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(54) **METHODS AND APPARATUS FOR COOLING FLUID**

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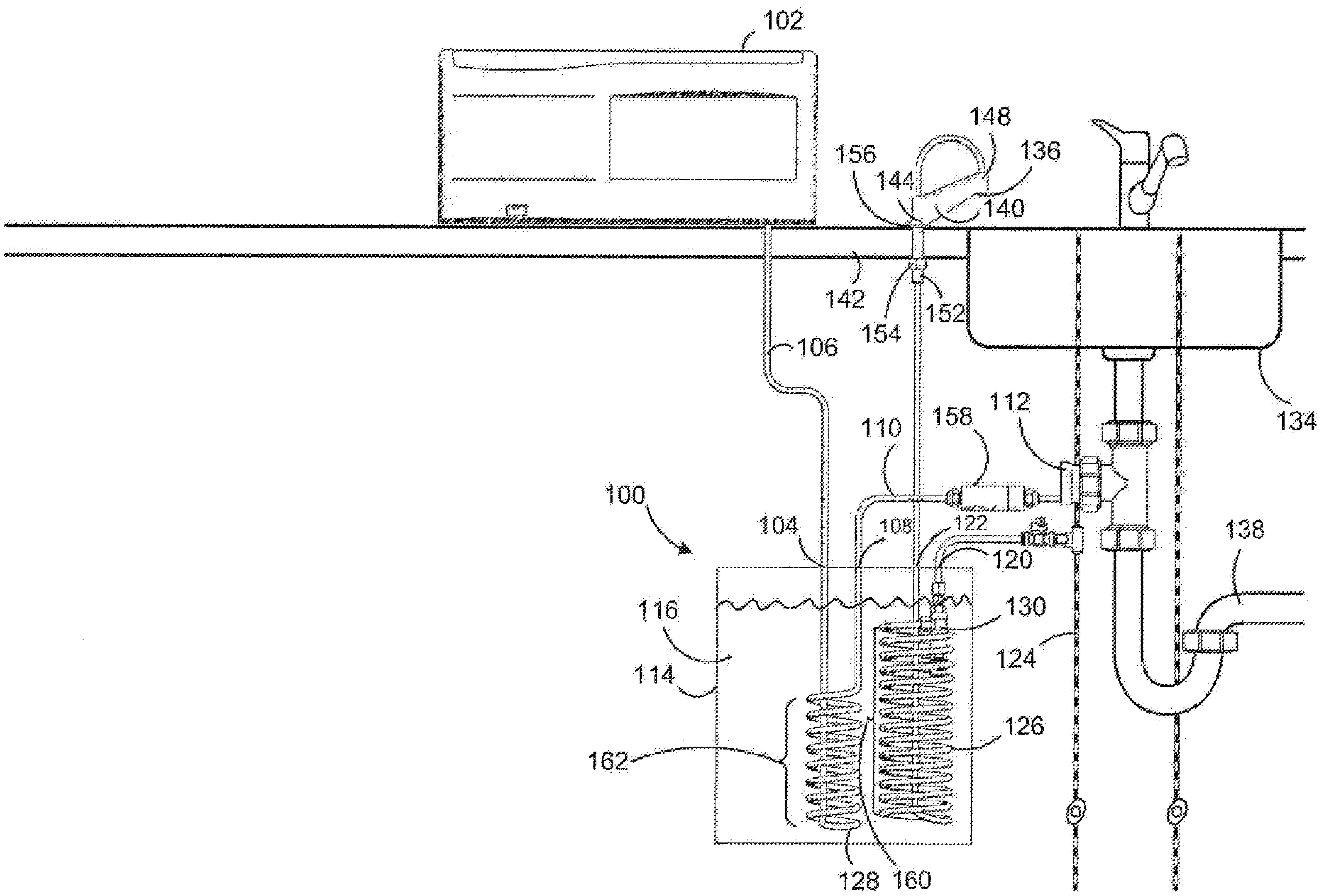
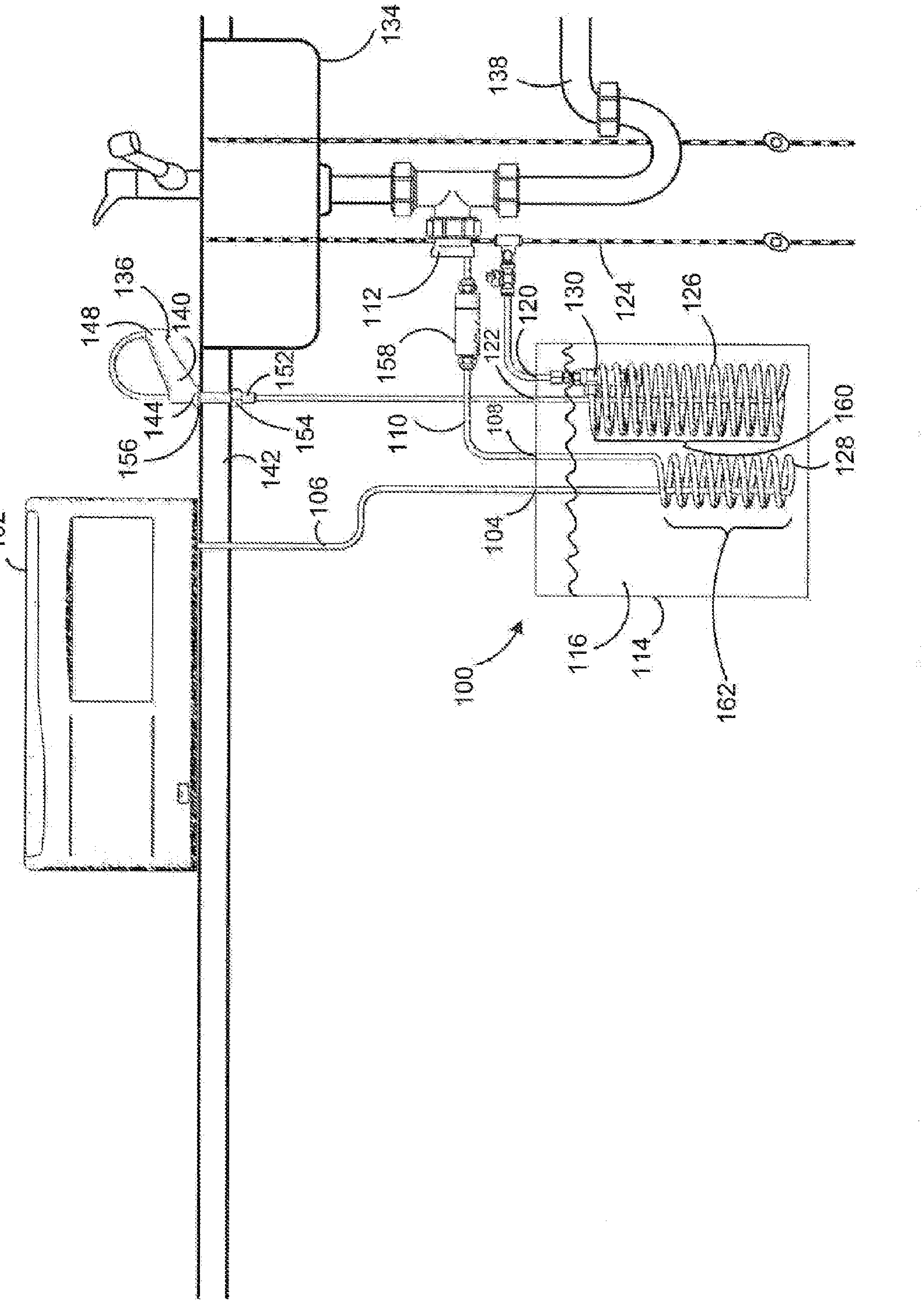
(57) **ABSTRACT**

A fluid cooler, fluid cooler core and method of condensing gas is disclosed. The fluid cooler includes a container for a liquid transfer medium. The container includes first and second hot fluid inlets, first and second cooled liquid outlets, a cooling liquid inlet, and a cooling liquid outlet. A first conduit extends within the container and fluidly couples the first hot fluid inlet to the first cooled liquid outlet. A second conduit extends within the container and fluidly couples the second hot fluid inlet to the second cooled liquid outlet. A third conduit extends within the container and fluidly couples the cooling liquid inlet to the cooling liquid outlet. The first, second, and third conduits are positioned to be at least partially submerged in the liquid transfer medium when the container contains the liquid transfer medium.

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148
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104
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100
116
114
162

FIG. 1

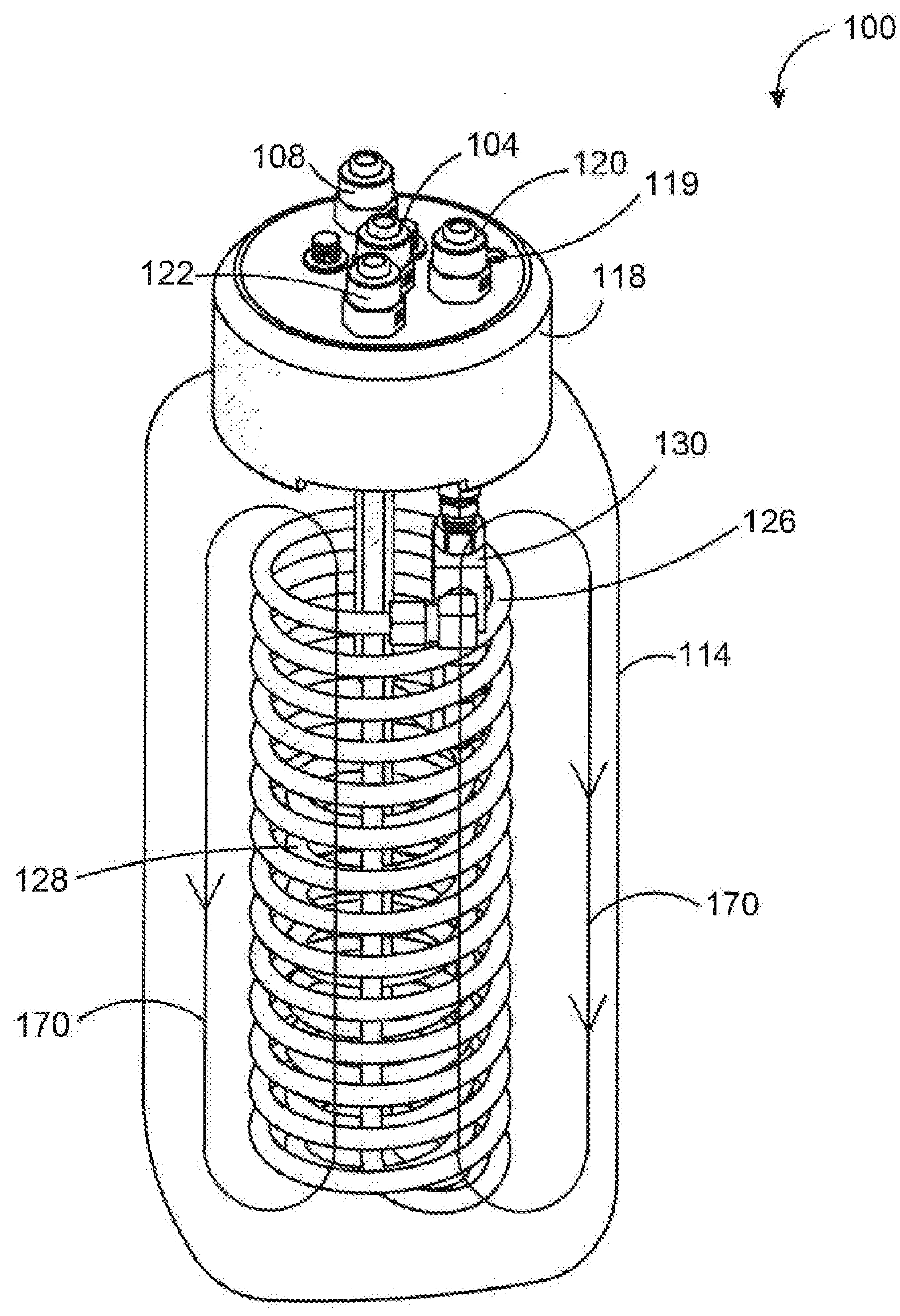
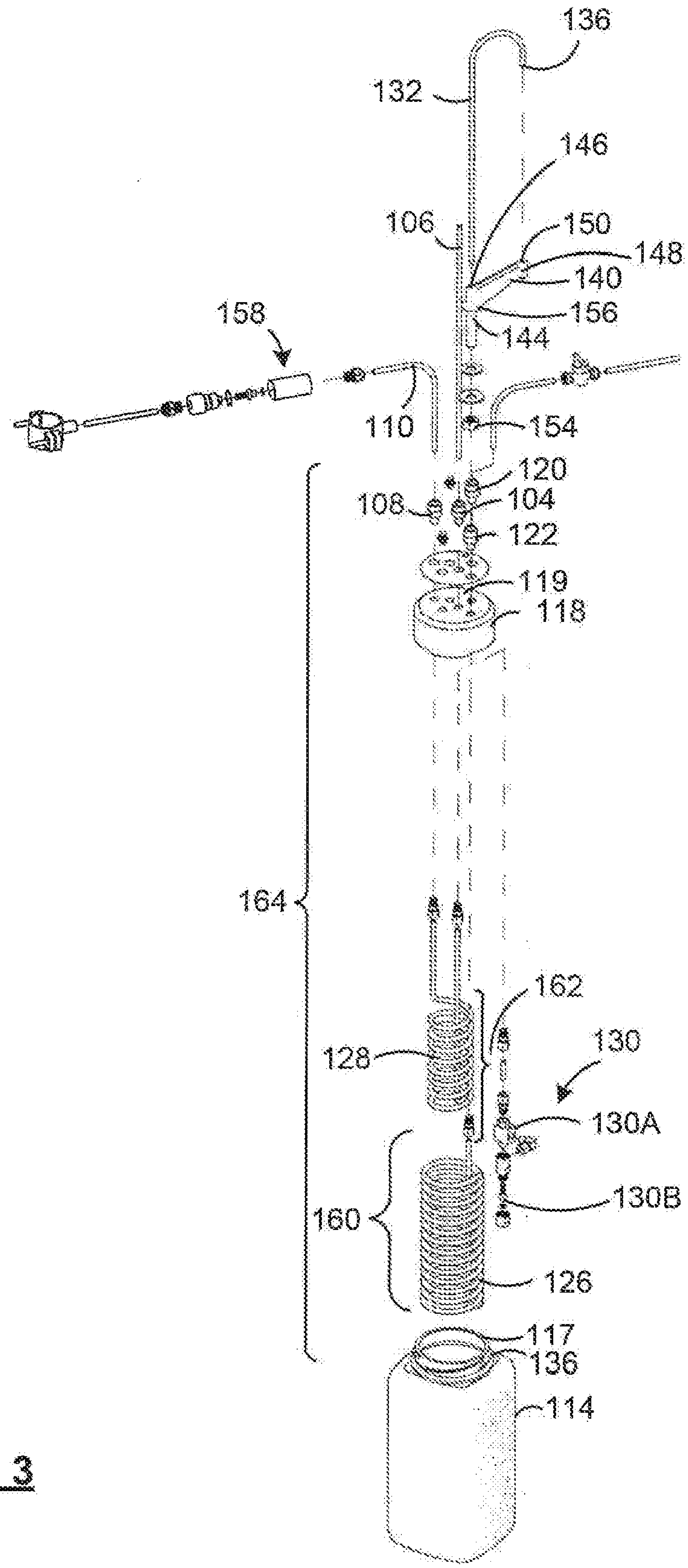


FIG. 2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132
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118
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162
128
130
130A
160
130B
126
117
136
114

FIG. 3

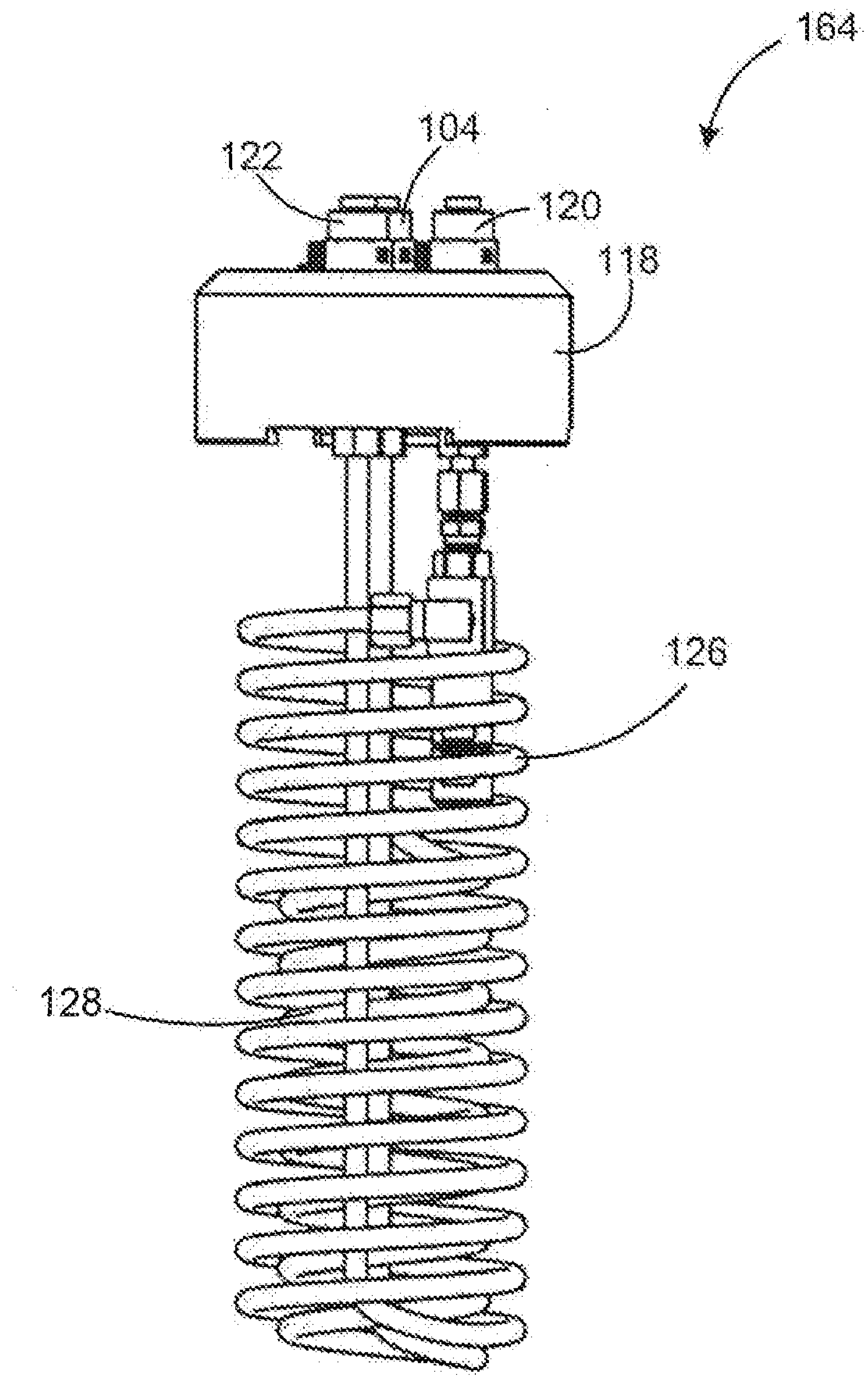
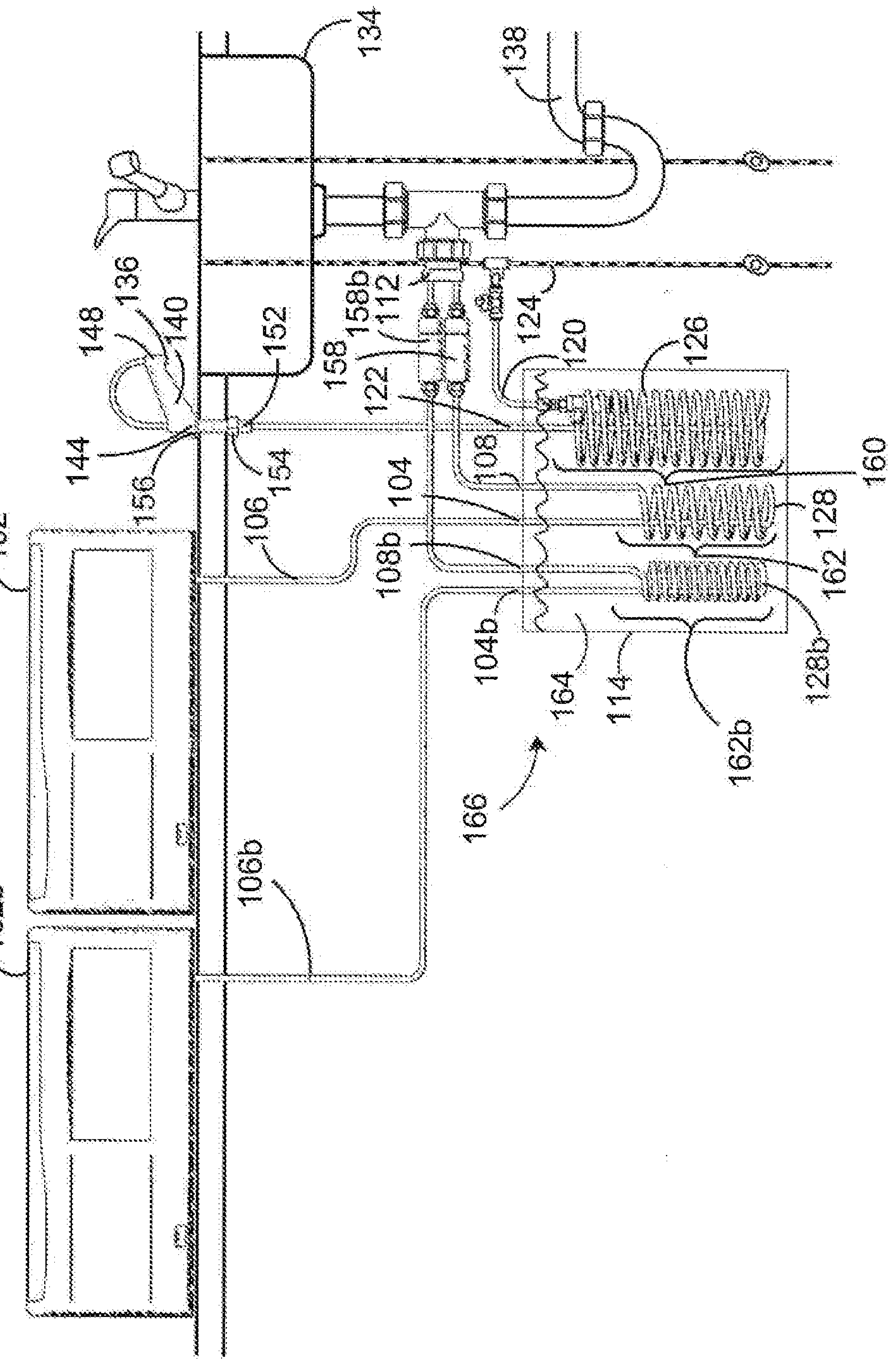


FIG. 4


134
138
136
148
140
152
158b
112
158
124
120
126
122
144
156
154
106
104
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128
102
108b
162
104b
164
114
128b
162b
166
106b
102b

FIG. 5

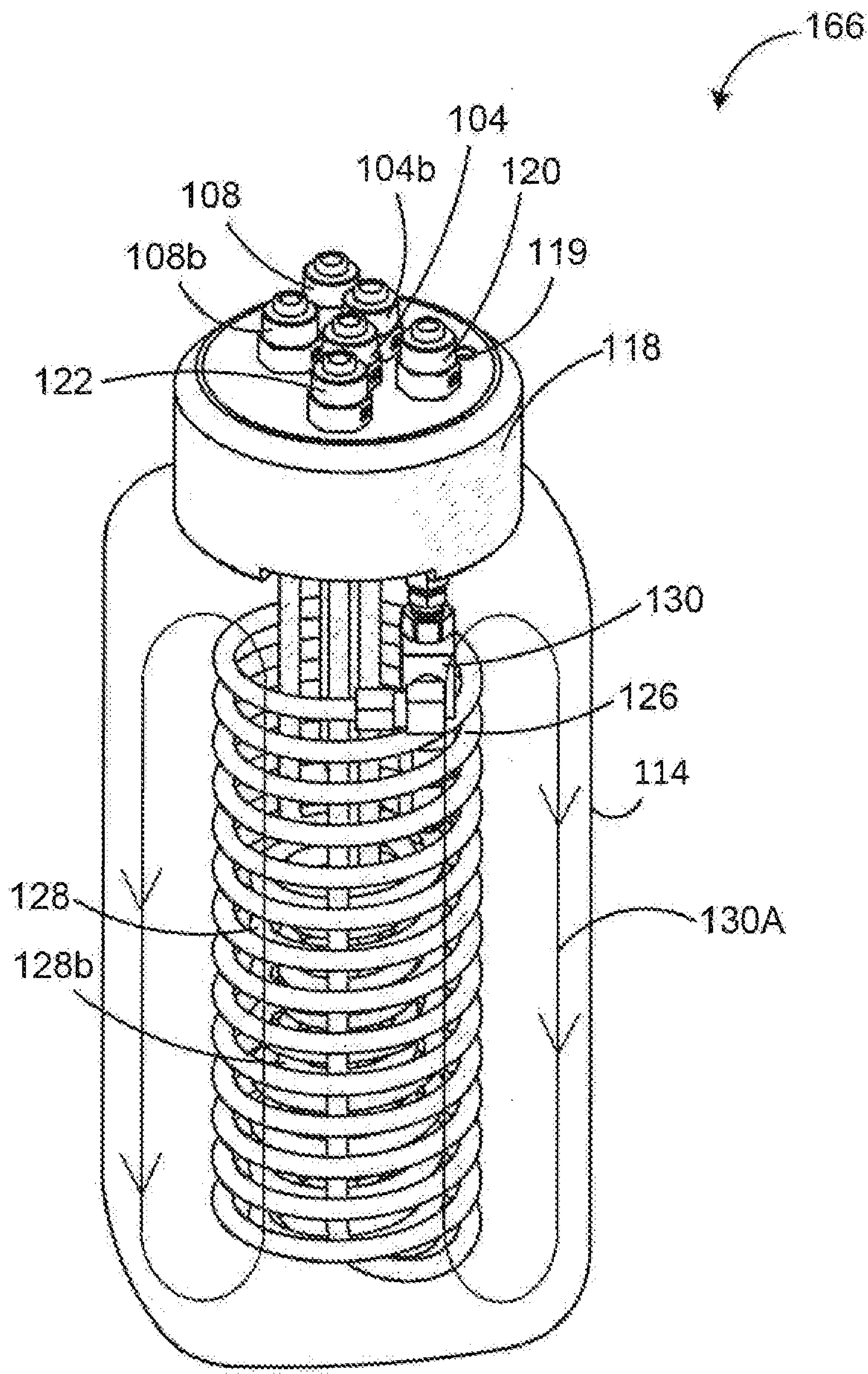
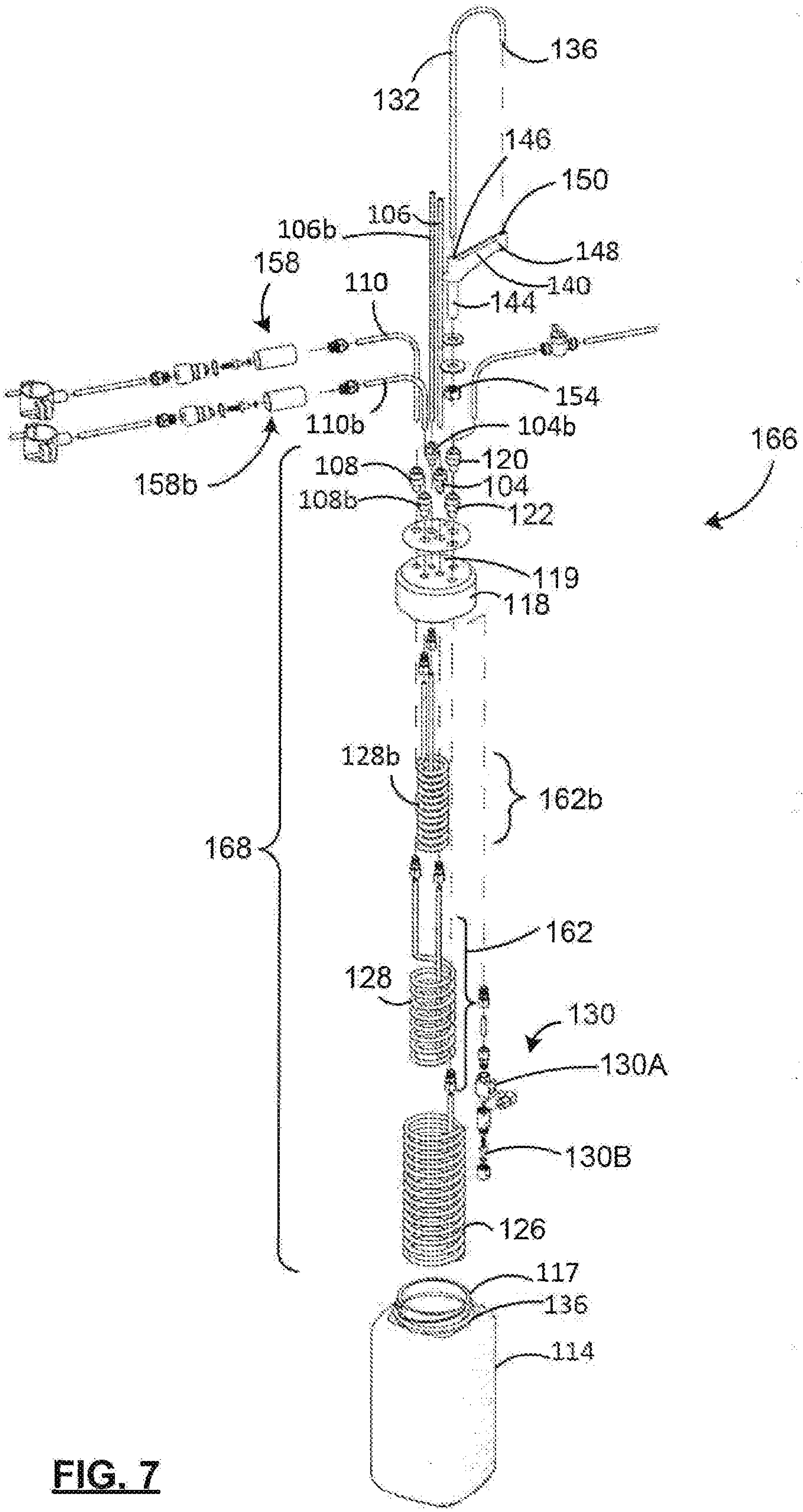


FIG. 6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106
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110b
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120
104
158b
108b
122
119
118
128b
162b
168
162
128
130
130A
130B
126
117
136
114

FIG. 7

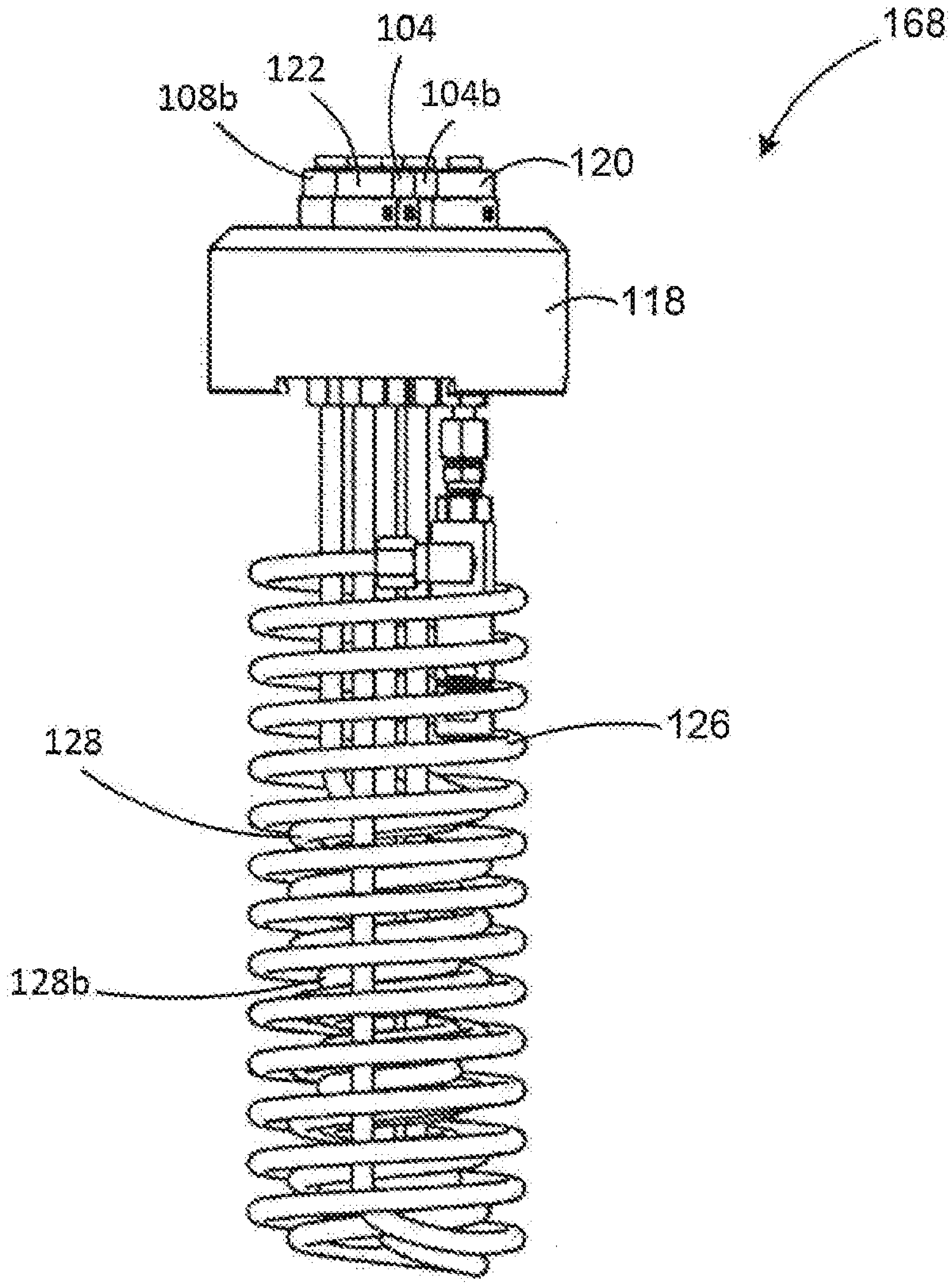

FIG. 8

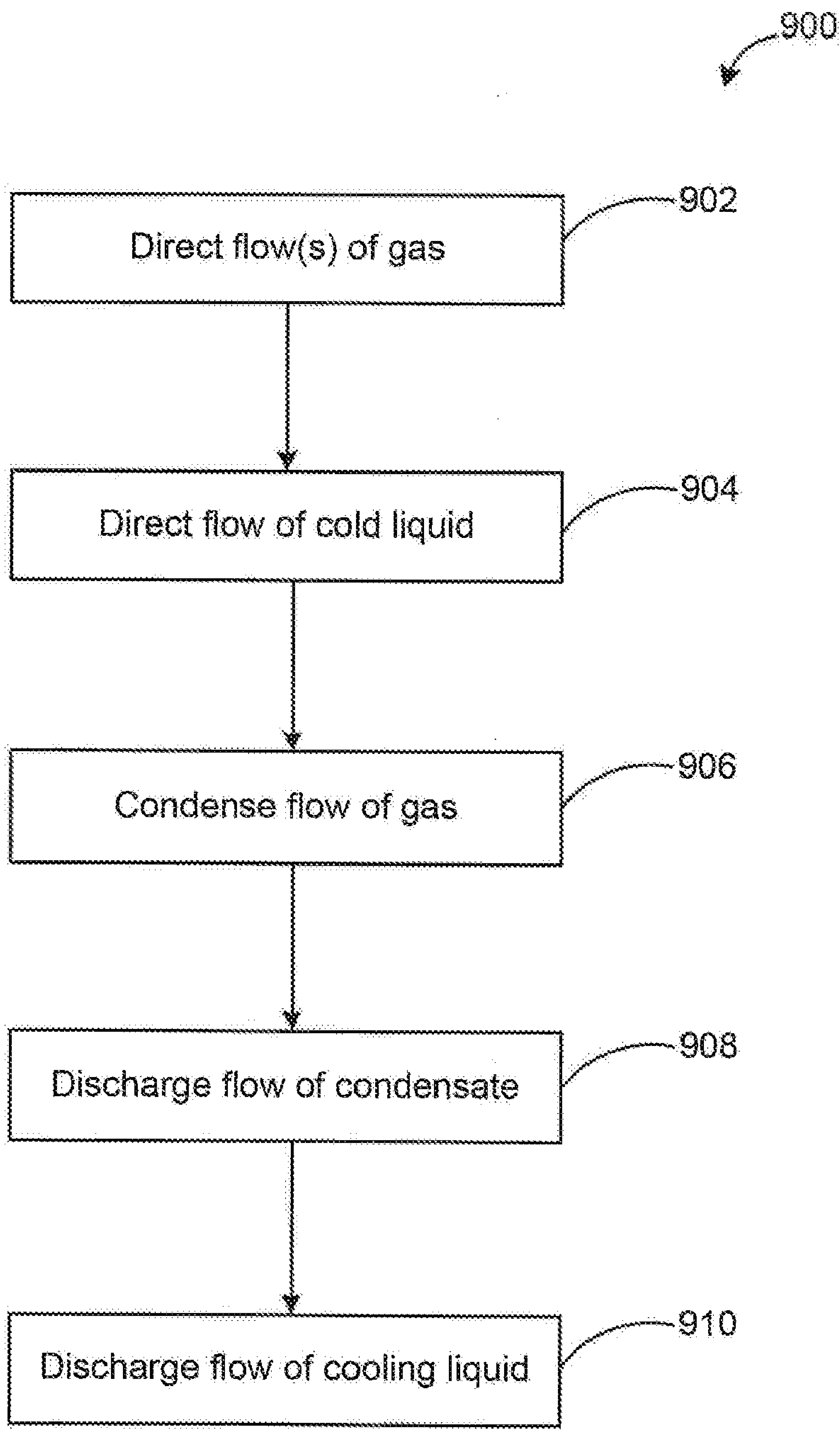
900
Direct flow(s) of gas
902
Direct flow of cold liquid
904
Condense flow of gas
906
Discharge flow of condensate
908
Discharge flow of cooling liquid
910

FIG. 9

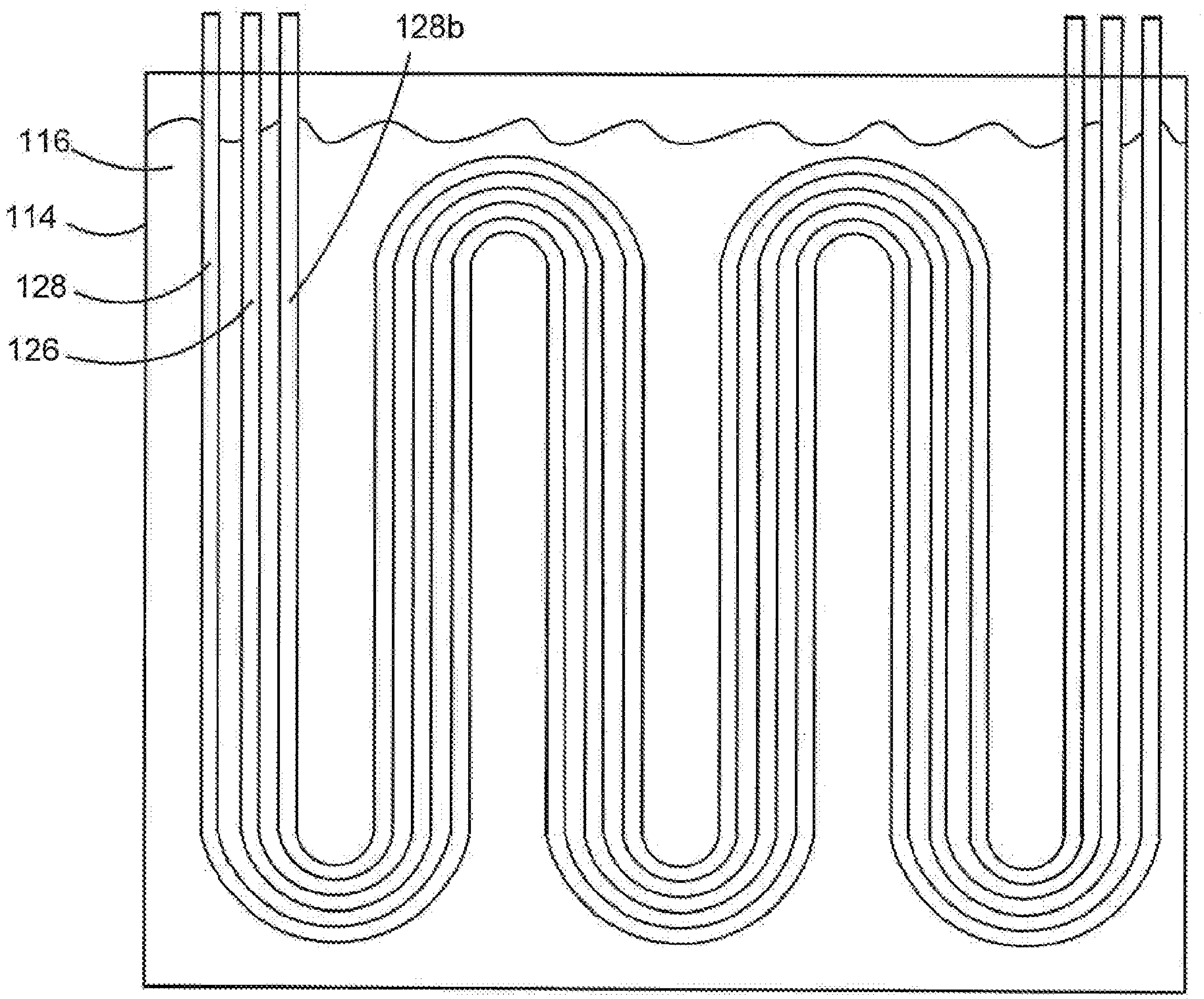

FIG. 10

METHODS AND APPARATUS FOR COOLING FLUID

FIELD

[0001] The disclosed embodiments relate to the field of fluid coolers, and to methods and apparatus for cooling fluids.

INTRODUCTION

[0002] In the dental and medical fields, among others, equipment may be sterilized using a sterilizer. Some sterilizers, such as cassette and chamber autoclaves, use high temperature steam to sterilize equipment. At least some of these apparatus include an outlet for the disposal of exhaust steam or hot liquid fluid.

[0003] Disposing of exhaust steam or hot liquid directly into a sewer or drain pipe is prohibited in many municipalities. In many cases, steam or hot liquid must be cooled to a liquid no hotter than 65° C. before it can be legally discharged into a sewer or drain pipe. Moreover, many municipalities impose strict backflow prevention policies for protecting potable water from contamination.

SUMMARY

[0004] In a first aspect, there is a fluid cooler comprising a container for a liquid transfer medium. The container may include first and second hot fluid inlets, first and second cooled liquid outlets, a cooling liquid inlet, and a cooling liquid outlet. A first conduit may extend within the container and fluidly couple the first hot fluid inlet to the first cooled liquid outlet. A second conduit may extend within the container and fluidly couple the second hot fluid inlet to the second cooled liquid outlet. A third conduit may extend within the container and fluidly couple the cooling liquid inlet to the cooling liquid outlet. The first, second, and third conduits may be positioned to be at least partially submerged in the liquid transfer medium when the container contains the liquid transfer medium.

[0005] In some embodiments, the container may include a removable lid, and at least one of the first and second hot fluid inlets, the first and second cooled liquid outlets, the cooling liquid inlet, and the cooling liquid outlet may be located in the removable lid.

[0006] In some embodiments, the fluid cooler may further comprise a thermally sensitive flow regulator fluidly coupled to the third conduit.

[0007] In some embodiments, the flow regulator may include a valve operated by a thermally sensitive actuator.

[0008] In some embodiments, the flow regulator may positioned within the container such that the flow regulator is at least partially submerged when the container contains the liquid transfer medium.

[0009] In some embodiments, at least one of the first, second and third conduits may be at least partially coiled.

[0010] In some embodiments, one conduit of the first, second, and third conduits may include a coiled portion defining an interior volume; and at least one other of the first, second and third conduits may extend through the interior volume.

[0011] In some embodiments, the container may have a top, and a bottom. Each of the first, second, and third conduits may include a coiled portion. The coiled portion of the third conduit may be closer to the top of the container than the coiled portions of the first and second conduits.

[0012] In some embodiments, the fluid cooler may further comprise a discharge conduit which may extend exterior the container and may have a first end fluidly coupled to the cooling liquid outlet.

[0013] In some embodiments, the discharge conduit may include a second end exposed to open air.

[0014] In another aspect, there is a fluid cooler core comprising a container lid having an inward facing side, a hot fluid inlet, a cooled liquid outlet, a cooling liquid inlet, and a cooling liquid outlet, A first conduit may extend from the inward facing side and fluidly couple the hot fluid inlet to the cooled liquid outlet. A second conduit may extending from the inward facing side and fluidly couple the cooling liquid inlet to the cooling liquid outlet. When the container lid closes an opening to a container, the first and second conduits may extend into the container.

[0015] In some embodiments, the fluid cooler core may further comprise a thermally sensitive flow regulator fluidly coupled to the second conduit.

[0016] In some embodiments, the flow regulator may include a valve operated by a thermally sensitive actuator.

[0017] In some embodiments, at least one of the first and second conduits is at least partially coiled.

[0018] In some embodiments, one conduit of the first and second conduits may include a coiled portion defining an interior volume, and the other of the first and second conduits may extend through the interior volume.

[0019] In some embodiments, each of the first and second conduits may include a coiled portion, and the coiled portion of the second conduit may be closer to the lid than the coiled portion of the first conduit.

[0020] In some embodiments, the container lid may include a second hot fluid inlet, and a second cooled liquid outlet, and a third conduit may extend from the inward facing side and fluidly couple the second hot fluid inlet to the second cooled liquid outlet.

[0021] In another aspect, there is a method of condensing gas. The method may comprise directing a flow of cold liquid through a first conduit, the first conduit being at least partially submerged in a liquid transfer medium, to cool the liquid transfer medium; and directing a flow of hot gas through a second conduit, the second conduit being at least partially submerged in the liquid transfer medium, to condense the flow of steam into a flow of cold liquid condensate.

[0022] In some embodiments, directing a flow of cold liquid may comprise directing a flow of cold water from a municipal supply line through the first conduit. The method may further comprise discharging the flow of cold liquid into a municipal drain through open air.

[0023] In some embodiments, directing a flow of cold liquid may comprise directing a flow of cold water from a municipal supply line through the first conduit. The method may further comprise discharging the flow of cold liquid into a municipal drain through one or more of a double check-valve and a reduced pressure zone assembly.

[0024] In some embodiments, the method may further comprise regulating the flow rate of cold liquid with a thermally sensitive flow regulator at least partially submerged in the liquid transfer medium.

[0025] In some embodiments, directing the flow of steam may comprise directing a flow of steam discharged from a sterilizer through the second conduit.

[0026] In some embodiments, the method may further comprise directing a second flow of steam through a third conduit, the third conduit being at least partially submerged in the liquid transfer medium, to condense the second flow of steam into a second flow of cold liquid condensate.

DRAWINGS

[0027] FIG. **1** shows a schematic of a fluid cooler fluidly coupled to a hot fluid source, in accordance with at least one embodiment;

[0028] FIG. **2** shows a perspective view of a fluid cooler, in accordance with at least one embodiment;

[0029] FIG. **3** shows an exploded view of the fluid cooler of FIG. **2**, in accordance with at least one embodiment;

[0030] FIG. **4** shows a side elevation view of a fluid cooler core in accordance with at least one embodiment;

[0031] FIG. **5** shows a schematic of a fluid cooler fluidly coupled to a first and second hot fluid source, in accordance with at least one embodiment;

[0032] FIG. **6** shows a perspective view of a fluid cooler, in accordance with at least one embodiment;

[0033] FIG. **7** shows an exploded view of the fluid cooler of FIG. **6**, in accordance with at least one embodiment;

[0034] FIG. **8** shows a side view of a fluid cooler core, in accordance with at least one embodiment;

[0035] FIG. **9** shows a flowchart illustrating a method of cooling fluid, in accordance with at least one embodiment; and

[0036] FIG. **10** shows another embodiment of a fluid cooler including conduits having a serpentine portion, in accordance with at least one embodiment.

DESCRIPTION OF VARIOUS EMBODIMENTS

[0037] The terms "an embodiment," "embodiment," "embodiments," "the embodiment," "the embodiments," "one or more embodiments," "some embodiments," and "one embodiment" mean "one or more (but not all) embodiments of the present invention(s)," unless expressly specified otherwise.

[0038] The terms "including," "comprising" and variations thereof mean "including but not limited to," unless expressly specified otherwise. A listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise. The terms "a," "an" and "the" mean "one or more," unless expressly specified otherwise.

[0039] A description of an embodiment with several components in communication with each other does not imply that all such components are required. On the contrary a variety of optional components are described to illustrate the wide variety of possible embodiments of the present invention.

[0040] When a single element is described herein, it will be readily apparent that more than one element may be used in place of the single element. Similarly, where more than one element is described herein, it will be readily apparent that a single element may be used in place of the more than one element.

[0041] Reference is first made to FIGS. **1** to **3**. FIG. **1** shows a schematic of a fluid cooler **100** fluidly coupled to a hot fluid source **102**, in accordance with at least one embodiment. FIG. **2** shows a perspective view of fluid cooler **100**, in accordance with at least one embodiment. FIG. **3** shows an exploded view of fluid cooler **100**, in accordance with at least one embodiment.

[0042] In the example shown, fluid cooler **100** includes a hot fluid inlet **104** fluidly coupled by a hot fluid conduit **106** to hot fluid source **102**. Fluid cooler **100** is shown further including a cooled liquid outlet **108** fluidly coupled by a cooled liquid conduit **110** to a drain pipe **112**. As shown, exhaust hot fluid from hot fluid source **102** is directed through hot fluid conduit **106** to fluid cooler **100**. As used herein, and in the claims, a fluid is either liquid or steam, and a hot fluid has a temperature greater than a cooled liquid. Further, as used herein, and in the claims, steam refers to any gas which changes phase from gas to liquid at atmospheric pressure and a temperature in the range of 50° C. to 200° C. In one example, steam is water vapor having a temperature above 100° C.

[0043] In use, at least one embodiment of fluid cooler **100** cools the exhaust hot fluid from hot fluid source **102** (and if the hot fluid is steam then condenses it) into a cooled liquid which is then discharged through cooled liquid outlet **108** and cooled liquid conduit **110** into drain pipe **112**. In at least some cases, the cooled liquid has a temperature at discharge of less than or equal to 65° C.

[0044] In some examples, hot fluid source **102** is a cassette autoclave which uses steam for sterilizing equipment, such as dental and medical equipment for example, and exhausts steam into hot fluid conduit **106**. However, in alternative embodiments, hot fluid source **102** is any apparatus which outputs hot fluid and that can be fluidly coupled to fluid cooler **100**. In some examples, hot fluid source **102** is a steam oven, a steam washer, a steam drier, or a washer/disinfector. In some cases, hot fluid discharged from hot fluid source **102** has a temperature between 85° C. and 300° C.

[0045] Fluid cooler **100** is shown including a container **114** for a liquid transfer medium **116**. Container **114** can take any form which can house a volume of liquid. Generally, container **114** includes one or more walls which cooperate to contain a volume of liquid. FIGS. **2** and **3** illustrate an example container **114** shaped as a generally cuboid bottle. In alternative examples, container **114** is generally cylindrical or spherical. In some embodiments, container **114** includes one or more deformable walls, like a bag.

[0046] Referring to FIG. **3**, container **114** as shown includes an upper opening **117**. In the example shown, fluid cooler **100** includes a lid **118** for selectively closing opening **117**. Optionally, lid **118** includes one or more openings **119**. Opening **119** may permit gas pressure inside of container **114** to equalize, and may permit liquid **116** to exit (e.g. during an overflow). In some examples, lid **118** includes one or more retention members (e.g. threads or latches, not shown) for mating with one or more retention members **135** (e.g. threads or notches) provided on container **114**. In some examples, lid **118** includes a sealing element (e.g. a gasket) that is urged against container **114** by lid **118** to enhance a liquid-tight seal between lid **118** and container **114**.

[0047] Fluid cooler **100** in some alternative embodiments (not shown) does not include a lid **118**. In one example, container **114** includes an opening **117** that remains uncovered during use. In another example, container **114** does not include opening **117** and is permanently sealed from the outside atmosphere.

[0048] Referring again to FIGS. **1** to **3**, container **114** can be made of any suitable material. In some examples, container **114** is made of one or more of glass, metal, plastic, wood, and rubber. In the example shown, container **114** includes an at least partially transparent material, such as transparent glass or transparent plastic. This may permit the liquid transfer medium **116** to be visible from outside of container **114** for monitoring the level and quality (e.g. coloration) of the liquid transfer medium **116**. An excess or deficiency of liquid transfer medium **116**, or a change in coloration of liquid transfer medium **116** may be indicative of a problem (e.g. a leaking container **114**, or a leaking conduit inside container **114**).

[0049] In the example shown, fluid cooler **100** further includes a cooling liquid inlet **120** and a cooling liquid outlet **122**. As shown, cooling liquid inlet **120** is fluidly coupled to a cooling liquid source **124**. In some examples, cooling liquid source **124** is a municipal cold water supply line or any other source of cold liquid. In some cases, cooling liquid from cooling liquid source **124** has a temperature between 0° C. and 50° C.

[0050] As shown, fluid cooler **100** includes a cooling liquid conduit **126**, and a cooling conduit **128**. Cooling liquid conduit **126** is shown fluidly coupling cooling liquid inlet **120** and cooling liquid outlet **122**. Cooling conduit **128** is shown fluidly coupling hot fluid inlet **104** and cooled liquid outlet **108**.

[0051] During the use of at least one embodiment of fluid cooler **100**, cooling liquid from cooling liquid source **124** enters fluid cooler **100** by cooling liquid inlet **120** and flows through cooling liquid conduit **126** to cooling liquid outlet **122**. Similarly, hot fluid from hot fluid source **102** enters by hot fluid inlet **104**, and flows through cooling conduit **128** in which the hot fluid is cooled (and condensed if the hot fluid is steam) to a cooled liquid which exits at cooled liquid outlet **108**.

[0052] As shown, each of cooling liquid conduit **126**, and cooling conduit **128** is at least partially submerged in liquid transfer medium **116**. At least some of the cooling liquid flowing through cooling liquid conduit **126** provides a heat sink, which draws heat from the hot fluid inside cooling conduit **128**. The heat from the cooling conduit **128** transfers through liquid transfer medium **116** and into cooling liquid conduit **126**. In operation, the temperature of a given volume of hot fluid, inside cooling conduit **128**, may fall as heat is lost to the cooling liquid inside of cooling liquid conduit **126**. Where the hot fluid is steam, and the temperature falls below a threshold temperature, the steam changes phase to liquid condensate. The temperature of a given volume of the condensate, inside cooling conduit **128**, may further fall as heat is lost from the condensate to the cooling liquid in cooling liquid conduit **126**.

[0053] Generally, the rate of heat transfer from the hot fluid inside cooling conduit **128**, to the cooling liquid inside cooling liquid conduit **126** depends on, among other things, the temperature difference between the cooling liquid and the hot fluid, and the physical properties of the conduits **126**, **128** and the liquid transfer medium **116**. Conduits **126** and **128** can be made of any suitable material. In some examples, conduits **126** and **128** are made of one or more of metals (e.g, copper, aluminum, or stainless steel), plastics, and ceramics (e.g. glass, or porcelain). Further, conduits **126** and **128** can have any suitable cross-sectional shape for transporting fluids, such as a circular, rectangular or triangular shape for example.

[0054] Liquid transfer medium **116** can be any suitable liquid. In some examples, liquid transfer medium **116** is potable water. Alternatively, liquid transfer medium **116** can be a gel, an oil, or any other suitable liquid having desired characteristics.

[0055] In the example shown, fluid cooler **100** includes a thermally sensitive flow regulator **130** operable to control the flow rate of cooling liquid through cooling liquid conduit **126** based on one or more of a temperature inside container **114**, and a temperature of liquid transfer medium **116**. This may permit an efficient control of cooling water usage, while preserving the performance of fluid cooler **100** (e.g. maintaining a discharge of cooled fluid at a temperature at or below a target temperature). In some examples, flow regulator **130** is at least partially submerged in liquid transfer medium **116** for responding to the temperature of liquid transfer medium **116**. In at least one embodiment, flow regulator **130** includes a valve **130**A operated by a thermally sensitive actuator **130**B. The thermally sensitive actuator may gradually or stepwise move the valve between open and closed, or toggle the valve between open and closed, in response to a sensed fluid temperature (e.g. of the liquid transfer medium **116** in which it is at least partially submerged).

[0056] In at least one embodiment, fluid cooler **100** includes a cooling liquid discharge conduit **132** coupled to cooling liquid outlet **122**. In the example shown, cooling liquid discharge conduit **132** directs cooling liquid from cooling liquid outlet **122** to a sink **134**. In alternative embodiments, cooling liquid outlet **122** can direct cooling liquid to anywhere, such as a basin, a bottle, a floor drain, or onto the ground outside for example.

[0057] Fluid cooler **100**, as shown, is configured to lessen the possibility of dirty cooled liquid contaminating cooling liquid source **124**. As shown, cooled liquid conduit **110** is fluidly coupled to a drain for disposing of cooled liquid from hot fluid source **102** into the drain. Moreover, the conduits which transport dirty hot fluid and cooled liquid (hot fluid conduit **106**, cooling conduit **128** and cooled liquid conduit **110**) are shown fluidly isolated from the conduits which transport cooling liquid (e.g. potable water) from cooling liquid source **124** (cooling liquid conduit **126** and cooling liquid discharge conduit **132**).

[0058] In the example shown, two conduit walls (e.g. of conduits **126** and **128**) and liquid transfer medium **116** separates the dirty hot fluid and cooled liquid from the cooling liquid and liquid source **124**. This may help reduce the possibility of the dirty hot fluid and cooled liquid from contaminating the cooling liquid source **124**. For example, if cooling liquid conduit **126** were to rupture, then cooling liquid source **124** could become exposed to liquid transfer medium **116** (which may be potable water), but conduit **128** could continue to isolate the dirty hot fluid and cooled liquid therein from contaminating cooling liquid source **124**. Similarly, if cooling conduit **128** were to rupture and contaminate liquid transfer medium **116**, then cooling liquid conduit **126** could continue to isolate the cooling liquid source **124** from the contaminated liquid transfer medium **116**.

[0059] As shown, cooling liquid discharge conduit **132** includes a free end **136** for discharging cooling liquid into sink **134**. In the example shown, free end **136** is exposed to open air. This may lessen the possibility of drain **138** backing up and contaminating cooling liquid source **124** through free end **136**. In some examples, there is a bracket **140** mountable to a tabletop **142** adjacent a sink, bottle, basin or other reservoir, for directing cooling liquid discharge conduit **132** into the sink, bottle, basin or other reservoir.

[0060] As shown, bracket **140** includes a first end **144**, for penetrating a tabletop and having a first bore **146** for receiving cooling liquid discharge conduit **132**. Bracket **140** is also shown including a second end **148** having a second bore **150** for receiving free end **136** of cooling liquid discharge conduit **132**. In some examples, first end **144** includes any one or more retentive elements for securing to tabletop **142**. In the example shown, first end **144** includes a cylindrical threaded portion **152** and a nut **154** which cooperate with a flange **156** to clamp bracket **140** onto tabletop **142**. In alternative embodiments, the retentive element(s) of first end **144** includes one or more of snaps, magnets, thumbscrews, hooks, loops, straps, buckles, or any other suitable retentive element.

[0061] In at least some examples, first bore **146** and second bore **150** are substantially parallel. Cooling liquid discharge conduit **132**, in some examples, extends through first and second bores **146** and **150**, such that the direction of cooling liquid flow through first bore **146** (e.g. up) is approximately opposite to the direction of cooling liquid flow through second bore **150** (e.g. down).

[0062] In alternative embodiments (not shown), cooling liquid discharge conduit **132** is physically coupled to drain **138** by another backflow prevention device, such as a double check-valve, or a reduced pressure zone assembly.

[0063] In the example shown, cooled liquid conduit **110** includes a thermal shut-off valve **158**. Thermal shut-off valve **158** closes conduit **110** to the flow of fluid in response to detecting a fluid temperature above a threshold. This may prevent fluid above a certain temperature from entering drain pipe **112**, which might otherwise be a contravention of municipal law, safety standards or design parameters. Generally, a failure of fluid cooler **100** (e.g. container **114** leaks liquid transfer medium **116**, flow regulator **130** malfunctions, or cooling liquid source **124** shuts off) can give rise to a discharge of fluid through cooled liquid conduit **110** above the threshold at which thermal shut-off valve **158** closes conduit **110**. This may subsequently trigger an abnormal cycle fault condition in the hot fluid source **102**, causing hot fluid source **102** to stop exhausting hot fluid.

[0064] Cooling liquid conduit **126** and cooling conduit **128** are shown extending within container **114**. In the example shown, cooling liquid conduit **126** includes a coiled portion **160**, and cooling conduit **128** includes a coiled portion **162**. Coiled portions **160** and **162** may provide long path lengths and large surface areas for heat transfer to occur between cooling conduit **128** and cooling liquid conduit **126**. However, in alternative examples, one or both of conduits **126** and **128** has a short path length and is free of coiled portions.

[0065] In at least some embodiments, coiled portions **160** and **162** are arranged in spaced relation within container **114**, as shown by way of example in FIG. **1**. In other embodiments, coiled portion **160** and **162** are arranged in nested relation, as shown by way of example in FIGS. **2** and **3**. Nesting coiled portions **160** and **162** may enhance heat transfer between coiled portions **160** and **162**. In the examples shown in FIGS. **2** and **3**, coiled portion **162** of cooling conduit **128** is nested inside coiled portion **160** of cooling liquid conduit **126**. As shown, coiled portion **160** defines an interior volume through which coiled portion **162** extends. In alternative embodiments (not shown), coiled portion **160** is nested inside coiled portion **162** and extends through an interior volume defined by coiled portion **162**.

[0066] FIG. **4** shows a side view of a fluid cooler core **164** in accordance with at least some embodiments. In the example shown, fluid cooler core **164** is a component of fluid cooler **100** (see FIG. **3**). As shown, fluid cooler core **164** includes lid **118** in which inlets and outlets **104**, **108** (obscured from view), **120** and **122** are located, and to which conduits **126** and **128** are connected. In some examples, fluid cooler core **164** is a unitary assembly including lid **118** which can be secured to any container having a compatible opening. This may permit embodiments of fluid cooler **100** to be formed by combining fluid cooler core **164** with different sized or shaped containers **114**. This may also permit container **114** to be easily replaced if container **114** becomes worn or damaged. In some cases, a user may use a fluid cooler core **164** with a compatible container that they already own.

[0067] Referring again to FIGS. **1** to **3**, in alternative embodiments (not shown), one or more of inlets and outlets **104**, **108**, **120** and **122** are located on a wall of container **114** other than a removable lid **118**. In some examples, one or more of inlets and outlets **104**, **108**, **120**, and **122** are located on a side wall or a bottom wall of container **114**.

[0068] In at least some embodiments, fluid cooler **100** includes a plurality of cooling liquid circuits (e.g. a second cooling liquid inlet, a second cooling liquid conduit, and a second cooling liquid outlet) each coupled to the same or different cooling liquid source(s). Similarly, in at least some embodiments, fluid cooler **100** includes a plurality of cooling circuits (e.g. a second hot fluid inlet, a second cooling conduit, and a second cooled liquid outlet) each coupled to the same or different hot fluid source(s) and drain pipe(s).

[0069] Reference is now made to FIGS. **5** to **8**. In at least some embodiments, an element shown in any of FIGS. **5** to **8**, which is labeled by the same reference numeral as a previously described element shown in any of FIGS. **1** to **4**, is generally analogous to that previously described element. Furthermore, in at least some embodiments, an element shown in any of FIGS. **5** to **8** which is labeled by a reference numeral suffixed "b" is generally analogous to the element shown in any of FIGS. **1** to **4** labeled by the same reference numeral, without the suffix "b".

[0070] FIG. **5** shows a schematic of a fluid cooler **166** fluidly coupled to hot fluid source **102** and a second hot fluid source **102*b***, in accordance with at least one embodiment. In at least some embodiments, fluid cooler **166** has features that are generally analogous to fluid cooler **100**, and in addition includes a second cooling circuit (e.g. a second hot fluid inlet, a second cooling conduit, and a second cooled liquid outlet). FIG. **6** shows a perspective view of fluid cooler **166**, in accordance with at least one embodiment. FIG. **7** shows an exploded view of fluid cooler **166**, in accordance with at least one embodiment. FIG. **8** shows a side view of a fluid cooler core **168**, in accordance with at least one embodiment. In at least some embodiments, fluid cooler core **168** has features that are generally analogous to fluid cooler core **164**, and in addition includes a second cooling circuit.

[0071] FIG. **5** shows fluid cooler **166** including a second cooling circuit which cools hot fluid from a second hot fluid source **102*b*** into cooled fluid and discharges the cooled fluid into drain pipe **112**. As shown, hot fluid source **102** is fluidly coupled by second hot fluid conduit **106*b*** to second hot fluid inlet **104*b***, and a second cooling conduit **128*b*** fluidly couples second hot fluid inlet **104*b*** to second cooled liquid outlet **108*b***. A second cooled liquid conduit **110*b*** is shown fluidly coupling second cooled liquid outlet **108*b*** to drain pipe **112**. Second cooled liquid conduit **110*b*** is also shown including optional second thermal shutoff valve **158*b***. In at least some embodiments (not shown), second cooled liquid conduit **110*b***

is fluidly coupled to a second drain pipe, or other reservoir other than drain pipe **112** to which cooled liquid conduit **110** is connected.

[0072] In at least some embodiments, one or more of conduits **126**, **128** and **128***b* includes a coiled portion. In the example shown, cooling liquid conduit **126** includes coiled portion **160**, cooling conduit **128** includes coiled portion **162**, and second cooling conduit **128***b* includes a coiled portion **162***b*. Coiled portions **160**, **162**, and **162***b* may provide long path lengths and large surface areas for heat transfer to occur between cooling liquid conduit **126** and conduits **128** and **128***b*.

[0073] In some alternative embodiments, one or more of conduits **126**, **128**, and **128***b* follow a shaped path other than a coil to provide a long path length. FIG. **10** illustrates an example embodiment in which each of conduits **126**, **128**, and **128***b* include a planar serpentine portion. In the example shown, the serpentine portion of conduits **128**, and **128***b* are nested with and surround the serpentine portion of conduit **126**, which may enhance heat transfer. In alternative embodiments, some or all of conduits **126**, **128**, and **128***b* do not include a coiled, serpentine or otherwise shaped portion.

[0074] FIGS. **6** and **7** show embodiments of fluid cooler **166** including nested cooling liquid and cooling conduits **126**, **128**, and **128***b*. In the example shown, coiled portions **162** and **162***b* of cooling conduits **128** and **128***b* are nested inside coiled portion **160** of cooling liquid conduit **126**. As shown, coiled portion **160** defines an internal volume through which coiled portion **162** and **162***b* extend. Further, coiled portion **162***b* of cooling conduit **128***b* is shown nested inside coiled portion **162** of cooling conduit **128**. As shown, coiled portion **162** defines an internal volume through which coiled portion **162***b* extends.

[0075] FIG. **8** shows fluid cooler core **168** including a second cooling circuit (second hot fluid inlet **104***b*, second cooled liquid outlet **108***b*, and second cooling conduit **128***b*). As described above in connection with fluid cooler core **164**, fluid cooler core **168** includes a lid **118** which in some embodiments can be secured to a compatible bottle to form a fluid cooler (e.g. fluid cooler **166**).

[0076] FIGS. **1** to **4** show example embodiments in which coiled portion **160** of cooling liquid conduit **126** extends upwardly further than coiled portion **162** of cooling liquid conduit **126**, when the embodiment is oriented in a working upright position. Similarly, FIGS. **5** to **8** show example embodiments in which coiled portion **160** of cooling liquid conduit **126** extends upwardly further than coiled portions **162** and **162***b* of cooling conduits **128** and **128***b*. In some examples, such as those shown in FIGS. **2** to **4**, and **6** to **8**, the coiled portion **160** of cooling liquid conduit **126** is positioned closer to an upper lid **118** than the coiled portion(s) **162** (and **162***b*) of cooling conduit(s) **128** (and **128***b*). In at least some cases, this may induce liquid transfer medium **116** to circulate in the direction of arrow **170** (see FIGS. **2** and **6**).

[0077] In some cases, the liquid transfer medium **116** present in the upper region of container **114**, where coiled portion **160** of cooling liquid **126** extends past coiled portion (s) **162** (and **162***b*), has a lower temperature and therefore slightly higher density. This can cause the liquid transfer medium **116** in this upper region to flow by gravity downwardly. Similarly, in some cases the liquid transfer medium **116** present in the lower region, where coiled portion(s) **162** (and **162***b*) extends, has a higher temperature than the aforementioned upper region and therefore also a slightly lower density than the aforementioned upper region. This can cause the liquid transfer medium **116** in this lower region to flow upwardly by buoyancy.

[0078] An induced circulation, such as for example in the direction of arrow **170**, may in some cases further enhance the transfer of heat from cooling conduit(s) **128** (and **128***b*) to cooling liquid conduit **126**. In alternative embodiments, a fluid cooler or fluid cooler core does not include a structure which induces a flow of liquid transfer medium. In some examples (not shown), the coiled portion(s) **162** (and **162***b*) extends above the coiled portion **160**, and/or the coiled portion **160** extends below the coiled portion(s) **162** (and **162***b*).

[0079] FIG. **9** shows a flowchart illustrating a method **900** of cooling fluid, in accordance with at least one embodiment. For clarity of illustration, method **900** is described below with reference to fluid coolers **100** and **166**. However, method **900** is not limited to the use of fluid coolers **100** and **166**, and can be practiced using any suitable apparatus. Further the flowchart shown in FIG. **9** illustrates the steps of method **900** organized in a particular order. However, method **900** is not limited to the steps ordered as shown, and in some embodiments of method **900** some steps are practiced in a different order and some steps are practiced simultaneously.

[0080] At **902**, a flow of hot fluid (e.g. hot fluid discharged from hot fluid source **102**) is directed through cooling conduit **128**, which is at least partially submerged in liquid transfer medium **116** (e.g. potable water). In some examples, the flow of hot fluid is intended for a regulated drain (e.g. a municipal drain) into which hot fluid is prohibited. Accordingly, in some cases the flow of hot fluid can be cooled (and condensed if the hot fluid is steam) to a cooled liquid, and discharged into the drain (e.g. drain pipe **112**) at a permissible temperature. In some embodiments, a second flow of hot fluid (e.g. discharged from a second hot fluid source **102***b*) is directed through a second cooling conduit **128***b*, which is at least partially submerged in liquid transfer medium **116**.

[0081] At **904**, a flow of cooling liquid (e.g. cold water) from cooling liquid source **124** (e.g. a municipal cold water supply line) is directed through cooling liquid conduit **126**, which is at least partially submerged in liquid transfer medium **116**. In at least some cases, the cooling liquid provides a heat sink to induce a transfer of heat from the flow of hot fluid in cooling conduit **128** across liquid transfer medium **116** to the cooling liquid inside cooling liquid conduit **126**.

[0082] In some examples, the flow of cooling liquid is regulated by a thermally sensitive flow regulator **130** that is at least partially submerged in the liquid transfer medium **116**. In some examples, the flow regulator **130** alters the flow rate of the cooling liquid in response to the temperature of the liquid transfer medium **116**. In one example, when the temperature of the liquid transfer medium **116** falls, the flow regulator **130** reduces the flow rate of cooling liquid (e.g. by constricting the passage of cooling liquid through cooling liquid conduit **126**), and when the temperature of the liquid transfer medium **116** again rises, the flow regulator **130** increases the flow rate of cooling liquid (e.g. by unconstricting the passage of cooling liquid through cooling liquid conduit **126**).

[0083] At **906**, the flow of hot fluid is cooled, by the loss of heat to liquid transfer medium **116** and cooling liquid inside cooling liquid conduit **126**, into a flow of cooled liquid. In at least some cases, the temperature of the flow of cooled liquid is reduced to a temperature at which the cooled liquid is permitted (e.g. by law, safety standards, or design parameters) to be discharged into a drain (e.g. drain pipe **112**). In some embodiments, the second flow of hot fluid is similarly cooled, by a loss of heat to liquid transfer medium **116** and cooling liquid inside cooling liquid conduit **126**, into a second flow of cooled liquid.

[0084] At **908**, the cooled liquid is discharged from the cooling conduit **128**. In some cases, the cooled liquid is discharged directly into drain pipe **112**. Alternatively, the cooled liquid is discharged into a storm drain, a floor drain, a basin or bottle.

[0085] At **910**, the cooling liquid is discharged from cooling liquid conduit **126**. In some cases, the cooling liquid is discharged directly into drain **138**. Alternatively, the cooling liquid is discharged into a storm drain, a floor drain, a basin or a bottle. In some embodiments, the cooling liquid is discharged through open air into drain **138**. This may prevent a backup of drain **138** from contaminating the cooling liquid source which is fluidly coupled to cooling liquid conduit **126** from which the cooling liquid is being discharged.

[0086] While the above description provides examples of the embodiments, it will be appreciated that some features and/or functions of the described embodiments are susceptible to modification without departing from the principles of operation of the described embodiments. Accordingly, what has been described above has been intended to be illustrative of the invention and non-limiting and it will be understood by persons skilled in the art that other variants and modifications may be made without departing from the scope of the invention as defined in the claims appended hereto. The scope of the claims should not be limited by the preferred embodiments and examples, but should be given the broadest interpretation consistent with the description as a whole.

1. A fluid cooler comprising:
a container for a liquid transfer medium,
the container including first and second hot fluid inlets, first and second cooled liquid outlets, a cooling liquid inlet, and a cooling liquid outlet;
a first conduit extending within the container and fluidly coupling the first hot fluid inlet to the first cooled liquid outlet;
a second conduit extending within the container and fluidly coupling the second hot fluid inlet to the second cooled liquid outlet; and
a third conduit extending within the container and fluidly coupling the cooling liquid inlet to the cooling liquid outlet;
wherein the first, second, and third conduits are positioned to be at least partially submerged in the liquid transfer medium when the container contains the liquid transfer medium.

2. The fluid cooler of claim **1**, wherein:
the container includes a removable lid, and
at least one of the first and second hot fluid inlets, the first and second cooled liquid outlets, the cooling liquid inlet, and the cooling liquid outlet is located in the removable lid.

3. The fluid cooler of claim **1**, further comprising:
a thermally sensitive flow regulator fluidly coupled to the third conduit.

4. The fluid cooler of claim **3**, wherein:
the flow regulator includes a valve operated by a thermally sensitive actuator.

5. The fluid cooler of claim **3**, wherein:
the flow regulator is positioned within the container such that the flow regulator is at least partially submerged when the container contains the liquid transfer medium.

6. The fluid cooler of claim **1**, wherein:
at least one of the first, second and third conduits is at least partially coiled.

7. The fluid cooler of claim **1**, wherein:
one conduit of the first, second, and third conduits includes a coiled portion defining an interior volume; and
at least one other of the first, second and third conduits extends through the interior volume.

8. The fluid cooler of claim **1**, wherein:
the container has a top, and a bottom;
each of the first, second, and third conduits includes a coiled portion; and
the coiled portion of the third conduit is closer to the top of the container than the coiled portions of the first and second conduits.

9. The fluid cooler of claim **1**, further comprising:
a discharge conduit extending exterior the container and having a first end fluidly coupled to the cooling liquid outlet.

10. The fluid cooler of claim **9**, wherein:
the discharge conduit includes a second end exposed to open air.

11. A fluid cooler core comprising:
a container lid having an inward facing side, a hot fluid inlet, a cooled liquid outlet, a cooling liquid inlet, and a cooling liquid outlet;
a first conduit extending from the inward facing side and fluid ly coupling the hot fluid inlet to the cooled liquid outlet; and
a second conduit extending from the inward facing side and fluidly coupling the cooling liquid inlet to the cooling liquid outlet;
when the container lid closes an opening to a container, the first and second conduits extend into the container.

12. The fluid cooler core of claim **11**, further comprising:
a thermally sensitive flow regulator fluidly coupled to the second conduit.

13. The fluid cooler core of claim **12**, wherein:
the flow regulator includes a valve operated by a thermally sensitive actuator.

14. The fluid cooler core of claim **11**, wherein:
at least one of the first and second conduits is at least partially coiled.

15. The fluid cooler core of claim **11**, wherein:
one conduit of the first and second conduits includes a coiled portion defining an interior volume; and
the other of the first and second conduits extends through the interior volume.

16. The fluid cooler core of claim **11**, wherein:
each of the first and second conduits includes a coiled portion; and
the coiled portion of the second conduit is closer to the lid than the coiled portion of the first conduit.

17. The fluid cooler core of claim **11**, wherein:
the container lid includes a second hot fluid inlet, and a second cooled liquid outlet; and
a third conduit extends from the inward facing side and fluidly couples the second hot fluid inlet to the second cooled liquid outlet.

18. A method of condensing gas, the method comprising:

directing a flow of cold liquid through a first conduit, the first conduit being at least partially submerged in a liquid transfer medium, to cool the liquid transfer medium; and

directing a flow of hot gas through a second conduit, the second conduit being at least partially submerged in the liquid transfer medium, to condense the flow of steam into a flow of cold liquid condensate.

19. The method of claim **18**, wherein:

directing a flow of cold liquid comprises directing a flow of cold water from a municipal supply line through the first conduit, and

the method further comprises

discharging the flow of cold liquid into a municipal drain through open air.

20. The method of claim **18**, wherein:

directing a flow of cold liquid comprises directing a flow of cold water from a municipal supply line through the first conduit, and

the method further comprises

discharging the flow of cold liquid into a municipal drain through one or more of a double check-valve and a reduced pressure zone assembly.

21. The method of claim **18**, further comprising:

regulating the flow rate of cold liquid with a thermally sensitive flow regulator at least partially submerged in the liquid transfer medium.

22. The method of claim **18**, wherein:

directing the flow of steam comprises directing a flow of steam discharged from a sterilizer through the second conduit.

23. The method of claim **18**, further comprising:

directing a second flow of steam through a third conduit, the third conduit being at least partially submerged in the liquid transfer medium, to condense the second flow of steam into a second flow of cold liquid condensate.

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