May 8, 1956 R. E. COLEMAN 2,744,470

THERMOPUMP

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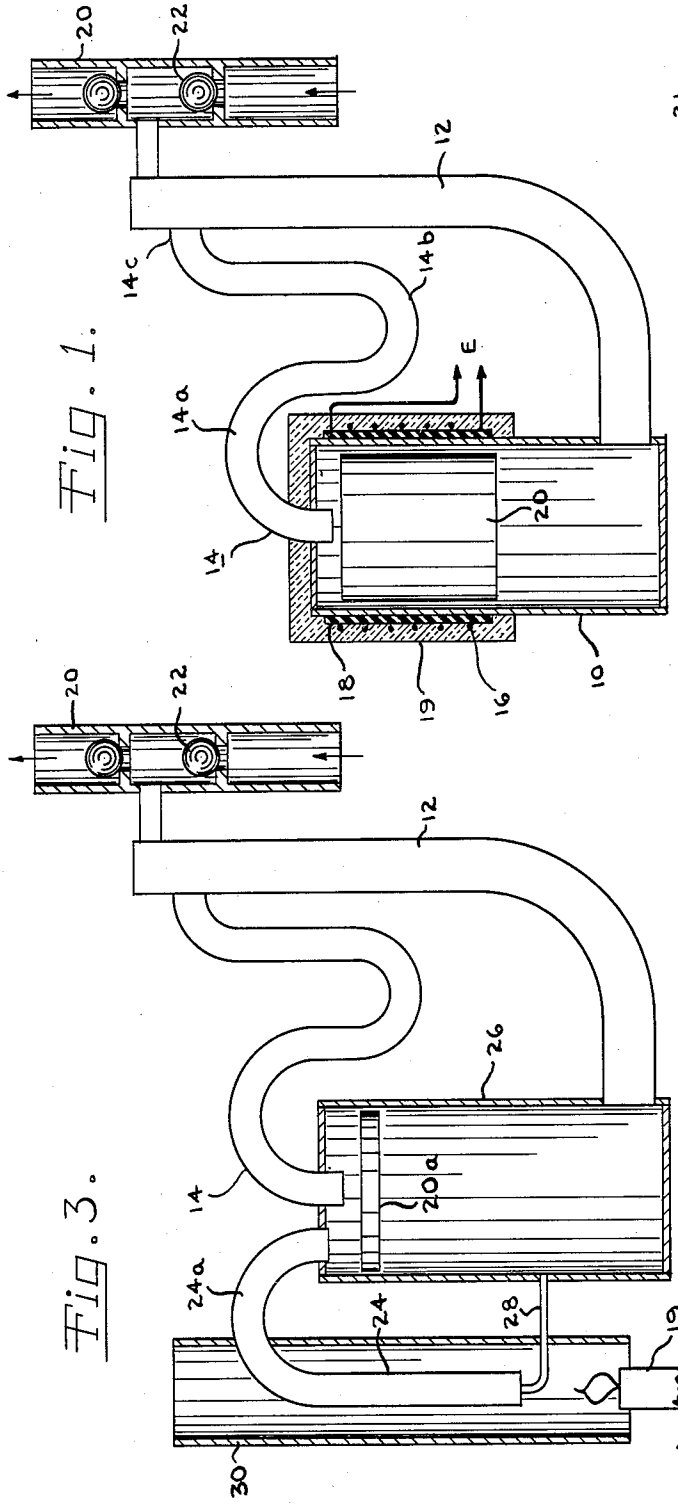


Fig. 1.

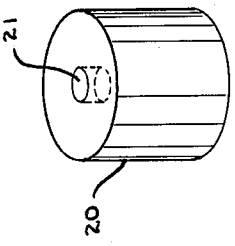


Fig. 1A.

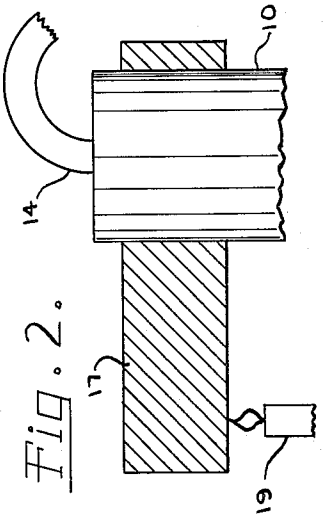


Fig. 2.

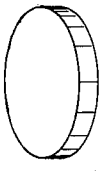


Fig. 3A.

Fig. 3.

BY

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2,744,470

THERMOPUMP

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12 Claims. (Cl. 103—255)

This invention relates to improvements in pumps, and particularly to an improved heat-actuated pump, referred to herein as a thermopump.

Briefly, a thermopump comprises a closed system in which a fluid is heated to form vapor. This vapor is recurrently collected and condensed by cyclically reversing the relative rates of vaporization and condensation in the system.

By connecting the system to a fluid supply source and a delivery point or load through a pair of check valves, the fluid expansion and contraction accompanying this cyclical action can be utilized to effect a transfer of liquid from the source to the load.

In theory, the thermopump has many attractive features. For example, it can be essentially noiseless in operation, it has practically no moving parts subject to wear, it can be flame operated, utilizing a relatively small and readily portable fuel supply source (e. g. "bottled gas") and, where waste heat is available, it provides a simple means of utilizing such heat for pumping, as in pumping liquid fuel and the like. In practice, however, the utility of such pumps has been materially limited by limitations encountered in attainable output. These limitations on output have, in general, had a dual aspect. For one thing, the efficiency (i. e., the pump output per unit of heat input) has been so low that the use of the thermopump has been principally limited to applications where waste heat is available or to situations where heat is the only conveniently available type of energy. In addition to the low efficiency limitation, thermopump output has been limited by the fact that if a relatively low heat input were exceeded, the required reversal in the relative rates of vaporization and condensation could not be obtained, and the system would gradually fill with vapor and eventually boil dry—a condition conveniently referred to as "lockout." Since the pump output is directed related to the heat input, the attainable pumping rate has been greatly limited by this "lockout" limitation on heat input.

It is a general object of the present invention to provide a thermopump that is adapted to operate with relatively high heat input without locking out, and to provide a thermopump wherein heat losses are materially decreased. Further objects of the invention include the provision of means for speeding up the action of a thermopump by increasing the number of pumping strokes per unit time, as well as provision of means for preventing unnecessary heating of the parts in a thermopump system and of the liquid contained therein.

In accordance with the invention, the foregoing and other related objects and advantages are attained by the provision in a thermopump system of a float element which has the effect of thermally isolating the heated and unheated parts of the system, thereby reducing heat transfer from the points at which heat is needed to points where it is a definite detriment. In certain types of pumps, the float member can be arranged to reduce the

amount of liquid presented to the applied heat, and thereby reduce unnecessary heating of liquid.

A more complete understanding of the invention, together with further objects, advantages and features thereof, can be had by reference to the following description of illustrative embodiments thereof, when read in connection with the accompanying drawing, wherein

Fig. 1 is a side view, partly in section, of one type of thermopump embodying my invention,

Fig. 1*a* is a perspective view of a float element suitable for use in the thermopump shown in Fig. 1,

Fig. 2 is a fragmentary side view of a thermopump similar to that shown in Fig. 1, illustrating an alternative heating arrangement,

Fig. 3 is a view, similar to Fig. 1, showing a modified form of thermoump embodying my invention, and

Fig. 3*a* is a perspective view of a float element such as may be used in the thermopump shown in Fig. 3.

In Fig. 1, there is shown a thermopump comprising a chamber **10** in which to generate and collect a body of vapor, and a second chamber **12** in which to condense vapor transferred thereto from the chamber **10** through a vapor tube **14**.

Preferably, the generator-collector **10** comprises an elongated cylinder or tube, joined at the bottom to the lower end of a somewhat smaller diameter condensing cylinder or tube **12**.

Near the upper end of the cylinder **10**, means are provided for heating the cylinder to generate vapor therein. In the embodiment shown in Fig. 1, the heating means comprises an electrical heating coil **16**, wound about the upper end of the cylinder **10**. If the cylinder **10** is made of metal or other electrically conductive material, a thin layer of insulation **18**, such as mica or the like, is provided to prevent the wire **16** from being short-circuited by the walls of the chamber **10**. For best efficiency, the heated portion of the tube **10** is surrounded by a layer of insulating material **19**, such as glass wool.

It is, of course, apparent that heat can be applied to the chamber **10** in ways other than that shown in Fig. 1. For example, heat can be supplied by means of a heat conductor bar **17** as shown in Fig. 2, one end of the bar **17** being clamped or otherwise held in close contact with the chamber **10**, and the other end of the bar being exposed to a flame supplied by any type of burner **19**.

The vapor tube **14** in the thermopump of Fig. 1 is a tube of relatively small cross-section for transferring collected vapor from the chamber **10** to the condenser **12**, and has special significance in the control of "cycling" or "switch-over" from relatively high vaporization rate to relatively high condensation rate. The tube **14** includes a first inverted U-shaped portion **14***a* leading from just the top of the chamber **10** to a second U-shaped portion **14***b* which extends from the first U-bend **14***a* down alongside the chamber **10** and then up to a point **14***c* slightly above the highest point in the first U-bend **14***a*.

At the top of the condenser tube **12**, a pair of check valves **20**, **22** provide one-way inlet and outlet passages to and from the pump system. For simplicity, no complete liquid circulation path has been shown beyond the check valves **20**, **22**, it being understood that inlet and outlet lines (not shown) will be used to connect the system to the desired liquid source and load.

Prior to operation, it will also be understood that the entire closed system comprising the chambers **10**, **12** and the vapor tube **14** will be filled with a quantity of the liquid to be pumped, such as water, fuel oil or the like.

When electric current from a suitable source (designated "E") is passed through the coil **16**, the liquid in the upper part of the chamber **10** will be heated to the boiling point and will vaporize. The vapor thus formed

will collect in the top of the chamber **10**, and in so doing will force liquid from the system through the outlet valve **20**, the principal flow of liquid being down through the chamber **10** and up through the condenser column **12**. Vapor will also collect in the inverted U-bend **14***a* of the vapor tube **14**, gradually forcing the liquid level down into the second U **14***b* in step with the lowering of the liquid level in the chamber **10**. Once the vapor in the tube **14** reaches the lowermost point in the bend **14***b* and and starts up toward the high point **14***c*, the hydrostatic balance in the system will be upset. The head of liquid in the condenser column **12** now will force liquid to flow upwardly in the chamber **10** in order to equalize the levels in the chamber **10** and in the tube **14**. In turn, this will force the vapor out of the chamber **10** through the tube **14**. Meanwhile, the vapor forced through the tube **14** will condense as it is discharged into the relatively cool condenser **12**. The hydrostatic refilling of the chamber **10** will proceed very rapidly, once initiated, so that the vapor in the chamber **10** will all be delivered quite abruptly to the condenser, where it can condense very quickly if the condenser temperature is low enough. The resulting pressure drop in the system will cause a fresh charge of liquid to be drawn in through the inlet valve **22** to replace the condensed vapor.

When the system is operating properly, the condensation of vapor will take place very rapidly, as stated; much faster than the generation of the same amount of vapor. However, the hotter the condenser becomes, the longer it will take for the liquid to condense. If the heat input is too great, the rate of vaporization will become equal to the condensation rate and the pump will lock out. If the heat source is not removed, the vaporization rate soon will continually exceed the condensation rate and the entire system will "boil dry."

While it is evident that some heating of the condenser must take place due to the repeated delivery of hot vapor thereto, it has been found that the condenser in most prior art thermo-pumps will become hot enough to cause lock-out at a much lower heat input than would be expected. This, together with the fact that the pump output per unit of heat input has been very far below the theoretical limit attainable, has suggested that a considerable part of the applied heat has not been utilized in generating vapor, and that a substantial portion of this wasted heat has reached the condenser, leading to premature lockout.

It has already been found that the anti-lockout characteristics of a thermopump can be improved by providing cooling means in the form of a reservoir or the like between the vapor generator and the condenser, as described in U. S. Patent No. 2,553,817—Kleen. Such a reservoir helps to dissipate heat that could otherwise be conducted through the liquid in the system from the generator to the condenser and thereby helps to prevent premature lock-out. However, investigation has shown that this is not a completely satisfactory expedient because it is a means of throwing away heat already wasted, rather than a preventative of the original waste of heat. In accordance with an important feature of the present invention, the problem is attacked by reducing the original waste of heat.

In the embodiment of the invention shown in Fig. 1, the means for reducing heat loss comprises an element **20** of low enough density to float in the particular liquid being used in the pump. Accordingly, when vapor collects in the chamber **10**, the upper end of the float **20** will be exposed above the surface of the liquid to cut down heat transfer from the vapor to the liquid. As the liquid level drops in the chamber **10**, the float **20** will also move downwardly, thereby maintaining a line of demarkation between liquid and vapor. It can be seen that any liquid contacting the vapor must be essentially at the boiling point to prevent condensing the vapor as fast as it is generated. Since some turbulence in the collecting chamber is unavoidable, it follows that without the float **20** there would be a large area of liquid-vapor contact and a resulting continual loss of heat to the liquid. This lost or wasted heat rather quickly will find its way to the condenser as the liquid in the system continuously moves back and forth, mixing the warmer and cooler liquid strata, and generally heating up the entire pump system.

The float **20** greatly reduces the area of contact between the liquid and the vapor, and presents to the vapor a surface that needs to be heated only once rather than a turbulent liquid surface that must be continuously heated.

In order to have the smallest possible area of liquid-vapor contact, the float **20** is preferably shaped to conform rather closely in cross-section to the inside cross-section of the chamber **10**, and with cross-sectional dimensions just enough smaller than the corresponding inside dimensions of the chamber **10** to allow free float movement.

A second useful feature of the float **20** is that it will function to interrupt a convection path through which a great deal of heat can otherwise be lost. Without the float, it is seen that there is a continuous circuit, starting at the top of the chamber **10**, through the vapor tube **14**, down through the condenser column **12**, and up through the chamber **10**, through which liquid can flow by convection before enough vapor forms to fill the top bend **14***a* in the vapor tube. Heretofore, it has been the practice to make the cross-section of the vapor tube **14** as small as possible in order to have the highest possible resistance to convection of hot liquid. This is not a completely satisfactory expedient because it does not entirely eliminate convection, but only tends to decrease it. With the float **20** in place, however, it is evident that prior to vapor formation the float will close off the collector end of the vapor tube **14**, preventing convection currents from flowing therethrough. Of course, as soon as enough vapor is formed to drop the float away from the inlet to the tube **14**, the convection path will be broken by this vapor.

Preferably, as previously stated, the collector end of the tube **14** extends a short way into the chamber **10**. This is done so that the vapor collector will not completely refill with liquid. It is found that the pumping action is speeded up if a small amount of vapor is retained in the top of the collector at the end of the condensation stroke, probably because complete refilling of the collector will cool the top of the float (and the top of the chamber **10**) slightly and thereby create some delay in vapor collection until this surface can be reheated. In fact, it is found that this retention of a small "priming charge" of vapor is helpful in speeding up pump action with or without a float. The protruding tip of the vapor tube will be blocked off either by the rising float, or by the liquid itself if no float is used, before the chamber **10** completely refills with liquid.

A further feature of the float in the pump of Fig. 1 is that it makes feasible the use of a relatively large diameter generator-collector chamber **10**, and yet presents to the heat source a very small quantity of liquid to be vaporized. In other words, without the float a large diameter chamber **10** would contain a large quantity of liquid in the area where the heat is being applied, and substantially all of this liquid would have to be heated before vapor could be formed. Accordingly, it has been customary to have a relatively small cross section generator chamber to minimize the quantity of liquid in the vaporizing zone. This, however, involves a compromise. If the pump stroke is made relatively short, there is an increase per unit of time in the number of "dead-time" intervals between condensation and vaporization, with an attendant decrease in pump output. If a "long" pump stroke is used, then there will be a large change in the liquid level in the generator. This will result in a large change, during each pumping stroke, in the amount of heated surface in contact with liquid and a corresponding decrease in vaporization at a time (prior to condensation) when continued rapid vaporization is desirable.

The float **20**, in effect, makes the chamber **10** a variable volume chamber, providing a small volume of liquid to receive heat from the walls of the chamber **10**, but moving out of the way to provide a relatively large vapor collecting volume with a small change in liquid level.

To take advantage of the above-described "variable volume" feature, in the type of pump shown in Fig. 1 a relatively long float **20** is preferable. Specifically, the float should be slightly longer than the section of the chamber **10** to which heat is applied. For a cylindrical condenser-collector chamber **10**, therefore, the float **20** preferably also would be cylindrical, as shown in Fig. 1*a*. A slight indentation **21** in the top of the float, slightly larger than the corresponding vapor tube cross-sectional dimension, is sometimes helpful in obtaining a good anti-convection seal.

The material of which the float is made will be largely dependent on the density, corrosive effect and other properties of the liquid being pumped. To function as a heat transfer barrier, a structure of negligible heat conductivity should, of course, be used. A thin-walled hollow metal chamber, a block of "foam glass," and/or wood with a moisture-proof coating to prevent swelling, all have been used successfully as float elements.

In Fig. 3 there is shown a somewhat different type of thermopump provided with a float in accordance with the invention. The pump shown in Fig. 3 has a condenser tube **12** and a vapor tube **14**, generally similar to the corresponding parts of the pump shown in Fig. 1. However, in the Fig. 3 system, separate chambers **24**, **26** are provided for vapor generation and vapor collection. The vapor generator **24** comprises a tube of relatively small cross-section, shaped as an inverted U with legs of unequal length. The shorter leg of the U opens into the top of a vapor collecting chamber **26** which preferably comprises an elongated cylinder of substantially greater cross-section than the tube **24**. The generator tube **24** opens into the top of the chamber **26** at a point slightly off center, while the vapor tube **14** preferably enters the top of the chamber **26** substantially in the center. The condenser tube **12** is connected into the side of the collecting chamber **26** at or near the bottom end thereof, while a very small diameter tube **28** leads into the bottom of the generator tube **24** from a point part way up the side of the collector **26**.

The pump shown in Fig. 3 represents an alternative approach to the problem of having only a small body of liquid in the heated portion of the system, a pumping stroke of reasonable volume and yet only a small change in the liquid level in the generator. It can be seen that a relatively large quantity of vapor can be collected in a rather short longitudinal section of the top of the large cross-section chamber **26**, and with a small theoretical change in the generator liquid level. However, it has been found that this theoretical correspondence between the generator and collector liquid levels does not always work out. Observation of the action in glass models of thermopumps with separate generators and collectors has revealed that vapor tends to form in the generator in somewhat erratic "bursts." If the bottom of the longer leg of the generator tube has an unrestricted opening into the collector **26**, each of these generation "bursts" will force practically all of the liquid out of the generator tube. The higher level of the liquid in the collector then will cause liquid to flow back into the generator and the generated vapor will flow over into the collector. This recurrent change in the generator liquid level, of course, contributes further to erratic vapor generation because of the recurrent change in the amount of liquid contacting the hot generator surfaces. It has been found that by placing a restrictor, such as the small diameter tube **28**, in the flow path between the generator **24** and the collector **26**, these sudden changes in the generator liquid level can be largely overcome, so that the generation of vapor will be much more nearly continuous.

A float **20***a* serves two important functions in the pump of Fig. 3, acting both as a liquid-vapor separator to reduce heat losses and as a deconvector to prevent convection flow through the tubes **14**, **12**, **26** just before vapor begins to collect on each stroke of the pump.

One type of float that can be used in the pump of Fig. 3 comprises a thin wafer or disc as illustrated in Fig. 3*a*. As far as the direct transfer of heat from the heat source to the liquid is concerned, the separate generator **24** makes it unnecessary to provide for a thin film of liquid along an extended longitudinal surface of the collecting chamber **26**, because no heat is applied directly to the collector as it is to the chamber **10** in Fig. 1. A thin wafer or disc float has the advantage that it will have very little tendency to become jammed or rub against the inside of the chamber **26** if the pump is tipped. It is preferable, of course, to keep the collecting chamber axis as nearly vertical as possible, although it has been found that operation will continue with the collection chamber axis as much as 30 degrees or more off vertical.

On the other hand, there is a factor of secondary heating of the liquid in the pump system that justifies the use of a longer float in the pump of Fig. 3 in any situation where jamming of the float is not a problem. In order for vapor to collect in the chamber **26**, the chamber walls exposed to the vapor must be hot enough so that no appreciable condensation will take place on those walls. With a thin float, it is evident that each suction stroke of the pump will bring a substantial volume of the relatively cool liquid below the float into contact with at least a portion of the wall surface that has just been exposed to vapor. This, of course, will result in some heat loss. Accordingly, a relatively long float can sometimes be used to advantage in the pump of Fig. 3.

Although the float **20** materially decreases heat transfer in the pumps of Figs. 1 and 3, it is evident that some heat transfer can still take place from vapor to liquid around the edges of the float. Therefore, for high capacity (i. e. high heat input) pumps it is preferable to make the collecting chamber (**10** or **26**) long enough to provide a cooling reservoir in the system as taught in the above-identified Kleen patent.

While the generator **24** of the pump shown in Fig. 3 can be heated electrically or by a conductor bar in the manner illustrated in Figs. 1 and 3, the separate generator **24** of Fig. 3 can also be heated conveniently by direct flame impingement, which may be more efficient where only a small flame is available. As illustrated, the generator **24** can be placed inside a flue **30** for confining and directing the flame from any suitable type of burner **19**. Such an arrangement is difficult to use with a pump having a combined generator-collector as in Fig. 1 without heating the liquid below the float.

When the pump of Fig. 3 is operating, vapor generated in the tube **24** will flow over into the chamber **26** and be collected above the float **20***a*, gradually depressing the liquid level in the collector **26** until "cycling" and condensation occur in the manner already described in connection with the pump of Fig. 1.

From the foregoing, it can be seen that the present invention provides an improved thermopump wherein heat waste and heat losses are materially reduced to obtain high pump delivery rates in a simple and efficient manner.

I claim:

1. In a thermally actuated pump of the type comprising a liquid filled system within which to generate and condense vapor and including means defining a generally vertically disposed chamber, of substantially uniform horizontal cross-section from top to bottom, within which to recurrently collect a body of vapor, the improvement which comprises a float member in said chamber of negligible heat conductivity and of density less than that of

the liquid in said system, said float member having a horizontal cross-sectional shape generally conforming to the corresponding internal horizontal cross-sectional shape of said chamber, and said float member being shorter vertically than said chamber and slightly smaller in horizontal cross-section than the corresponding internal cross section of said chamber so that said float member fits closely in said chamber but is freely movable vertically therein and floats with its upper end exposed as vapor is collected in said chamber.

2. In a thermally actuated pump of the type comprising a liquid filled system within which to generate and condense vapor and including means defining a generally vertically disposed substantially cylindrical chamber within which to recurrently collect a body of vapor, the improvement which comprises a float member in said chamber of negligible heat conductivity and of density less than that of the liquid in said system, said float member having a horizontal cross-sectional shape generally conforming to the corresponding internal horizontal cross-sectional shape of said chamber, and said float member being shorter vertically than said chamber and having a slightly smaller diameter than the corresponding internal diameter of said chamber so that said float member fits closely in said chamber but is freely movable vertically therein and floats with its upper end exposed as vapor is collected in said chamber.

3. In a thermally actuated pump of the type comprising a liquid filled system within which to generate and condense vapor and including means defining a generally vertically disposed chamber within which to recurrently collect a body of vapor, the improvement which comprises a float member in said chamber of negligible heat conductivity and of density less than that of the liquid in said system, said float member being shorter vertically than said chamber and having throughout its length a substantially sliding fit in said chamber so that said float member fits closely in said chamber but is freely movable vertically therein and floats with a relatively thin horizontal section of its upper end exposed as vapor is collected in said chamber.

4. In a thermally actuated pump, means defining a generally vertically disposed substantially cylindrical chamber within which to generate and collect vapor, an elongated tube substantially vertically disposed beside said chamber within which to condense vapor, a liquid connection between the lower ends of said chamber and said tube, a vapor delivery tube extending from the upper end of said chamber to said condenser tube, said vapor tube comprising a first inverted U-shaped portion having one leg extending a short distance into the top of said chamber and a second U-shaped portion extending from the other leg of said first portion to a point on said condenser tube above the level of the top of said first portion of said vapor tube, means for heating liquid in the upper portion of said chamber, and fitting closely inside but freely movable in said chamber an elongated cylindrical float element of length equal to that of the heated portion of said chamber and of density less than that of the liquid in said system.

5. In a thermally actuated pump, means defining a generally vertically disposed substantially cylindrical chamber within which to generate and collect vapor by applying heat to a portion of said chamber, means defining a chamber within which to condense vapor, liquid and vapor communicating means between said chambers, and fitting closely inside but freely movable in said first-named chamber an elongated cylindrical float element of length equal to that of the heated portion of said chamber, of negligible heat conductivity and of density less than that of the liquid in said system.

6. In a thermally actuated pump, means defining a generally vertically disposed substantially cylindrical chamber within which to generate and collect vapor, an elongated tube substantially vertically disposed beside said chamber within which to condense vapor, a liquid connection between the lower ends of said chamber and said tube, a vapor delivery tube extending from the upper end of said chamber to said condenser tube, and fitting closely inside but freely movable in said chamber an elongated cylindrical float element of length equal to that of the heated portion of said chamber, of negligible heat conductivity and of density less than that of the liquid in said system.

7. In a thermally actuated pump of the type comprising a liquid filled system within which to generate and condense vapor and including means defining a generally vertically disposed chamber within which to recurrently collect a body of vapor, a tube within which to condense vapor, a liquid connection between said chamber and said tube, a vapor delivery tube extending from the upper end of said chamber to said condenser tube, said vapor tube comprising a first inverted U-shaped portion having one leg extending a short distance into the top of said chamber and a second U-shaped portion extending from the other leg of said first portion to a point on said condenser tube above the level of the top of said first portion.

8. In a thermally actuated pump of the type comprising a liquid filled system within which to generate and condense vapor, and including means defining a generally vertically disposed substantially cylindrical chamber within which to recurrently collect a body of vapor, means defining a chamber within which to condense vapor, a liquid connection between said chambers, a vapor delivery tube extending from the upper end of said collecting chamber to said condenser chamber, said vapor tube comprising a first inverted U-shaped portion having one leg extending a short distance into the top of said collecting chamber and a second U-shaped portion extending from the other leg of said first portion to a point on said condenser chamber above the level of the top of said first portion of said tube, means for heating liquid in the upper portion of said collecting chamber, and fitting closely inside but freely movable in said collecting chamber an elongated cylindrical float element of length equal to that of the heated portion of said collecting chamber and of density less than that of the liquid in said system.

9. In a thermally actuated pump of the type comprising a liquid filled system including a heating tube provided with means for heating a portion of said tube to heat liquid in the tube to a vaporizing temperature, means defining a generally vertically disposed collecting chamber within which to recurrently collect a body of vapor, means defining a chamber within which to condense vapor, liquid and vapor communicating means between said tube and said chambers, and fitting closely inside but freely movable in said collecting chamber an elongated cylindrical float-element, of negligible heat conductivity and of density less than that of the liquid in said system.

10. In a thermally actuated pump, a closed system including an inverted U-shaped heating tube, means defining a substantially vertically disposed cylindrical chamber within which to collect vapor delivered thereto from said heating tube, an elongated tube substantially vertically disposed beside said chamber within which to condense vapor, liquid and vapor communicating means between said tubes and said chamber, and fitting closely inside but freely movable in said chamber a disc-shaped float element of negligible heat conductivity and of density less than that of the liquid in said system.

11. A closed system including a heating tube provided with means for heating liquid in the tube to a vaporizing temperature, a condensing tube adapted to contain liquid for condensing vaporized liquid produced in said heating tube and conveyed to the condensing tube, a vapor tube for conveying vapor produced in the upper portion of the heating tube to the upper portion of the condensing tube, connection means providing liquid communication between the lower portions of the heating and condensing tubes, and a float member of negligible heat conductivity

substantially filling said upper portion of said heating tube and freely movable in said heating tube, said float member having a density less than that of the liquid in said system.

12. A closed system including a heating tube provided with means for heating liquid in the tube to a vaporizing temperature, a vapor collecting tube, a condensing tube adapted to contain liquid for condensing vaporized liquid produced in said heating tube and conveyed to the condensing tube, vapor tubes for conveying vapor produced in the upper portion of the heating tube to the upper portion of the collecting tube and from the collecting tube to the condensing tube, connection means, of smaller cross-sectional flow area than any of said tubes, providing liquid communication between the heating and collecting tubes, connecting means providing liquid communication between the collecting and the condensing tubes, and a float member substantially filling the upper portion of said collecting tube and freely movable in said collecting tube, said float member having a density less than that of the liquid in said system.

References Cited in the file of this patent

UNITED STATES PATENTS

47,051	Thayer	Mar. 28, 1865
2,015,240	Scott-Snell	Sept. 24, 1935
2,226,537	Steenbergh	Dec. 31, 1940
2,241,620	Shoeld	May 13, 1941
2,553,817	Kleen	May 22, 1951