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REFRIGERATION

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2 Sheets-Sheet 1

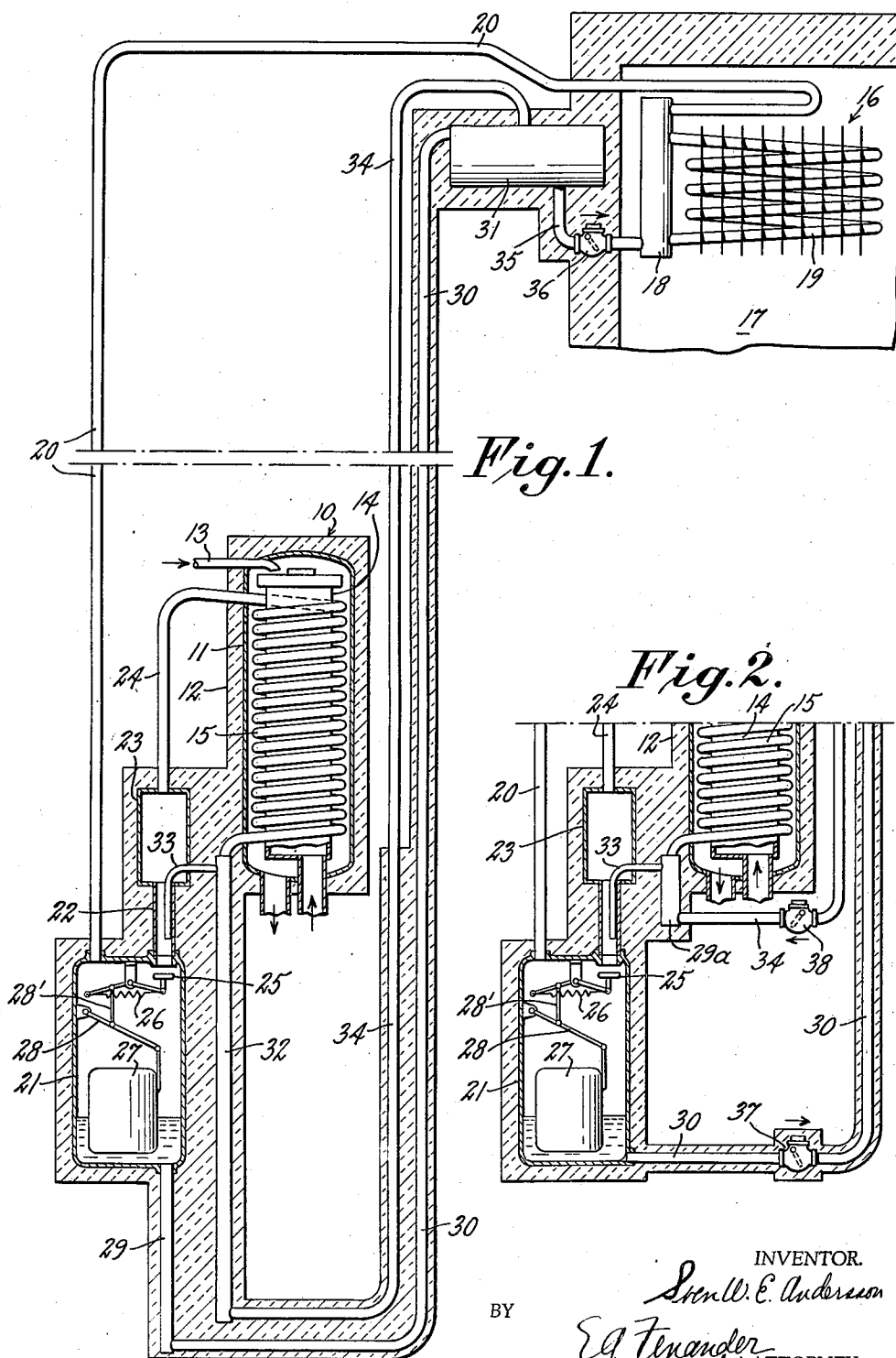


Fig. 1.

Fig. 2.

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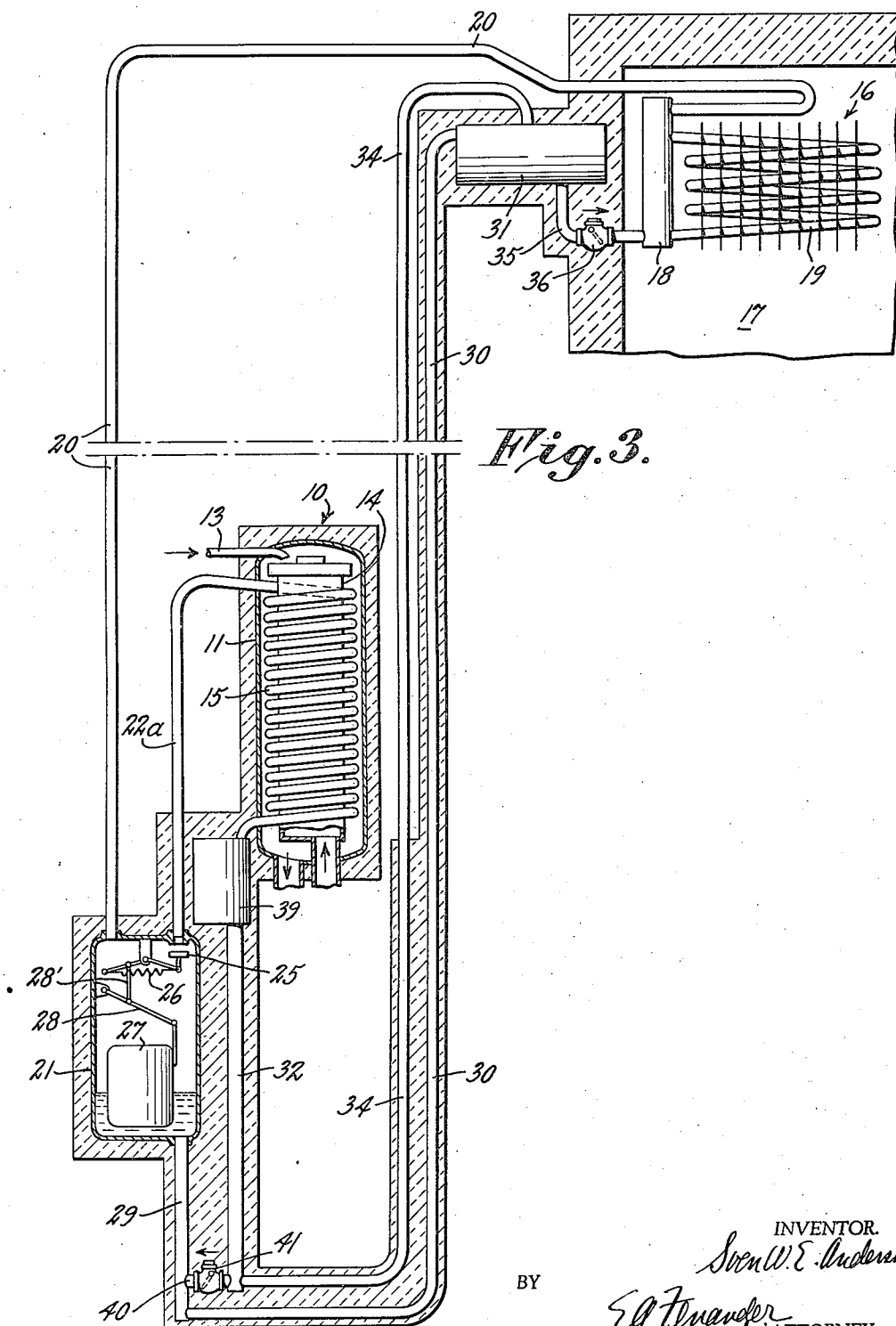
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REFRIGERATION

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15 Claims. (Cl. 62—125)

This invention relates to refrigeration, and it is an object of the invention to provide an improvement for transferring heat so that cooling may be effectively produced at a place above a source of refrigeration. More particularly, it is an object of the invention to provide an improvement in a heat transfer system of the type having a liquid transfer vessel at a lower level and a receiver at a higher level adjacent to the evaporator of the heat transfer system. The invention is concerned with locating the receiver substantially at the same level as the evaporator and still making liquid flow past a check valve or similar blocking device from the receiver into the evaporator.

The above and other objects and advantages of the invention will be better understood from the following description and accompanying drawings forming a part of this specification, and of which:

Fig. 1 more or less diagrammatically illustrates a heat transfer system embodying the invention;

Fig. 2 is a fragmentary view illustrating a modification of the system shown in Fig. 1; and

Fig. 3 is a further modification of the heat transfer system illustrated in Fig. 1.

In Fig. 1 the invention is shown in connection with a cooling element or evaporator 10 of a refrigeration system of a uniform pressure absorption type, and like that described in A. R. Thomas application S. N. 107,852, filed October 27, 1936. The cooling element 10 includes an outer shell 11 which is embedded in insulation 12. Liquid refrigerant, such as ammonia, enters the upper part of shell 11 through a conduit 13. An inert gas, such as hydrogen, enters the upper part of shell 11 through the upper open end of a cylinder 14 disposed within the shell. Liquid refrigerant evaporates and diffuses into inert gas within shell 11 to produce a refrigerating effect.

Since the refrigeration system associated with cooling element 10 forms no part of the invention and is merely illustrative, further description thereof will not be made here. If desired, reference may be made to the aforementioned Thomas application for a description of the refrigeration system, the disclosure of which may be considered to be incorporated in this application.

The refrigerating effect produced by cooling element 10 is utilized to cool and liquefy a volatile fluid flowing into a condenser 15 which is in the form of a coil. The condenser 15 is arranged about cylinder 14 in such a manner that

liquid refrigerant flows by gravity over successive turns of the coil. Above condenser 15 and at a higher level is located an evaporator 16 of the flooded type which is located in a thermally insulated storage space 17. Evaporator 16 includes a receiver 18 and a looped coil 19 connected thereto. The condenser 15 and evaporator 16 form part of a closed fluid heat transfer circuit which is partly filled with a suitable volatile liquid that evaporates in evaporator 16 and takes up heat thereby producing cold. Vapor flows from evaporator 16 into condenser 15 in a manner to be described hereinafter, and the vapor is cooled and condensed by cooling element 10. In this manner heat taken up by evaporator 16 is given up by condenser 15 to cooling element 10, whereby heat is transferred downward.

In addition to condenser 15 and evaporator 16, the heat transfer system comprises structure including a conduit 20 which connects the upper part of evaporator 16 and the upper part of a transfer vessel 21. The upper part of transfer vessel 21 is connected by a conduit 22 to the bottom of a receiver 23, and the top of the receiver is connected by a conduit 24 to the upper part of condenser 15.

A valve 25 in transfer vessel 21 is arranged to close the lower end of conduit 22. The valve 25 is connected to a snap-action toggle mechanism 26 which is operated by a float 27 to close and open valve 25 with rise and fall of liquid, respectively, in transfer vessel 21. To this end float 27 is connected to a pivoted lever 28 which in turn is connected by a link 28' to toggle mechanism 26.

To the lower part of transfer vessel 21 is connected a downwardly extending conduit 29 which is connected at its lower end to a conduit 30. Conduit 30 extends upwardly above condenser 15 and is connected at its upper end to the upper part of a receiver 31.

To the lower end of condenser 15 is connected a downwardly extending conduit 32 which terminates at its lower end above the lower end of conduit 29. Adjacent the upper end of conduit 32 is provided an overflow conduit connection 33 which permits liquid to overflow from conduit 32 into conduit 22.

The lower end of conduit 32 is connected by a conduit 34 to the upper part of receiver 31. The lower part of receiver 31 is connected by a conduit 35 to the bottom of evaporator 16. In conduit 35 is provided a check valve 36 which only permits flow of liquid from receiver 31 into evaporator 16.

In addition to cooling element 10, parts of the heat transfer system just described are also embedded in insulation 12 to prevent evaporation of volatile liquid therein. As shown in Fig. 1, these parts include transfer vessel 21, conduit 22 and receiver 23. Conduits 29, 32 and 33 are also embedded in insulation so that undesirable evaporation of volatile liquid will not take place in these conduits. Conduit 30 and receiver 31 may also be insulated, and conduit 34 may be provided with insulation to a region just above the overflow connection of conduit 33.

The operation of the heat transfer system just described is substantially as follows: Assuming that all of the parts of the system are at room temperature, volatile liquid in the system will collect in the lower parts thereof including the U trap formed by conduits 29 and 30, the U trap formed by conduits 32 and 34, and transfer vessel 21. When the refrigeration system of which cooling element 10 is a part is started, the temperature of condenser 15 is reduced by the refrigerating effect produced by cooling element 10, whereby the vapor in condenser 15 condenses to liquid. This causes a decrease in pressure in the heat transfer system so that evaporation of liquid takes place in evaporator 16, creating a cooling effect for cooling the storage compartment 17. The vapor flows from evaporator 16 through conduit 20, vessel 21, open valve 25, conduit 22, receiver 23, and conduit 24 to the condenser coil 15.

With liquid in conduit 32 to the connection of overflow conduit 33, liquid from condenser 15 will flow through conduit 33 into conduit 22 and thence into transfer vessel 21. With rise in liquid level in transfer vessel 21 the float 27 will be raised, and, due to such raising of the float, the snap-action toggle mechanism 26 will operate to close valve 25.

The transfer vessel 21 is now segregated from condenser 15 by valve 25 and by liquid in the U traps formed by conduits 32 and 34 and conduits 29 and 30. Due to collapse of vapor in condenser 15 the pressure therein becomes lower than the pressure in transfer vessel 21 and evaporator 16. The lower pressure in condenser 15 cannot be transmitted to evaporator 16 because these parts are segregated from each other, as pointed out above.

When the pressure difference between condenser 15 and transfer vessel 21 becomes sufficiently great, liquid in vessel 21 is transferred therefrom and forced through conduits 29 and 30 to receiver 31 at a higher level. When the liquid level in transfer vessel 21 falls a definite distance due to lowering of float 27, snap-action toggle mechanism 26 operates to open valve 25. With valve 25 open, the pressures in evaporator 16 and condenser 15 are substantially equalized and vapor formed in evaporator 16 can flow into condenser 15 and condense into liquid in the latter. The path of flow of vapor from evaporator 16 includes conduit 20, transfer vessel 21, conduit 22, receiver 23, and conduit 24.

Before liquid will again flow from condenser 15 into control vessel 21, liquid must first accumulate in the lower part of conduit 34 and in conduit 32 to the connection of conduit 33. With liquid flowing into vessel 21 float 27 will move upward and again cause snap-action toggle mechanism 26 to close valve 25. The evaporator 16 and transfer vessel 21 are again segregated from condenser 15. When the pressure difference between condenser 15 and transfer vessel 21 again in-

creases sufficiently, liquid is forced from transfer vessel 21 into receiver 31.

Conduits 29 and 32 are provided so that receiver 31 can be located at substantially the same level as evaporator 16 and also facilitate and insure flow of liquid from receiver 31 into evaporator 16. By locating the receiver 31 at the same level as evaporator 16, it is meant that the receiver need not extend above evaporator 16 any considerable distance to form a liquid head whereby liquid will flow into the evaporator past check valve 36 due to such liquid head.

At the termination of a liquid lifting period and when valve 25 is open, liquid columns will be formed in conduits 29 and 32 by liquid flowing from condenser 15. Some evaporation of liquid takes place in receiver 31 to establish an equilibrium condition whereby the vapor above the liquid exerts a pressure corresponding to the temperature of the receiver. This evaporation of liquid takes place because the insulation about the receiver is not perfect and does not completely block off flow of heat from the surroundings into the receiver. Due to this evaporation of liquid, therefore, a slight increase in pressure is produced in receiver 31.

With liquid columns formed in conduits 29 and 32, the vapor pressure above the surface level of liquid in receiver 31 increases sufficiently to open check valve 36 whereby liquid will flow through conduit 35 into evaporator 16. The vapor pressure will increase in an amount corresponding to the shortest of the liquid columns formed in conduits 29 and 32, taking into consideration that the vapor pressure above the liquid column in conduit 29 is somewhat higher than that above the liquid column in conduit 32, due to the small pressure drop of vapor flowing past valve 25. When the vapor pressure tends to increase to such a value that it overbalances the shortest of the liquid columns in conduits 29 and 32, some vapor will bubble through the shortest liquid column until the liquid column is capable of balancing the trapped vapor. The released vapor flows into condenser 15 in which it is condensed. In this manner the vapor pressure above liquid in receiver 31 is maintained at a slightly greater value than that in evaporator 16 by trapped vapor to cause flow of liquid into evaporator 16.

When valve 25 closes and segregates condenser 15 from evaporator 16 and transfer vessel 21, vapor from evaporator 16 no longer can enter condenser 15. Due to collapse of vapor in condenser 15 there is a reduction in pressure above the liquid column in conduit 32. This reduction in pressure creates a suction effect on the liquid column in conduit 32, whereby liquid is withdrawn from the trap formed by conduits 32 and 34. The withdrawn liquid flows through conduit 33 into conduit 22, and, since valve 25 is closed, the liquid will accumulate in receiver 23.

When the liquid moves downward sufficiently in conduit 34, vapor in receiver 31 will bubble through the liquid column in conduit 32 and pass into condenser 15 in which it condenses. The receiver 23 is located at such a level and is of such size that when liquid accumulates therein, the flow of vapor into condenser 15 through the liquid column in conduit 32 is not blocked. With valve 25 closed and no vapor flowing from evaporator 16 into condenser 15, therefore, the full capacity of the condenser becomes effective to withdraw and release trapped vapor from receiver 31 through conduit 34, which may be re-

ferred to as a vent line, and through the liquid column in conduit 32.

Due to the relatively small heat intake of receiver 31 by virtue of the insulation surrounding it, and hence the relatively small rate of evaporation of liquid therein, the condenser pressure will fall rapidly. The pressure in receiver 31 will also be reduced as a result of the pressure drop in the condenser and will only be slightly above the pressure of the condenser in an amount corresponding to the height of the liquid column in conduit 32.

At the same time that condenser 15 has been acting to withdraw vapor from receiver 31, the pressure in evaporator 16 and transfer vessel 21 has increased slightly due to continued evaporation of liquid in the evaporator after valve 25 has closed. When the pressure difference between condenser 15 and transfer vessel 21 becomes sufficiently high, therefore, liquid is raised from vessel 21 to the receiver 31 which is also at low pressure as a result of vapor withdrawal therefrom by the condenser.

In refrigeration systems of the type disclosed in the above-mentioned Thomas application, the temperature of the cooling element decreases when the load thereon is reduced. When valve 25 closes and flow of vapor from evaporator 16 into condenser 15 is stopped, the load on cooling element 10 is reduced, whereby the temperature of both cooling element 10 and condenser 15 decreases. Due to such decrease in temperature there is a corresponding reduction in pressure of condenser 15. When the full capacity of condenser 15 becomes effective to withdraw vapor from receiver 31, therefore, the pressure of the condenser drops rapidly due to the small load placed on cooling element 10 by virtue of the small heat input into receiver 31.

In order to effect release of trapped vapor from receiver 31 during the liquid transfer periods, as described above, the pressure difference between condenser 15 and transfer vessel 21 for a definite lift of liquid must be increased by a value corresponding to the height of the liquid column in conduit 32. This distance is relatively short compared with the total height through which liquid is lifted so that it will not affect transfer of liquid from the lower level to the higher level. While the receiver 31 is shown embedded in insulation in Fig. 1, it may also be located in the thermally insulated storage space 17 so that a slight increase in pressure is obtained in the receiver to cause flow of liquid therefrom to evaporator 16, as explained above.

Instead of providing the vertical conduits 29 and 32 to form liquid columns, as in the embodiment just described, check valves may be connected in conduits 30 and 34, respectively, to insure flow of liquid from receiver 31 into evaporator 16. Such a modification is shown in Fig. 2 in which the conduits 29 and 32 extending below transfer vessel 21 are eliminated. Conduit 30 is connected directly to the lower part of control vessel 21 and conduit 34 is connected to a vertical conduit 29a into which liquid flows from condenser 15. In conduit 30 is connected a check valve 37 which only permits flow of liquid from transfer vessel 21 to receiver 31. In conduit 34 is connected a loaded check valve 38 which only permits sustained flow of fluid toward conduit 29a.

When valve 25 closes to instigate a liquid lifting period, the full capacity of condenser 15 becomes effective to withdraw vapor from receiver 31, as in the embodiment of Fig. 1 and described

above. At this time check valve 38 opens and vapor from receiver 31 will bubble through liquid in conduit 29a and pass into condenser 15 in which it condenses. The pressure of condenser 15 and also that of receiver 31 fall rapidly, and, when the condenser pressure falls sufficiently and the pressure difference between receiver 31 and transfer vessel 21 is high enough, liquid is raised from vessel 21 into receiver 31.

When valve 25 is opened by lowering of float 27, 10 vapor will flow from evaporator 16 through conduit 20, transfer vessel 21 and into condenser 15. Liquid formed in condenser 15 by condensation of vapor flows into transfer vessel 21 through conduit 33. As in the embodiment described above, 15 some evaporation of liquid takes place in receiver 31. The check valve 38 is loaded, that is, a certain pressure must be overcome before this valve will open. In this way a definite pressure is maintained above the liquid in receiver 31 which is sufficiently high to cause check valve 36 to open and permit liquid to flow from receiver 31 into 20 evaporator 16 through conduit 35. When the pressure in receiver 31 tends to rise above the definite pressure which is desired therein, check valve 38 opens momentarily to permit release of 25 some vapor.

In this modification the pressure of trapped vapor in receiver 31 is dependent upon the action of check valves 37 and 38 although a small U trap 30 is formed by conduit 29a and conduit 34. This differs from the embodiment of Fig. 1 where the operation is dependent solely upon liquid columns in conduits 29 and 32 which balance the vapor pressure in receiver 31 so that check valve 36 will 35 open to permit and insure flow of liquid from the receiver to the evaporator.

The check valve 37 forming a flow restriction in conduit 30 has the added function of preventing liquid in conduit 30 from draining back into 40 transfer vessel 21 at the end of a liquid lifting period.

The modification shown in Fig. 3 is provided with conduits 29 and 32 to form liquid columns, as in the embodiment in Fig. 1 described above. 45 Similar parts in Figs. 1 and 3 are designated by the same reference numerals. When valve 25 opens vapor from evaporator 16 flows through conduit 20, transfer vessel 21, and conduit 22 to the upper part of condenser 15. The vapor con- 50 densifies to liquid in condenser 15 and flows therefrom into a receiver 39 to the lower part of which is connected conduit 32. A conduit 40 connects the lower parts of conduits 29 and 32. In conduit 40 is connected a check valve 41 which only per- 55 mits flow of liquid from conduit 32 into conduit 29.

The operation of the system shown in Fig. 3 is substantially the same as that described above in connection with Fig. 1. When valve 25 is open 60 vapor formed in evaporator 16 by evaporation of liquid therein can flow past valve 25 into condenser 15 in which it condenses to liquid. The liquid flows into conduits 32 and 34 to form a liquid trap. During this period, which may be referred 65 to as the normal refrigerating period, check valve 41 opens to permit flow of liquid from conduit 32 into transfer vessel 21 through conduits 40 and 29. The float 27 is raised with rise in liquid level in transfer vessel 21, and, when sufficient liquid 70 has accumulated in the transfer vessel, float 27 causes snap-action toggle mechanism 26 to close valve 25.

With valve 25 closed the full capacity of condenser 15 becomes effective to withdraw vapor 75

from receiver 31. This takes place in the same manner as described above in connection with the embodiment of Fig. 1, and, when the pressure differential between receiver 31 and vessel 21 is sufficiently high, liquid is raised from vessel 21 into receiver 31.

When the liquid level in transfer vessel 21 falls sufficiently to cause snap-action toggle mechanism 26 to open valve 25, vapor formed in evaporator 16 can again flow into condenser 15 and condense into liquid in the latter. This liquid flows into conduits 32 and 29 to form liquid columns in these conduits. The receiver 31 is now segregated from condenser 15 by these liquid columns, and, as pointed out above, some evaporation of liquid takes place in receiver 31 whereby the pressure in the receiver is increased. The vapor pressure in receiver 31 will increase in an amount corresponding to the shortest of the liquid columns in conduits 29 and 32, whereby check valve 36 is caused to open to permit flow of liquid from receiver 31 into evaporator 16.

It will now be understood that the improvement described above makes it possible always to locate the evaporator and receiver at the same level. Inasmuch as the evaporator usually is located in the upper part of a storage space and adjacent to the ceiling thereof, it will readily be apparent that the improvement is of particular advantage in installations where it would be exceedingly difficult to extend the receiver above the evaporator because of space limitations.

While several embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that various modifications and changes may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. In the art of transferring heat with the aid of a system in which fluid is vaporized in a place of vaporization at an upper elevation and the vaporized fluid is condensed in a place of condensation at a lower elevation, the condensate is raised to the upper elevation by vapor in the system, and a body of liquid is formed at the upper elevation by the raised condensate, the improvement which consists in flowing liquid from the body at the upper elevation to the place of vaporization by trapping vapor above the liquid surface level thereof to exert force thereon.

2. In the art of transferring heat with the aid of a system in which fluid is vaporized in a place of vaporization at an upper elevation and the vaporized fluid is condensed in a place of condensation at a lower elevation, the condensate is raised to the upper elevation by vapor in the system, and a body of liquid is formed by the raised condensate at the upper elevation and at a place at a temperature above that of said place of condensation, the improvement which consists in increasing the pressure above the surface level of such body of liquid by segregating the body from the place of condensation to cause flow of liquid from the body to the place of vaporization.

3. In the art of transferring heat with the aid of a system in which fluid is vaporized in a place of vaporization at an upper elevation and the vaporized fluid is condensed in a place of condensation at a lower elevation, the condensate is raised to the upper elevation by vapor in the system, and a body of liquid is formed by the raised condensate at the upper elevation and at a place at a temperature above that of said place of condensation, the improvement which consists in in-

creasing the vapor pressure above the liquid surface level of the body by segregating the body from the place of condensation with liquid columns of condensate to cause flow of liquid from the body to the place of vaporization.

4. In the art of transferring heat in which fluid is vaporized in a place of vaporization at an upper elevation and the vaporized fluid is condensed in a place of condensation at a lower elevation, the condensate is raised to the upper elevation by vapor in the system, and a body of liquid is formed at the upper elevation by the raised condensate, the improvement which consists in conducting liquid in a path of flow extending from the body of liquid below the surface level thereof to the place of vaporization by alternately trapping and releasing vapor above the surface level of the liquid to exert pulsating force thereon.

5. The improvement as set forth in claim 4 in which vapor is released from above the surface level of the body of liquid to the place of condensation.

6. The improvement as set forth in claim 4 in which the vapor above the surface level of said body of liquid is trapped by liquid columns of condensate and the vapor is released by bubbling through one of the liquid columns.

7. A method of heat transfer which includes vaporizing fluid in a place of vaporization at an upper elevation, condensing the vaporized fluid in a place of condensation at a lower elevation, forming a body of liquid from the condensate, raising at least a part of the body of liquid in a path of flow extending upward from below the liquid surface level thereof to the upper elevation by intermittently trapping vapor above the liquid surface level to exert pulsating force thereon, forming another body of liquid at the upper elevation from the raised condensate, and conducting raised liquid in a path of flow extending from the other body below the surface level thereof to the place of vaporization by intermittently trapping vapor above the surface level of the other body to exert pulsating force thereon.

8. In a method of heat transfer in which a first body of liquid heat transfer fluid is maintained at an upper elevation, fluid is vaporized from the body, the vaporized fluid is condensed at a lower elevation, a second lower body of liquid is formed from the condensate, condensate is raised in a path of flow extending from the lower body of liquid below the surface level thereof upward to the upper elevation by intermittently trapping vapor from the upper elevation above the surface level of liquid in the lower body to exert pulsating force thereon, and forming a third body of liquid at the upper elevation from the raised condensate, the further step of conducting liquid in a path of flow from the third body to the first body by intermittently trapping vapor above the liquid surface level of the third body.

9. A heat transfer system comprising a circuit for heat transfer fluid including an evaporator at an upper elevation, a vessel for accumulating liquid at the upper elevation, a condenser at a lower elevation, means for raising liquid between said elevations to the vessel, a conduit connecting the lower part of the vessel below the liquid surface level therein and the evaporator, a device cooperating with the conduit and only permitting flow of liquid from the vessel to the evaporator, and means for intermittently trapping vapor above the surface level of liquid in the vessel to cause flow of liquid in the conduit past the control device from the vessel to the evaporator.

10. A heat transfer system comprising a circuit for heat transfer fluid including an upper liquid accumulator and an evaporator at a first elevation, a conduit connecting the lower part of the upper accumulator and the evaporator, a control device cooperating with the conduit and only permitting flow of liquid from the upper accumulator to the evaporator, a condenser and a lower liquid accumulator below the first elevation, a conduit connecting the lower accumulator below the liquid surface level therein and the vapor space of the upper accumulator, such conduit having a part extending below the lower accumulator to form a liquid trap, a second conduit connecting the condenser and the vapor space of the upper accumulator, the second conduit forming a second liquid trap having the lowest part thereof above that of the first-mentioned trap, the first trap being connected to receive condensate from the condenser after the second trap is filled with condensate, means for alternately admitting condensate to the lower accumulator and trapping vapor from the evaporator above the surface level of liquid in the lower accumulator to cause rise and fall of the liquid surface level and upward flow of liquid in the first conduit upon the fall of the surface level, the second trap being constructed and arranged to permit venting of the upper accumulator and both of said traps being constructed and arranged to provide liquid columns to trap vapor above the surface level of liquid in the upper accumulator to cause flow of liquid past the control device from the upper accumulator to the evaporator.

11. A heat transfer system comprising a circuit for heat transfer fluid including a liquid accumulator and an evaporator at an upper elevation, a conduit from the lower part of the accumulator below the surface level of liquid therein to the evaporator, a control device cooperating with the conduit and only permitting flow of liquid from the accumulator to the evaporator, a condenser at a lower elevation, means for raising liquid from the condenser to the accumulator by vapor in the system, and means to intermittently cause flow of liquid in the conduit from the accumulator to the evaporator past the control device by alternately trapping and

releasing vapor above the surface of liquid in the accumulator to exert pulsating force thereon.

12. A heat transfer system as set forth in claim 11 in which said means to intermittently cause flow of liquid in the conduit from the accumulator to the evaporator past the control device includes a liquid trap for releasing vapor from the accumulator to the condenser, the released vapor bubbling through liquid in the trap.

13. A heat transfer system as set forth in claim 11 including a first U trap through which condensate is raised from the condenser to the accumulator, and in which said means to intermittently cause flow of liquid in the conduit from the accumulator to the evaporator past the control device includes a second U trap providing a vent to release vapor from the accumulator, the U traps providing liquid columns to balance the pressure of trapped vapor in the accumulator.

14. A heat transfer system as set forth in claim 11 in which said means for raising liquid includes a first conduit for conducting liquid from the condenser to the accumulator, and said means to intermittently cause flow of liquid in the conduit from the accumulator to the evaporator past the control device includes a second conduit to release vapor from the accumulator to the condenser, the first conduit having a device only permitting flow of liquid from the condenser to the accumulator, and the second conduit having a device only permitting flow of fluid from the accumulator to the condenser, the second device being operative to open only upon a definite increase in pressure at the accumulator.

15. In the art of transferring heat with the aid of a system having a vaporization portion and a condensation portion and a receiver connected to receive condensate from the condensation portion and conduct condensate to the vaporization portion, the improvement which consists in blocking flow of liquid from the receiver to the vaporization portion when liquid flows from the condensation portion into the receiver, and trapping vapor in the receiver to render blocking of liquid ineffective so that liquid flows from the receiver to the vaporization portion when liquid does not flow from the condensation portion into the receiver.

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