United States Patent [19]

Ledner

[11] **3,765,799**

[45] **Oct. 16, 1973**

[54] **THERMAL-GRAVITY FLUID PUMPING METHOD AND APPARATUS**

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[22] Filed: **May 1, 1972**

[21] Appl. No.: **249,032**

[52] **U.S. Cl.** **417/53,** 60/25, 417/379, 417/389

[51] **Int. Cl.** **F04b 35/02,** F03g 3/00

[58] **Field of Search** 417/379, 383, 53, 417/55, 389; 60/25

[56] **References Cited**

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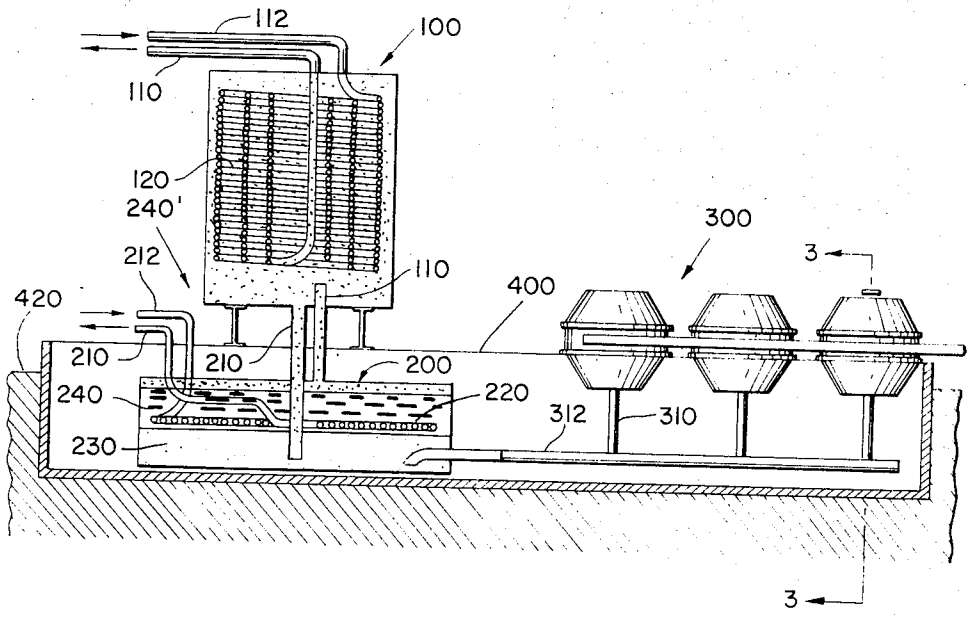
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Primary Examiner—Carlton R. Croyle
Assistant Examiner—Richard Sher
Attorney—J. Gibson Semmes

[57] **ABSTRACT**

A large volume pumping method and apparatus comprising an economical thermal-gravity pumping system which is non-polluting, and employs relatively free and limitless, generally available, sources of energy input. The invention is particularly useful in pumping water into a tank reservoir for the ultimate purpose of generating hydroelectric power by conventional turbine-operated generator.

9 Claims, 6 Drawing Figures



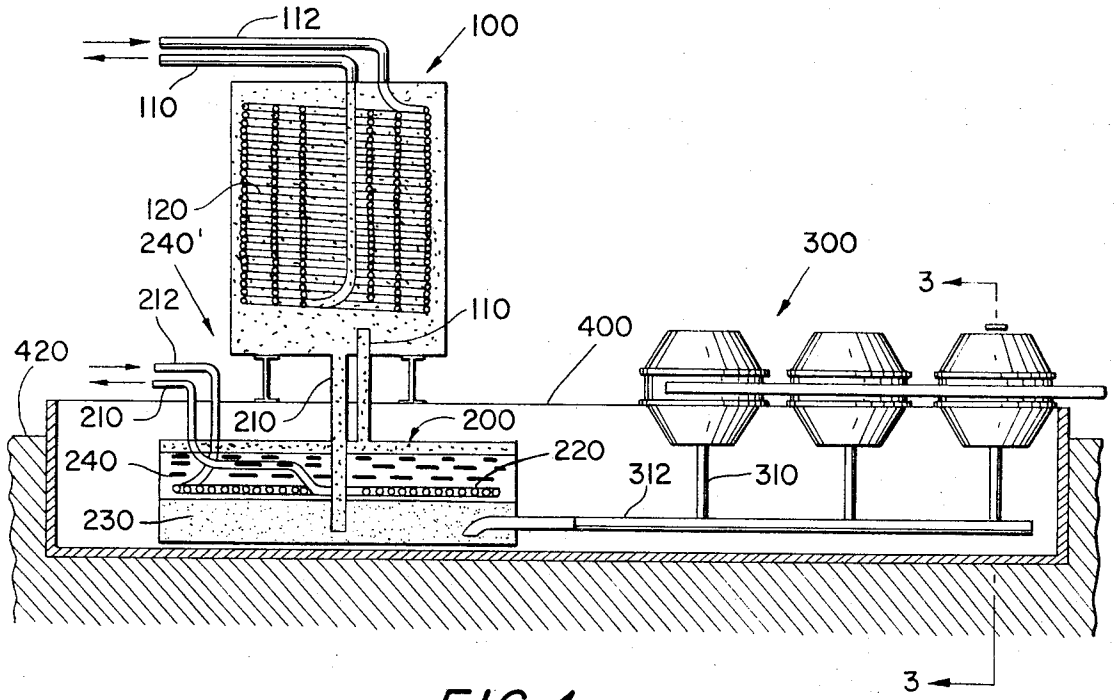

112
100
110
120
240'
212
300
3
110
400
420
210
210
200
240
220
312
310
230
3

FIG. 1

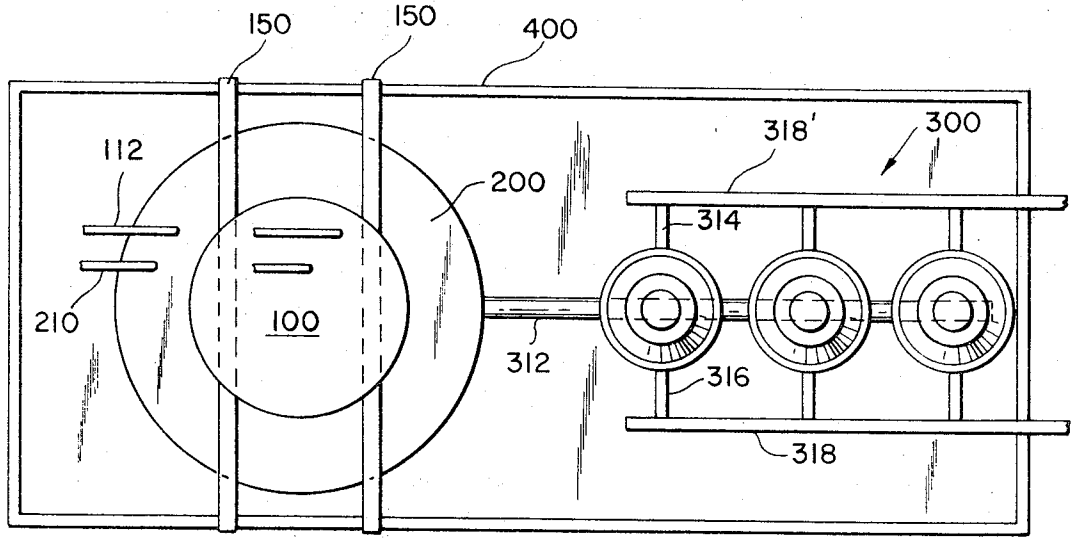
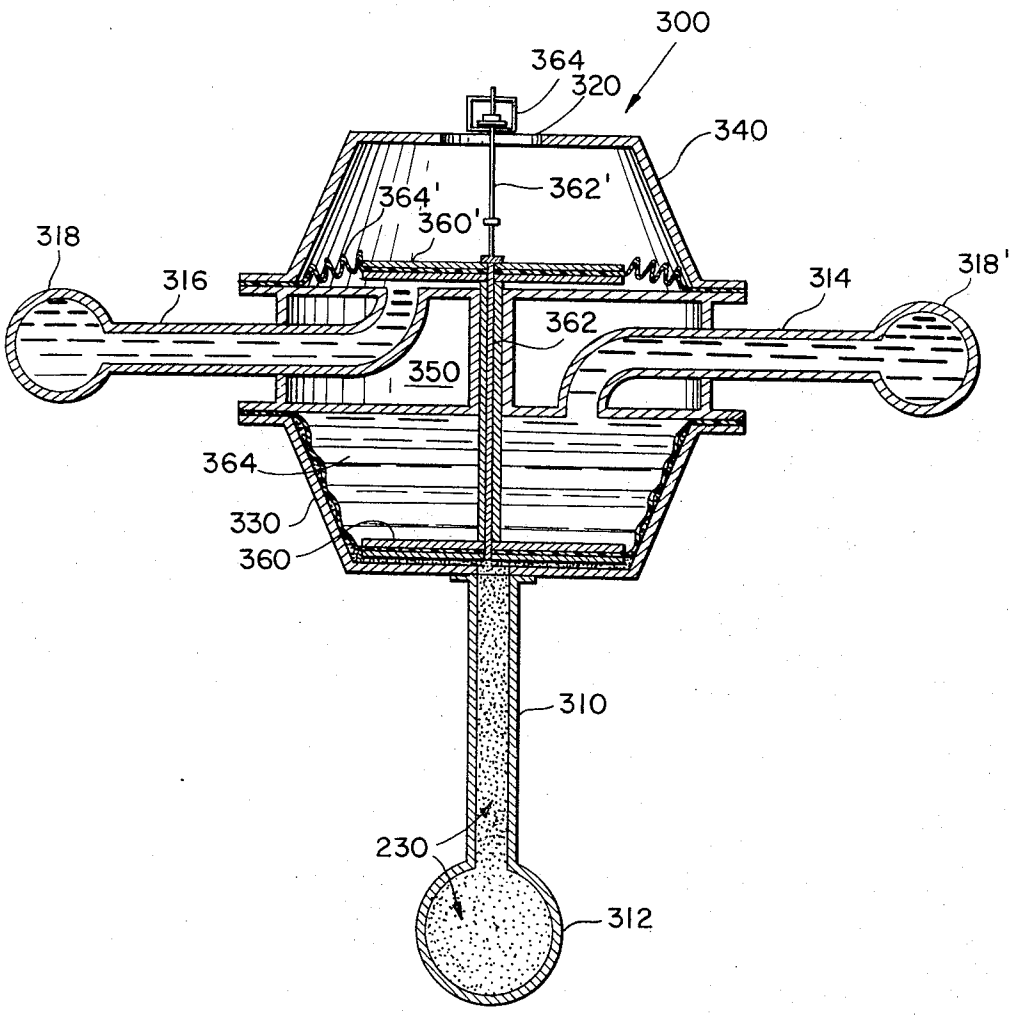

150
150
400
318'
300
112
200
314
210
100
312
316
318

FIG. 2

FIG. 3


300
364
320
340
362'
364'
360'
318
316
314
318'
362
350
364
330
360
310
230
312

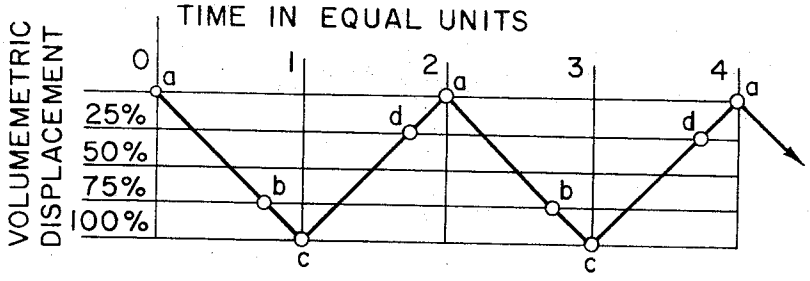

TIME IN EQUAL UNITS
VOLUMEMETRIC DISPLACEMENT
0
1
2
3
4
25%
50%
75%
100%
a
b
c
d

FIG. 6

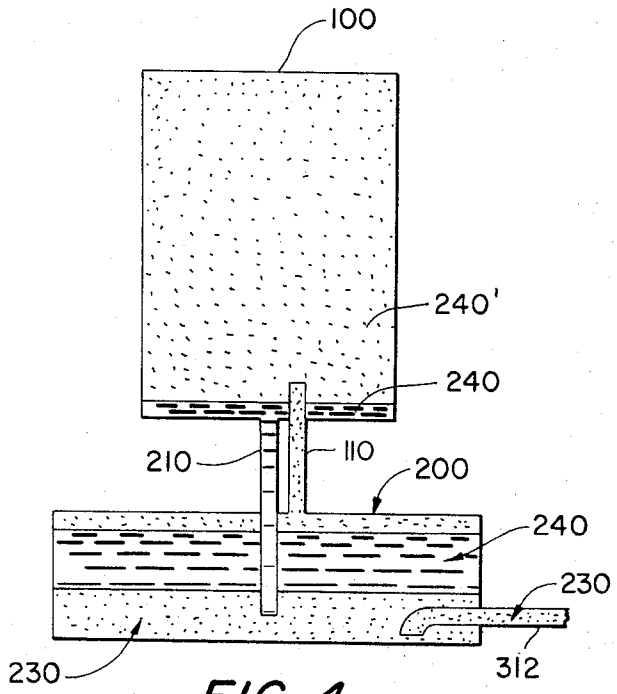

100
240'
240
210
110
200
240
230
230
312

FIG. 4

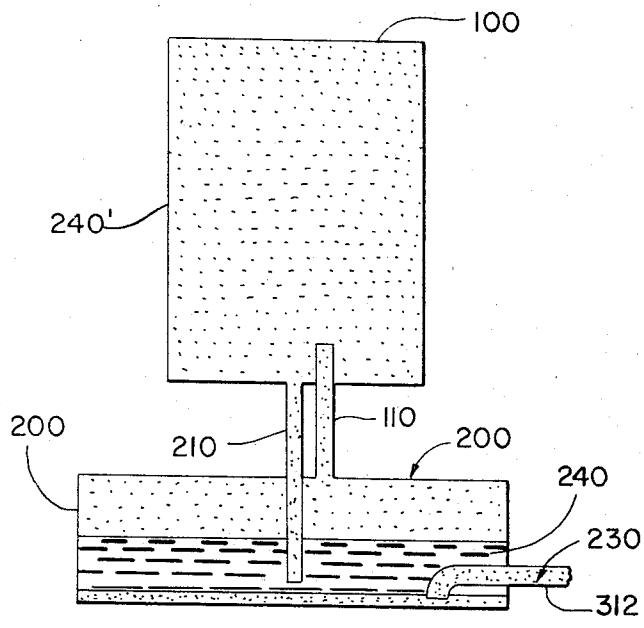

100
240'
200
210
110
200
240
230
312

FIG. 5

THERMAL-GRAVITY FLUID PUMPING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

The use of natural sources of energy as in heliothermal systems viz: solar-energy utilization and those using heat energy of the sea in which thermodynamic agents are used have been advanced in varying degrees of application, relative to producing electrical power. None of these systems has proven entirely satisfactory or commercially feasible because of low conversion efficiency, intermittent operations, high costs, and highly restrictive conditions for plant locations. Of the known art, reference is made to Santos U.S. Pat. No. 2,660,030 and Patterson U.S. Pat. No. 2,884,866, respectively distinguishable from the present invention.

SUMMARY

The present invention provides method and means for pumping large volumes of water discharged from turbines, operating electric generators, into verticle tank reservoirs for recirculation through said turbines. In the practice of invention conversion efficiency is relatively high, operations continuous, plant costs comparatively low, as are maintenance and operational costs and restrictive conditions for plant locations moderately low. The invention resides in the application of thermal and gravity forces in a selected and controlled working relationship to produce continuous fluid pumping. In essence, the invention embodies the use of a hydraulic-type pump having a thermodynamic fluid such as fluoro-chloro hydrocarbon in coactive relationship to a liquid piston, for example comprising mercury, the latter having a specific head pressure. The invention provides a continuous cycle of reciprocating flow of the mercury, resulting from the controlled expansion and contraction of the thermodynamic agent by means of separate heat exchangers, which may conduct cold water on the contraction cycle and hot water on the expansion cycle. Specific preconditions permit use of a natural, free source of unrecirculated cooling water through its heat exchanger and a minimum Btu heat input for the recirculated hot water through its heat exchanger. Essentially, the inventive method comprises practical utilization of heat as an energy source, converting said heat into work and secondarily provides an economical, pollution-free system, using a relatively limitless source of convertible energy for pumping water into tank reservoirs for use in generating hydroelectric power by conventional turbine-operated generators.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in side elevation of a preferred means of practicing the invention, the exterior portions of the operating tanks being exposed to the interiors thereof;

FIG. 2 is a top plan view of the FIG. 1 concept;

FIG. 3 is an enlarged vertical sectional view on the line 3—3 of FIG. 1, showing a double-acting diaphragm pump activated by the reciprocating flow of the liquid piston from the thermal-gravity operating tanks;

FIG. 4 is a diagrammatic sectional view of the thermal-gravity tanks, per se, showing the relative positions of the thermodynamic fluid and vapor and the liquid piston at the maximum point of the contraction cycle;

FIG. 5 is a diagrammatic sectional view of the thermal-gravity tanks, showing the relative positions of the thermodynamic fluid and vapor and the fluid piston at the maximum point of the expansion cycle; and

FIG. 6 is a time/displacement chart indicating the relationship of time increments to volumetric displacement and and showing the time spans for energy input to accomplish said displacement.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the selected embodiment of the invention, there is illustrated in FIGS. **1** and **2**, for purposes of disclosure, a Thermal-Gravity pumping system comprising two cylindrical tanks, **100** and **200**. Tank Unit **200** is disposed directly below Tank Unit **100** with parallel connecting piping **410** and **412**. Piping **410** will provide return flow of a condensed thermodynamic fluid from Tank **100** into Tank **200**. Piping **412** will, as seen, provide an open connection between the tanks **100** and **200**, maintaining thereby a common vapor pressure environment at all times within the respective two tanks.

Construction and detailing of Tanks **100** and **200** are of conventional means as applies to pressurized tanks. Tank **100** is supported at its base by suitable structural members **150**, which in turn are supported on concrete walls of the Foundation **400**. Tank **200** is supported directly upon the base of the Foundation **400**, said foundation extending to form a base for Pump Units **300**, as illustrated. This foundation not only provides concrete support for the Tank Units and Pump Units, but also, provides a concrete pit below grade terrain **420** which would assure retainage of mercury and/or the thermodynamic fluid in the event of a leak in the system.

As Tank Unit **100** functions the condenser unit a i.e. contraction, side of the system. Tank Unit **200** functions as the boiler unit, i.e. expansion, side of the system. Tank **200** also serves as the container for the liquid piston of mercury. Within each of the Tank Units **100** and **200**, are heat exchangers consisting respectively of a continuous coil of suitable metal tubing **120** and **220**, as illustrated in FIG. **1**, being of conventional design and fabrication. Piping **110** and **112** at top of Unit **100** and Piping **210** and **212** at top of Unit **200** are supply and return piping, as illustrated in FIG. **1**, to and from metal coil heat exchangers **120** and **220** housed respectively in the Tank Units **100** and **200**.

Obvious calculations are required for determining the cubic amount of mercury and specific fluoro-chloro hydrocarbon, known as Freon or Genetron, used in filling the system, as well as method employed installing the required amounts of said material as illustrated in FIGS. **4** and **5**. For simplicity, all conventional valves, pressure gauges, temperature reading instruments and other types of recording instruments have been omitted from the drawings, suffice it to say that the operative function of the apparatus will be clear from the ensuing details.

The composite Thermal-Gravity pumping system of FIGS. **1** and **2** is shown provided with three double-acting diaphragm pumps, respectively **300**. Obviously, the number of these pump units serving a single Thermal-Gravity pumping system may vary, and in actual application be a greater number than shown without departing from the scope of the invention. Tank Unit **200** is connected to Pump Units **300** by piping and branch piping, as illustrated in FIG. **2 3**. Pump Units **300** are connected respectively to a tank reservoir with related turbine/generator unit and tail water pool reser-

voir, not shown, by branch piping **314** and **316** to piping **318** and **318'**, as illustrated in FIG. **3.**

FIGS. **4** and **5** being diagrammatic views of the Thermal-Gravity Pump show the relative positions of the mercury **230,** a fluoro-chloro hydrocarbon fluid **240** and the fluoro-chloro hydrocarbon vapor **240'** at the maximum points of the contraction and expansion cycles shown as points a and c respectively on the Time/-Displacement Chart, FIG. **6.** The chart illustrates graphically, the movement of the liquid piston of mercury in its reciprocal cycles and also indicates the time flow of hot water through its heat exchanger coil viz: starting at point a and stopping at point *b* during an expansion cycle and cold water through its heat exchanger coil, starting at point *c* and stopping at point *d* during a contraction cycle.

The diaphragm pump **300** having the respective conduits **310, 314** and **316** introduced into its interior from the bottom and side positions shown, includes at its top an aperture **320,** disposed centrally thereof. The pump is divided into chambers **330,** at the bottom, and **340** at the top, said chambers being spacially set apart by the spacer **350,** said spacer **350** defining a central channel for a connecting rod **362** joining the respective diaphragm plates **360, 360'** in fixed relation to each other. These plates are maintained in diaphragm supported relationship, relative to the chambers **330** and **340** by means of the flexible diaphragms **364** and **364',** said diaphragms being in sealed connection with the respective chambers **330, 340** and the spacer **350** interposed therebetween. In extension of the connecting rod **362** is the rod **362',** effecting at its uppermost extension a switch connection with the switch **364.**

In operation, these pump units **300** work as follows. At the start of an expansion cycle, mercury **230** rises into the lower chamber **330,** forcing diaphragm plate **360** and its crimped neoprene diaphragm **364** to rise, causing water within this section of the pump to flow out through pipes **314** and **318'** to a suitable one-way valve, allowing flow into the tank reservoir. Simultaneously connecting rod **362** raises metal plate **360'** and its crimped neoprene diaphragm **364'** located in the upper chamber of said pump, causing water to be drawn into this section of the pump through pipes **316** and **318** from a suitable one-way valve, allowing flow from the tail water pool reservoir, not shown, to said pump. At the end of the expansion cycle, mercury **230** fills the lower chamber, having compressed the diaphragm **360** in this section of the pump and expanded the diaphragm element **360'** in the upper sections, which is now filled with water. At the start of the contraction cycle, mercury **230** flows from the lower chamber back to the thermal-gravity pump **300** into tank **200,** thus pulling the double diaphragm elements down, resulting in the reverse flow of water to and from the tank reservoir and the tail water pool reservoir through piping **314, 316, 318** and **318',** the upper chamber of said pump units **300** being open to atmospheric pressure.

The Thermal-Gravity pumping system operates as follows:

Beginning at the start of an expansion cycle, point a on the chart shown in FIG. **6,** a circulating pump, not shown, which is on piping line **210** is activated by electric control switch **364,** FIG. **3,** when the rod **362'** of the switch assembly is in the lowermost position as shown in FIG. **3.** Hot water circulates, from a source not shown, through the heat exchanger coil **220** in Tank **200,** which causes the fluoro-chloro hydrocarbon to boil, resulting in the immediate expansion of vapor through conduit **412** into tank **100,** raising the pressure in Tanks **100** and **200** to a predetermined amount which, in all cases, would be slightly more than twice the working head pressure of the water in the tank reservoir, required for the turbine operation. In reality, said vapor pressure is working against a head of mercury, which is equal in pressure to the working head of water in the tank reservoir. When the system commences an expansion cycle, reference FIG. **4,** the head of mercury is sufficient to balance the static head of water bearing on diaphragm plate **360** of FIG. **3.** At the conclusion of the expansion cycle, reference FIG. **5,** the thermodynamic fluid vapor is of sufficient pressure to support the column of mercury now in conduit **310** and chamber **330,** plus the static head of water in the tank reservor. During the expansion cycle approximately after three-fourths of displacement of the mercury in Tank 200 corresponding to point *b* on the Chart of FIG. **6,** the hot water circulating pump may be stopped without terminating the expansion cycle. This is an important feature of the present invention in that Btu energy input is conserved. Between points *b* and *c* on said Chart the mercury continues moving in a coasting manner until movement stops at point *c,* the maximum point of the expansion cycle, as shown in FIG. **5.** Piping **410,** it will be noted, terminates near the bottom of Tank **200,** a predetermined distance above the outlet opening of piping **312,** allowing the thermodynamic fluid **240** condensate, resulting from the previous contraction cycle and retained in the bottom of Tank **100** during the previous contraction cycle, to flow into Tank **200.** This occurs near the end of the expansion cycle between said points *b* and *c* and is possible due to the fact that the mercury level is, at this time during the expansion cycle, below the bottom of piping **410** as shown in FIG. **5.** The cooled condensate flowing from piping **410** is heated from immediate contact with the warmer mercury and is further heated by mixing with the heated thermodynamic fluid. This feature of the present invention provides for a minimum of heat loss of the hot water in the heat exchanger coil in Tank **200** during the contraction cycle.

Rod **362',** which activates switch **364** controlling the circulating pumps for the heat exchanger coils, has now moved upward, during the expansion cycle, being activated by the diaphragm plate **360'** of the operating pump units **300,** FIG. **3,** now switches off the pump controlling the hot water circulation at point *b* shown on said Chart and switching on, at point *c,* another pump, not shown, which is on piping line **112** and circulates cold water through the heat exchanger coil in Tank **100.** This immediately causes condensation of the fluoro-chloro hydrocarbon vapor in Tank **100,** resulting in a rapid lowering of vapor pressure in both tanks, starting the contraction cycle, which continues until point *a* is reached, completing the total expansion-contraction cycle. At the start of the contraction cycle the fluoro-chloro hydrocarbon fluid reverses flow, resulting in the reverse flow of the mercury due to the effects of gravity. The head of mercury shown as dimension *e,* FIG. **4** and **5,** is now acting as a counterweight to the pressure of the working heat of water in the tank reservoir. That is, as the mercury returns to tank **200,** diaphragm plate **360'** is drawn downward forcing water

from chamber 340 upward against the static head of water in the tank reservoir. During the contraction cycle approximately after three-fourths of the mercury has returned into Tank 200, corresponding to point *d* on the chart of FIG. 6, the cold water circulating pump may be stopped without terminating the contraction cycle. Rod 362', activating switch 364 which controls said circulating pumps for the heat exchanger coils, has moved downward during the contraction cycle, switching off each respective pump, controlling the cold water circulation, at point d on the scale of FIG. 6 chart. Between points *d* and *a* on said chart the mercury continues moving until movement stops at point *a*, the maximum point of the contraction cycle and immediate start of a new expansion-contraction cycle.

The present invention offers the means of producing power, primarily for conversion to electrical energy, at a relatively lower cost than has been possible in the past, with the additional features of being non-polluting and using a relatively free and limitless source of energy input.

Another important feature of the present invention resides in the use of a natural, free source of unrecirculated cooling water through heat exchanger coil unit for the condenser unit. Any suitable cold water source such as streams, rivers, lakes, seas, etc. with maximum temperature of approximately 70 degrees F. may be used. The minimum constant temerature of the water to be used in the condenser unit coil is an important criterion in determining the specific fluoro-chloro hydrocarbon used in the pumping system.

Another important feature of the present invention resides in the use of a free or relatively inexpensive source of hot water for use through heat exchanger coil unit for the boiler unit. The natural free sources would include Solar-energy, heliothermal application in areas permitting, geothermal heat sources in areas permitting, and biothermal process such as compost system for municipal garbage disposal, as wel as combustion heat from conventional municipal or industrial incineration plants. Other sources which may be free or relatively inexpensive would include waste heat from many diverse types of industrial processes, including the tremendous waste heat from existing atomic energy generating plants which presently pose a serious thermal pollution problem.

Another important feature of the present invention resides in the economic use of Btu heat input for the boiler unit. For example, it has been observed that with 130 degrees F. supply water, circulated through the heat exchanger coil unit for the boiler unit, the average temperature of the return water is 118 degees F. during the expansion cycle. Obviously, this indicates that, once the hot water source is at the necessary temperature for a required vapor pressure during the expansion cycle, the Btu input for the hot water return from the heat exchanger coil unit will be minimal compared with existing heat conversion systems. This feature is of great importance when the present pumping system requires recirculation of the hot water due to the unavailability of natural or man-made waste heat sources.

Another important feature of the present invention resides in the use of mercury in working relationship with the thermodynamic fluid. The mercury functions as a liquid piston, providing a relatively low friction hydraulic system compared to a mechanical system. Also, the mercury provides its own seal in maintaining a closed system for the thermodynamic fluid and vapor. In addition to these features the mercury also functions as a counterweight to the working head of water in the tank reservoir, providing continuous pumping of water into said reservoir during the contraction cycle as related in detail herein.

I claim:

1. A reciprocating fluid pumping system comprising:

A. a first compartment having a bottom;

B. a gravity responsive liquid located in the first compartment;

C. a thermodynamic liquid located in the first compartment in liquid contact with the gravity responsive liquid;

D. means in the first compartment for heating the thermodynamic liquid to create a vapor thereof in the first compartment;

E. first means connected to the first compartment for channeling the gravity responsive liquid away from the first compartment in response to the rise in pressure caused by the vapor and for channeling the gravity responsive liquid toward the first compartment upon a drop in the pressure caused by the vapor;

F. means connected to the first channeling means for pumping a fluid in response to the pulsating flow of the gravity responsive liquid;

G. means for condensing the vapor of the thermodynamic liquid comprising a second compartment located in superposition to the first compartment and having a bottom; a condensing coil located in the second compartment; and, a conduit extending from the bottom of the second compartment into the first compartment and terminating near the bottom of the first compartment; and,

H. a conduit extending from the first compartment into the condensing means and terminating above the bottom of the second compartment, whereby the vapor may flow from the first compartment to the condensing means and the first compartment and the condensing means will be at common pressure.

2. The apparatus of claim **1**, wherein the thermodynamic liquid comprises a liquid from the group consisting of fluoro-chloro hydrocarbons and wherein the gravity responsive liquid comprises mercury.

3. The apparatus of claim **1**, wherein the pumping means comprises:

F.**1.** A first chamber having a first opening connected to the first channeling means, a second opening for alternate intake and exhaust of the fluid to be pumped and a first flexible diaphragm sealingly isolating the first opening from the second opening;

F.**2.** A second chamber having a third opening to ambient, a fourth opening for alternate intake and exhaust of the fluid to be pumped and a second flexible diaphragm sealingly isolating the third opening from the fourth opening; and,

F.**3.** Rod means connecting the first and second diaphragms for causing them to move to tandem as the first diaphragm moves in response to the motion of the gravity responsive liquid, whereby the fluid to be pumped is expelled from the first chamber via the second opening as the gravity responsive liquid enters the first opening and is drawn into the second chamber via the fourth opening as the second

diaphragm moves in tandem with the first diaphragm.

4. The apparatus of claim **3**, further comprising: means actuated by the rod means for selectively controlling the heating and condensing means.

5. The apparatus of claim **1**, further comprising:

I. means for activating the heating means when the gravity responsive liquid completes its flow toward the first compartment;

J. means for deactivating the heating means when a substantial portion of the gravity responsive liquid has been channeled away from the first compartment;

K. means for activating the condensing means when the gravity responsive liquid completes its forward flow; and,

L. means for deactivating the condensing means when a substantial portion of the gravity responsive liquid has been channeled toward the first compartment.

6. A method for pumping fluids, using enclosed thermodynamic and gravity responsive liquids in expansion and contraction cycles of the thermodynamic liquid to effect reciprocating movement of the gravity responsive liquid, comprising the steps of:

A. disposing a gravity responsive liquid in a first closure;

B. disposing a thermodynamic liquid in the first closure in liquid contact with the gravity responsive liquid;

C. heating the thermodynamic liquid to vaporize it, thereby increasing the pressure within the first closure;

D. channeling the gravity responsive liquid away and upwardly from the first closure in response to the rise in pressure within the first closure to a mechanical fluid pumping means operatively responsive to reciprocating movement of the gravity responsive liquid;

E. discontinuing the heating of the thermodynamic liquid while a substantial amount of the gravity responsive liquid remains in the first closure whereby the gravity responsive liquid may continue to channel away and upwardly from the first closure due to the momentum of the gravity responsive liquid and the residual pressure of said thermodynamic vapor;

F. cooling the vapor of the thermodynamic liquid to form a condensate, thereby lowering the pressure within the first closure;

G. channeling the gravity responsive liquid downwardly and away from the mechanical pumping means by gravity flow to the first closure;

H. collecting the vapor condensate in a second, separate closure at a pressure equal to the pressure within the first closure for return to the thermodynamic liquid in the first closure during the subsequent pumping cycle;

I. discontinuing the cooling of the vapor of the thermodynamic liquid;

J. repeating steps C through E;

K. channeling at least a portion of the vapor condensate collected in Step H of the previous pumping cycle back to the thermodynamic liquid within the first closure;

L. repeating Steps F through I; and

M. repeating Steps J through L, thereby continuously actuating the mechanical pumping means of Step D due to the resulting reciprocating flow of the gravity responsive liquid.

7. A method according to claim **15** wherein the thermodynamically responsive fluid comprises a fluid from the group consisting essentially of fluoro-chloro hydrocarbons and wherein the gravity responsive fluid comprises mercury.

8. The method according to claim **6** wherein step B is as follows:

disposing a thermodynamic liquid in the first closure in superposed liquid contact with the gravity responsive liquid.

9. The method according to claim **6** wherein the steps I and J are as follows:

I. discontinuing the cooling of the vapor of the thermodynamic liquid while a substantial amount of the gravity responsive liquid remains to be channeled back into the first closure by gravity; and

J. repeating steps C to E, after the remaining gravity responsive liquid returns to the closure by gravity.

* * * * *