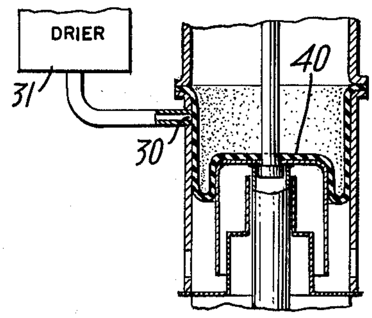
DRIER
31
30
40

FIG. 2

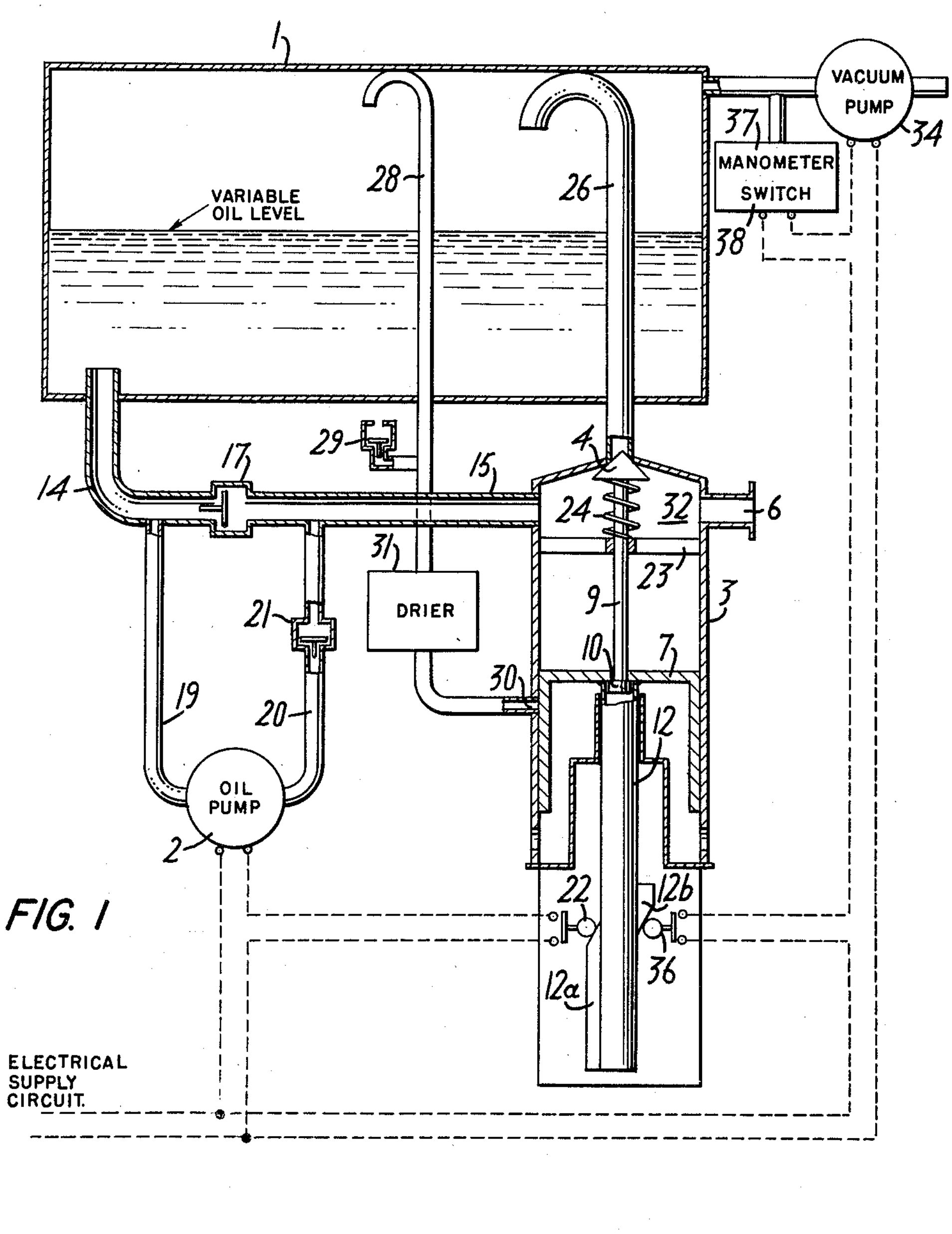
1
VACUUM
PUMP
34
37
MANOMETER
SWITCH
38
VARIABLE
OIL LEVEL
28
26
29
4
17
15
14
24
32
6
31
DRIER
23
3
9
21
10
7
30
19
20
12
OIL
PUMP
2
22
12b
36
12a
ELECTRICAL
SUPPLY
CIRCUIT

FIG. 1

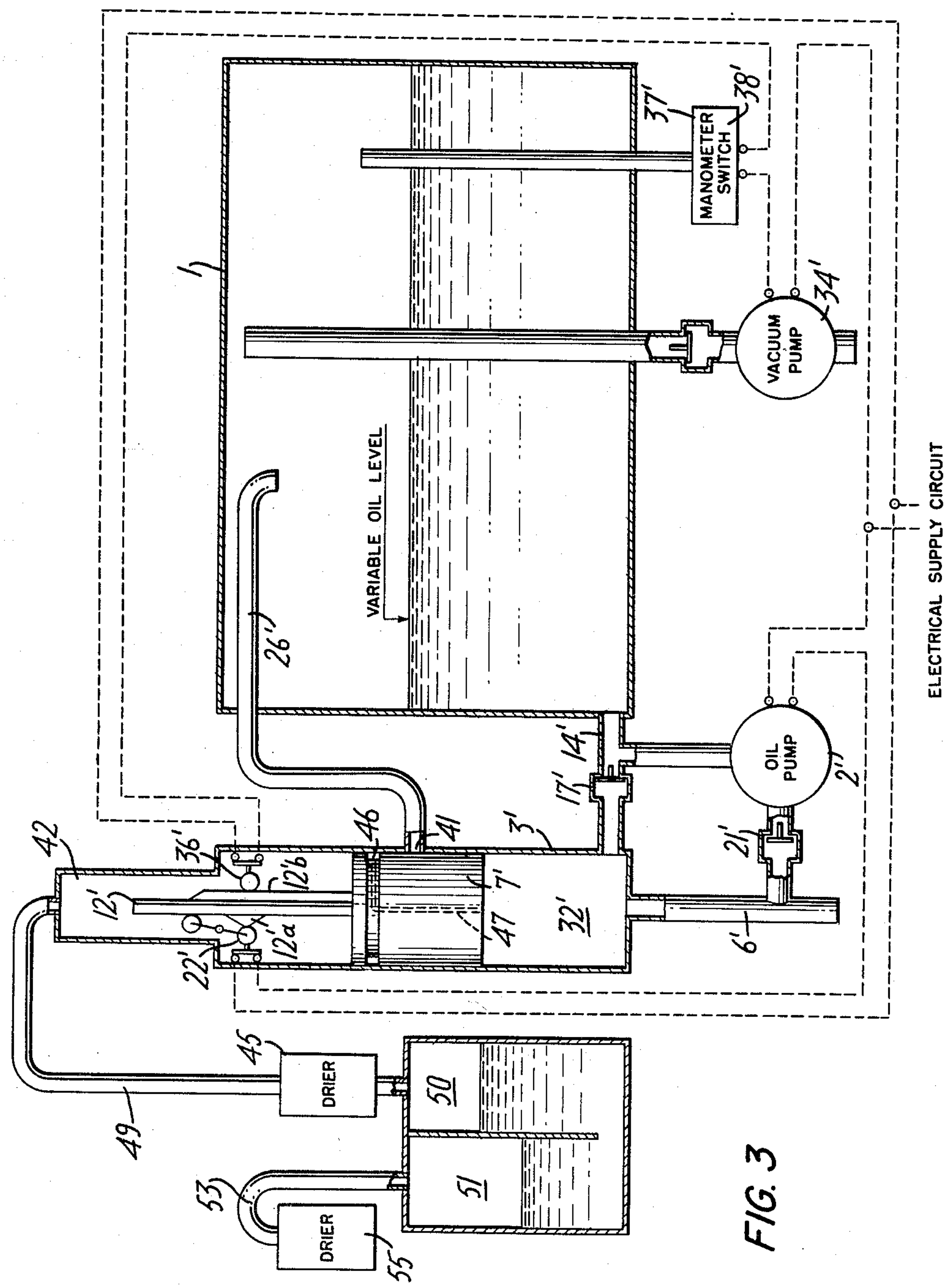
MANOMETER SWITCH
VACUUM PUMP
VARIABLE OIL LEVEL
ELECTRICAL SUPPLY CIRCUIT
OIL PUMP
DRIER
DRIER

FIG. 3

United States Patent Office

3,098,891

Patented July 23, 1963

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3,098,891

APPARATUS FOR THE PRESERVATION AND REGENERATION OF INSULATING OIL FOR ELECTRICAL APPARATUS PROVIDED WITH AN OIL RESERVOIR

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9 Claims. (Cl. 174—15)

This invention relates generally to electrical devices cooled with an insulating fluid and particularly to an apparatus for preserving the insulating and dielectric qualities of the insulating fluid and for decontaminating it.

In known electrical apparatus filled with an insulating fluid, for example, insulating oil, and provided with an oil expansion tank or reservoir, a part of the oil is in contact with air at atmospheric pressure and therefore tends to deteriorate. This deterioration is caused by oxidation and the oil is contaminated by the accumulation of moisture which rapidly affects the dielectric characteristics and insulating properties of the insulating oil. This may have serious consequences, particularly in modern high power and very high voltage apparatus unless the contaminated oil is regenerated or decontaminated by a process of filtration, heating and degasification in vacuo. This necessitates quite expensive equipment and involves placing the electrical apparatus out of operation.

The use of an oil reservoir in electrical apparatus also creates a certain danger, for example, in the event of a terminal breaking and possibly causing fire. The oil expansion reservoir can empty itself on to the site of the defect and thus accelerate the destruction of the apparatus.

Devices are already known which retard the deterioration of the oil drying or dehydrating the air in contact with the oil in the reservoir and which is generally renewed by the breather of the apparatus. Contamination of the oil is also retarded by cutting off all communication between the air and the outside atmosphere by means of a deformable diaphragm capable of responding to the volume variations of the oil in the apparatus due to variations of the oil temperature. However, these protective devices do not ensure the degasification and permanency of dehydration of the oil under service conditions.

Devices are also known which prevent the oil reservoir from discharging its oil in the event of a failure of the main tank of the apparatus.

The present invention has for a principal object to provide an apparatus which combines the advantages of the known devices and which further offers the possibility of continuous regeneration and decontamination of the oil.

It is a simple matter to create a vacuum above the oil in the oil reservoir and to seal the reservoir so the vacuum would permit the oil to rise and fall in the reservoir according to the variations of the volume of oil in the apparatus, without appreciable variation of the absolute pressure at the surface of the oil. This arrangement would involve placing the main tank of the apparatus under great negative pressure, which would favor the entry of air and humidity through the numerous and inevitable joints of this type of tank thereby affecting the insulating properties of the oil. Furthermore it is known that application of a negative pressure to the oil which insulates the operative parts of the electrical apparatus is unfavorable from the point of view of stability of its dielectric properties.

The apparatus according to the invention permits the

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maintenance of a high or partial vacuum on the surface of the oil in the reservoir, while maintaining in a reliable manner the atmospheric pressure or even a slightly higher pressure in the main tank of the electrical apparatus or device.

One advantage of the present invention is that the level of oil can rise freely in the reservoir. The vacuum acting on the surface of the oil operates, in service, to eliminate the last traces of moisture or gases dissolved or entrained in the oil, and by reason of the pressure existing at the same time in the main tank of the electrical device formation of bubbles, which would reduce the dielectric properties of the oil, need not be feared. In the event of fracture of the main tank or of one of the oil lines connecting it with its usual accessories, the oil from the reservoir cannot pour out to add to the danger of fire.

According to the invention, the apparatus for preservation and regeneration of insulating oil for electrical devices provided with an oil reservoir communicating with the exterior through a pipe, which may contain a dryer or dehydrator, is characterised in that the admission of oil from the reservoir, in which a low pressure obtains, to the main tank of the apparatus, in which atmospheric or slightly higher pressure obtains, is effected by a pump controlled by the actual variations of the oil volume in the main tank. The flow of oil from the main tank to the reservoir is effected through a delivery valve, the opening of which is also controlled by the variations of the oil volume in the main tank of the oil-cooled device.

The valve controlling means responsive to the variations of the volume of oil in the tank, preferably comprises a piston reciprocable in a cylinder connected directly to the main tank and it includes means for controlling the pump and means for controlling a delivery valve.

The upper part of the oil reservoir above the oil level has no communication with the exterior or atmosphere except through an escape valve permitting the escape of gases or air above the oil level and communication with the atmosphere can be established through a dehydrator to which the communication is controlled by the movements of the piston, but access or communication thereto is closed in normal operation.

When the oil level rises in the reservoir, a certain volume of gas is expelled to the atmosphere through the escape valve, and when the oil contracts a partial vacuum is established over the surface of the oil. It may be advantageous to increase this vacuum by the provision of a vacuum pump for this purpose.

According to one embodiment of the invention, the means for regulating a delivery valve to the reservoir is constituted by a piston responsive to the variations of the oil volume in the main oil tank of the oil-cooled device. The cylindrical surface of this piston is utilized as the means for opening and closing the delivery valve.

Other features and advantages of the system or apparatus in accordance with the present invention will be better understood as described in the following specification and appended claims in conjunction with the following drawings in which:

FIG. 1 is a schematic elevation view, partly in section, of an apparatus according to the invention;

FIG. 2 is a fragmentary, sectional, detail view of another embodiment of a pressure-responsive element for sensing oil volume variations in the apparatus shown in FIG. 1;

FIG. 3 is a schematic elevation view, partly in section, of another embodiment of the apparatus shown in FIG. 1.

According to the drawings and more particularly FIG. 1 an apparatus for preserving the insulation and dielectric properties of insulating oil and for regenerating the insulating oil of a main oil tank (not shown) of an oilinsulated device, for example, an oil-cooled transformer (not shown), comprises an oil reservoir 1 to which is connected a motor-driven oil pump 2 and a cylinder 3 in which a delivery valve is operable as hereinafter explained for allowing oil flow from the main oil tank into the reservoir. The cylinder 3 is provided with connection line 6 providing communication between the interior of the cylinder and the main oil tank of the transformer (not shown).

The cylinder 3 is provided with means responsive to variations of the volume of the oil in the main oil tank comprising a piston 7 reciprocable in opposite directions in the cylinder 3. A valve 4 is provided with a long valve stem 9 extending into the piston and having a shoulder 10 which is engaged by the piston for unseating the valve 4 as later herein explained. The piston is provided with a rod internally of the skirt thereof in the form of a tail rod 12 provided with a cam 12*a* for starting and stopping the oil pump 2 in response to variations in the volume of the oil in the main tank.

The pump 2 is connected to the reservoir 1 and the cylinder 3 through lines 14 and 15 between which is disposed a non-return valve 17 and branch lines 19, 20 connected downstream and upstream of the non-return valve 17 respectively. The line 20 is a discharge line from the pump and a non-return valve 21 is disposed therein. Both non-return valves allow oil flow in the direction toward the cylinder 3 and to the main oil tank.

It is readily apparent that upward travel of the piston 7 from the position shown in FIG. 1 will cause the cam 12*a* to engage a switch 22 and close it to drive the pump from an electrical supply circuit as shown. When the piston moves in an opposite or downward direction to the position shown the switch 22 is allowed to open in the position of the switch shown. The cam 12*a* is elongated and allows a range of positions or travel of the piston for carrying the switch closing function.

When the oil in the main transformer tank expands, it leaves that tank through the pipe or line 6 and enters into the cylinder 3. It finds no outlet, since the non-return valves 17 and 21 will close. The oil passes through a spider or perforated plate 23 supporting a spring 24 constantly urging the valve 4 to a seated or closed position. The oil moves the piston 7 in a downwardly direction to the limit of its downward travel. This downward movement of the piston causes the enlargement or shoulder 10 of the stem 9 of the valve 4 to be moved downwardly which opens the valve 4 and permits delivery of oil into the reservoir 2 through the line 26. The valve 4 is opened against the pressure exerted by its spring 24 and against its own tendency to close again by reason of the movement of the oil passing towards the reservoir 1. In this unseated position of the valve 4 and downward position of the piston 7 and tail rod 12, the switch 22 is open and the pump 2 is stopped or out of operation.

The entry of oil into the reservoir 1 increases the air pressure therein. In view of a vacuum normally obtaining in the reservoir, however, the air pressure after arrival of a certain quantity of oil from the transformer tank may either remain below atmospheric pressure, in which case nothing will happen, or become greater than atmospheric pressure. In the later case, if a vacuum pump is not provided in the system or apparatus the excess pressure above the level of the oil in the reservoir is eliminated by escape of air through a line 28 and a non-return escape valve 29.

When the oil in the main transformer tank begins to contract, the intake of oil from the reservoir through the line 6 reduces and cancels the pressure which had kept the piston 7 at the lower limit of its travel and the spring 24 raises the piston back to the position shown in the drawing in which the valve 4 is closed. The upward movement of the piston 7 may continue even though the valve 4 is closed, the piston thereby moves its tail rod 12 upwardly and, by means of the cam 12*a* closes the switch 22 which starts the pump 2 and sets it in operation. Oil is then taken from the reservoir 1 through the line 14 by the pump 2 and passes through the valve 21 into the line 15 and issues through the line 6 into the main tank of the electrical device. If the delivery of the pump 2 is greater than the maximum possible intake of the main tank through the line 6, the piston 7 will resume the downward position at its lower limit as mentioned above. The switch 22 will, therefore, open and the pump 2 will stop until, as a result of a decreased volume of oil, the piston 7 again reascends and starts the pump again.

The ratio of the pump delivery to the maximum intake of the main tank, which takes place in cold weather and on total shutdown of the load on the device or transformer, is calculated in such a way that the pumping cycles succeed one another at a sufficiently slow rate.

The flow of oil into the reservoir creates in the air space above the oil level therein a partial vacuum, favorable to the degasification of the oil entering through the line 26. The oil gives up entrained and dissolved gases and air. In normal service, even without a vacuum pump, the reservoir will always be under a partial vacuum. Theoretically this partial vacuum is a function of the difference between the maximum volume of oil which the reservoir has contained and the volume contained therein at the moment under consideration.

If the oil from the main tank of the electrical apparatus contracts, but the pump 2 is out of action, for example in the event of current failure in the motor driving the pump, the intake through the line 6 progressively raises the piston 7 again. The piston, at a given moment, unmasks an opening 30 which allows the vacuum in the reservoir to be broken by permitting atmospheric air to enter the reservoir through the opening 30, a drier 31 and the line 28. The travel of the piston 7 between its normal position and the position at which it unmasks the opening 30 determines a reserve volume of oil which retards the breaking of the vacuum in the reservoir in the event of failure of the pump 2. The valves 17 and 21 being subjected on both sides to the same pressure, can open to permit circulation of oil from the reservoir to the main tank. At this time, the reservoir operates like a normal reservoir provided with an air vent, and the flow of oil takes place towards the main tank through the line 14, the valve 17 and the line 6, as well as by any leakages in the pump 2 and at the valve 21. This arrival of oil returns the piston 7 into the position shown in the drawing, and the cycle will recommence. The ratio of the rate of flow of oil into the main tank to the volume of the cylinder 3 is calculated so that the opening 30 is only unmasked after a failure of current, in the motor driving the pump, of a sufficiently long and predetermined duration. It should be noted that the air drier 31 is only placed in communication with the atmospheric air in the event of failure of the oil pump, thus its drying properties are kept at a maximum.

The reservoir 1 is almost constantly under vacuum, or, if not, under a reduced pressure due to a slow outflow of oil through line 14, valve 17, line 15 and an upper space 32 of the cylinder 3 and out line 6 or through lines 14, 19, the pump 2 and valve 21, line 15, the space 32 and line 6. Because of this the oil in the reservoir will not run out upon rupture of the main tank, breakage of terminals or some similar accident. In fact, in such a case, the valves 17 and 21 close firmly on their seats and an out-flow from the reservoir is prevented. The air rushing in through the tank opening or rupture will replace the oil in the top end space 32 of the cylinder 3 and in the line 15 leading to the reservoir. Under these conditions, the piston 7 is not subjected to pressure or vacuum, but only to the weight of the oil contained in the cylinder 3 up to the lower edge of the line 6. The piston then remains in the position shown in the drawing, since this weight of oil is not sufficient to overcome the force of the spring 24. The valve 4 therefore remains closed and the oil from the reservoir 1 cannot flow towards the main tank.

The apparatus is preferably provided with a motor-driven vacuum pump shown schematically at **34** connected to take a vacuum drag on the reservoir or expansion tank **1** above the level of the oil therein.

By the use of a vacuum pump the pressure in the reservoir can always be kept below a predetermined value, which greatly improves the effectiveness of the reservoir as a degasifier and dehydrator.

The vacuum pump **34** is preferably controlled by the piston rod **12** by means of a cam **12***b* thereon which closes a switch **36** when the delivery valve **4** opens. The closing of switch **36** electrically energizes the motor-driven vacuum pump **34** from the electrical supply circuit as shown. In order to prevent the vacuum pump from remaining in operation when the pressure in the reservoir is sufficiently low, it is possible to control it by a manometer **37** which senses the pressure above the oil level in reservoir **2** and operates a switch **38** in series with the switch **36**. When the pressure is low the manometer opens the switch **38**.

In order to guard against a possible defect in the tightness of the piston **7**, there may be substituted for the piston, by way of a variant, a deformable elastic diaphragm **40** of known type, as shown in FIG. 2. In this case, the masking of the orifice or opening **30** leading to the air drier **31** can be effected by the deformable diaphragm covering the opening **30**. This arrangement is equivalent to a valve and permits the elimination of the valve **29** as shown in FIG. 1. The air expelled from the reservoir by expansion of the oil is then compelled to pass first into the drier **31** before being released to the exterior, but this presents no great disadvantage.

In another example of an embodiment of the invention as shown in FIG. 3, in which the parts corresponding to those in the embodiment in FIG. 1 are shown with corresponding but primed reference numerals, the apparatus for oil preservation and regeneration is connected to the main tank (not shown) of a transformer by means of a line **6′** and it comprises a reservoir **1′**, a motor-driven oil pump **2′**, a device responsive to variations of the volume of oil contained in the closed main tank of the transformer, and a delivery valve formed by an opening **41** in a line **26′** in conjunction with a piston **7′**.

The device responsive to the variations of the oil volume is constituted by a cylinder **3′** into which the pipe **6′** opens, and said piston **7′**. The piston **7′** is provided with an element, in the present case a head rod **12′** provided with a cam **12′***a* for starting and stopping the pump **2′** according to the variations of the oil volume in the closed main tank, which variations are measured by the position of the piston **7′** in the manner heretofore described with respect to the embodiment in FIG. 1.

The means for controlling the delivery valve is constituted by the piston **7′** itself, since the cylindrical walls of its skirt form a slide valve for the opening and closing of the opening **41**. The pump **2′** is controlled by switch **22′** and the valves **17′**, **21′** and line **14′** here carry out the same functions as already described with reference to their corresponding parts in FIG. 1.

When the oil in the oil-filled main tank of the oil-coated apparatus (not shown), expands it flows from the main tank through the line **6′** and pushes the piston **7′** upwards until it unmasks the opening **41**, permitting the flow of oil through the line **26′** against the pressure exerted by the weight of the piston **7′** and its head rod **12′**. In the raised position of the piston **7′** the switch **22′** is opened and the pump **2′** is stopped.

When the oil in the main tank contracts, the piston **7′** descends under its own weight and that of its head rod **12′** and masks the opening **41**. The cam **12′***a* closes the switch **22′** which starts the pump **2′**. As the output of the pump **2′** is greater than the maximum possible intake by the tank, the piston **7′** resumes its upper position and the switch **22′** interrupts the current to the pump, until the piston **7′** descends again to start the pump, when the oil diminishes.

In the event of failure of the supply voltage feeding the pump **2′** and a vacuum pump **34′** the piston **7′** will be unable to start the pump **2′**. Due to this fact, the piston will descend to a level sufficiently low to place the opening **41** in communication with an upper space **42** of the cylinder **3′** which is connected to the free atmosphere through a dryer or dehydrator **45**. Shortly before the communication of the reservoir **1′** with the atmosphere is established by the descent of the piston, a switch **36′** is opened by a cam **12′***b* on the rod **12′** so that the vacuum pump is prevented from operating if the supply voltage from the electrical supply circuit shown should be restored at this moment. This embodiment of the invention is also provided with a manometer operated switch **38′** operable similar to switch **38** in the embodiment of FIG. 1.

The time taken by the piston **7′** to descend, as described above, to the lower limit of its travel is sufficient for the atmospheric pressure to be fully re-established in the reservoir, which permits the reservoir to operate then like a conventional expansion reservoir provided with a dehydrator.

It will be seen that the pressure in the transformer tank is always equal to the atmospheric pressure obtaining above the piston **7′** plus the weight of the piston and of the column of oil contained in the line **6′** and in a space **32′** inside the cylinder **3′**.

In order to avoid entry of atmospheric air to the vacuum space of the reservoir through leakage around the piston **7′** a groove **46**, situated near the top of the piston, is placed in communication with the oil beneath the piston through a small bore passageway **47**. This groove **46** is thus constantly filled with oil, and in the event of a defect in the tightness of the piston, it is this oil which is sucked into the reservoir, and not atmospheric air.

The oil contained in this groove **46** is in contact with the atmospheric air in the narrow clearance between piston **7′** and the cylinder wall. This clearance is so small that the air therein is incapable of contaminating the oil to any appreciable extent. Nevertheless, by way of variant, it is possible to connect the space **42** above the piston **7′** through a line **49** to an oil reservoir **50** in communication with a second oil reservoir **51**, the upper part of which is in communication with the atmosphere through a line **53** and a dehydrator or drier **55**. The volume of oil contained in the two reservoirs **50** and **51** will completely insulate the air situated above the piston **7′** from the atmosphere. It is readily apparent that this air can be replaced by an inert gas.

The dimensions of the reservoirs **50** and **51** and the quantity of oil which they contain is so determined that in case the reservoir **1′** is placed under atmospheric pressure, dried air which has been dehydrated by the drier **55** will bubble through the oil, in passing from the reservoirs **50**, **51** without carrying any oil into the line **49**.

It will be understood that the weight of the piston **7′** and the clearance between that piston and the cylinder wall are determined in such a way that the highest level reached by the oil between those parts is above the groove **46** but not above the top of the piston.

While preferred embodiments of the invention have been shown and described, it will be understood that many modifications and changes can be made within the scope of the invention.

What I claim and desire to secure by Letters Patent is:

1. Apparatus for preserving and regenerating insulating liquid for liquid-cooled electrical devices having an expansion reservoir comprising, an expansion cylinder, means providing communication between said cylinder and said device and means for providing communication between said cylinder and said reservoir, means comprising a valve and a piston reciprocable in said cylinder for operating said valve in response to volume variations of said insulating liquid in said device and movable in one direc-

tion for controlling liquid flow into said reservoir when the liquid in said device expands and flows in a direction toward said reservoir and movable in an opposite direction for controlling flow of liquid from said reservoir to said device when the liquid contracts and flows in a direction toward said device, a fluid pump in communication with said reservoir and said cylinder, means for intermittently operating said pump in response to a preselected range of positions of said piston for pumping liquid from said reservoir to said device to maintain a preselected volume of insulating liquid in said device, means for creating a partial vacuum in said reservoir comprising a vacuum pump in communication with said reservoir, means actuated by said piston to intermittently operate said vacuum pump and valve means in said means providing communication between the reservoir and the cylinder operable to a closed position for maintaining the liquid in said reservoir in the event of loss of liquid out of said device.

2. Apparatus for preserving and regenerating insulating liquid for liquid-cooled electrical devices having an expansion reservoir under a partial vacuum comprising, an expansion cylinder, means providing communication between said cylinder and said device and means for providing communication between said cylinder and said reservoir, means comprising a delivery valve and a piston operably connected to said valve and reciprocable in said cylinder in response to volume variations of said insulating liquid in said device and movable in one direction for controlling liquid flow into said reservoir when the liquid in said device expands and flows in a direction toward said reservoir and in an opposite direction for controlling flow of liquid from said reservoir to said device when the liquid contracts and flows in a direction toward said device, and a pump in communication with said reservoir and said cylinder, means for intermittently operating said pump in response to a preselected range of positions of said piston for pumping insulating liquid from said reservoir to said device to maintain a preselected volume of insulating liquid in said device, means to periodically increase the vacuum in said reservoir to a preselected value under control of said piston, and means actuated by said piston to intermittently operate the last mentioned means.

3. Apparatus for preserving and regenerating insulating liquid for liquid-cooled electrical devices having a liquid expansion reservoir under a partial vacuum comprising, an expansion cylinder, means providing communication between said cylinder and said device and means for providing communication between said cylinder and said reservoir, a piston reciprocable in said cylinder in response to volume variations of said insulating liquid in said device, a valve operable to an open position by said piston in one direction of travel thereof for allowing liquid to flow into said reservoir when the liquid in said device expands and flows in a direction toward said cylinder and operable to a closed position by said piston in its other direction of travel when liquid in said device contracts and flows in a direction toward said device, said means providing communication between the pump and cylinder comprising a pump, a one-way series-valve connected in series with said pump and another one-way valve connected in parallel with said pump and said series valve, and means for intermittently operating said pump in response to a preselected range of positions of said piston for pumping insulating liquid from said reservoir to said device to maintain a preselected volume of insulating liquid in said device.

4. Apparatus according to claim 3, including means actuated by said piston in dependence upon its travel exceeding a predetermined range of positions for placing said reservoir in communication with the atmosphere for allowing the liquid to flow from the reservoir to said cylinder and said device through said valve connected in parallel.

5. Apparatus for preserving and regenerating insulating liquid for liquid-cooled electrical devices having a liquid expansion reservoir comprising, an expansion cylinder, means providing communication between said cylinder and said device and means for providing communication between said cylinder and said reservoir, means comprising a piston reciprocable in said cylinder in response to volume variations of said insulating liquid in said device and movable in one direction for controlling liquid flow into said reservoir when the liquid in said device expands and flows in a direction toward said reservoir and movable in an opposite direction for controlling flow of liquid from said reservoir to said device when the liquid contracts and flows in a direction toward said device, valve means controlled by said piston for controlling said liquid flow, a fluid pump in communication with said reservoir and said cylinder, means for intermittently operating said pump in response to preselected positions of said piston for causing said pump to pump liquid from said reservoir to said device to maintain a preselected volume of insulating liquid in said device, means for creating a partial vacuum in said reservoir comprising a vacuum pump in communication with said reservoir, and means actuated by said piston for operating said vacuum pump intermittently in dependence upon said piston being in positions of travel other than said preselected positions of said piston.

6. Apparatus for preserving and regenerating insulating liquid for liquid-cooled electrical devices having an expansion reservoir comprising, an expansion cylinder, means providing communication between said cylinder and said device and means for providing communication between said cylinder and said reservoir, means comprising a valve and a piston reciprocable in said cylinder for operating said valve in response to volume variations of said insulating liquid in said device and movable in one direction for controlling fluid flow into said reservoir when the liquid in said device expands and flows in a direction toward said reservoir and movable in an opposite direction for controlling flow of liquid from said reservoir to said device when the fluid contracts and flows in a direction toward said device, a pump in communication with said reservoir and said cylinder, means for intermittently operating said pump in response to a preselected range of positions of said piston for causing said pump to pump liquid from said reservoir to said device to maintain a preselected volume of insulating liquid in said device, means for creating a partial vacuum in said reservoir comprising a vacuum pump in communication with said reservoir and means actuated by said piston to intermittently operate said vacuum pump in dependence upon said piston being in positions of travel other than said range of positions.

7. Apparatus for preserving and regenerating insulating liquid for liquid-cooled electrical devices having an insulating liquid expansion reservoir comprising, an expansion cylinder, means providing a communication between said cylinder and said device and means for providing communication between said cylinder and said reservoir, a piston reciprocable in said cylinder in response to volume variations of said insulating liquid in said device, first valve means operable by said piston to an open position allowing liquid to flow into said reservoir when the liquid in said device expands and operable by said piston to a closed position when the liquid in said device contracts, one-way valve means connected to allow liquid to flow from said reservoir through said means providing communication between said cylinder and said reservoir to said cylinder toward said device when the liquid contracts, a pump in communication with said device and said reservoir, and means for operating said pump intermittently in response to preselected positions of said piston for causing said pump to pump liquid from said reservoir to said device to maintain a preselected volume of insulating liquid in said device.

8. Apparatus for preserving and regenerating insulating liquid for liquid-cooled electrical devices having an insulating liquid expansion reservoir comprising, an expansion cylinder, means providing communication between said

cylinder and said device and means for providing communication between said cylinder and said reservoir, a piston reciprocable in said cylinder in response to volume variations of said insulating liquid in said device, first valve means connected to said piston operable to an open position for allowing liquid to flow from said device into said reservoir when the fluid in said device expands and operable to a closed position when the liquid in said device contracts and in the event of loss of fluid out of said device, one-way second valve means disposed in said means providing communication between said cylinder and said reservoir to allow insulating liquid to flow in a direction only from said reservoir through said cylinder to said device when the liquid contracts and in the event of loss of said device, whereby said first and second valve means provide communication between the reservoir and the cylinder and are operable to a closed position for maintaining the liquid in said reservoir in the event of fluid loss out of said device, and a pump in communication with said reservoir and said cylinder, means for intermittently operating said pump in response to a preselected range of positions of said piston and for causing said pump to pump liquid from said reservoir to said device to maintain a preselected volume of insulating liquid in said device.

9. Apparatus for preserving and regenerating insulating liquid for liquid-cooled electrical devices having an insulating liquid expansion reservoir comprising, an expansion cylinder, means providing communication between said cylinder and said reservoir, a first valve, a piston operably connected to said first valve and reciprocable

in said cylinder in response to volume variations of said insulating liquid in said device and movable in one direction for controlling liquid flow through said first valve into said reservoir when the liquid in said device expands and flows in a direction toward said cylinder and said reservoir, second valve means for allowing the liquid to flow only from said reservoir to said device when the liquid contracts and flows in a direction toward said device, and a pump in communication with said reservoir through said means providing communication between said cylinder and said reservoir to said device when the liquid contracts and flows in a direction toward said device, and a pump in communication with said reservoir and said cylinder intermittently operable in response to preselected positions of said piston for pumping liquid from said reservoir to said device to maintain a preselected volume of insulating liquid in said device, means operable by said piston to intermittently operate said pump in response to given positions of travel of said piston, and a vacuum pump connected to create and maintain a partial vacuum in said reservoir over the oil level therein.

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