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.
THERMAL-GRAVITY FLUID PUMPING METHOD AND APPARATUS

REFERENCE TO RELATED APPLICATIONS

This is a Continuation-in-Part of copending Patent Application, Ser. No. 249,032, filed May 1, 1972, entitled THERMAL-GRAVITY FLUID PUMPING METHOD AND APPARATUS, in the name of the same inventor.

BACKGROUND OF THE INVENTION

The use of natural sources of energy as in heliother
d 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 ap
lication, relative to producing electrical power. None of these systems has proven entirely satisfactory or commercially feasible because of low conversion effi
ciency, 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 Pat. No. 2,884,866, respec
respectively distinguishable from the present invention.

SUMMARY OF THE INVENTION

The present invention provides method and means for pumping large volumes of water discharged from turbines, operating electric generators, into vertical
tank reservoirs for recirculation through said turbines. In the practice of the invention conversion efficiency is relatively high, operation, continuous; and plant cost, comparatively low. Maintenance and operational costs and restrictive conditions for plant locations are moder
ately 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 functioning as a li
quid piston, acting upon water. The invention provides a continuous cycle of reciprocating flow of water, result
resulting from the controlled expansion and contraction of the thermodynamic agent by means of separate heat exchangers, which may conduct cold water on the con
traction 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. Essent
entially, the invention method comprises practical utiliza
tion of heat as an energy source, converting said heat into work and secondarily provides an economical, pol
lation-free system, using a relatively limitless source of

CONSTRUCTION OF THE DRAWINGS

FIG. 1 is a view in side elevation of a preferred means of practicing invention, the exterior portions of the op
erating tanks being exposed to the interiors thereof;
FIG. 2 is a top plan view of the FIG. 1 concept;
FIG. 3 is a horizontal sectional view on the line 3—3 of FIG. 1, showing the relationship of two tanks, one with the other;
exchanger consisting of a continuous coil of suitable metal tubing 320, as illustrated in FIG. 1, being of conventional design and fabrication. Piping 312 and 310 at top of unit 300 are supply and return hot water piping, as illustrated in FIG. 1, to and from metal coil heat exchanger 320.

Tank unit 200 functions as the interchange unit between tanks 100 and 300, receiving thermodynamic vapor 350 from tank 300 during an expansion phase prior to said vapor flow into tank 100 during a contraction phase and also receives a thermodynamic fluid 340° condensate from tank 100 during a contraction phase prior to said condensate flow into tank 300 during an expansion phase. Tank 200 also serves as the container for the liquid piston of thermodynamic fluid 340 which is retained between the two tanks 200 and 300, as illustrated in FIGS. 1 and 3.

Piping 214 at top of tank 200, as illustrated in FIG. 1, serves as conduit for the flow of thermodynamic vapor 350 in the lower portion 113 of chamber 110' of tank unit 100 during a contraction phase. Said piping 214 connects to an air cooled heat exchanger consisting of a continuous coil of suitable metal tubing 140, as illustrated in FIG. 1, being of conventional design and fabrication. Said air cooled heat exchanger coil 140 connects to the vapor discharge unit 145 housed within the lower portion 113 of chamber 110' of tank unit 100 and positioned directly below plate 160 as illustrated in FIG. 1. Vapor discharge unit 145 is fabricated from suitable metal tubing, formed in a circular pattern with a series of equally spaced small discharge nozzles 146 located on the top side of said discharge unit so that vapor is discharged against the bottom side of plate 160.

Tank unit 400 functions as a subsidiary tank of tank unit 200, serving as the container for water 440 which is pumped in and out of tank 400 through piping 420 and 418 respectively, as illustrated in FIG. 1. The liquid piston of thermodynamic fluid 340 flowing to and from tank unit 200 flows through piping 412 into tank 400, acting upon the water 440 as illustrated in FIGS. 5A through 5E. Tank 400 is connected to a tank reservoir with related turbine/generator unit and tail water pool reservoir, not shown, by piping 418 and 420, respectively, as illustrated in FIGS. 1 and 2. Check valves 426 and 426' on piping 418 and 420, respectively, provide control of the one way flow of water from tank 400 to a tank reservoir with related turbine/generator unit, not shown, and from a tail water pool reservoir, not shown, to tank 400.

Obvious calculations are required for determining the cubic amount 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. 1 and 5A through 5E. For simplicity, all conventional valves, pressure gauges, temperature reading instruments and other types of recording instruments and instrumentation have been omitted from the drawings; suffice it to say that the operative function of the apparatus will be clear from the ensuing details.

FIGS. 5A through 5E are schematic views of tanks 200 and 400 showing the interrelated positions of the thermodynamic fluid 340 and vapor 350 and water 440 at the maximum and mid points of the contraction and expansion cycles, representing the sequence of operation through one full pumping cycle for one thermal-gravity pump unit. Electrically energized mercury float switches 270 and 280 within tank unit 200 control the operation of the solenoid valves 224 and 324 serving tanks 200 and 300, respectively. The sequenced control and operation of the solenoid valves and mercury float switches are indicated on the valve and switch scheduling chart, FIG. 6.

The thermal-gravity pumping system operates as follows:

- Beginning at the start of an expansion cycle, tanks 200 and 400, FIG. 5A, two pre-conditions exist: 1) hot water continuously circulated, from a source not shown, through the heat exchanger coil 320, in tank 300, has caused the thermodynamic fluid to boil, resulting in the expansion of vapor, raising the pressure in the boiler tank 300 to an amount which, at all times during operation, would be a pre-determined amount more than the working head pressure of the water in the tank reservoir required for the turbine operation; 2) cold water continuously circulated, from a source not shown, around heat exchanger tubes 130 and through heat exchanger coil 120 in condensing tank unit 100 has cooled the thermodynamic vapor 350 in chamber 110' of tank unit 100, causing the thermodynamic vapor 350 to condense, thus lowering the pressure in the condenser chamber 110' of tank unit 100 to an amount which, at all times during operation, would be a pre-determined amount less than the head pressure of the tail water pool reservoir at atmospheric pressure. At the start of an expansion cycle, tank 200, FIG. 5A, the thermodynamic fluid 340 liquid piston has just completed its upward movement terminating a contraction cycle and, thus, activating switch 270 which, at this point of operation, closes and opens respectively the indicated solenoid valves 324 and 224, energizes switch 280 and de-energizes itself, all in accordance with the sequence indicated on the valve/switch chart, FIG. 6. Solenoid valve 224 is closed and solenoid valve 324 is opened, causing the thermodynamic liquid piston 340, tank 200, to move downward under pressure of the expanding thermodynamic vapor 350 released from tank 300 through piping 314. Through hydraulic action, piston 340 reacts instantaneously on the water 440, tank 400, thus pumping water into the tank reservoir, not shown. During this phase of the pumping cycle thermodynamic fluid 342° condensate which has been retained within the condensate reservoir at the bottom of tank 210, resulting from the previous contraction cycle during which thermodynamic fluid condensate flowed into tank 210 from tank unit 100, is allowed to flow into tank 300. This return flow, by gravity, of the thermodynamic fluid 342° condensate back into boiler tank 300 is possible due to the fact that the pressure in tanks 200, 210 and 300 during an expansion cycle is the same. Check valve 326 on piping 316 allows one-way flow only, from tank 210 into tank 300 so that during a contraction phase no flow of thermodynamic fluid 342 from tank 300 through piping 316 occurs.

At the start of a contraction cycle, tank 200, FIG. 5C, the thermodynamic fluid 340 liquid piston has just completed its downward movement terminating an expansion cycle and, thus, activating switch 280 which, at this point of operation, opens and closes the indicated solenoid valves 224 and 324, energizes switch 270 and de-energizes itself, all in accordance with the sequence indicated on the valve/switch chart, FIG. 6. Solenoid
valve 324 is closed and solenoid valve 224 is opened, causing the thermodynamic liquid piston 340, tank 200, to move upward resulting from the immediate release of thermodynamic vapor 350 into chamber 110' of tank unit 100, flowing from tank 200 through piping 214 into air cooled heat exchanger coil 140 and then into vapor discharge unit 145 as illustrated in Fig. 1. The upward movement of thermodynamic liquid piston 340 reacts instantaneously on the water 440 in tank 400 through hydraulic action, thus pumping water from the tail water pool reservoir, not shown, into tank 400. This reverse flow of water into tank 400 is possible due to the fact that the thermodynamic vapor pressure in chamber 110' is below atmospheric pressure and also less than the head pressure of the tail water pool reservoir.

The air cooled heat exchanger coil 140 functions as a first phase condensing unit, providing immediate reduction in vapor pressure prior to its discharge into the second phase condensing area, being that portion of chamber 110' below plate 160. A mixture of thermodynamic fluid condensate and vapor is released through vapor discharge unit 145, via nozzles 146, said mixture discharged being against the underside of plate 160 as illustrated in Fig. 1. Since the top side of plate 160 retains a certain amount of thermodynamic fluid condensate 344', due to the extension of collar 180 above the opening in plate 160, there occurs an additional heat exchange when said fluid and vapor discharged from vapor discharge unit 145 hits the underside of plate 160. In this heat exchange a certain portion of discharged vapor is condensed which collects at the bottom of chamber 110' as thermodynamic fluid 346' condensate.

The discharged vapor 350 which is not condensed flows around heat exchanger coil 120 resulting in further condensation during its final flow into the third phase condensing unit, being that portion of chamber 110' above plate 160, including flow into heat exchanger tubes 130. Thermodynamic fluid 344' condensate resulting from condensation within condensing tubes 130 collects in the condensate reservoir formed by plate 160 and collar 180. The overflow condensate 340' which flows through collared opening 180 to the bottom of chamber 110' is allowed to flow into tank 210. This return flow, by gravity, of said condensate through piping 216 is possible due to the fact that the pressure in tanks 200, 210 and chamber 110' of tank unit 100 during the latter portion of a contraction cycle is the same. Check valve 226 on piping 216 allows one-way flow only, from chamber 110' into tank 210 so that during an expansion phase no flow of thermodynamic fluid 340' condensate or vapor 350 from tank 210 through piping 216 occurs.

At the completion of a contraction cycle, tank 200, Fig. 5E, the thermodynamic fluid 340 liquid piston has completed its upward movement, thus activating switch 270, resulting in the immediate start of a new expansion-contraction cycle. It becomes obvious from the above disclosure that with two or more thermal-gravity pump units a continuous pumping operation of water, to and from a tank reservoir with related turbine/generator unit and tail water pool reservoir, is possible.

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°F. may be used. The minimum constant temperature of the water to be used in the condenser unit coil is an important criterion in determining the specific fluorochlorohydrocarbon 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 well 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 170°F. supply water, circulated through the heat exchanger coil unit for the boiler unit, the average temperature of the return water is 160°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 water in working relationship with the thermodynamic fluid. The thermodynamic fluid functions as a liquid piston, providing a relatively low friction hydraulic system compared to a mechanical system. Also, the thermodynamic fluid provides its own seal in maintaining a closed system for the thermodynamic vapor.

I claim:

1. A method for pumping water employing enclosed thermodynamic pumping liquids in expansion and contraction relation to the water to effect reciprocating movement of said thermodynamic liquid relative to the water, comprising the steps of:
   A. disposing in expansion cycle a first volume of thermodynamic liquid in a first closure;
   B. disposing a second volume of the thermodynamic liquid in a second closure which is connected to the said first closure;
   C. introducing a volume of water to be pumped into a third closure which is connected to the said second closure;
   D. heating the volume of thermodynamic liquid within the said first closure to vaporize a portion of the thermodynamic liquid and transferring the cre-
ated thermodynamic vapor to the said second closure, thereby increasing the pressure within the second closure;
E. channelling the thermodynamic liquid of the second closure away and upwardly from the second closure to the third closure in response to the rise in pressure within said second closure, for responsive movement thereof in contact with the water in the third closure, whereby the volume of water in the third closure is by hydraulic action of the thermodynamic liquid therein exhausted from the third closure as the thermodynamic liquid enters in response to the pressure of the thermodynamic vapor within said second closure;
F. blocking the transfer of heated thermodynamic vapor from the first closure to the second closure;
G. directing the said thermodynamic vapor from the second closure to a fourth closure thereby lowering the pressure within the second closure;
H. condensing the thermodynamic vapor in the fourth closure for subsequent return of the condensate to the second closure in commencement of a contraction cycle;
I. channelling the thermodynamic liquid from the third closure back to the second closure in response to the reduction in pressure therein;
J. drawing water into the third closure in response to the negative pressure therein;
K. returning a portion of thermodynamic liquid from the second closure to the first; and
L. repeating Steps C through K whereby water is continuously pumped from the third closure in response to the respective expansion and contraction cycles.
2. The method according to claim 1 wherein the thermodynamic liquid comprises a fluid from the group consisting of fluoro-chloro hydrocarbons.
3. An apparatus for pumping water comprising:
A. first, second, third, and fourth encased tanks;
B. a volume of thermodynamic liquid contained in at least a part of the first and second of said tanks;
C. means for heating the thermodynamic liquid in said first tank, whereby a vapor thereof is generated;
D. conduit means for conveying said vapor from said first tank to said second tank;
E. conduit means connecting said second tank to said third tank, whereby the thermodynamic liquid in said second tank may be forced from said second tank to said third tank by the pressure of the vapor generated in said first tank;
F. means for conveying water to and from said third tank; whereby water may be forced out of said third tank by the introduction of thermodynamic liquid from said second tank, and whereby water may be drawn into said third tank upon the transfer of thermodynamic liquid from the third tank back to said second tank;
G. conduit means connecting said second tank to said fourth tank, whereby said vapor may be conveyed to said fourth tank;
H. means for cooling the vapor in said fourth tank for returning said vapor back into liquid state;
I. conduit means for returning thermodynamic liquid from said fourth tank to said first tank;
J. means for automatically controlling the cyclic admission of vapor from the first tank to the second tank and from the second tank to the fourth tank so that cyclic pumping of water into and out of said third tank is accomplished.
4. The apparatus of claim 3 wherein the thermodynamic liquid is selected from the group consisting of fluoro-chloro hydrocarbons.
5. The apparatus according to claim 3 further comprising:
means for producing signals in response to predetermined low and high levels of the thermodynamic liquid in the second tank, respectively;
said means for controlling the cyclic admission of the vapor comprising valve means in said conduit connecting said first tank to said second tank for opening in response to said high level signal and closing in response to said low level signal;
said means for cooling the vapor comprising valve means in said conduit means connecting said second tank to said fourth tank for closing in response to said high level signal and opening in response to said low level signal;
means for collecting the vapor condensate comprising check valve means for permitting one-way flow from the fourth tank to the first tank.