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THERMALLY ACTUATED LIQUID PULSE PUMP

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Fig. 1.

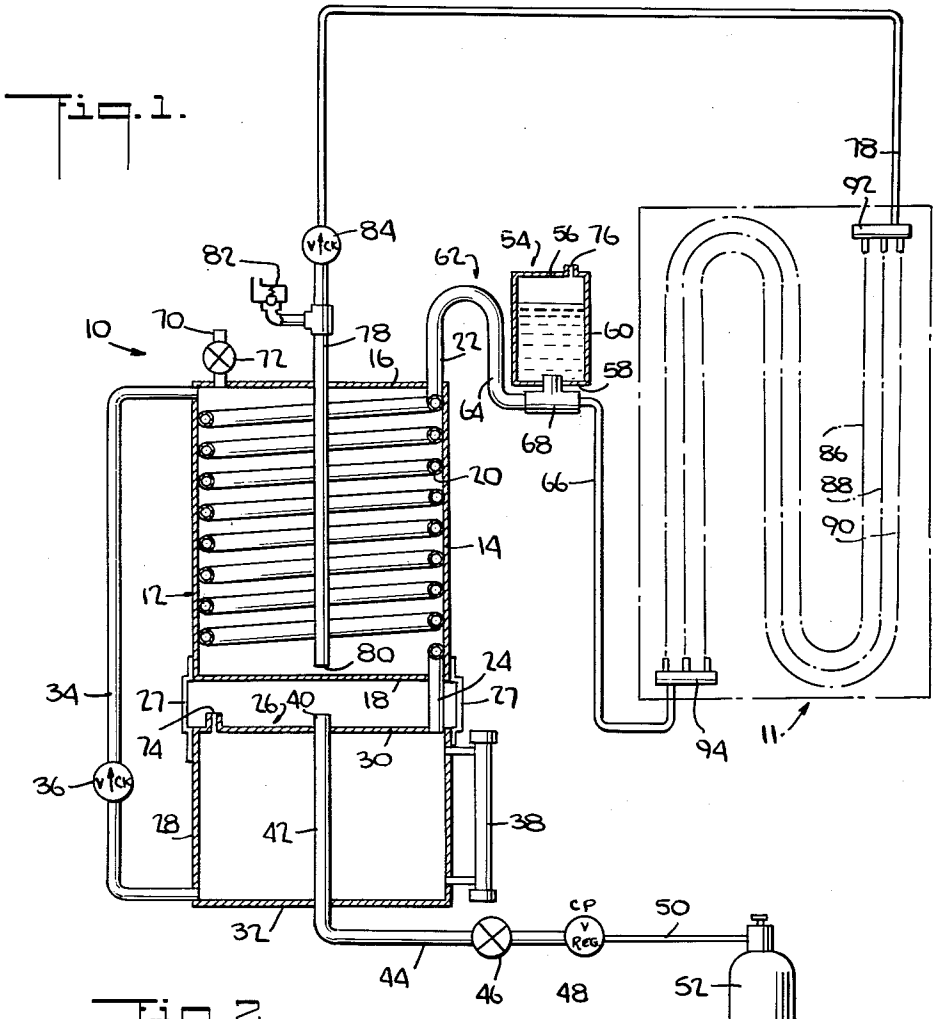
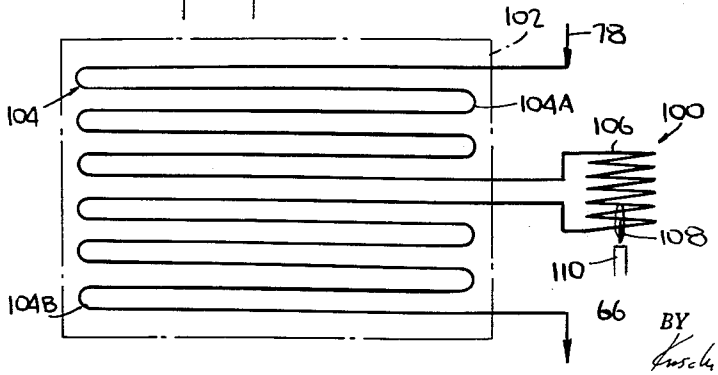


Fig. 2.



INVENTOR.
JOSEPH BERNARD

BY
Kirschstein, Kirschstein & Ottinger
ATTORNEYS

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THERMALLY ACTUATED LIQUID PULSE PUMP

Joseph Bernard, Millington, N.J. (% U.S. Fiber & Plastics Corp., 323 Union Ave., Stirling, N.J.)

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This invention relates to a thermally actuated liquid pulse pump.

It is an object of my invention to provide a device of the character described which comprises few and simple parts and is compact and reliable in operation.

It is another object of my invention to provide a device of the character described which is rugged, light and small and is particularly adapted to warm persons where electricity is not available.

It is an ancillary object of my invention to provide a device of the character described which is adapted to form part of a portable heating system including an encompassing-type heat utilization mechanism, as for instance, a heated poncho, garment or blanket.

It is another object of my invention to provide a device of the character described which efficiently transforms heat into pumping energy without introducing into the liquid circulating medium vapor that would inhibit positive pumping action.

It is another object of my invention to provide a device of the character described which simultaneously heats and pumps a liquid circulating medium and operates at a mild liquid temperature, that is to say, a temperature below the volatilization point of said medium so as to minimize radiation losses and avoid burning the user or deteriorating the heat utilization mechanism.

It is another object of my invention to provide a device of the character described which is capable of generating substantial pumping pressures capable of forcing a liquid circulating medium through great lengths, e.g., 100 feet, of heat exchange tubing.

It is another object of my invention to provide a device of the character described which can be used with supplemental heaters whereby the liquid circulating medium after passing through one section of heat exchange tubing, can be reheated before introduction into another section.

It is another object of my invention to provide a device of the character described which is safe and reliable and can be made and operated easily and at low cost.

Other objects of my invention in part will 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 devices hereinafter described and of which the scope of application will be indicated in the appended claims.

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

FIG. 1 is a partially sectional, partially schematic view of a thermally actuated liquid pulse pump constructed in accordance with my invention and connected to a heating blanket; and

FIG. 2 is a schematic view of a modified form of my invention illustrating the use of a supplemental heater.

Referring now in detail to the drawings, and more particularly to FIG. 1, the reference numeral **10** denotes a thermally actuated liquid pulse pump embodying the present invention and used to force a heated liquid circulating medium through a heat utilization mechanism such as blanket **11**.

The pump **10** includes a generator **12** in the form of a hollow vessel, preferably made of metal in order that a wall thereof may be heated to a temperature above the volatilization point of the liquid circulating medium employed. Said medium conveniently is water. The vessel

12 comprises a tubular side wall **14** and top and bottom walls **16**, **18** integrally joined to the side wall so as to form a hermetically tight enclosure. If desired, the side and top walls may be made of a light material, as for example, aluminum or plastic. I prefer to have the bottom wall made from a material with good thermal conductivity, as for example, copper or steel, so as to encourage heat transfer therethrough.

A heat exchanger is provided in heat exchange relationship with the generator, preferably inside the same in order to promote efficiency. Said exchanger is a helical coil **20** of tubing which is located around and, if desired, secured in contact with the side walls **14** of the generator. The tubing is of metal to expedite transfer of heat through its walls. The intake end of the heat exchange tubing terminates in a run **22** extending vertically upwardly through the generator, as for instance, through the top wall **16** thereof. Said run is hermetically sealed to the generator so that no liquid or vapor can escape through the opening in the generator. The outlet end of the heat exchange tubing terminates in a downwardly extending run **24** that passes through a lower portion of the generator, as for example, through the bottom wall **18** thereof. Said run **24** likewise is hermetically sealed to the generator to prevent escape of liquid or vapor.

The pump further includes a reservoir **26** that for the sake of compactness is located directly below the generator **12**. Desirably the generator and reservoir are physically inter-connected, as by braces **27**, so that they can be handled as a single unit. Like the generator, the reservoir **26** is a hollow vessel with a side wall **28**, a top wall **30** and a bottom wall **32**, hermetically joined to one another to form a water-tight enclosure. To conserve space the reservoir may be of the same horizontal cross-section as the generator.

There are two liquid passageways extending between the generator and reservoir, although, strictly speaking, one of these passageways connects the reservoir with the heat exchanger rather than with the generator. More particularly, the downwardly extending run **24** of the heat exchanger discharges into the reservoir, as for instance, by connection to the reservoir at the top wall thereof. The other passageway constitutes a tube **34**, the lower end of which is connected to the lower portion of the reservoir, as to the bottom wall **32** or the side wall **28**, and the upper end of which is connected to the upper portion of the generator, as to the top wall **16** or side wall **14**. A check valve **36** is located in the tube **34** to permit flow of the liquid circulating medium therethrough only in a direction from the reservoir to the generator. Said valve opens quite easily, as for example, at a pressure differential of about 2 pounds p.s.i.

Although it is not necessary to the operation of my invention, I find it desirable to include a conventional transparent tubular gage **38** connected to the reservoir to indicate the level of liquid therein.

Means further is provided to heat the generator **12** and therefore the liquid circulating medium contained therein. For this purpose I provide a burner **40**, the tip of which is located directly beneath and is centrally disposed with respect to the bottom wall **18** of the generator. It will be understood that heat can be supplied to the generator in any suitable manner, even, if convenient, by electricity. Alternatively, I may feed liquid fuel to the burner **40**. Nevertheless for several reasons, including for instance, safety, weight, easy storability, easy replenishment and usefulness outdoors, I prefer to employ gas fuel and, accordingly, the burner **40** is a gas burner. One desirable gas is propane.

The gas is led to the burner through a conduit **42** that to economize on space extends vertically through the reservoir **26**. Said conduit **42** has a horizontal run **44**

beneath the reservoir in which there is interposed a hand controlled valve **46** and a pressure regulator **48** that is connected as by flexible tubing **50** to the outlet of a propane tank **52**. Conventionally such tanks contain propane under high pressure. They weigh only a few pounds and are small and readily available in hardware and general merchandise stores throughout the United States.

I also use in connection with the pump **10** a high-level receiving tank **54** constituting a hollow vessel which comprises a top wall **56**, a bottom wall **58** and a tubular side wall **60** integrated with one another to form a hermetically closed vessel at least the top of which is higher than the top of the heat exchanger **20**. Associated with the receiving tank is a siphon connector **62** in the form of an inverted U, the outlet leg of which is connected to and may comprise the upwardly extending run **22** and the inlet leg **64** of which communicates with a lower portion of the receiving tank. The bend of the siphon connector is higher than the top of the heat exchanger **20** and is no higher than the top of the receiving tank. Also in communication with the receiving tank is a return conduit **66**, the purpose of which soon will be described. Said conduit can be connected to any part of the receiving tank, not necessarily a lower portion as is necessary in the case of the inlet leg **64** of the siphon. However, for convenience both the conduit and said inlet leg can be connected to the same portion of the receiving tank. More particularly the conduit **66** and the inlet leg **64** run into opposite ends of the arms of a **T 68** the shank of which is connected to a lower portion of the receiving tank **54**, as for instance, through an opening in the bottom wall **58** thereof.

The three vessels **12**, **26** and **54** have openings other than those aforementioned. These include: an opening at an upper portion of the generator **12** into which there is inserted a filling pipe **70** that is closed during pumping by a hand operated valve **72**, a vent opening **74** at an upper portion, e.g., the top wall **30**, of the reservoir **26** and a vent opening **76** at an upper portion, e.g., the top wall **56** of the receiving tank **54**.

Finally, the pump **10** includes an outflow conduit **78** having an intake end **80** connected to a lower portion of the generator **12**. Although this connection can be effected through a side wall or the bottom wall of a generator, for the sake of compactness the outflow conduit enters the generator **12** through the top wall **16** thereof, being hermetically sealed at this point, and continues downwardly inside the generator with its intake end **80** located slightly above the bottom wall **18**. The outflow conduit is provided with a safety relief valve **82**, e.g., a valve having a spring loaded closure, which prevents the build up of too great a presure within the pump, and with an egress check valve **84** which operates at a slight pressure differential, e.g., in the vicinity of 2 pounds p.s.i. to permit water to flow out of the generator.

The foregoing constitute all of the parts of the pump. However, in order to facilitate understanding of the pump operation, it is best first to describe the heat utilization mechanism, i.e., the blanket **11** which the pump is to serve. Said blanket is essentially a large area flexible heat exchanger. It includes a length of flexible tubing **86**, or a plurality of lengths of flexible tubing **86**, **88**, **90** connected in parallel (through manifolds **92**, **94**, between the the outflow conduit **78** and the return conduit **66**). The blanket **11** simply may comprise a pair of face-to-face joined plies of blanket material, e.g., felt, or cloth between which are located the lengths of tubing **86**, **88**, **90** disposed in a suitable arrangement to provide uniform heat over a large area of the blanket. In the particular example being described I prefer to form the lengths of tubing **86**, **88**, **90**, from inexpensive light material, for example, a polyvinyl resin.

The pump and heat utilization mechanism are prepared for operation by pouring water into the generator **12** through the filling pipe **70**, and into the reservoir **26** in any suitable manner, as for instance, by removing the vent **74** which may be detachable and subsequently replacing it after the reservoir is substantially full. These two vessels do not have to be completely filled but it is preferred that before starting operation the water level therein be very close to their tops. Also the lengths of tubing **86**, **88**, **90** in the blanket **11** and the return and outflow conduits **66**, **78** are filled with water. The heat exchanger **20**, receiving tank **54** and siphon connector **62** are left empty, that is to say, empty of water but full of air. In other words, the entire heating system is filled with water except for the receiving tank, the heat exchanger in the generator, the syphon connector and small air cushions at the tops of the reservoir and generator. Gas now is fed to the burner **40** and the same is lit.

Application of heat to the generator quickly raises the temperature of the water therein and in a short time will form vapor that is trapped at the top of the generator. Initially vapor evolves somewhat slowly. However as the pump warms up vapor forms fairly rapidly. Since the generator is hermetically closed and since the check valve **36** prevents escape of water through the tube **34** back into the reservoir, the pressure built up by the vapor can be relieved only by egress of water through the intake **80** into the outflow conduit **78**. Such flow will occur as soon as pressure within the generator exceeds the loading, i.e., 2 pounds p.s.i., of the check valve **84** thereby pumping water from the generator to the blanket. The water entering the outflow conduit **78** forces circulation through the lengths of tubing **86**, **88**, **90** to the return conduit **66** and into the receiving tank **54**. Because the siphon connection and receiving tank initially are empty, water will not immediately reach the coil **20** but gradually will accumulate in the inlet leg **64** of the return conduit **66** and in the receiving tank, the water level in both of these being substantially alike. At the same time the vapor space at the top of the generator increases.

The receiving tank has a volume which is less than the volume of the generator but preferably greater than the capacity of the heat exchanger **20**, one satisfactory arrangement being where the receiving tank has about one quarter of the volume of the generator. The top, i.e. bend, of the siphon connector is below the level of the top of the receiving tank so that before the generator empties, before the receiving tank fills and after there has been a substantial rise of water in the receiving tank, the level of the water in the siphon connector will reach the bend. Thereupon water will flow down into the outlet leg **22** and the siphon will be full. Once the siphon is full it will induce flow of water from the receiving tank to the helical coil **20** that will continue as long as there is water in the receiving tank.

It will be appreciated that as liquid flows through the blanket it will, although initially hot as introduced into the blanket, eventually cool off during its circulation through the lengths of heat exchange tubing **86**, **88**, **90** and by the time it reaches the receiving tank it will be about as cool as the ambient atmosphere. It therefore will be colder than the liquid in the generator which is being heated by the burner. As a result, the cool water discharging from the receiving tank during the operation of the siphon connector and entering into the heat exchange helical coil **20** will chill the water in the generator and thereby condense a substantial amount of the vapor at the top of the generator. The consequent drop of pressure in the generator closes the egress check valve **84**, opens the ingress check valve **36** and induces flow of water from the reservoir through the tube **34** into the generator. The water in the reservoir likewise is cool and therefore will further chill the water in the generator so as to draw in additional reservoir water, whereby at this stage of the pump cycle the generator will be substantially refilled. The burner **40** continues to heat the gen-

erator so that in a few moments vapor again is generated to start the build-up of the pressure within the generator, this being the pumping part of the cycle.

However pumping does not recommence until all the liquid in the receiving tank has been discharged through the siphon connector and the connector again is empty. Any air that enters the system at such time is discharged from the reservoir through the vent **74**.

The aforesaid cycle of operation is repeated, pressure alternately being built up in the generator to force hot water into the heat utilization mechanism and pressure then being reduced in the generator as the siphon connector becomes effective and as water enters the generator from the reservoir. The alternate above-pressure and below-pressure phases of generator operation create a pulsing flow of water through the outflow conduit **78**, this being the characteristic from which my pump derives its name. It will be observed that at no time does anything but liquid enter the outflow conduit and circulate through the lengths of heat exchange tubing **86**, **88**, and **90**.

The reservoir, receiving tank, generator and entire heating system may be of any relative capacities with the sole qualification heretofore mentioned, i.e. that the receiving tank be smaller than the generator. By way of example, I have secured excellent results where the receiving tank is about one quarter as large as the generator and is about one fifteenth as large as the entire system, and where the reservoir is about one half as large as the generator.

With this arrangement I have provided a heating system which can be thermally actuated by portable heating means such as a small light gas tank, which makes efficient use of heat both to pump liquid and to heat the liquid being pumped, and which makes efficient use of the heated liquid by excluding vapor from the flow of the heating medium. Because of the excellent heat exchange I can design a pump and heating system of low weight and small size.

It will be apparent that although the liquid in the system is heated in the generator and therefore hot at the time of its introduction into the intake manifold **92**, the heat utilization mechanism, e.g., the blanket **11**, may be so large that the liquid will be too cool before it reaches the outflow manifold **94**. Such difficulty easily can be overcome when it is realized that the pump **10** has two independent functions, to wit, circulation and heating. If the circulating capacity is sufficient and it merely is desired to supply more heat, it is not necessary to increase the size of the pump, it sufficing to provide a supplementary heating means. A modified form of my invention embodying a supplementary heating means **100** is schematically indicated in FIG. 2. In said figure the reference numeral **102** denotes a heat utilization mechanism such as a blanket and the reference numeral **78** an outflow conduit from the pump **10**. Said conduit is connected to a heat exchange tubing **104** within the blanket **102**, the tubing being so long or being designed for use under such severe conditions that the temperature of the water return to the conduit **66** would be too low for proper operation of the blanket. Accordingly I subdivide the tubing into two sections **104A** and **104B** between which the supplementary heating means **100** is interposed. Said means constitutes a heat exchange coil **106** series connected between the two sections **104A**, **104B** and disposed in heat exchange relationship with a source of heat such as a flame **108** issuing from a burner **110** which is fed with gas from the tank **52**. The flame **108** heats the liquid forced through the coil **106** by the pump **10**. The supplementary heating means does not pump.

It thus will be seen that I have provided devices 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 described my invention I claim as new and desire to secure Letters Patent:

1. A thermally actuated liquid pulse pump for a heat utilization mechanism having a continuous fluid passageway running from an intake end to an outlet end comprising a generator, means to heat the generator, heat exchange means disposed in heat exchange relationship with the generator, said heat exchange means including a heat exchange passageway therethrough, said passageway having an intake end and outlet end, means providing fluid communication between the outlet end of the heat exchange passageway and the generator, said last-named means including a check valve permitting flow of liquid only in a direction from the outlet end of the heat exchange passageway to the generator, an outflow conduit having an intake end connected to the generator below the top thereof, said outflow conduit being adapted to be connected to the intake end of the fluid passageway for the heat utilization mechanism, said outflow conduit including a check valve permitting flow of liquid only in a direction away from the generator, a return conduit having a discharge end, said return conduit being adapted to be connected to the outlet end of the fluid passageway for the heat utilization mechanism, a receiving tank smaller than the generator and at least in part higher than the heat exchange means and to which said discharge end of the return conduit is connected, a siphon connector at least in part higher than the heat exchange means and having an inlet end and an outlet end, means providing fluid communication between the inlet end of the siphon connector and the receiving tank below the top thereof, means providing fluid communication between the outlet end of the siphon connector and the inlet end of the heat exchange passageway, and a vaporizable liquid within the generator so that when the generator is heated vapor created therein will force liquid into the outflow conduit and into the heat utilization mechanism and liquid from the heat utilization mechanism will return through the return conduit to flow into the receiving tank until it reaches a level sufficiently high to initiate operation of the siphon connector which thereby will cause the returning liquid to be discharged into the heat exchange means so as to cool the liquid in said generator and thereby reduce pressure therein, whereby to induce flow of liquid from the heat exchange means into the generator, the cycle of operations being repeated to intermittently pump liquid from the generator to the outflow conduit.

2. A pump as set forth in claim 1 wherein the receiving tank is vented.

3. A pump as set forth in claim 1 wherein the top of the siphon connector is below the top of the receiving tank.

4. A thermally actuated liquid pulse pump for a heat utilization mechanism having a continuous fluid passageway running from an intake end to an outlet end comprising a generator, means to heat the generator, heat exchange means disposed in heat exchange relationship with the generator, said heat exchange means including a passageway therethrough, said passageway having an intake end and outlet end, a reservoir, means providing fluid communication between the outlet end of the heat exchange passageway and the reservoir, means providing fluid communication between the reservoir and the generator, said last-named means including a check valve permitting flow of liquid only in a direction to the generator, an outflow conduit having an intake end connected to the generator below the top thereof, said outflow conduit being adapted to be connected to the intake end of the fluid passageway for the heat utilization mechanism, said outflow conduit including a check valve permitting flow of liquid only in a direction away from the generator,

a return conduit having a discharge end, said return conduit being adapted to be connected to the outlet end of the fluid passageway for the heat utilization mechanism, a receiving tank smaller than the generator and at least in part higher than the heat exchange means and to which said discharge end of the return conduit is connected, a siphon connector at least in part higher than the heat exchange means and having an inlet end and an outlet end, means providing fluid communication between the inlet end of the siphon connector and the receiving tank below the top thereof, means providing fluid communication between the outlet end of the siphon connector and the inlet end of the heat exchange passageway, and a vaporizable liquid within the generator so that when the generator is heated vapor created therein will force liquid into the outflow conduit and into the heat utilization mechanism and liquid from the heat utilization mechanism will return through the return conduit to flow into the receiving tank until it reaches a level sufficiently high to initiate operation of the siphon connector which thereby will cause the returning liquid to be discharged into the heat exchange means so as to cool the liquid in said generator and thereby reduce pressure therein, whereby to induce flow of liquid from the heat exchange means into the generator, the cycle of operations being repeated to intermittently pump liquid from the generator to the outflow conduit.

5. A pump as set forth in claim 4 wherein the reservoir is located immediately below the generator.

6. A pump as set forth in claim 4 wherein the reservoir is vented.

7. A heating system having a heat utilization mechanism for a heated liquid, said heat utilization mechanism having an intake end and outlet end, a thermally actuated liquid pulse pump comprising a generator, means to heat the generator, heat exchange means disposed in heat exchange relationship with the generator, said heat exchange means including a heat exchange passageway therethrough, said passageway having an intake end and outlet end, means providing fluid communication between the outlet end of the heat exchange passageway and the

generator, said last-named means including a check valve permitting flow of liquid only in a direction from the outlet end of the heat exchange passageway to the generator, an outflow conduit having an intake end connected to the generator below the top thereof, said outflow conduit including a check valve permitting flow of liquid only in a direction away from the generator, a return conduit having a discharge end, a receiving tank smaller than the generator and at least in part higher than the heat exchange means and to which said discharge end of the return conduit is connected, a siphon connector at least in part higher than the heat exchange means and having an inlet end and an outlet end, means providing fluid communication between the inlet end of the siphon connector and the receiving tank below the top thereof, means providing fluid communication between the outlet end of the siphon connector and the inlet end of the heat exchange passageway, means providing fluid communication between the outflow conduit and the intake end of the heat utilization mechanism, means providing fluid communication between the outlet end of the heat utilization mechanism and the return conduit, and a vaporizable liquid within the generator so that when the generator is heated vapor created therein will force liquid into the outflow conduit and into the heat utilization mechanism and liquid from the heat utilization mechanism will return through the return conduit to flow into the receiving tank until it reaches a level sufficiently high to initiate operation of the siphon connector which thereby will cause the returning liquid to be discharged into the heat exchange means so as to cool the liquid in said generator and thereby reduce pressure therein, whereby to induce flow of liquid from the heat exchange means into the generator, the cycle of operations being repeated to intermittently pump liquid from the generator to the outflow conduit.

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