one or more treatment chemicals into the feed water if the measured hardness reaches or exceeds a first predetermined threshold and the determined water quantity reaches or is below a second predetermined threshold.
15. A method according to claim 14 further comprising disabling the softener and enabling a further softener if the measured hardness reaches or exceeds the first predetermined threshold and the determined water quantity reaches or is below a third predetermined threshold.
16. A method according to claim 14 comprising measuring the hardness of water treated by the softener at predetermined intervals and generating a hardness alarm signal if the measured hardness of each of a predetermined number of feed water samples drawn and analyzed reaches or exceeds the first predetermined threshold.
17. A method according to claim 14 further comprising measuring a temperature of the feed water downstream of a deaerator and introducing or increasing a quantity or concentration of an oxygen scavenger into the feed water if the measured temperature reaches or is below a predetermined threshold.
18. A method according to claim 14 further comprising introducing an inert tracer into the feed water, drawing and analysing a water sample from the boiler, measuring the

conductivity of the drawn water sample and measuring the concentration of the inert tracer therein and, if either the measured conductivity or concentration reaches a respective predetermined set point, generating an audible or visible alarm or sending a signal to a remote monitoring system or initiating a blow down cycle in response thereto.

19. A computer readable medium having a program stored thereon, where the program is arranged to make a computer execute a procedure to implement a method comprising measuring the hardness of water treated by a softener, determining a quantity of water treated by the softener and introducing or increasing a quantity or concentration of one or more treatment chemicals into the feed water if the measured hardness reaches or exceeds a first predetermined threshold and the determined water quantity reaches or is below a second predetermined threshold.
20. A computer readable medium according to claim 19 incorporated within a controller.

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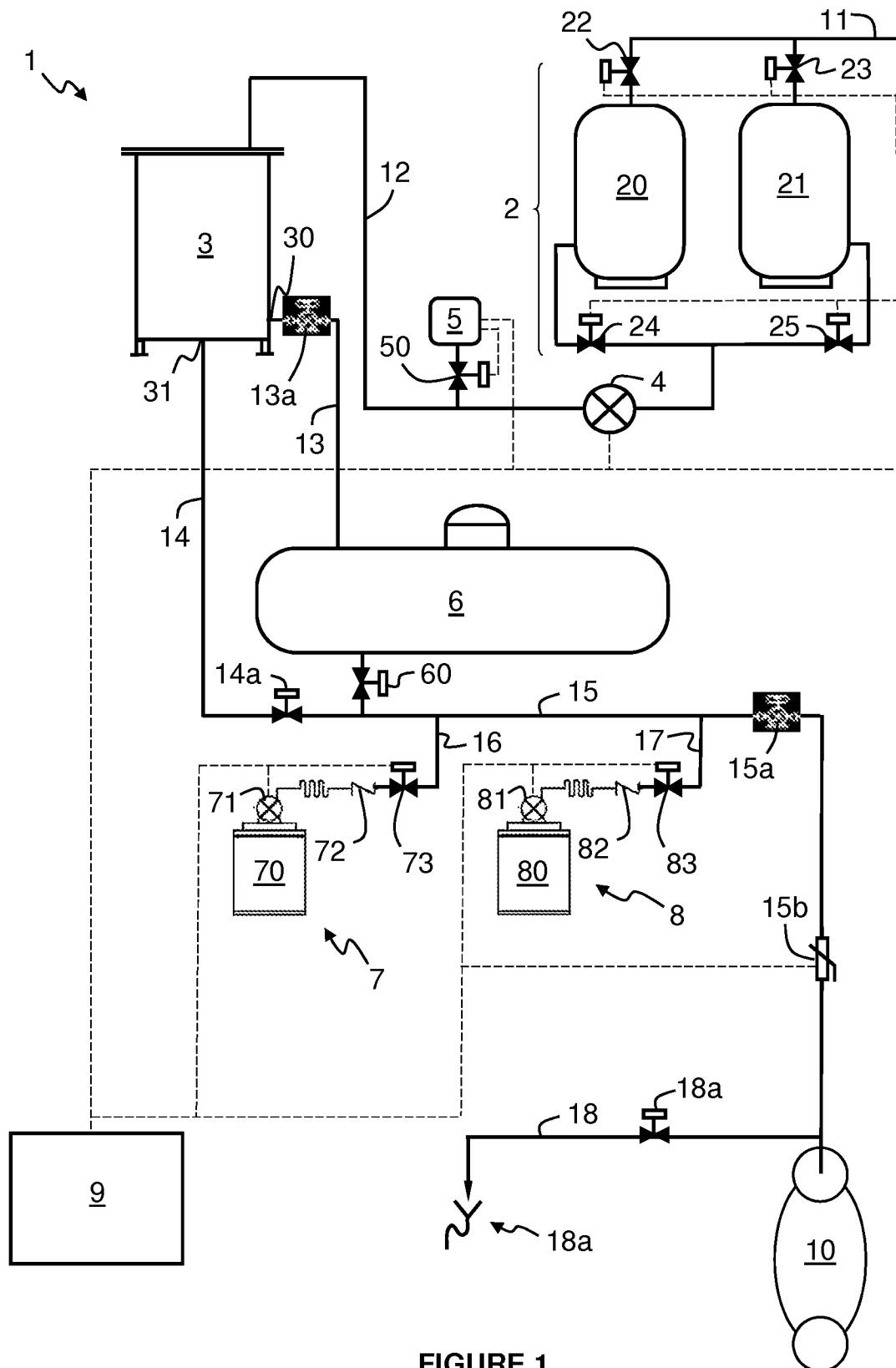


FIGURE 1

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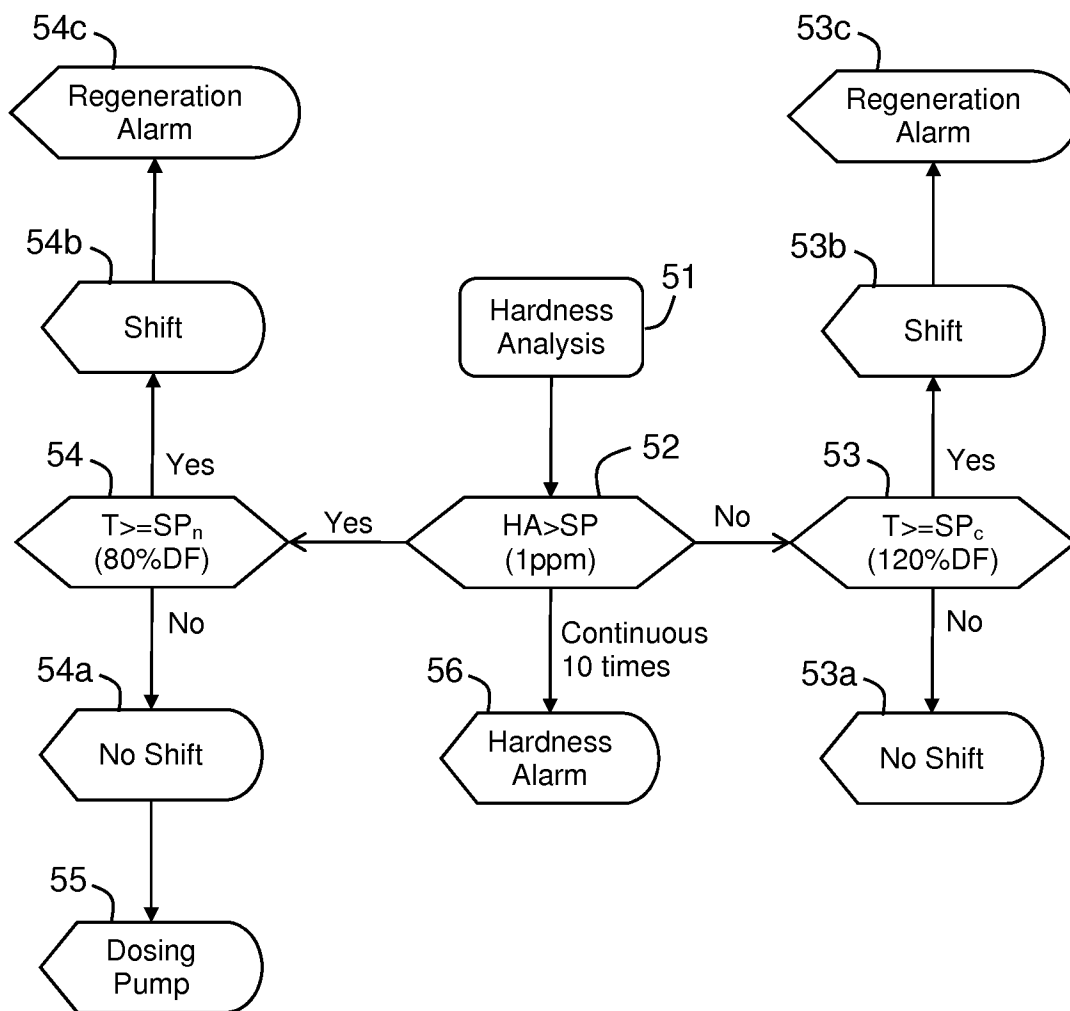


FIGURE 2

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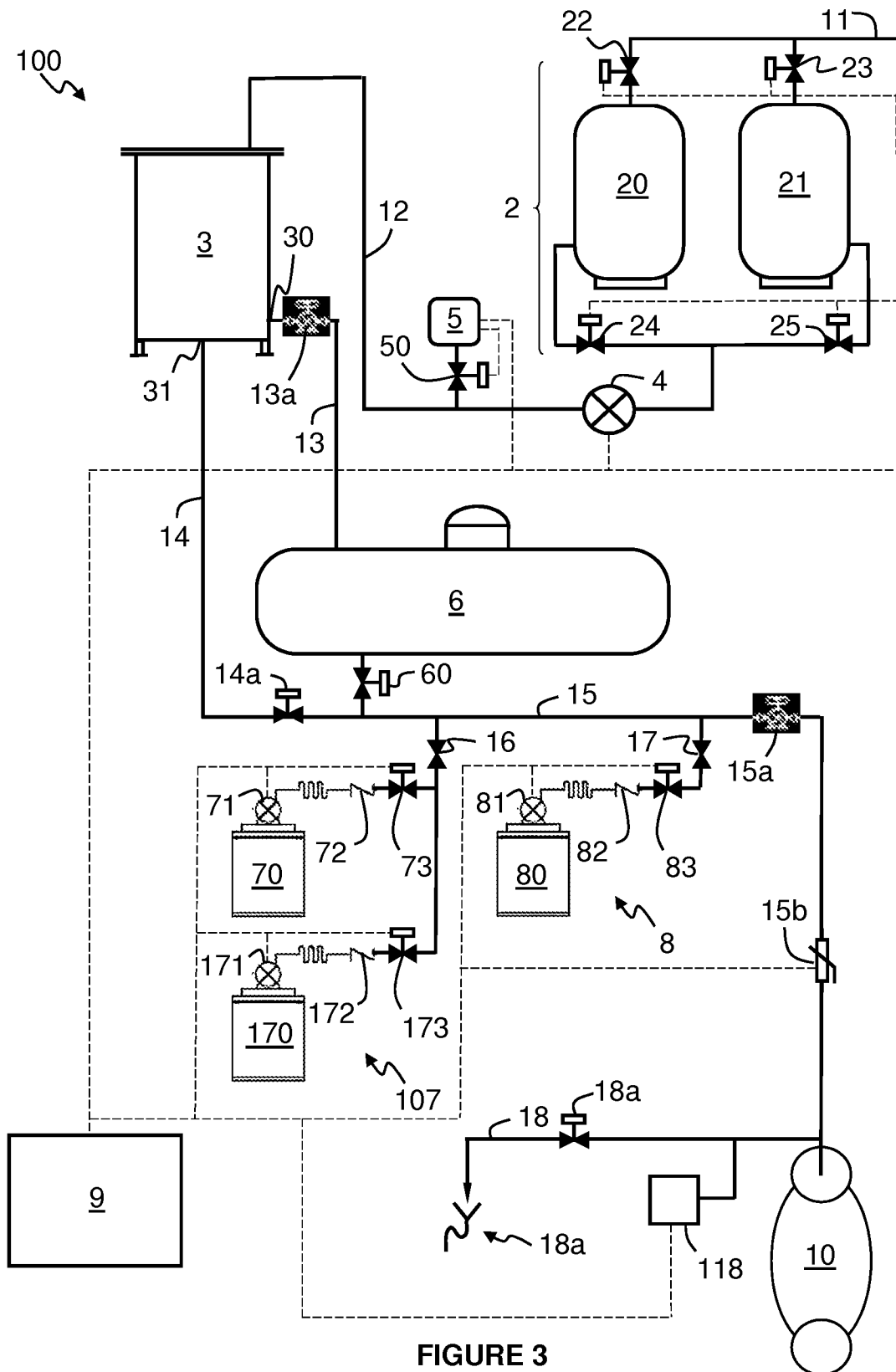
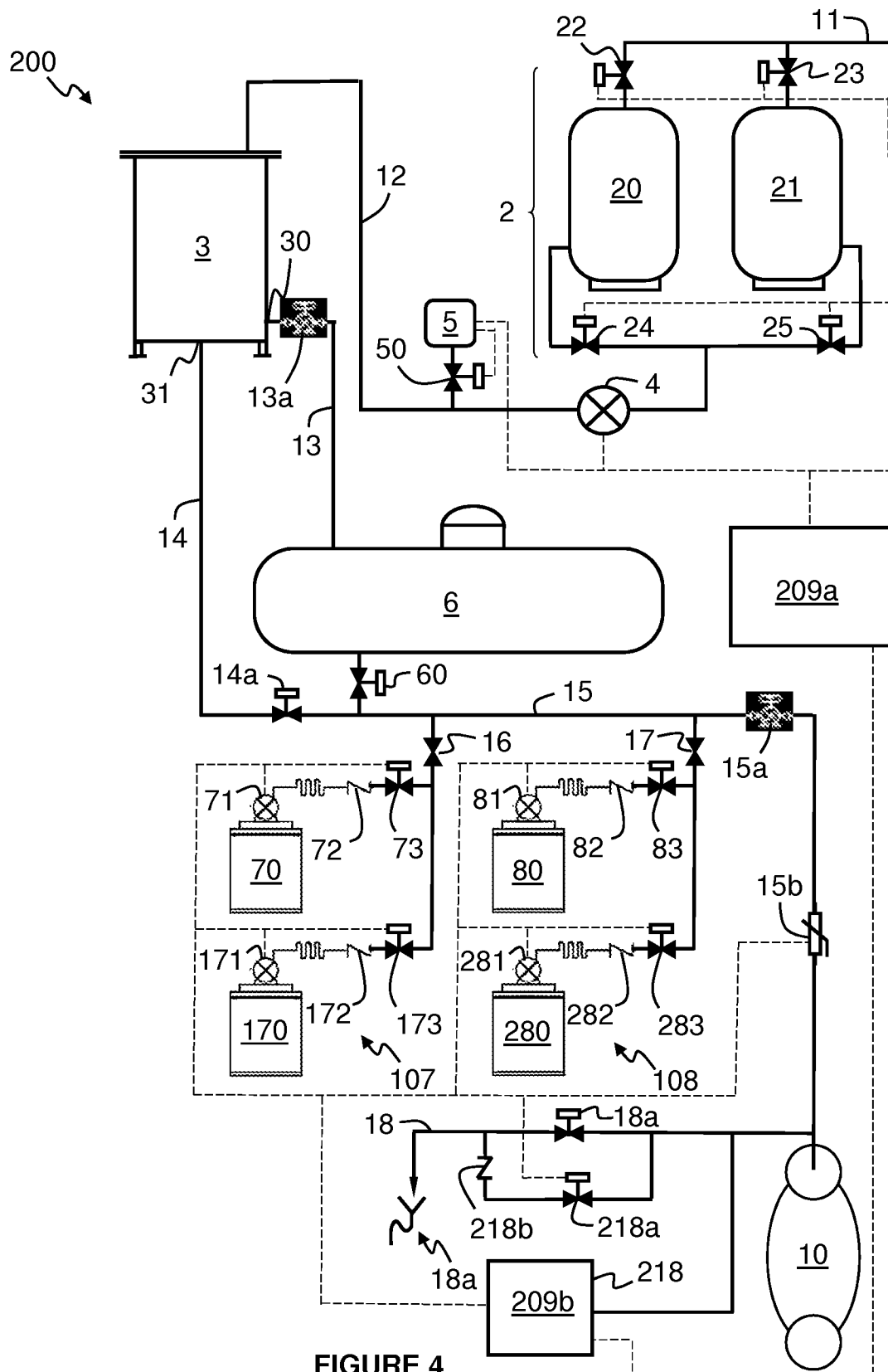


FIGURE 3

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/060500

A. CLASSIFICATION OF SUBJECT MATTER

IPC (2016.01) C02F 5/02, F22B 37/38, F22B 37/42, F22B 37/56, C23F 14/02, G01N 27/27

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC (2016.01) C02F 5/02, F22B 37/38, F22B 37/42, F22B 37/56, C23F 14/02, G01N 27/27

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

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

See extra sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6587753 B2 (FOWEE ROGER W, ; ONDEO NALCO COMPANY) 01 Jul 2003 (2003/07/01) Fig. 1-7; Column 1 line 36 - column 2 line 34, column 3 line 47 - column 4 line 58, column 8 lines 46-63, column 9 lines 1-7, column 10 lines 36-39;	1-20
X	US 5041386 A (NALCO CHEMICAL COMPANY) 20 Aug 1991 (1991/08/20) Fig. 1, 7; Column 2 lines 30-33, column 5 lines 50-66, column 7 lines 38-48, column 8 lines 25-41, column 9 lines 35-60 [Disclosed by the applicant];	1-20
A	JP 2009125641 A (MIURA CO LTD, ; MIURA PROTECH LTD) 11 Jun 2009 (2009/06/11) Fig. 1; paragraphs: 0010, 0013, 0016, 0018, 0020-0026;	1,6,14,15
A	US 2014212978 A1 (FISHER-ROSEMOUNT SYSTEMS, INC) 31 Jul 2014 (2014/07/31) Paragraphs: 0003, 0019, 0033, 0039, 0051, 0052.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

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

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

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

“&” document member of the same patent family

Date of the actual completion of the international search

24 Feb 2016

Date of mailing of the international search report

24 Feb 2016

Name and mailing address of the ISA:

Israel Patent Office

Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel

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Authorized officer

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Telephone No. 972-2-5651722

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/060500

B. FIELDS SEARCHED:

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

Databases consulted: THOMSON INNOVATION, Google Patents

Search terms used: scavenge, absorb, sodium sulfite, Na₂SO₃ deaerator, hard, scale, incrust, encrust, crust, boiler, sediment, soft, treat, inhibit, retard, ion exchange, dose, inject, meter, control, analyze, analyze, monitor, evaluate, sense, signal, alarm, alert, warning, oxygen, flow, volume, quantity, shift, change,

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2015/060500

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Information on patent family members

International application No.
PCT/US2015/060500

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		JP 2014146334 A	14 Aug 2014