March 20, 1956 N. L. LIEBERMAN 2,738,928

HEAT EXCHANGE SYSTEM

Filed Sept. 3, 1952

Fig. 1.

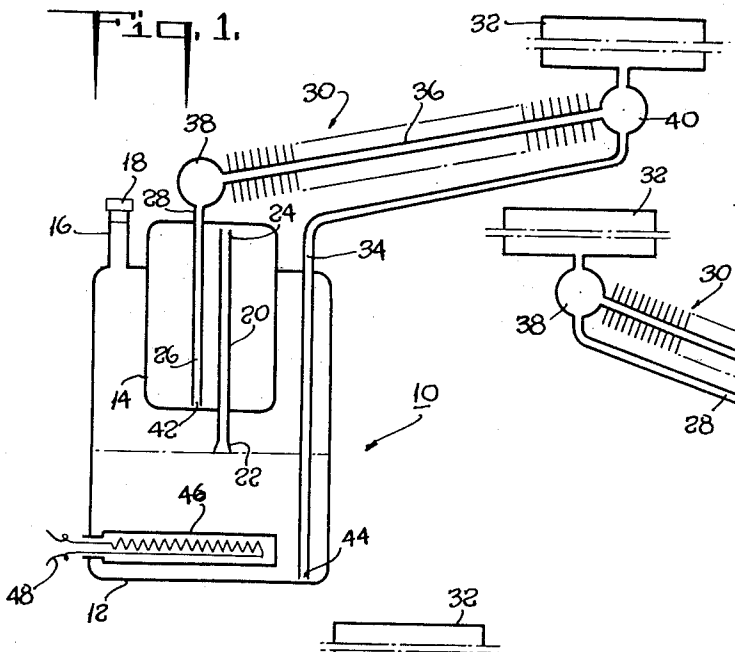


Fig. 2.

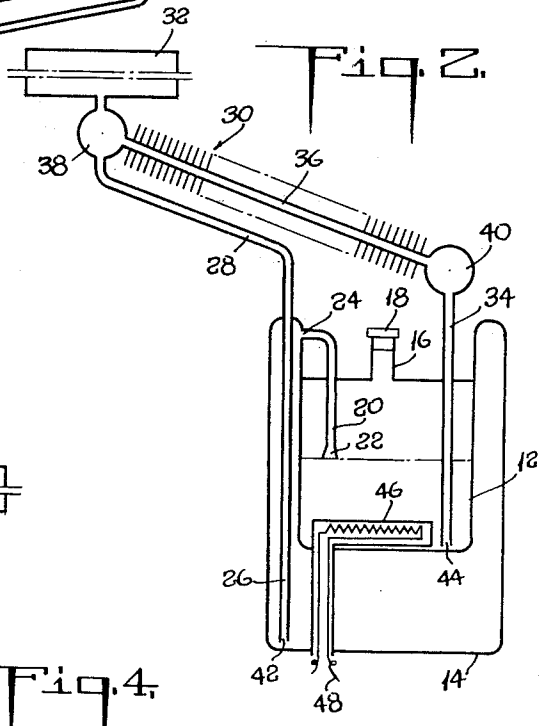


Fig. 4.

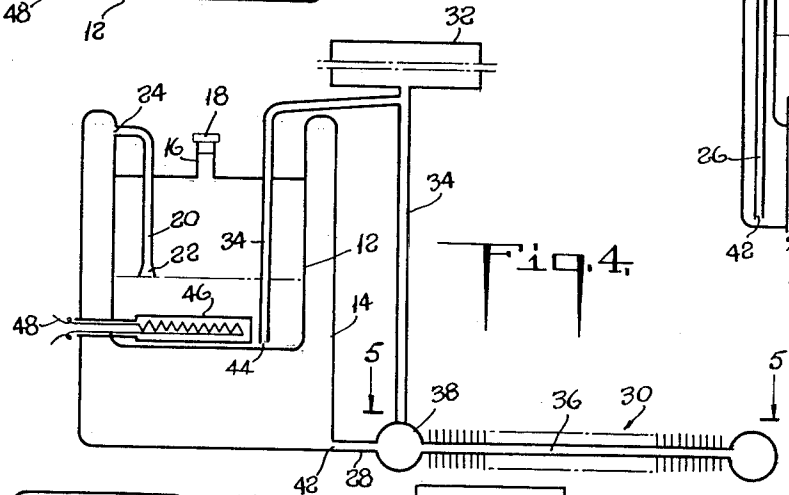


Fig. 3.

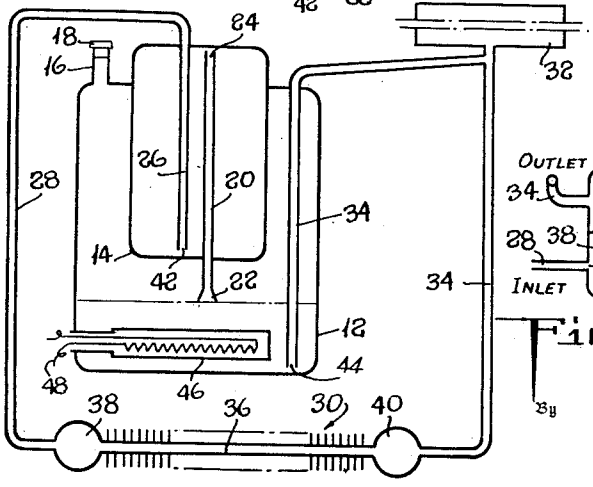
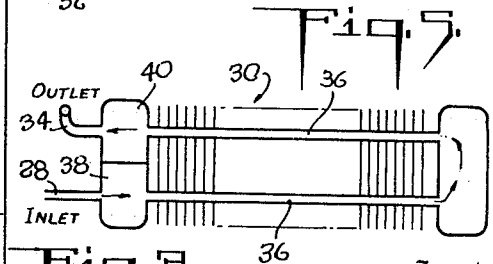


Fig. 5.



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HEAT EXCHANGE SYSTEM

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8 Claims. (Cl. 237—60)

This invention relates to a heat exchange system, and more particularly pertains to a method and system for heating and circulating a liquid. The system is particularly well adapted for and therefore will be described with reference to a self-contained heating or cooling system or a combination thereof.

Circulation in heating system for liquids generally depend either on a weight difference due to the expansion of the liquid in one part of the system and the contraction of the liquid upon passage through the heat exchangers causing the return of the contracted heavier liquid by gravity, or on a pumping system that may be either mechanical or pneumatic. Both the gravitational and pumping systems require either large storage units or circulating accessories. All gravitational systems require both the discharge and return openings in the heating vessels to be submerged at all times. If the heating vessel is not open to the atmosphere, both the gravitational and pumping systems usually require the entire system to be completely filled with liquid, when the system is cold. In these latter systems, the liquid content of the heating vessel is not diminished during operation. In other systems, when the heating vessel is closed and subject to vapor pressure, the piping and heat exchangers may be empty when the system is cold and subsequently filled with liquid discharged from the heating vessel. Such systems require the complete submergence of the liquid of the heating vessel of both the discharge and return openings since otherwise vapor under pressure would enter the external part of the system and prevent gravitational circulation. When gravitational systems are operated without being subject to vapor pressure, the entire system external to the heating vessel must lie below the waterline in said vessel, therefore the entire system is filled with liquid. All the above systems require a change of heat in a large volume of liquid—obviously an expensive process.

In some other systems, circulation is sustained by bubble action within confined portions of the system. These bubbles are introduced either from external mechanisms, or are generated within the confined portions by the application of heat. The external source of bubbles obviously requires compressors or other pneumatic equipment. The heat generation of bubbles in the liquid within the confined portions of the system requires parts that will control the action of the bubbles as prime movers of a liquid mass. This includess systems that operate on the generation and growth of bubbles in one part of the heating vessel and the subsequent diminution of the bubbles in another portion of the heating vessel.

It is an object of the present invention to provide a heat exchange system of the character described which avoids the foregoing defects.

It is another object of my invention to provide a heat exchange system of the character described in which circulation is positive, i. e. not dependent in its entirety upon gravity but in which no external pumping mechanism is included.

It is another object of my invention to provide a heat exchange system of the character described having an internal pumping mechanism which includes no moving mechanical parts.

It is another object of my invention to provide a heat exchange system of the character described which is more efficient in the use of heat than present-day systems of a similar nature.

It is another object of my invention to provide a heat exchange system of the character described in which the heating vessel is full when the system is cold and which is but partially full during operation so that less heat is needed to maintain the liquid in the heating vessel at an elevated temperature.

More specifically, it is an object of my invention to provide a heat exchange system of the character described in which only a minimum volume of heat exchange liquid is heated.

The present invention operates by the vapor pressure generated over a liquid which is initially contained wholly or substantially wholly in a heating vessel, all other parts of the system preferably being empty when cold. The operation does not depend on the rate, size, or frequency with which bubbles may be formed in the liquid in the heating vessel either as prime movers or in connection with the generation of vapor pressure over the liquid in the heating vessel. The vapor pressure forces a definite part of the liquid contents of the heating vessel through a connecting passageway into a distributing vessel, and through a distribution passageway into an external system consisting of piping and one or more heat exchangers. The liquid level in the heating vessel ultimately is lowered by this discharge to the bottom of the connecting passageway which connects the heating vessel with the distributing vessel and this proximate level is maintained as long as the system is in operation. At this proximate level the vapor under pressure which thereafter is generated in the heating vessel intermittently escapes from the heating vessel through the connecting passageway into the distributing vessel—discharging the liquid above it in the connecting passageway into the distributing vessel—and thereby forcing, i. e. pumping, liquid from the distributing vessel into the external system. The reduction in vapor pressure within the heating vessel due to the intermittent escape through the connecting passageway sets up a return flow from the external system to the heating vessel thus restoring the original proximate level. The connection between the heating vessel and the distributing vessel may be one or more tubes or annular spaces of length and section hereinafter described.

Thus the present invention obviates the necessity of external pumping mechanisms, of completely filling the entire system with liquid when the system is cold, of heating a maximum volume of liquid, of locating the external portion of the system below the water line in the heating vessel, of complete submergence of the discharge opening, of maintaining critical water temperatures in the heating vessel, of employing accessories or parts therein to control the action of generated or introduced bubbles, and of maintaining and heating a completely liquid filled heating vessel.

Other objects of my invention will in part be obvious and in part will be pointed out hereinafter.

My invention accordingly consists in the features of construction, combinations of elements and arrangements of parts which will be exemplified in the systems hereinafter described and of which the scope of application will be indicated in the appended claims.

In the accompanying drawing, in which are shown various possible embodiments of my invention,

Fig. 1 is a diagrammatic vertical sectional view of a heat exchange system constructed in accordance with my invention;

Fig. 2 is a view similar to Fig. 1 of a heat exchange system embodying a modified form of my invention;

Fig. 3 is a view similar to Fig. 1 of a heat exchange system embodying another modified form of my invention;

Fig. 4 is a view similar to Fig. 1 of a heat exchange system embodying still another modified form of my invention; and

Fig. 5 is a plan view of the heat exchanger shown in Fig. 4.

In general the present invention consists of a heat exchange system containing two sections, to wit (*a*) a combination heating and circulating unit, hereinafter referred to as the "generating" part of the system; and (*b*) piping and heat-exchangers, hereinafter referred to as the "external" part of the system. The generating part of the system includes two interconnected closed vessels, to wit, a heating vessel and a distributing vessel. An opening located within the distributing vessel is at or above the top of the heating vessel and is connected by a passageway to a lower horizontal opening located within the heating vessel. Said upper and lower openings are respectively spaced vertically from the top of the distributing vessel and the top of the heating vessel. Direct communication between the two vessels preferably is through this passageway only. At or near the bottom of the distributing vessel is a horizontal opening through which the distributing vessel is connected to the external piping and heat-exchanger inlets. The upper opening in the connecting passageway is above the latter opening. At or near the bottom surface of the heating vessel is an opening that connects the heating vessel to the return from the heat exchangers. The lower opening in the connecting passageway is above this return opening. The heating and distributing vessels may be separate or contiguous, and the distributing vessel should have at least a portion above the top of the heating vessel. Associated with the heating vessel is any means for heating the liquid in that vessel.

Referring now in detail to the drawings, and more particularly to Fig. 1, the reference numeral 10 denotes a heat exchange system embodying the present invention. Said system comprises a heating vessel 12 constituting a tank of any suitable shape and size. Conveniently the heating vessel may comprise a cylindrical boiler shell closed at both ends and having its cylindrical axis vertically disposed.

Located partly above and partly within the heating vessel 12 is a distributing vessel 14. The heating vessel has a filling tube 16 consisting of a pipe whose upper end is closed by a plug 18. The bottom of the filling tube is connected to the top of the heating vessel in order to enable the heating vessel to be completely filled when the system is cold.

A passageway, such for example as a tube 20, connects the heating vessel and the distributing vessel. Although this passageway is illustrated as a tube it will be understood the same may be in the form of an annular space wholly or partly circumscribing the vessels. Said passageway terminates at its lower inlet end in a horizontal opening 22 which for reasons that later will be pointed out preferably has a flared, i. e. bell, shape. The upper, i. e. discharge, end of the passageway is denoted by the reference numeral 24. Pursuant to my invention the discharge must be located above the inlet opening and above the bottom of the distributing vessel and above the top of the heating vessel, and the inlet opening must be below the top of the heating vessel.

A passageway, such for example, as a pipe 26, runs from the distributing vessel to the external part of the system which consists of piping 28, one or more heat exchangers 30, an expansion tank 32 and a return pipe 34. If desired, the heat exchanger 30 may include several pipes 36 in parallel and to this end I may include an inlet manifold 38 and an outlet manifold 40. It will be observed that the inlet manifold in this embodiment of my invention is below the outlet manifold. The expansion tank 32 is connected to the higher of the two manifolds, to wit, the outlet manifold.

Any desired number of heat exchangers can be employed and the same can be arranged in series or in parallel and fed individually or from a single distribution pipe. The return likewise may be individual or manifolded.

The distribution passageway 26 extends into the distributing tank and terminates therein at a horizontal inlet opening 42, which, pursuant to my invention, is above the bottom of the distributing tank and below the discharge opening of the connecting passageway 20. However, if desired, this pipe may be external to the distributing and the heating vessels. The return pipe terminates at a discharge opening 44 in the heating vessel which in pursuance of my invention is below the inlet opening of the connecting passageway 20.

Any suitable means may be employed to raise the temperature of the liquid in the heating vessel 12. For example, such means may constitute an electric heater 46 conventionally energized through a pair of leads 48.

The heating vessel 12 is completely filled with a suitable vaporizable heat exchange liquid, such as water, through the filling tube 16, which then is hermetically sealed by the plug 18. The liquid will rise in the connecting tube 20 and in the return pipe 34 to the same level as in the heating vessel 12, namely to the top of said heating vessel.

When the electric heater is energized the temperature of the liquid in the heating vessel will rise. The liquid in said vessel will be thermically expanded causing an overflow thereof through the connecting tube 20 into the distributing vessel 14 to cover the bottom of the latter. Expansion of the liquid in the heating vessel also will cause discharge of the liquid through the opening 44 into the return pipe 34.

Since the distributing vessel communicates with the heating vessel only through the discharge opening 24 in the connecting tube 20, liquid which overflows from said tube 20 into the distributing vessel cannot return through the connecting tube back to the heating vessel; accordingly this overflow liquid compresses the original air volume of the distributing vessel and the external part of the system, i. e. the distributing pipe 26, the external distributing piping 28, the heat exchanger 30, the expansion tank 32 and the return pipe 34.

Up to the instant that the overflow from the connecting tube into the distributing vessel seals the inlet opening 42 at the lower end of the distributing passageway 26, the distributing vessel is in air communication with the external part of the system. Thus the pressure due to compression of the total air volume by overflow of liquid into the distributing tank, until the opening 42 is sealed by the said overflow in the distributing tank, will be the same in said tank as it is in the external part of the system. As long as the distributing vessel is in air communication with the external part of the system, liquid discharged through the return opening 44 into the return pipe cannot rise any higher in said return pipe than the upper opening 24 of the connecting tube. Therefore any further discharge from the heating vessel will occur through the said connecting pipe into the distributing vessel until the opening 42 is sealed. The pressure in the external part of the system will be augmented by the effect of the temperature of the liquid discharge into the distributing vessel. The liquid displacement due to the thermic expansion of the liquid in the heating vessel at-

tains a maximum when the boiling point of the liquid is reached.

Further application of heat will produce steam, i. e. vapor, under pressure over the liquid in the heating vessel. This vapor under pressure will force liquid out of the heating vessel through both the connecting tube **20** and the return pipe **34**. The liquid in the connecting tube will overflow into the distributing vessel. Since the distributing opening **42** is sealed by liquid previously discharged through the connecting tube **20**, the air volume of the distributing vessel will be compressed as the liquid level in said vessel rises. Note should be taken that the opening **42** may be so located that it will be sealed either by thermic expansion as mentioned above or by initial overflow under the influence of vapor pressure. Liquid force from the heating vessel into the return pipe will compress the air in the external part of the system until a balance of pressure is established with the vapor pressure in the heating vessel. At any instant, for any vapor pressure in the heating vessel and for any liquid level in said vessel, equilibrium must exist at each of three openings, to wit, the connecting inlet opening **22**, the distributing opening **42** and the return opening **44**. It can be shown that the pressure in the heating vessel is greater than the pressure in the distributing vessel and that the latter pressure in turn is greater than the pressure in the external part of the system. Therefore, the action at the stage of operation during which air is being compressed in the distributing vessel and the external part of the system is: (*a*) liquid is forced from the heating vessel through the connecting tube into the distributing vessel and from the heating vessel through the return opening into the return pipe; (b) the level of the liquid rises in the distributing vessel and compresses the air volume therein; (*c*) the level of the liquid rises in the return pipe and compresses the air volume in the external part of the system; (*d*) the force of the compressed air in the distributing vessel forces liquid from said vessel through the distributing opening **42** into the distribution passageway and external piping.

From the physical dimensions of the distributing vessel it is possible to calculate the pressures existing therein for various compressed air volumes, or, equivalently, for different levels of liquid discharged from the heating vessel into the distributing vessel. Similarly from the physical dimensions of the external part of the system the pressures existing may be computed for different compressed air volumes or, equivalently, for different levels of liquid discharged into the external system from both the heating vessel and distributing vessel.

As more heat is applied to the heating vessel the foregoing adjustments in pressure continue until a maximum liquid level is established in the distributing vessel and the external part of the heating system is completely filled, exclusive of the expansion tank wherein the air volume has been compressed. The dimensions of the generating part of the system and the location of the connecting inlet opening **22** are so related to the dimensions of the external part of the system that when the external part is completely filled with liquid and the distributing vessel is filled to the "balance" level the liquid level in the heating vessel has dropped to the connecting inlet opening **22**. The volume of the heating vessel from the level of the opening **22** to the top of the heating vessel therefore is equal to the maximum liquid level volume in the distributing vessel, plus the volume of the external part of the system, exclusive of the expansion tank, plus a volume for evaporation for the generation of pressure in **12**.

The connecting tube **20** preferably is of capillary calibre so that as long as the inlet opening **22** is in contact with liquid in the heating vessel there will be a rise within the connecting tube **20**, regardless of all other factors.

In a preferred form of my invention the diameter of the connecting opening **22** is, for the foregoing purpose,

made approximately one-quarter of an inch, for which the rise of liquid, disregarding all other effects such for instance as the influence of generated vapor pressure, would be about 0.39 inch. It may be noted here that, to maintain this capillary rise, and yet have a greater effective cross-sectional passageway, it only is necessary to employ a number of such tubes. By using this diameter or smaller diameter of connecting tube, when the liquid level in the heating vessel is forced down to the level of the connecting inlet opening, said opening will be sealed by the capillary rise of liquid within said tube. The opening is further sealed by the liquid forced into the tube by the pressure in **12**. Capillary effect is useful only after pressure has escaped from **12** into **14** to reseal the opening and permit pressure build-up.

Up to this point in the operation of the system the heat applied to the heating vessel has caused expansion of the liquid in said vessel and the subsequently generated vapor pressure in said heating vessel has caused a unidirectional discharge of liquid through the connecting tube into the distributing vessel and through the return pipe **34** into the external part of the system, exclusive of the expansion tank, causing a compression of air volume in the distributing vessel and in the expansion tank, and the compressed air in the distributing vessel has caused a discharge of liquid through the distributing pipe **26**.

The compression of the air in the distributing vessel by the discharge of liquid from the heating vessel through the connecting tube brings the following factors into play:

At the distributing opening **42** the forces acting are the compressed air in the external part of the system plus the height of the liquid in the distributing pipe **26** and the external piping **28** above the distributing opening opposing the force of the compressed air in the distributing vessel plus the height of the liquid in the distributing vessel above the distribution opening. Since the distributing opening is water-filled, it hydraulically seals the distributing vessel from the distributing pipe **26**. Therefore any liquid discharged from the heating vessel through the connecting tube into the distributing vessel cannot force air from the distributing vessel into the distributing pipe without first lowering the existing liquid level in the distributing vessel. Because the only low opening in the distributing vessel is the distributing opening **42**, any liquid below the upper opening **24** in said vessel must be discharged from the distributing vessel through said distributing opening. The force due to the compressed air volume in the distributing vessel therefore will act to discharge liquid into the distributing pipe **26** through the distributing opening **42**. This discharge will be opposed by the compressed air pressure existing in the external part of the system, plus any liquid head present in the distributing pipe **26** and piping **28** above the distributing opening. The compressed air volume pressures depend upon the relative values of the air volume in the distributing vessel and air volume in the external part of the system as well as the liquid height in the heating vessel above the connecting inlet opening **22**. By plotting curves of pressure versus volume for both the distributing vessel and the external part of the system, the corresponding conditions of volume and pressure in both the distributing vessel and the external system can be determined simultaneously when the air volume in the external part of the system is compressed into the expansion tank. From the pressure in the distributing vessel, as thus determined, the vapor pressure in the heating vessel is computed from the physical characteristics of the system.

Up to this point there is no circulation in the system. The operation thus far has discussed the filling of the external system and part of the distributing vessel which were empty when the heating system was cold. As heating of the liquid in the heating vessel is continued after such filling of the system, further vapor pressure is gen-

erated in the heating vessel above the liquid. This additional vapor pressure will depress the liquid level below the level of the connecting inlet opening 22. However, said opening is connected to the depressed liquid level by a meniscus due to the surface tension of the liquid. Inasmuch as surface tension decreases with rising temperature and the boiling point increases with rising pressure, it is apparent that the surface tension decreases as the vapor pressure increases. The meniscus acts as a water seal preventing a discharge of vapor under pressure through the connecting inlet opening and the connecting tube. If the liquid were quiescent the meniscus would be broken only when the surrounding liquid level is depressed beyond the value of the sustaining surface tension. However, due to convection currents set up by the heating of the liquid in the heating vessel and to vapor bubbles constantly rising through the liquid in said vessel, the liquid surface in the heating vessel is in a state of constant agitation. Therefore a point soon is reached where both the agitation of the liquid surface and the increased vapor pressure will rupture the constantly stretching meniscus causing an instantaneous opening in the fluid through the meniscus to the connecting inlet opening and exposing the opening or at least a part thereof to the surrounding vapor under pressure. The vapor under pressure thereupon will discharge through the exposed connecting inlet opening into the connecting tube. This is the equivalent of an instantaneous opening of a variable throttle at the connecting inlet opening and for the instant that a clear space exists vapor under pressure will flow from above the liquid level in the heating tank into the connecting tube. Due to the momentary drop in the surrounding vapor pressure caused by this instantaneous discharge the liquid level is raised by a return flow through 44, and aided by the agitation of the liquid surface as aforementioned surface tension reestablishes the meniscus, sealing the connecting inlet opening against the surrounding vapor under pressure as if the above-mentioned imaginary throttle were closed.

The rupture of the meniscus may result in a large or small opening depending upon local circumstances. To facilitate the formation of a larger opening caused by such rupture, and therefore the admission of a larger amount of vapor under pressure, the lower end of the connecting tube at the connecting inlet opening is flared outwardly as described above. The foregoing action is equivalent to admitting vapor under pressure into a nozzle that discharges into a long cylinder fitted with a continuous and flexible-ended piston. The continuous and flexible-ended piston is the column of liquid in the connecting tube supported by the vapor pressure of the liquid in the heating vessel before rupture of the meniscus. As already noted, this column of liquid is sustained in part by capillary action.

When the meniscus is re-established the vapor is trapped in the tube and will form an upper meniscus with the liquid above it inside the tube and a lower meniscus with the lower sealing capillary liquid. Being of lesser density than the liquid in the tube, the vapor thus trapped will start to rise in the liquid column and at the same time expand in volume. This rising and expansion of the vapor forces part of the liquid column up through the connecting tube and out through the opening 24 at the upper end of said tube into the distributing vessel. Furthermore since the density of the entire liquid column in the connecting tube is reduced by the volume of the trapped vapor, the vapor pressure which originally sustained the solid liquid column in the connecting tube now will force liquid at the new higher level from the heating vessel into the connecting inlet opening in order to reestablish equilibrium, discharging into the distributing vessel 14 the trapped vapor and the liquid column above said vapor. Thus the liquid in the connecting tube which the trapped vapor caused to be discharged from said tube into the distributing vessel is immediately replaced in said tube from the heating vessel. Simultaneously, the reduction in volume of the heating vessel contents caused by replacement of liquid into the connecting tube is compensated for by liquid returning through the return opening 44 from the external part of the system thereby maintaining equilibrium at the three critical openings, to wit, the connecting inlet opening 22, the distributing opening 42 and the return opening 44. In this manner circulation is started and maintained as long as heat is supplied to the heating vessel and vapor pressure is generated over the liquid in said vessel while said liquid stays at the proximate level of the connecting inlet opening.

The action of the system during circulation may be summarized as follows:

The vapor trapped in the connecting tube reduces the density of the liquid column therein and when said liquid column is forced into the distributing vessel by the pressure restored in the heating vessel, said column carries the trapped vapor with it. Both the liquid and the vapor alternately and intermittently discharge into the distributing vessel and create a steady pressure therein, the upper air in the distributing vessel acting as a balancing chamber on the entering pulses of vapor and liquid. This is analogous to the balancing chamber which is employed in a fire hose system to provide a steady stream at the nozzle despite the pulsations of the pump which feeds the hose. From the distributing vessel liquid is continuously discharged under the accumulated pressure through the heat exchanger from whence it is returned to the heating vessel. Pressure is restored in the heating vessel by continued evaporation of liquid therein, it being noted that replenishing condensation occurs in the distributing vessel.

To summarize, the meniscus at the inlet 22 is intermittently ruptured. Vapor from the heating vessel enters the column of liquid in the connecting tube. This vapor is trapped by liquid above and by the meniscus formed by capillary action below. The escaping vapor decreases the pressure in the heating vessel. The trapped vapor reduces the density of the liquid column in the connecting tube. The pressure in the heating vessel is rapidly restored by evaporation of liquid to reestablish equilibrium at the inlet opening 22. Thus the column of reduced density is lifted thereby discharging vapor and liquid intermittently and alternately into the distributing vessel. The vapor directly increases the pressure therein and the liquid increases the pressure in the distributing vessel by decreasing the air volume. The increased pressure in the distributing vessel overcomes the equilibrium at the distributing opening and forces liquid from the distributing vessel into the heat exchanger. The flow is continuous with slight fluctuations in velocity to the return opening 44. The return flow raises the level of liquid in the heating vessel against the reduced pressure therein thus reestablishing the meniscus and resealing the inlet opening 22.

It will be appreciated from analysis that a critical relationship exists between certain elements of my system. Thus the connecting inlet opening 22 must be below the discharge opening 24 of the connecting passageway and below the top of the heating vessel, the distributing opening 42 must be below the discharge opening 24 of the connecting tube, the return opening 44 must be below the connecting inlet opening 22, the distributing vessel must have a portion at least above the top of the heating vessel although the remainder of the distributing vessel may be located as desired, the heat exchanger 30 may be located at any level with respect to the heating or the distributing vessels, and the volume of the heating vessel above the connecting inlet opening must exceed the volume of the external part of the system exclusive of the expansion tank.

In the preferred form of my invention the ratio of the liquid contents of the distributing vessel in its operating condition to the total liquid discharge from the heating

vessel is generally equal to the ratio of the entire volume of the distributing vessel to the combined volumes of the distributing vessel and the entire external part of the system including the expansion tank. Thus if the distributing vessel is approximately 30% of the combined volumes of the external part of the system plus the distributing vessel the liquid content of the distributing vessel in its operating condition will be approximately 30% of the total liquid discharge from the heating vessel. The system is closed to the atmosphere so that it does not have to be replenished with liquid.

The form of the invention described with reference to Fig. 1 constitutes the simplest embodiment thereof. In it the distributing vessel is principally above the heating vessel. However, if desired, substantially all of the distributing vessel may be level with and below the heating vessel, this form of my invention being illustrated in Fig. 2 in which figure and in all following figures the same reference numerals refer to the same parts. It also should be observed that the expansion tank is located at the highest point of the external part of the system. In Fig. 1 wherein the inlet to the heat exchanger is lower than the outlet, the expansion tank is located at the outlet manifold 40. However in Fig. 2 wherein the outlet is lower than the inlet, the expansion tank is located at the inlet manifold 38.

Fig. 3 illustrates the same heat exchange and circulating system modified however to show the use of said system with a heat exchanger below the distributing and heating vessels.

Fig. 4 illustrates a further modification in the system wherein the distributing vessel is in part below the heating vessel and further wherein the heat exchanger **30** is at substantially the level of the distributing opening, which, in this instance, is about the level of the bottom of the distributing vessel. Attention is called to the fact that the heat exchanger has its inlet and outlet located at the same end, this being best seen in Fig. 5 from which it will be apparent that the manifold at one end of the heat exchanger is partitioned and the manifold at the other end is employed as a return.

It thus will be seen that I have provided systems which achieve all the objects of my invention and are well adapted to meet the conditions of practical use.

As various possible embodiments might be made of the above invention, and as various changes might be made in the embodiments above set forth, it is to be understood that all matter herein described, or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. A sealed heat exchange and a liquid circulating system comprising a heating vessel in which a vaporizable liquid is adapted to be disposed and be heated, a distributing vessel at least a portion of which is above the heating vessel, a connecting passageway between said vessels and having a horizontal inlet end in the heating vessel and a discharge end in the distributing vessel above the bottom thereof, a heat exchanger, a distributing passageway having an inlet end located in the distributing vessel and running from the distributing vessel to the inlet of the heat exchanger, a return passageway running from the outlet of the heat exchanger to the heating vessel and having a discharge end located in the heating vessel, the discharge end of the connecting passageway being above the inlet end thereof and above the top of the heating vessel, the inlet end of the connecting passageway being below the top of the heating vessel, the inlet end of the distributing passageway being below the discharge end of the connecting passageway, and the discharge end of the return passageway being below the inlet end of the connecting passageway, the only openings in said distributing vessel being those of the connecting and distributing passageways, said system including a vaporizable liquid and a gas which, when the system is idle, are so distributed that there is liquid in the heating vessel above the inlet end of the connecting passageway, liquid in the distributing vessel up to the inlet end of the distributing passageway, gas in the distributing vessel above the liquid therein, and gas in the part of the system external to the two vessels, whereby in the operation of the system liquid initially is discharged from the heating vessel through the return passageway and liquid also is discharged from the heating vessel through the connecting passageway into the distribution vessel and thence through the distribution passageway until the heat exchanger is filled and the liquid in the heating vessel is at the proximate level of the inlet opening of the connecting passageway and thereafter the meniscus between the level of the liquid in the heating vessel and the inlet opening of the connecting passageway is intermittently ruptured to discharge alternately and intermittently liquid and vapor under pressure from the heating vessel to the distributing vessel from which distributing vessel liquid only is continuously discharged through the heat exchanger and returned to the heating vessel thus establishing a circulation of heated liquid through the system.

2. A heat exchange and liquid circulating system as set forth in claim 1 wherein the distributing passageway includes a portion at a level higher than its inlet end.

3. A heat exchange and liquid circulating system as set forth in claim 2 wherein the external part of the system is empty of liquid when the system is idle.

4. A heat exchange and liquid circulating system as set forth in claim 3 wherein the volume of the heating vessel above the inlet opening of the connecting passageway is greater than the volume of the heat exchanger, a portion of the distributing vessel, the distributing passageway and the return passageway above the top of the heating vessel.

5. A heat exchange and liquid circulating system as set forth in claim 1 wherein an expansion tank is connected to the highest point of the system outside of the distributing vessel and the heating vessel.

6. In a sealed liquid circulating system a heating vessel in which a vaporizable liquid is adapted to be disposed and be heated, a distributing vessel at least a portion of which is above the heating vessel, a connecting passageway between said vessels and having a horizontal inlet end in the heating vessel and a discharge end in the distributing vessel above the bottom thereof, a distributing passageway running from the distributing vessel, having an inlet end located in the distributing vessel and a return passageway running to the heating vessel and having a discharge end located therein, the discharge end of the connecting passageway being above the inlet end thereof and above the top of the heating vessel, the inlet end of the connecting passageway being below the top of the heating vessel, the inlet end of the distributing passageway being below the discharge end of the connecting passageway, and the discharge end of the return passageway being below the inlet end of the connecting passageway, the only openings in said distributing vessel being those of the connecting and distributing passageways said system including a vaporizable liquid and a gas which, when the system is idle, are so distributed that there is liquid in the heating vessel above the inlet end of the connecting passageway, liquid in the distributing vessel up to the inlet end of the distributing passageway, and gas in the distributing vessel above the liquid therein, whereby in the operation of the system liquid is discharged from the heating vessel through the connecting passageway into the distributing vessel and thence through the distributing passageway and thereafter circulation is effected by intermittent rupture of a meniscus between the level of the liquid in the heating vessel and the inlet opening of the connecting passageway, the liquid being returned to the heating vessel through the return passageway thus establishing a circulation of liquid through the system.

7. In a sealed liquid circulating system a heating vessel in which a vaporizable liquid is adapted to be disposed and be heated, a distributing vessel at least a portion of which is above the heating vessel, a connecting passageway between said vessels and having a horizontal inlet end in the heating vessel and a discharge end in the distributing vessel above the bottom thereof, a distributing passageway running from the distributing vessel, having an inlet end located in the distributing vessel and a return passageway running to the heating vessel and having a discharge end located therein, the discharge end of the connecting passageway being above the inlet end thereof, and above the top of the heating vessel, the inlet end of the connecting passageway being below the top of the heating vessel, the inlet end of the distributing passageway being below the discharge end of the connecting passageway, and the discharge end of the return passageway being below the inlet end of the connecting passageway, the only openings in said distributing vessel being those of the connecting and distributing passageways said system including a vaporizable liquid and a gas which, when the system is idle, are so distributed that there is liquid in the heating vessel above the inlet end of the connecting passageway, liquid in the distributing vessel up to the inlet end of the distributing passageway, and gas in the distributing vessel above the liquid therein.

8. In a sealed liquid circulating system a heating vessel in which a vaporizable liquid is adapted to be disposed and be heated, a distributing vessel at least a portion of which is above the heating vessel, a connecting passageway between said vessels and having a horizontal inlet end in the heating vessel and a discharge end in the distributing vessel above the bottom thereof, a distributing passageway running from the distributing vessel and having an inlet end located in the distributing vessel, the discharge end of the connecting passageway being above the inlet end thereof and above the top of the heating vessel, the inlet end of the connecting passageway being

below the top of the heating vessel, and the inlet end of the distributing passageway being below the discharge end of the connecting passageway, the only openings in said distributing vessel being those of the connecting and distributing passageways said system including a vaporizable liquid and a gas which, when the system is idle, are so distributed that there is liquid in the heating vessel above the inlet end of the connecting passageway, liquid in the distributing vessel up to the inlet end of the distributing passageway, and gas in the distributing vessel above the liquid therein whereby in the operation of the system liquid is discharged from the heating vessel through the connecting passageway into the distributing vessel and thence through the distributing passageway and thereafter circulation is effected by intermittent rupture of a meniscus between the level of the liquid in the heating vessel and the inlet opening of the connecting passageway.

References Cited in the file of this patent

UNITED STATES PATENTS

1,791,441	Bertsch	Feb. 3, 1931
1,798,946	Maiuri	Mar. 31, 1931
1,859,455	Munters	May 24, 1932
2,141,609	Lenning	Dec. 27, 1938
2,170,225	Unge	Aug. 22, 1939
2,192,338	Ullstrand	Mar. 5, 1940
2,251,314	Ashby	Aug. 5, 1941
2,354,982	Bikkers	Aug. 1, 1944
2,357,340	Miller	Sept. 5, 1944
2,504,784	Ashby	Apr. 18, 1950
2,507,624	Edel	May 16, 1950

FOREIGN PATENTS

339,683	France	June 16, 1904
377,388	France	July 9, 1906
911,491	France	July 9, 1946