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2,229,445

REFRIGERATION

Filed March 4, 1938

2 Sheets-Sheet 1

Fig. 2.

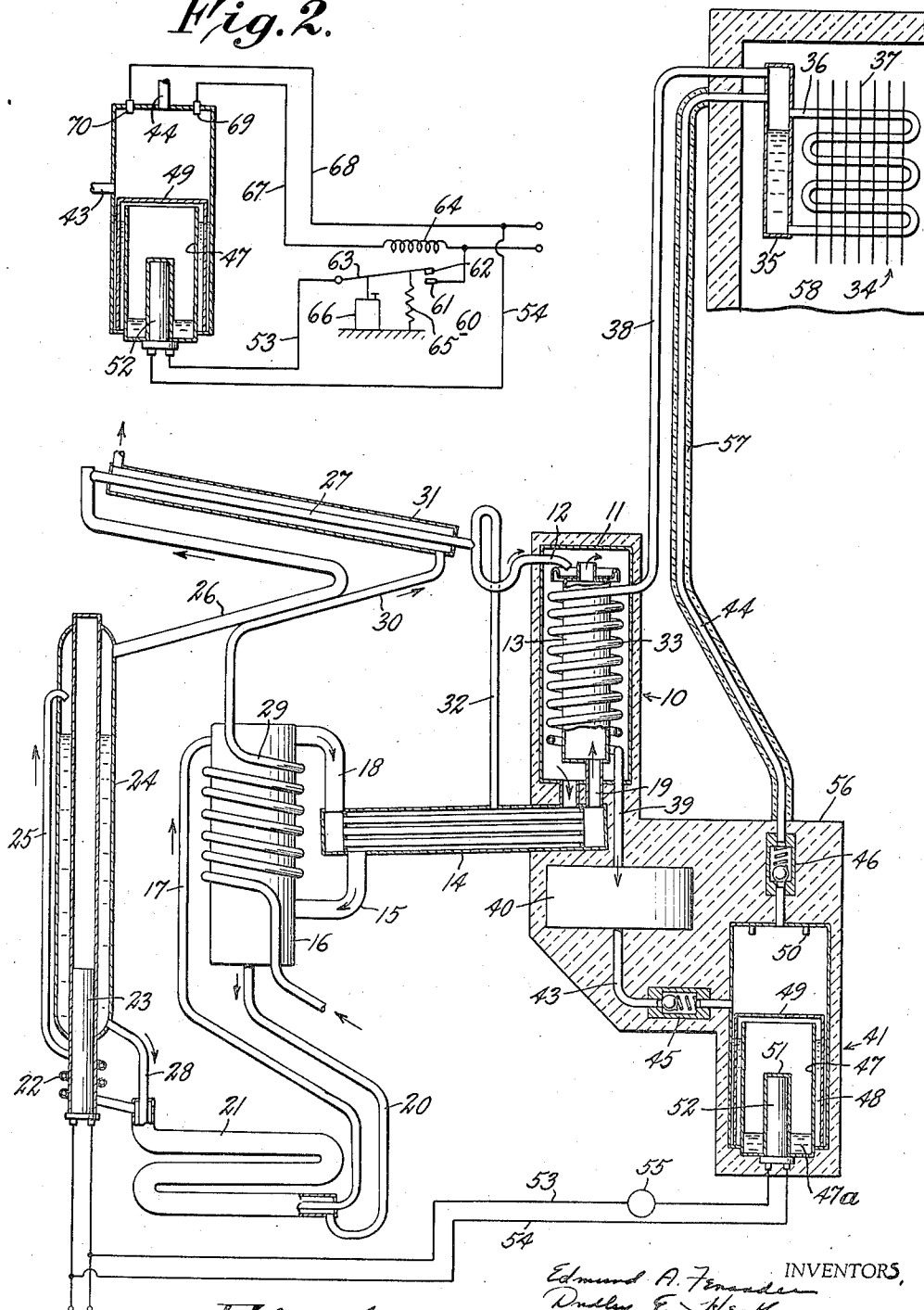


Fig. 1.

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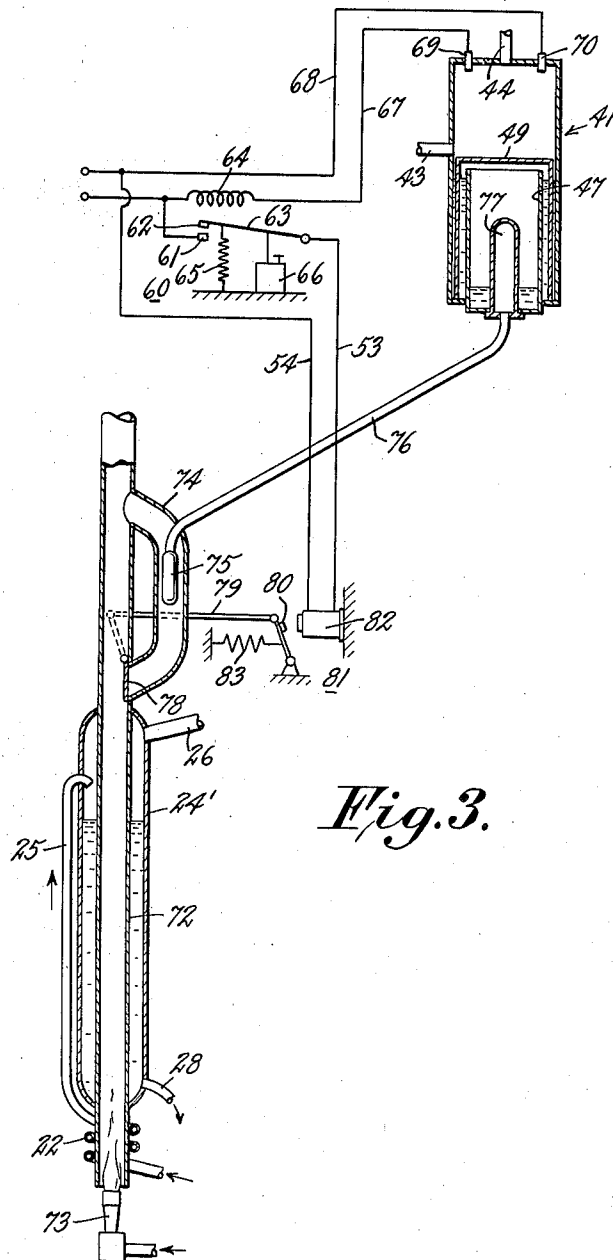


Fig. 3.

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UNITED STATES PATENT OFFICE

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REFRIGERATION

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13 Claims. (Cl. 62—5)

This invention relates to refrigeration, and more particularly to refrigeration apparatus provided with a heat transfer system so that cooling may be produced at a place above a cooling element of the refrigeration apparatus.

It is an object of this invention to provide an improvement in a heat transfer system of the type wherein vapor is utilized to raise volatile liquid from a place of condensation to a higher place of evaporation. This is accomplished by raising liquid in a heat transfer system from a low to a higher level with the aid of vapor which is formed outside the system.

Another object of this invention is to raise a volatile liquid in a closed fluid circuit from a low to a higher level by intermittently evaporating and condensing a volatile fluid out of contact with the fluid circulating in the system.

A further object of this invention is to raise a volatile liquid in a heat transfer system from a low to a higher level by the same source of energy employed to operate refrigeration apparatus with which the heat transfer system is associated.

The above and other objects and advantages of this invention will be better understood from the following description and accompanying drawings forming a part of this specification, and of which Fig. 1 is a view diagrammatically illustrating refrigeration apparatus and a heat transfer system embodying the invention; Fig. 2 is a fragmentary view illustrating a modification of the heat transfer system shown in Fig. 1; and Fig. 3 is a fragmentary view illustrating another modification of the refrigeration apparatus and heat transfer system shown in Fig. 1.

In Fig. 1 the invention is shown in connection with refrigeration apparatus of a uniform pressure absorption type containing a pressure equalizing gas, and like that generally described in Patent No. 1,837,767 to Thore M. Elfving. The apparatus includes a cooling element 10 having an outer shell 11. Liquid refrigerant, such as ammonia, enters the upper part of cooling element 10 through a conduit 12. An inert gas, such as hydrogen, enters the upper part of the cooling element from the upper end of a cylinder 13 disposed within the shell. Liquid refrigerant evaporates and diffuses into inert gas within cooling element 10 to produce a refrigerating effect. The resulting gas mixture of refrigerant and inert gas flows from cooling element 10 through an outer passage of a gas heat exchanger 14 and conduit 15 to an absorber 16.

In absorber 16 refrigerant gas is absorbed by

a suitable liquid absorbent, such as water, which enters through a conduit 17. The inert gas, which is practically insoluble and weak in refrigerant, is returned to the lower part of cooling element 10 through conduit 18, the inner passage of gas heat exchanger 14 and conduit 19; and the enriched absorption liquid is conducted from absorber 16 through a conduit 20 and an outer passage of a liquid heat exchanger 21 to a coil 22. The coil 22 is disposed about an electrical heating element 23 extending into the lower part of a generator 24.

By heating coil 22, liquid is raised by vapor-lift action through conduit 25 to the upper part of generator 24. Liberated refrigerant vapor entering generator 24 through conduit 25, and the vapor expelled from solution in the generator, flows upward through conduit 26 to a condenser 27. Refrigerant vapor is liquefied in condenser 27 and returned to cooling element 10 through conduit 12 to complete the refrigerating cycle.

The weakened absorption liquid from which refrigerant has been expelled flows from the lower part of generator 24 through conduit 28, the inner passage of liquid heat exchanger 21, and conduit 17 to the upper part of absorber 16. The heat liberated with absorption of refrigerant vapor in absorber 16 is transferred to a cooling medium which flows through a coil 29 which is disposed about the absorber. The upper part of coil 29 is connected by conduit 30 to a jacket 31 surrounding condenser 27, whereby the same cooling medium may be utilized to effect cooling of the condenser.

A conduit 32 is connected to conduit 12 and to the gas circuit, as at the gas heat exchanger 14, for example, so that any non-condensable gas which may pass into the condenser can flow into the gas circuit and not be trapped in the condenser.

The cooling element 10 constitutes a source of refrigeration and the refrigerating effect produced thereby is used to cool and liquefy a volatile fluid flowing through a coil 33 which is arranged about cylinder 13. The coil 33 forms a condenser of a heat transfer system and is located below an evaporator 34. The evaporator is of the flooded type and is disposed in a thermally insulated storage compartment 58. The evaporator 34 includes a receiver 35 having a looped coil 36 connected thereto which is provided with heat transfer fins 37.

The condenser 33 and evaporator 34 form part of a closed fluid circuit which is partly filled with a suitable volatile liquid, such as methyl chloride, 55

for example, that evaporates in evaporator 34 and takes up heat thereby producing cold. The vapor flows from evaporator 34 through a conduit 38 into condenser 33, and the vapor is cooled and condensed by cooling unit 10. The condensate formed in condenser 33 flows through a conduit 39 into a vessel 40 in which the condensate accumulates and collects.

In accordance with this invention condensate is returned to evaporator 34 by a device 41. The device 41 includes a casing 42 to the upper part of which liquid flows from vessel 40 through conduit 43. Liquid is raised from casing 42 through conduit 44 which is connected at its upper end to the upper part of receiver 35. In the lower parts of conduits 43 and 44 are provided check valves 45 and 46.

Below the connection of conduit 43 to casing 42 and within the latter is provided a cylinder 47. The cylinder 47 is open at its upper end and is smaller in diameter than casing 42 to provide a space 48 therebetween. Between cylinder 47 and casing 42 is disposed an inverted cup or dome 49 which is closed at its upper end and preferably fits closely within casing 42. The dome 49 is freely movable within casing 42 and the outer surface of the dome and inner surface of the casing are preferably machined to provide smooth contacting surfaces. The space 48 is filled with a suitable liquid of high specific gravity, such as mercury, for example. Stops 50 may be provided at the upper closed end of casing 42 to limit upward movement of dome 49.

The bottom of cylinder 47 is provided with a pocket 51 to receive an electrical heating element 52 which is connected by conductors 53 and 54 to the same source of electrical supply as heating element 23 of the refrigeration apparatus. The cylinder 47 is partly filled with a suitable volatile liquid 47a, such as ethyl chloride, for example. A timing switch 55 may be connected in conductor 53 to control the energization of electrical heating element 52.

The cooling element 10, vessel 40, and device 41 are preferably embedded in insulating material 56 to prevent undesirable evaporation of volatile liquid in these parts due to heat transfer from surrounding air. Similarly, conduit 44 is provided with a heat insulating casing 57 to prevent evaporation of liquid in this conduit.

During operation, vapor formed in evaporator 34 flows through conduit 38 into condenser 33 in which the vapor is condensed. The condensate flows from condenser 33 through conduit 39 into accumulation vessel 40. Liquid flows from vessel 40 through conduit 43 into the upper part of casing 42. The check valve 45 permits liquid to flow into casing 42 until the liquid head in conduit 43 and vessel 40 becomes sufficiently small so that check valve 45 will close.

With liquid in the upper part of casing 42, electrical heating element 52 is connected to the source of electrical supply by timing switch 55, whereby the volatile liquid 54 in cylinder 47 is evaporated. The vapor formed in the chamber defined by cylinder 47 and dome 49 is trapped, and, when the vapor pressure is sufficiently great, dome 49 is moved upward. The liquid in the upper part of casing 42 is raised by upward movement of dome 49 and is forced upward through conduit 44 into the receiver 35 of evaporator 34.

After an interval of time the electrical heating element 51 is disconnected from the source of electrical supply by the timing device 55. The

vapor within the chamber defined by cylinder 47 and dome 49 is rapidly condensed by heat transfer to the cold condensate above the dome, whereby the latter falls by gravity to its lower position. When the upper part of dome 49 moves downward past the lower end of conduit 43 liquid may again flow into the upper part of casing 42.

The timing switch 55 may be adjusted to connect and disconnect heating element 52 to and from the source of electrical supply at such intervals of time that the heating element is disconnected from the source of supply when dome 49 reaches the upper limit of its movement and is again connected to the source of supply when the dome 49 has reached the lower limit of its movement.

If desired, the check valve 45 may be omitted since upward movement of dome 49 from its lower position past the lower end of conduit 43 cuts off the conduit from the upper part of casing 42. The check valve 46 is provided to maintain liquid in conduit 44 after each pumping stroke, so that the liquid head is not lost when liquid is raised with successive pumping strokes of dome 49.

The amount of liquid in cylinder 47 is relatively small and only enough is needed so that, upon vaporization thereof, the vapor pressure developed in the cylinder is sufficient to force dome 49 upward in casing 42. At the end of the pumping stroke and when heating element 52 is disconnected from the source of electrical supply, the vapor is immediately condensed by heat transfer to cold liquid above the dome 49.

The same volatile fluid may be used in the heat transfer system and in cylinder 47, respectively, or different volatile fluids may be used with the fluid in cylinder 47 having a higher boiling point than the fluid in the heat transfer system. As stated above, methyl chloride may be used as the heat transfer fluid and ethyl chloride may be used as the pump operating fluid. The vapor formed in cylinder 47 is out of contact with the heat transfer fluid. In other words liquid is returned from condenser 33 to evaporator 34 by vapor other than that formed in the heat transfer circuit. With condensation of vapor in cylinder 47 the vapor space therein decreases whereby dome 49 moves downward to its lower position. Since the amount of volatile liquid in cylinder 47 is relatively small, the quantity of heat transferred to liquid above the dome is not very great when condensation of vapor takes place in cylinder 47 at the end of each pumping stroke.

The dome 49 may be operated automatically by providing a suitable electrical relay in the circuit of heating element 52. Such a modification is shown in Fig. 2 which differs from Fig. 1 in that a relay 60 is substituted for the timing device 55. The relay 60 includes a fixed contact 61 and a cooperating movable contact 62 which is fixed to a pivoted arm 63. The relay further includes an energizing coil 64 which is adapted to attract arm 63 and separate the contacts against the action of a spring 65. Arm 63 is connected to a dash-pot 66 so that, when coil 64 is deenergized, spring 65 is effective to close contacts 61 and 62 after a time delay.

The cooperating contacts 61 and 62 are connected in conductor 53 and coil 64 is connected in one of two conductors 67 and 68 which are connected to the source of electrical supply. The conductors 67 and 68 are connected to contacts 69 and 70 which are located at the upper end of

casing 42 and serve as stops to limit upward movement of dome 49.

Assuming that contacts 61 and 62 are closed, heating element 52 is energized whereby heating of liquid in cylinder 47 is effected. When the vapor pressure in cylinder 47 becomes sufficiently great, dome 49 is raised and liquid above the dome is forced upward through conduit 44 into the evaporator. When dome 49 reaches its uppermost position and engages contacts 69 and 70, an electrical circuit is completed for coil 64 whereby the latter is energized and attracts arm 63 to open contacts 61 and 62. This deenergizes heating element 52 and condensation of vapor within cylinder 47 takes place due to heat transfer to cool liquid above dome 49.

With initial downward movement of dome 49 due to a decrease in the vapor space within cylinder 47, the coil 64 is deenergized whereby spring 65 becomes effective to close contacts 61 and 62. The dash-pot 66 is adjusted so that contacts 61 and 62 are closed by spring 65 when dome 49 reaches its lower position. When dome 49 is in its lower position and contacts 61 and 62 are again closed, heating element 52 is again energized and dome 49 is raised to effect another pumping stroke.

In Fig. 3 is shown a further modification whereby the heat transfer system is operated by the high temperature flue gases utilized to effect heating of the generator of the refrigeration apparatus. Only the generator of the refrigeration apparatus has been shown in Fig. 3, the remaining parts of the apparatus being similar to those shown in Fig. 1. In Fig. 3 coil 22 is disposed about the lower end of a flue 12 which extends upwardly through generator 24'. Generator 24' is heated by a gas burner 73 which is located at the lower end of flue 72. The flue 72 is provided with a by-pass passage 74 above generator 24' and within which is located a member 75.

The member 75 constitutes the vaporization portion of a closed fluid circuit and is connected by a conduit 76 to a member 77 which constitutes the condensation portion of the circuit. The member 77 is located in a pocket of cylinder 47 and serves as a heating element for the device 41. The circuit including members 75 and 77 and connecting conduit 76 is partly filled with a volatile liquid which transfers heat from the hot flue gases in passage 74 to device 41. In this modification it will be noted that device 41 is at a higher level than generator 24' of the refrigeration apparatus.

The flow of hot flue gases in by-pass passage 74 is controlled by a valve member 78 which is pivoted within flue 72 and operative to close or open the lower end of the by-pass passage. The valve member 78 is operatively connected by linkage mechanism 79 to an armature element 80 of a relay 81. Relay 81 includes a coil 82 which is connected to conductors 53 and 54 and arranged to attract armature element 80 against the action of a spring 83.

During operation and assuming that dome 49 is moving downward and has not yet reached its lower position, the contacts 61 and 62 of relay 80 are open and coil 82 is therefore deenergized. Under these conditions spring 83 is effective to move armature element 80 toward the left whereby valve member 78 is in its closed position. The hot flue gases therefore pass upwardly through flue 72 and no heating of member 75 is effected in by-pass passage 74. When dome 49 reaches

its lower position and contacts 61 and 62 are closed, coil 82 of relay 81 is energized and attracts armature element 80 against the action of spring 83. When armature element 80 is moved toward the right, valve member 78 opens and permits hot flue gases to flow through by-pass passage 74.

The liquid in member 75 is now evaporated due to the high temperature of the flue gases and the vapor thus formed passes upward through conduit 76 into member 77 in which it is condensed. The vapor condensed in member 77 flows downward through conduit 76 and back to member 75 where it is again evaporated. The evaporation of liquid in member 75 takes up heat from the hot gases in by-pass passage 74 and the condensation of vapor in member 77 gives up heat to liquid in cylinder 47, whereby the liquid within the cylinder is evaporated to cause upward movement of dome 49. With upward movement of dome 49, liquid above the dome is forced upward through conduit 44 into evaporator 34.

When dome 49 engages contacts 69 and 70, coil 64 is energized whereby contacts 61 and 62 are opened and coil 82 of relay 81 is deenergized. This permits valve member 78 to close through the action of spring 83, so that hot flue gases no longer pass through the by-pass passage 74. With liquid in member 75 no longer heated by the high temperature flue gases, heat is no longer transferred from by-pass passage 74 to device 41 so that condensation of vapor in cylinder 47 can take place. With initial downward movement of dome 49 due to a decrease in the vapor space, coil 64 is deenergized. After an interval of time determined by the adjustment of dash-pot 66, contacts 61 and 62 are closed by the action of spring 65 and the above described operation is repeated to force liquid upwardly from device 41 to evaporator 35.

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, as pointed out in the following claims.

What is claimed is:

1. Refrigeration apparatus including a heat receiving part and a cooling element, a secondary heat transfer circuit including an evaporator and a condenser below said evaporator and in heat exchange relation with said cooling element, and structure associated with said heat transfer circuit to return liquid from said condenser to said evaporator and including a member in thermal exchange relation with said heat receiving part, and a heater for heating said part.

2. In a heat transfer system including a closed fluid circuit partly filled with a volatile liquid and having a condensation portion at one level 60 and an evaporation portion at a higher level, means including an hermetically closed device connected in said circuit to return liquid condensate from said condensation portion to said evaporation portion at the higher level, said device including structure so constructed and arranged that liquid condensate is raised to said evaporation portion at the higher level by alternate expansion and contraction of a body of fluid confined in one place within said hermetically closed device and outside of said circuit.

3. In a heat transfer circuit including a closed fluid circuit partly filled with a volatile liquid and having a condensation portion at one elevation and an evaporation portion at a higher 75

elevation, structure to raise liquid between said elevations including a liquid accumulator having a movable wall portion, fluid pressure means including an enclosed space having a heat receiving part and containing a volatile fluid which undergoes vaporization and condensation, said structure being so constructed and arranged that volatile fluid is only intermittently heated in said heat receiving part and during such heating periods substantially all of the heat received by said part is utilized to vaporize volatile fluid with the vaporized fluid being effective to exert force on said movable wall portion to cause movement of the latter to effect raising of liquid.

4. A heat transfer circuit as set forth in claim 3 in which a part of said enclosed space is defined by said movable wall portion.

5. A heat transfer circuit as set forth in claim 3 in which condensation of volatile fluid is effected by heat transfer from such fluid to liquid in said circuit.

6. In a heat transfer circuit including a closed fluid circuit partly filled with a volatile liquid and having a condensation portion at one level and an evaporation portion at a higher level, structure to raise liquid between said levels including a liquid accumulator having a movable wall portion, fluid pressure means providing a closed space containing a volatile fluid, and a heater to heat said volatile fluid, said structure being so constructed and arranged that said heater intermittently heats said volatile fluid whereby the latter undergoes vaporization and condensation with the vaporized fluid being effective to exert force on said movable wall portion to cause movement of the latter to effect raising of liquid.

7. In a method of transferring heat which includes evaporating refrigerant in a place of evaporation at an upper elevation and condensing evaporated refrigerant in a place of condensation at a lower elevation, raising liquid refrigerant between said elevations by force produced by vaporizing fluid in a closed space during periods alternating with periods in which the vaporized fluid is condensed, and intermittently heating fluid in said closed space.

8. In a heat transfer system including a closed fluid circuit partly filled with a volatile liquid and having an evaporation portion at an upper elevation and a condensation portion at a lower elevation, structure to raise liquid between said elevations including a liquid accumulator having a movable wall portion, and means to cause movement of said wall portion in both directions by intermittent force produced only by intermittent heating of volatile fluid to cause vaporization of the latter during periods alternating with periods when no heating of such volatile fluid is effected.

9. In a heat transfer system including a closed circuit partly filled with a volatile liquid and having an evaporation portion at an upper eleva-

tion and a condensation portion at a lower elevation, structure to raise liquid between said elevations including a liquid accumulator connected to receive liquid from said condensation portion and a conduit connecting said accumulator and said evaporation portion, said liquid accumulator having a movable wall portion which is operative to raise liquid in said conduit with movement thereof, and said structure including means so constructed and arranged that movement of said wall is effected by intermittent force produced by intermittent heating of volatile liquid with substantially all of the heat received by such volatile liquid being available to cause vaporization thereof.

10. In the art of transferring heat with the aid of a closed fluid circuit partly filled with a volatile liquid and having an evaporation portion at an upper elevation and a condensation portion at a lower elevation, the improvement which consists in raising liquid condensate between said elevations with alternate expansion and contraction of a confined body of fluid in a place outside of said circuit by intermittently subjecting such confined body of fluid to a heating influence.

11. In a heat transfer system including a closed fluid circuit partly filled with a volatile liquid and having a condensation portion at a lower elevation and an evaporation portion at an upper elevation, structure to raise liquid between said elevations including a liquid accumulator having a movable wall portion, said wall portion with movement thereof being operative to exert lifting force on the liquid, means to move said wall portion by force produced by vaporization of volatile fluid, a heater for vaporizing such volatile fluid, and means responsive to movement of said wall portion for controlling said heater.

12. In combination with refrigeration apparatus having a heat receiving part provided with a flue, a burner arranged to project its flame into the lower end of said flue, and a cooling element, a heat transfer circuit including an evaporator and a condenser below said evaporator and in heat exchange relation with said cooling element, and structure associated with said circuit to return liquid from said condenser to said evaporator and including a member arranged to be heated by the hot products of combustion produced by the burner flame and passing through said flue.

13. Apparatus as set forth in claim 12 in which said flue includes a by-pass for the hot products of combustion and said member is arranged to be heated by the hot products of combustion flowing in said by-pass, a damper to control flow of the hot products of combustion through said by-pass, and a control responsive to operation of said structure for controlling said damper.

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