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(54) Title: FEED COLLECTOR, PARTICULARLY FOR A MULTIPLE SOURCE HEAT PUMP

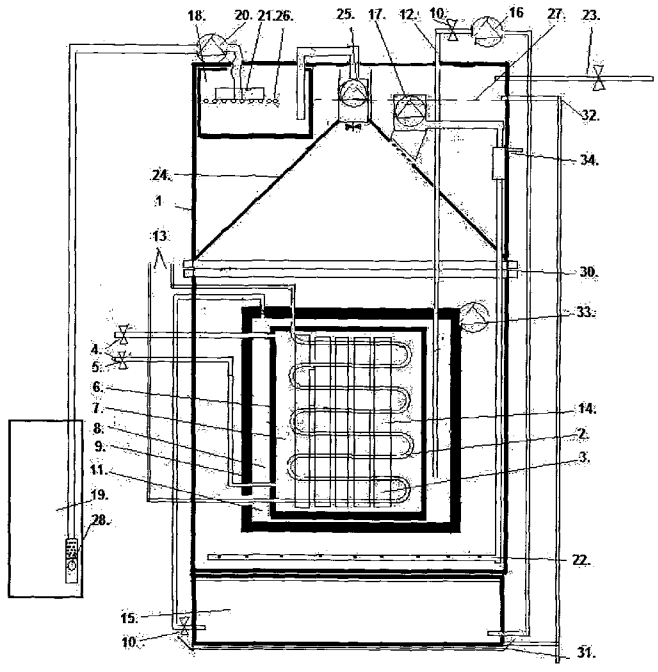


Fig.1

(57) Abstract: The present invention refers to a feed collector, particularly for a multiple source heat pump. A collector has a water filled body (1) having the form of a reservoir, whose top cap end (24) in the form of a reverse funnel inserted into an ice slurry reservoir (18) located thereover is provided with an ice- breaking pump (25) on the top, said pump having a discharge conduit with an outlet going into an ice slurry reservoir (18), which has a pump (20) for removal of accumulating ice, and in the body (1) of the collector, below the water bath level (27) there is at least one heat exchanger (8), which has the form of a flat chamber filled with a refrigerant medium, enclosed, provided with a pipe and a stub pipe (12J with a cut-off valve (10), said chamber having deformable walls (11), which can deform to at least a small extent when exposed to internal pressure in the chamber of the heat exchanger (8), wherein there is an evaporator (14) in the chamber of the heat exchanger (8), said evaporator favorably having a form of a ribbed coil pipe (2) in Tichelman arrangement, a meander arrangement or a worm arrangement, said coil provided with a radiator (3) fed with compressed gas from the compressor of a heat pump (13).

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Feed collector, particularly for a multiple source heat pump

The present invention relates to a feed collector, particularly for a multiple source heat pump, using the energy of water phase change to ensure continuity and stability of feeding parameters.

A heat pump is a heat machine forcing heat flow from a lower temperature area to a higher temperature area. This process runs opposite to a natural heat flow direction and is achieved thanks to external mechanical energy like in compressor heat pumps, or thanks to external heat energy, like in absorption pumps. In the simplest embodiment, a heat pump comprises a condenser, a throttle valve, an evaporator and a compressor. A heat pump needs an external energy source to work. When heat flows in a natural direction, that is from a higher temperature area to a lower temperature area, the flow of this heat can be used to drive a heat engine. To make heat flow in a direction opposite to the natural one, that is to have it flow from a lower temperature area to a higher temperature area, external energy source must be used for as a driving force.

Compressor heat pumps provide thermodynamic circulation (Linde's circulation) in a direction reverse to a heat engine circulation. Heat is extracted by evaporating liquid medium at a constant low pressure [phase change heat], a thermodynamic medium (freon, ammonia, carbon dioxide) in an evaporator (bottom heat source) and later on goes as steam into a compressor, where its pressure and internal energy increase. Highly pressurized steam gives off heat while condensing in a heat exchanger - a condenser (top heat source) and a medium in liquid form through a throttle valve or a capillary tube or a pressure recovery turbine reducing pressure level, and then goes back to an evaporator.

Heat pumps use low temperature (in practice 0 °C - 6 °C) heat energy as a bottom energy source, which is difficult for other practical use.

Efficiency reflects an effect to expenditure ratio. In a heat pump, an effect means the quantity of heat transferred in a top source. If a pump operated according to the perfect Carnot cycle, it would be a product of a top source temperature and entropy increment. Expenditure means the quantity of energy provided by a compressor in the form of work stream. According to energy balance, the value of this work is a difference between the quantity of heat transferred in a top source and the quantity of heat consumed by a bottom source. To have perfect circulation, summary entropy increment is zero, therefore a pump efficiency formula is a quotient of a top source temperature and a delta between top and bottom source temperatures.

COP of a heat pump is greater than 1 and is strongly dependent on a difference in temperature of a top and bottom temperature source.

$$COP_g = \frac{E_s}{E_e} \leq \frac{T_s}{T_s - T_p} = \frac{1}{\eta_c}$$

where:

- E_s, E_e- energy transferred in a condenser and energy provided in a compressor
- T_s, T_p - temperature of a condenser and an evaporator (in absolute values),
- η_c- Carnot cycle efficiency

In practice, a condenser's temperature is by several up to dozen degrees higher than the temperature of a heated room, and temperature of an evaporator is by several degrees lower than temperature of a bottom heat source.

According to the formula, heat pumps are characterized by quite high efficiency when a difference between temperatures is low, and they lose this efficiency when this difference increases.

Equality in the above formula can only be achieved in a perfect reversible heat pump. Real-life machines have lower efficiency, mainly due to the impact of two effects:

- irreversibility of heat transfer processes in an evaporator and a condenser (reversible processes would have to be infinitely slow, so in practice they would be useless),
- energy losses (friction) in a compressor and resistance in the flow of a cooling medium.

The most frequently used heat pumps are ground source heat pumps using saline and/or water as a thermal energy medium.

Additionally, if an evaporator extracts heat from the surrounding water, there comes to a steep decrease in efficiency at a temperature of below 0 °C on evaporator's surface. This is caused by ice buildup formation on evaporator's surface and a necessity of regular deicing.

There is known from the international patent application WO/2013/14248 a heat pump system comprising a heat- exchanger extracting latent heat from liquid stored in a reservoir, thereby forming ice slurry, and means for delivering said heat to a heat consumer, characterized in that the heat pump system comprises random input of extrinsic liquid into the reservoir and means for removing ice slurry stored in the reservoir outward the system.

There is known from the US patent US4,12,678 a combined heat pump system and ice making system which includes a heat pump system used for normal heating purposes. The heat pump system is augmented with an ice making system wherein ice is formed on the system evaporator.

This ice making improves the operational efficiency of the heat pump system during cold or sunless periods. Additionally, the resulting ice is collected and stored for use as ice.

There is known from the US patent US6,681,593 B1 a thermal energy storage system which includes an ice-water shallow pool used for storing and extracting thermal energy cyclically, by thawing the ice and freezing water intra-seasonally. A series of heat extractors positioned within the shallow pool are adapted to extract heat during the formation of ice. Bladders are connected to the heat extractors and also connected to a conventional heat pump and have an anti-freeze mix that is maintained at sub-freezing temperatures flowing through their interiors to remove heat from the heat extractors. The heat extractors are made of flexible material that can be expanded to release ice from their surfaces, and are adapted to pivot up and out of the way to allow the released ice to float to the top of the reservoir.

There is known from the US patent US6,053,006 a cold storage installation provided with an ice storage reservoir. The ice storage reservoir comprises a container filled with water and containing first heat exchangers through which a cooled medium flows when the ice storage reservoir is charged. The water in the container thus turns to ice. For discharging the ice storage reservoir, a medium can be conveyed through the first heat exchangers which is passed through a second heat exchanger. Coolable in the second heat exchanger is a working medium which circulates in a working-medium circuit and can be supplied after cooling to a cooling plant. At the same time, during the discharge operation water is withdrawn from the container via drainage facilities, conveyed over a third heat exchanger, and returned to the container. The working medium precooled by the second heat exchanger is led through the third heat exchanger in which

further heat is withdrawn from the working medium. Optimum efficiency of the ice storage reservoir is achieved by means of these two circuits.

There is known from the US patent US6,772,605 a liquid air conditioner of the geothermal energy type. This air conditioner includes a collector of the geothermal energy type, a heat exchanger, an energy lift device, a discharging pump, a returning pump and an air conditioner. Said energy lift device consists of a heating cycle and a heat exchanging cycle; said two cycles arc sequentially connected with a compressor, a condenser, a liquid reservoir, a drying filter, a restriction choke, an evaporator and a gas-liquid separator.

There is known from the US patent US7,363,772 a method and device for a refrigerant-based thermal storage system wherein a condensing unit and an ice-tank heat exchanger can be isolated through a second heat exchanger.

Whereas, there is known from the US patent US4,373,345 a system for ice-making and water-heating. Useful heat from an ice-maker is efficiently recovered and employed to heat water without any significant increase in the energy normally expanded in making ice. Expanded refrigerant is returned to a compressor through an accumulator, and high-pressure vapor is condensed by heat-exchange with a circulating stream of water withdrawn from a storage tank. Condensed refrigerant is returned to the receiver through a restrictor. During the harvesting cycle, relatively warm, high pressure vapor from the receiver is fed to the evaporator, and any of it condensed to liquid therein is trapped in the accumulator. Harvesting and ice-making, and any refrigerant trapped in the accumulator is used to subcool the high-pressure liquid prior to its expansion in the subsequent ice-making cycle.

US patent US4,280,335 discloses an ice-bank system for refrigerating produce areas and providing air conditioning in supermarkets. The ice-bank system allows a supply of ice to be built up in an ice-bank storage tank in off-peak hours when the cost of electrical power is lowest. Cold water is circulated from the ice-bank storage tank to the various produce areas where cooling is required. Each produce area is provided with a heat exchanger which receives cold water from the ice-bank storage tank to maintain a low refrigeration temperature in the produce area. Each produce area is tapped into a main water conduit extending from the ice-bank storage tank. The spent water from each produce area is returned to the ice-bank storage tank via a return conduit. The spent water is still sufficiently cold to be used to maintain a low condensing temperature in a conventional refrigeration unit. The cold water from the ice-bank storage tank is also supplied to an air conditioning unit to cool the ambient air in the supermarket.

There is known from the US patent US4,294,078 a method and system for the compact storage of heat and coolness by phase change materials. The invention covers the use of heat storage materials of various compositions and adapted for use over a wide range of temperatures and provides a system including a heat exchanger which provides for phase change to occur approximately simultaneously throughout the volume of the entire storage mass eliminating problems of thermal expansion, stratification and sub-cooling.

The present invention refers to a feed collector, particularly for a multiple source heat pump, using the energy of water phase change to ensure continuity and stability of feeding parameters.

A feed collector according to the invention is provided with a water-filled body having the form of a reservoir, whose top cap end in the form of a reverse funnel inserted into an ice slurry reservoir thereover is provided

with an ice breaking pump on the top, said pump having a discharge conduit with an outlet going into said ice slurry reservoir, which is provided with a deicing device. In the collector's body, under the level of the water inside, there is at least one heat exchanger in the form of a flat chamber filled with a refrigerant, enclosed and provided with a stub pipe with a cut-off valve, said chamber having deformable walls which can sustain at least a small deformation due to internal pressure. In the heat exchanger's chamber there is an evaporator, favorably in the form of a flat ribbed coil pipe in Tichelman arrangement, meander arrangement or worm arrangement, provided with a radiator fed with gas compressed by a heat pump compressor.

In a favorable embodiment, a heat exchanger has the form of an enclosed frame made of a flexible profile, which on both sides has fixed plates on the circumference, said plates being deformable side walls.

The collector's body, which is a water flow chamber, can be made of steel, concrete or plastic.

To enable quick installation, assembly and disassembly, as well as repair, the collector can be also a modular structure spilt into segments, which can be installed at any place on the surface of the earth, underground or underwater in a water reservoir.

A reverse-funnel shaped end cap of the collector promotes thickening of ice slurry and facilitates separation of ice pieces.

Feed collector according to the invention utilizes a phase change of fresh or salt water through a heat exchanger with an evaporator. A collector according to the invention has two operating cycles: work cycle and recovery cycle, wherein it gives off energy to a heat pump in both cycles.

If a collector according to the invention is provided with multiple heat exchangers with evaporators they can be sequentially or serially connected

to each other, and particularly favorably in Tichelman arrangement, wherein due to cathothermal phenomena (inverse stratification of water) a collector according to the invention works particularly well if heat exchangers are installed in a water reservoir in a feed collector's body below the mid level of filling water.

To improve collector's efficiency it is an advantage if evaporators provided with radiators are positioned in a substantially vertical way.

To facilitate ice separation and deicing of a heat exchanger, a collector according to the invention can be provided with a water pump connected to an injector. During recovery cycles such a system makes it possible to aerate water through an injector, which promotes ice separation and deicing.

Favorably, a heat exchanger of a collector according to the invention is provided with a vibrator which expedites thorough deicing of the surface of a heat exchanger during a recovery cycle.

In a favorable embodiment, a feed collector according to the invention has a saline circulation system including a saline reservoir, a saline pump with reversible pumping direction and pumping stub pipes used for charging a refrigerant to and discharging it from a heat exchanger chamber.

Favorably, deicing system of an ice slurry reservoir includes a pump connected on one end to a suction float, and on the other end to an outlet pipeline closed with a floating ball non-return valve placed in the inner ice storage container. The floating ball non-return valve makes it possible to separate and remove water from the internal reservoir, and, if needed, to return it to the main flow tank in the collector's body.

Ice slurry generated by the collector can be used for an air conditioning installation, but can also be dumped to the sewage system as inoffensive waste.

A collector according to the invention, provided with multiple heat exchangers, can at the same time work with several heat pumps.

A collector according to the invention can have a modular compartment structure of sections connected to each other, with extension and transport possibilities.

The object of the present invention is shown in embodiments in the attached drawing, where

Fig.1 shows a schematic vertical section of a collector,

Fig.2 shows an evaporator being part of the collector, and its vertical section with the wall in the a) charged state and b) discharged state,

Fig.3 shows a vertical section of a heat exchanger with an evaporator being part of the collector, a heat exchanger chamber with temporarily deformed side walls in a recovery cycle at a) negative pressure and b) positive pressure;

Fig.4 shows a schematic view of a system including a collector according to the invention cooperating with a heat pump;

Fig.5 shows a cross-section of a modular system with two collectors according to the invention, to be installed in a container.

A collector according to the invention has a body **1** in the form of a water filled reservoir, whose top end cap **24** in the form of a reverse funnel inserted into an ice slurry reservoir **18** thereover is provided with an ice breaking pump **25** on the top, said pump having a discharge conduit with an outlet going into an said ice slurry reservoir **18**, which is provided with a deicing pump **20**, which is on the one end connected to a suction float **21**, and on the other end to an outlet pipeline closed with a floating ball non-return valve **28** located in an external ice storage container **19**. In the body **1**

of the feed collector, below the level of filling water, there is a series of serially connected exchangers **8**, each of which is a saline-filled enclosed parallel-sided flat chamber provided with a stub pipe with a cut-off valve **10**, said chamber having side walls **11** which are deformable when under pressure. There is an evaporator **14** in the chamber of the heat exchanger **8**, which has a form of a coil pipe **2**, provided with a radiator **3**. The evaporator **14** is fed by compressed gas from a heat pump compressor which is supplied through conduits **13**. The chamber of the evaporator **14** has the form of an enclosed frame **6** made of a flexible profile, which, on both sides, has some plates attached on its circumference, said plates defining a wall and deformable side walls **7**. Heat exchangers **8** with evaporators **14** are arranged vertically in a water reservoir in the body **1** of the collector below mid level of filling water **27.** The body **1** of the collector, which has the form of a water flow chamber, is made of reinforced steel plates.

A collector according to the invention has a water pump **17** connected with an injector **34**. Heat exchangers **8** of a collector according to the invention are fixed permanently to a vibrator **33**. A collector has a saline reservoir **15**, a saline pump **16** of reversible pumping direction and pumping pipes and stub pipes **12** which are there to charge and discharge saline from the chambers of said heat exchangers **8**.

Collector's body **1** is placed over a saline reservoir **15**, which makes it have a compact structure which does not require much space. Water at a temperature of around 4^0C on the collector reservoir bottom preheats saline in preparation for a recovery cycle.

A collector has a segment-based modular structure, which facilitates its transportation and assembly and disassembly at any site.

A feed collector according to the invention uses a fresh or salt water phase change to feed a heat pump through a heat exchanger **8** with an evaporator **14**, which is isolated twice by evaporator's wall **7** and heat

exchanger's wall **11**. Glycol and saline are separated in both chambers and water is separated in the main reservoir of the collector **1**. Consequently, it is possible to use an evaporator **14** simultaneously for different available sources which require different media to feed their installations.

In other embodiments of a collector according to the invention, the wall **11** of the heat exchanger **8** can be made of metal or plastic panels. Flat walls **11** of the heat exchanger **8** are attached to a flexible frame **9** on their circumference only, and they can sustain minor deformations as shown in Fig. 3 a, b, when subjected to internal pressure of saline in the chamber of the heat exchange r**8**. As an ice layer building up on the outer wall surfaces of the heat exchanger's chambers is sensitive to side stresses, even minor deformations of the wall **11** of the chamber of the heat exchanger **8**, generated by changes in the pressure of a filling medium, inside a chamber of the heat exchanger **8** lead to cracking and separation of an ice layer in a recovery cycle. In other embodiments the chamber of the heat exchanger **8** can have a form of a flexible blank or can be modular and assembled from elements made of different materials joined using known methods such as welding or gluing.

A collector can be fed by various heat-carrying liquid media, such as for example saline, glycol, gases and mixtures thereof. A collector according to the invention has two operating cycles: a work cycle and a recovery cycle, wherein in both of them it continuously transfers energy to a heat pump. A work cycle of an exchanger determined on an empirical basis is around 0.5 hour to 1 hour long, and a recovery cycle is 2 minutes to 5 minutes long. To be able to use an inverse stratification phenomenon when water is sub-cooled in a reservoir as a result of energy extraction, the reservoir in the body **1** of the collector should be twice as deep as the evaporator's height. Collector's structure, which uses temperature stratification in a reservoir, improves efficiency of the unit. After sub-cooling, a layer of water

at a temperature of 1°C is located in the top part of the collector's reservoir, whereas in its bottom part, in the area of the heat exchanger **8**, water layer has a temperature of around 4°C. Gas introduced into the evaporator **14** from the top gets heated up after passing to the bottom of the evaporator **14**. Evaporator wall **7**, which surrounds the evaporator **14** and is fixed on the flexible frame **6** is filled with glycol which provides energy to evaporator pipes **2** and evaporator radiator **3**. Chamber of the evaporator **14** is filled with glycol through pipes and feed stub pipes **4** closed with valves **5.** Glycol helps in even distribution of heat over an evaporator **14.** Installation of the evaporator **14** in the chamber of the evaporator **8** reduces its size to reduce saline quantity required for recovery of the evaporator **8**.

During recovery cycle, a layer of ice is removed from the outer surface of the walls **11** of the heat exchanger **8** by pumping saline into the chamber of the heat exchanger **8**, which leads to a small deformation of the side walls **11** of the chamber of the heat exchanger **8**, which, however, is sufficient for ice to get separated from the walls. A valve on the feed stub pipe **10** of the heat exchanger **8** which supplies saline, cuts off saline inflow and keeps the side walls **11** of the chamber of the heat exchanger **8** tense and deformed until ice gets separated. Ice covering the outer side wall **11** of the heat exchanger **8** cracks and gets separated as a result of even a small deformation of the wall, and, as its specific weight is lower than specific weight of water, it accumulates on the surface area of the collector's reservoir, which is possible thanks to a top end cap of the body **24** having the form of a reverse funnel. Saline, which has a positive temperature and which heats up the heat exchanger's wall **11** from the inside also speeds up ice separation process. Water on the bottom of the reservoir, at a temperature of around 4°C which flows down the separated ice melts it on the surface and prevents its re-adhesion to heat exchanger walls **11**. Installation of a heat exchanger increases water buoyant force, which pushes ice up to the top end cap **24** of the collector reservoir. A water pump

17, which pumps water aerated by an injector 34 during a recovery cycle also facilitates ice floating. A vibrator 33 attached to the frame of the heat exchanger 8 switches on during a recovery cycle and improves efficiency of ice separation from the outer surface of the wall 11 of the heat exchanger 8.

In a work cycle, after a valve is opened at the saline stub pipe 10 , saline is discharged, and later on when a negative pressure is generated, said valve is closed and a negative pressure is maintained in the chamber of the heat exchanger 8. After pumping out saline from the chamber of the heat exchanger 8, as a result of external pressure of water in the main reservoir of the collector 1 and negative pressure generated by the saline pump 16 walls 11 of the chamber of the heat exchanger 8 adhere to the walls 7 of the evaporator 14. As a result of tight adhesion of both walls to the evaporator 14 energy of water phase change is extracted again. Ice which has accumulated on the top end cap 24 of the collector 1, is discharged during a recovery cycle by an ice-breaking pump 25 and it goes to an ice slurry reservoir 18. Excess water pumped out by the ice-breaking pump 25 to the ice-slurry reservoir 18 flows back to the reservoir in the body 1 of the collector through overflow holes 26 at the water bath level. Ice slurry remains in the ice-slurry reservoir 18. An ice slurry pump 20 pumps ice slurry to an ice storage container 19 by draining the ice slurry reservoir 18. A feed conduit for an ice reservoir is closed with a non-return valve 28 having a ball float which makes it possible to pump ice slurry into the reservoir. Switching the direction of the pump's movement makes it possible to pump water in a reverse direction to the ice slurry reservoir 18, from which water flows through overflow holes 26 to the reservoir of the collector 1. The non-return valve 28 with a ball float makes it possible to pump out the water while blocking ice which stays in the container 19. Ice slurry can be used as a feed material for an air conditioning unit. Water losses in the reservoir in the body 1 of the collector are compensated by external inflow 23. As the cold tank in the body 1 gets covered with dew, there is a condensate tray 31 on

the bottom which enables condensate discharge into the sewage system. The reservoir is provided with an overflow pipeline **32** with an outlet into the sewage system. The collector is provided with an electrical power supply and control system for pumps and valves, which enables cyclical operation of the device and which also enables cooperation with other connected installations in order to reach the best possible efficiency.

In an embodiment of the collector in a container-modular version as shown in fig. 5, it is possible to assemble the device from system elements having the form of modules. They are composed of separate reservoirs with heat exchangers installed into them. In this case deicing, glycol and saline installations can feed multiple collectors at the same time. As a recovery cycle of one such module lasts around 5 minutes, in one hour one installation, e.g. a deicing installation, can work for 10 modules with heat exchangers.

It is possible to reinforce the operation of the collector according to the invention by connection of an underground glycol collector directly to the glycol circulation system of the evaporator. In case glycol is replaced with water in a ground collector, it is possible to connect the installation directly to the reservoir of the collector according to the invention. In said assist system, a circulation pump of the installation pumps water, which increases the temperature of water in the reservoir while going through the ground collector connected to the reservoir of the collector according to the invention. If parameters delivered by underground collectors deteriorate, a ground collector installation can be disconnected and, then, energy is obtained only from water phase change. This solution is very favorable to assist feed installations which use geothermal energy. Water used in a ground collector has a much higher heat capacity ratio than glycol, thanks to which the quantity of water to be pumped through the installation is reduced.

Temperature of water in the installation is never lower than 1^0C, therefore the soil around a ground collector does not freeze. Aforesaid installation can be put under building at the stage of foundation works. The deeper a collector is in the ground, the better parameters it has when it comes to geothermal energy sourcing. Installation of collectors under a building at the stage of foundation work reduces the costs of installing such a system and increases the utilization potential of underground collectors. A possibility to obtain phase change energy makes it possible to change the parameters of energy off-take from underground parameters. A heat pump can operate on a continuous basis and it is not necessary to switch it off for a recovery cycle of a ground collector. A ground collector can recover while obtaining phase change energy ensuring stable and regular source of energy; working as a basic energy feed system it can operate without being switched off or at the time which is most convenient for the user from their economical perspective.

Operation of the collector according to the invention can be assisted by obtaining geothermal energy through exchange of water in the main flow reservoir of the collector according to the invention, that is a water-water system. Extraction of energy by the evaporator makes water cool down to around 1 ^{0}C. Continuous flow of water through the reservoir of the collector leads to an increase in the temperature of water in the reservoir of the collector according to the invention and slows down the process of ice accumulation on heat exchanger walls, that is slows down phase change. Water can be supplied from a well, a pond, a river, a sea or an underground reservoir with heat parameters higher than water phase change, that is a water source where water has a temperature over 1°C. Connection of a water feed line, correspondingly to a water-water type feed system for the bottom source, that is use of a feed well and an absorbing well makes it possible to improve operational parameters of the collector according to the invention and to obtain better efficiency (COP). There is a substantial

difference in the operation of a traditional well system after it is connected to a collector according to the invention. A possibility of heat exchanger's icing makes it possible to change operational parameters of the installation with water flow rate reduced to small quantities as assistance for energy extraction and improvement in COP. This solution is an effective one to reduce consumption of electricity needed to pump significant quantities of water in a traditional feed system. When water flow rate through the tank drops due to shortage of water, a collector according to the invention switches automatically to the operation with the use of water phase change energy only, which is a continuous and stable energy source.

A collector according to the invention can also improve operation of an air-fed heat pump in the air-water system. If air temperature drops, it eliminates a requirement to use heaters in order to defrost an evaporator. Connection of an air evaporator of a heat pump to an evaporator of a collector makes it possible to preheat gas following water phase change. A collector according to the invention will supply energy for the installation from the phase change only. Using a collector according to the invention in the existing heat pump installations based on the air-water system improves COP of these installations and enables continuous operation of a machine irrespective of ambient temperature while having a constant feed parameter obtained on water phase change.

A collector according to the invention can also be connected to a saline installation or a water installation of other available heat sources.

If a collector according to the invention interacts with solar collectors, where an energy carrying medium is saline, a saline circulation system can be boosted with a heat exchanger recovery installation as in the collector according to the invention. For solar collectors where glycol is used, a glycol circulation system can be reinforced with an evaporator like in a collector according to the invention. Solar collectors, due to their direct

heating function, do not virtually use temperature below 15°C. Such a temperature range is high for a collector according to the invention, as a temperature of feed water in a ground collector rarely exceeds 8°C. Reheating of saline or glycol makes it possible to increase a recovery temperature of an exchanger in a collector according to the invention which results in better efficiency of equipment and utilization of this unused energy.

If a collector according to the invention is connected to a recovery installation of the sewage and septic tank system, it is possible to recycle waste energy of the sewage system. Temperature of sewage and septic tanks is around 20°C, wherein a temperature of sub-cooled water in a collector is around 1°C. Using this energy to increase temperature in the main reservoir of a collector according to the invention through indirect water heating is possible for example using a coil pipe in a septic tank or using a septic tank with a double jacket. Water heated inside the jacket and pumped to a collector according to the invention gives off energy, and usage of this energy leads to actual improvement in efficiency of a collector according to the invention.

A collector according to the invention can operate with multiple heat pumps at the same time. Installation of separate energy sourcing solutions in a collector according to the invention does not change its working parameters. Heat extraction installations can be divided in to low-temperature ones, e.g. floor heating systems, and high-temperature ones, e.g. installations producing hot utility water. Use of e.g. two heat pumps makes it possible to supply heat of completely different parameters. Thanks to a possibility to select a device combined with separate control systems for both installations the efficiency of equipment improves drastically. Accordingly, a single collector can be used for joint operation of pumps in

the saline installation -recovery, deicing and other elements of the installation.

An installation including a collector according to the invention which is fed by a water phase change energy, replaces, supplements or enables integration of existing heat feed installations of the bottom heat source for saline-water and water-water type heat pumps. Currently, the most common system for such a heat pump is a worm-shaped or flat ground collector or vertical probes. Heat pump installations with such a collector are exposed to a risk of energy unavailability in the ground. Impossibility of continuous operation and switch-off breaks for recovery cycles restrict and reduce energy extraction efficiency of an installation. The existing solutions mentioned above rely on randomness, both when it comes to delivery and receipt of starting parameters, which depend only on geological, water or weather conditions which a human being is unable to influence. Other solutions for heat pumps feeding which use a water phase change operate on a direct circuit of the heat pump, evaporator and condenser require that a pump be switched off or disturb its operation in order to reverse the flow of a refrigerant necessary for evaporator's defrosting. For evaporator's defrosting, they also use recycled heat from a condenser, which reduced efficiency of a heat pump. There is also known a solution with two evaporators operating alternately, which, however, uses recycled energy for defrosting. Each switch-on and switch-off of a heat pump while reversing the flow of a medium is also connected with significant electricity consumption.

Design of a collector according to the invention allows multiple energy sources at same time, among them water phase change, horizontal collectors in the saline-water system, and a well in the water-water system, which offers a possibility to choose a source which has the best feed parameters at a given time. It is also possible to connect a waste recovery installation to the sewage system, and also to use the energy of solar collectors at temperatures, which have not been used in these installations

so far, that is below 15°C. A collector according to the invention enables continuous operation of a heat pump while maintaining feed parameters also during a recovery cycle of heat exchangers in the collector. Use of a collector according to the invention reduces electricity consumption and improves power usage. A possibility of continuous operation thanks to supply of water for a phase change in a collector according to the invention makes it possible to use heat pumps of lower power rating than in the known analogous systems. Revamping of the existing ground collector installations by additional connection of a collector according to the invention makes it possible to improve efficiency of these installations.

In order to check operational effectiveness of a collector according to the invention, an operational test was performed in a system as shown in Fig. 4 consisting of:

1. Evaporator
2. Collector reservoir
3. Condenser
4. Heat pump compressors
5. Heat receiver

where the following values were measured:

T_p – temperature after passing through the heater

T_z – heater feed temperature

T_{s1} – condenser's temperature at entry

T_{s2} – condenser's temperature at exit

T_{p1} – evaporator's temperature at entry

T_{p2} – evaporator's temperature at exit

T_{z1} – temperature on reservoir bottom

T_{z2} – temperature on reservoir surface

P_s - pressure of R-407C medium in the condenser

P_p - pressure of R-407C medium in the evaporator

Q – heat generated by the pump (meter reading)

E_e - electricity consumption of the device (meter reading) - a compressor, a water exchange-deicing pump, circulation pump of a central heating installation

Efficiency ratio (COP) reflects efficiency of a heat pump. Calculation of COP for a heat pump consists in comparing the quantity of heat obtained from a condenser (Q) to electricity supplied to a compressor (E_e) according to the formula:

$COP = Q / E_e$

Results of the operational test are shown in table no. 1.

Table no. 1

time	E_e	Q	COP	T_{s1}	T_{s2}	T_z	T_p	T_{p1}	T_{p2}	T_{z1}	T_{z2}	P_s	P_p
	kWh	GJ		°C	°C	°C	°C	°C	°C	°C	°C	Mpa	Mpa
	1 470,60	2,7609		92,0	41,0	39,6	26,5	-6,3	0,9	4,0	1,0	1,7	0,1
1 hour	1 472.10	2.7989	7.0371	95.0	37.6	42.6	30.2	-7.9	1.0	4.0	1.0	1.8	0.1
2 hours	1 473.70	2.8282	5.0868	108.7	40.1	45.5	30.2	-6.2	0.9	4.0	1.0	2.9	0.08
3 hours	1 475.20	2.8565	5.2408	110.0	41.4	46.0	33.2	-8.3	1.1	4.0	1.0	3.0	0.07
4 hours	1 476.60	2.8829	5.2381	112.0	40.0	44.5	32.7	-8.5	0.9	4.0	1.0	3.0	0.06

A heat pump connected to a collector according to the invention generated 33.8 kW of electricity during a 4-hour operation, consuming 6 kWH of electricity, which means a average COP at the level of 5.5. The results confirm the assumptions mentioned in the description referring to the structure of the collector and a possibility to generate phase change energy in the collector according to the invention.

Patent claims

1. A feed collector, particularly for a multi source heat pump, comprising an evaporator, a heat exchanger, an ice slurry reservoir, a deicing device, an ice storage container, an external water supply line, a circulation system for a heat carrying medium, a suction and force pump, suction and force conduits, valves, **characterized in that** it a has water filled body (1) having the form of a reservoir, whose top cap end (24) in the form of a reverse funnel inserted into an ice slurry reservoir (18) located thereover is provided with an ice-breaking pump (25) on the top, said pump having a discharge conduit with an outlet going into an ice slurry reservoir (18), which has a pump (20) for removal of accumulating ice, and in the body (1) of the collector, below the water bath level (27) there is at least one heat exchanger (8), which has the form of a flat chamber filled with a refrigerant medium, enclosed, provided with a pipe and a stub pipe (12) with a cut-off valve (10), said chamber having deformable walls (11), which can deform to at least a small extent when exposed to internal pressure in the chamber of the heat exchanger (8), wherein there is an evaporator (14) in the chamber of the heat exchanger (8), said evaporator favorably having the form of a ribbed coil pipe (2) in Tichelman arrangement, a meander arrangement or a worm arrangement, said coil provided with a radiator (3) fed with compressed gas from the compressor of a heat pump (13).
2. A collector according to claim 1, **characterized in that** an evaporator (14) is enclosed by a hollow flexible frame (6), which on both sides of its circumference has plates which are firmly attached to it, said plates forming deformable side walls (7) and made of metal or plastic.

3. A collector according to claim 1, **characterized in that** a heat exchanger (**8**) is a hollow flexible frame (**9**), which on both sides of its circumference has plates which are firmly attached to it, said plates forming deformable side walls (**11**) and made of metal or plastic.
4. A collector according to claim 1, **characterized in that** the body (**1**) of the collector, which is a water flow chamber, can be made of steel, concrete or plastic.
5. A collector according to claim 1, **characterized in that** it has multiple evaporators (**14**) which are sequentially or serially connected to each other and/or form Tichelman arrangement.
6. A collector according to claim 1, **characterized in that** heat exchangers (**8**) are installed in a water reservoir of the body (**1**) below mid water bath level.
7. A collector according to claim 1, **characterized in that** heat exchangers (**8**) are substantially in a vertical arrangement.
8. A collector according to claim 1, **characterized in that** it has a mixing water pump (**17**) provided with an injector (**34**) for aeration.
9. A collector according to claim 1, **characterized in that** a heat exchanger (**8**) is provided with a vibrator (**33**).
10. A collector according to claim 1, **characterized in that** it has a circulation system for saline or another non-freezing medium, connected with at least one heat exchanger (**8**), comprising a saline reservoir (**15**), a saline pump (**16**) of reversible pumping direction, valves (**10**) as well as pumping pipes and stub pipes (**12**).
11. A collector according to claim 1, **characterized in that** a deicing system comprises an ice-breaking pump (**25**) connected on the one side to a suction float (**21**), and on the other side to an outlet pipeline closed with a floating ball non-return valve (**28**) installed in an internal ice storage container (**19**).

12. A collector according to claim 1, **characterized in that** a collector has a modular structure divided in connectable separate segments such as a reservoir of the collector (**1**), ice slurry reservoir (**18**), saline reservoir (**15**), ice storage container (**19**).
13. A collector according to claim 1, **characterized in that** an evaporator (**14**) has double separation by evaporator wall (**7**) and heat exchanger wall (**11**), separating glycol and saline, and separating water from the main reservoir of the collector (**1**)

AMENDED CLAIMS
received by the International Bureau on 15 December 2014 (15.12.2014)

1. A feed collector, particularly for a multi source heat pump, comprising an evaporator, a heat exchanger, an ice slurry reservoir, a deicing device, an ice storage container, an external water supply line, a circulation system for a heat carrying medium, a suction and force pump, suction and force conduits, valves, **characterized in that** it a has water filled body (1) having the form of a reservoir, whose top cap end (24) in the form of a reverse funnel inserted into an ice slurry reservoir (18) located thereover is provided with an ice-breaking pump (25) on the top, said pump having a discharge conduit with an outlet going into an ice slurry reservoir (18), which has a pump (20) for removal of accumulating ice, and it has a mixing water pump (17) provided with an injector (34) for aeration to disturbing a laminarity of water in a body (1) and for regulating a water temperature in the bottom –zone thereof, and in the body (1) of the collector, below the water bath level (27) there is at least one heat exchanger (8), preferably provided with a vibrator, and which exchanger has the form of a flat chamber filled with a refrigerant medium, enclosed, provided with a pipe and a stub pipe (12) with a cut-off valve (10), said chamber having deformable, elastic frames and stiff walls (11), which can deform to at least a small extent when exposed to internal pressure in the chamber of the heat exchanger (8), wherein there is an evaporator (14) in the chamber of the heat exchanger (8), said evaporator (14) has double separation by evaporator wall (7) and heat exchanger wall (11), separating glycol and saline, and separating water from the main reservoir of the collector (1) , favorably having the form of a ribbed coil pipe, in Tichelman arrangement, a meander arrangement or a worm arrangement, said coil provided with a radiator (3) fed with compressed gas from the compressor of a heat pump (13).
2. A collector according to claim 1, **characterized in that** an evaporator (14) is enclosed in a container formed by a hollow flexible , capable for a deformation

frame (6), which on both sides of its circumference has plates which are firmly attached to it, said plates forming deformable side walls (7) and made of metal or plastic.

3. A collector according to claim 1, **characterized in that** a heat exchanger (8) is a hollow flexible, deformable frame (9), which on both sides of its circumference has stiff plates which are firmly attached to it, said plates forming deformable side walls (11) capable to deformation relating to a deformation of the frame (9) and made of metal or plastic.

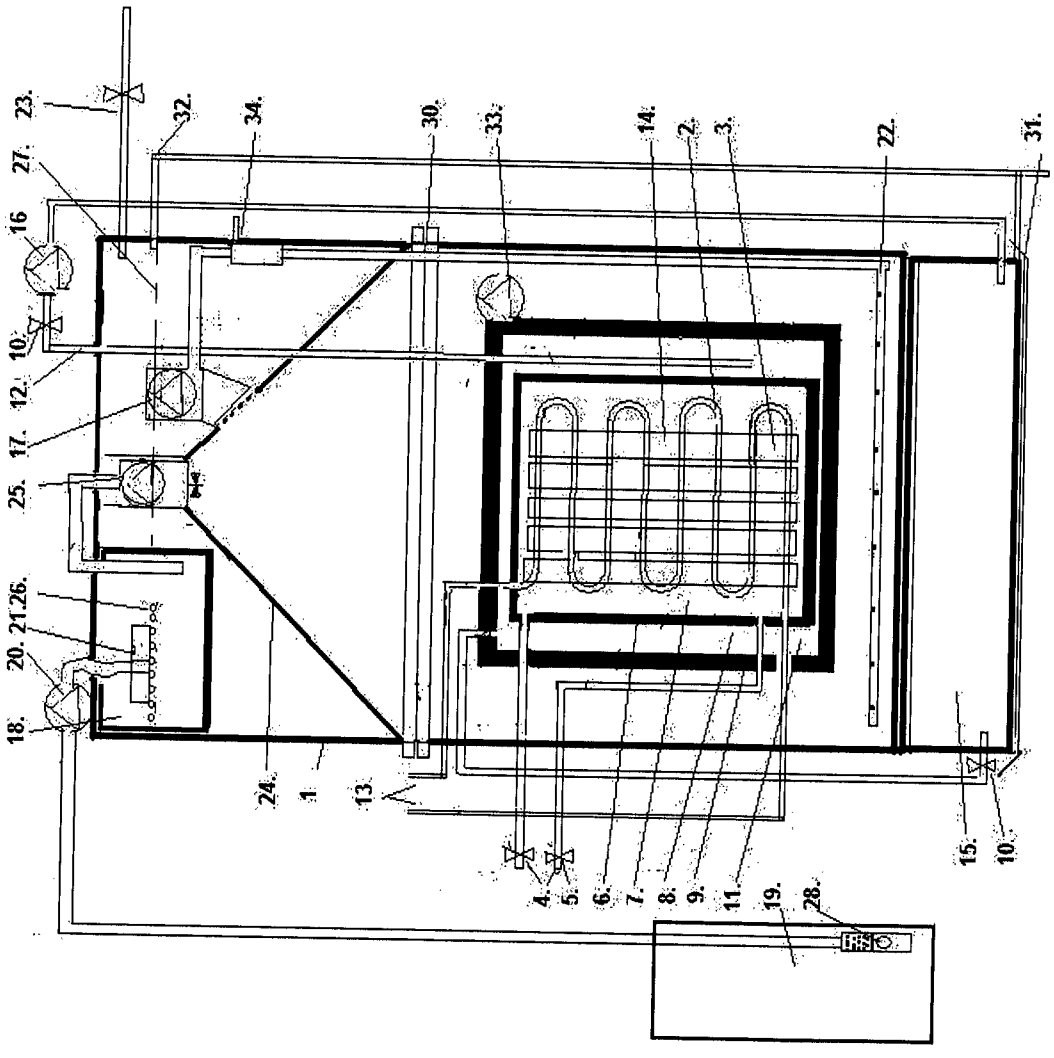

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Fig.1

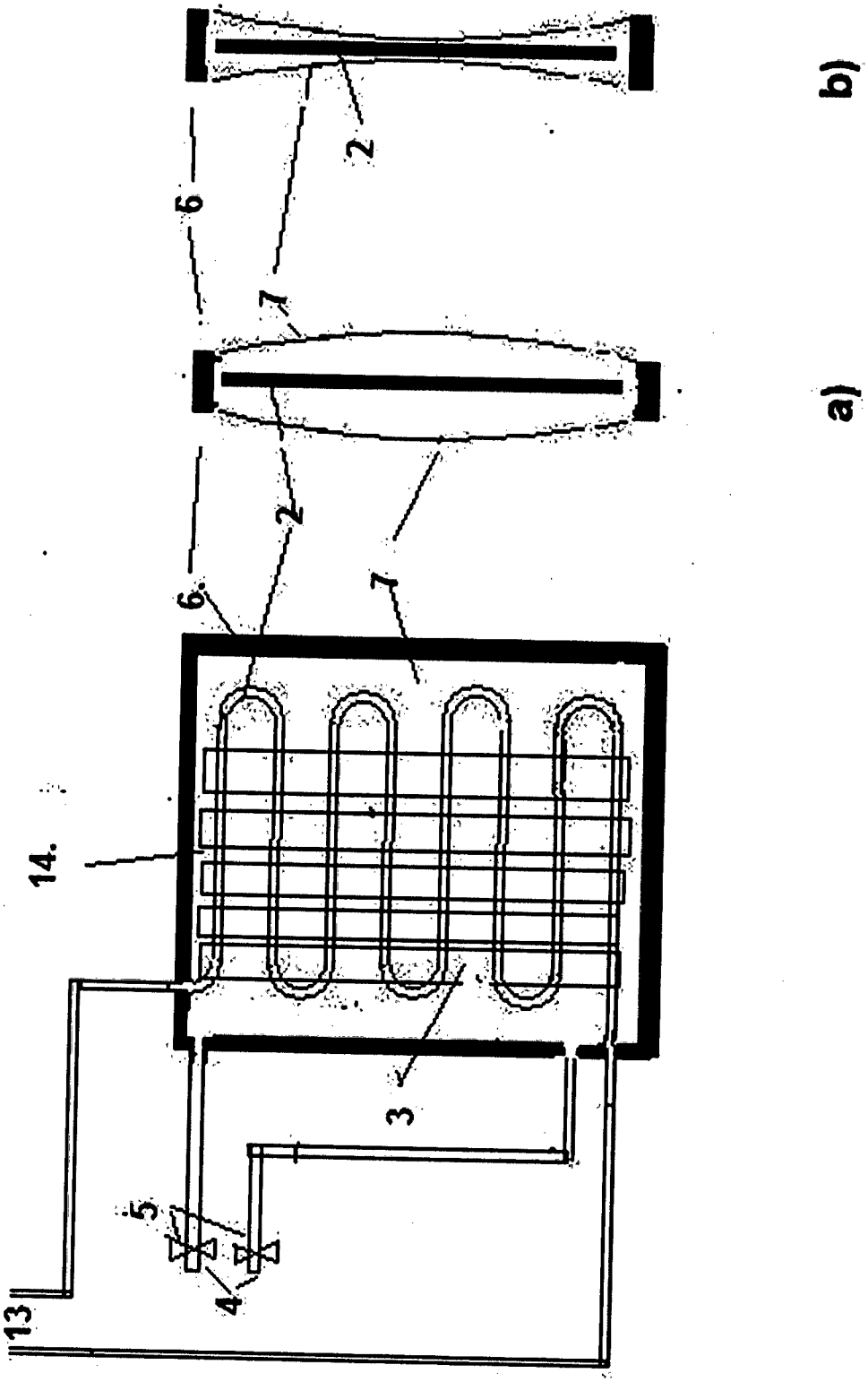


Fig. 2

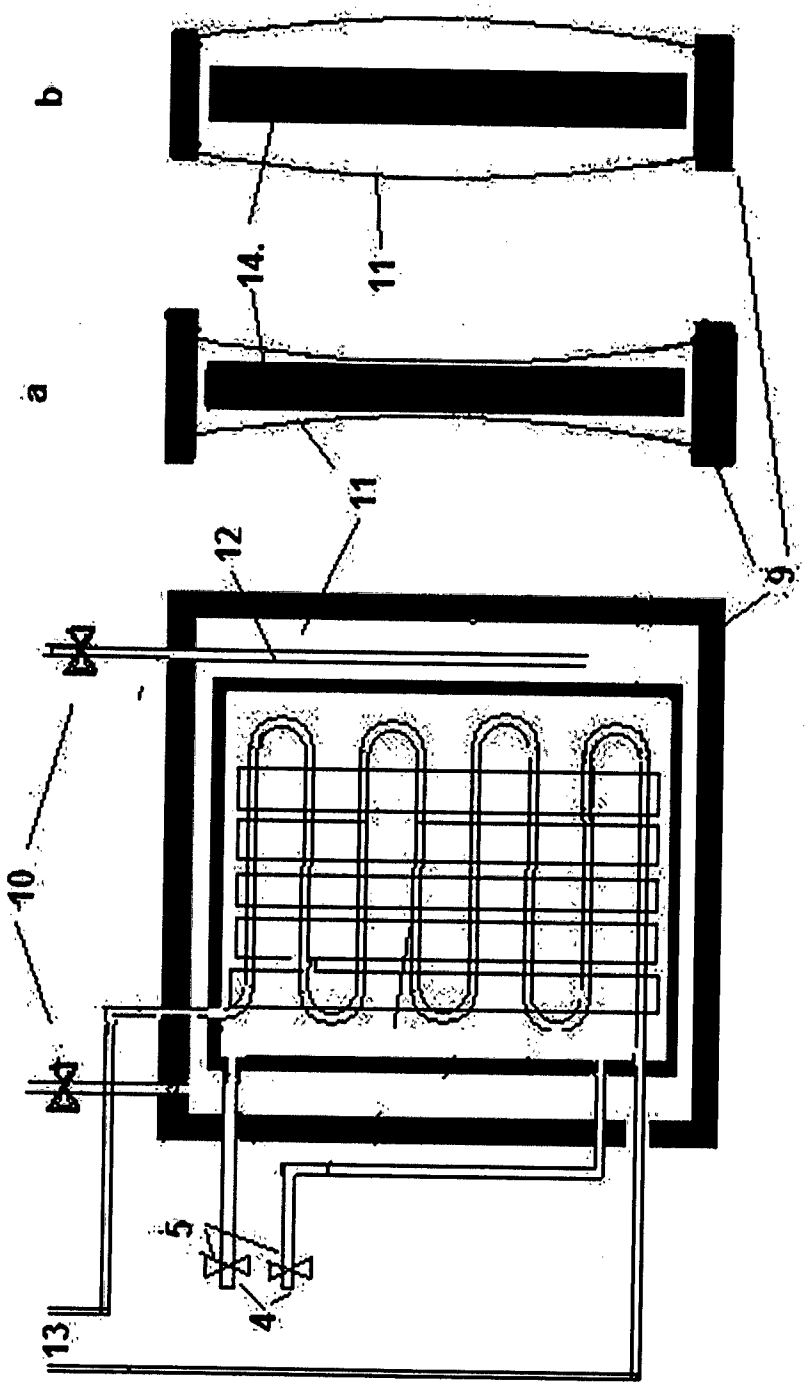


Fig. 3

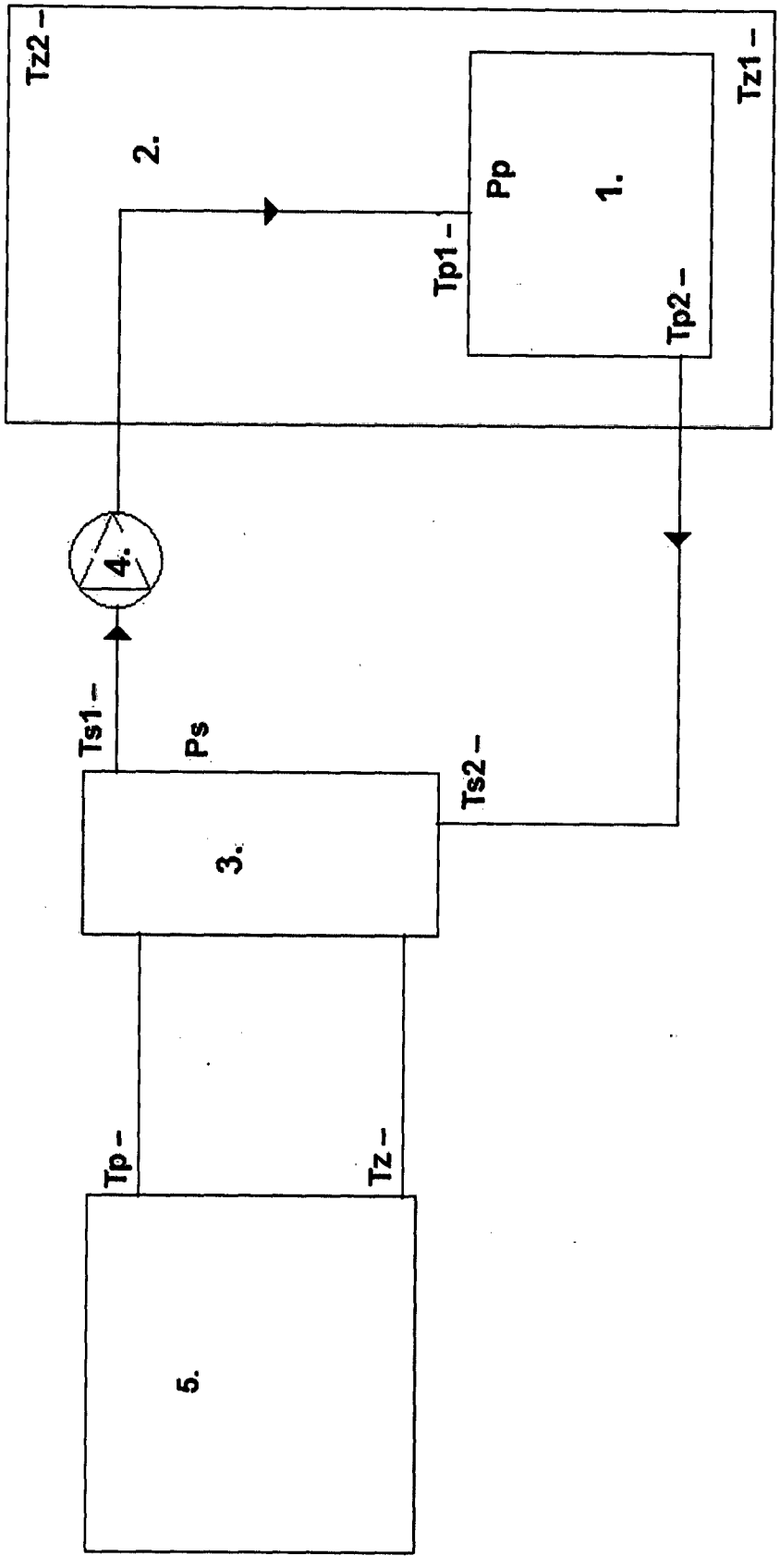


Fig.4

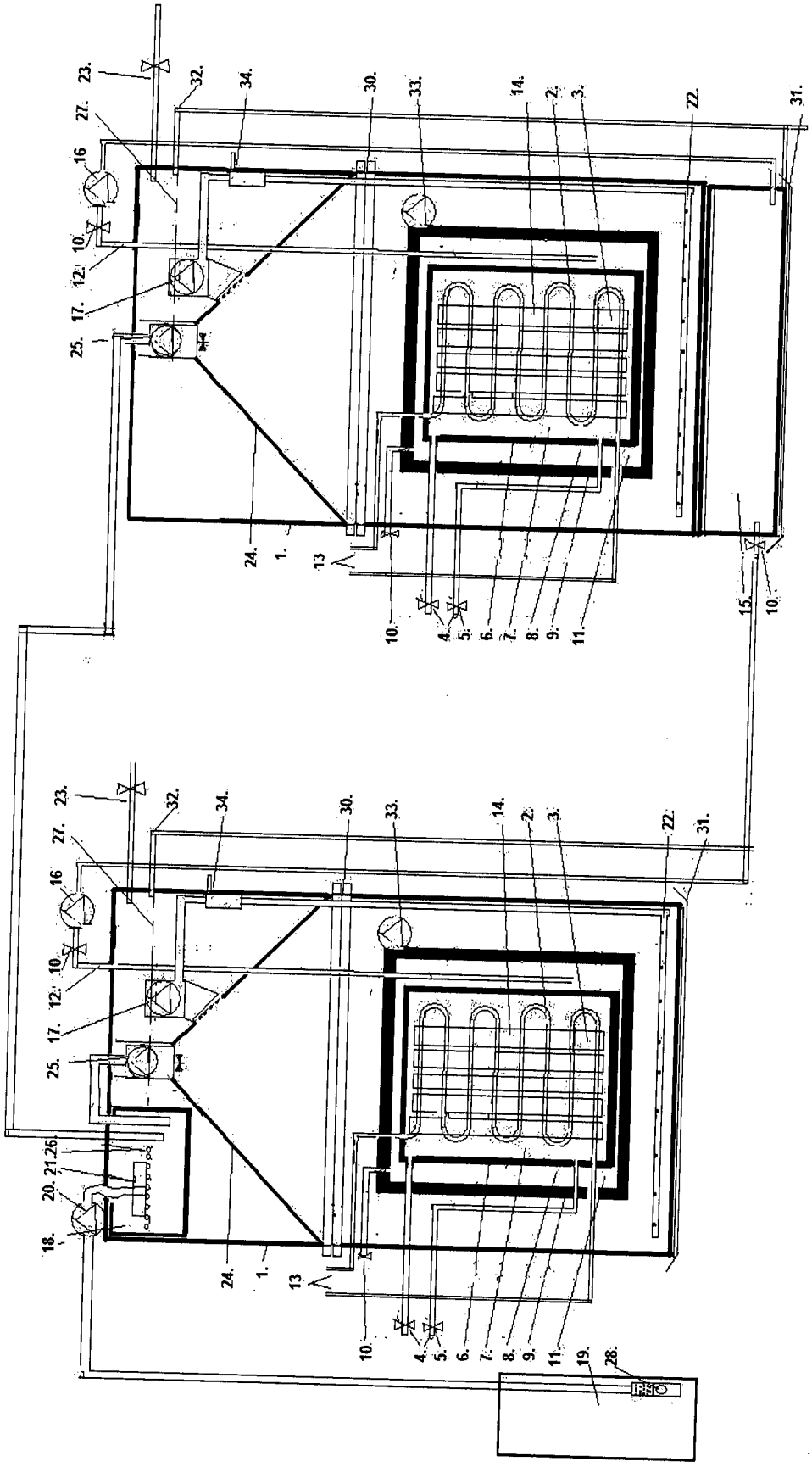

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Fig. 5.

INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2014/000008

A. CLASSIFICATION OF SUBJECT MATTER
INV. F25B30/06 F25C5/06 F28D20/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25C F25B F24F F28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 198 39 867 A1 (HEGELE FRANZ [DE]) 11 May 2000 (2000-05-11) abstract; figures 1-4	1-13
A	US 5 383 342 A (EL-BOHER ARIE [IL] ET AL) 24 January 1995 (1995-01-24) abstract; figure 11 column 9, line 56 - column 10, line 8	1,9
A	JP H11 142031 A (KANSAI ELECTRIC POWER CO; MAEKAWA SEISAKUSHO KK) 28 May 1999 (1999-05-28) abstract; figure 1	1
A	US 2 683 356 A (GREEN JR CHARLES M) 13 July 1954 (1954-07-13) figure 4	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 October 2014	22/10/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Yousufi, Stefanie

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/PL2014/000008

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