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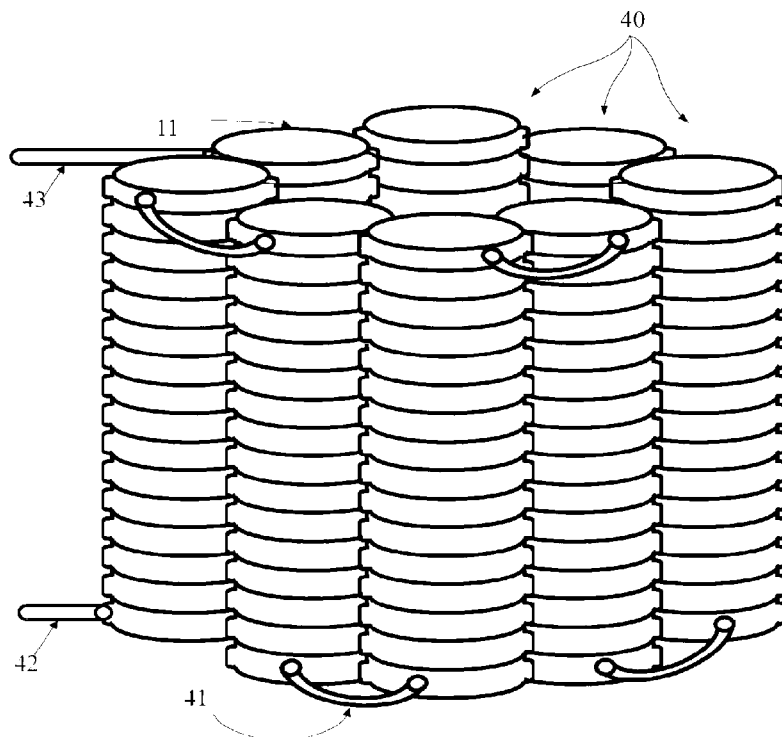
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[Continued on next page]

(54) Title: AIR SOURCE HEAT EXCHANGE SYSTEM AND METHOD UTILIZING TEMPERATURE GRADIENT AND WATER

[Fig. 4]



(57) Abstract: This invention utilizes the ultimate convection potential of air, high heat conduction potential of water and temperature gradient to maximize heat exchange efficiency. This method could be used in heat pump in the area with no extreme cold and other means such as refrigeration.

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## Description

# AIR SOURCE HEAT EXCHANGE SYSTEM AND METHOD UTILIZING TEMPERATURE GRADIENT AND WATER

### Technical Field

- [1] This invention generally relates to a system and method for heat exchange method utilizing the temperature gradient and air source heat depots, and, more particularly, to air source heat exchange utilizing heat depots having improved efficacy of heat exchange using water as an intermediate heat exchange media between heat exchange panel in heat pump or refrigerator and air.

### Background Art

- [2] The air source heat exchange method has been in use for some time. In a typical air source heat exchange system, air is used to carry heat to and from the user's heat exchange location and nearby atmosphere to absorb from or dissipate heat into.
- [3] Air source heat exchange systems are one of the most convenient ways of achieving heat exchange in heating and cooling systems, and especially with respect to heat pump type systems in respect to the air source heat pump system requiring minimum labor, equipment and space to install.
- [4] Air is very low density material with low heat content and low heat conduction potential compared to water. In order to increase heat exchange capacity, water-cooled-evaporative-air conditioning methods has been used to increase heat exchange efficiency by 60-70 % compared to the conventional air source air conditioner. (<http://www.toolbase.org/Technology-Inventory/HVAC/water-cooled-evaporative-air-conditioning>). Utilization of this method in heating mode is limited due to the possible freezing of the sprayed water at the heat exchange pipes in user's location. Use of the anti-freezer is not applicable since the recycling of the water after evaporation is limited.
- [5] Generally, placing an air source heat exchange system to conduct thermal exchange in air-conditioning, heat-pump and refrigerator incorporates several characteristics.
- [6] First, thermal exchange is dependent upon total heat exchange surface area of the heat exchange coil exposed to the air.
- [7] Next, the thermal heat exchange is highly limited at air temperature drops low near by the freezing points due to the freezing of the moisture of water in air to use in heating mode, i.e., temperature drops near 40 F. By the time air source heat-pumps may require auxiliary electric heat strip to supply the heat in need.
- [8] The heat exchange is limited by loose heat content of the air with specific heat of  $6 \times 10^{-6}$  cal./g of air. The heat exchange capacity is limited by the low density of the air

0.001184 g/cubic centimeter. As such, the heat content of the air in the same volume of the water is product of the two numbers.

- [9] The heat exchange is governed by the conduction potential of the heat transfer material near by the heat exchange coil, which is air in air source heat exchange system. The heat conduction potential of the air is 0.026, which is 1/23rd of that of the water 0.60 k(W/m·K).
- [10] As a solution, ground source heat pump has been risen as an alternative and the most efficient ways of achieving heat exchange according to the DOE in USA. However geothermal heat exchange is limited by the conduction potential of the soil near by the heat exchange device and limited heat exchange surface, one the other hand air source heat pump is not limited due to the ultimate convection potential of air.
- [11] Therefore, there is need for air source heat exchange system and method to substantially increase heat exchange surface area in air soure heat exchange method to enhance the overall efficiency of the system and method.
- [12] There is need for air source heat exchange system and method to work at lower temperature environment, especially in heating mode. Therefore, there is need for air source heat exchange system and method to increase heat conduction potential to increase heat exchange capability. There is also a need for a air source heat exchange system and method to take advantage of the ultimate convection potential air with increased heat transfer efficiency by using air.
- [13] Kinoshita et al [Patent No. US4,545,214] and Inoue, et al [Patent No. US5,904,052] used water as a heat exchange medium as in a storage tank for the air conditioner by passing cooling medium, refrigerant in a plurality of the heat exchangers (cooper piping) but failed to provide efficient recharging of the heat exchange medium in a storage tank and sufficiently increase in heat exchange area.
- [14] Yamada et al [US4,796,439] successfully described use of hot water tank and cool water tank in the high building where heating need and cooling needs could compensates. The invention mainly uses compensatory heats for the larger building. While there exists the need for the cooling dominated or heating dominated efficient heat pump with air cooled water source heat pump. But it failed to provide efficient recharging of the heat exchange medium in a storage tank and sufficiently increase in heat exchange area except to circulating from top of and to the bottom of the building.
- [15] Forgy et al [Patent No.: US 6,595,011 B1] also described the water based cooling system using evaporative cooling by air after water absorbed heat from the heat exchanger from the air conditioner. This method in limited use in cooling system.

## **Disclosure of Invention**

### **Technical Problem**

- [16] In order to get these needs, the air source water source heat-pump and refrigerator using air source heat depot was developed. Traditional closed-loop water source heat pump uses geothermal energy to conduct heat exchange. The current invention utilize the air source heat instead of geothermal heat to supply and dissipate heat to and from the air-source heat depot. Distinguished from the geothermal heat depot, air source heat depot requires less unit body size and more surface area to conduct sufficient heat exchange.

### **Technical Solution**

- [17] The temperature differences of hot or cold water to the air in a closed thin layer bottle placed in the air disappears in a few tens or a few hours pending on the wind condition (convection) of the air. The hot material placed in water lose heat much quicker compared to that placed in the air. Conversely cold material placed in water gain heat much quicker compared to that placed in the air. The present invention takes benefits of these phenomena.
- [18] During the heating mode, the temperature differences between heat source air and heat exchange causes freezing of the moisture in the air at the heat exchange coil when air temperature drops to certain degree due to the extremely cold temperature of the heat exchange coil (i.e. - 40 F). The current invention uses water as heat exchange mediator between air and heat exchange coil, which lead less likelihood of freezing.
- [19] An aspect of the present invention provides a heat depot supported air source heat exchange system and method. The system and method include use of a plurality of heat depots in open air space. A heat depot includes a sealed container filled with a heat exchange fluid, composed of a material allowing efficient heat transfer between the heat exchange fluid and air to the container. The surface of the heat depot may have several folding and/or curvature and/or other means of increasing air contact area to increase air contact surface area. Use of the folding and/or curvature in geothermal heat exchange system provides minor advantage since the geothermal heat exchange is limited by the heat conduction potential of the geothermal mass in a limited distance. However air is free moving material with high convection potential so increase in air contacting surface area could proportionally increase heat exchange efficiency. Each heat depot also includes an input heat transfer line and an output heat transfer line for carrying the heat exchange fluid, the input line proceeding through a surface of the container at least a minimal distance into the container, and the output heat transfer line originating immediately at the other side surface of the container preferably farthest part. The the heat depots are connected to one another in a continuous unbroken chain having a first heat depot and a last heat depot, such that the output heat transfer line from one depot is the input heat transfer line for another depot, with the

input heat transfer line for the first depot originating at an output from a pump from a user heat exchanger, and the output heat transfer line for the last depot terminating at an input for the user heat exchanger. In an embodiment of the invention, the heat depots place in an air open space. The heat exchange fluid is pumped into the first heat depot through its input heat transfer line, which then overflows through its output heat transfer line which is the input heat transfer line for the next heat depot in the chain, which then overflows into the next heat depot, and so on, until the heat transfer fluid flows into the last heat depot in the chain, from which it overflows through its output heat transfer line to the user heat exchanger, and on to the pump, completing the cycle in an amount of time measured by flow rates greater than a few tens minute or more pending on the application. In an embodiment of the present invention, the air fan may be added to the arrangement of the heat depots to aid rapid heat transfer by the forced convection of the air. The optional fan may be in action when the temperature difference between inlet and outlet of the user heat exchanger is below the system set temperature, i.e., 10 F. During the circulation, water absorbs or dissipates heat from or to the air space.

[20] In another aspect of the invention, the air source heat depot supported heat exchange system and method used in refrigeration system and method. In an embodiment of the present invention, the compressor and heat exchange panel of the refrigerator is located at the bottom of the user's refrigeration. The back (and/or) side and bottom of the refrigeration system body is covered by unchanneled thin layer of panel to hold water or water with antifreeze inside. When refrigeration is required, heat is dissipated by the heat exchange panel to the water at the bottom of the thin layer panel. The warm water moves naturally moves upward and cold water moves downward by the natural convectional force created by the temperature differences. The large surface area of thin layer of panel serves heat exchange surface between air and water inside.

[21] In another aspect of the invention, the air source heat depot supported heat exchange system and method used in refrigeration system. In an embodiment of the present invention, the compressor and heat exchange panel of the refrigerator is located at the bottom of the refrigeration system. The back (and/or) side and bottom of the refrigeration system body is covered by continuously channeled thin layer of panel to hold water or water with antifreeze inside. When refrigeration is required, heat is dissipated by the heat exchange panel to the water at the bottom of the thin layer panel. The warm water moves through the channeled thin layer panel by water circulating pumps. The large surface area of thin layer of panel serves heat exchange surface between air and water inside.

### **Brief Description of Drawings**

- [22] Figure 1 is a schematic diagram illustrating a typical air source heat depot folded horizontally, in accordance with an embodiment of the present invention;
- [23] Figure 2 is a schematic diagram illustrating a typical air source heat depot folded in vertically, in accordance with an embodiment of the present invention;
- [24] Figure 3 is a schematic diagram illustrating a typical air source heat depot with no folding, in accordance with an embodiment of the present invention;
- [25] Figure 4 is a schematic diagram illustrating a typical air source heat depot arranged in circular mode, in accordance with an embodiment of the present invention;
- [26] Figure 5 is a schematic diagram illustrating a typical air source heat depot arranged in circular mode with fan support, in accordance with an embodiment of the present invention;
- [27] Figure 6 is a schematic diagram illustrating a typical air source heat depot of thin plate types arranged in multiple tower mode, in accordance with an embodiment of the present invention;
- [28] Figure 7 is a schematic diagram illustrating a typical air source heat depot of thin plate types arranged in parallel mode, in accordance with an embodiment of the present invention;
- [29] Figure 8 is a schematic diagram illustrating a typical air source heat depot of thin plate types arranged in linear mode, in accordance with an embodiment of the present invention;
- [30] Figure 9 is a schematic diagram illustrating a typical air source heat depot, heat pump connection, in accordance with an embodiment of the present invention;
- [31] Figure 10 is a schematic diagram illustrating a typical air source heat depot, uses in refrigeration, in accordance with an embodiment of the present invention;
- [32] Figure 11 is a schematic diagram illustrating a typical air source heat depot, uses in refrigeration with circulating fan, in accordance with an embodiment of the present invention;

### **Mode for the Invention**

- [33] In the following description, for purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the invention. It will be apparent, however, to one having ordinary skill in the art, that the invention may be practiced without these specific details. In some instances, well-known features may be omitted or simplified so as not to obscure the present invention. Furthermore, reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of the phrase "in an embodiment" in various places in the

specification are not necessarily all referring to the same embodiment.

- [34] The present invention advantageously provides air source heat exchange system and method that provides increased efficiency, weather durability and easier installation and manufacturing
- [35] The present invention also provides for a air source heat exchange system and method that could take advantage of the high heat conduction potential and heat capacity of water.
- [36] The present invention also provides for a air source heat exchange system and method that could lower down the critical operating temperature of the heat pump in winter time, so that air source heat pump could be used in a moderate cold regions.
- [37] The present invention also provides for a air source heat exchange system and method that could maximize convection potential of the air to provide or dissipate heat with no or moderate use of the fan.
- [38] Thanks to the inventive use of heat depots, this invention greatly increases the efficiency of the air source heat pump comparable to that of geothermal heat pump system without marked increase in significant cost of installation.
- [39] Thermal exchange efficiency, also known as thermal conductivity, is dependent upon the temperature differential between donors, total area of exchange, and the heat transfer rate. As shown in the following equations of conductive heat transfer, equation (1) and convective heat transfer equation
- [40] (1)  $q=kAdT/s$
- [41] (2)  $q=kAdT$
- [42] Where  $q$  = heat transferred per unit time (W, Btu/hr),  $A$  = heat transfer area ( $m^2$ ,  $ft^2$ ),  $k$  = thermal conductivity of the material (W/m.K or W/m. $^{\circ}$ C, Btu/(hr  $^{\circ}$ F  $ft^2/ft$ )) for equation (1) and  $k$  = convective heat transfer coefficient of the process (W/m.K or W/m. $^{\circ}$ C) for equation (2),  $dT$  = Temperature difference across the material (K or  $^{\circ}$ C,  $^{\circ}$ F),  $s$  = material thickness (m, ft).
- [43] The "air source heat depot" heat exchange system and method of the present invention was designed to take advantage of high conduction potential of the water compared to air in a limited surface area of the heat exchange chamber. In an embodiment of the current invention, the surface area of the heat exchange is expanded to the ratio of the area of the metal piping inside heat exchange chamber to the external surface area of plurality of heat depots.
- [44] In the present invention, the air source heat depot heat pump is based on the principle of providing the optimal heat exchange in the gradient based heat exchange system. The heat exchange capacity is proportional to the temperature difference between thermal donor and recipient. As presented in the embodiment of the current invention, air-source heat depot is composed of the plurality of the air-source heat depots in a

successive order. So temperature difference between donor (air in heating mode and water in air source heat depot in cooling mode) and recipient (water in air source heat depot in heating mode and air in cooling mode) is greatest at the recipient air source heat depot from the heat pump and lowest at the donor air source heat depot to the heat pump. As such, in the present invention, the water stays over several tens of minutes in the air to allow enough heat exchange before returning to the heat pump.

[45] In the present invention, the air source heat depot heat pump is conducting heat exchange utilizing wide surface area, does not always require air circulating fan. As such, this further enhances the efficiency of the air source heat exchange system.

[46] Figure 1 illustrates an exemplary air source heat depot 11. In accordance with an embodiment of the present invention, an air source heat depot 11 is several feet long with shallow diameters to allow large surface area of heat exchange, further folded in several layers to increase enough surface area for the heat exchange. Nos. 2 and 3 represents the entrance and exit of the air source heat depot materials. Pending on the location of the plurality of the heat depots, the entrance and exit could be used as exit and entrance.

[47] Figure 2 illustrates an exemplary air source heat depot 21. In accordance with an embodiment of the present invention, a air source heat depot 21 is several feet long with shallow diameters to allow large surface area of heat exchange, further folded vertically to increase enough surface area for the heat exchange. Nos. 2 and 3 represents the entrance and exit of the air source heat depot materials. Pending on the location of the air source in the plurality of the heat depots, the entrance and exit could be used as exit and entrance.

[48] Figure 3 illustrates an exemplary air source heat depot 31. In accordance with an embodiment of the present invention, a air source heat depot 31 is several feet long with shallow diameters to allow large surface area of heat exchange. Nos. 2 and 3 represents the entrance and exit of the air source heat depot materials. Pending on the location of the air source in the plurality of the heat depots, the entrance and exit could be used as exit and entrance.

[49] Figure 4 illustrates an exemplary air source heat depot in a circular mode. In accordance with an embodiment of the present invention, a air source heat depot 40 could be selected as single or multiple shape of the air-source heat depots as shown in figures 1 to 3 and their alterations. Nos. 41, 42 and 43 represents water loop connecting adjacent air-source heat depots, water loop connected to the entrance and exit of the use heat exchange device, respectively. In the embodiment of the present invention, the water from the exit of the heat pump enters into air source heat depots through loop 42 and passing through air source heat depots in order through loop 41 and re-enters into heat pumps through loop 43. The size of the recommended air source heat depot in the

present invention is diameter of 0.5 ft and height of 3 ft with volume of 4 gallons. Use of the 5 air source heat depot allows 10 min of the circulation time to the one ton unit heat pump. In a one ton unit of the heat pump (12,000 BTU) requires approximately 2 gallons of water flow with 10 F temperature differences between heat pump entering and exiting water. As such, the embodiment of the present invention requires number of the air source heat depots to allow the gain or dissipation of the heat while passing through the air-source heat depots.

[50] Figure 5 illustrates an exemplary air source heat depot 40 in a circular mode with supportive air fan. In accordance with an embodiment of the present invention, a air source heat depot 40 could be selected as single or multiple shape of the air-source heat depots as shown in figures 1 to 3 and their alterlations. Nos. 41, 42, 43, 54 and 55 represents water loop connecting adjacent air-source heat depots, water loop connected to the entrance, exit of the water source heat depot, air circulating fan and air circulating fan house respectively. In the embodiment of the present invention the water from the exit of the heat pump enters into air source heat depots through loop 42 and passing through air source heat depots in order through loop 41 and re-enters into heat pumps through loop 43. Use of the 5 air source heat depot allows 10 min of the circulation time to the heat pump. In a one ton unit of the heat pump (12,000 BTU) requires approximately 2 gallons of water flow with 10 F temperature differences between heat pump entering and exiting water. As such the embodiment of the present invention requires number of the air source heat depots to allow the gain or dissipation of the heat while passing through the air-source heat depots. In the current embodiment of the invention, air circulating fan is activated if the water temperature differences between the entrance and exit is below system defined temperature, i.e., 10 F to allow more heat exchange to and from the air.

[51] Figure 6 illustrates an exemplary air source heat depot 61 having thin rectangle prism in placed in vertical parallel mode. Nos. 61, 62, 63 and 64 represent air source heat depot body in rectangle prism shape, heat depot inter-connector, inlet and outlet of the water from and to the heat depot. Water from the exit heat pump enters heat depot 61 through inlet 63, circulating heat depot through heat depot connection 62 and reenters into heat pump through outlet 64. During the circulation heat exchange between heat depot and air occurs. The desired shape of the air source heat depot for this configuration is thin wide place type prism. The current configuration shows over 3 \* 3 square ft area with depth of over 1 inch, which comprise total volume of 5.7 gallon per plate. for the one ton unit allowing 20 min circulation to conduct heat exchange would require 7 plate connection respectively.

[52] Figure 7 illustrates an exemplary air source heat depot 61 having thin rectangle prism in placed in staggered mode. Nos. 61, 62, 63 and 64 represent air source heat depot

body in rectangle prism shape, heat depot inter-connector, inlet and outlet of the water from and to the heat depot. Water from the exit heat pump enters heat depot 61 through inlet 63, circulating heat depot through heat depot connection 62 and reenters into heat pump through outlet 64. During the circulation heat exchange between heat depot and air occurs. The desired shape of the air source heat depot is thin wide place type prism. The current configuration shows over 3 \* 3 square ft area with depth of over 1 inch, which comprise total volume of 5.7 gallon per plate. for the one ton unit allowing 20 min circulation to conduct heat exchange would require 7 plate connection respectively.

[53] Figure 8 illustrates an exemplary air source heat depot 61 in parallel mode. In accordance with an embodiment of the present invention, a air source heat depot 61 could be selected as single or multiple shape of the air-source heat depots as shown in figures 1 to 3 and their alterations. Nos. 41, 42 and 43 represents water loop connecting adjacent air-source heat depots, water loop connected to the entrance and exit of the water source heat depot, respectively. In the embodiment of the present invention the water from the exit of the heat pump enters into air-source heat depots through loop 42 and passing through air source heat depots in order through loop 41 and re-enters into heat pumps through loop 43. The size of the minimally required air-source heat depot in the present invention is diameter of about 0.5 ft and height of the 3 ft with volume of 4 gallons. In a one ton unit of the heat pump (12,000 BTU) requires approximately 2 gallons of water flow with 10 F temperature differences between heat pump entering and exiting water. Use of the 5 air source heat depot allows 10 min of the circulation time to the heat pump. As such, the embodiment of the present invention requires number of the air source heat depots to allow the gain or dissipation of the heat while passing through the air-source heat depots. This embodiment of the present invention could be easily used in the wall mounted air conditioner.

[54] Figure 9 illustrates an exemplary connection of the air source heat depot 73 and heat pump 72 in ambient atmosphere 71 through connection loop 742 and 743. In accordance with an embodiment of the present invention, user heat pump 72 gets water from air source heat depot 73 through loop 42, expelling heat into the heat pump and leaving heat pump through loop 43 and reenters into air source heat depot 73, and water passes through air-source heat depot 73 to get heat from the air before re-entering heat pump 72 in heating mode. In cooling mode, the water absorbs heat from heat pump 72 and releases heat into air source heat depot 73. The total circulating time could exceeds 20-30 min. The air fan is in motion when the temperature differences between loop 742 and loop 743 is below system set values.

[55] Figure 10 illustrates an exemplary connection of the air source heat depot use in refrigerator. In accordance with an embodiment of the present invention, numbers 82, 83,

84, and 87 represents heat expansion unit, lower bottom water housing of refrigerator housing heat expansion unit, back wall water housing of the refrigerator and compressor. The condensing unit is not shown in this figure. Arrows indicates temperature gradient dependent water movement. In active mode, compressor 87 emits hot refrigerant into heat expansion unit 82. Hot refrigerant in heat expansion unit dissipates heat into water in lower bottom water housing 83. Heated water in lower bottom housing, naturally moves into higher position into back wall water housing 84. After dissipating heat into the open space, the water cool down and comes down to the lower bottom water housing 82 in exchange for the hot water. Total volume of water in the water housing 83 and 84 may exceed the volume of water required to operate refrigerator for one hour by gaining 10 F without heat exchange with external air. Most of the refrigerators, requires total less than 5 gallons of water to operates.

- [56] Figure 11 illustrates an exemplary connection of the air source heat depot use in refrigerator. In accordance with an embodiment of the present invention, numbers 81, 82, 83, 84, 87 and 88 represents water flow, heat expansion unit, lower bottom water housing of refrigerator housing heat expansion unit, back wall water housing of the refrigerator, compressor and water circulating pump. The condensing unit is not shown in this figure. In active mode, compressor 87 emits hot refrigerant into heat expansion unit 82. Hot refrigerant in heat expansion unit dissipates heat into water in lower bottom water housing 82. Heated water in lower bottom housing, moves into higher position into back wall water housing 84 by water pump 88. In this configuration, back panel water housing is separated by the several layers to further exert stepwise temperature gradient. After dissipating heat into the open space, the water cool down and comes down to the lower bottom water housing 82 in exchange for the hot water in the lower bottom water housing 83. The water is circulated by the water circulating pump 88. Total volume of water in the water housing 83 and 84 may exceed the volume of water required to operate refrigerator for one hour by gaining 10 F without heat exchange with external air. Most of the refrigerators, requires total less than 5 gallons of water to operates according to the energy star guide.

### **Industrial Applicability**

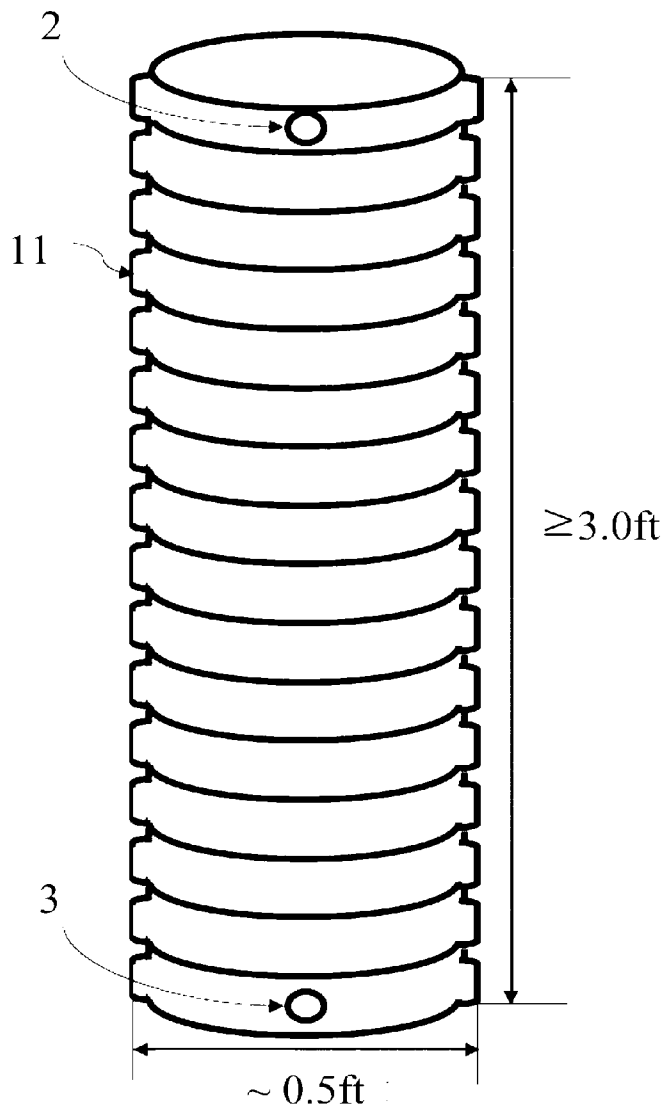
- [57] This system could be used in heat pump in the area with no extreme cold and other means such as refrigeration.
- [58] Although the invention herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the

present invention as defined by the appended claims.

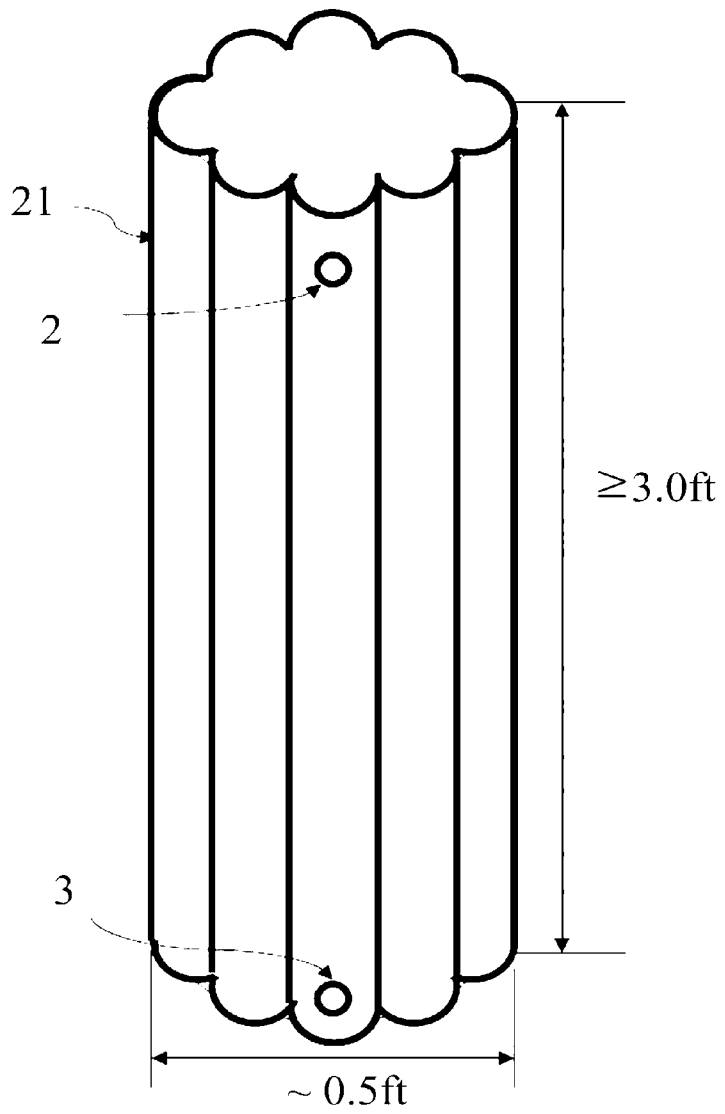
## Claims

- [1] A air source heat exchange method comprising a plurality of air source heat depots using water as an intermediate medium, wherein a heat depot comprises a sealed container filled with a heat exchange fluid, the container composed of a material allowing efficient heat transfer between the heat exchange fluid and a air external to the container, heat exchange method and device these heat depots intake heat exchange fluid from the heat pump, passing through heat depots sequentially and return heat exchange fluid back to the heat pump,
- [2] A heat exchange method and device in Claim 1, whose surface is open air.
- [3] A heat exchange method and device in Claim 1, whose heat exchange is conducted by the conduction of water and/or air.
- [4] A heat exchange method and device in Claim 1, where forced fan is used to provide forced air conduction.
- [5] A heat exchange method and device in Claim 4, where forced fan is activated when the temperature difference between inlet and outlet heatpump is below preset value.
- [6] A refrigeration system utilizing an air source heat exchange system comprising thin plate container filled with a heat exchange fluid, the container composed of a material allowing efficient heat transfer between the heat exchange fluid and a air external to the container, and thin plate container is a continuously channeled plate container located on the back, side and bottom of the refrigeration system; the heat exchange panel is located at the lower bottom of the thin layer container. In active mode of the refrigeration cycle, the heat is dissipated into the surrounding water in the lower bottom of the container. The warm water is circulated by the water pump through the compartmentalized of the thin layer plate.
- [7] A refrigeration system utilizing an air source heat exchange system in claim 6, where the thin plate container of about 3 gallon size.
- [8] A refrigeration system utilizing an air source heat exchange system filled with efficient heat exchange fluid to conduct heat exchange with air, comprised of thin layer plate located at bottom, side or upper wall; heat exchange plate is located at the bottom; and in active stage, heat is dissipated at the bottom of the container and heated water moves through the thin layer by water pump,
- [9] A refrigeration system utilizing an air source heat exchange system in claim 8, where the thickness of the thin layer plate is 0.5-1 inch and the volume of the thin-layer plate is about 3 gallon.

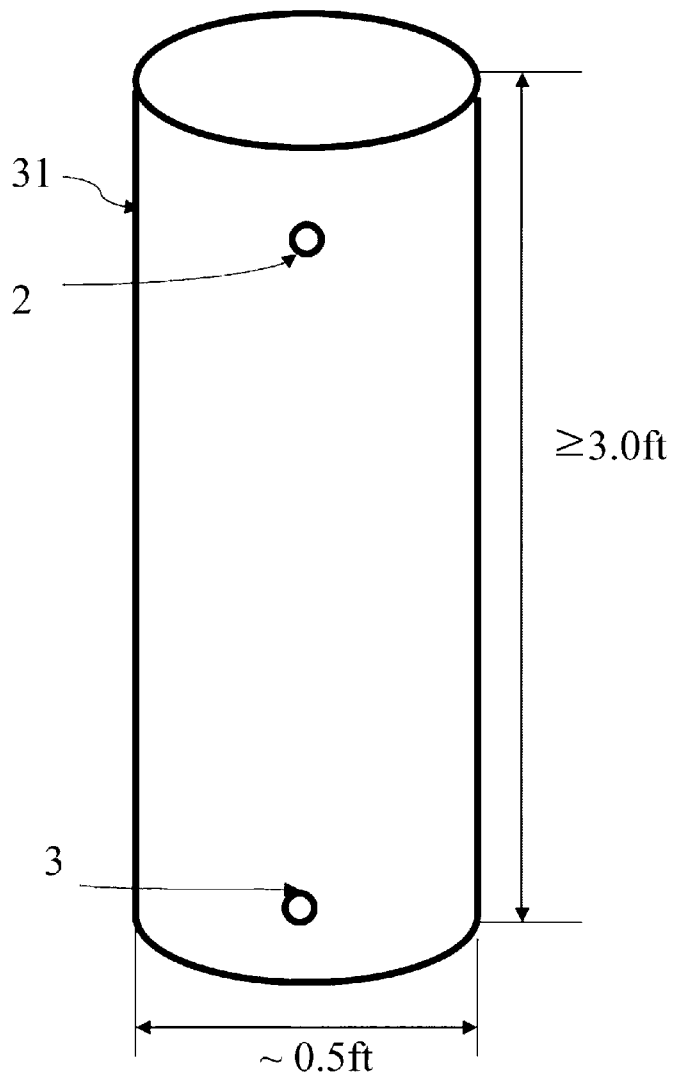
[Fig. 1]



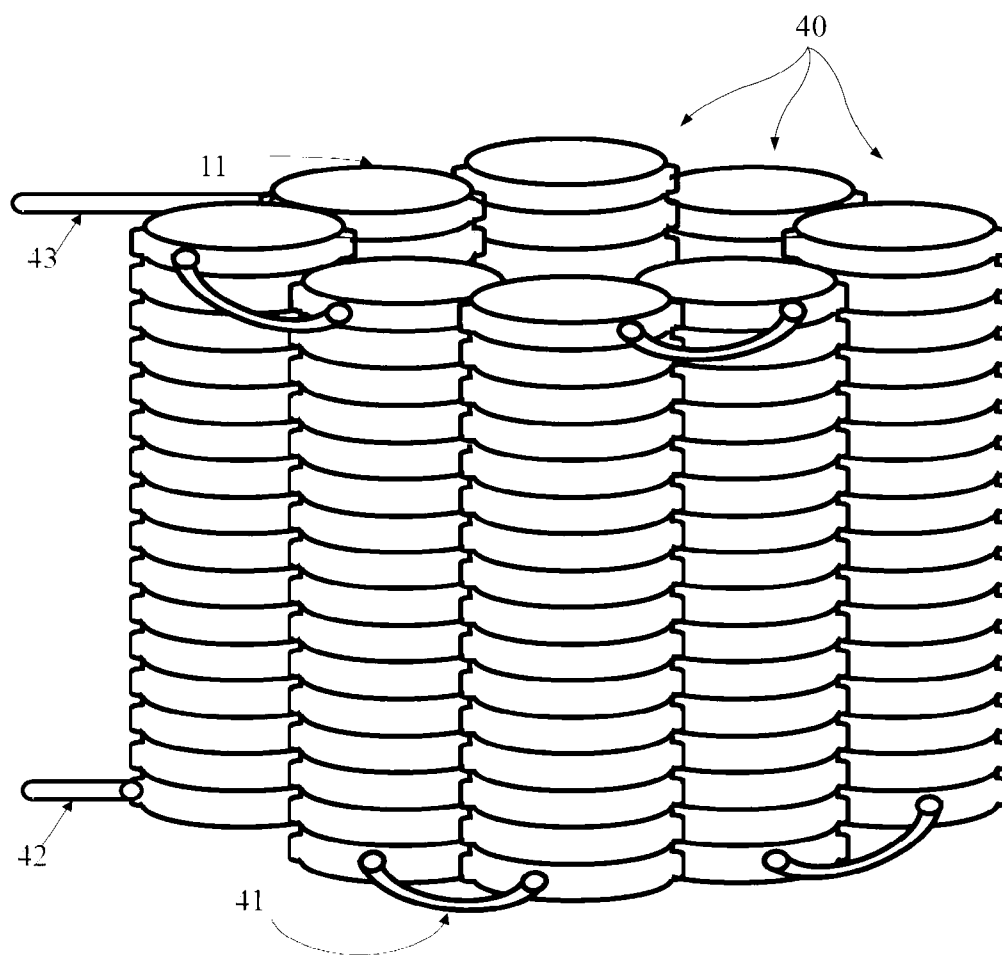
[Fig. 2]



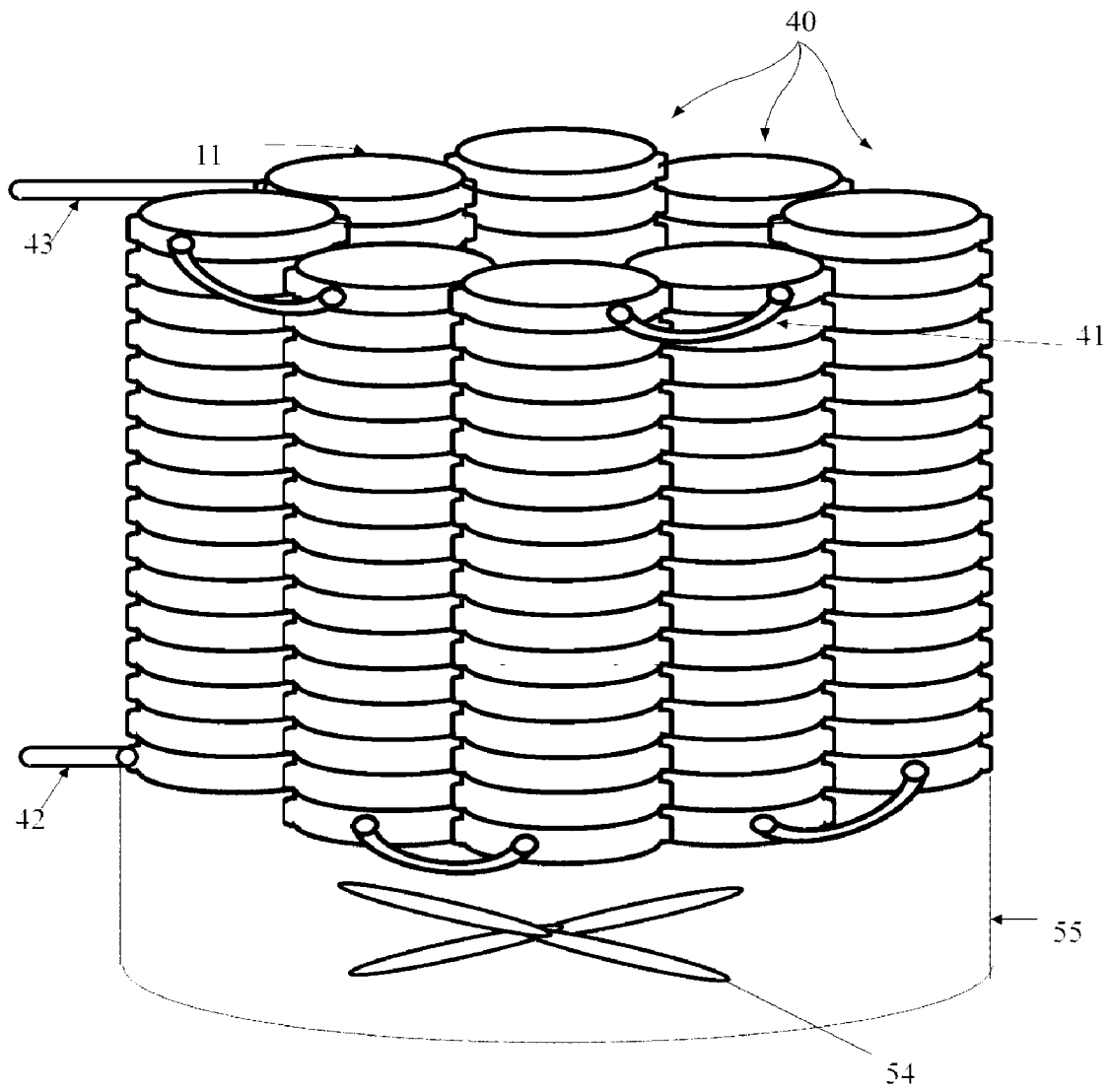
[Fig. 3]



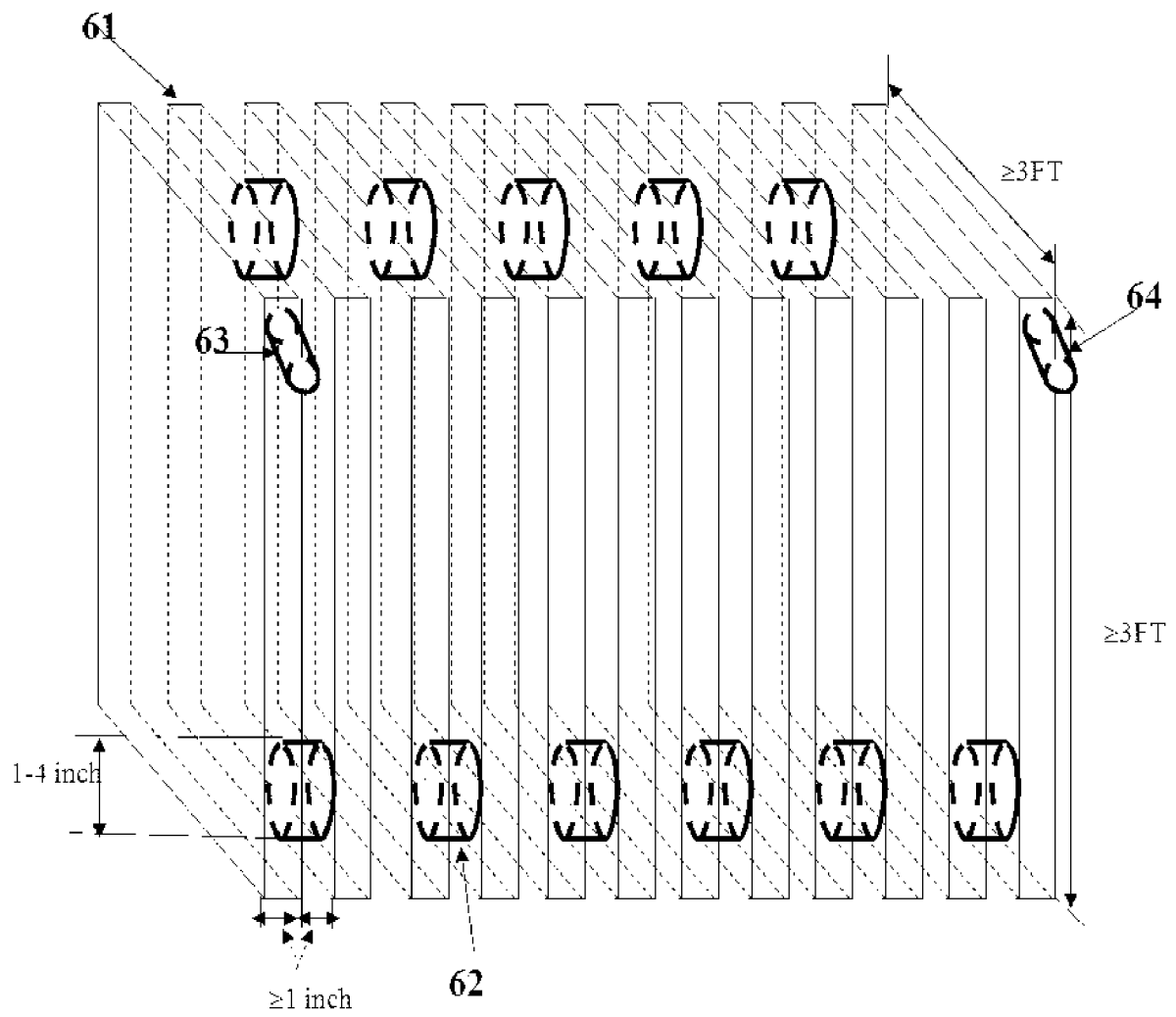
[Fig. 4]



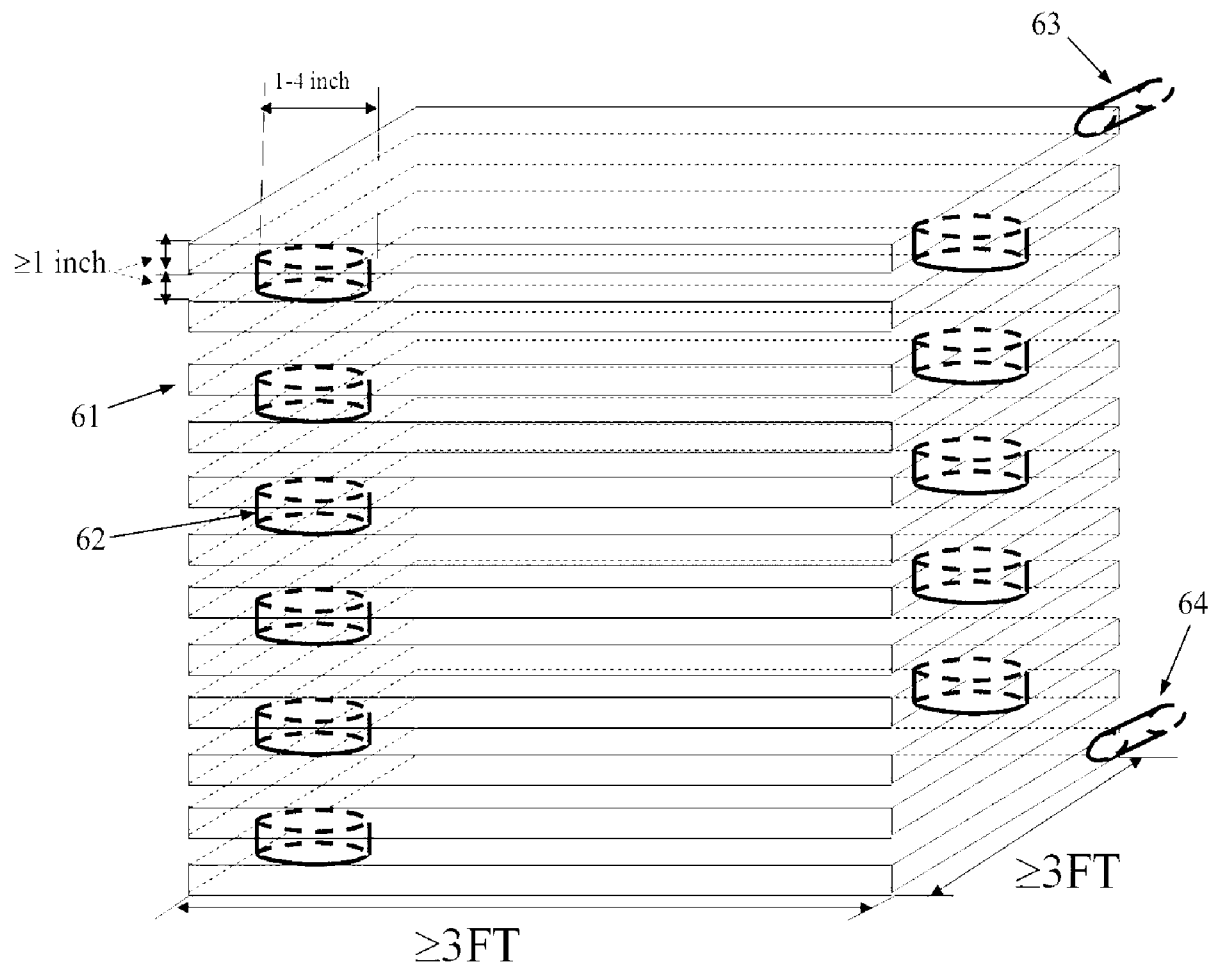
[Fig. 5]



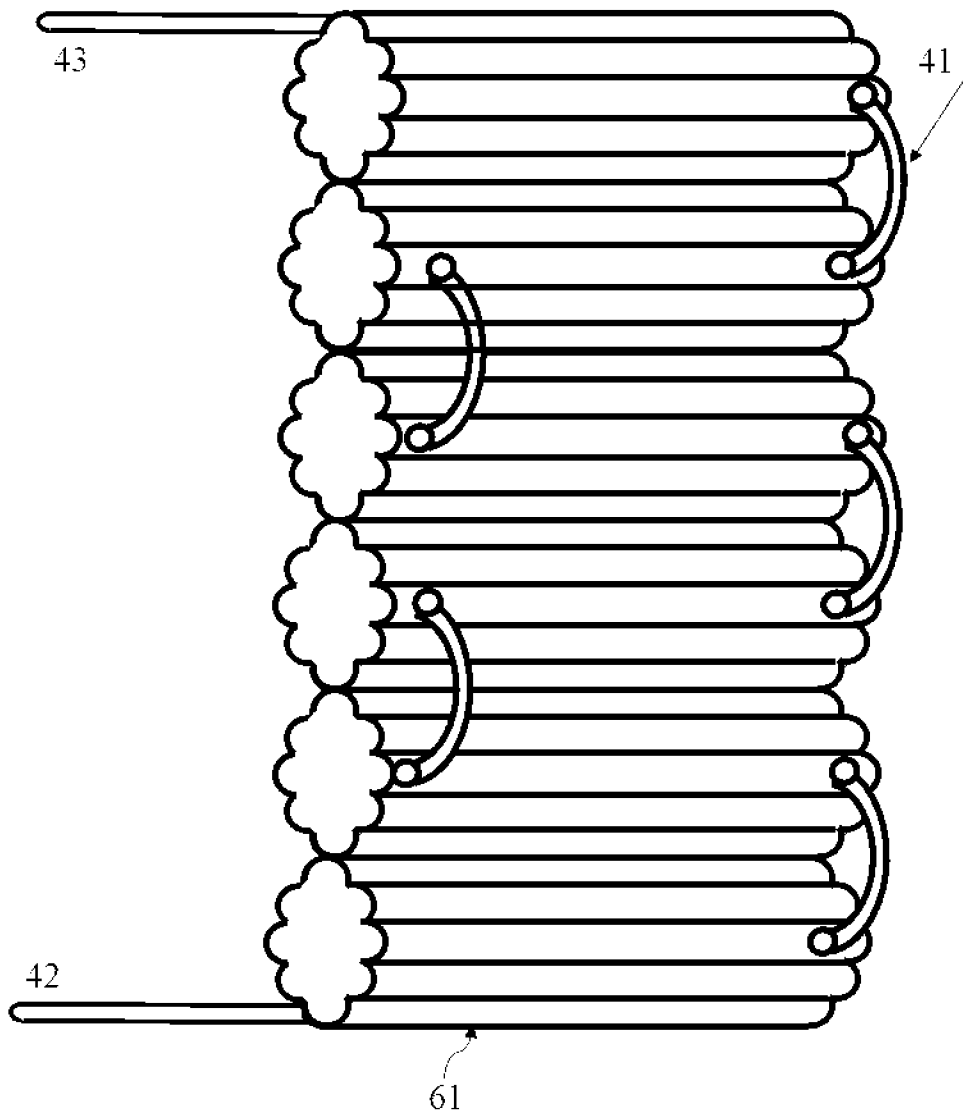
[Fig. 6]



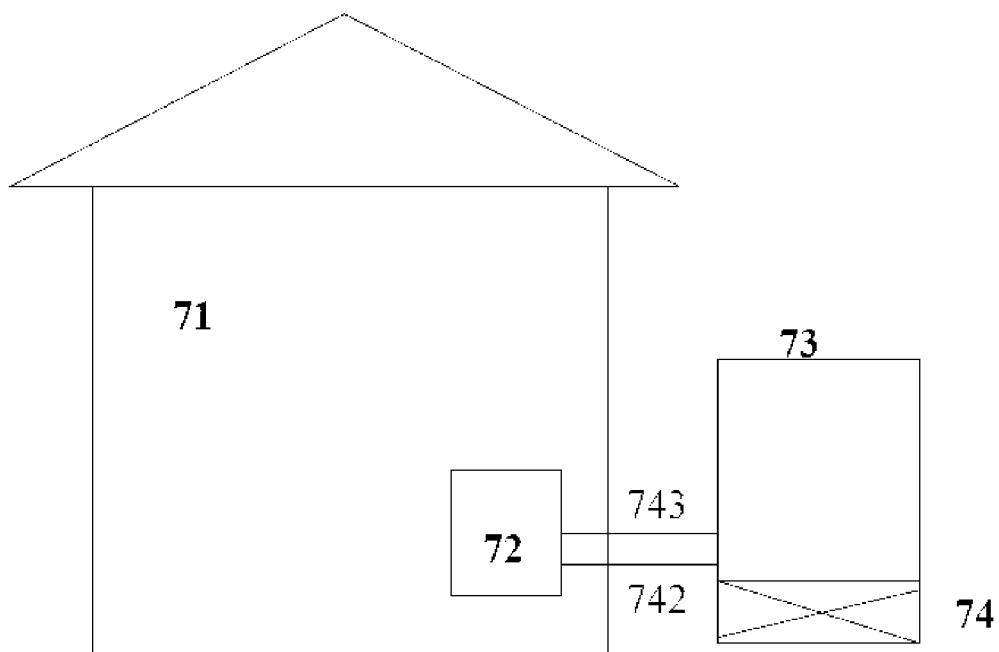
[Fig. 7]



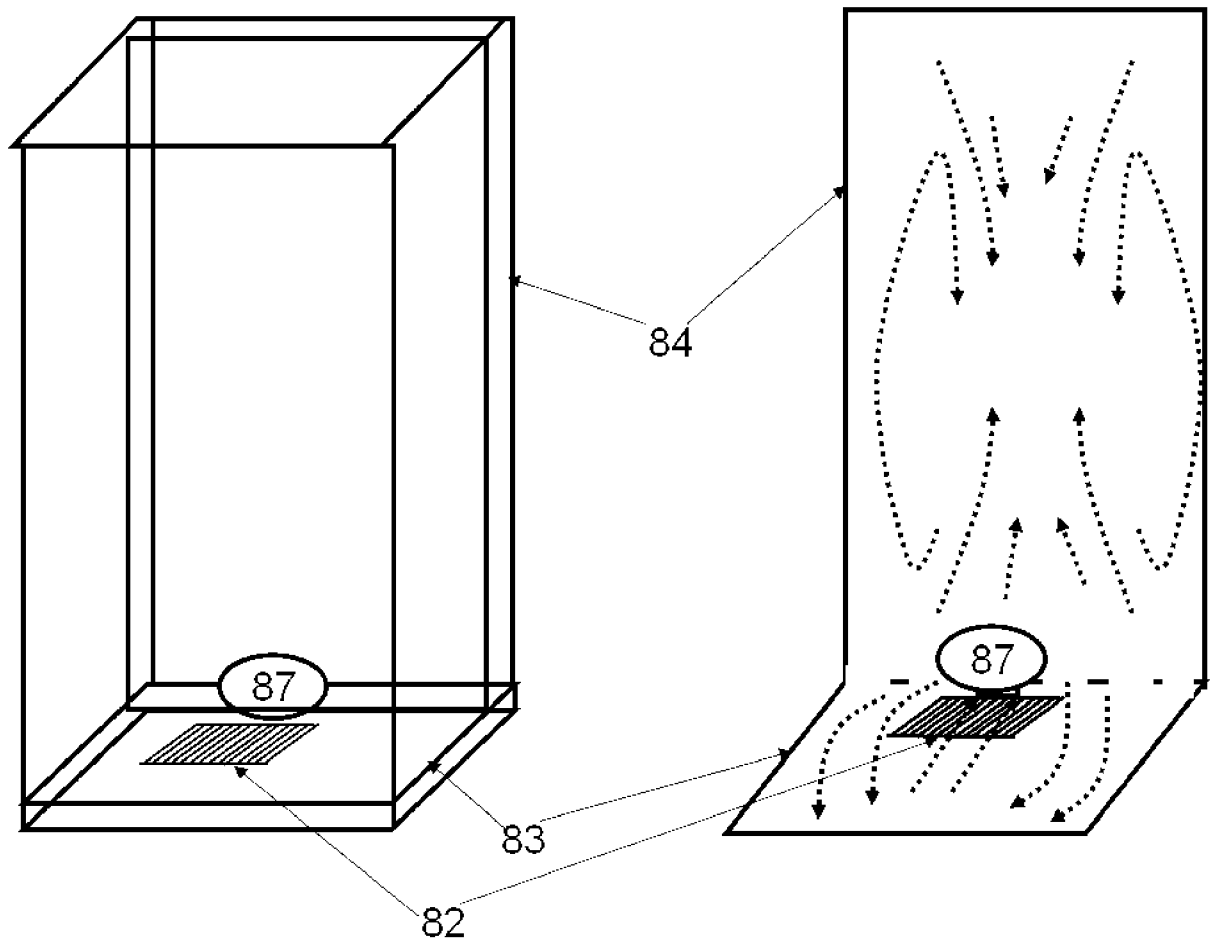
[Fig. 8]



[Fig. 9]



[Fig. 10]



[Fig. 11]

