

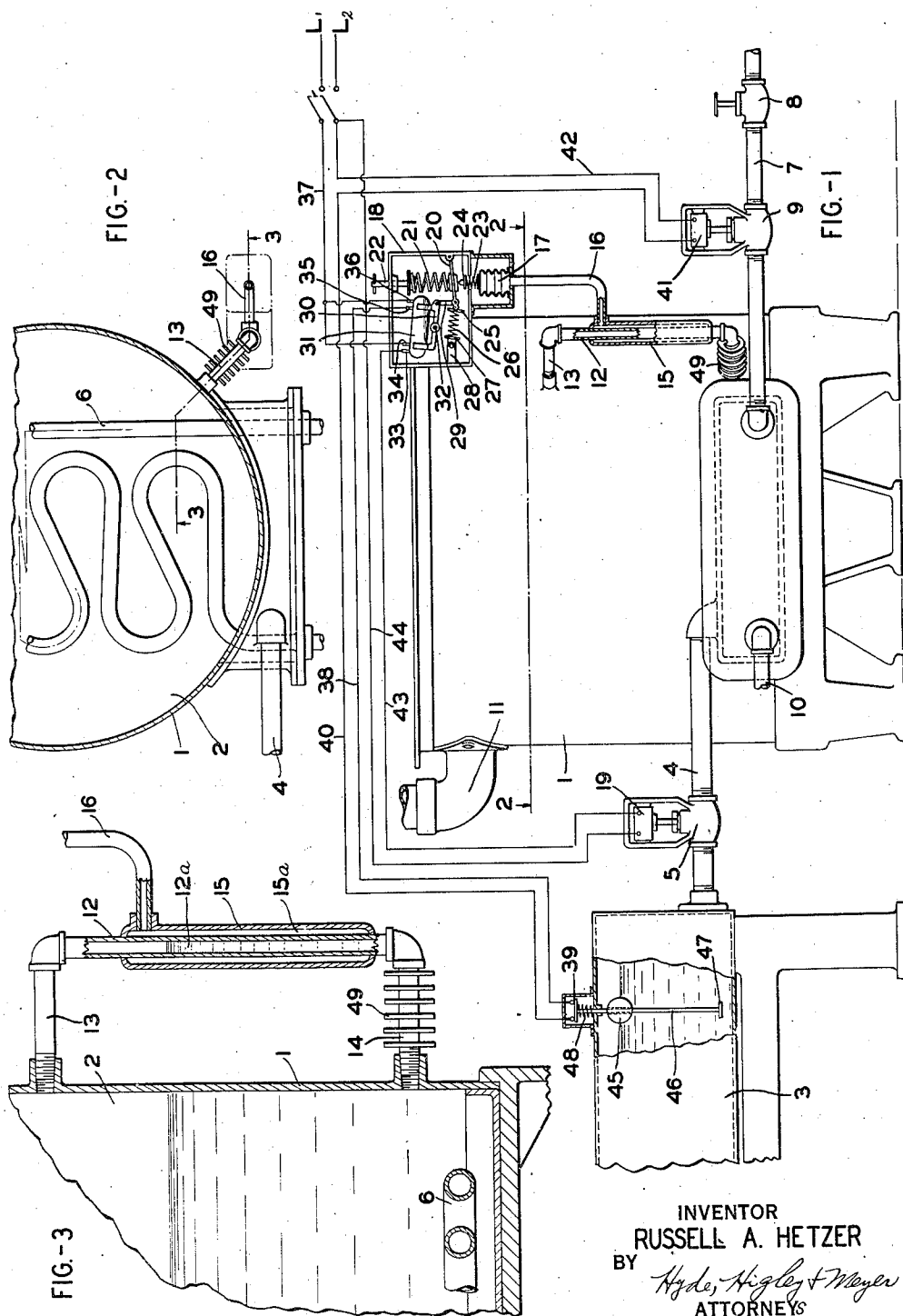
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AUTOMATIC CONTROL OF THE LIQUID LEVEL FOR EVAPORATORS

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AUTOMATIC CONTROL OF THE LIQUID
LEVEL FOR EVAPORATORS

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My invention relates to evaporators or stills and more particularly to improved means for automatically regulating the supply of liquid thereto and the supply of a heating medium to vaporize the liquid therein.

In dry cleaning systems in which a volatile or low boiling point solvent containing a chlorine compound, such as carbon tetrachloride or perchlorethylene or a petroleum derivative, such as naphtha or benzine is employed, it is the practice to renovate or reclaim used solvent for reutilization in the treating process. For this purpose the used solvent is usually drained from the treating vessel into a sump tank which serves as a supply tank for a still or evaporator in which the liquid is vaporized at a pressure not materially exceeding atmospheric, the vapors being subsequently condensed and collected in a storage tank for reuse in the process.

It is the aim of the present invention to provide an improved apparatus by means of which the liquid to be reclaimed may be automatically supplied to an evaporator of the kind described when the liquid surface in the evaporator falls to a predetermined level and by means of which a heating medium may be automatically supplied to evaporate the liquid in the evaporator when its surface rises to a predetermined level. Means also may be provided to automatically prevent a supply of heating medium to the evaporator when the surface of the liquid in a supply tank for the evaporator falls below a predetermined level.

It is, therefore, an object of my invention to provide an evaporator or still operating at a pressure not materially exceeding atmospheric and having a chamber for volatile solvent liquid and a vapor space above said liquid in combination with automatic means responsive to the effect of both the liquid and the vapors in the chamber for supplying liquid to the evaporator when the liquid surface falls to a predetermined level and for supplying a heating medium to evaporate the liquid when its surface rises to a predetermined level.

Another object of my invention is to provide a still or evaporator of the character described having a chamber containing a liquid to be evaporated and a vapor space in the chamber above the liquid, in combination with a supply tank for said evaporator, and automatic means for supplying heat to volatilize the liquid in said evaporator when its surface rises to a predetermined level, the supply of heat being shut off when the surface of the liquid in the evaporator falls to a predetermined level and being withheld from the

evaporator if the level of liquid in the supply tank is at or reaches an abnormally low level.

A further object of my invention is to provide an improved control device for evaporators or stills of the character described, which is actuated by the effect of both the liquid and vapors in the evaporator, to supply liquid to the evaporator when the liquid surface in the evaporator falls to a predetermined level, and which is provided with cooling means tending to prevent the possibility of operation of the control device by the effect of the evaporator liquid alone.

My invention will be better understood by reference to the accompanying drawing, in which

Fig. 1 is an elevation of an evaporator and a fragmentary portion of a supply tank, with parts broken away, and showing my improved control device in diagrammatic form applied to the evaporator and supply tank;

Fig. 2 is a sectional plan view on the line 2-2 of Fig. 1; and

Fig. 3 is a sectional elevation on the line 3-3 of Fig. 2.

While my improved control device may be applied to any evaporator or still which is adapted to be operated at a pressure or at pressures at or below atmospheric, or, at least, not materially exceeding atmospheric, for purposes of illustration it is shown applied to the evaporator of a reclamation unit of a dry cleaning system to which liquid may be intermittently supplied from a supply tank into which used solvent is drained from a fabric-treating vessel after each cleaning operation, the evaporator operating at substantially atmospheric pressure.

As shown in the drawing, the numeral 1 designates the evaporator having a chamber 2 to which liquid is supplied from a supply tank 3 through a pipe 4 controlled by a valve 5. While any convenient means may be provided for supplying heat to the liquid in the evaporator, as illustrated in the drawing it is heated by means of steam supplied to a coil 6 located in the bottom of the evaporator from a suitable source through a supply pipe 7 controlled by hand valve 8 and automatic valve 9, the steam from coil 6 being exhausted through pipe 10. Vapors from the still pass through the vapor pipe 11 to a suitable condenser, not shown, for recovery and reuse in the process, said condenser being open to atmosphere when the still is operated at atmospheric pressure, or being connected to vacuum producing apparatus when the still operates below atmospheric pressure, as will be readily understood.

In accordance with my invention, automatic

means is provided for supplying liquid from supply tank 3 to the evaporator when the surface of the liquid in the evaporator falls to a predetermined level and for supplying steam to the heating coil 6 when the surface of the liquid in the evaporator rises to a predetermined level. For this purpose I provide the still with a generator type regulator, including an auxiliary container 12 whose chamber 12a is connected by pipe 13 to the vapor space of chamber 2 and by pipe 14 with its liquid space. The regulator also includes a chambered jacket 15, surrounding container 12, and whose chamber 15a contains a control fluid which, for reasons later to be referred to, has a higher vapor pressure than the liquid undergoing treatment. A conduit 16 connects chamber 15a of the jacket 15 to a suitable operating device forming part of a controller, shown as a movable abutment 17 which, as illustrated, is in the form of an expansible and contractible hollow bellows sensitive externally to atmospheric pressure and internally to the pressure of the control fluid.

As shown in the drawing, the fluid in the jacket 15 is in heat exchange relationship with both the liquid and the vapor in container 12. In other words, it crosses the liquid level line of the still. Therefore, the amounts of the vapor and the liquid of the still which are in heat exchange relation with the control fluid depend upon the level of the surface of the liquid in evaporator 1. As will be seen from Fig. 3 of the drawing, as the surface of the liquid in evaporator 1 falls, the amount of the vapor in heat exchange with the fluid in jacket 15 increases and the amount of the liquid which is in heat exchange relationship with the fluid decreases. On the other hand, as the surface of the liquid in evaporator 1 rises, the amount of liquid which is in heat exchange relationship with the fluid in jacket 15 increases and the amount of vapor in heat exchange relationship with the fluid decreases.

Because of the greater heat transfer ability of vapor, due to the latent heat of vaporization, as the amount of vapor in chamber 12a in heat exchange relationship with the control fluid in chamber 15a increases, the vapor pressure of the control fluid likewise increases until finally it becomes sufficient to move abutment 17 a sufficient extent to operate the control device, marked generally 18, of which it forms a part, which then becomes effective to supply additional liquid to evaporator 1. As the level of the surface of the liquid rises in evaporator 1, however, the amount of liquid in chamber 12a which is in heat exchange relationship with the fluid in chamber 15a increases and the amount of vapor which is in heat exchange relation with the control fluid decreases, thereby causing a decrease in the vapor pressure of the control fluid. When the vapor pressure of the control fluid decreases to a predetermined extent, however, the control device 18 is operated reversely and becomes effective to shut off the supply of liquid to the evaporator and to supply heat thereto.

As before stated, the control device includes the movable abutment or expansible bellows 17. While the operating connections between abutment 17 and the valves 5 and 9, for operating the latter, may be of any type or form suitable for the purpose, I have utilized electrical operating mechanism. As illustrated in the drawing the control device is of the snap-acting type and includes a pivotally mounted arm 20 interposed between a loading spring 21 held in compression

by an adjustable screw 22 and a spring 23 resting against abutment 17 and supporting a plunger 24. Arm 20 is connected to one side of a block 25, a compression snap-acting spring 26 being attached to the other side of the block and the other end of the spring being secured to a block 27 supported by a bracket 28 on a wall of the casing. Extending upwardly from arm 20 and connected at one end thereto, is a link 29 which is connected at its opposite end to one end of a bracket 30 supporting a mercury switch 31, the bracket for the mercury switch being pivotally mounted to the casing at the point 32. As the vapor pressure of the control fluid in bellows 17 increases, the plunger 24 raises arm 20 which rotates bracket 30 and mercury switch 31 in a counterclockwise direction and compresses spring 26. As arm 20 passes dead center, spring 26 expands with a snap action and completes the rotation of bracket 30 and mercury switch 31, thereby forming an electrical connection between terminals 33 and 34. When the vapor pressure in chamber 15a decreases, however, spring 21 forces arm 20 in the opposite direction, rotating bracket 30 and mercury switch 31 in a clockwise direction and compressing spring 26 until arm 20 passes through dead center, whereupon spring 26 expands with a snap action and completes the rotation of bracket 30 and mercury switch 31, thereby forming an electrical connection between terminals 35 and 36.

The drawing shows the parts in that position which they occupy when the vapor pressure in chamber 15a is relatively low and abutment bellows 17 is contracted. At this time current is being supplied from line L₁ through conductor 37, terminal 36, terminal 35, and conductor 38 to normally closed switch 39 and from thence through conductor 40 to solenoid 41 and conductor 42 to line L₂. The energized solenoid 41 has raised valve 9 and steam is being supplied to the coil 6 to evaporate the liquid.

As the surface of the liquid in evaporator 1 falls, the amount of vapor in chamber 12a which is in heat exchange relationship with the control fluid in chamber 15a increases and the amount of liquid which is in heat exchange relationship with the control fluid decreases, thereby causing an increase in the vapor pressure of the fluid in chamber 15a. Control bellows 17 therefore expands forcing plunger 24 against arm 20, which moves the arm upwardly and rotates bracket 30 and mercury switch 31 in the counterclockwise direction, the expansion of spring 26 completing the rotation of the bracket and mercury switch as the lever 20 passes the unstable position of spring 26. A circuit is thus established from line L₁ through conductor 37, terminal 34, terminal 33, and conductor 43 to solenoid 19 and by conductor 44 to line L₂. Energization of solenoid 19 opens valve 5 and liquid flows from the sump tank 3 into evaporator 1. As the level of liquid in the evaporator 1 rises, the proportion of liquid from evaporator 1 which is in heat exchange relation with the fluid in chamber 15a increases, until finally there is a sufficient decrease in the vapor pressure of the control fluid to permit spring 21 to operate lever 20 in the opposite direction and thereby terminate liquid flow from the sump tank and also supply heat to the still.

In an arrangement such as described, using a generator type regulator for actuating an operating device in the control system, and more especially where the operating device is of the movable abutment or expansible bellows variety

sensitive externally to atmospheric pressure and internally to the pressure of the control fluid, the control system as a whole must be of a character suitable to produce movement of the actuating device in accordance with fluctuations in level, in the generator type regulator, of the liquid being vaporized. The fluid in the closed control system must be of such a character, under the prevailing conditions, as to generate sufficient pressure to cause operation of the actuating device against the load of its duty. Depending upon the character of the control mechanism, this duty may be the movement of valves, switches, relays, or like devices, springs, etc. In the arrangement shown in the drawing, the load or duty of the actuating device 17, in addition to that of overcoming atmospheric pressure against which it operates, is that of overcoming the compression of loading spring 21 and snapping spring 26, together with the friction of the moving parts of the mechanism.

When a still or evaporator is of the steam boiler variety, to-wit, one evaporating water, the still is usually operated under pressure, say one hundred pounds pressure per square inch above atmospheric. Excepting for losses of heat by radiation it is possible, in a generator regulator control system for a steam boiler, with water used as the control fluid in the closed system, to generate pressure of the control fluid approaching or of the general order of the pressure in the boiler. The control fluid pressure, for example, might be as much as seventy-five pounds per square inch, and that pressure is more than amply sufficient to take care of any load or duty of the control device.

The present invention, however, is not concerned with a still or evaporator operating at material or substantial pressures above atmospheric, such as in the case of a steam boiler. The still or evaporator here involved has no purpose of transferring either heat or pressure, but is designed solely for the purpose of evaporating or distilling, for purifying purposes, a volatile or low boiling solvent liquid, such as those heretofore referred to. While the present still or evaporator may be operated at a pressure slightly above atmospheric, say a few pounds, it is usually operated at atmospheric pressure or below atmospheric pressure. Even when the pressure is above atmospheric, it would not be sufficiently elevated above atmospheric to produce sufficient pressure in the closed control system to operate an actuating device and control mechanism, if the control fluid were identical with that being vaporized in the evaporator or if the vapor pressure of the fluids in the evaporator and closed control system were close together.

Accordingly, when the present still is used for any particular volatile or low boiling point liquid, whether it be one used as a solvent in a dry cleaning system as in my Patent No. 2,142,726, granted January 3, 1939, or for other purposes, I operate the still at a pressure or pressures not materially higher than atmospheric and utilize a control fluid whose vapor pressure is sufficiently higher than the vapor pressure of the liquid being reclaimed, so that assuming the pressure in the still to remain fairly constant, as is the case when it is operated at substantially atmospheric pressure, sufficient pressure may be generated by the regulator in the closed control system to actuate the control device, including its actual load or duty, as above referred to.

When carbon tetrachloride is the liquid being

reclaimed, ethyl ether has been found suitable for a control fluid because it has been found that operating at a pressure which is not materially higher than atmospheric pressure when vaporizing carbon tetrachloride, ethyl ether in the closed control system will generate a pressure of substantially thirty-eight pounds per square inch, which, operating against atmosphere, effective externally on the bellows 17, is sufficient to cause operation of the control mechanism.

Other control fluids having a sufficiently high vapor pressure to operate the control device at atmospheric pressure or not materially higher than atmospheric pressure also may be employed. For example, when carbon tetrachloride or trichlorethylene are being vaporized any one of the fluids, methylene chloride, methyl alcohol, ethyl bromide, acetone, or methyl formate, may be utilized as the control fluid. It will be noted that in general these organic compounds have boiling points ranging approximately from 34° to 65° C., with corresponding vapor pressures.

Of course, in the distillation of certain liquids, reduced pressure or vacuum is employed. That is true, for example, in the distillation of certain petroleum distillates having a comparatively high boiling point, such as Stoddard's solvent, with a boiling point of 420° F. In that case the control fluid again must be selected with a vapor pressure sufficiently higher than that of the liquid being reclaimed, in order to generate sufficient pressure in the closed control system to operate the control device.

In accordance with my invention means also may be provided for preventing application of heat to the evaporator 1 should the surface of the liquid in supply tank 3 ever fall below a predetermined abnormal level. In such an event, it might be impossible to cause the surface of the liquid in evaporator 1 to rise to a sufficient level to cause immediate actuation of the control device for the purpose of closing valve 5 and supplying heat to the evaporator. Therefore, the liquid in the evaporator might cool and the vapors would condense due to the loss of heat by radiation, thus causing a decrease in the vapor pressure of the control fluid, and spring 21 might actuate the control device to supply heat to the evaporator. Since a further supply of liquid to the evaporator would not be available when the control device was actuated in the opposite direction, the liquid in the evaporator would eventually all be vaporized. For preventing this, the supply tank is provided with a float 45 through which the stem 46 of the switch 39 extends, the lower portion of stem 46 being provided with a head 47. Under normal conditions when there is sufficient supply of fluid in supply tank 3, switch 39 is held in closed position by means of a spring 48 interposed between the switch 39 and the top of the supply tank. However, if the surface of the liquid in the supply tank falls to an abnormally low level, float 45 engages head 47 opening the switch 39, which prevents the energization of solenoid 41 and valve 9 remains closed. Supply of heating medium to the evaporator, therefore, is prevented.

In the event that a control liquid is utilized which has such a high vapor pressure that sufficient pressure to operate the control device might be generated in the control fluid by that portion of the liquid being vaporized which is in the generator regulator before the surface of said liquid falls to the desired level, means

may be provided for cooling the liquid passing from evaporator 1 into auxiliary container 12. As illustrated, fins 49 are provided for this purpose, upon the tube 14 which communicates with the liquid space of the evaporator and auxiliary container 12. Liquid from the evaporator passing into container 12 is consequently cooled, which decreases the amount of heat transferred from the liquid to the control fluid and prevents the operation of the control device until the surface of the liquid in the evaporator falls to the desired level.

The invention described makes it possible to evaporate low boiling point liquids, such as volatile solvents, at a pressure not materially higher than atmospheric, using a generator type regulator which generates enough pressure of the control fluid to actuate a controlling device, and thus to control either or both of the supply of liquid to the still or the supply of heat thereto, and also to prevent application of heat to the still when the supply of liquid therefor is depleted or abnormally low, and finally, to overcome any tendency of the liquid being vaporized alone to cause sufficient response in the generator type regulator to call for liquid supply when none is required.

Other advantages of the invention will be apparent to those skilled in the art.

What I claim is:

1. Apparatus of the class described comprising a supply tank containing a liquid to be vaporized, an evaporation chamber for said liquid, a source of heating medium for vaporizing said liquid, communicating means between said tank and said chamber, means responsive to the fall of the liquid surface in said chamber to a predetermined level during vaporization for automatically supplying liquid from said supply tank to said chamber, means responsive to the rise of the surface of the liquid in said evaporator to a predetermined level for supplying said heating medium to vaporize the liquid in said evaporator, and means responsive at a predetermined low level of the surface of the liquid in said

supply tank for preventing a supply of heating medium to said vaporizing means.

2. Apparatus of the class described comprising a supply tank containing a liquid to be vaporized, an evaporation chamber for said liquid, a source of heating medium for vaporizing said liquid, communicating means between said tank and said chamber, means responsive to the fall of the liquid surface in said chamber to a predetermined level during vaporization for automatically supplying liquid from said supply tank to said chamber, means responsive to the rise of the surface of the liquid in said evaporator to a predetermined level for supplying said heating medium to vaporize the liquid in said evaporator, said means actuated by said fall and rise of liquid comprising a movable member responsive respectively to the vaporization and condensation of a volatile liquid, and means responsive at a predetermined low level of the surface of the liquid in said supply tank for preventing a supply of heating medium to said vaporizing means.

3. Apparatus of the class described comprising a supply tank containing a liquid to be vaporized, an evaporation chamber for said liquid, a source of heating medium for vaporizing said liquid, communicating means between said tank and said chamber, said apparatus being provided with a vapor outlet to maintain the chamber at substantially atmospheric pressure, means responsive to the fall of the liquid surface in said chamber to a predetermined level during vaporization for automatically supplying liquid from said supply tank to said chamber, means responsive to the rise of the surface of the liquid in said evaporator to a predetermined level for supplying said heating medium to vaporize the liquid in said evaporator, and means responsive at a predetermined low level of the surface of the liquid in said supply tank for preventing a supply of heating medium to said vaporizing means.

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