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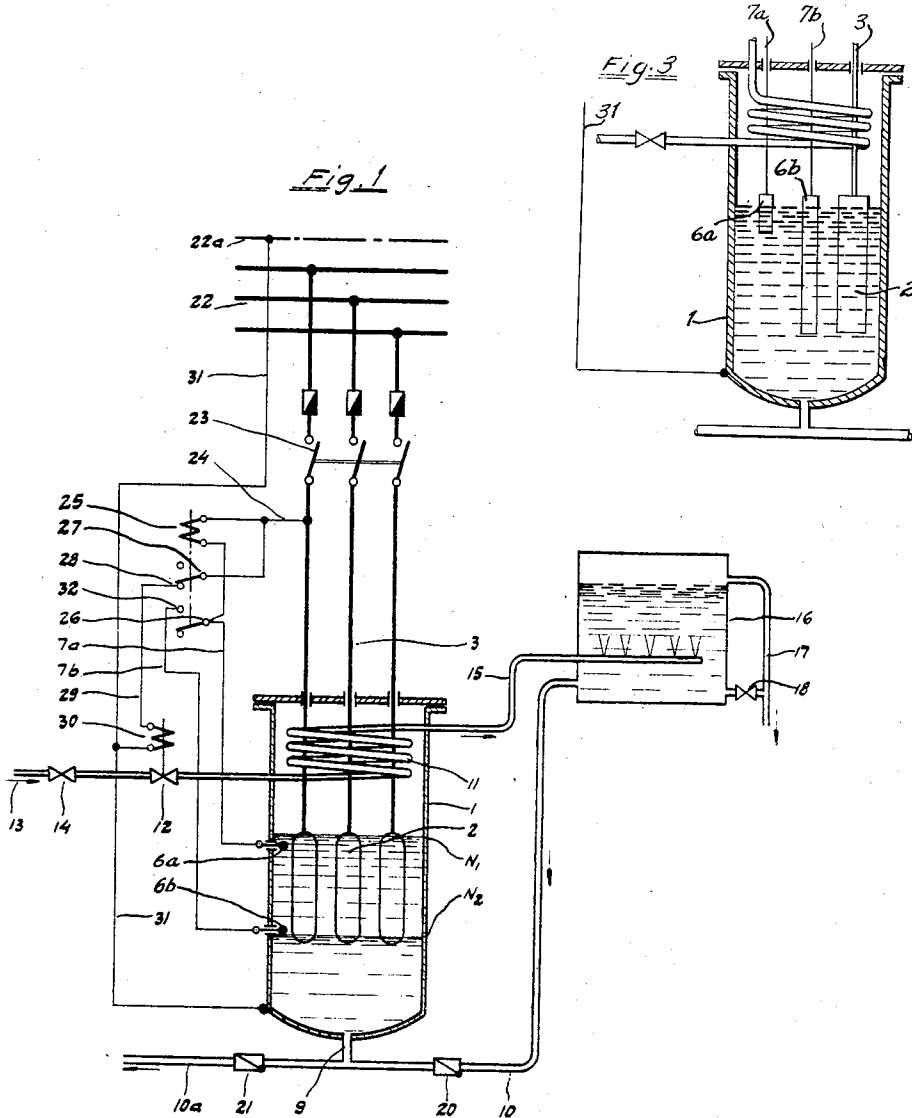
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LIQUID PUMPS

Filed May 5, 1953

3 Sheets-Sheet 1



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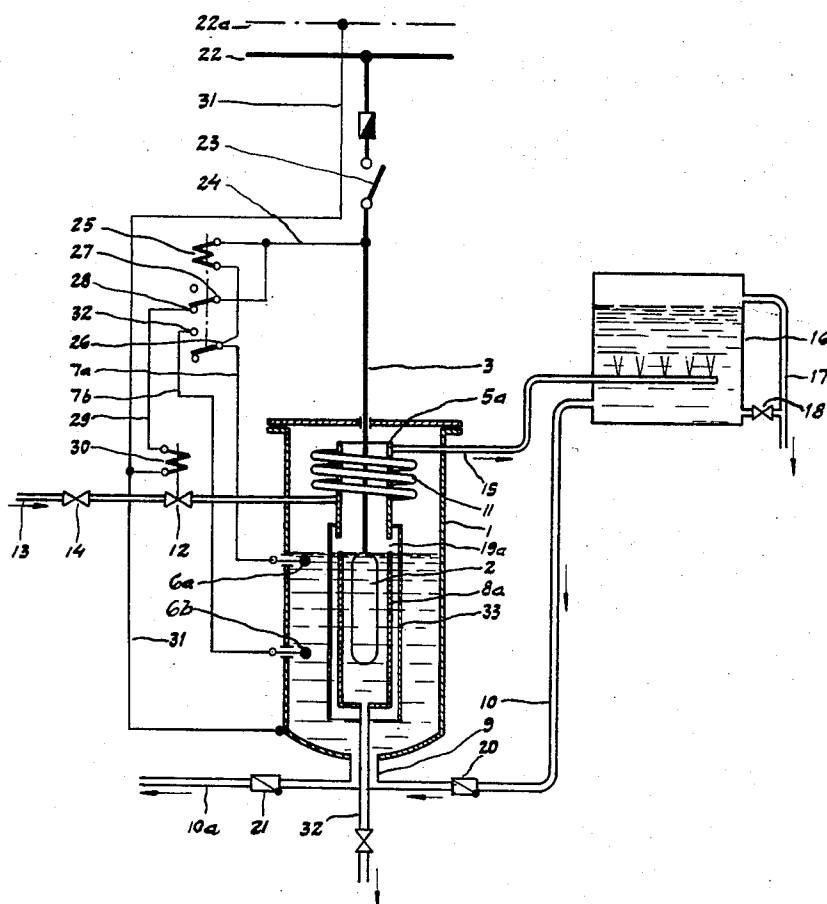
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Fig.4

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LIQUID PUMPS

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The present invention relates to an arrangement in liquid pumps having a pumping chamber in which, by producing steam generation and steam condensation in alternation, the pressure is brought to alternate between an overpressure and an underpressure so that at the overpressure a quantity of liquid is forced out of the pumping chamber (the pumping stroke) and at the underpressure a quantity of liquid is drawn into the pumping chamber (the suction stroke).

One object of the present invention is to produce a simplified pump of this type which may be driven electrically and operate at a higher efficiency than hitherto and pump liquid even against very high counter-pressure.

A further and important object of the invention is to avoid the use of movable parts.

To obtain said and other advantages the present steam generator consists of an electrode device in an electrically conducting liquid, for instance water, whereas the pumping chamber is influenced by an intermittently operating cooling device the shifting of which from its operative to its idle state and vice versa is depending on the liquid level in the pumping chamber. According to the invention the shifting is assured by the provision of two auxiliary electrodes in an electrically conducting liquid the level of which is depending on the liquid level in the pumping chamber the one of said electrodes being adapted to make the cooling device operative at the end of the pumping stroke and the second one being adapted to disconnect the cooling device at the end of the suction stroke.

According to the present invention it is preferable to supply a cooling medium to the cooling device via a valve electromagnetically controlled by a control circuit adapted to be energized by said one auxiliary electrode so that the valve is opened and the cooling medium enters the cooling device and to be deenergized by said second auxiliary electrode so that the valve is again released and closed. Preferably the cooling medium leaving the cooling device is brought to give off its heat to the liquid to be pumped which is particularly important, for instance, when pumping feed water into a steam boiler. The steam generating electrodes may be provided in the pumping chamber or else be formed in a special vessel the steam space of which communicates with the steam space of the pumping chamber it being preferable to make the volume of the steam generating vessel considerably less than that of the pumping chamber.

The invention will be more closely described with reference to the accompanying drawings on which Fig. 1 is a circuit diagram for a plant made according to the present invention,

Fig. 2 illustrates a modified arrangement,

Fig. 3 illustrates a modified detail, and

Fig. 4 illustrates a further modification.

In the embodiment shown in Fig. 1 the pump is made as a vertical cylindrical vessel 1 into which three steam

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generating electrodes 2 extend downwards. Electrical supply lines 3 pass through insulating bushings in the cover of the pumping vessel down to the electrodes 2. The vessel 1 or any part metallicity connected therewith is provided with an electric return line 31, preferably carrying earth potential and being connected, for instance, to an electrical neutral line 22a.

In the vessel 1 there are inserted two auxiliary electrodes 6a and 6b with supply lines 7a and 7b drawn through insulating bushings in the wall of the vessel 1. This vessel communicates close to its bottom via the pipe 9 with a supply pipe 10. In the upper portion of the vessel 1 and preferably above the level of the operative surface of the auxiliary electrode 6a a cooling spiral 11 is provided in one or more turns. The input end of the cooling spiral is via a normally closed valve 12 in communication with a water supply line 13 having an ordinary shut-off valve 14. The output end of the cooling spiral communicates via the pipe 15 with a liquid reservoir 16 from the lower part of which the pipe 10 extends. The upper portion of the reservoir 16 is provided with an overflow pipe 17 and its lower portion has a tapping-off valve 18. The supply line 10 is provided with two non-return valves 20, 21 having such an action that they let through liquid only in the direction of the arrows but form a barrier against a flow in the opposite direction. The pressure line 10a is assumed to communicate with a vessel under pressure which is to be supplied with liquid. The lines 3 are branched off from an electric three phase line 22 via a switch 23. From the line 22 there is also drawn a control line 24 via the switch 23. A current path is branched off therefrom via a relay coil 25, a contact 26 and the line 7a to the auxiliary electrode 6a. Another branch is traced from the line 24 via normally closed contacts 27 and 28, a line 29, a relay coil 30 and a return line 31 back to the neutral line 22a. The relay coil 30 controls the normally closed valve 12 so that this is open when the coil is passed by electric current. When the relay 25 is energized the contacts 27 and 28 are interrupted while a connection is closed between the contacts 26 and 32 and the line 7b to the second auxiliary electrode 6b.

This arrangement operates as follows:

Assuming that the liquid level in vessel 1 takes up the position N1 and that the arrangement is cold, the course will be as follows. When the switch 23 is closed a current path is closed through line 24, relay 25, line 7a, auxiliary electrode 6a, the liquid in the vessel 1 and the wall of the vessel 1 to the return line 31. The relay 25 attracts its armature and breaks the contact 28 so that the relay coil 30 is deenergized and the cooling water valves 12 remains in its normal closed position. At the same time as the relay 25 is energized also the contacts 26, 32 are closed and the current passes also through line 7b, the auxiliary electrode 6b and the liquid in the vessel 1 to the walls thereof and to the return line 31. Simultaneously with the closing of the switch 23 alternating current passed through the lines 3 to the electrodes 2 whereby the liquid in the vessel 1 starts to evaporate.

Through the proceeding evaporation the pressure in the vessel 1 starts to increase. When the pressure has become sufficiently high to overcome the counter-pressure of the liquid in the pressure line 10a at the left of the non-return valve 21, liquid starts to be forced out of vessel 1 and through the line 9 and the non-return valve 21 which lets through the pressure liquid. The level in the vessel 1 sinks and the contacts between the liquid and the auxiliary electrode 6a ceases whereby the current through the line 7a is interrupted. The relay 25 is still held energized via the contact 26, 32 and the electrode 6b. However, when the liquid level in the vessel

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1 has sunk further to the position N2 marked in dash-and-dot lines the contact between the liquid and the electrode 6b also ceases and the current through the relay coil 25 is interrupted so that the relay 25 drops its armature and the contacts 26, 32 are interrupted whereas the contacts 27, 28 are closed. Hereby a current path is closed through the line 29, the relay coil 30 and the line 31 back to the neutral line 22a. The relay 30 is energized and the valve 12 opened. Then cooling medium, such as water from the water mains, flows in through the line 13, the pipe spiral 11 and the pipe 15 to the reservoir 16. The steam in the vessel 1 is then cooled off which results in that the overpressure sinks rapidly whereby the non-return valve 21 is closed immediately. The pressure will now be changed to a negative pressure the non-return valve 20 being then opened and letting through liquid from the reservoir 16 and the pipe 10. This liquid flows through pipe 9 to the vessel 1. When the liquid in the vessel 1 again reaches contact with the electrode 6b this causes no change because the contact 26, 32 is now broken. When the level has again reached position N1 the relay coil 25 is again energized whereby the contact 27, 28 is interrupted so that the relay 30 is de-energized and releases the valve 12 to the closed position thereof and the contact 26, 32 is closed. Hereby the cooling period is finished and steam starts again to develop in vessel 1 which is now filled with fresh water up to level N1.

It should be observed that the cooling of the steam when the pipe spiral 11 is passed by cooling medium always requires a certain, although short, time so that it is to be expected generally that the pumping vessel is entirely emptied before the liquid level again starts to rise and gradually reaches the electrode 6b. The pipe 9 should therefore be connected sufficiently far down, preferably in the bottom of, the pumping chamber 1 whereby the volume of the pumping chamber can be entirely utilized.

The embodiment shown in Fig. 2 differs from the one shown in Fig. 1, before all therein that the steam generating electrodes 2 are provided in a special steam generating vessel 8. Also here there are provided auxiliary electrodes 6a and 6b in the pumping vessel. At its upper portion the vessel 8 is provided with a steam line 5 leading to the upper portion of the pumping vessel 1. Further the vessel 8 is provided at its upper portion with a liquid supply line 19 branched off from a supply line 10.

By providing the vessel 8 as a pocket the liquid level therein will be independent of the fluctuating level in the vessel 1 but dependent solely on the rate of evaporation. Due thereto the cross section of the vessel 8 may be considerably less than that of the vessel 1 whereby the quantity of water to be heated to boiling temperature may be held at a minimum. The mouth of the pipe 19 in the vessel 8 is preferably provided on a level with the liquid level N1 at the end of the suction stroke whereas the mouth of the pipe 5 in the vessel 8 is slightly higher up.

The fact that the pipe 19 is directly connected to the supply line 10 in front of the branching off point of the pipe 9 affords the advantage that the steam generation vessel 8 is always fed with fresh water and does thus not receive distilled and non-conducting water. This could have been the case if the pipe 19 instead had been extended from the vessel 1 which is absorbing condensed water during the steam condensation periods. This results in turn therein that the percentage of salt in the water in the vessel 8 rises gradually due to the evaporation whereby the electric conductivity of the water is rising. This means, however, no inconvenience as long as the percentage of salt is kept within reasonable limits. If after some time the salt content should be too high which is clearly indicated on the ampere meter of the plant one may blow out a quantity of water by opening a bottom valve 32 during a pressure stroke. This is

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replaced in the next suction stroke by fresh water whereby the salt content is reduced.

The embodiments illustrated may be modified in different manners without departing from the inventive idea. According to Fig. 3 one may supply single phase alternating current to the steam generation vessel via the line 3 to a single steam generating electrode 2. The return line 31 from the vessel 1 is in ordinary manner passing to a neutral line 22a. The two auxiliary electrodes 6a, 6b are in this figure provided in the pumping vessel 1.

Fig. 4 illustrates a combination of the arrangements according to Figs. 1 and 2 because the special electrode vessel 8a is provided inside the pumping vessel 1 but is separated from the pumping space proper by means of an insulating tube 33 surrounding and spaced from the electrode vessel said insulating tube being of a temperature proof and heat insulating material, such as a ceramic material. This is above tightly united with a wide steam pipe 5a above communicating with the steam space in the pumping vessel 1. The insulated pipe 33 is open below and communicates there with the water space of the pumping vessel 1. The electrode vessel 8a is above provided with at least one hole 19a through which water may enter from the interspace between parts 33 and 8a to the electrode vessel 8a. This communicates at its bottom with a blow off pipe 32. The pipe 9 here surrounds the blow off pipe 32.

The arrangement according to Fig. 4 operates on the whole in the same manner as the device according to Fig. 2. The insulating vessel 33 then prevents or reduces the heat transport from the electrode vessel 8a to the water outside the pipe 33. Due to the fact that the water at the end of each suction stroke is refilled at the electrode vessel 8a from above through the hole 19a the salts enriched by the evaporation remain in the electrode vessel 8a. A correction of the concentration of salt may, as in Fig. 2, be made by blowing out water from the electrode space through the pipe 32. In Fig. 4 only one single phase electrode 2 has been drawn the walls of the electrode vessel 8a then serving as a neutral electrode. There is, of course, nothing in the way to provide in known manner, for instance, three electrodes in the vessel 8a, fed with three phase current, compare Fig. 2.

Due to the fact that the cooling spiral according to the shown embodiment is placed inside the pumping chamber those mechanical stresses on the vessel walls are softened which may be caused by the rapid temperature changes in the pumping chamber it being understood that the stresses would be considerably heavier if the cooling was applied on the outside of the vessel walls.

In certain cases it may be of advantage to cause the cooling by injecting cold liquid directly into the pumping chamber.

I claim:

1. A liquid pump comprising means for containing a liquid under pressure, a steam generator within said liquid containing means, means for discharging liquid from said containing means in response to pressure produced by the generation of steam by said steam generator, means for preventing reverse flow through said discharge means, means for condensing steam within said containing means, means for supplying liquid to said containing means, means for preventing reverse flow through said supply means, and means including an electrical control circuit and a pair of electrodes connected to said circuit and positioned at different levels within said containing means for actuating said condensing means when the level of the liquid within said containing means falls below the lower one of said electrodes and for deactuating said condensing means when the level of the liquid within said containing means moves to the level of the upper one of said electrodes.

2. A liquid pump comprising means for containing a

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liquid under pressure, a steam generator within said liquid containing means, means for discharging liquid from said containing means in response to pressure produced by the generation of steam by said steam generator, means for preventing reverse flow through said discharge means, means within said containing means for conducting a cooling medium for condensing steam within said containing means, means for supply liquid to said containing means, means for preventing reverse flow through said supply means, and means including an electrical control circuit, an electromagnetically operated cooling medium flow control valve connected to said circuit and a pair of electrodes connected to said circuit and positioned at different levels within said containing means, said circuit acting to open said valve when the level of the liquid within said containing means falls below the lower one of said electrodes and acting to close said valve when the level of the liquid within said containing means rises to the level of the upper one of said electrodes.

3. A liquid pump comprising means for containing a liquid under pressure, a steam generator within said liquid containing means, means for discharging liquid from said containing means in response to pressure produced by the generation of steam by said steam generator, means for preventing reverse flow through said discharge means, means for condensing steam within said containing means, means for supplying liquid to said containing means, means for preventing reverse flow through said supply means, and means including an electrical control circuit and a pair of electrodes connected to said circuit and positioned at different levels within said containing means for actuating said condensing means when the level of the liquid within said containing means falls below the lower one of said electrodes and for deactuating said condensing means when the level of the liquid within said containing means rises to the level of the upper one of said electrodes, said circuit including a holding relay which when energized is energized through the lower of said electrodes and when deenergized is reenergized only through the upper of said electrodes.

4. A liquid pump comprising means for containing a liquid under pressure, a steam generator within said liquid containing means, means for discharging liquid from said containing means in response to pressure provided by the generation of steam by said steam generator, means for preventing reverse flow through said discharge means, means within said containing means for conducting a cooling medium for condensing steam within said containing means, means for supplying liquid to said containing means, means for preventing reverse flow through said supply means, means for controlling flow of said cooling medium providing flow of said cooling medium for condensing steam when the level of liquid within said containing means falls below a predetermined level and shutting off flow of said cooling medium when the level of liquid within said containing means rises above a predetermined level, and means for delivering heat carried off by said cooling medium to the liquid to be heated by said steam generator.

5. A liquid pump comprising means providing a steam generating chamber, at least one steam generating electrode positioned within said steam generating chamber, means providing a pumping chamber, means providing for flow of steam from said steam chamber to said pumping chamber, means for discharging liquid from said pumping chamber in response to pressure produced by the generation of steam in said steam generating chamber, means for preventing reverse flow through said discharge means, means for condensing steam in said pumping chamber, means for supplying liquid to said steam generating chamber and said pumping chamber and providing a fluid connection between said pumping chamber and said generating chamber, means for preventing reverse flow through said supply means, and

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means for actuating said condensing means when the level of the liquid within said pumping chamber falls below a predetermined level and for deactuating said condensing means when the level of the liquid within said pumping chamber rises above a predetermined level, and said fluid connection being at a level in said generating chamber approximately corresponding to the level of liquid existing therein when said condensing means is deactuated.

6. A liquid pump comprising means providing a steam generating chamber, at least one steam generating electrode positioned within said steam generating chamber, means providing a pumping chamber, means providing for flow of steam from said steam chamber to said pumping chamber, means for discharging liquid from said pumping chamber in response to pressure produced by the generation of steam in said steam generating chamber, means for preventing reverse flow through said discharge means, means for condensing steam in said pumping chamber, means for supplying liquid to said steam generating chamber and said pumping chamber, and means for actuating said condensing means when the level of the liquid within said pumping chamber falls below a predetermined level and for deactuating said condensing means when the level of the liquid within said pumping chamber rises above a predetermined level, all fluid connection between said pumping chamber and said generating chamber entering said generating chamber at a level in said generating chamber not lower than the level of liquid existing therein when said condensing means is deactuated.

7. A liquid pump comprising means providing a steam generating chamber, at least one steam generating electrode positioned within said steam generating chamber, means providing a pumping chamber, means providing for flow of steam from said steam chamber to said pumping chamber, means for discharging liquid from said pumping chamber in response to pressure produced by the generation of steam in said steam generating chamber, means for preventing reverse flow through said discharge means, means for condensing steam in said pumping chamber, means for supplying liquid to said steam generating chamber and said pumping chamber, means for preventing reverse flow through said supply means, and means including an electrical control circuit and a pair of electrodes connected to said circuit and positioned at different levels within said pumping chamber for actuating said condensing means when the level of the liquid within said pumping chamber falls below the lower one of said electrodes and for deactuating said condensing means when the level of the liquid within said pumping chamber rises to the level of the upper one of said electrodes.

8. A liquid pump comprising means providing a steam generating chamber, at least one steam generating electrode positioned within said steam generating chamber, means providing a pumping chamber, said steam generating chamber being positioned inside of said pumping chamber and heat insulated therefrom, means providing for flow of steam from said steam chamber to said pumping chamber, means for discharging liquid from said pumping chamber in response to pressure produced by the generation of steam generating chamber, means for preventing reverse flow through said discharge means, means for condensing steam in said pumping chamber, means for supplying liquid to said steam generating chamber and said pumping chamber, means for preventing reverse flow through said supply means, and means for actuating said condensing means when the level of the liquid within said pumping chamber falls below a predetermined level and for deactuating said condensing means when the level of the liquid within said pumping chamber rises above a predetermined level.

9. A liquid pump comprising means providing a steam generating chamber, at least one steam generating elec-

trode positioned within said steam generating chamber, means providing a pumping chamber, means providing for flow of steam from the upper portion of said steam chamber to the upper portion of said pumping chamber, means for discharging liquid from the lower portion of said pumping chamber in response to pressure produced by the generation of steam in said steam generating chamber, means for preventing reverse flow through said discharge means, means for condensing steam in said pumping chamber, means for supplying liquid to the upper portion of said steam generating chamber and for supplying liquid to said pumping chamber while liquid is being supplied to said steam generating chamber, means for preventing reverse flow through said supply means, and means for actuating said condensing means when the level of the liquid within said pumping chamber falls below a predetermined level and for deactuating said condensing means when the level of the liquid within said pumping chamber rises above a predetermined level, displacement of liquid from said steam generating chamber during pumping occurring normally only from the conversion of liquid therein to steam.

10. A liquid pump comprising means for containing liquid under pressure, said means including a pump chamber and a steam generating chamber, a steam generator within said steam generating chamber, means for conducting steam from said generating chamber to said pumping chamber, means for conducting liquid from said pump chamber in response to pressure produced by the generation of steam by said steam generator, means for preventing reverse flow through said liquid conducting means, means for condensing steam within said pump chamber, means for supplying liquid to said steam generating chamber and to said pump chamber, means for preventing reverse flow through said liquid supplying means, and means including an electrical control circuit and a pair of electrodes connected to said circuit and positioned at different levels within said pumping chamber for actuating said condensing means when the level

of the liquid within said pump chamber falls below the lower one of said electrodes and for deactuating said condensing means when the level of liquid within said pump chamber moves to the region of the upper one of said electrodes.

11. A liquid pump comprising means for containing liquid under pressure, said means including a pump chamber and a steam generating chamber, a steam generator within said steam generating chamber, means for conducting steam from said generating chamber to said pumping chamber, means for conducting liquid from said pump chamber in response to pressure produced by the generation of steam by said steam generator, means for preventing reverse flow through said liquid conducting means, means for condensing steam within said pump chamber, means for supplying liquid to said pump chamber, means for supplying liquid to said steam generating chamber at a level in the vicinity of the uppermost level of liquid therein during pumping, means for preventing reverse flow through said pump chamber liquid supplying means, and means including an electrical control circuit and a pair of electrodes connected to said circuit and positioned at different levels within said pumping chamber for actuating said condensing means when the level of the liquid within said pump chamber falls below the lower one of said electrodes and for deactuating said condensing means when the level of liquid within said pump chamber moves to the region of the upper one of said electrodes.

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