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(54) **CONDENSATE PUMP ASSEMBLY & CONTROL METHODS**

(57) The present disclosure comprises a method of controlling a condensate pump assembly which comprises a pump and a controller connected to the pump, the method comprising measuring a current value drawn by the pump, comparing the measured current value to a predetermined threshold current value and controlling

operation of the condensate pump assembly based on the current value comparison. Also provided is a condensate pump assembly for use in an air conditioning system, comprising a housing comprising an upper housing portion and a pump arranged to pump liquid from a liquid inlet to a liquid outlet.

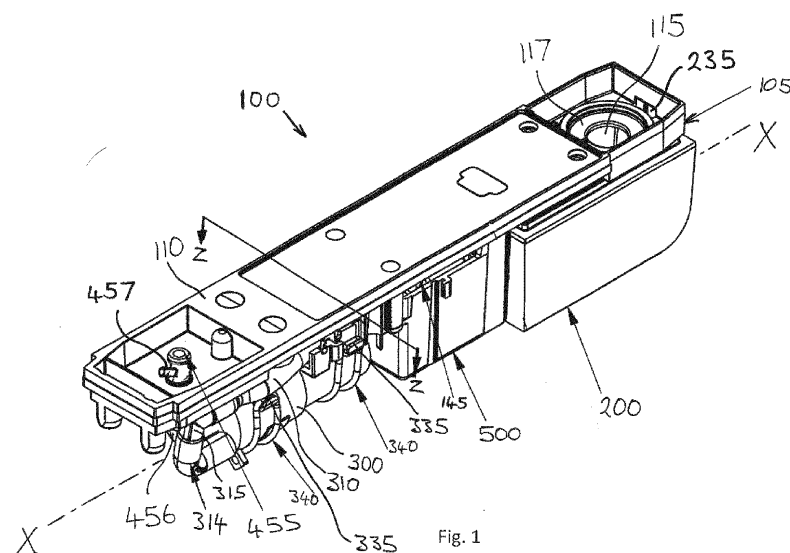


Fig. 1

Description

[0001] The invention relates to a condensate pump assembly and methods of operating the same.

BACKGROUND

[0002] Condensate pump assemblies are used to pump liquid condensate from appliances that produce condensate, for example an air conditioning system, HVAC (heating, ventilation and air conditioning) system, a condensing boiler system or a refrigerator, out of a room or building. In a typical air conditioning system, the air conditioning unit produces liquid condensate, i.e. water, which is typically collected in a tray or reservoir, and needs to be drained away from the appliance. If the appliance installation location is such that it is not practical to provide an open drainage duct to drain under gravity away from the appliance or tray/reservoir, a condensate pump assembly is required to pump the condensate away from the appliance to a suitable liquid drain.

[0003] Some prior art condensate pump assemblies include a liquid reservoir in the form of a liquid receptacle, and the condensate pump assembly may be mounted to a wall of the room or building, typically below the appliance. Such condensate pump assemblies are often an add-on to appliances such as air conditioning units, and not integrated into the appliance. When the liquid receptacle is sufficiently filled with liquid, the liquid is pumped from the liquid receptacle via a liquid inlet and away from the condensate pump assembly, for example outside the room, via a liquid outlet. If the condensate is not removed sufficiently quickly, such as by pump malfunction or the pump not operating sufficiently relative to how quickly condensate is created, this can cause an overflowing receptacle or other condensate escape. Leakage of condensate can also result in water damage to building surfaces and structure and resulting cosmetic or structural damage.

[0004] Conversely, if a condensate pump is allowed to continue operate once a certain amount of condensate has been pumped away, air may be entrained into the pump and downstream conduits, which might affect the lifespan of the pump and result in increased noise in operation.

[0005] In some condensate pump assemblies of the prior art, a clam-shell cover is affixed to the condensate pump assembly to secure the liquid receptacle in place in the condensate pump assembly, as well as to act as a sheath to improve the aesthetic appearance of the condensate pump assembly by hiding the liquid receptacle from view. Such covers and liquid receptacles increase the size of the condensate pump assembly and may create an additional source of noise by rattling against a housing of the condensate pump assembly during operation of the pump.

[0006] In some condensate pump assemblies of the prior art, liquid receptacles may have condensate form

on the outer surface of the liquid receptacle due to temperature differences across the receptacle wall. The formation of condensate is undesirable, as condensate may drip from the receptacle and onto surfaces or objects below, causing water damage in the process.

[0007] In some condensate pump assemblies of the prior art, operation of the pump within the condensate pump assembly can lead to noise being generated by the pump assembly, this is undesirable not only for aesthetic reasons, but also as vibrations may be significant to damage any mechanical fixations used to secure the condensate pump assembly against a wall. Appliances such as air conditioning units are increasingly being installed in domestic environments, in addition to commercial and industrial environments, and so any noise and vibration created during operation is significantly less acceptable in a domestic setting. In addition, it is important in domestic environments to reduce the overall size of the appliance/condensate pump assembly so as to minimise the aesthetic intrusiveness of the system and to enable the system to be more easily hidden from sight, as the space available for such systems in domestic settings is often more restricted than in commercial/industrial premises. Also, it is advantageous for aesthetic reasons to be able to make such condensate pump assemblies as small and discrete as possible.

[0008] The present disclosure seeks to provide at least an alternative to condensate pump assemblies of the prior art.

BRIEF SUMMARY OF THE DISCLOSURE

[0009] Viewed from a first aspect, there is provided a method of controlling a condensate pump assembly which comprises a pump and a controller connected to the pump, the method comprising:

powering the pump;
measuring a current value drawn by the pump;
comparing the measured current value to a predetermined threshold current value stored in the controller; and
controlling the pump to be powered to operate in a condensate pumping mode if the measured current value exceeds the predetermined threshold current value; or
rendering the pump unpowered if the measured current value is less than the predetermined threshold current value.

[0010] The step of powering the pump may comprise powering the pump to operate for a predetermined start-test period, and the step of measuring a current value may comprise measuring a current value drawn by the pump during the start-test period.

[0011] The method may comprise wherein if the measured current value is less than the predetermined threshold current value and the pump remains unpowered, then

allowing a predetermined start test interval to elapse and then repeating the steps of powering the pump to operate for a predetermined start test period, measuring a current value drawn by the pump during the start test period and comparing the measured current value to a predetermined threshold current value stored in the controller to determine if the pump should be powered or remain unpowered.

[0012] The method may comprise repeating the steps above whilst the condensate pump assembly remains operational.

[0013] The start-test time period may be a predetermined number of milliseconds, and may, for example, be between 10 to 100 milliseconds, and may be between 20 to 50 milliseconds.

[0014] In an embodiment of the method, the start test interval may comprise between 0.25 seconds to 60 seconds, and may be between 0.5 seconds to 20 seconds, and may be one second.

[0015] The method may comprise, in the step of powering the pump to operate for the predetermined start test period, providing a pulse width modulated voltage to the pump at a pwm value less than the maximum rated value of the pump.

[0016] The step of measuring a current value may comprise measuring a current value drawn by the pump during a condensate pumping mode whilst the pump is operating; and the step of controlling the pump to be powered to operate in a condensate pumping mode may comprise continuing to power the pump to operate in the condensate pumping mode.

[0017] The step of rendering the pump unpowered may comprise switching off power to the pump.

[0018] The method may comprise, wherein if the measured current value exceeds the predetermined threshold current value and the pump remains operating in a condensate pumping mode, then allowing a predetermined operating test interval to elapse and then repeating the steps of measuring a current value drawn by the pump during the condensate pumping mode whilst the pump is operating and comparing the measured current value to the predetermined threshold current value stored in the controller to determine if the pump should remain powered to operate in the condensate pumping mode or be switched off.

[0019] The method may comprise repeating the above-mentioned steps whilst the condensate pump assembly remains in the condensate pumping mode.

[0020] The predetermined operating test interval may be of any suitable time period, and may be between .025 seconds to a minute, and may be between 0.5 seconds to 20 seconds, and may be one second.

[0021] The method may comprise any combination of the above-described methods.

[0022] In another aspect, there is provided a method of controlling a condensate pump assembly which comprises a pump and a controller connected to the pump, the method comprising:

measuring a current value drawn by the pump during a condensate pumping mode whilst the pump is operating;

comparing the measured current value to a predetermined upper alert threshold current value stored in the controller; and

continuing to powering the pump to operate in the condensate pumping mode if the measured current value is below the predetermined upper alert threshold current value; or

switching off power to the pump if the measured current value exceeds the predetermined upper alert threshold current value.

[0023] In another aspect, there is provided a method of controlling a condensate pump assembly which comprises a pump and a controller connected to the pump, the method comprising:

powering the pump to operate for a predetermined start-test period;

measuring a current value drawn by the pump during the start-test period;

comparing the measured current value to a predetermined upper alert threshold current value stored in the controller; and

leaving the pump unpowered if the measured current value is below the predetermined upper alert threshold current value; or

leaving the pump unpowered and entering an fault alert mode if the measured current value exceeds the predetermined upper alert threshold current value.

[0024] The methods may comprise, wherein if the measured current value exceeds the predetermined upper alert threshold current value, then signaling an alarm.

[0025] The method may comprise, wherein if the measured current value exceeds the predetermined upper alert threshold current value, then controlling an appliance from which the condensate pump assembly is arranged to pump condensate, to switch off.

[0026] In an embodiment of the method, the step of controlling the appliance to switch off may comprise switching off an evaporator of an air conditioning or HVAC system.

[0027] In an embodiment, if it is determined that the measured current value exceeds the predetermined upper alert threshold current value, the method may additionally comprise the steps of operating the pump in a clearance mode for a predetermined clearance period. Thereafter, the method may comprise measuring a current drawn by the pump, comparing the measured current with a predetermined upper alert threshold current value, and then continuing to powering the pump to operate in the condensate pumping mode if the measured current value is below the predetermined upper alert threshold current value; or switching off power to the pump if the

measured current value still exceeds the predetermined upper alert threshold current value.

[0028] In the above method steps, the controller may control the pump to operate in a condensate pumping mode after operating the pump for the clearance period in the clearance mode, and the current is measured when the pump is operating in the condensate pumping mode for current value comparison with an upper alert threshold current value. Alternatively, the controller may measure the current value at the end of the clearance period while the pump is operating in the clearance mode. The current measured whilst the pump is operating in the clearance mode may be compared to a predetermined upper clearance mode alert threshold current value which may be different to the predetermined upper alert threshold current value that the measured current value is compared to when the pump is operating in the condensate pumping mode. The predetermined upper clearance mode alert threshold current value may be a higher current value than the predetermined upper alert threshold current value.

[0029] The clearance mode of operation of the pump may comprise running the pump at a maximum speed, or a higher speed than a condensate pumping mode. This may be in order to attempt to dislodge a blockage in the liquid system. For example, the higher speed of the clearance mode of operation of the pump may be 70 - 100% of the maximum pump speed, or between 80 - 90% of the maximum pump speed. Alternatively, the higher speed of the clearance mode of operation of the pump may be proportionally higher rate than the condensate pumping mode pump speed, for example, 150 - 200% of the condensate pumping mode pump speed.

[0030] The clearance period may be a predetermined period of time, for example between 1 second and 20 seconds, or between 1 second and 10 seconds, or between 1 second and 5 seconds.

[0031] A method may include any of the above-described method steps.

[0032] In another aspect there is provided a method of controlling a condensate pump assembly which comprises a pump, a liquid receptacle configured to receive condensate to be pumped, a liquid level sensor received in the liquid receptacle to sense a level of condensate within the liquid receptacle, and a controller connected to the pump and liquid level sensor, the method comprising:

powering the pump to operate for a predetermined start-test period;
measuring a current value drawn by the pump during the start-test period;
comparing the measured current value to a predetermined threshold current value stored in the controller; and
leaving the pump unpowered if the measured current value is less than the predetermined threshold current value; or

[0033] if the measured current value exceeds the predetermined threshold current value, then calibrating the liquid level sensor by:

5 obtaining a liquid level signal from the liquid level sensor; and
storing the liquid level signal as a threshold liquid level sensor signal in the controller.

10 **[0034]** The method may comprise powering the pump to operate in a condensate pumping mode if the measured current value exceeds the predetermined threshold current value.

15 **[0035]** In another aspect there is provided a method of controlling a condensate pump assembly which comprises a pump, a liquid receptacle configured to receive condensate to be pumped, a liquid level sensor received in the liquid receptacle to sense a level of condensate within the liquid receptacle, and a controller connected to the pump and liquid level sensor, the method comprising:

measuring a current value drawn by the pump during a condensate pumping mode whilst the pump is operating;

25 comparing the measured current value to a predetermined threshold current value stored in the controller; and

continuing to powering the pump to operate in the condensate pumping mode if the measured current value exceeds the predetermined threshold current value; or

30 if the measured current value is below the predetermined threshold current value, then calibrating the liquid level sensor by:

35 obtaining a liquid level signal from the liquid level sensor; and
storing the liquid level signal as a threshold liquid level sensor signal in the controller.

40 **[0036]** The method may comprise stopping operation of the pump if the measured current value is below the predetermined threshold current value.

45 **[0037]** In an embodiment, the step of measuring the current value may comprise taking a plurality of current measurements over a predetermined sample period and averaging the plurality of current measurements to obtain a single averaged current measurement value. The sample period may be a predetermined number of milliseconds, and may, for example, be between 10 to 100 milliseconds, and may be between 20 to 50 milliseconds.

[0038] In another aspect, there is provided a condensate pump assembly for use in an air conditioning system, the condensate pump assembly comprising:

55 a housing comprising an upper housing portion;
a pump arranged to pump liquid from a liquid inlet to a liquid outlet; and

an outlet tube element connecting an outlet of the pump to the liquid outlet;
 wherein the upper housing portion comprises a plurality of fixation features extending from an underside of the upper housing portion; and
 wherein the pump is secured to the underside of the upper housing portion by at least one resilient attachment member connected to one or more of the fixation features and extending at least partially around the pump.

[0039] In another aspect, there is provided a condensate pump assembly for use in an air conditioning system, the condensate pump assembly comprising:

a housing comprising an upper housing portion;
 a pump arranged to pump liquid from a liquid inlet to a liquid outlet; and
 an inlet tube element connecting the liquid inlet to an inlet of the pump;
 wherein the inlet tube element connects the liquid inlet directly to the inlet of the pump without an intermediate liquid receptacle.

[0040] The upper housing portion may comprise a plurality of fixation features extending from an underside of the upper housing portion, and the pump may be secured to the underside of the upper housing portion by at least one resilient attachment member connected to one or more of the fixation features and extending at least partially around the pump.

[0041] The or each fixation feature may comprise a hook-shaped member.

[0042] The or each resilient attachment member may comprise an elastically deformable member tensioned around the pump and fixation features. The or each resilient attachment member may comprise an elastomeric strip or band, and may comprise a rubber O-ring.

[0043] An inlet tube element may connect the liquid inlet directly to an inlet of the pump without an intermediate liquid receptacle.

[0044] The outlet of the pump may be connected directly to the liquid outlet by the outlet tube element without an intermediate liquid reservoir.

[0045] The pump may comprise a rotary diaphragm pump.

[0046] The condensate pump assembly may comprise a longitudinal axis, and the pump may comprise an axis of rotation, and the axis of rotation of the pump may be parallel or coaxial with the longitudinal axis of the condensate pump assembly.

[0047] The condensate pump assembly may comprise a potting box comprising electrical control components sealed within the potting box, and all high-voltage electrical components and connections of the condensate pump assembly may be sealed within potting box.

[0048] The condensate pump assembly may not include a liquid level sensor for contacting liquid condensate.

sate.

[0049] At least one resilient pad may be disposed between the pump and the housing to suppress transmission of vibrations from the pump to the housing.

[0050] The condensate pump assembly may be configured to operate according to any of the methods described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0051] Embodiments of the invention are described hereafter, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a top perspective view of a condensate pump assembly of an embodiment, with a lower housing portion removed;

Figure 2 is a bottom perspective view of the condensate pump assembly of Figure 1 with the lower housing portion and a liquid condensate receptacle removed;

Figure 3 is cross-sectional view of the condensate pump assembly of Figures 1 and 2 taken along a longitudinal direction of the assembly, with the lower housing portion and liquid receptacle fitted;

Figure 4 is another bottom perspective view of the condensate pump assembly with the lower housing portion fitted and liquid receptacle removed;

Figure 5 is a perspective cross-sectional view of the liquid receptacle of the condensate pump assembly;

Figure 6 is a cross-sectional view of the condensate pump assembly along the line Z-Z of Figure 1;

Figure 7 is a flow chart of a first control method of operating a condensate pump assembly;

Figure 8 is a flow chart of a second control method of operating a condensate pump assembly;

Figure 9 is a flow chart of a third control method of operating a condensate pump assembly comprising the combined control methods illustrated in Figures 4 and 5;

Figure 10 is a bottom perspective view of a condensate pump assembly of another embodiment, with a portion of an outer housing removed

Figure 11 is a flow chart of a fourth control method of operating a condensate pump assembly; and
 Figure 12 is a flow chart of a fifth control method of operating a condensate pump assembly comprising the combined control methods illustrated in Figures 9 and 11;

Figure 13 is a flow chart of a sixth control method of operating a condensate pump assembly; and
 Figure 14 is a flow chart of a seventh control method of operating a condensate pump assembly.

DETAILED DESCRIPTION

[0052] Figures 1 to 4 show a condensate pump assembly with a portion of a housing removed to illustrate in-

ternal features. The condensate pump assembly 100 comprises a housing 105 comprising an upper housing portion 110 and lower housing portion 111. The housing 105 contains a pump 300. The upper housing portion 110 comprises a fluid inlet 115. A liquid receptacle 200 is provided, detachably coupled to the upper housing portion 110 and arranged to receive liquid from the fluid inlet 115. The upper housing 110 also includes a fluid outlet 455. A seal is formed between the upper housing portion 110 and lower housing portion 111 by a gasket (not shown). The pump 300 may be a rotary pump, in particular the pump 300 may be a rotary diaphragm pump, although other configurations of pump may be provided within the scope of the invention, for example a reciprocating pump, or peristaltic pump. An outlet of the pump 300 is fluidly communicated with the fluid outlet 455 by an outlet tube 456.

[0053] When the condensate pump assembly 100 is installed as part of an air conditioning system, the fluid outlet 455 is in fluid communication with a liquid drain (not shown) so that excess liquid can be removed from the air conditioning system via the condensate pump assembly 100. The housing 105 preferably comprises a skirt 117 extending inwardly around the fluid inlet 115. The skirt 117 is configured to seal against an inlet pipe which, in use, would be fluidly coupled to a condensate outlet of an air conditioning system for condensate to flow into the fluid inlet 115 of the condensate pump assembly 100. The skirt 117 is preferably made from a rubberised material to accommodate different sizes of inlet pipe, including inlet pipes that have an outer diameter larger than an internal diameter of the skirt 117. The skirt 117 also acts to prevent noise being emitted from the interior of the condensate pump assembly 100/housing 105 or interior of the liquid receptacle 200. Furthermore, the skirt 117 may also act to suspend the inlet pipe such that an end of the inlet pipe remains spaced from a base surface 225 of the receptacle 200 to maintain a flow of liquid into receptacle 200 without the inlet pipe being blocked by contact with the base surface 225. The skirt 117 is preferably twin-shot moulded to the fluid inlet 115.

[0054] Figure 5 is a perspective cross-sectional view of the liquid receptacle 200. An upper portion of the liquid receptacle 200 is open to receive condensate from an air conditioning unit (not shown) via the fluid inlet 115. The liquid receptacle 200 is shown having an inner wall 205 and an outer wall 210 sealed together to form an insulating gap 260 extending around substantially the entire outer surface of the inner wall 205. By surrounding the inner wall 205 the insulating gap 260, the insulating effects are maximised and the risk of condensate forming on the outer surface of the outer wall 210 is minimised. Preferably the insulating gap 260 is filled with air. However, other gaseous compositions or insulating material may be included within the insulating gap 260.

[0055] A pair of support members 230 is also shown extending from the base surface 225 and configured to secure a filter 232 within the liquid receptacle 200. By

placing the filter 232 in the fluid flow path between the fluid inlet and the pump and securing the filter 232 such that the filter 232 extends across the width of the liquid receptacle, larger particulate debris can be prevented from reaching the pump 300. The filter 232 has a length along the surface of the filter 232 in a direction across the liquid receptacle 200 greater than the distance between the facing walls of the liquid receptacle 200. This ensures that the cross-sectional area of the filter 232 is greater than the cross-sectional area of the distance directly across the liquid receptacle 200 whereby to improve the capacity of the filter 232. While the filter 232 is shown comprising a plurality of circular holes, it would be apparent that other shapes of holes may be used. While a pair of support members 230 have been shown, it would be apparent that other arrangements may be used to secure the filter 232. Such arrangements may include more or fewer than two extending members 230. The filter 232 may be secured to the underside of the upper housing portion 110 or the base surface 225 of the liquid receptacle 200. The filter 232 may be secured by slots or grooves within the surfaces that define the liquid receiving volume.

[0056] The liquid receptacle 200 may be secured to the housing 105 by selective release means. The selective release means allows the liquid receptacle 200 to be movable from a first position, connected to the housing 105, to a second position, removed from the housing 105.

[0057] As shown in Figures 3 to 5, the selective release means may include a resilient clip 215 and a peg 235 at the opposite end of the liquid receptacle 200 configured, in use, to apply a force against the housing 105 to secure the liquid receptacle 200 when attached to the housing 105. The force may be applied against an inner surface 245 of the housing 105 via an outer surface 240 of the peg 235. The illustrated arrangement allows a user to remove the liquid receptacle 200 from the housing 105, for example to clear the filter 232 of debris, by squeezing their thumb and finger together. This means a user is able to remove the liquid receptacle 200 using only a single hand. For example, the user is able to remove the liquid receptacle 200 by squeezing together their thumb and finger of their left or right hand. By enabling the removal of the liquid receptacle 200 with either hand, the flexibility of the present arrangement is further improved. The action of squeezing the thumb and finger together releases the resilient clip 215 from the housing 105 and releases a protrusion 220 (see Figure 5) of the resilient clip 215 from a corresponding recess 222 in the lower housing portion 111 of the housing 105 (see Figures 3 and 4) used to secure the liquid receptacle 200 in the housing 105. By squeezing the resilient clip 215 and outer wall 210 using opposing digits on a hand of a user, the resilient clip 215 can be disengaged from its respective lip, and in a single movement of the hand, release the liquid receptacle 200 for movement from the first position towards the second position. The movement of the liquid receptacle 200 after disengagement of the resilient clip

215 is substantially downwards in use. It will be understood that the selective release means is operable by any one of the hands of a user, and does not require both hands of a user, neither does such operation require one particular hand of the user. That is to say, the left or right hand of the user may be used to operate the selective release means. Furthermore, squeezing the resilient clip 215 and outer wall 210 also serves to grip the liquid receptacle 200 securely in the hand of a user, preventing accidental spillage of the contents thereof. In the present example, the resilient clip 215 and outer wall 210 can be squeezed between a thumb and forefinger of the same hand for to release the liquid receptacle 200 from the first position. The outwardly biased resilient clip 215 and peg 235 exert a pressure against the respective corresponding recess 222 and inner wall 245, whereby to substantially prevent any rattle of the liquid receptacle 200 in the housing 105 when the liquid receptacle 200 is secured in the first position in the housing 105. The user's thumb or finger may be received by a slot 227 in the housing 105 to enhance the user's grip on the liquid receptacle 200 prior to squeezing the resilient clip 215. The outer wall 210 may have a protrusion 255 to further enhance the user's grip on the liquid receptacle 200. The thumb or finger of a user may rest on the protrusion 255 when removing the liquid receptacle 200 from the housing 105. The peg 235 may be stiffened by a support member 250 (see Figure 3) extending from the inner wall 205. The peg 235 may have a first longitudinal axis and the support member 250 may have a second longitudinal axis and the first longitudinal axis may be substantially parallel to the second longitudinal axis. The support member 250 may extend the length of the peg 235. While a resilient clip 215, in the form of a cantilever joint, and peg 235 are illustrated here, it would be apparent that other releasable joints may be used to secure the liquid receptacle 200. While a protrusion 255 may be in the form of a horizontal bar, it would be apparent that other arrangements to enhance the user's grip on the outer wall 210 are possible. Outer wall 210 may include one or more high friction materials to enhance the user's grip on the outer wall 210. For example, the outer wall may include one or more rubberised sections. The outer wall may be made from one or more thermally insulating materials, such as plastic.

[0058] The liquid receptacle 200 is shown having a raised section 265 extending upwardly from the base surface 225 of the inner wall 205. The raised section 265 is arranged to be located under the fluid inlet 115 to prevent an inlet pipe from resting against the bottom surface 225 of the receptacle 200. While it is preferable to have raised section 265 under the fluid inlet 115, the raised section 265 and/or skirt 117 are not essential to the present invention. While a raised section 265 comprising three extensions arranged in a radial manner is illustrated in Figure 5 it would be apparent that other shapes and configurations of extensions may be used to prevent the inlet pipe from contacting the base surface 225. For example,

more or fewer than three extensions may be used. Arrangements of extensions in a geometric arrangement, such as rows or a plurality of dimples, may be included in the liquid receptacle 200. The peg 235 used to secure the liquid receptacle 200 to the housing 105 may protrude through a cutaway 140 formed in the upper housing portion 110.

[0059] The housing 105 is also shown having a slot 130 (see Figure 3) extending into the liquid receiving volume defined by the inner wall 205. The slot 130 is configured to receive a liquid level sensor 165 (see Figures 2 and 4) that can detect a liquid level within the liquid receptacle 200 and control the pump 300 accordingly. While the liquid level sensor 165 is preferably a non-contact sensor, such as a capacitance sensor, it would be apparent that another type of liquid level sensor may be used instead.

[0060] As shown in Figures 1 to 3, the pump 300 contained within the housing 105 is connected to the liquid receptacle 200 by a pump inlet ducting 310. The inlet ducting 310 comprises a vertical pick-up pipe 311 which, in the assembled configuration of the condensate pump assembly 100, extends into the liquid receptacle 200 to near the base 225 to draw collected condensate out of the liquid receptacle 200. The pick-up pipe 311 is connected to a first inlet tube section 312 which extends along the majority of the length of the housing 105 to an angled coupler 313 which angles the inlet ducting by approximately 90 degrees downwards, and is then connected to a second inlet tube section 314 which fluidly connects the angled coupler 313 to an inlet of the pump 300. As mentioned above, the outlet of the pump 300 is connected to the liquid outlet 455 by the outlet tube 456.

[0061] The upper housing portion 110 comprises a plurality of fixation features 335 used to secure the pump 300 to the upper housing portion 110. In the exemplary embodiment shown, the fixation features comprise hooks 335 (see Figure 1). The hooks may be formed integrally with the upper housing 110, or may be provided on a separate member such as a support chassis which is secured to the upper housing portion 110 by known means, such as mechanical fastening such as with screws or the like, by welding, or by being bonded to the upper housing portion 110. The pump 300 is secured to the upper housing portion 110 by resilient attachment members 340 which extend around the hooks 335 and around a lower portion of the pump 300. As such, the pump 300 is suspended from the upper housing portion 110. The resilient attachment members 340 may comprise plastic or elastic members, and may comprise an elastomer material, and may comprise elastomeric bands or O-rings. The resilient attachment members 340 may be stretched between the hooks 335 so that they are in tension retaining the pump 300 in place.

[0062] A resilient pad 341 (see Figure 6) is also provided between the pump 300 and the upper housing portion 110 (or support chassis, if present), in direct contact with the pump 300 and the surface immediately adjacent

to the pump 300. The resilient attachment members 340 therefore serve to retain the pump 300 in contact with the resilient pad 341. The resilient pad 341 may be made of any suitable material, such as plastic or elastomer, and may be made of a sponge or rubber material. The resilient pad 341 therefore prevents direct contact between the pump 300 and an adjacent hard surface of the condensate pump assembly 100 such as the upper housing portion 110 and/or support chassis. It will be appreciated that more than one such resilient pad 341 may be provided within the scope of the present disclosure.

[0063] The above-described arrangement of fixation features 335, resilient attachment members 340 and resilient pad(s) can be considered as an anti-vibration arrangement configured to reduce the noise of the condensate pump assembly 100 in use. Suspending the pump 300 from the housing 105 in the above-described manner minimises the vibrations that are transmitted from the pump 300 to the housing 105 during operation. The resilient attachment members 340 may be sufficiently deformable to minimise the effects of vibrations which may be generated by the pump 300. Furthermore, the resilient pad(s) 341 preventing direct contact between the pump 300 and an adjacent hard surface of the condensate pump assembly 100 such as the upper housing portion 110 and/or support chassis, reduces or substantially prevents vibrations from the pump 300 during use being transmitted to those adjacent hard surfaces/components. Although two resilient attachment members 340 are shown in Figures 1 to 3, the invention is not limited to such arrangement, and one or more than two resilient attachment members 340 may be provided.

[0064] The housing 105 is generally elongate with a longitudinal axis shown as X-X in Figures 1 and 3. The pump 300 is shown as a substantially cylindrical body having a central axis Y-Y as shown in Figure 2. Embodiments of the condensate pump assembly 100 in which the pump 300 is a rotary pump, or functions in a rotary motion, may be preferred for providing an advantage of noise and vibration reduction. Since the inherent nature of motion of such pumps is rotary, vibration caused by alternative configurations of pump such as reciprocating pumps, is largely reduced or eliminated. Also, the continuous rotary movement of such rotary pumps in operation means that pulsations in the fluid flow, which can lead to excessive noise and vibration in use, are largely reduced or avoided. Further advantageously, the pump 300 may be mounted within the housing 105 such that the central axis Y-Y of the pump 300 is parallel to, or coaxial with, the longitudinal axis X-X of the housing 105. This can further ensure any vibration from the pump in use causes minimal, if any, noise or vibration of the overall condensate pump assembly 100. This is because the alignment of axes X-X, Y-Y reduces the possibility of eccentric/off-centre vibrations being transmitted to the housing 105.

[0065] A further advantage of utilising a rotary pump 300 in the arrangement illustrated is that the absence or

significant reduction in pulsations in the liquid condensate being pumped away by the condensate pump assembly 100 means that it is not necessary to include physical or structural features between the pump outlet and the liquid outlet 455 to dissipate pulsations in the pumped liquid to reduce noise or vibration in the condensate pump assembly 100. That is, the outlet of the pump 300 is connected directly to the liquid outlet 455 by the outlet tube 456 without any intermediate reservoir, container, baffles or other structural features to control the exiting fluid flow. This advantageously makes the condensate pump assembly 100 simpler and cheaper to manufacture with fewer component parts. The absence of an intermediate liquid reservoir between the pump outlet and the liquid outlet 455 also means that the overall housing 105, and so the overall condensate pump assembly 100, can be made smaller and more discrete, improving the aesthetics of the device.

[0066] It should be appreciated that the illustrated arrangement is just one way of mounting the pump 300 within the housing, and although provides one or more of the advantages discussed above, other arrangements suitable for mounting the pump 300 are intended to fall within the scope of the present disclosure. The pump 300 may alternatively be mounted in a vertical arrangement, or out of axial alignment with the longitudinal axis of the housing 105.

[0067] In an exemplary embodiment, the condensate pump assembly 100 includes an anti-syphoning device 457 (see Figure 1). Syphoning can arise from the pressure difference between a discharge line, through which liquid condensate is removed from the condensate pump assembly 100 out of the liquid outlet 455, continuing to remove liquid from the outlet tube 456 when the pump 300 is switched off. Without an anti-syphoning device, the pump 300 may run dry as liquid would be drawn through the pump 300. This could lead to the pump 300 starting up from a 'dry' state, which in turn would result in the pump 300 operating in a noisy manner. The anti-syphoning device may comprise a one-way valve formed in fluid communication with the liquid outlet 455 or with the outlet tube 456, configured to allow a fluid flow into the liquid outlet 455/outlet tube 456, but prevent fluid flow through the one-way valve out of the liquid outlet 455/outlet tube 456. Air may be drawn into the liquid outlet 455/outlet tube 456 if pressure in the discharge line is sufficient to cause syphoning. The inflow of air can equalise the pressure difference to prevent syphoning occurring. In alternative embodiments, the condensate pump assembly 100 may not include an anti-syphoning device but instead, an anti-syphoning device may be installed in a liquid outlet hose downstream of the liquid outlet 455.

[0068] The condensate pump assembly 100 of the first exemplary embodiment includes a liquid level sensor 165 configured to detect a liquid level within the liquid receptacle 200. As shown, the liquid level sensor 165 is a dip-sensor configured to output a signal indicative of the liquid level within the liquid receptacle 200 by detecting when

liquid is covering at least a portion of the liquid level sensor 165. In this example, the liquid level sensor 165 is a capacitive liquid level sensor arranged to output a signal indicative of the liquid level within the liquid receptacle 200 based on a change in capacitance of the medium in contact with a portion of the liquid level sensor 165. It will be appreciated, however, that other types of liquid level sensor may be used instead.

[0069] The condensate pump assembly 100 further comprises a sealed potting box 500 which houses the electrical control components, including a pump controller. The pump controller may be implemented in hardware or software, or a combination of both. The pump controller may comprise a processor and a memory. The pump controller is configured to operate the pump 300 when the liquid level sensor 165 outputs a first signal indicative of a liquid level within the liquid receptacle 200 at least a predetermined amount above a lower end of the slot 130 the liquid level sensor 165 is located within. The pump controller is also configured to stop the pump 300 when the liquid level sensor 165 outputs a second signal indicative of a liquid level within the liquid receptacle 200 approaching or below a level of the liquid inlet 115. The pump controller is also configured to output a warning when the liquid level sensor 165 outputs a warning signal indicative of a liquid level within the liquid receptacle 200 above a predetermined warning level within the liquid receptacle 200. The pump controller is arranged to stop operation of the air conditioning unit in response to the warning output.

[0070] The condensate pump assembly 100 may include a PCB 145 within the potting box 500, and the pump controller may be mounted on, or otherwise connected to, the PCB 145. Having control components of the condensate pump assembly sealed within the potting box can mean those components are secure from water contamination from condensate or other ambient liquids to prevent against malfunction and increase reliability of the overall condensate pump assembly 100. In particular, in an embodiment, the condensate pump assembly 100 receives power via a high voltage supply, such as 240V mains supply, and has low voltage operative components, such as the pump 300 and liquid level sensor 165, which may operate at, for example, 6V, 12V or 24V. The high voltage supply may be fed to the control components within the potting box 500 through a high voltage supply cable (not shown) fluidly sealed at the point the high voltage supply cable enters the potting box 500. All high voltage connections are advantageously contained within the sealed potting box 500, including transformer means to step down the high voltage supply to a required low voltage supply. Only low voltage electrical connections, via sealed low voltage wiring, exit the potting box 500 to feed to components of the condensate pump assembly 100 external to the potting box 500, such as the pump 300 and liquid level sensor 165. As such, all high voltage connections and electrical control components are sealed within the potting box 500 to prevent against ex-

ternal water contact which could damage the components and cause malfunction.

[0071] The pump controller may be configured to control operation of the condensate pump assembly 100 in a number of different ways, using a number of different and optional control algorithms within the scope of the present disclosure. Some methods of pump operation may relate to the operation of the condensate pump assembly 100 at a start-up process. Other methods of pump operation may relate to the operation of the condensate pump assembly 100 during operation. Methods of operation of a condensate pump assembly 100 of the present disclosure are described below.

[0072] Generally, in operation, the pump 300 will consume a certain current when pumping liquid condensate (i.e. water). If the pump 300 reaches a point where all of the condensate has been pumped away, the pump may begin to ingest air. Air may also ingress into the pump 300 if the effect of syphoning (described above) draws the liquid condensate out of the pump 300 and tubes of the condensate pump assembly 100 so that only air remains in the system. If the pump 300 continues to operate having ingested air, it will consume a lower current pumping air than when pumping liquid/water, due to the significant difference in viscosity, density and the compressibility of air. Accordingly, the pump controller can use measurements of consumed current during pump operation to effect various control methods, as described hereafter.

[0073] In a first arrangement, the pump controller may be arranged to measure the current consumed by the pump 300 as part of a start-up process. That is, when the condensate pump assembly 100 is off, to a point where the amount of accumulated condensate reaches a threshold value at which point the condensate pump assembly needs to operate to begin removing the condensate. Such start-up control method is shown schematically in Figure 7. In such first arrangement, the method starts at step S1, for example when the condensate pump assembly 100 is initially switched on or has completed initiation operation checks after having been initially switched on. At step S2, the pump controller initially supplies power to the pump for a short, predetermined start-test period and simultaneously measures the current I_m drawn by the pump 300 during the start-test period. At step S3, the pump controller compares the measured current I_m to a lower threshold current value I_{th} , which may be stored in the memory, and which is a low current value at which it is determined that a pump may be pumping air instead of liquid. If the measured current I_m is below the threshold value I_{th} , the pump controller determines that there is air in the pump and does not switch the pump 300 on continuously as it has determined there is not condensate in the system to be removed. The method then proceeds to step S4 where the pump controller ensures the pump 300 is unpowered, and then to step S5 where the pump controller allows a predetermined start test interval to elapse before the method

loops back to step S2 again.

[0074] If at step S3 the measured current I_m is above the threshold value I_{th} , the pump controller determines that there is water in the pump 300 and proceeds to step S6 to power the pump 300 in a condensate pumping mode, and/or continuously since it has determined there is condensate in the system which needs to be removed.

[0075] Whilst the measured current I_m remains below the threshold value I_{th} and so the pump 300 is not switched on continuously, the pump controller continues around the loop of method steps S2, S3, S4 and S5 to continue to interrogate or "poll" the pump current at the predetermined start test interval. This loop continues to be repeated until at step S3 the measured current I_m exceeds the threshold current value I_{th} and the condensate pump assembly 100 is required to operate.

[0076] The start-test time period in the above-described method at step S2 may be a predetermined number of milliseconds, and may, for example, be between 10 to 100 milliseconds, and may be between 20 to 50 milliseconds. Furthermore, the predetermined start test interval in the above-described method at step S5 may be of any suitable time period, and may be between 0.25 seconds to a minute, and may be between 0.5 seconds to 20 second, and may be every second.

[0077] In a second arrangement, the pump controller may be arranged to measure the current consumed by the pump 300 as part of an operation monitoring process. That is, when the condensate pump assembly 100 is on and is in a condensate pumping mode, pumping to remove condensate, to a point where the amount of accumulated condensate falls below a threshold value, which may be complete removal of accumulated condensate, at which point the condensate pump assembly needs to be stopped from operating. Such operation monitoring control process is shown schematically in Figure 8. In such second arrangement, at step S10, the pump is operating in a condensate pumping mode and/or continuously, and at step S11, the pump controller measures the current I_m being consumed by the pump 300. At step S12, the pump controller compares the measured current I_m to a lower threshold current value I_{th} , which may be stored in the memory and which is a low current value at which it is determined that a pump may be pumping air instead of liquid. If the measured current I_m is above the threshold value I_{th} , the pump controller determines that there is still water in the pump 300 and continues to power the pump to continue operating since it has determined there is still condensate in the system which needs to be removed. The method proceeds to step S13 where the pump controller allows a predetermined operating test interval to elapse before the method loops back to step S11 again.

[0078] If at step S12 the measured current I_m is below the threshold value I_{th} , the pump controller determines that there is air in the pump and proceeds to step S14 to stop powering the pump 300 as it has determined there is no longer condensate in the system needing to be re-

moved.

[0079] Whilst the measured current I_m is above the threshold value I_{th} and so the pump 300 is continued to be powered to operate continuously, the pump controller continues around the loops of method steps S11, S12 and S13 to continue to interrogate or "poll" the pump current at the predetermined operating test interval. This loop continues to be repeated until at step S12, the measured current I_m falls below the threshold current value I_{th} and the condensate pump assembly 100 is required to stop operating.

[0080] The predetermined operating test interval in the above-described method may be of any suitable time period, and may be between 0.25 seconds to 1 minute, and may be between 0.5 seconds to 20 seconds, and may be every second.

[0081] As mentioned previously, if a pump 300 runs whilst dry, it can create excessive noise and also may damage the pump 300, shortening the component's operational lifespan. An advantage of the above-described methods is that the pump 300 is prevented from starting, or continuing to operate, if the pump 300 has ingested air, thereby avoiding such problems, extending the pump life and reducing noise, and saving electrical energy. When used in the embodiment of condensate pump assembly 100 illustrated in Figures 1 to 4, the above methods of operation can also provide a failsafe mechanism in the event that the liquid level sensor 165, or other level sensing mechanism of known condensate pump assemblies, fails and would otherwise continue to power the pump when air had been ingested.

[0082] It will be appreciated that a condensate pump assembly 100 of the present disclosure may comprise a pump controller configured to employ both the first and second arrangements of control methods described above, or only one of those control methods. Figure 9 schematically shows a control method of a third arrangement which employs both the first and second arrangements shown in Figures 7 and 8 and described above. Description of those features of the control methods of Figures 7 and 8 will not be repeated. However, it will be noted that step S6 of the first control arrangement corresponds to the start step S10 of the second control arrangement. Also, after step S14 of the second control arrangement, the combined control method of Figure 9 then loops back to step S5 of the first control arrangement where the pump controller then waits for a start-test interval to elapse before beginning the start-up control method of the first arrangement.

[0083] In the first, start-up control method described above, when the pump controller initially supplies power to the pump 100 for a predetermined start-test period, the pump controller may supply a pulse width modulated ("pwm") voltage to the pump 300 which is less than the maximum voltage rating of the pump 300. For example, if the pump was a 12V rated pump, the pump controller may supply pwm 9V to the pump, or around 60 - 90% of the maximum voltage rating, or 70 - 80% of the maximum

voltage rating, or around 75% of the maximum voltage rating. The supplied pwm voltage may be just sufficient to get the motor of the pump 300 started. Similarly, during operation of the pump 300, the pump controller may continue to monitor the operation of the pump and supply a pwm voltage to the pump 300 which is just sufficient to maintain the pump in operation whilst it is required to be operating. An advantage of this operating method is that it is energy efficient in that only the minimum amount of power required for operation is supplied to the pump 300. Additionally, as the pump is operating at a lower power or voltage, it may be running more slowly and therefore more quietly, reducing the noise the unit generates, making the condensate pump assembly less intrusive during use.

[0084] A further advantage which can follow from the above-described control methods is that since pump current measurement is used to determine if condensate is present and so whether the condensate pump assembly needs to be operated or not, other the liquid level sensing components may be omitted and the condensate pump assembly operation may be determined solely by the current measuring methods described above. Such an alternative embodiment of condensate pump assembly 100 is intended within the scope of the present disclosure, and is illustrated in Figure 10 and described below.

[0085] Figure 9 shows an alternative configuration of condensate pump assembly 100 similar to that shown in Figures 1 and 2, and in which like features retain the same reference numerals and detailed description thereof will not be repeated. A difference in the embodiment of Figure 10 is that the liquid receptacle 200 is omitted, as is the liquid level sensor 165. Instead, the liquid inlet 115 is connected directly to the first inlet tube section 312 by a primary inlet tube 315. Or considered alternatively, the first inlet tube section 312 may extend continuously to the liquid inlet 115. The primary inlet tube 315/first inlet tube section 312 may be connected to the skirt 117 to allow inlet pipes of varying dimensions to be coupled to the condensate pump assembly 100, as described above.

[0086] An advantage of the condensate pump assembly 100 of the second embodiment is that by omission of the liquid receptacle 200, liquid level sensor 165, and associated physical and electrical connections, the condensate pump assembly 100 is simpler and therefore can be cheaper and easier to manufacture. In addition, the absence of the liquid receptacle 200 and liquid level sensor 165 means the overall condensate pump assembly 100 is smaller and more discrete, and so can be made less aesthetically intrusive, can more easily be hidden from view, or even more easily integrated into the appliance, such as air conditioning unit, with which it is to operate. Yet further, the absence of the liquid receptacle 200 and liquid level sensor 165 means there is less requirement for maintenance (for example, cleaning of receptacle filter 232) or risk of water escape from the liquid receptacle 200 and resulting damage.

[0087] In a fourth arrangement, the pump controller may be arranged to measure the current consumed by the pump 300 as part of an operation monitoring process but with the aim of detecting pump failure by means of a pump alert control method. In a situation where the pump 300 may become blocked through ingested debris, or if a mechanical fault may have occurred with the pump 300 preventing correct smooth operation, the pump may become jammed or struggle against the blockage or other mechanical fault. In such a case, the current consumed by the pump would be higher than in the regular correct functioning state. Also, if a pump 300 is continued to be powered to operate against such blockage/mechanical fault, it could lead to pump failure.

[0088] Such a pump alert monitoring control process is shown schematically in Figure 11. In such fourth arrangement, at step S20, the pump is operating in a condensate pumping mode and/or continuously, and at step S21, the pump controller measures the current I_m being consumed by the pump 300. At step S22, the pump controller compares the measured current I_m to an alert threshold current value I_{al} , which may be stored in the memory, and which is a high current value at which it is determined that a pump may be blocked or faulty. If the measured current I_m is below the alert threshold value I_{al} , the pump controller determines that the pump is functioning correctly without detected fault and continues to power the pump. The method proceeds to step S23 where the pump controller allows a predetermined operating test interval to elapse before the method loops back to step S21 again.

[0089] If at step S22 the measured current I_m is above the alert threshold value I_{al} , the pump controller determines that there is a fault with the pump and that continued operation of the pump could cause increased damage, failure and/or risk to the appliance/condensate pump assembly 100, and the method therefore proceeds to step S24 to stop powering the pump 300. Furthermore, since the condensate pump assembly 100 is then rendered inoperable, at step S24 the method may also cause the appliance, such as the air conditioning unit, to stop operating to prevent continued production of condensate. This may be by means of an alarm signal to activate a relay of the appliance and may comprise activating a relay of an air conditioning system condenser, which may trigger the overall system to switch off. Yet further, at step S24 an alert signal may be provided to trigger a fault alarm on the condensate pump assembly, or remotely to a connected device or control apparatus to alert operators that maintenance of the condensate pump assembly 100 is required.

[0090] Whilst the measured current I_m is below the alert threshold value I_{al} and so the pump 300 is continued to be powered to operate continuously, the pump controller continues around the loops of method steps S21, S22 and S23 to continue to interrogate or "poll" the pump current at the predetermined operating test interval. This loop continues to be repeated until at step S22, the meas-

ured current I_m exceeds the alert threshold current value I_{ai} and the condensate pump assembly 100 is controlled to stop operating.

[0091] The predetermined operating test interval in the above-described method may be of any suitable time period, and may be between .025 seconds to a minute, and may be between 0.5 seconds to 20 seconds, and may be around every second.

[0092] The fourth arrangement is described above in the context of the pump operating in a condensate pumping mode. However, the alert detection method of the fourth arrangement may equally be performed from when the pump is off, or as a start-up test method. In such a control method, instead of the pump operating in a condensate pumping mode at step S20, the method would start when the condensate pump assembly 100 off and the pump controller would initially supply power to the pump for a short, predetermined start-test period and simultaneously measures the current I_m drawn by the pump 300 during the start-test period. Thereafter, the method would continue from step S22 of the fourth arrangement described above.

[0093] In the above-described control methods, a current being consumed by the pump 300 is measured to determine the status of the pump and, based on the measured current, operation of the pump 300 is controlled accordingly. It may be sufficient to take one sample current measurement during pump operation in order to implement the respective control method. Alternatively, in an optional embodiment, a plurality of current measurements may be taken within a predetermined period of time. For example, in the first control method described above, at step S2, during the start-test period where the pump 300 is initially powered, the current I_m drawn by the pump 300 may be measured a plurality of times instead of just once. The pump controller may then sum the current measurements and divide by the number of current measurement events to obtain an average measured current value I_m .

[0094] An advantage of the above-described method of obtaining an average measured current value is that it helps avoid anomalies in current measurement, for example if one measurement was erroneously high or low, the error would largely be cancelled out by the averaging process of the subsequent correct current measurements. This therefore helps to compensate for discrepancies in the current readings taken. Furthermore, in a method where a pwm voltage is supplied to the pump, the method of obtaining an average measured current value helps smooth out variations in the current measurements which could occur depending on what point in the pwm voltage supply signal the individual current measurements are taken.

[0095] The number of individual current measurements taken in each sample period may vary within the scope of the invention, and may vary depending on the sample period and on the form of pwm voltage provided to the pump 300. Example numbers of individual current

measurements taken in each sample period may be between 2 and 15, and may be between 3 and 10, and may be 5 samples.

[0096] Although the method of obtaining an average measured current value is described above in the context of the first control method, it will be appreciated that such a current sampling method may be applied to any of the control methods or algorithms involving pump current measurement described herein.

[0097] In a variant of the fourth arrangement, if it is determined that the measured current is greater than the upper alert threshold value I_{ai} , it may be concluded that there is a blockage in the pipelines and it may be desirable to attempt to operate the pump to dislodge a blockage before then determining whether to stop operation of the pump or to continue to power the pump in a condensate pumping mode. Such additional function could be provided both during operation of the pump in a condensate pumping mode, and/or as part of the start-up test method described above.

[0098] Such a variant of the fourth arrangement is illustrated by the optional method steps shown in broken lines in Figure 11. Here, at step S22, if it is determined that the measured current I_m is above the alert threshold value I_{ai} , the pump controller instead proceeds to a step S25 where the controller operates the pump in a clearance mode for a predetermined clearance period.

[0099] Then, at step S26, the controller may revert to operating the pump in a condensate pumping mode and measures the current I_m being drawn by the pump 300. At step S27, the controller compares the measured current I_m with a predetermined upper alert threshold current value I_{ai} . At this stage, if the measured current value I_m is below the predetermined upper alert threshold current value I_{ai} , it is determined that the blockage has been cleared, it is safe to operate the pump, and the method reverts to step S20 to operate the pump in a condensate pumping mode. However, if at step S27 the measured current value I_m is greater than the predetermined upper alert threshold current value I_{ai} , it is determined that the blockage has not been cleared, and so operation of the pump should not continue. Therefore, the method reverts to step S24 at which the pump is stopped, and other operations described above are conducted.

[0100] In the above method, the controller may control the pump to operate in a condensate pumping mode after operating the pump for the clearance period in the clearance mode (at step S25), and before the current is measured again (at step S26). Therefore, the current may be measured when the pump is operating in the condensate pumping mode to obtain a current value for comparison with an upper alert threshold current value I_{ai} . Alternatively, the controller may measure the current value towards or at the end of the clearance period while the pump is operating in the clearance mode (at step S25). The current measured whilst the pump is operating in the clearance mode may be compared to a predetermined upper clearance mode alert threshold current value I_{cma} .

which may be different to the predetermined upper alert threshold current value I_{al} that the measured current value is compared to when the pump is operating in the condensate pumping mode. The predetermined upper clearance mode alert threshold current value I_{cma} may be a higher current value than the predetermined upper alert threshold current value I_{al} .

[0101] The clearance mode of operation of the pump may comprise running the pump at a maximum speed, or a higher speed than a condensate pumping mode. This may be in order to attempt to dislodge a blockage in the liquid system. For example, the higher speed of the clearance mode of operation of the pump may be 70 - 100% of the maximum pump speed, or between 80 - 90% of the maximum pump speed. Alternatively, the higher speed of the clearance mode of operation of the pump may be proportionally higher rate than the condensate pumping mode pump speed, for example, 150 - 200% of the condensate pumping mode pump speed.

[0102] The clearance period may be a predetermined period of time, for example between 1 second and 20 seconds, or between 1 second and 10 seconds, or between 1 second and 5 seconds.

[0103] It will be appreciated that a condensate pump assembly 100 of the present disclosure may comprise a pump controller configured to employ any combination of the first, second, third and fourth arrangements of control method described above, or only one of those control methods. Figure 12 schematically shows a control method of a fifth arrangement which employs both the third and fourth arrangements (that is, the first, second and fourth arrangements) shown in Figures 9 and 11 and described above. Description of those features of the control methods of Figures 9 and 11 will not be repeated. However, it will be noted that step S12 of the second/third control arrangement, if it is determined that the measured current I_m is greater than the threshold value I_{th} , the method then proceeds to the query step S22 of the fourth method, where it is determined whether the measured current I_m is greater than the alert threshold value I_{al} . If the measured current I_m is greater than the alert threshold value I_{al} , the method proceeds to step S24 as per the fourth arrangement to stop powering the pump 300, stop operation of the appliance and generate an alert signal. If however, at step S22 it is determined that the measured current I_m is less than the alert threshold value I_{al} , the method proceeds to step S13 of the second/third arrangement (equivalent to step S23 of the fourth arrangement) where the pump controller then waits for an operating test interval to elapse before looping back to step S11 of the second/third arrangement to measure the current I_m again.

[0104] In a sixth arrangement, the pump controller may be arranged to perform a calibration process for a liquid level sensor 165 in embodiments of condensate pump assembly including such liquid level sensor 165. Such control method may be performed during operation of the condensate pump assembly 100, that is, during a

condensate pumping mode, or at initial start-up of the condensate pump assembly 100. The calibration process comprises measuring the current consumed by the pump 300 and comparing the measured current to a threshold current value, and also cross-referencing with a liquid level signal provided by the liquid level sensor 165. Such a calibration process is shown schematically in Figure 13. In such sixth arrangement, the method starts at step S30, for example when the condensate pump assembly 100 is initially switched on or has completed initiation operation checks after having been initially switched on. At step S31, the pump controller initially supplies power to the pump for a short, predetermined start-test period and simultaneously measures the current I_m drawn by the pump 300 during the start-test period. At step S32, the pump controller compares the measured current I_m to a lower threshold current value I_{th} , which may be stored in the memory, and which is a low current value at which it is determined that a pump may be pumping air instead of liquid. If the measured current I_m is below the threshold value I_{th} , the pump controller determines that there is air in the pump and does not switch the pump 300 on continuously as it has determined there is not condensate in the system to be removed. The method then proceeds to step S33 where the pump controller ensures the pump 300 is unpowered, and then to step S34 where the pump controller allows a predetermined start test interval to elapse before the method loops back to step S31 again.

[0105] If at step S32 the measured current I_m is above the threshold value I_{th} , the pump controller determines that the condensate level in the liquid receptacle 200 has reached a point where there is water to be pumped away and there is therefore water in the pump 300. The method then proceeds to step S35 to obtain a signal or reading R_m from the liquid level sensor 165 representing the level of liquid condensate in the liquid receptacle 200 at that threshold point. At step S36, the pump controller then stores that liquid level signal or sensed reading as being the threshold lower liquid level R_{th} at which point the pump 300 needs to start operating to pump away condensate. At step S37, the pump controller then operates the pump 300 in a condensate pumping mode. The liquid level sensor 165 is thereby calibrated for future use of the condensate pump assembly 100.

[0106] In a seventh arrangement, the pump controller may be arranged to perform a calibration process for a liquid level sensor 165 in embodiments of condensate pump assembly including such liquid level sensor 165. The seventh arrangement is similar to the control method of the sixth arrangement, except it starts from a point in which the pump 300 is powered in a pumping mode. Such a calibration process is shown schematically in Figure 14. In such seventh arrangement, at step S40, the pump 300 is operating in a condensate pumping mode and/or continuously, and at step S41, the pump controller measures the current I_m being consumed by the pump 300. At step S42, the pump controller compares the measured

current I_m to a lower threshold current value I_{th} , which may be stored in the memory and which is a low current value at which it is determined that a pump may be pumping air instead of liquid. If the measured current I_m is above the threshold value I_{th} , the pump controller determines that there is still water in the pump 300 and continues to power the pump to continue operating since it has determined there is still condensate in the system which needs to be removed. The method proceeds to step S43 where the pump controller allows a predetermined operating test interval to elapse before the method loops back to step S41 again.

[0107] If at step S42 the measured current I_m is below the threshold value I_{th} , the pump controller determines that there is air in the pump as the liquid level in the liquid receptacle 200 has reached a point where there is no condensate left to be pumped away, or it has reached a lower threshold level where pumping is no longer required. The method then proceeds to step S44 to obtain a signal or reading R_m from the liquid level sensor 165 representing the level of liquid condensate in the liquid receptacle 200 at that threshold point. At step S45, the pump controller then stores that liquid level signal or sensed reading as being the threshold lower liquid level R_{th} at which point the pump 300 no longer needs to operate to pump away condensate. At step S46, the pump controller then stops the pump 300 from operating in a condensate pumping mode. The liquid level sensor 165 is thereby calibrated for future use of the condensate pump assembly 100.

[0108] It will be appreciated that the sixth and seventh arrangements may be combined into a single calibration process, which calibrates the liquid level sensor both at start up and during operation. In such an embodiment, the step S37 of the sixth arrangement is the same and equivalent to step S40 of the seventh arrangement. Furthermore, after step S46 of the seventh arrangement, the method would loop back to step S34 of the sixth arrangement.

[0109] It is intended within the scope of the present disclosure that a condensate pump assembly may utilise either one of the control methods of the sixth and seventh arrangements, or both of those control methods, to calibrate a liquid level sensor 165. Furthermore, the scope of the present disclosure is intended to encompass any non-mutually exclusive combination of any of the control methods of the first to seventh arrangements.

[0110] Although a number of control methods for operation of a condensate pump assembly are described herein together with some embodiments of condensate pump assembly 100, the control methods are not intended to be implemented in or used only with the embodiments of condensate pump assembly shown and described, and any one or combinations of such control methods may be implemented in or used with any other suitable condensate pump assembly.

[0111] Throughout the description and claims of this specification, the words "comprise" and "contain" and

variations of them mean "including but not limited to", and they are not intended to (and do not) exclude other moieties, additives, components, integers or steps. Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

[0112] Features, integers, characteristics or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith. All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. The invention is not restricted to the details of any foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A method of controlling a condensate pump assembly which comprises a pump and a controller connected to the pump, the method comprising:
 - powering the pump;
 - measuring a current value drawn by the pump;
 - comparing the measured current value to a predetermined threshold current value stored in the controller; and
 - controlling the pump to be powered to operate in a condensate pumping mode if the measured current value exceeds the predetermined threshold current value; or
 - rendering the pump unpowered if the measured current value is less than the predetermined threshold current value.
2. A method according to claim 1, wherein the step of powering the pump comprises powering the pump to operate for a predetermined start-test period, and wherein the step of measuring a current value comprises measuring a current value drawn by the pump during the start-test period.
3. A method according to claim 2, wherein if the measured current value is less than the predetermined threshold current value and the pump remains unpowered, then allowing a predetermined start test

- interval to elapse and then repeating the steps of powering the pump to operate for a predetermined start test period, measuring a current value drawn by the pump during the start test period and comparing the measured current value to a predetermined threshold current value stored in the controller to determine if the pump should be powered or remain unpowered.
4. A method according to claim 2 comprising repeating the steps of claim 2 whilst the condensate pump assembly remains operational.
 5. A method according to claim 3 or claim 4, wherein the start test interval comprises between 0.25 seconds to 60 seconds, and may be between 0.5 seconds to 20 seconds, and may be one second.
 6. A method according to any of claims 2 to 5, wherein the step of powering the pump to operate for the predetermined start test period comprises providing a pulse width modulated voltage to the pump at a pwm value less than the maximum rated value of the pump.
 7. A method according to claim 1, wherein the step of measuring a current value comprises measuring a current value drawn by the pump during a condensate pumping mode whilst the pump is operating; and wherein the step of controlling the pump to be powered to operate in a condensate pumping mode comprises continuing to power the pump to operate in the condensate pumping mode.
 8. A method according to claim 7, wherein, if the measured current value exceeds the predetermined threshold current value and the pump remains operating in a condensate pumping mode, then allowing a predetermined operating test interval to elapse and then repeating the steps of measuring a current value drawn by the pump during the condensate pumping mode whilst the pump is operating and comparing the measured current value to the predetermined threshold current value stored in the controller to determine if the pump should remain powered to operate in the condensate pumping mode or be switched off.
 9. A method according to claim 8 comprising repeating the steps of claim 7 whilst the condensate pump assembly remains in the condensate pumping mode.
 10. A method according to any of claims 7 to 9, further comprising the method of any of claims 2 to 6.
 11. A method of controlling a condensate pump assembly which comprises a pump, a liquid receptacle configured to receive condensate to be pumped, a liquid level sensor received in the liquid receptacle to sense a level of condensate within the liquid receptacle, and a controller connected to the pump and liquid level sensor, the method comprising:
 - powering the pump to operate for a predetermined start-test period;
 - measuring a current value drawn by the pump during the start-test period;
 - comparing the measured current value to a predetermined threshold current value stored in the controller; and
 - leaving the pump unpowered if the measured current value is less than the predetermined threshold current value; or
 - if the measured current value exceeds the predetermined threshold current value, then calibrating the liquid level sensor by:
 - obtaining a liquid level signal from the liquid level sensor; and
 - storing the liquid level signal as a threshold liquid level sensor signal in the controller.
 12. A method according to claim 11, comprising powering the pump to operate in a condensate pumping mode if the measured current value exceeds the predetermined threshold current value.
 13. A method of controlling a condensate pump assembly which comprises a pump, a liquid receptacle configured to receive condensate to be pumped, a liquid level sensor received in the liquid receptacle to sense a level of condensate within the liquid receptacle, and a controller connected to the pump and liquid level sensor, the method comprising:
 - measuring a current value drawn by the pump during a condensate pumping mode whilst the pump is operating;
 - comparing the measured current value to a predetermined threshold current value stored in the controller; and
 - continuing to powering the pump to operate in the condensate pumping mode if the measured current value exceeds the predetermined threshold current value; or
 - if the measured current value is below the predetermined threshold current value, then calibrating the liquid level sensor by:
 - obtaining a liquid level signal from the liquid level sensor; and
 - storing the liquid level signal as a threshold liquid level sensor signal in the controller.
 14. A method according to claim 13, comprising stopping

operation of the pump if the measured current value is below the predetermined threshold current value.

15. A method according to any preceding claim, wherein the step of measuring the current value comprises taking a plurality of current measurements over a predetermined sample period and averaging the plurality of current measurements to obtain a single averaged current measurement value.

16. A method of controlling a condensate pump assembly which comprises a pump and a controller connected to the pump, the method comprising:

measuring a current value drawn by the pump during a condensate pumping mode whilst the pump is operating;
comparing the measured current value to a predetermined upper alert threshold current value stored in the controller; and
continuing to powering the pump to operate in the condensate pumping mode if the measured current value is below the predetermined upper alert threshold current value; or
switching off power to the pump if the measured current value exceeds the predetermined upper alert threshold current value.

17. A method of controlling a condensate pump assembly which comprises a pump and a controller connected to the pump, the method comprising:

powering the pump to operate for a predetermined start-test period;
measuring a current value drawn by the pump during the start-test period;
comparing the measured current value to a predetermined upper alert threshold current value stored in the controller; and
leaving the pump unpowered if the measured current value is below the predetermined upper alert threshold current value; or
leaving the pump unpowered and entering an fault alert mode if the measured current value exceeds the predetermined upper alert threshold current value.

18. A method according to claim 15 or claim 16, wherein if the measured current value exceeds the predetermined upper alert threshold current value, then signaling an alarm.

19. A method according to any of claims 15 to 17, wherein if the measured current value exceeds the predetermined upper alert threshold current value, then controlling an appliance from which the condensate pump assembly is arranged to pump condensate, to switch off.

20. A method according to claim 18 wherein the step of controlling the appliance to switch off comprises switching off an evaporator of an air conditioning or HVAC system.

21. A method of any of claims 15 to 19, further comprising the method steps of any of claims 1 to 9.

22. A condensate pump assembly for use in an air conditioning system, the condensate pump assembly comprising:

a housing comprising an upper housing portion;
a pump arranged to pump liquid from a liquid inlet to a liquid outlet; and
an outlet tube element connecting an outlet of the pump to the liquid outlet;
wherein the upper housing portion comprises a plurality of fixation features extending from an underside of the upper housing portion; and
wherein the pump is secured to the underside of the upper housing portion by at least one resilient attachment member connected to one or more of the fixation features and extending at least partially around the pump.

23. A condensate pump assembly for use in an air conditioning system, the condensate pump assembly comprising:

a housing comprising an upper housing portion;
a pump arranged to pump liquid from a liquid inlet to a liquid outlet; and
an inlet tube element connecting the liquid inlet to an inlet of the pump;
wherein the inlet tube element connects the liquid inlet directly to the inlet of the pump without an intermediate liquid receptacle.

24. A condensate pump assembly according to claim 22, wherein the upper housing portion comprises a plurality of fixation features extending from an underside of the upper housing portion; and
wherein the pump is secured to the underside of the upper housing portion by at least one resilient attachment member connected to one or more of the fixation features and extending at least partially around the pump.

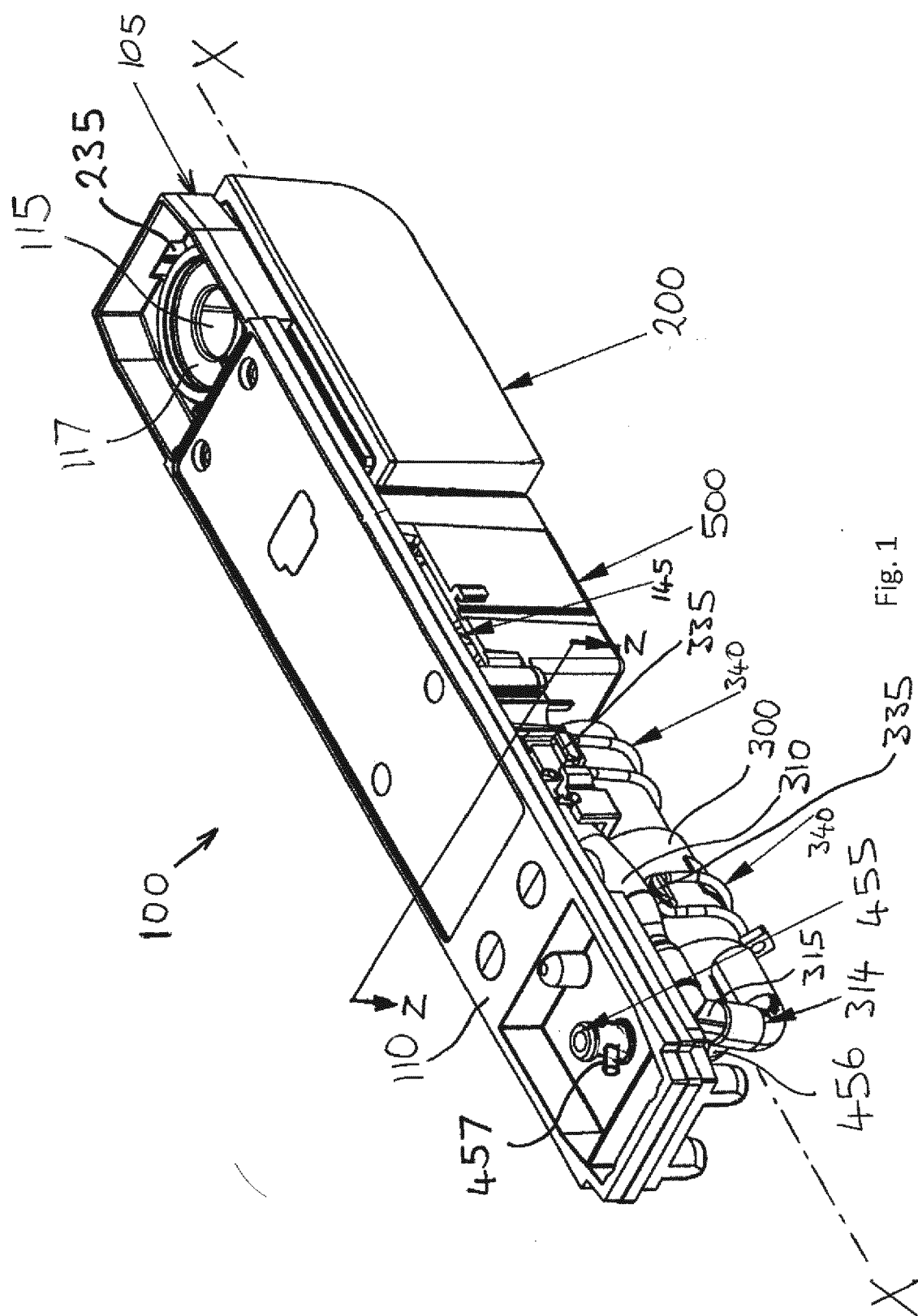
25. A condensate pump assembly according to claim 21 or claim 23 wherein the or each fixation feature comprises a hook-shaped member.

26. A condensate pump assembly according to claim 21, claim 23 or claim 24
wherein the or each resilient attachment member comprises an elastically deformable member tensioned around the pump and fixation features.

27. A condensate pump assembly according to claim 25 wherein the or each resilient attachment member comprises an elastomeric strip or band, and may comprise a rubber O-ring. 5
28. A condensate pump assembly according to claim 21, wherein an inlet tube element connects the liquid inlet directly to an inlet of the pump without an intermediate liquid receptacle. 10
29. A condensate pump assembly according to claim 21 or claim 27, wherein the outlet of the pump is connected directly to the liquid outlet by the outlet tube element without an intermediate liquid reservoir 15
30. A condensate pump assembly according to any of claims 21 to 28 wherein the pump comprises a rotary diaphragm pump. 20
31. A condensate pump assembly according to claim 29, wherein the condensate pump assembly comprises a longitudinal axis, and the pump comprises an axis of rotation, and wherein the axis of rotation of the pump is parallel or coaxial with the longitudinal axis of the condensate pump assembly. 25
32. A condensate pump assembly according to any of claims 21 to 30 comprising a potting box comprising electrical control components sealed within the potting box, and wherein all high-voltage electrical components and connections of the condensate pump assembly are sealed within potting box. 30
33. A condensate pump assembly according to any of claims 21 to 31, wherein the condensate pump assembly does not include a liquid level sensor for contacting liquid condensate. 35
34. A condensate pump assembly according to any of claims 21 to 32, wherein at least one resilient pad is disposed between the pump and the housing to suppress transmission of vibrations from the pump to the housing. 40
35. A condensate pump assembly according to any of claims 21 to 33, configured to operate according to the methods of any of claims 1 to 20. 45

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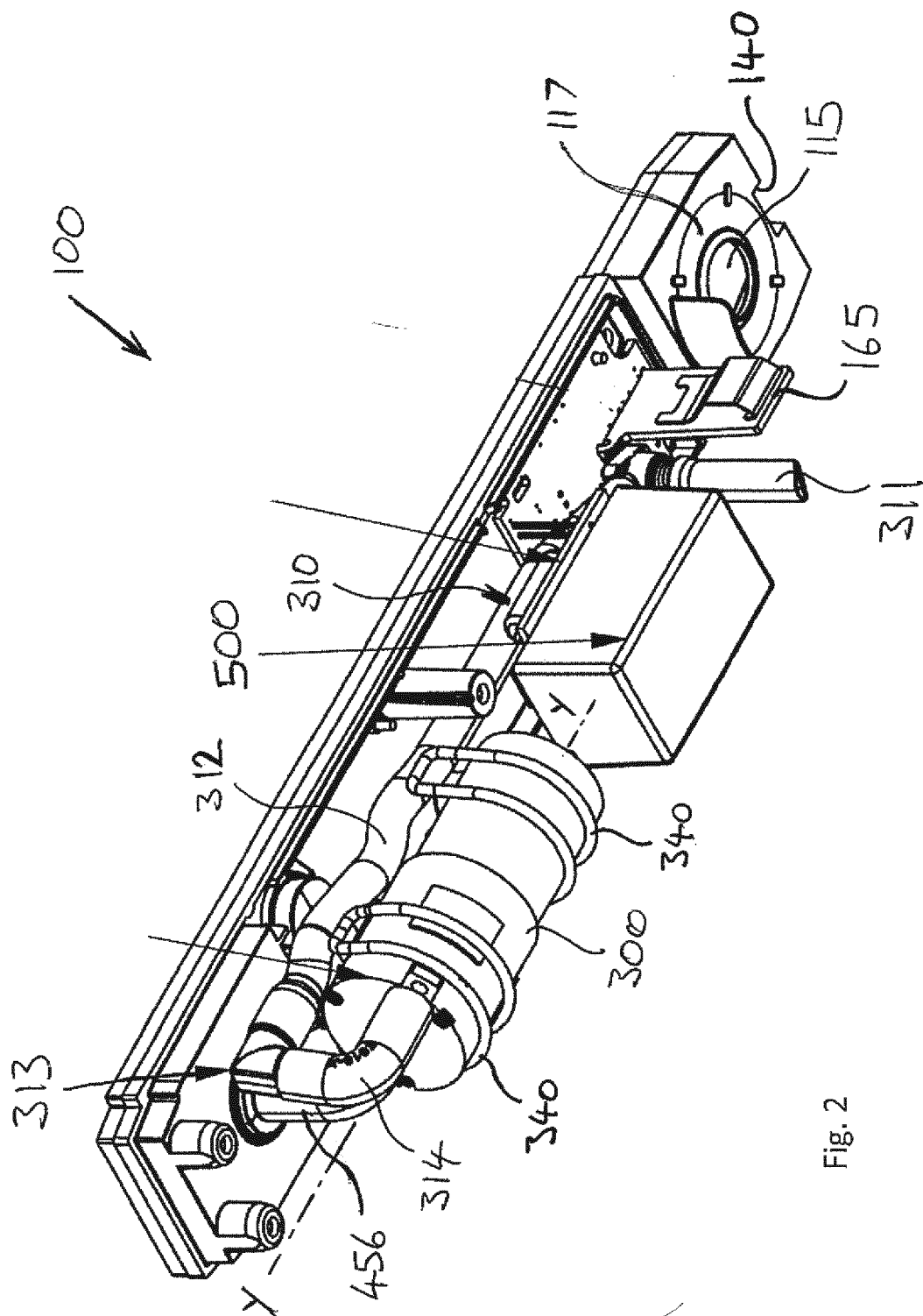


Fig. 2

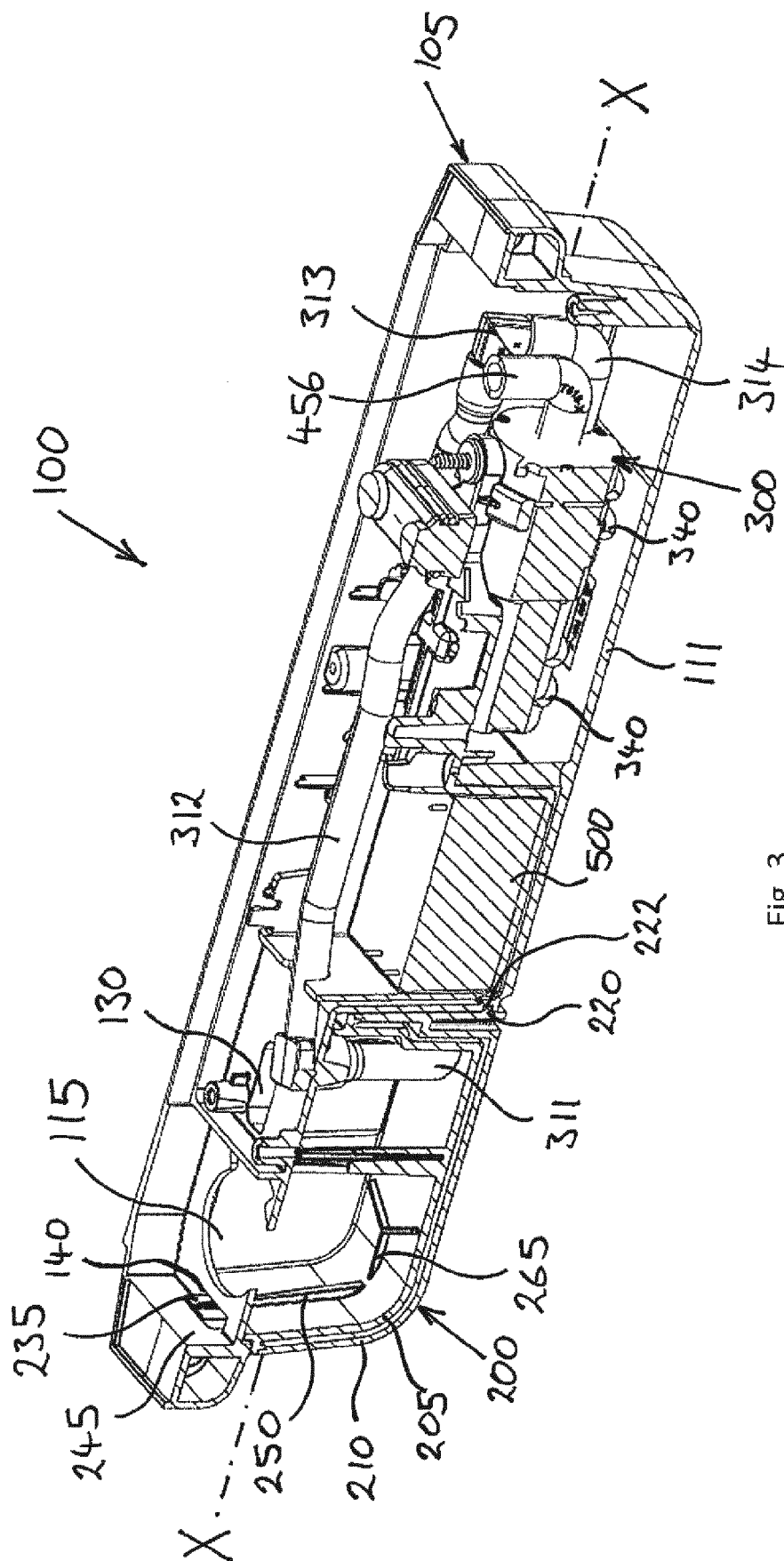


Fig. 3

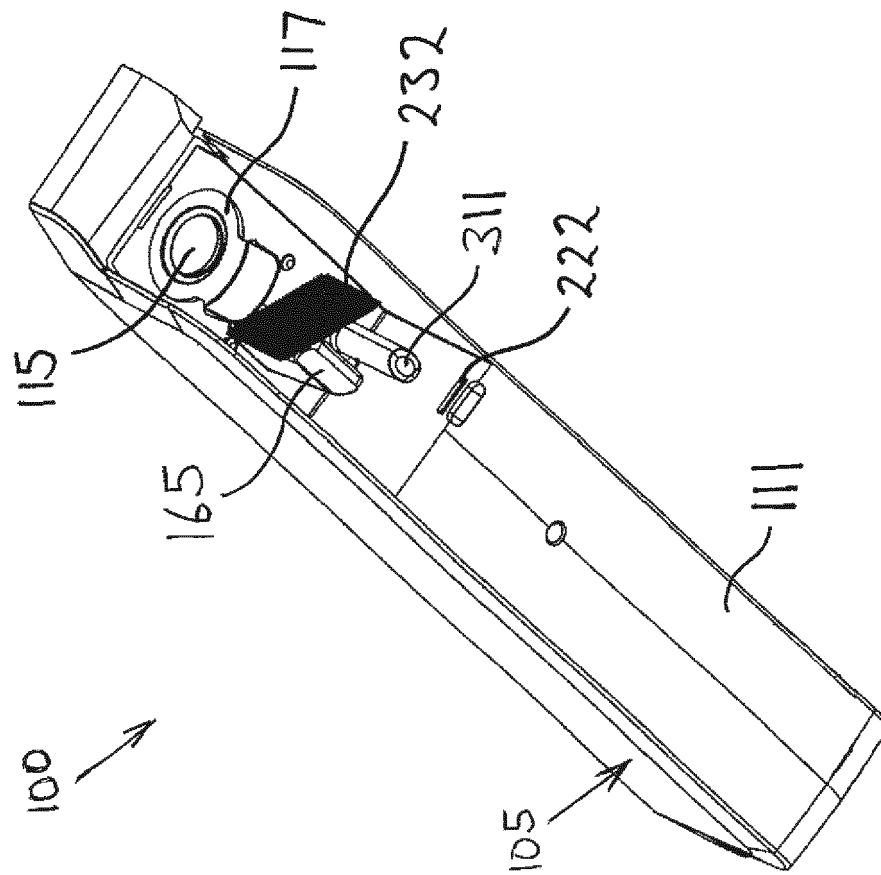


Fig. 4

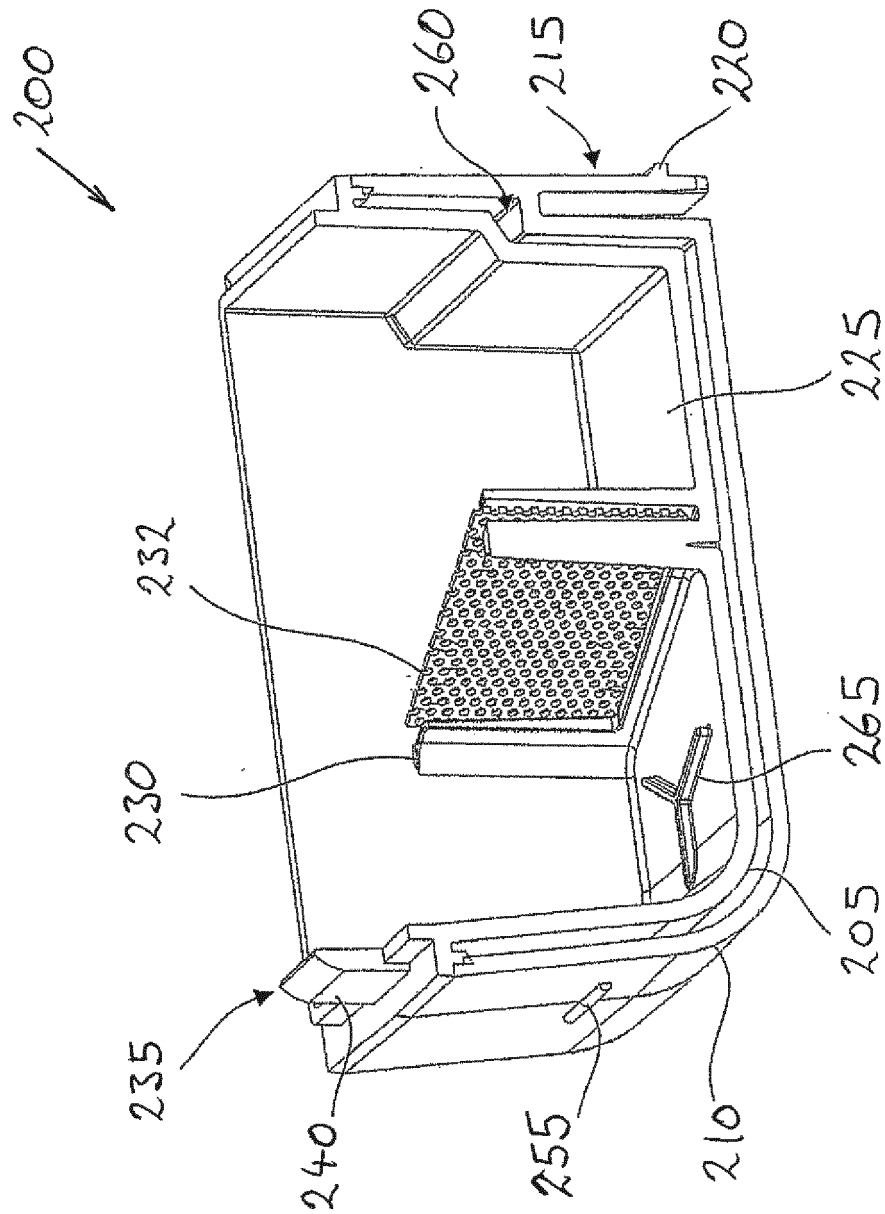


Fig. 5

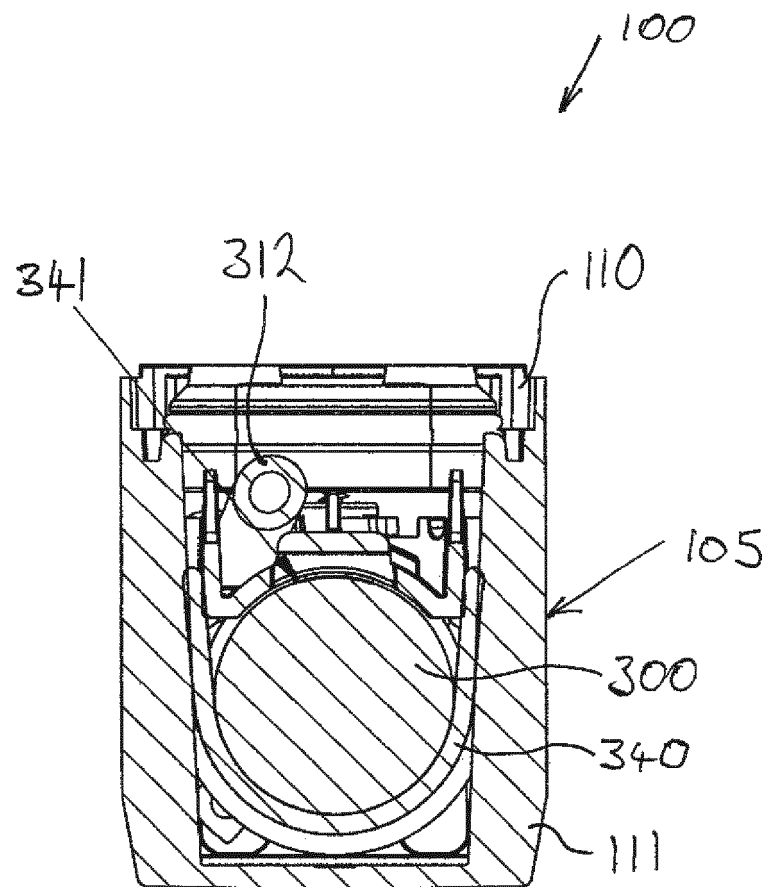


FIG. 6

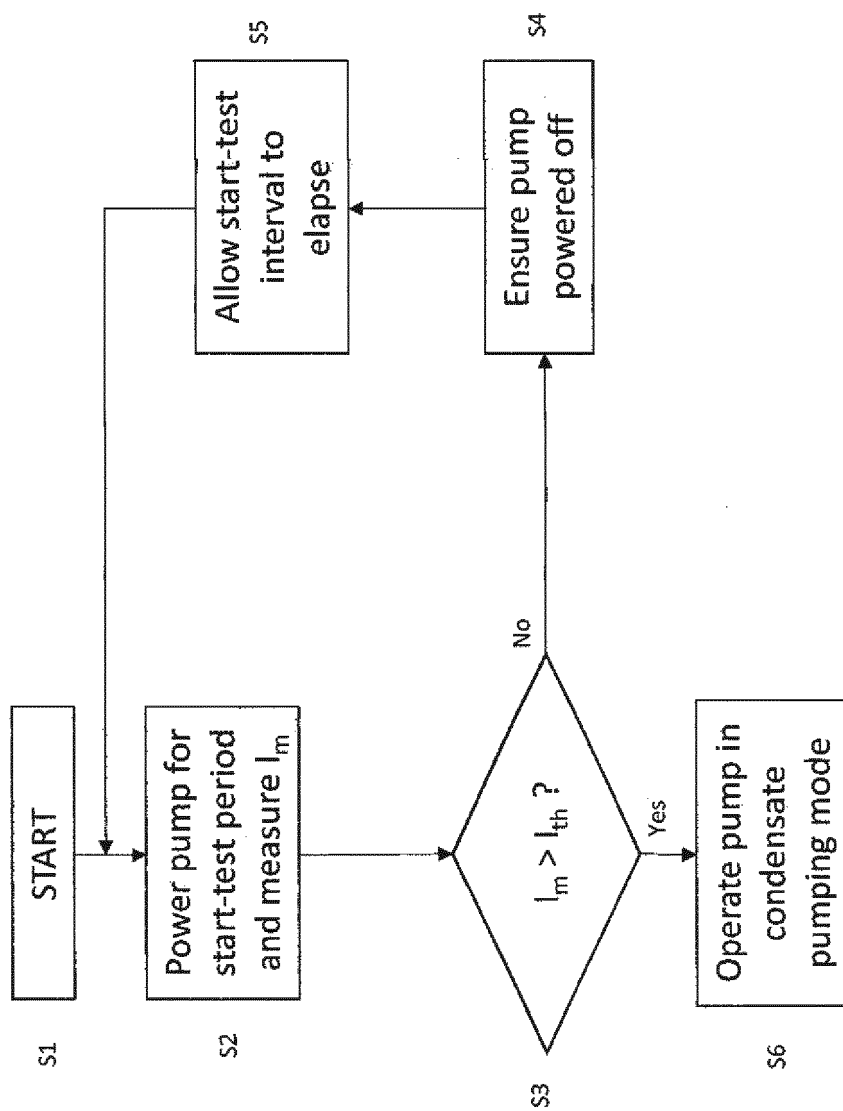


Fig. 7

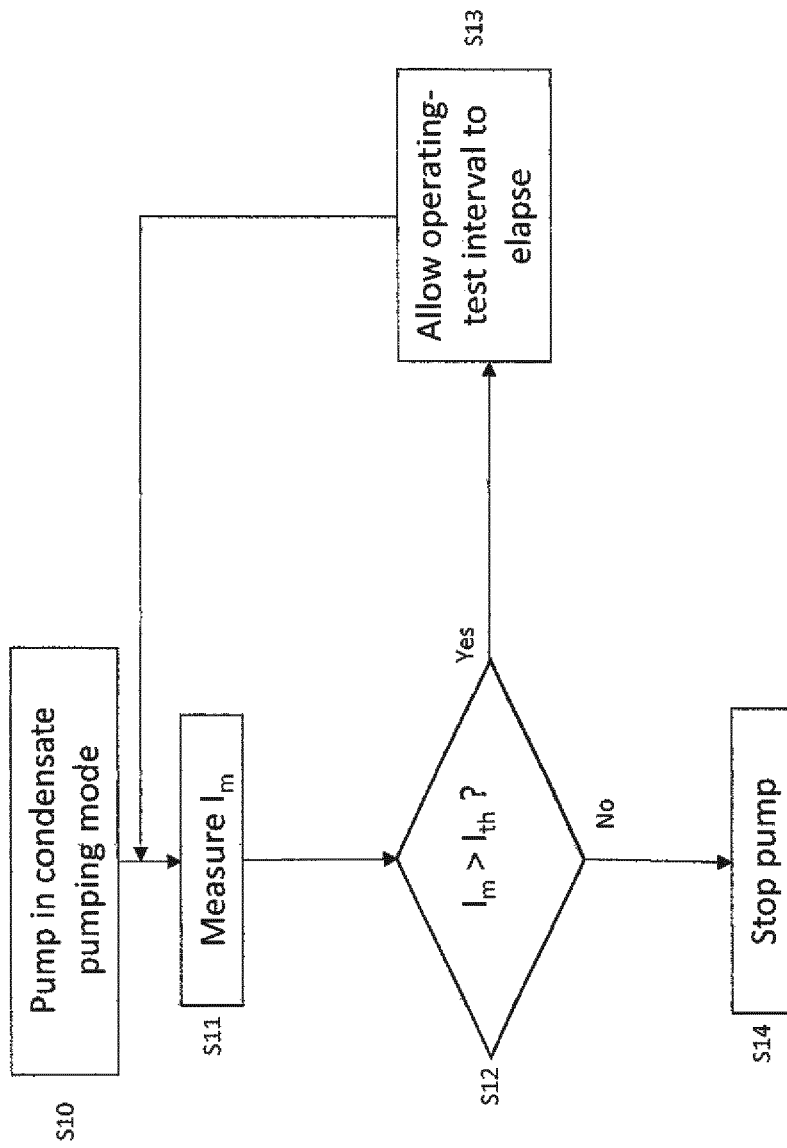


Fig. 8

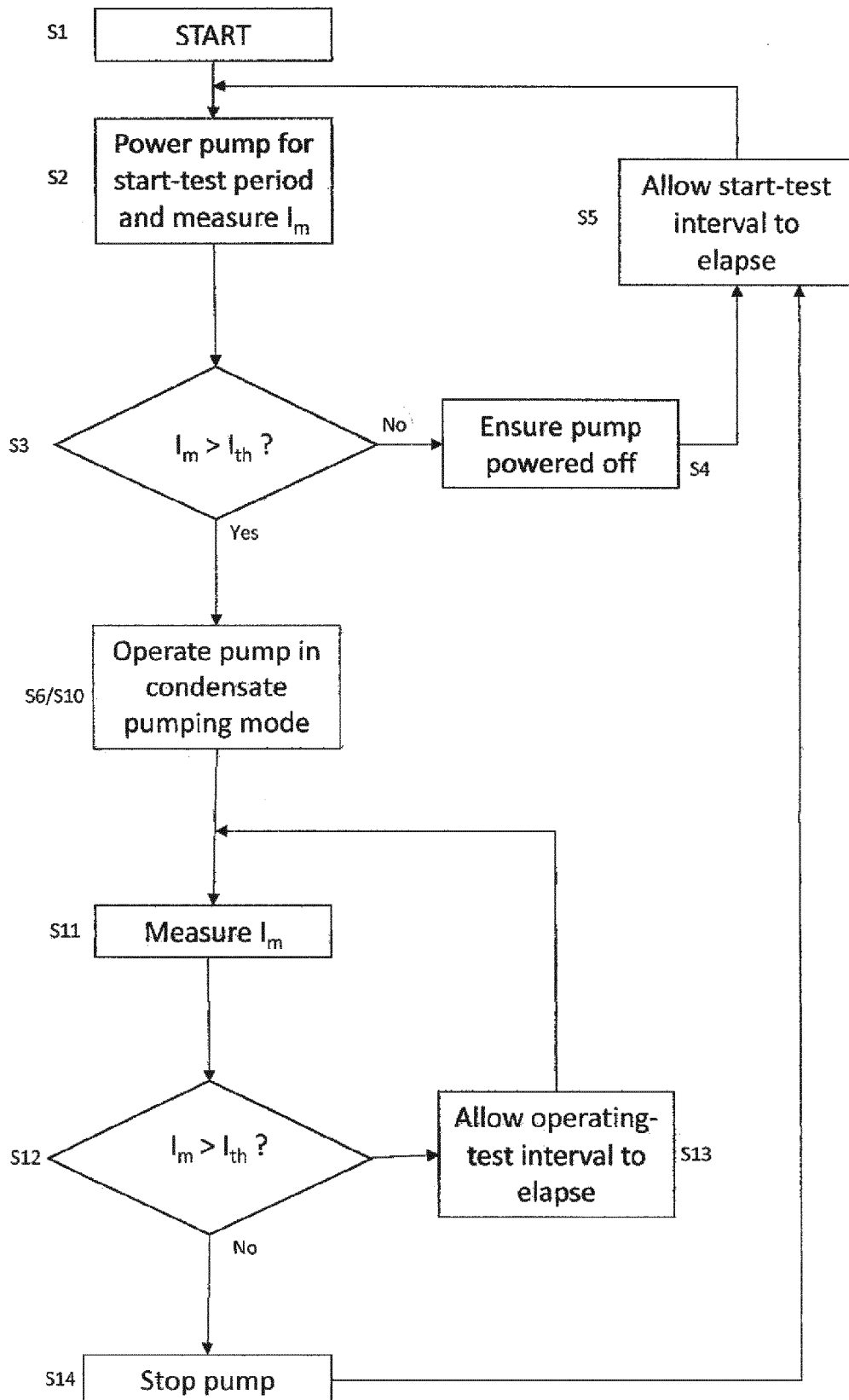


Fig. 9

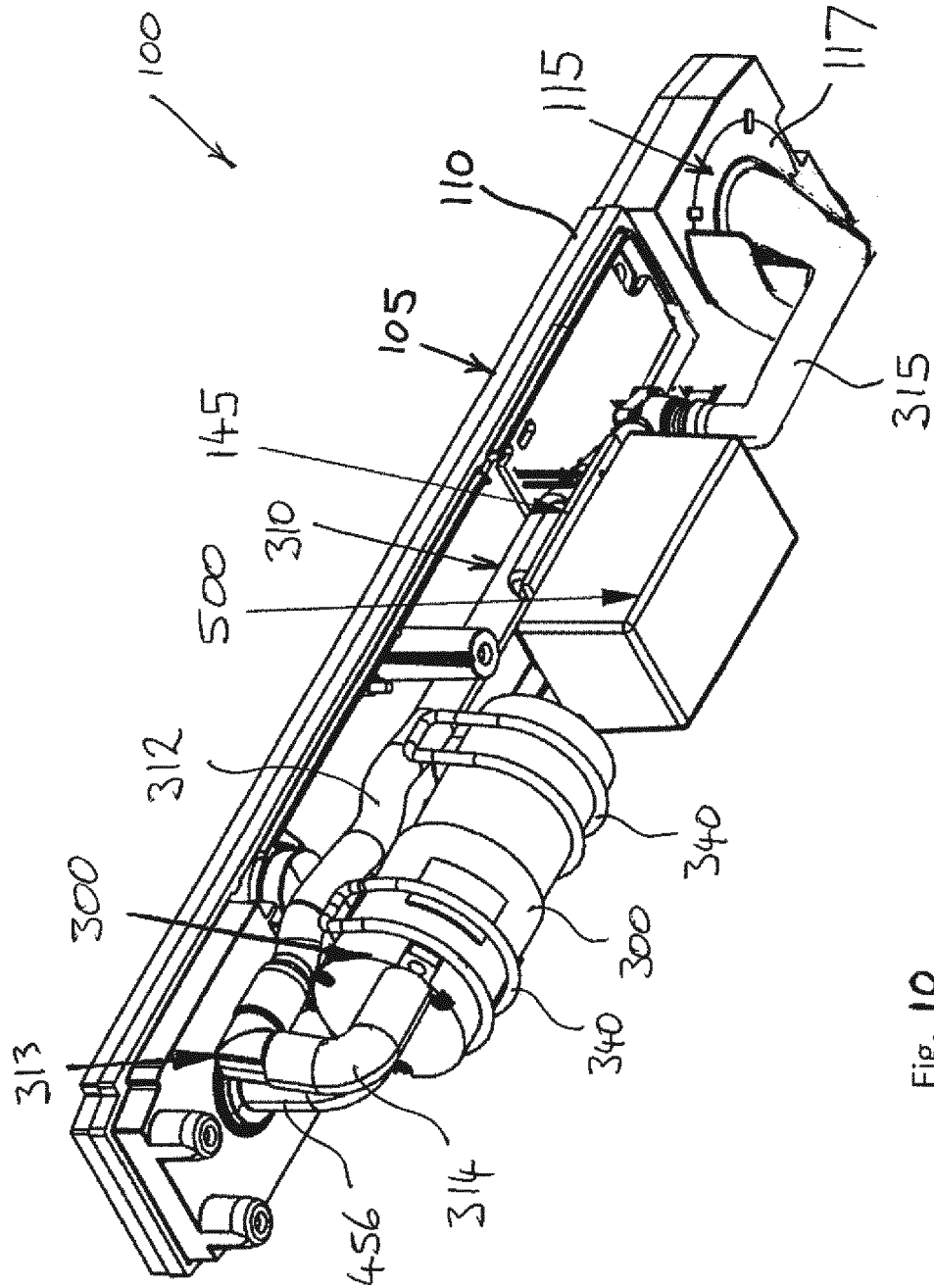


Fig. 10

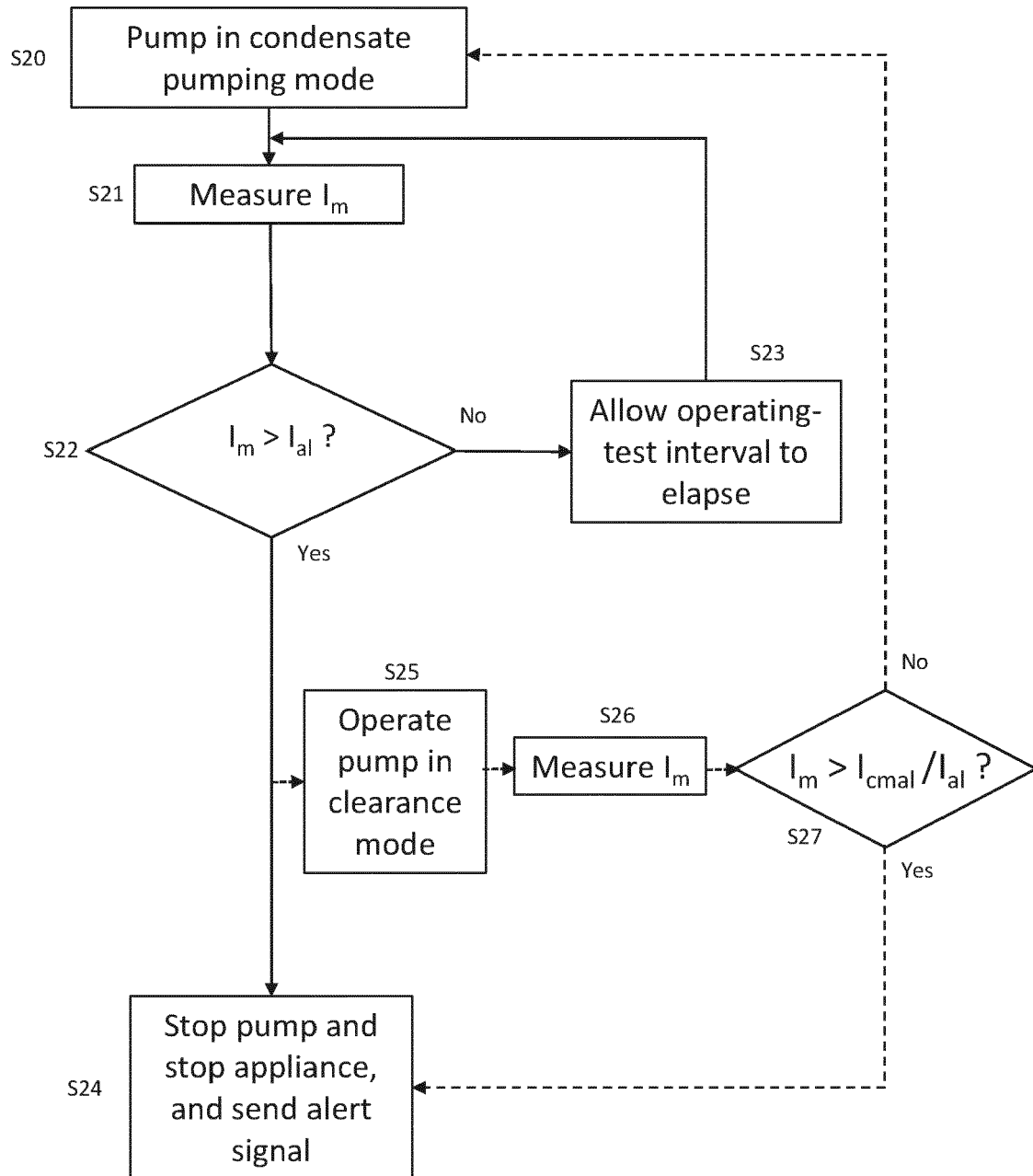


Fig. 11

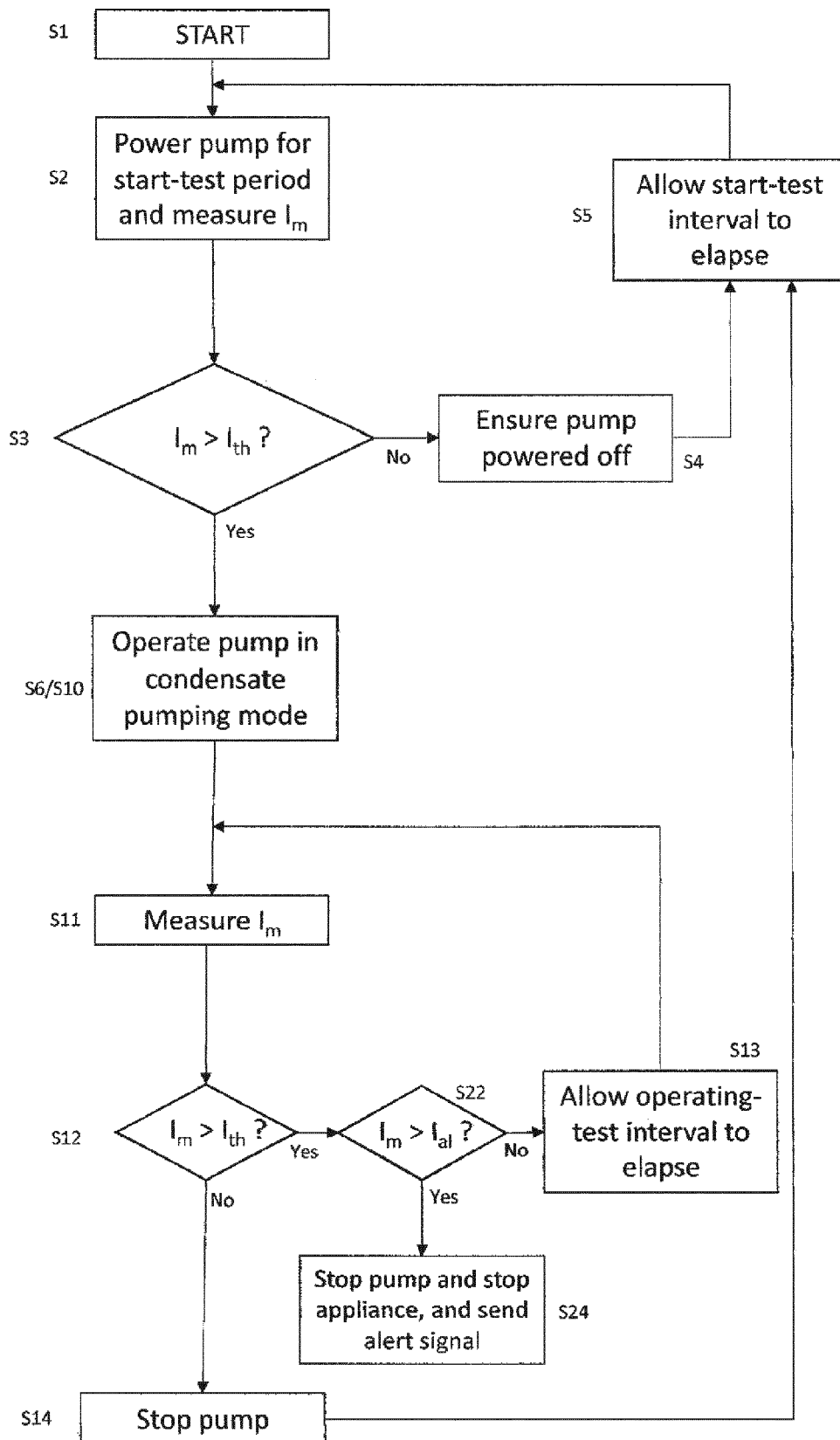


Fig. 12

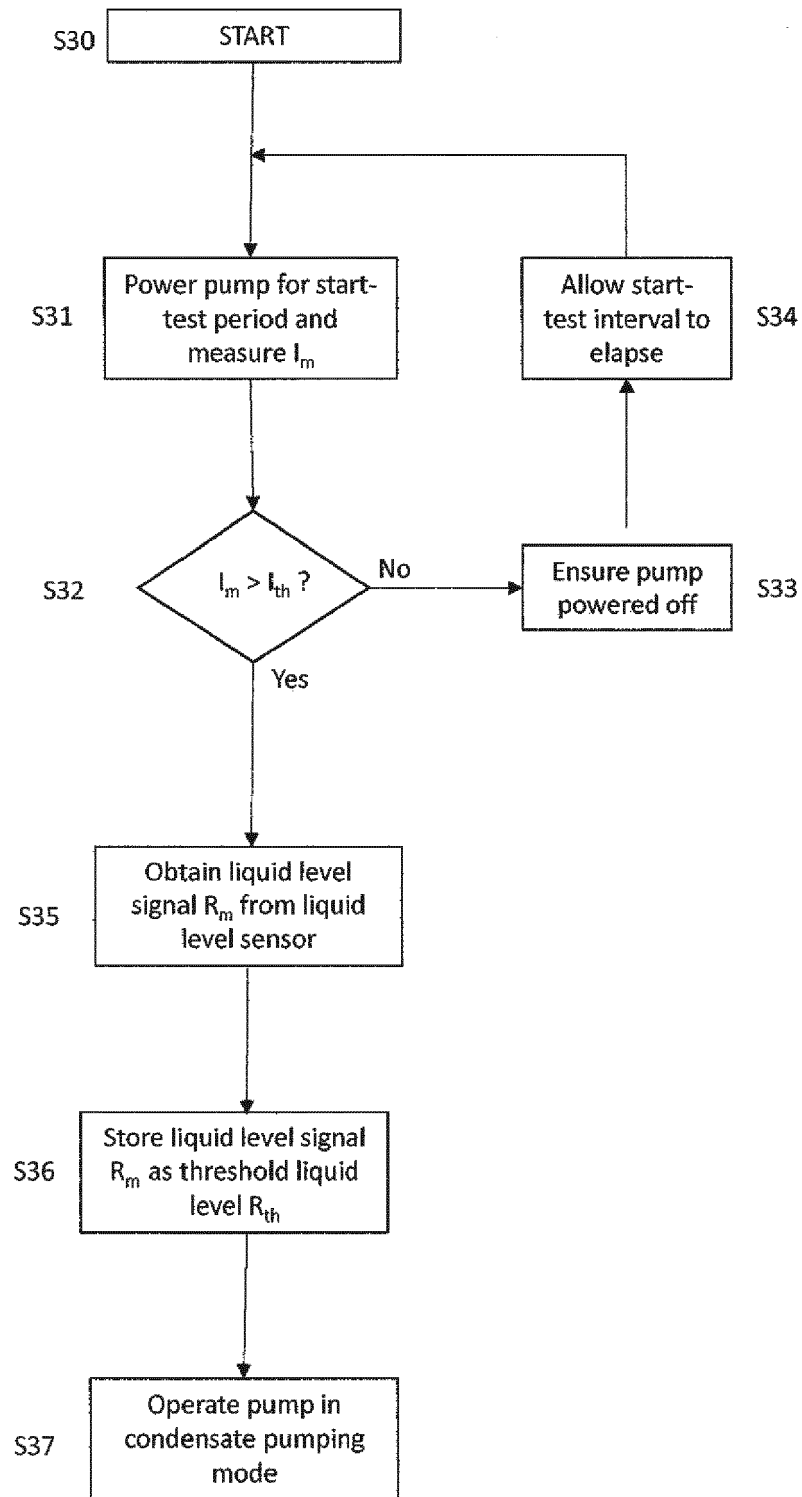


Fig. 13

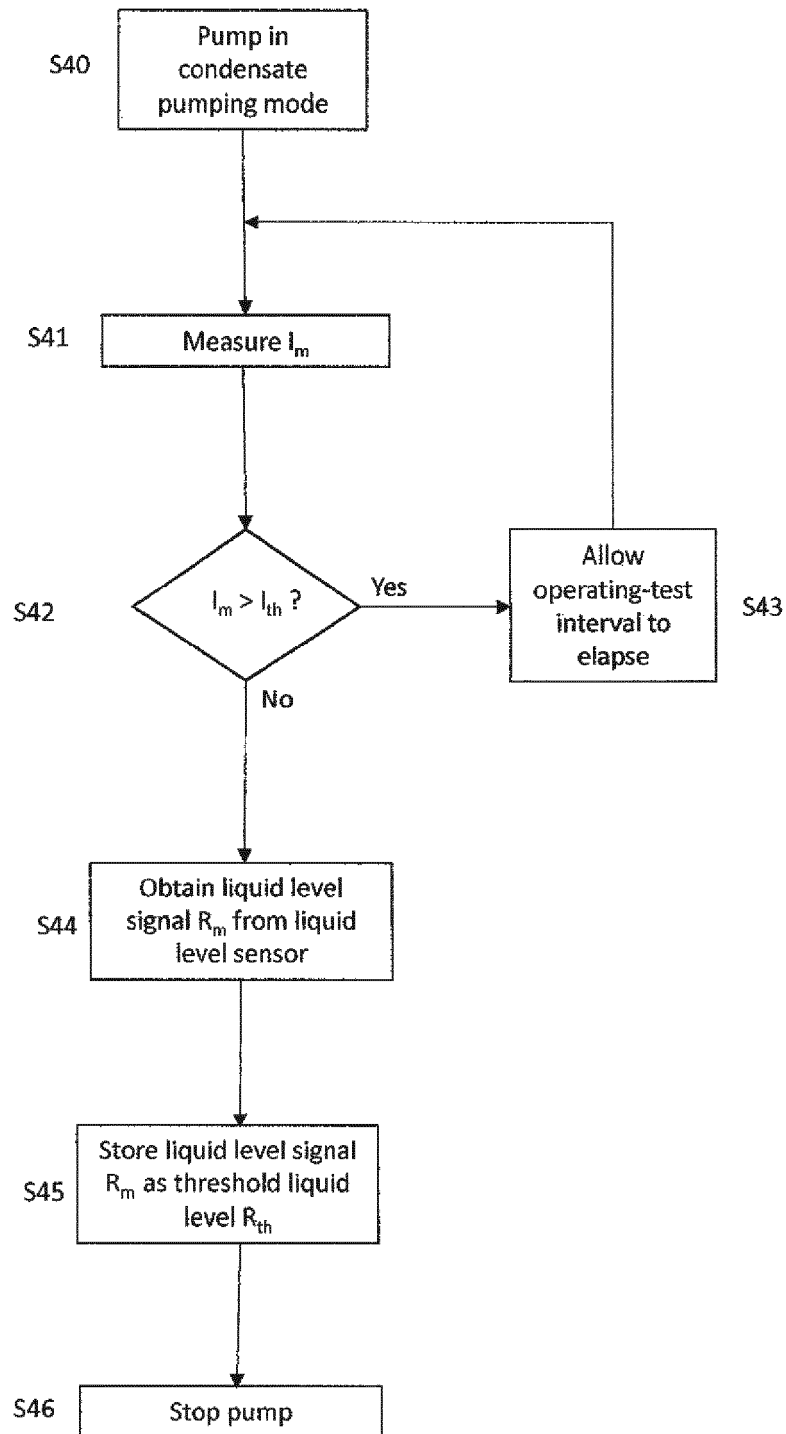


Fig. 14