Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2820869 A1 2011/06/16

(21) **2 820 869**

(12) **DEMANDE DE BREVET CANADIEN**
CANADIAN PATENT APPLICATION

(13) **A1**

(86) **Date de dépôt PCT/PCT Filing Date:** 2010/12/07
(87) **Date publication PCT/PCT Publication Date:** 2011/06/16
(85) **Entrée phase nationale/National Entry:** 2013/06/07
(86) **N° demande PCT/PCT Application No.:** US 2010/059344
(87) **N° publication PCT/PCT Publication No.:** 2011/071959
(30) **Priorité/Priority:** 2009/12/08 (US61/282,057)

(51) **Cl.Int./Int.Cl.** *F25B 30/06* (2006.01), *F25B 27/00* (2006.01), *F25B 41/04* (2006.01), *F25B 49/02* (2006.01)

(71) **Demandeur/Applicant:**
GET GREEN ENERGY CORPORATION, CA

(72) **Inventeur/Inventor:**
OCHNIK, CLAUDIA IRMA, CA

(74) **Agent:** NA

(54) **Titre :** POMPE A CHALEUR
(54) **Title:** HEAT PUMP

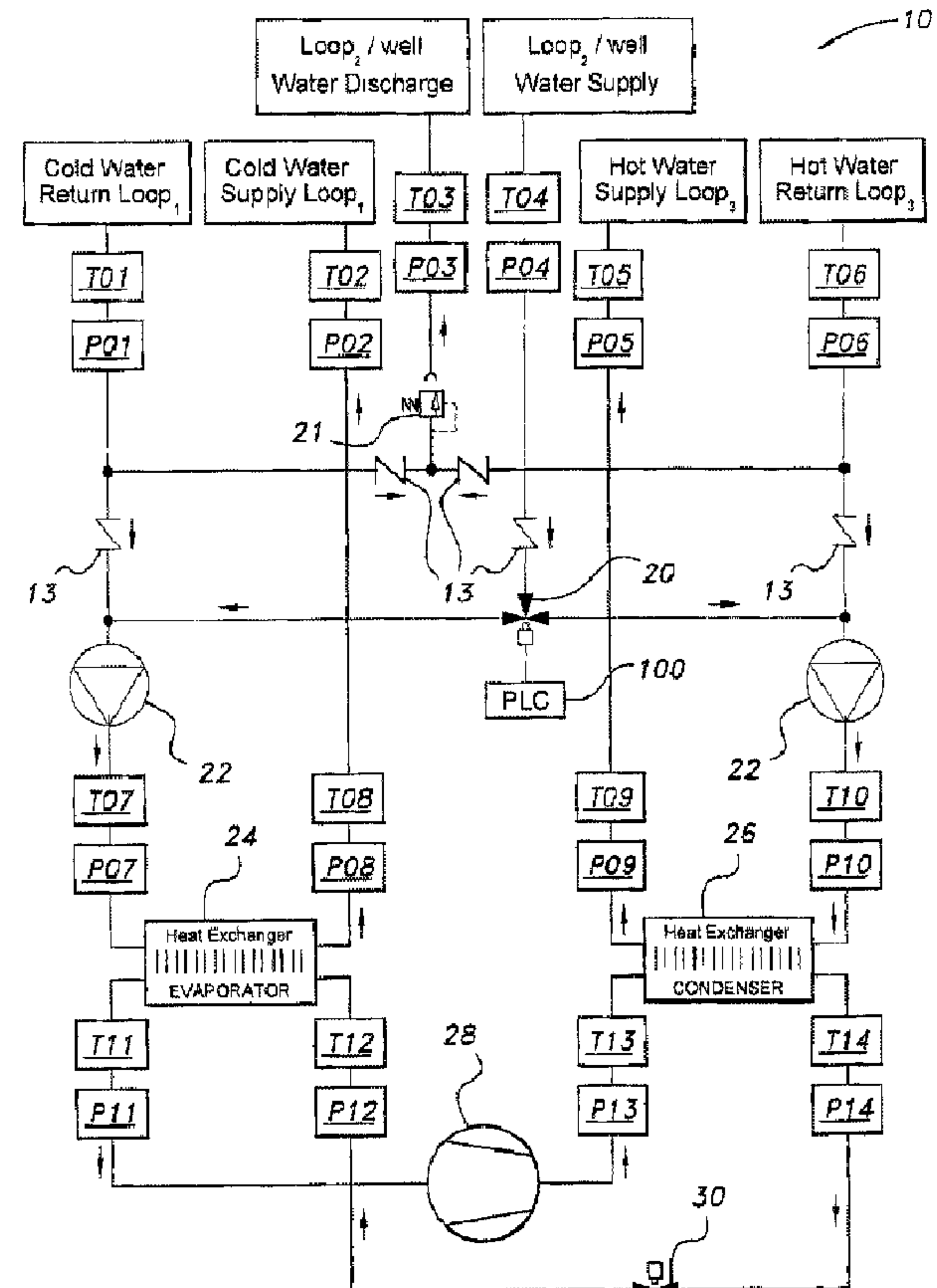

FIG. 1

(57) **Abrégé/Abstract:**
The geothermal heat pump has a programmable logic controller (PLC) that provides real time control and monitoring of a water-to-water geothermal heat pump system to effect simultaneous heating and cooling. Directing water flow from an evaporative

(57) Abrégé(suite)/Abstract(continued):
exchanger or a condensing exchanger achieves temperature control without the need for a conventional reversing valve. To provide system scalability, the PLC can be connected to modular units in a master/slave control configuration. Combinations of units having different refrigerant physical properties provide a "fusion" of adaptability, thereby eliminating difficulties in using carbon dioxide (C02) in home and commercial markets. Various operating refrigerant units (C02, R410a, and the like) may be combined for optimization of overall performance. Hybrid units include solar panels to preheat water. The PLC allows integration of alternative heat/cooling sources to form the hybrid units.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 June 2011 (16.06.2011)

PCT

(10) International Publication Number
WO 2011/071959 A3

(51) International Patent Classification:
F25B 30/06 (2006.01) ***F25B 41/04*** (2006.01)
F25B 49/02 (2006.01) ***F25B 27/00*** (2006.01)

(21) International Application Number:
PCT/US2010/059344

(22) International Filing Date:
7 December 2010 (07.12.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/282,057 8 December 2009 (08.12.2009) US

(71) Applicant *(for all designated States except US)*: **GET GREEN ENERGY CORPORATION** [US/US]; 202 Thornbird Place, Waterloo, Ontario N2T 2P1 (CA).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **OCHNIK, Claudia, Irma** [CA/CA]; 202 Thornbird Place, Waterloo, Ontario N2T 2P1 (CA).

(74) Agent: **EISNBERG, Michael**; 3258 Caminito Eastbluff, Suite 89, La Jolla, CA 92037 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

[Continued on next page]

(54) Title: HEAT PUMP

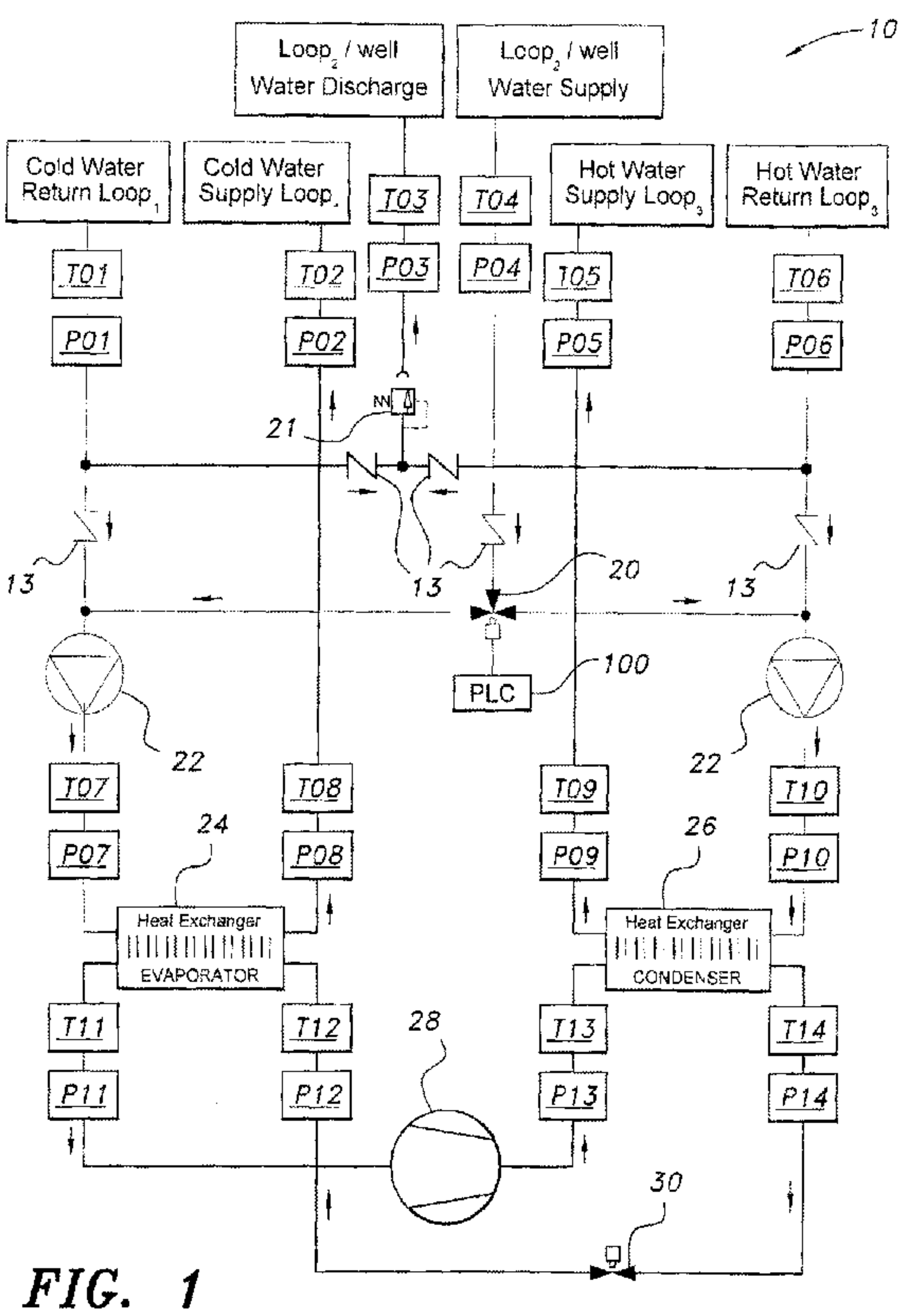

FIG. 1

(57) Abstract: The geothermal heat pump has a programmable logic controller (PLC) that provides real time control and monitoring of a water-to-water geothermal heat pump system to effect simultaneous heating and cooling. Directing water flow from an evaporative exchanger or a condensing exchanger achieves temperature control without the need for a conventional reversing valve. To provide system scalability, the PLC can be connected to modular units in a master/slave control configuration. Combinations of units having different refrigerant physical properties provide a "fusion" of adaptability, thereby eliminating difficulties in using carbon dioxide (C02) in home and commercial markets. Various operating refrigerant units (C02, R410a, and the like) may be combined for optimization of overall performance. Hybrid units include solar panels to preheat water. The PLC allows integration of alternative heat/cooling sources to form the hybrid units.

WO 2011/071959 A3

WO 2011/071959 A3

GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
3 November 2011

HEAT PUMP

Cross-References to Related Applications

[0001] This application claims priority from U.S. Provisional Application Serial Number 61/282,057 filed on December 8, 2009, which is hereby incorporated herein by reference in its entirety.

Technical Field

[0002] The present invention relates generally to HVAC systems, and more specifically to a geothermal heat pump system controlled by a programmable logic controller (PLC)

Background of the Invention

[0003] Heat pumps are often used in heating, ventilation, and air conditioning (HVAC) systems. Heat pumps comprise a first heat exchanger, a second heat exchanger, and a reversing valve in order to provide heating or cooling. The reversing valve is a source of loss of efficiency, for example, in providing an unwanted pressure drop, heat exchange and noise.

[0004] It would be highly desirable to provide a heat pump system in which the reversing valve is eliminated, and energy balance is maintained during continuous operation of simultaneous heating and cooling, or cooling only, or heating only. Thus, a geothermal heat pump solving the aforementioned problems is desired.

Brief Summary of Embodiments of the Invention

[0005] According to one embodiment of the invention, a method and system are provided, for forcing evaporation of a solvent from a coating on a surface of a panel, through an airflow characterized by turbulence moving in the same direction of the airflow.

[0006] The geothermal heat pump system includes a processor, e.g., a programmable logic controller (PLC), to provide a real time control of the system. Optionally, a computer system can be used in place of a PLC. The system provides simultaneous heating and cooling. Temperature control is achieved by directing water flow from an evaporativeheat exchanger or a condensing heat exchanger without the need for aconventional reversing valve. Modular units can be connected in a matrix and may utilize a controller in a master/slave unit configuration so that the total system may be scaled up or down by the addition/reduction of master-slave units as dictated by a specific application.

[0007] The system allows a combination of units with different refrigerant physical properties, thereby providing a "fusion" of adaptability and physical characteristics of refrigerant that eliminate the difficulties in using carbon dioxide (CO2) in home and commercial markets. Various operating refrigerant units (CO2, R410a, etc.) maybe combined for optimization of overall performance. The system may include "hybrid" units, wherein solar panels are used to preheat water. The PLC allows integration of alternative heat/cooling sources to form these hybrid units. Many additional benefits and features are provided, especially those deriving from the PLC capabilities, e.g., real time COP (Coefficient of Performance), RTSC (Real Time Soil Heat Conductivity), cost savings reporting, trending, zone control, telemetry, selectable operating parameters, self-modulation, payback, calculations, and the like.

[0008] In variant, a heat pump comprises: a controller; a heating fluid supply line; a condensing heat exchanger connected to the heating fluid supply line. The condensing heat exchanger is configured for extracting heat from a source to continuously provide heating fluid for a variable heating load. The heat pump further comprises: a cooling fluid supply line; an evaporative heat exchanger connected to the cooling fluid supply line for sinking heat into a sink to provide cooling fluid for a variable cooling load; a refrigeration circuit operably connected to the evaporative heat exchanger; a three-way mixing valve connected to the cooling fluid supply line, and the heating fluid supply line and adapted for connection to a neutral supply line of fluid, the controller being connected to the three-way mixing valve and configured to control mixing of the neutral supply line fluid with the heating supply line fluid and the cooling supply line fluid according to requirements of the variable heating and cooling loads; and pumps disposed in the fluid supply lines. The pumps configured for pressurizing the system for delivery of fluid through the heating and cooling supply lines.

[0009] In another variant, the heat pump comprises a check valve.

[0010] In a further variant, the the heat pump comprises at least one temperature sensor.

[0011] In still another variant The heat pump of claim 1, comprising at least one pressure sensor.

[0012] In yet a further variant, the heat pump comprises a compressor.

[0013] In another variant, the controller is configured to command the three-way mixing valve to mix fluid in the supply line with fluid in the cooling fluid supply line if the temperature of the cooling fluid is above or below a predetermined temperature.

[0014] In a further variant, wherein the controller is configured to command the three-way mixing valve to mix fluid in the supply line with fluid in the heating fluid supply line if the temperature of the heating fluid is below or above a predetermined temperature.

[0015] In still another variant, the pump is configured to perform a real time coefficient of performance calculation and a real time soil heat conductivity calculation.

[0016] In yet a further variant, a system of heat pumps are connected in a matrix configuration and each pump is in network communication with at least one other pump.

[0017] In another variant, the system of heat pumps comprises at least one master heat pump and at least one slave heat pump.

[0018] In a further variant, the system of heat pumps comprises at least one heat pump having an inverter compressor and at least one other heat pump having a fixed speed compressor or inverter compressor, wherein the system is configured to vary the relative outputs of the heat pumps containing the different compressors to prevent an individual heat pump from exceeding a predetermined output level.

[0019] In still another variant, the heat has a network interface, wherein the heat pump is connected to a network via the network interface and is configurable remotely via the network.

[0020] In yet a further variant, the heat pump is configured to modulate down in output in response to reduced pressure in the supply lines and shut off completely only if the pressure in at least one of the supply lines drops to a predetermined output level.

[0021] In another variant, the heat pump is configured to perform a self diagnostic test and configure itself in response to the outcome of the test, during operation.

[0022] In a further variant, the heat pump is configured to record an operating history.

[0023] In still another variant, temperature sensors are disposed in the cooling fluid supply and the heating fluid supply, wherein the geothermal pump is configured to: read a temperature sensor; compare the read temperature with a set point temperature; if the temperature in the cooling fluid supply is below a set point, then mixing fluid from the neutral supply with the cooling fluid; and if the temperature in the heating fluid supply is above a set point, then mixing fluid from the neutral supply with the heating fluid.

[0024] In yet a further variant, the pump is configured to simultaneously output a first fluid that is elevated in temperature and a second fluid that is reduced in temperature compared to an input source fluid.

[0025] In another variant, the heat pump is configured to simultaneously heat and dehumidify air.

[0026] In a further variant, the heat pump is configured to compute the unit's electrical power consumption near instantaneously as the unit operates.

[0027] In still another variant, the heat pump comprises a payback countdown taker for displaying the date a cost of the pump has been recouped with direct energy saving and after the date the cost has been recouped, and calculating the further cost savings until the pump is replaced.

[0028] In yet a further variant, the heat pump comprises a smart meter configured to reduce power consumption costs of operating the pump, by lowering power usage of the pump during times of peak power costs and automatically switching the pump from a water saving mode to an energy saving mode.

[0029] In another variant, a system of heat pumps comprises pumps having a plurality of refrigerant types

[0030] In a further variant, the heat pump is configured to automatically shut down the pump in response to one of: the expiration of a lease agreement; a prior agreed upon payment is not received by an owner of the pump; and the pump is moved outside a predetermined area. The pump comprises a GPS unit and the pump is connected to a network for remote monitoring of the pump.

[0031] In still another variant, the pump comprises a geothermal heat pump and the source and the sink is sub-gradient level soil.

[0032] Other features and aspects of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the features in accordance with embodiments of the invention. The summary is not intended to limit the scope of the invention, which is defined solely by the claims attached hereto.

Brief Description of the Drawings

[0033] The present invention, in accordance with one or more various embodiments, is described in detail with reference to the following figures. The drawings are provided for purposes of illustration only and merely depict typical or example embodiments of the invention. These drawings are provided to facilitate the reader's understanding of the invention and shall not be considered limiting of the breadth, scope, or applicability of the invention. It should be noted that for clarity and ease of illustration these drawings are not necessarily made to scale.

[0034] Some of the figures included herein illustrate various embodiments of the invention from different viewing angles. Although the accompanying descriptive text may refer to such views as "top," "bottom" or "side" views, such references are merely descriptive and do not imply or require that the invention be implemented or used in a particular spatial orientation unless explicitly stated otherwise.

[0035] Fig. 1 is a block diagram of the geothermal heat pump system according to the present invention.

[0036] Fig. 2 is a flow diagram of PLC processing in a geothermal heat pump system according to the present invention.

[0037] Fig. 3 is a block diagram showing a matrix configuration of the geothermal heat pump system according to the present invention.

[0038] Fig. 4 is a plot showing scalability of the geothermal heat pump system according to the present invention.

[0039] Similar reference characters denote corresponding features consistently throughout the attached drawings.

[0040] The figures are not intended to be exhaustive or to limit the invention to the precise form disclosed. It should be understood that the invention can be practiced with modification and alteration, and that the invention be limited only by the claims and the equivalents thereof.

[0041] Implementation of the method and/or system of embodiments of the invention can involve performing or completing selected tasks manually, automatically, or a combination thereof. Moreover, according to actual instrumentation and equipment of embodiments of the method and/or system of the invention, several selected tasks could be implemented by hardware, by software or by firmware or by a combination thereof using an operating system.

[0042] For example, hardware for performing selected tasks according to embodiments of the invention could be implemented as a chip or a circuit. As software, selected tasks according to embodiments of the invention could be implemented as a plurality of software instructions being executed by a computer using any suitable operating system. In an exemplary embodiment of the invention, one or more tasks according to exemplary embodiments of method and/or system as described herein are performed by a data processor, such as a computing platform for executing a plurality of instructions. Optionally, the data processor includes a volatile memory for storing instructions and/or data and/or a non-volatile storage, for example, a magnetic hard-disk and/or removable media, for storing instructions and/or data. Optionally, a network connection is provided as well. A display and/or a user input device such as a keyboard or mouse are optionally provided as well.

Detailed Description of the Embodiments of the Invention

[0043] From time-to-time, the present invention is described herein in terms of example environments. Description in terms of these environments is provided to allow the various features and embodiments of the invention to be portrayed in the context of an exemplary application. After reading this description, it will become apparent to one of ordinary skill in the art how the invention can be implemented in different and alternative environments.

[0044] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art to which this invention belongs. All patents, applications, published applications and other publications referred to herein are incorporated by reference in their entirety. If a definition set forth in this section is contrary to or otherwise inconsistent with a definition set forth in applications, published applications and other publications that are herein incorporated by reference, the definition set forth in this document prevails over the definition that is incorporated herein by reference.

[0045] Referring to Fig. 1, a geothermal heat pump (or geothermal heat pump system) 10 comprises a first heat exchanger 26 acting as a condenser to sink heat into a resource, e.g., below grade soil, which is provided to the first heat exchanger 26, and the second heat exchanger 24 acting as an evaporator to source heat from the resource (e.g. below grade soil), which is provided to the second heat exchanger 24. A geothermal heat pump is one application of the broader principles of the invention. The pump can be configured with other sources for exchanging heat, including a chimney, waste water, air exchange system, outdoor ambient air, and industrial process and others.

[0046] A processor 100 which may be a PLC, (as shown in Fig. 1), computer, or the like, provides real time control and monitoring of flow in the water-to-water geothermal heat pump system 10 to effect simultaneous heating and cooling. Directing water flow from the evaporative exchanger 24 or the condensing exchanger 26 achieves temperature control without the need for a conventional reversing valve. As shown in Fig. 3, the system 10 can be configured to provide system scalability, wherein the PLC 100 can be connected to modular geothermal heat pump units 10 in a master/slave control configuration having matrix topology represented by columns A, B, and C. Combinations of geothermal heat pump units 10 having different refrigerant physical properties provide a “fusion” of adaptability, thereby eliminating difficulties in using CO_2 in home and commercial markets. Various operating refrigerant units (CO_2, R410a, and the like) may be combined for optimization of overall performance. Hybrid versions of the geothermal heat pump 10 can include solar panels to preheat water. The PLC 100 allows integration of alternative heat/cooling sources to form such a hybrid version of the geothermal heat pump 10.

[0047] The geothermal heat pump system 10 provides constant “on” fluid heating via heat exchanger 26 and constant “on” fluid cooling via heat exchanger 24 simultaneously. Heating and cooling requirements are met without the need for reversing valves to exchange hot and cold functions. As a result, the hot condenser side and the cold evaporator side are predicted to always be constant on during equipment operation.

[0048] As most clearly shown in Fig. 1, a three-way modulating valve 20 disposed in the system 10 accepts a loop or well water supply having an environmental temperature as a mixing input and diverts the loop/well supply to mix with either the cold water supply loop or the hot water supply loop in a proportional manner, varying from between 0% to 100% under the control of PLC 100, which has control instructions to effect heating and cooling functions by proportional flow control of water pumped by pumps 22 from the cold supply heat exchanger 24 and the hot supply heat exchanger 26 in the system 10. The pumps 22 range from 3 to 12 US GPM, and are preferably variable speed pumps. Under proportional control by the PLC controller 100, the system 10 heats the hot water supply line as it concurrently cools the cold water supply line. Moreover, the three-way mixing valve 20 will shut off the loop/well supply from mixing either cold or hot supply lines in response to commands from the controller 100.

[0049] Conduits in the heating and cooling circuitry of the system 10 are preferably at least approximately one inch in diameter to keep flow pressure at reasonable levels. However, check valves 13 are disposed throughout the system 10 to prevent back flow of the added water into the return loops or mixing of the cold and hot loops. A pressure relief valve 21 is disposed inline with the loop/well water discharge line in order to prevent system over pressure. A compressor 28 cycles refrigerant between the evaporative heat exchanger 24 and the condensing heat exchanger 26 in the refrigeration circuit portion of the geothermal heat pump system 10. The PLC controls the modulating electronic expansion valve 30 to regulate the expansion of the refrigerant as the refrigerant flows back into the evaporator 24.

[0050] A plurality of temperature and pressure sensors (T01-T14, P01-P14) is disposed throughout the geothermal heat pump system 10. The PLC 100 is preferably in operable communication with the sensors. Using the sensors (T01-T14, P01-P14), the PLC 100 can determine whether the heating and cooling sides are balanced at nominal set point temperatures and nominal pressure in the system 10. If the sides have the proper set point temperatures, then the PLC 100 commands the three-way valve 20 to shut the Loop2 well water supply, since there is no need for mixing.

[0051] If the PLC 100 detects that the cold side is too warm, e.g., a temperature of 40°C, then the PLC 100 commands the three-way valve 20 to open the Loop2 well supply to mix with cold water supply Loop1, thereby cooling the cold side to the desired set point, e.g., to 30°C. Similarly, if the PLC 100 detects that the hot side is too warm, e.g., a temperature of 60°C, then the PLC 100 commands the three-way valve 20 to open the Loop2 well supply to mix with hot water supply Loop3, thereby cooling the hot side to the desired set point, e.g., 55°C.

[0052] Fig. 2 shows another example of the aforementioned processes of controller 100. At step 202, temperature sensors are read by the PLC 100. At step 204, stored data parameters are input. At step 206, set point temperatures are checked. At step 208, if the cold water supply is too cold, then, under control of the PLC controller 100, the well supply is mixed in by valve 20 to warm up the cold supply. At step 209, if the hot supply is too hot, then, under control of the PLC controller 100, the well supply is mixed in by valve 20 to cool the hot supply. At step 210, under control of the PLC controller 100, the three-way valve 20 is closed if no temperature adjustments are required. Temperatures shown are merely exemplary, and may be adjusted up or down. Preferably, under the control logic of the PLC 100, the three-way mixing valve 20 maintains a fixed "Production Hot Water" and "Production Cold Water".

[0053] Electronic components of system 10 are controlled by the PLC 100, which throttles valve components on or off and/or proportionally modulates their positions. The PLC 100 has mode control functions that allow the geothermal heat pump 10 to operate in a "save water" mode or a "save energy" mode, depending upon the circumstances associated with the installation. The PLC performs Real Time Coefficient of Performance (RTCOP) and Real Time Soil Heat Conductivity calculations, and provides the calculation results to the user.

[0054] The real time COP allows an installer and a home owner to gauge the performance of the geothermal heat pump 10, as well as assisting in the recognition of a problem immediately and assisting in problem correction, resulting in a real time indication of cost savings.

[0055] The real time soil conductivity allows the installer to perform tests to determine the heat transfer of the soil and components during installation and operation. The installation advantage allows an installer to drill one vertical loop and run an actual test to compare the physical conditions to his/her designed mathematical conditions. If the actual conditions are different than the calculated condition, changes in design can be made to allow the geothermal heat pump to function correctly without correction or over-designing.

[0056] Cost saving can be realized if the actual real time soil conductivity indicates that there is a higher conductivity than expected by reducing the number of bore holes or field piping. In the event that the conductivity is lower than calculated, an installer can adjust the design by increasing the number of bore holes or field piping. This feature saves the installer from oversizing or undersizing the piping requirements.

[0057] The combination of both RT COP (Real Time Coefficient of Performance) and RTC will eliminate costly remobilization of equipment and service return calls due to faulty installations of the geothermal heat pump The RT COP and RTC results produced by the PLC 100 assist in isolating the problem as being the equipment or the installation for warranty applications and problem solving.

[0058] Additionally, the output produced by the system 10 can be scaled by the number of geothermal heat pumps 10 having executive control function (masters) versus the number of responsive geothermal heat pumps (slaves) being controlled by the executive control portion of geothermal heat pump system 10. It is contemplated that the system 10 can be installed in a wide variety of locations, from small residential to large commercial industrial applications. The modularity of geothermal heat pump system 10 also reduces the size and weight of anyone of the pump systems 10, thereby allowing an individual geothermal heat pump to be easily transported in a building via an elevator or the like. Moreover, as shown in Fig. 3, the units can be configured in a matrix topology 300, featuring exemplary "A", "B", and columns “C”. Such a configuration, which includes redundant master controllers, means that failure of a single geothermal heat pump unit has minimal impact on the remaining system 1 0, which continues to operate, providing heating and cooling at their individual capacities. Smaller individual geothermal heat pumps 10 can be installed in ceilings, under floors, or in other physically restrictive areas.

[0059] Geothermal heat pump units having different operational characteristics can be combined, thereby allowing them to benefit from the advantages of each system. It should be understood that the type of compressor 28 being used depends upon a specific heating and cooling application. For example, as shown in graph 400 of Fig. 4, assuming that Compressor 1 is an inverter compressor while Compressors 2 and 3 are fixed speed compressors, the inverter (Compressor 1) ramps up and down the heating and cooling output, while the fixed speed compressor(s) (Compressor 2 and 3) complement operation of the geothermal heat pump system 10 by providing continuous output as needed.

[0060] After compressor 1 ramps up from 0% output to 120% output, Compressor 1 turns off and Slave (Compressor 2) is turned on 100%. When a demand for additional output occurs, master Compressor 1 begins to modulate upwards to increase output. Again, when the master reaches 120%, the next slave Compressor 2 turns on 100%. Since additional output was needed, the master compressor begins to ramp up to the maximum output or peak on the graph. In modulating down to reduce capacity, the reverse is true.

[0061] The use of the PLC 100 allows the geothermal heat pump system 10 to be installed in a modular format (Le., installed in a Matrix), using a primary geothermal heat pump 10 and a number of respondent geothermal heat pumps taking orders from the processor 100 of the master, i.e., the primary, unit. The PLC 100 of separate geothermal heat pumps 10 are electrically (wired or wirelessly) connected together, thereby providing a communication link between the executive PLC 100 and subordinate, Le., slave, geothermal heat pumps', whose outputs may be controlled by the primary designated PLC 100 as if all units were one large geothermal heat pump 10.

[0062] As shown in Fig. 3, the communications link between controllers 100 belonging to multiple geothermal heat pumps 10 allows the systems 10 to be arranged in a matrix 300 of units 10. Thus, the matrix 300 of geothermal heat pump systems 10 may be a combination of having a variety of refrigerant physical properties, such as CO2, to broaden or expand operating conditions and outputs of systems 10 in the matrix 300 to meet broader applications and further increase the performance of the equipment specifically, but not limited to, the Coefficient of Performance (COP). The matrix 300 of units 10 provides a "fusion" of adaptability and physical characteristics of the refrigerant that eliminates the difficulties currently found in the implication of CO2 in the home residential and commercial markets.

[0063] The combination of a variety of geothermal heat pumps can satisfy the limitations of other refrigerants in the regard to their transcritical properties. Transcritical heat pump cycles, using CO2 as the working fluid, require low temperatures (15°C-20°C) and hot water return to be efficient. The compressed CO2 must be cooled down to 18°C-25°C in the gas-cooler for an efficient transcritical cycle. This is why a transcritical cycle does not usually lend itself to winter heating applications, while it is ideal for sanitary water heaters. Such as an application has water inlet temperatures to the gas cooler in the order of 13°C-15°C. However, CO2 heat pumps for tap water heaters are very common, but when geothermal heat pumps 10 utilizing R410a are combined with geothermal heat pumps utilizing C02 in the aforementioned executive control-master slave relationship, this problem can be overcome.

[0064] The configuration of the geothermal heat pump 10, along with the ability to modulate valve 20, allows the geothermal heat pump 10 to self-test and self-configure itself in real time to operational conditions. If water volume or pressure is reduced, the geothermal heat pump 10 will not shut off, but rather modulates down in output to meet the current conditions and ramps up in output when the condition is corrected.

[0065] The modulation function provided by the three-way modulating valve 20 being connected and responsive to the PLC processor 100 also allows the geothermal heat pump system 10 to be installed in a retrofit building that has been previously heated by hot water. In this case, the boiler sends tempered water throughout the supply piping system. The geothermal heat 15pump 10 extracts the heat (or dumps the heat) from the supply water and conditions the environment zone via heating or cooling accordingly. The supply piping would need minimal, if any, insulation. The supplied water would be a cooler temperature, reducing heat loss. Thus, the geothermal heat pump 10 allows more efficient heating and cooling of specific zones. This application is best used in large buildings where distance in delivery is a consideration.

[0066] The processor 100 has operating history, i.e., data-recording functions, which include COP and soil heat conductivity as well as recording the BTUs sent to each zone. The data-recording functions provide accurate data tracing for heating/cooling audits. Moreover, the processor 100 is able to calculate a consumption cost for each zone for accounting functions, individual billing in an industrial apartment geothermal heat pump application, or the like. The data-recording function can also calculate the unit or buildings heat loss during a variety of weather conditions. The processor 100 may also have a data analysis function, which can be used to calculate the best heat loss prevention measures that may need to be applied to increase efficiency.

[0067] For example, if it is known that the heat loss is greater during a windy day vs. a calm day at the same temperature, e.g., at -10°C, then it may be determined that the loss is due to wind penetration. If the heat loss does not change significantly, it could be determined that there is sufficient water vapor to decrease the heat loss. Due to the extensive temperature and pressure data recorded by the system 10, a building manager could focus efforts on the cause of heat loss and reduce the guesswork involved. The real time analysis of system 10 allows a scientific solution to the problem.

[0068] When solar panels are added to the system 10, the PLCs 100 of the geothermal heat pump system 10 have a solar panel management function that can provide preheated water in addition to the open loop or ground loop shown in Fig. 1. This multiple heat source function allows the geothermal heat pump 10 to operate as a "Hybrid" unit.

[0069] The PLC 100 has a maintenance function that provides a preventative and real time data communications link to a service department via an Internet port, or a phone port, or the like. The other function of the communication port is to allow the owner the ability to monitor or adjust functions from a distance. For example may wish to turn up his furnace two hours before he arrives at the cottage. The geothermal heat pump is also equipped with an emergency alert. If the geothermal heat pump is not able to keep up or maintain a minimum set temperature, the geothermal heat pump will contact the owner, notifying him or her of the issue. The owner can then take the appropriate measures to correct the issue, which may include asking a neighbor to check that all the doors and windows are secured and closed.

[0070] Through the Internet/phone line, the geothermal heat pump can contact a cottage owner that the heating system cannot maintain a preset minimum temperature of, for example, 15°C. At this alert, an owner can have the problem investigated before winter freezing damage occurs.

[0071] The PLC 100 has the capability to integrate the geothermal heat pump function along with external functions, (wired or wireless), which include zone control and ice melting functions, intruder, fire, water level, smoke alarms, pumps, fans, valves, thermostat, lights as part of a whole home (wired or wireless) monitoring and control function with Internet access.

[0072] Because the geothermal heat pump 10 is able to concurrently produce both hot and cold water, the system 10 can heat potable water or a swimming pool and air condition a building at the same time. Because heating and cooling functions are simultaneous, the capacity of the geothermal heat pump 10 is increased and the performance is increased, while electrical power consumption (energy consumption) is maintained.

[0073] The geothermal heat pump 10 has a soft start feature that reduces power surges and dips.

[0074] The geothermal heat pump 10 can be directly connected to a battery system (eliminating energy losses in conversion to AC) or to an AC power system.

[0075] The geothermal heat pump 10 can produce a COP of 4.5 for heating and a COP of 4 for cooling, totaling 8.5 COP. A smaller size geothermal heat pump 10 is needed if both heating and cooling are required. Without sacrificing the cost of operating the geothermal heat pump 10, water can be produced at two temperatures. The extremely hot water can be used to heat the hot domestic water, and the cooler hot water can be used for in-floor heating or ice melt. Because the geothermal heat pump 10 can produce hot and cold at the same time, the geothermal heat pump 10 is capable of dehumidifying in both home heating and cooling cycles.

[0076] The PLC 100 is embedded within the system 10, and therefore has integrated zone controls and BTU memory for the system 10.

[0077] The system 10 may be equipped with an integrated ice melt control function. This is a traditional option that allows the installer to include snow melt for outdoor walkways in colder northern climates.

[0078] By constantly running at lower speeds, the geothermal heat pump 10 generally achieves a high COP. Moreover, constant operation will also reduce the size of air ductwork required in a retrofit, and may eliminate costly duct alterations.

[0079] The PLC 100 continually monitors all necessary operating conditions to provide the best and most effective operation in either water saver mode or high COP energy saving mode. No installer adjustments are needed.

[0080] In the event that water pressure or flow rate decreases, as measured by sensors T01-T14 and P01-P14, the geothermal heat pump 10 will modulate downward and reduce output, but it will not auto shutoff or freeze up, as in conventional units.

[0081] The system 10 has real time electrical power consumption metering. A payback countdown calculator is also provided and allows-the owner to realize that the equipment cost and installation has paid for itself with the direct energy saving. At payback, the geothermal heat pump begins to calculate and accumulate savings until the system needs to be replaced.

[0082] The system 10 can be equipped with a smart meter to offset power consumption costs. Via introduction of the smart meter, a homeowner can achieve additional energy savings by lowering usage during peak time and automatically switch the geothermal heat pump from a water-saving mode to an energy-saving mode. This function will save the owner money and reduce energy demand during peak loads.

[0083] Geothermal heat pumps 10 can be stacked on top of one another to save in floor space requirements. Moreover, the units 10 have a low operational sound level deadening with fire resistant perlite. The insulation portion of the system 10 fills all internal geothermal heat pump cavities with a sound dampening and fire resistant stone to reduce sound and the risk of fire. Thus, the geothermal heat pump 10 provides quiet operation in livable areas, such as basements of homes.

[0084] The geothermal heat pump 10 has built-in passwords to allow different levels of program access, with an auto reset to original factory settings.

[0085] In the event the geothermal heat pump 10 is on a leasing program or payment plan, the geothermal heat pump 10 has a built-in auto shutoff to terminate operation of the geothermal heat pump 10 if payments have not been made or the geothermal heat pump has been stolen.

[0086] The geothermal heat pump 10 contains an integrated Power Factor Correction Technology that is designed to reduce total home electrical power consumption and prolong the life of the geothermal heat pump and other home electrical appliances (on AC units only).

[0087] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not of limitation. Likewise, the various diagrams may depict an example architectural or other configuration for the invention, which is done to aid in understanding the features and functionality that can be included in the invention. The invention is not restricted to the illustrated example architectures or configurations, but the desired features can be implemented using a variety of alternative architectures and configurations. Indeed, it will be apparent to one of skill in the art how alternative functional, logical or physical partitioning and configurations can be implemented to implement the desired features of the present invention. Also, a multitude of different constituent module names other than those depicted herein can be applied to the various partitions. Additionally, with regard to flow diagrams, operational descriptions and method claims, the order in which the steps are presented herein shall not mandate that various embodiments be implemented to perform the recited functionality in the same order unless the context dictates otherwise.

[0088] Although the invention is described above in terms of various exemplary embodiments and implementations, it should be understood that the various features, aspects and functionality described in one or more of the individual embodiments are not limited in their applicability to the particular embodiment with which they are described, but instead can be applied, alone or in various combinations, to one or more of the other embodiments of the invention, whether or not such embodiments are described and whether or not such features are presented as being a part of a described embodiment. Thus the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments.

[0089] Terms and phrases used in this document, and variations thereof, unless otherwise expressly stated, should be construed as open ended as opposed to limiting. As examples of the foregoing: the term “including” should be read as meaning “including, without limitation” or the like; the term “example” is used to provide exemplary instances of the item in discussion, not an exhaustive or limiting list thereof; the terms “a” or “an” should be read as meaning “at least one,” “one or more” or the like; and adjectives such as “conventional,” “traditional,” “normal,” “standard,” “known” and terms of similar meaning should not be construed as limiting the item described to a given time period or to an item available as of a given time, but instead should be read to encompass conventional, traditional, normal, or standard technologies that may be available or known now or at any time in the future. Likewise, where this document refers to technologies that would be apparent or known to one of ordinary skill in the art, such technologies encompass those apparent or known to the skilled artisan now or at any time in the future.

[0090] A group of items linked with the conjunction “and” should not be read as requiring that each and every one of those items be present in the grouping, but rather should be read as "and/or" unless expressly stated otherwise. Similarly, a group of items linked with the conjunction "or" should not be read as requiring mutual exclusivity among that group, but rather should also be read as "and/or" unless expressly stated otherwise. Furthermore, although items, elements or components of the invention may be described or claimed in the singular, the plural is contemplated to be within the scope thereof unless limitation to the singular is explicitly stated.

[0091] The presence of broadening words and phrases such as "one or more," "at least," "but not limited to" or other like phrases in some instances shall not be read to mean that the narrower case is intended or required in instances where such broadening phrases may be absent. The use of the term "module" does not imply that the components or functionality described or claimed as part of the module are all configured in a common package. Indeed, any or all of the various components of a module, whether control logic or other components, can be combined in a single package or separately maintained and can further be distributed across multiple locations.

[0092] Additionally, the various embodiments set forth herein are described in terms of exemplary block diagrams, flow charts and other illustrations. As will become apparent to one of ordinary skill in the art after reading this document, the illustrated embodiments and their various alternatives can be implemented without confinement to the illustrated examples. For example, block diagrams and their accompanying description should not be construed as mandating a particular architecture or configuration.

Claims

What is claimed is:

1. A heat pump, comprising:

a controller;

a heating fluid supply line;

a condensing heat exchanger connected to the heating fluid supply line, the condensing heat exchanger extracting heat from a source to continuously provide heating fluid for a variable heating load;

a cooling fluid supply line;

an evaporative heat exchanger connected to the cooling fluid supply line, the evaporative heat exchanger sinking heat into a sink to provide cooling fluid for a variable cooling load;

a refrigeration circuit operably connected to the evaporative heat exchanger;

a three-way mixing valve connected to the cooling fluid supply line, and the heating fluid supply line and adapted for connection to a neutral supply line of fluid, the controller being connected to the three-way mixing valve and configured to control mixing of the neutral supply line fluid with the heating supply line fluid and the cooling supply line fluid according to requirements of the variable heating and cooling loads; and

pumps disposed in the fluid supply lines, the pumps pressurizing the system for delivery of fluid through the heating and cooling supply lines.

2. The heat pump of claim 1, comprising a check valve.

3. The heat pump of claim 1, comprising at least one temperature sensor.

4. The heat pump of claim 1, comprising at least one pressure sensor.

5. The heat pump of claim 1, comprising a compressor.

6. The heat pump of claim 1, wherein the controller is configured to command the three-way mixing valve to mix fluid in the supply line with fluid in the cooling fluid supply line if the temperature of the cooling fluid is above or below a predetermined temperature.

7. The heat pump of claim 1, wherein the controller is configured to command the three-way mixing valve to mix fluid in the supply line with fluid in the heating fluid supply line if the temperature of the heating fluid is below or above a predetermined temperature.

8. The heat pump of claim 1, wherein the pump is configured to perform a real time coefficient of performance calculation.

9. The heat pump of claim 1, wherein the pump is configured to perform a real time soil heat conductivity calculation.

10. A system of heat pumps according to claim 1, wherein the heat pumps are connected in a matrix configuration and each pump is in network communication with at least one other pump.

11. The system of heat pumps of claim 10, comprising at least one master heat pump and at least one slave heat pump.

12. The system of heat pumps of claim 11, comprising at least one heat pump having an inverter compressor and at least one other heat pump having a fixed speed compressor or inverter compressor, wherein the system is configured to vary the relative outputs of the heat pumps containing the different compressors to prevent an individual heat pump from exceeding a predetermined output level.

13 The heat pump of claim 1, further comprising a network interface, wherein the heat pump is connected to a network via the network interface and is configurable remotely via the network.

14. The heat pump of claim 1, wherein the heat pump is configured to modulate down in output in response to reduced pressure in the supply lines.

15. The heat pump of claim 1, wherein the heat pump is configured to modulate down in output in response to reduced pressure in the supply lines, and shut off completely only if the pressure in at least one of the supply lines drops to a predetermined output level.

16. The heat pump of claim 1, wherein the heat pump is configured to perform a self diagnostic test and configure itself in response to the outcome of the test, during operation.

17. The heat pump of claim 1, wherein the heat pump is configured to record an operating history.

18. The heat pump of claim 3, further comprising temperature sensors disposed in the cooling fluid supply and the heating fluid supply, wherein the geothermal pump is configured to:

read a temperature sensor;

compare the read temperature with a set point temperature;

if the temperature in the cooling fluid supply is below a set point, then mixing fluid from the neutral supply with the cooling fluid; and

if the temperature in the heating fluid supply is above a set point, then mixing fluid from the neutral supply with the heating fluid.

19. The heat pump of claim 1, wherein the pump is configured to simultaneously output a first fluid that is elevated in temperature and a second fluid that is reduced in temperature compared to an input source fluid.

20. A heat pump configured to simultaneously output a first fluid that is elevated in temperature and a second fluid that is reduced in temperature compared to an input source fluid.

21. The heat pump of claim 1, wherein the pump is configured to simultaneously heat and dehumidify air.

22. A heat pump configured to simultaneously heat and dehumidify air.

23. The heat pump of claim 1, wherein the heat pump is configured to compute the unit's electrical power consumption near instantaneously as the unit operates.

24. The heat pump of claim 1, further comprising a payback countdown taker

for displaying the date a cost of the pump has been recouped with direct energy saving and after the date the cost has been recouped, calculating the further cost savings until the pump is replaced.

25. The heat pump of claim 1, further comprising a smart meter configured to reduce power consumption costs of operating the pump, by lowering power usage of the pump during times of peak power costs and automatically switching the pump from a water saving mode to an energy saving mode.

26. The system of heat pumps of claim 11, further comprising pumps having a plurality of refrigerant types

27. The heat pump of claim 1, configured to automatically shut down the pump in response to one of:

the expiration of a lease agreement;

a prior agreed upon payment is not received by an owner of the pump; and

the pump is moved outside a predetermined area.

wherein the pump comprises a gps unit and the pump is connected to a network for remote monitoring of the pump.

28. The heat pump of claim 1, wherein the pump comprises a geothermal heat pump and the source and the sink is sub-gradient level soil.

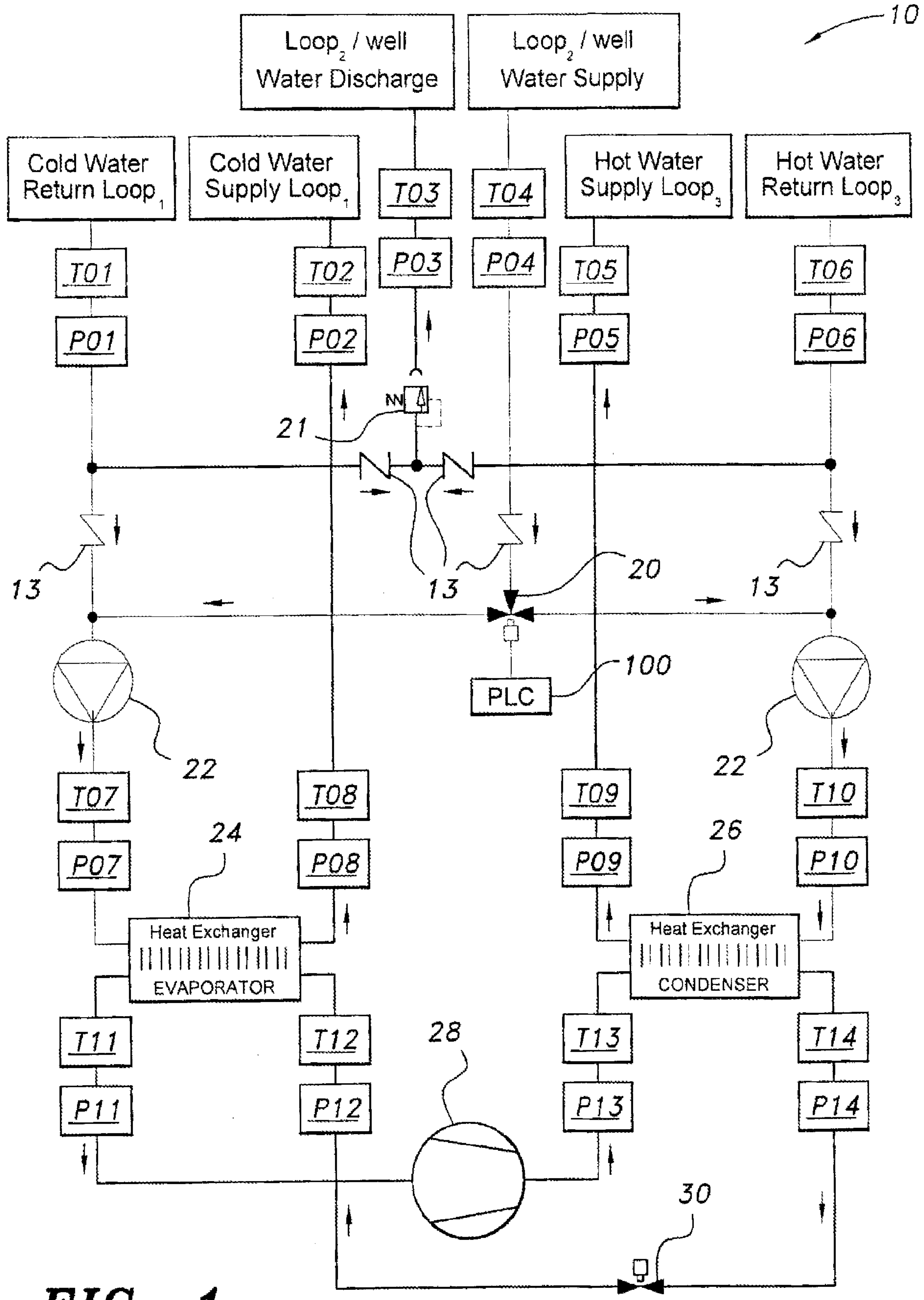
10
Loop2 / well Water Discharge
Loop2 / well Water Supply
Cold Water Return Loop1
Cold Water Supply Loop1
Hot Water Supply Loop3
Hot Water Return Loop3
T03
T04
P03
P04
T01
T02
T05
T06
P01
P02
P05
P06
21
13
13
20
13
13
100
PLC
22
22
T07
T08
T09
T10
P07
P08
P09
P10
24
26
Heat Exchanger
EVAPORATOR
Heat Exchanger
CONDENSER
T11
T12
T13
T14
P11
P12
P13
P14
28
30

FIG. 1

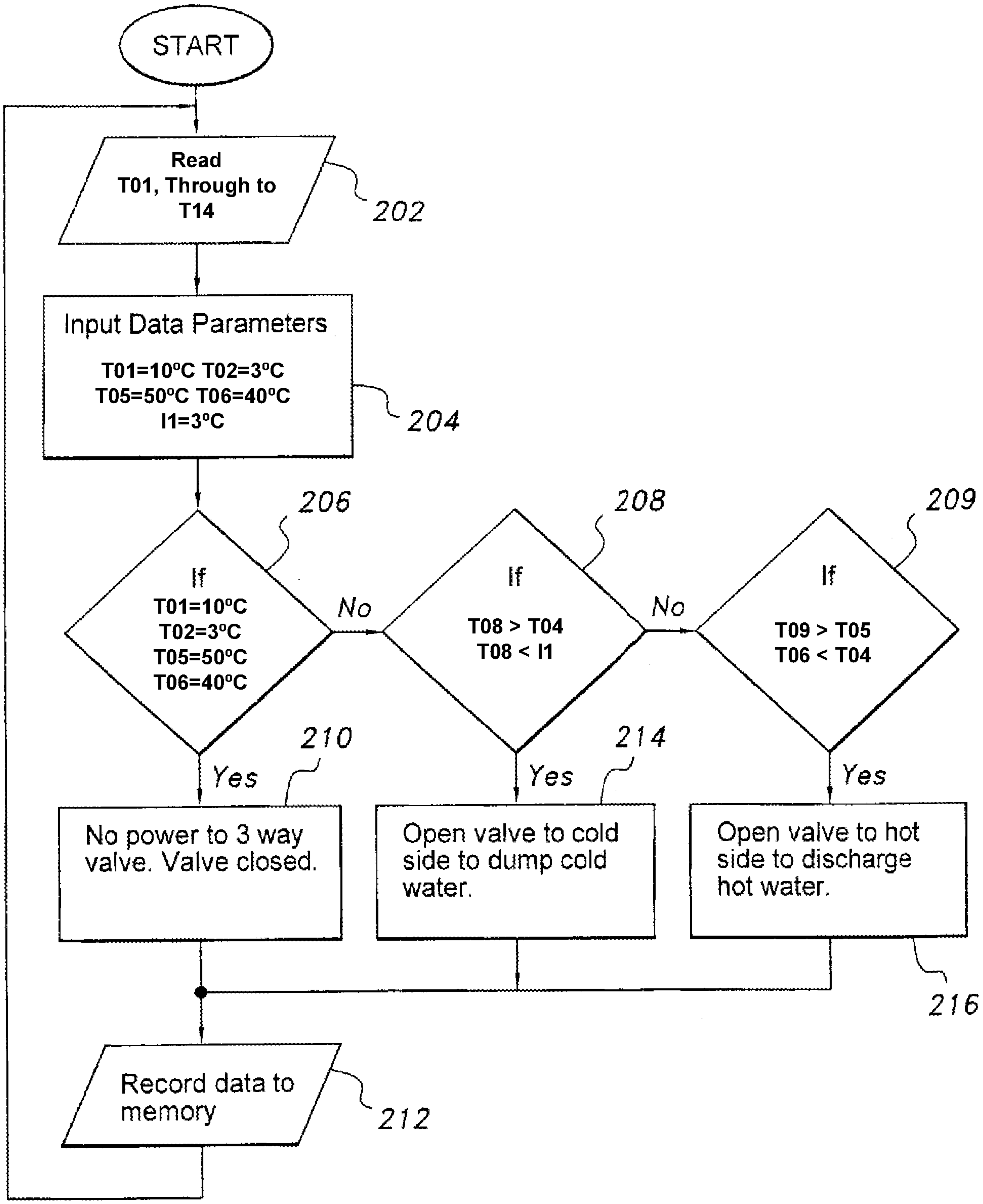
START
Read
T01, Through to
T14
202
Input Data Parameters
T01=10°C T02=3°C
T05=50°C T06=40°C
I1=3°C
204
206
If
T01=10°C
T02=3°C
T05=50°C
T06=40°C
No
208
If
T08 > T04
T08 < I1
No
209
If
T09 > T05
T06 < T04
210
Yes
No power to 3 way valve. Valve closed.
214
Yes
Open valve to cold side to dump cold water.
Yes
Open valve to hot side to discharge hot water.
216
Record data to memory
212

FIG. 2

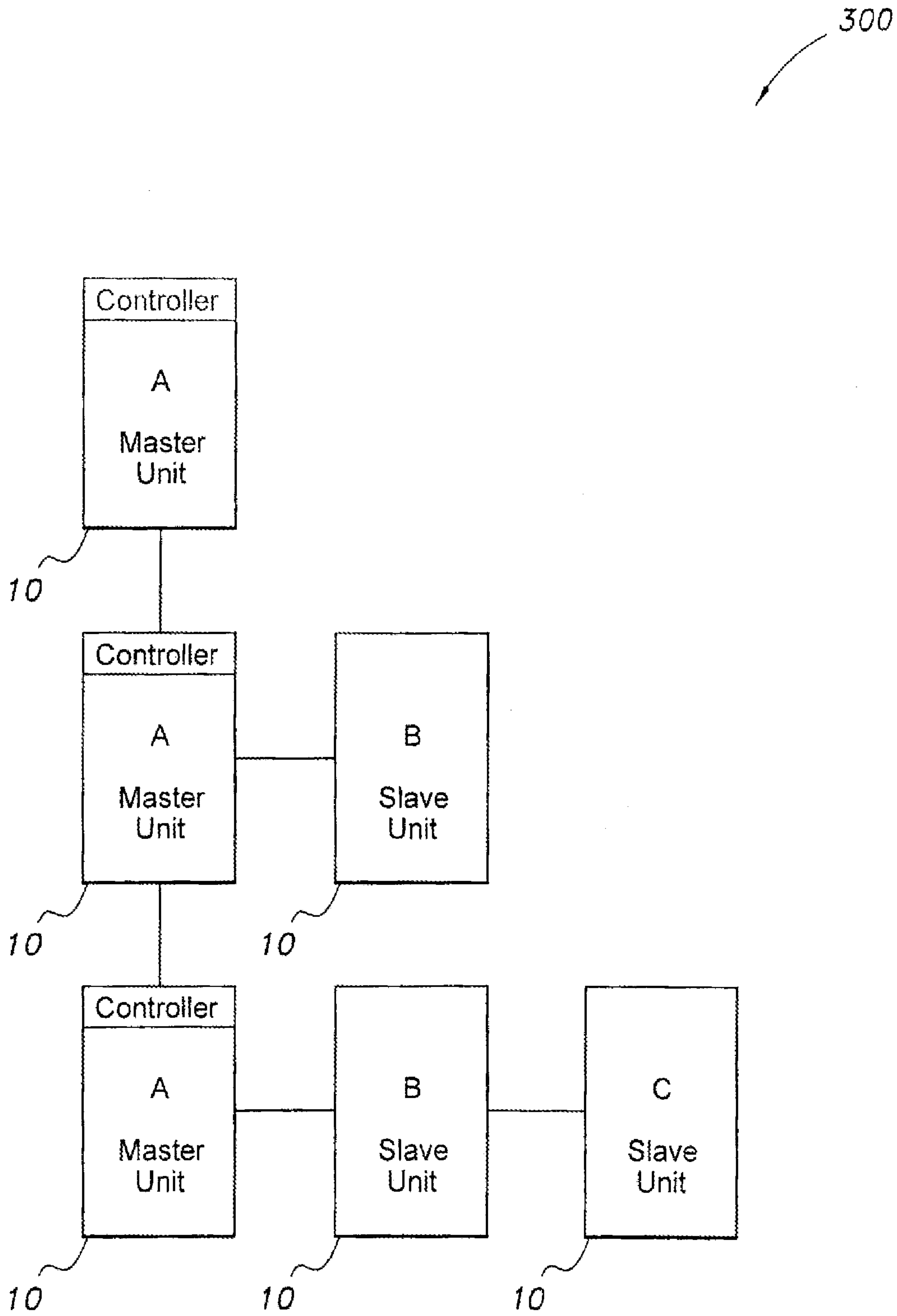
300
Controller
A
Master
Unit
10
Controller
A
Master
Unit
B
Slave
Unit
10
10
Controller
A
Master
Unit
B
Slave
Unit
C
Slave
Unit
10
10
10

FIG. 3

400

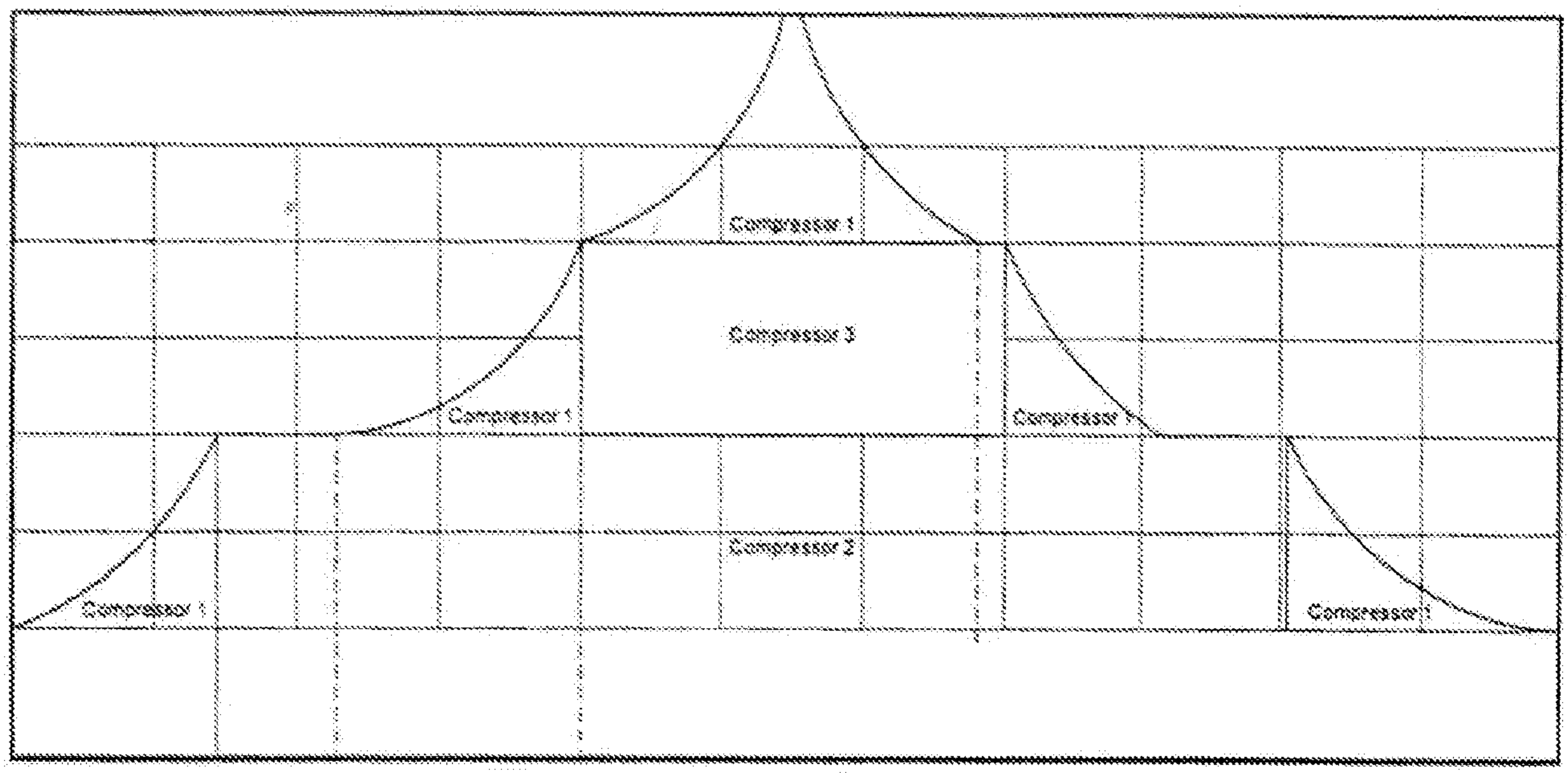
Compressor 1
Compressor 3
Compressor 1
Compressor 1
Compressor 2
Compressor 1
Compressor 1

FIG. 4

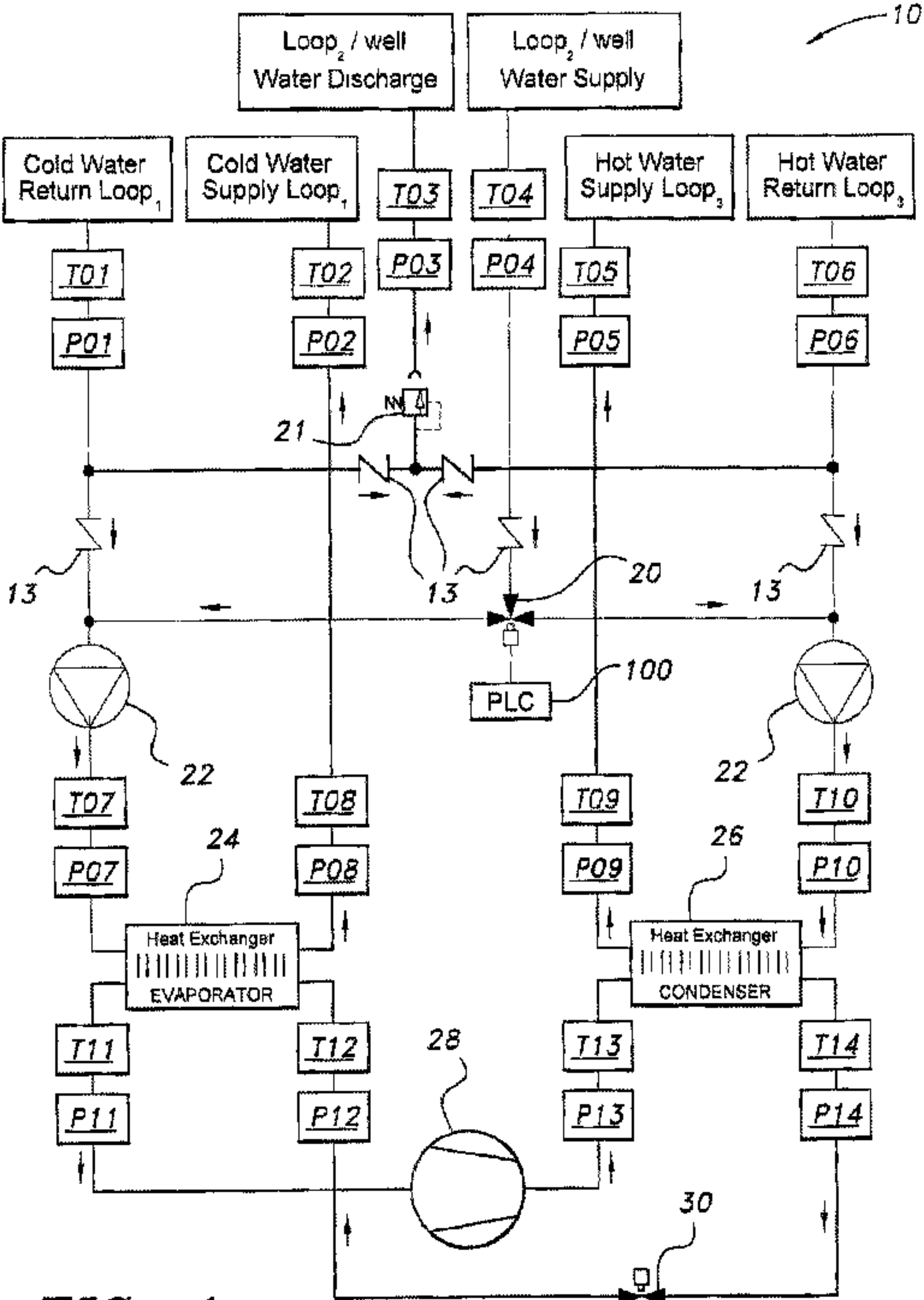
10
Loop2 / well Water Discharge
Loop2 / well Water Supply
Cold Water Return Loop1
Cold Water Supply Loop1
T03
T04
Hot Water Supply Loop3
Hot Water Return Loop3
T01
T02
P03
P04
T05
T06
P01
P02
P05
P06
21
13
13
20
13
PLC
100
22
22
T07
T08
T09
T10
24
26
P07
P08
P09
P10
Heat Exchanger
EVAPORATOR
Heat Exchanger
CONDENSER
28
T11
T12
T13
T14
P11
P12
P13
P14
30

FIG. 1