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(54) **Titre : PROCEDE INFORMATISE DE SURVEILLANCE DES PERFORMANCES D'UNE MEMBRANE D'OSMOSE INVERSEE**
(54) **Title: A COMPUTER-IMPLEMENTED METHOD OF MONITORING THE PERFORMANCE OF A REVERSE OSMOSIS MEMBRANE**

(57) **Abrégé/Abstract:**
A computer-implemented method of monitoring the performance of a reverse osmosis membrane in a drinking water supply system is provided. The method is carried out by a microcontroller wherein a computer program resides. Functional steps of the method encompass: initiating a reverse osmosis membrane recalibration; determining the flow of a predetermined amount of water through the system; measuring the downstream initial water conductivity; calculating, using the measured initial water conductivity, a threshold trip point which corresponds to a predetermined total dissolved solids rejection ratio; determining whether the product water conductivity is below the threshold trip point; and indicating when the product water conductivity is below the threshold trip point.

ABSTRACT

A computer-implemented method of monitoring the performance of a reverse osmosis membrane in a drinking water supply system is provided. The method is carried out by a microcontroller wherein a computer program resides. Functional steps of the method encompass: initiating a reverse osmosis membrane recalibration; determining the flow of a predetermined amount of water through the system; measuring the downstream initial water conductivity; calculating, using the measured initial water conductivity, a threshold trip point which corresponds to a predetermined total dissolved solids rejection ratio; determining whether the product water conductivity is below the threshold trip point; and indicating when the product water conductivity is below the threshold trip point.

A COMPUTER-IMPLEMENTED METHOD OF MONITORING THE PERFORMANCE OF A REVERSE OSMOSIS MEMBRANE

FIELD OF INVENTION

The present invention relates to water treatment systems and, in particular, to such systems having an encapsulated manifold head and a reverse osmosis cartridge and one or more filter cartridges.

BACKGROUND OF THE INVENTION

Reverse osmosis systems are known. The main part of the system is a semipermeable membrane through which the untreated water passes. Such systems typically include an additional carbon or ceramic filter which removes contaminates either prior to passing through the membrane or after. Such systems are often installed in residential applications.

The prior art includes electronic systems which detect when the reverse osmosis membrane requires replacement. Typical prior art systems include measuring the conductivity of the water entering the reverse osmosis cartridge, and then measuring the conductivity of the water at the outlet of the reverse osmosis cartridge. The conductivity of the water is proportional to the total dissolved solids. A ratio of the conductivity levels will provide an indication of the rejection efficiency of the reverse osmosis membrane.

Prior art systems also include an application wherein a permeate pump is included in a factory installation. The permeate pump provides greater efficiency in the system. The permeate pump increases the net pressure across the reverse osmosis membrane by isolating the membrane pressure from the pressure in the products water and thus reducing the permeate back pressure.

The prior art also includes systems which address reducing the spillage of fluid occurring during replacement of the cartridges.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved locking mechanism for a filter cartridge and manifold head.

It is a further object of the present invention to provide an improved method of monitoring the performance of a reverse osmosis membrane in a drinking water supply system.

It is further object of the present invention to provide a modular manifold head system.

It is an object of the present invention to provide a system for retrofitting a reverse osmosis filter system to include a permeate pump application.

It is an object of the present invention to provide a cartridge which has a reduced inlet opening to reduce spillage during changing of the cartridge.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a water treatment system with a reverse osmosis cartridge and two filter cartridges.

Fig. 2 is a perspective view of a filter cartridge of Fig. 1.

Fig. 3 is a top view of the filter cartridge of Fig. 2.

Fig. 4 is an exploded view of the filter cartridge of Fig. 2.

Fig. 5 is a bottom perspective view of a manifold head incorporated in the water treatment system of Fig. 1.

Fig. 6 is a block diagram of a reverse osmosis membrane monitoring system.

Fig. 7 is a process flow chart for the system of Fig. 6.

Fig. 8 is a perspective view of a modular manifold head system.

Fig. 9 is top perspective view of a modular manifold head.

Fig. 9A is a detailed view of the flange of Fig. 9.

Fig. 10 is a schematic diagram of a reverse osmosis water treatment system with a permeate pump.

Fig. 11 is a cross-sectional view of the modular manifold head and cartridges of Fig. 1.

Fig. 12 is a top perspective view of a modular manifold head in a permeate pump application.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 shows one embodiment of a water treatment system 10 in accordance with the present invention. The system includes a manifold head 12, (see Fig. 5) a first filter cartridge 14, a reverse osmosis cartridge 16 and a second filter cartridge 14. A manifold cover 20 is also shown.

Fig. 2 shows a filter cartridge 14 in accordance with the present invention. The filter cartridge 14 includes a housing 22 having an outer annular collar 24 with a double lead thread 26. An inner annular collar 28 is also shown which includes an O ring 30 to provide a seal. A connection fitting 32 is shown extending through the annular collar 28.

Fig. 3 shows a top view of the filter cartridge 14 and shows the cylindrical wall 34 of the inner annular collar 28, as well as the longitudinal extending bead 36.

Fig. 4 shows the filter cartridge 14 in an exploded view so as to more clearly show the longitudinal extending bead 36. It can be seen that the longitudinal extending bead 36 includes a leading end 38.

Fig. 5 shows the manifold head 12 having the filter cartridge connection fitting 40. The filter cartridge connection fitting 40 includes a threaded outer annular collar 42 and an inner annular collar 44. The inner annular collar 44 having an annular lip 46 and four longitudinal slots 48. The longitudinal slots 48 are equally spaced apart from one another.

It will be appreciated that when the filter cartridge 14 is rotated into a fully secured position onto the connection fitting 40, the filter cartridge 14 comes to rest with the longitudinal extending beads 36 being received by the respective slot 48.

Fig. 6 shows a block diagram of a system 50 for monitoring the performance of a reverse osmosis membrane. The system 50 includes a microcontroller 52 having a memory 54 wherein a program resides. The system 50 includes a single probe set 58 which is located downstream of the reverse osmosis membrane. The probe set 58 includes a reference resistor 60 and a thermal resistor 62. The microcontroller 52 is coupled to a faucet LED 64 for providing an indication to replace the reverse osmosis cartridge. The microcontroller 52 is also coupled to an onboard LED 66 for feedback during operation of an onboard push button 68 also coupled to the microcontroller 52. A water flow sensor 70 is also coupled to the microcontroller 52.

Fig. 7 shows a block diagram 72 which represents the functional steps as executed by the program resident in the memory 54.

Step 74 provides the initiate recalibration routine. The initiate recalibration routine occurs after the reverse osmosis membrane has been replaced and after a power on routine occurs. At step 76, the system measures the flow of water through the system. At step 78, the system determines or detects the flow of fifteen gallons of water through the system. At step 80, the system measures the initial water conductivity downstream of the reverse osmosis membrane. In one embodiment, step 80 the initial product water conductivity value is based on averaging approximately 10-50 water conductivity measurements. At step 82, the product water conductivity value or average conductivity is assumed to equal a 90% rejection. Step 82 then calculates a threshold trip point based on 75% rejection. Step 84 stores the threshold trip point. Step 86 consists of routinely measuring the product water conductivity value. Step 88 consists of averaging the previous twenty measurements of the water conductivity. At Step 90, it is determined whether the average of step 88 is below the threshold trip point of step 84. In the event the average is below the threshold trip point, the system proceeds to step 92 which provides an LED indication to replace the reverse osmosis membrane.

Figure 8 is an embodiment of a modular water treatment system 94. The water treatment system 94 shown in Fig. 8 includes a modular manifold head 96, a manifold cover 98, a first filter cartridge 100, a reverse osmosis cartridge 102 and a second filter cartridge 100. Also shown is a further modular manifold head 104 and cover 106, as well as an additional cartridge unit 108. The system of Fig. 8 provides a modular system wherein additional modular manifold units 104, 106, 108 may be coupled to the water treatment system 94 via a clip 110. The clip 110 includes a plurality of arms 112 extending from a planar body portion 114. Each arm 112 includes a slot 116 and a slanted leading edge 118. The clip 110 also includes a tubular portion 120 extending through the main body portion 114. The tubular portion 120 includes a bore 122 extending throughout the tubular portion 120.

Each manifold 12, 96, 104 includes an end wall 124 having four openings 126.

Fig. 9 shows a perspective view of the manifold 12 including the two end walls 124 each having four openings 126. The openings 126 are arranged in pairs, one above the other. For example, lower opening 126 and upper opening 126 comprise one pair. Each pair of openings 126 includes a pair of upright walls 130 in a spaced apart facing relationship. The upright walls 130 are shown extending from the interior surface 132 of the end wall 124 and the lower surface 134 of the manifold head 12. A flange 136 extends from the inner surface 132 of the end wall 124 towards the interior compartment of the manifold head 12. The flange 136 includes an upper ramp 138 and a lower ramp 140. The flange 136 includes a forward edge 142 and first and second side edges 144, 146. The forward edge 142 is generally parallel to the end wall 124. The first side edge 144 and second side edge 146 form the upper ramp and lower ramp 138, 140. The upper ramp 138 and lower ramp 140 diverge from one another in a direction away from the inner interior surface 132 towards the interior compartment of the manifold head 12. One of the four flanges 136 is shown in phantom in Fig. 9. The ramps 138, 140 include a proximal end 148 and a distal end 150. The proximal end 148 is located slightly away from the edge of the opening 126. The distal end 150 is spaced in an interference relationship regarding alignment of the opening 126. Fig. 9A shows additional detail.

With reference to Fig. 8, it will be appreciated that as the clip 110 is inserted into the openings 126 of the manifold head 96 to the right of the figure, the slanted edge 118 of each of the resilient arms 112 will be deflected by the respective ramp 138, 140. Once the clip 110 is fully inserted through the four openings 126, the slot 116 will extend past the distal end 150 and the two arm pairs will clamp about the respective distal end 150 with the edge of the slot 116 coming into locking engagement with the distal end 150 of the ramp 138, 140. Meanwhile, the tubular portion 120 will be received by the tube fitting connector 152 for sealing engagement. The other modular manifold head 104 will be coupled in similar manner.

Fig. 10 shows a graphical representation of a water treatment system 160 wherein an automatic shut-off valve cover 162 (see Figs. 5 and 9) may be removed and replaced with another cover 164 adapted to accommodate a permeate pump application. With reference to Fig. 11, a cross-section of a water treatment system is shown including the modular manifold head 12, first cartridge 14, reverse osmosis cartridge 16 and second filter cartridge 14. The manifold head 12 is shown to include a connection fitting 166 for receiving the respective connection fitting 168 of the reverse osmosis cartridge 16. The manifold head 12 includes a first manifold access port 170 for coupling to an output of a reverse osmosis cartridge 16, a second manifold access port 172 coupled to an output of a reverse osmosis stage. A non-permeate pump cover 162 is adapted to seal the first and second access ports 170, 172 for a non-permeate pump application. A permeate pump cover 164 is adapted to also seal the first and second access ports 170, 172 and includes a permeate pump output port 174 which receives a tube fitting connector 175. The permeate pump cover 164 includes a first access and a second access port 176, 178 and a flow channel 180 in communication with the first and second access ports, as well as the permeate pump output port 174. A check valve assembly is located in the first access port 176 for coupling the output of the reverse osmosis cartridge 16. The second cover 164 includes a substantially planer body portion 184 which defines a first end and a second end. Mounting holes 186 are provided for fastening the cover to the manifold head.

The manifold includes a lower diaphragm receptacle portion 188 having an opened upper portion. The second cover 164 includes an upper diaphragm receptacle portion 190 for mating with the opened upper portion to form a diaphragm cavity which receives a diaphragm. The upper diaphragm receptacle portion 190 includes an opening 192 in fluid communication with the fluid channel 180. The manifold head includes a flow channel coupled to an output port of a pre-filter stage and an input port of the reverse osmosis stage, wherein the flow channel is in fluid communication with the lower diaphragm receptacle portion 188 of the manifold head. It will appreciated that the water treatment system may be assembled at the factory with a non-permeate pump cover 162, wherein the plug 194 is provided at the permeate pump output port 174. A retrofit kit may be provided wherein the first cover 162 is removed and replaced with the second cover 164 having the tube fitting connector 175. A quarter inch tubing 196 may then be coupled to the tube fitting connector 175 and extend through a routing hole 198 as shown in Fig. 12. The tubing 196 extends downward and to a permeate pump 200 as shown in Fig. 10. The permeate pump 200 has a permeate outport 202 having a tubing 204 which runs to a T-connector 206. The T-connector 206 has a further tubing 208 coupled to a storage tank 210, as well a tubing 212 coupled back to the manifold head. The brine side of the permeate pump includes a brine in 214 from the drain flow 216 of the manifold head and a brine out tubing 218 which couples to the drain point. For sake of completeness, the tubing 220 is also shown coming from the supply inlet and tubing 222 is shown going to the faucet.

The installation kit includes at a minimum the second cover 164 and further may include a replacement check valve, as well replacement O rings, tubing, fasteners and installation instructions.

Fig. 11 also shows the filter cartridge 14 having a reduced gap at the connection fitting 32 in order to minimize spillage during changing of the filter cartridge. The novel features of the filter cartridge are explained below. However, it will be apparent that the features can be incorporated into the reverse osmosis cartridge as well.

The filter cartridge 14 includes external cartridge housing 22 having a cylindrical portion with a top portion and a bottom portion. The bottom portion has a closed end. The top portion includes a shoulder 250 having a generally cylindrical neck portion 252 extending upward from the shoulder 250. The cylindrical neck portion 252 defines a portion of a connection fitting. The cylindrical neck portion 252 defines a cylindrical bore having a cylindrical bore wall which defines a first diameter. The cylindrical bore wall includes an annular ring 254 protruding from the wall and defining a second diameter which is smaller than the first diameter. An internal cartridge housing 256 includes a top portion with a shoulder 258, a tube portion 260 extending upward from the internal shoulder 258, and the tube portion 260 defining an outlet bore. The tube portion 260 defines an outer diameter having a third diameter, wherein the third diameter is smaller than the first and second diameter. The tube portion 260 and the annular ring 254 define a cartridge inlet having an annular gap. It will be appreciated that the annular gap is minimized by this design and thereby reduces the likelihood of spillage. The manifold head is adapted to conform with the filter cartridge 14. In particular, the manifold head includes a connection fitting 40 which includes an internal annular collar having a length defined such that when the cartridge 14 is assembled to the manifold, the internal annular collar extends around the tube portion 260 and up to the annular ring, with a minimum spacing for tolerance.

Claims:

1. A computer-implemented method of monitoring the performance of a reverse osmosis membrane in a drinking water supply system, the method carried out by a computer program, the method comprising the steps of:

initiating a reverse osmosis membrane recalibration;

determining the flow of a predetermined amount of water through the system by measuring the flow rate;

measuring the initial water conductivity downstream of the reverse osmosis membrane;

calculating, using the measured initial water conductivity, a threshold trip point which corresponds to a predetermined total dissolved solids rejection ratio, wherein calculating said threshold trip point includes:

measuring initial product water conductivity values by averaging a range of substantially 10 to 50 water conductivity measurements;

equating an average of said initial product water conductivity values to said total dissolved solids rejection ratio; and

calculating said threshold trip point as a percentage of said average; and

storing the threshold trip point in memory of the system;

routinely measuring the product water conductivity downstream of the reverse osmosis membrane;

determining whether the product water conductivity, as routinely measured in the prior step, is below the threshold trip point; and

indicating, by means of an indicator, when the product water conductivity is below the threshold trip point.

2. The method of claim 1, wherein the step of initiating includes a POWER ON routine.

3. The method of claim 1, wherein the step of initiating occurs after the reverse osmosis membrane has been replaced.

4. The method of claim 3, wherein the step of initiating includes sending an initiate recalibration signal to a microcontroller of the system.

5. The method of claim 1, 3, or 4, wherein the step of initiating includes a user activated switch to signal a reverse osmosis membrane change and to initiate a recalibration.

6. The method of claim 1, 3, 4, or 5, wherein the predetermined amount of water is 15 gallons.

7. The method of claim 1, 3, 4, 5, or 6, wherein the step of measuring the water conductivity includes the step of averaging 20 measurements.

8. The method of claim 1, wherein the step of measuring the initial water conductivity downstream of the reverse osmosis membrane and the step of routinely measuring the water conductivity includes measuring product water.

9. The method of any one of claims 1 to 7, wherein the step of calculating includes associating the initial measured water conductivity with an assumed percentage rejection of total dissolved solids.

10. The method of any one of claims 1 to 9, wherein said indicator is a light emitting diode.

11. The method of claim 1, wherein the memory is a nonvolatile memory.

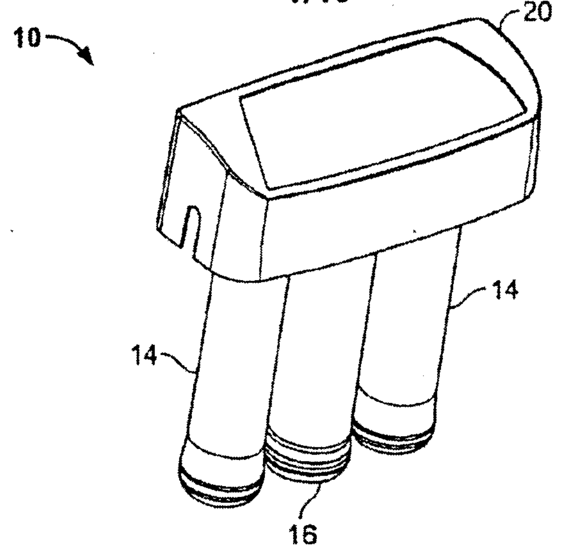


FIG. 1

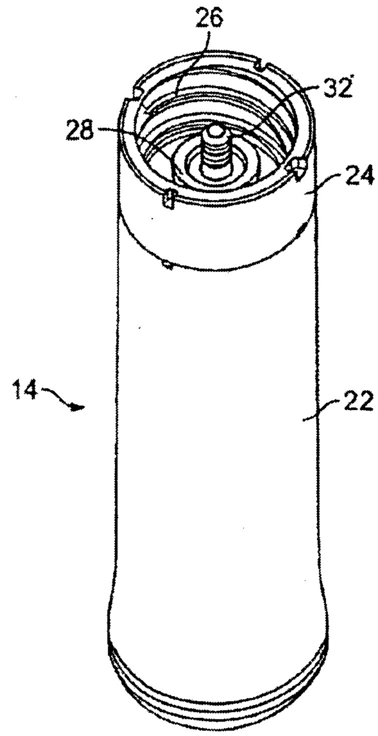


FIG. 2

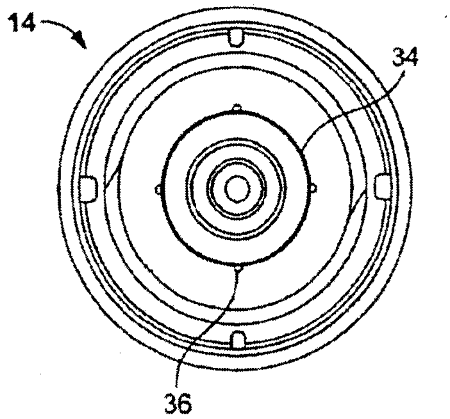


FIG. 3

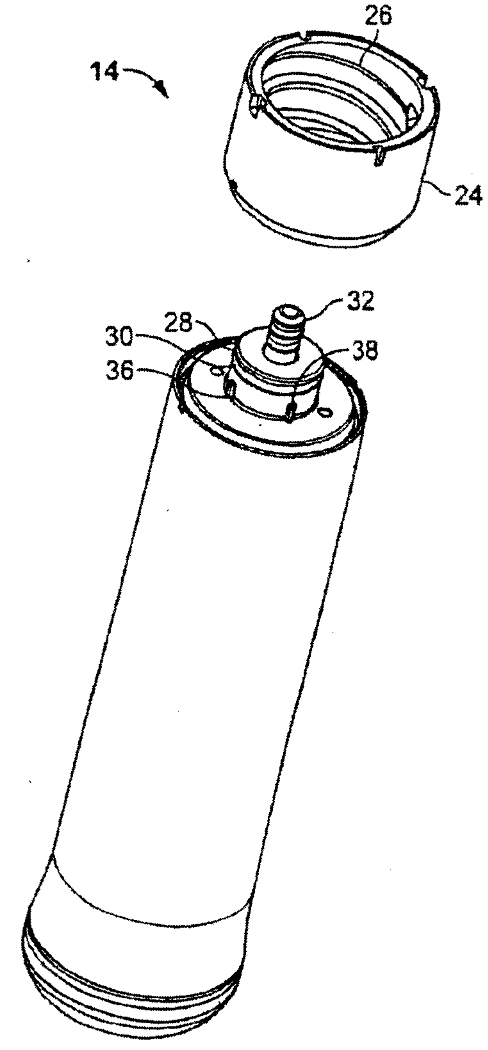


FIG. 4

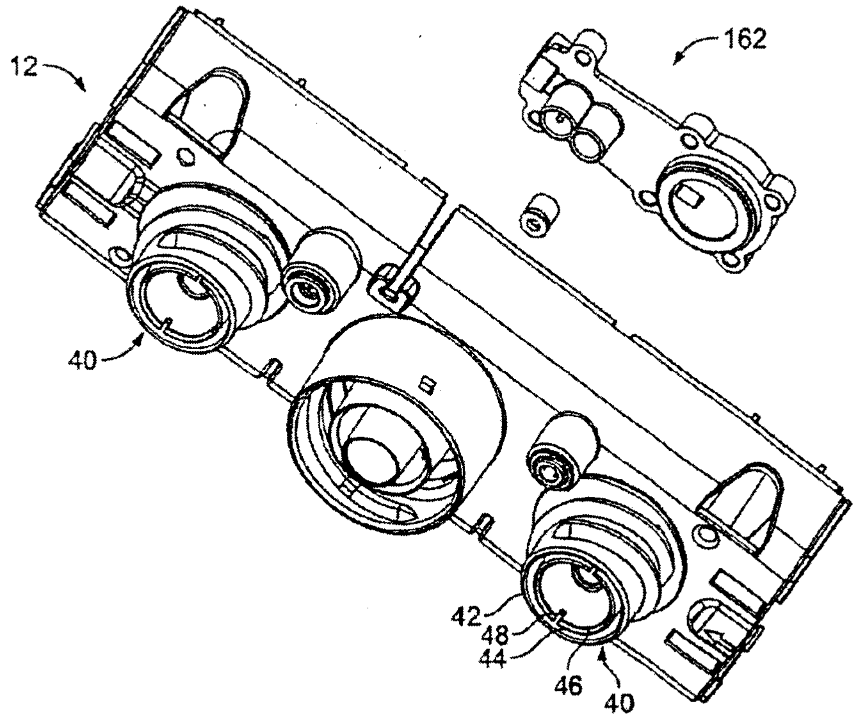


FIG. 5

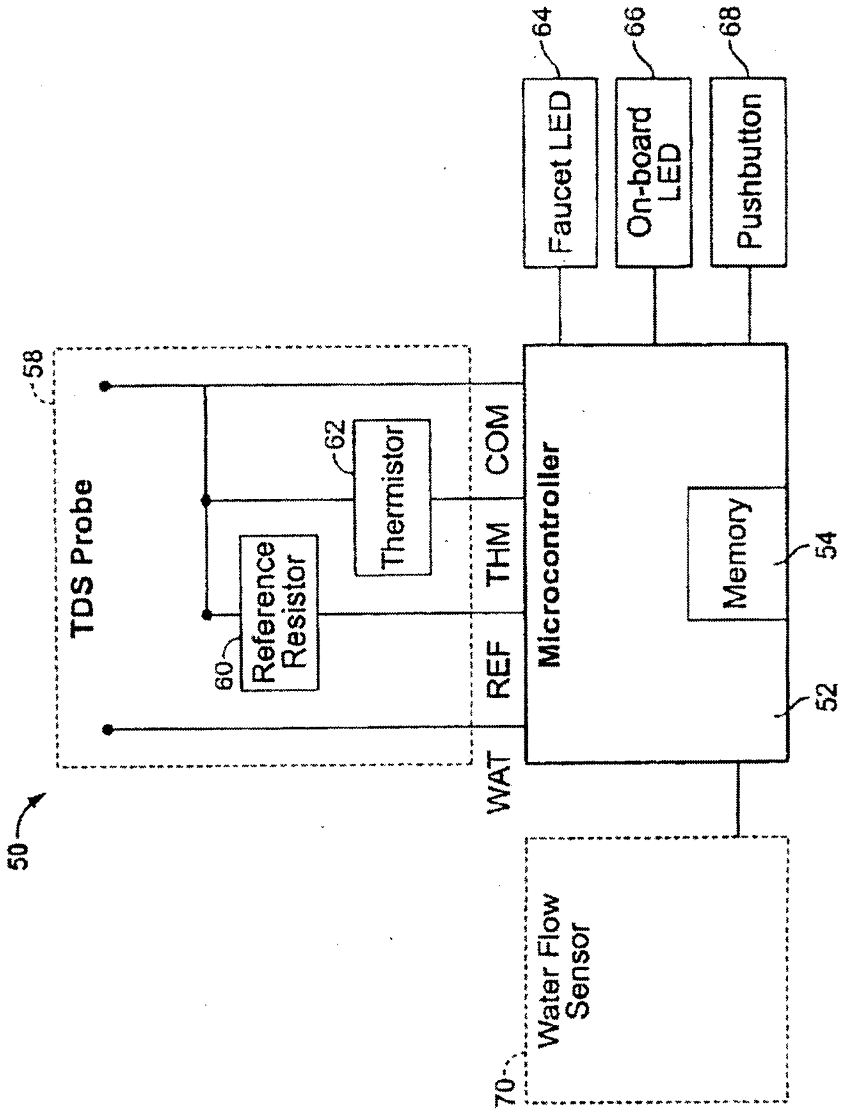

50
58
TDS Probe
60
Reference Resistor
62
Thermistor
WAT
REF
THM
COM
Microcontroller
Memory
54
52
Faucet LED
64
On-board LED
66
Pushbutton
68
Water Flow Sensor
70

FIG. 6

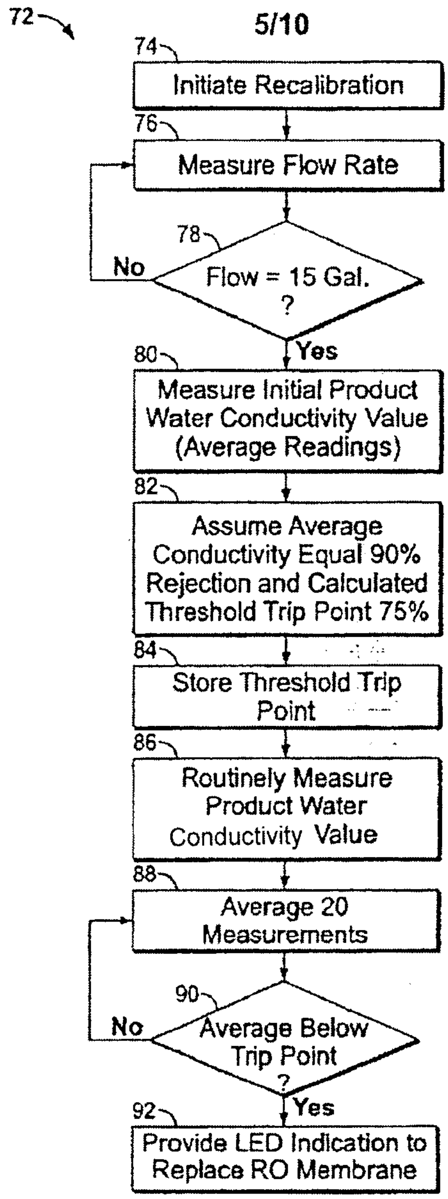
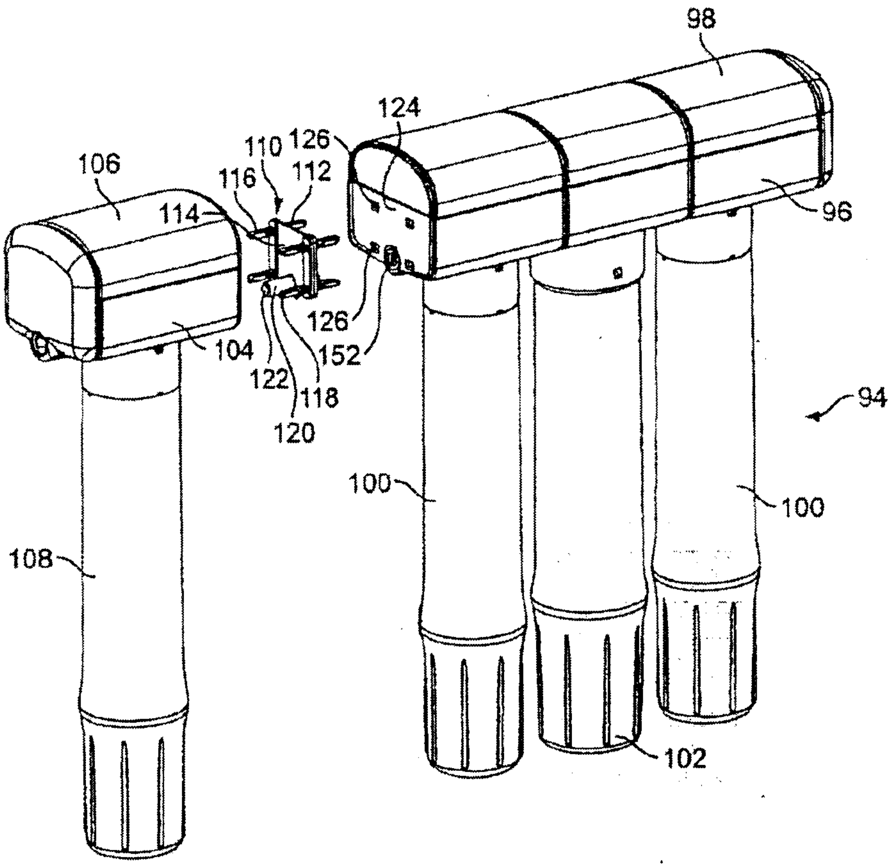

72
74
Initiate Recalibration
76
Measure Flow Rate
78
No
Flow = 15 Gal.
?
Yes
80
Measure Initial Product
Water Conductivity Value
(Average Readings)
82
Assume Average
Conductivity Equal 90%
Rejection and Calculated
Threshold Trip Point 75%
84
Store Threshold Trip
Point
86
Routinely Measure
Product Water
Conductivity Value
88
Average 20
Measurements
90
No
Average Below
Trip Point
?
Yes
92
Provide LED Indication to
Replace RO Membrane

FIG. 7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94
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100
108
102

FIG. 8

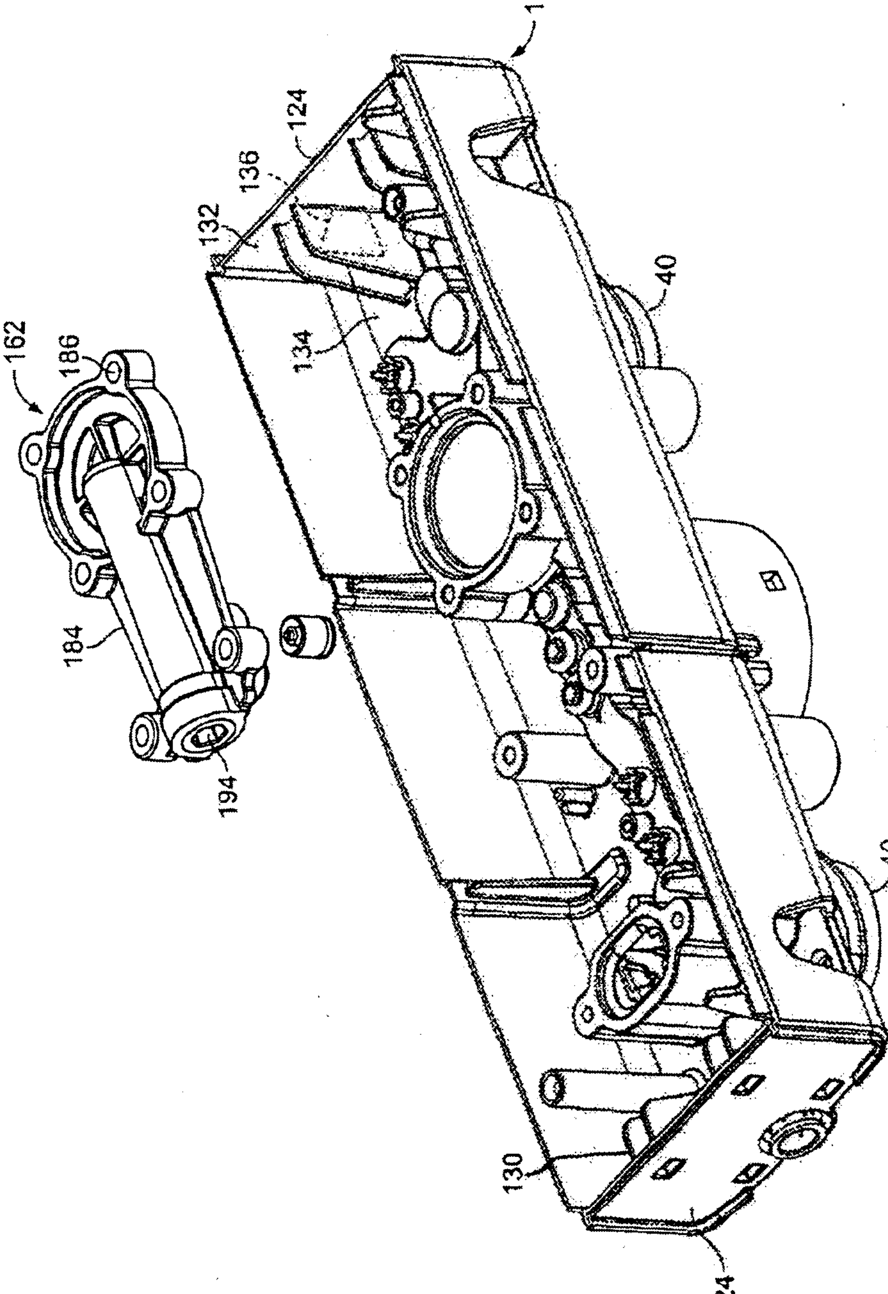
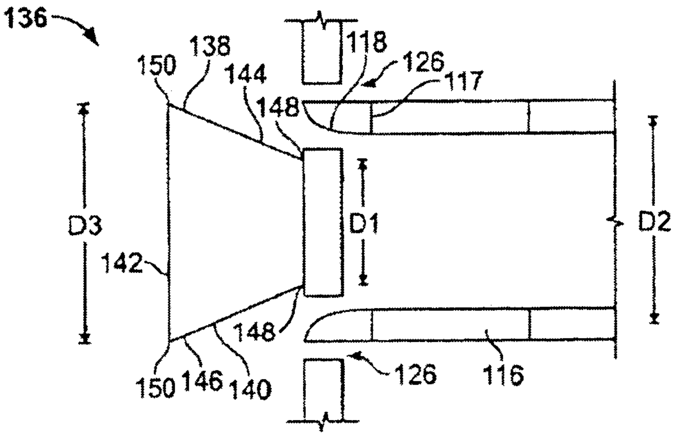


FIG. 9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138
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118
126
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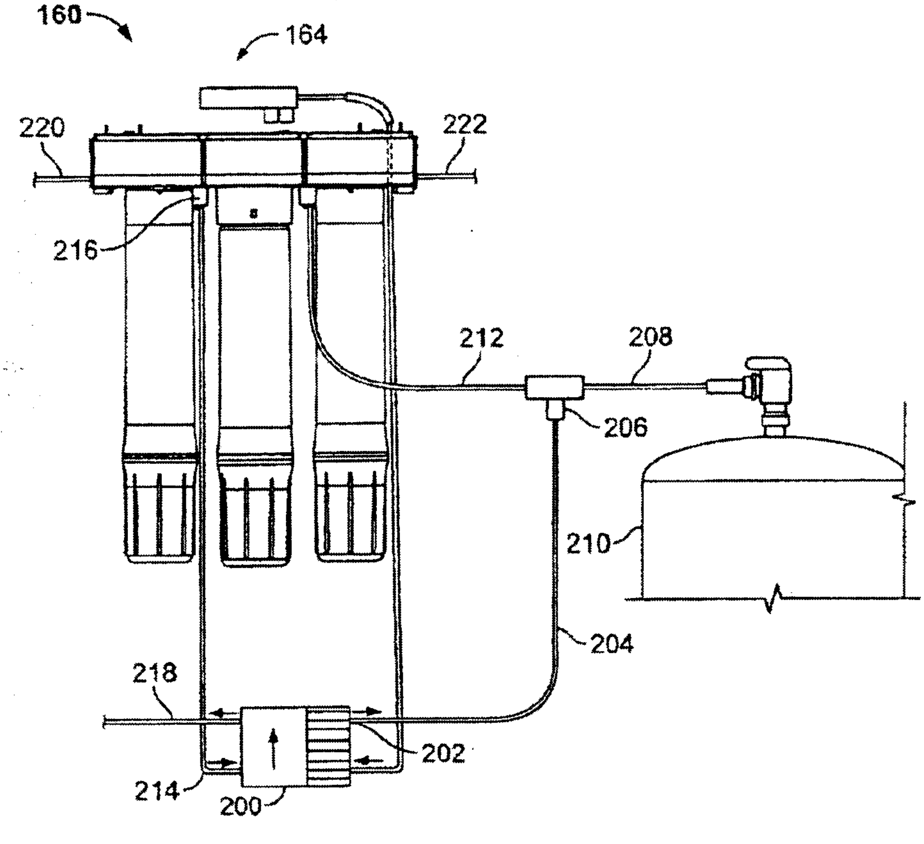
D3
D1
D2
142
148
150
146
140
126
116

FIG. 9A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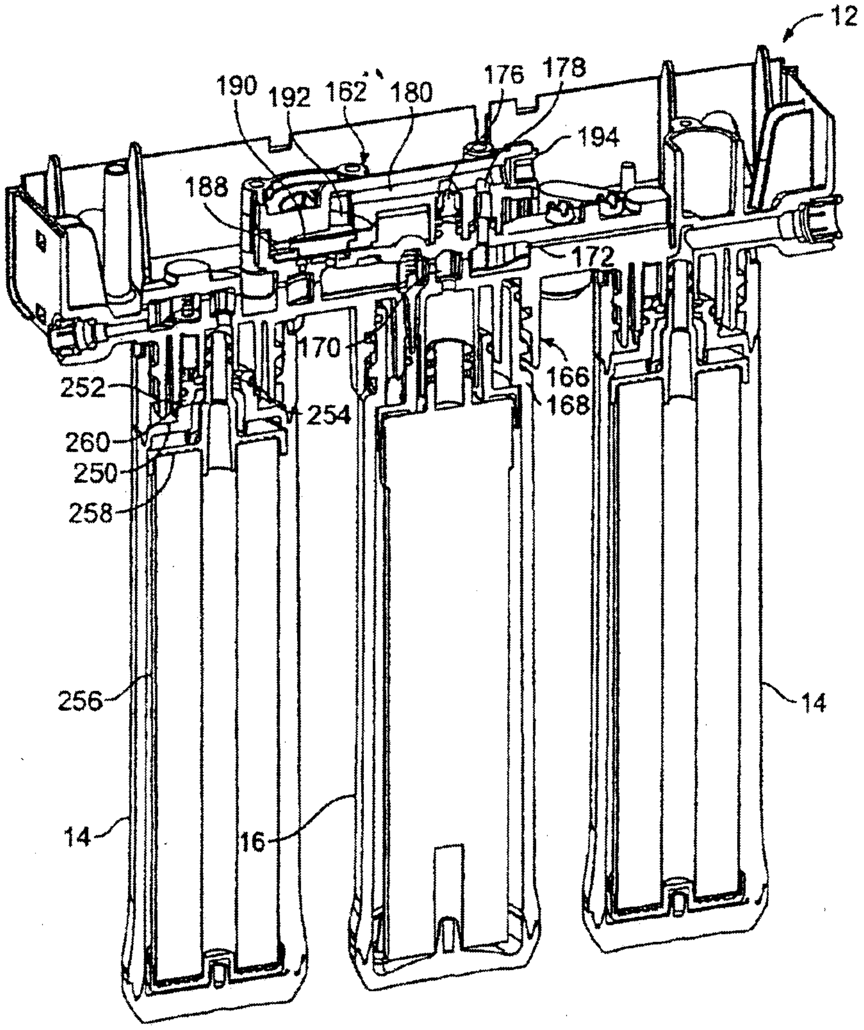
214
200

FIG. 10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190
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166
168
252
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250
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14
16
14

FIG. 11

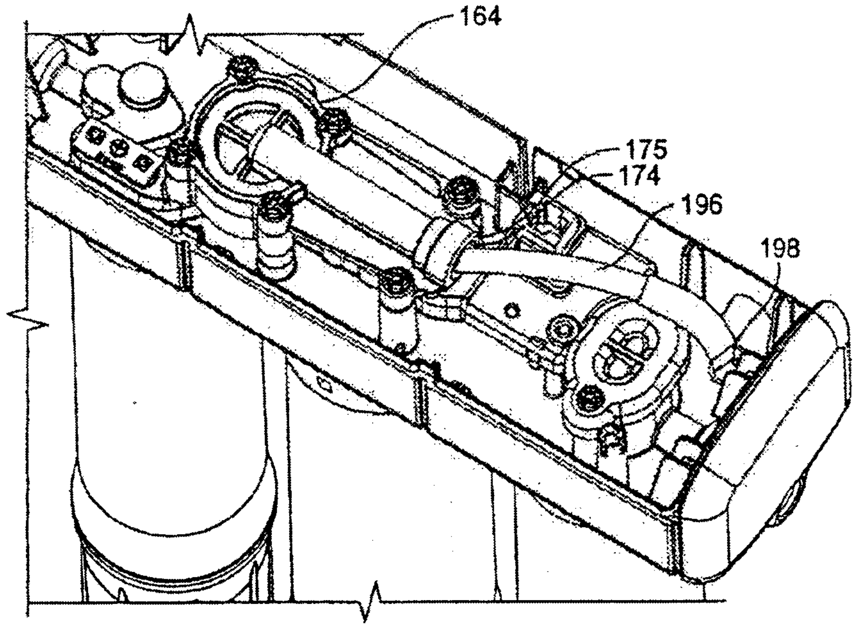

FIG. 12