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(54) HIGH EFFICIENCY COOLING AND HEATING APPARATUS

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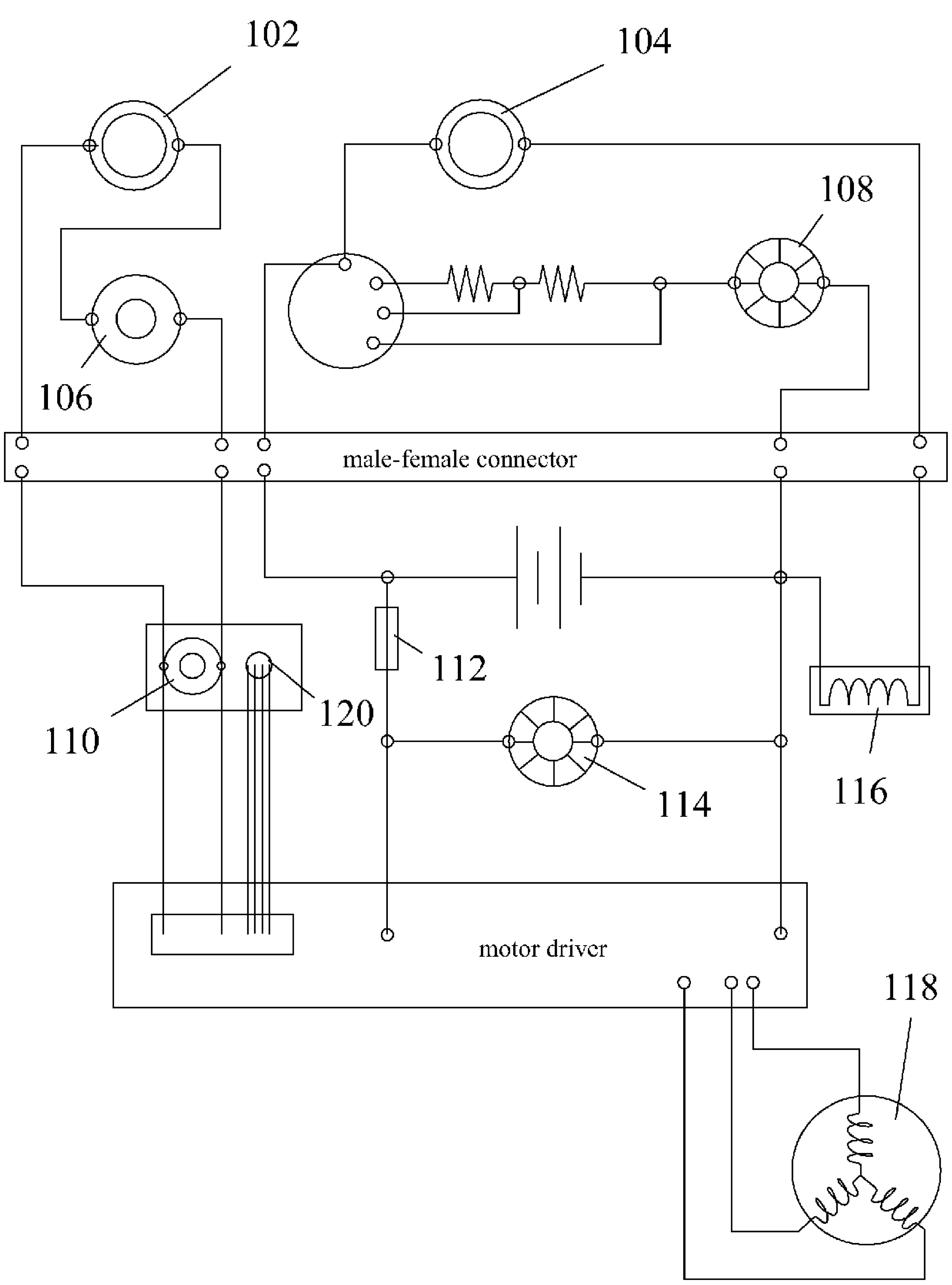
(57) **ABSTRACT**

A high efficiency cooling and heating apparatus comprises an outdoor condensing unit having a high speed fan disposed within a housing. Also disposed with the housing is a micro compressor run by a high speed brushless DC motor with a custom winding to increase efficiency and decrease weight. A control circuit allows the motor to operate at high speeds almost instantaneously. The fan pulls air across a dual condenser coil disposed within the housing. An indoor evaporative unit also houses a high speed fan along with a control circuit to allow an operator to select cooling or heating an air flow. The indoor and out door units are connected with hoses to provide heat exchange. The apparatus can be operated at a much higher ambient temperature than conventional air cooling and heating systems.



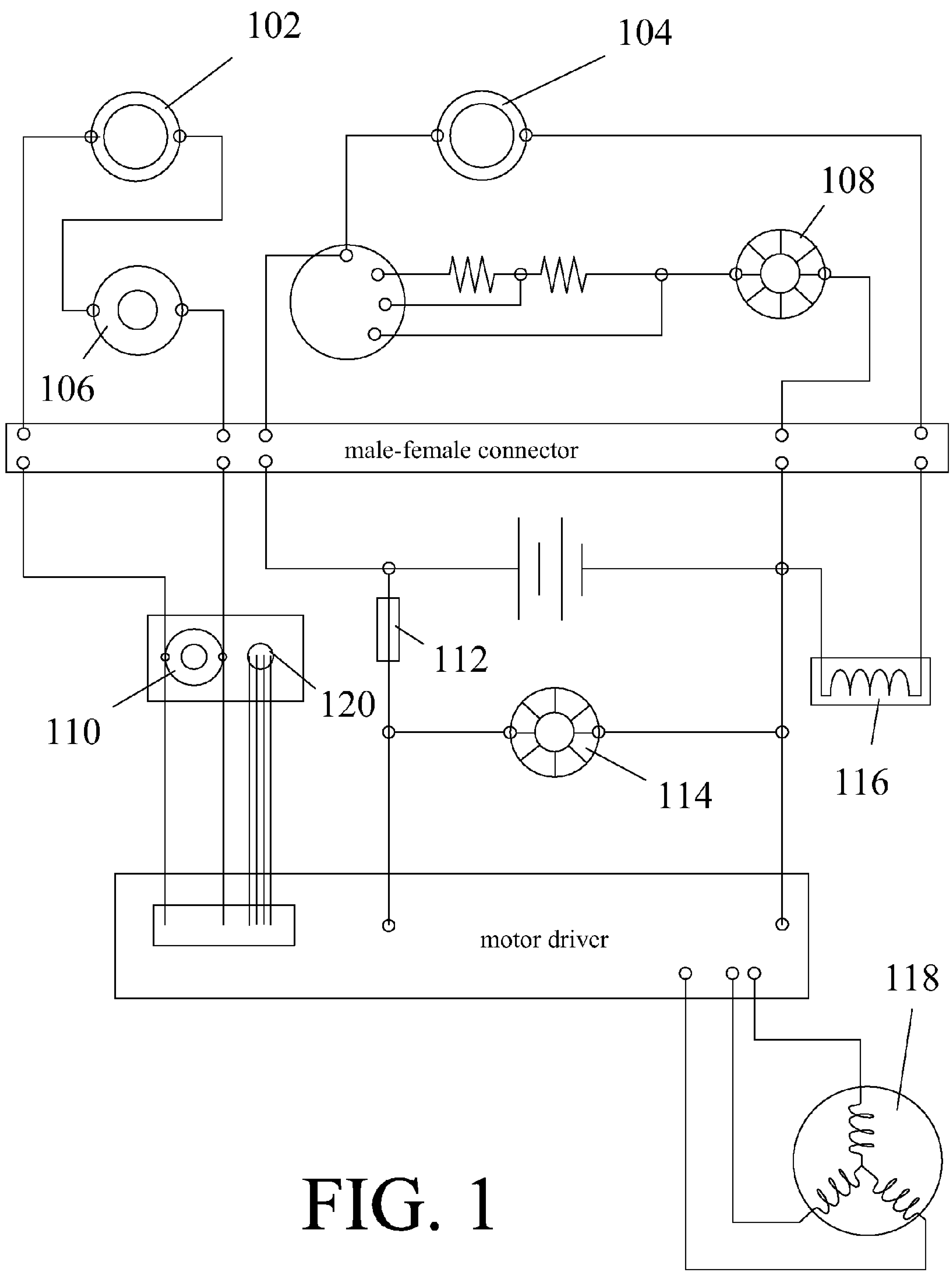

102
104
108
106
male-female connector
112
110
120
114
116
motor driver
118

FIG. 1

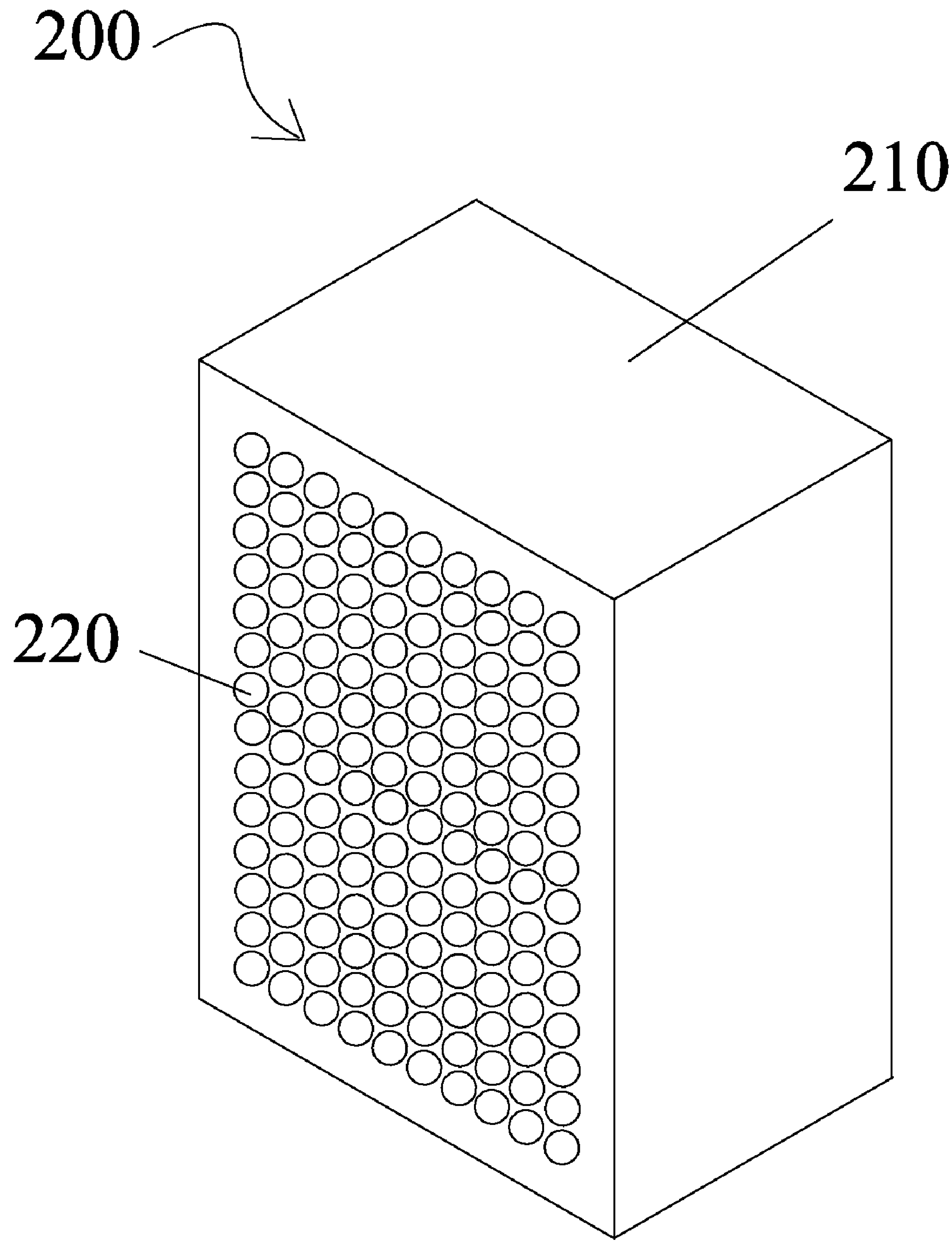


FIG. 2

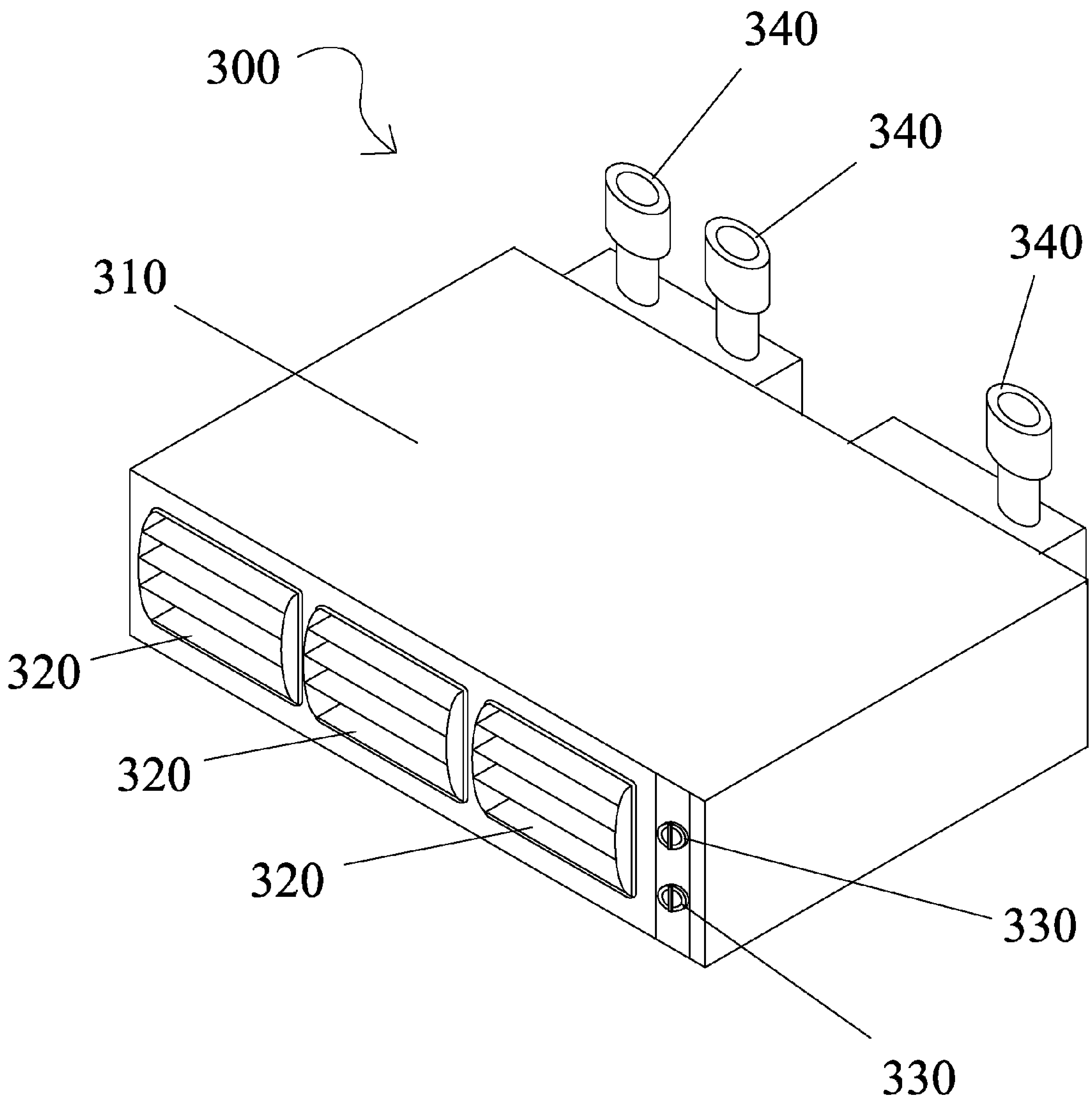


FIG. 3

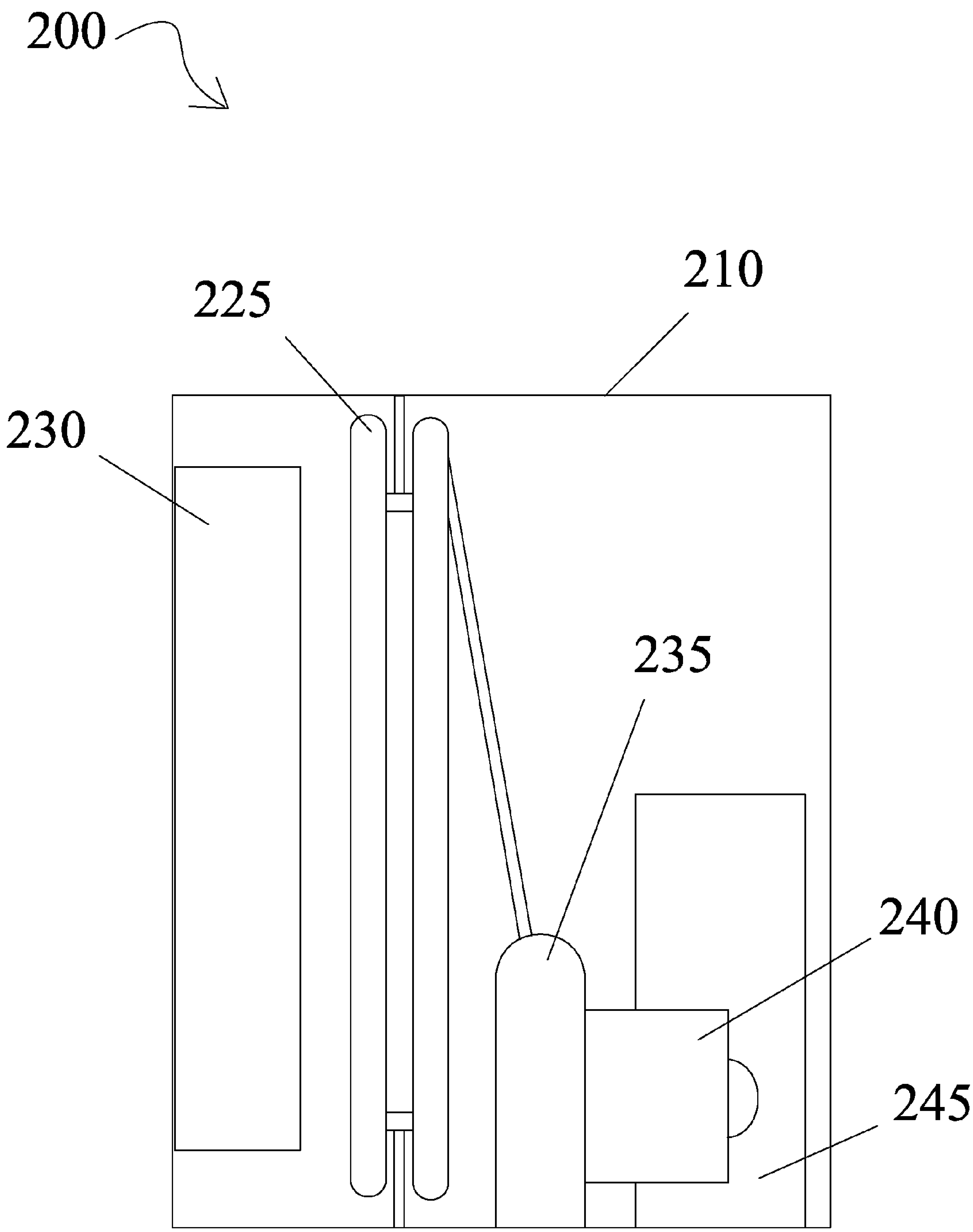


FIG. 4

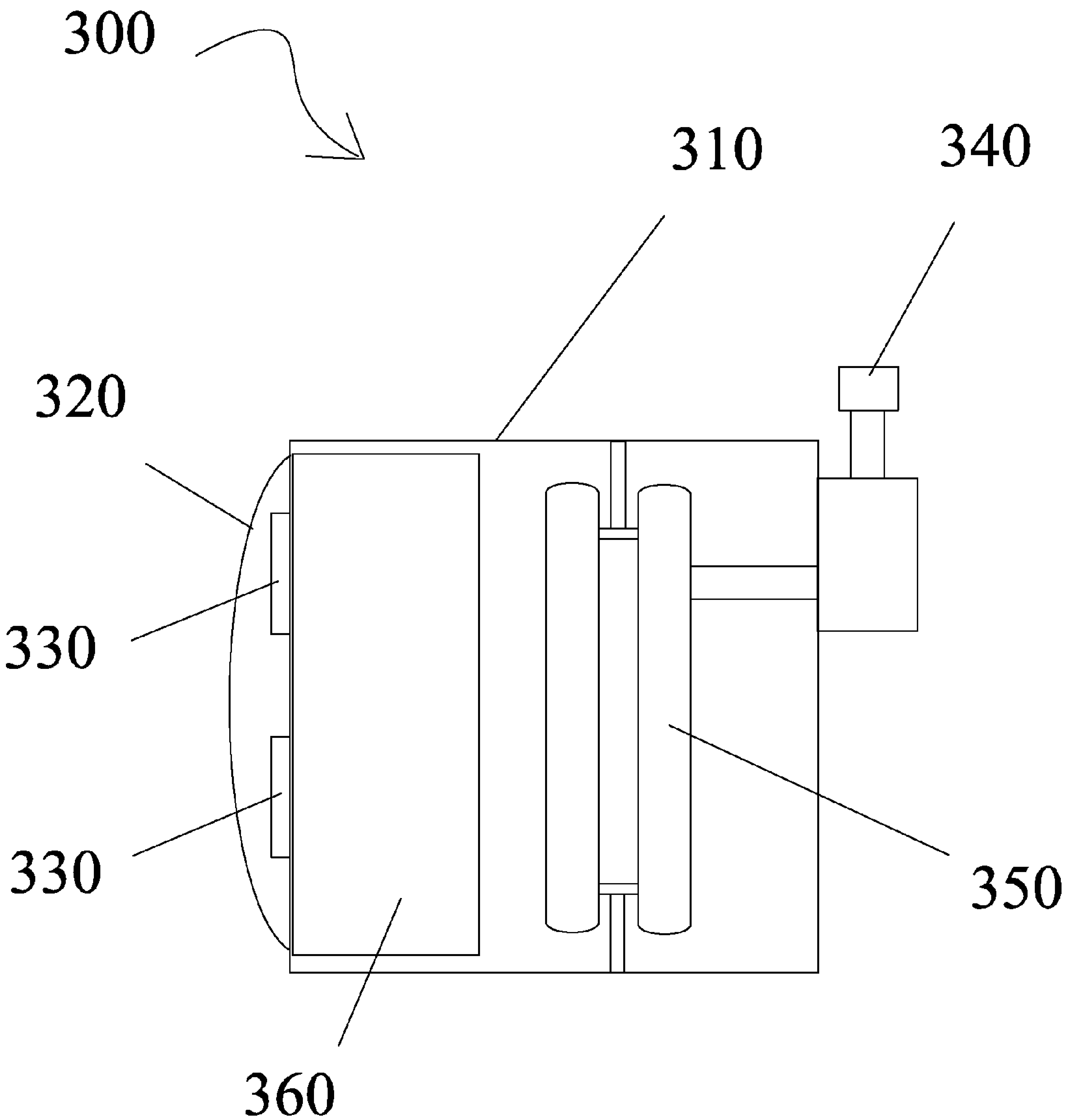


FIG. 5

HIGH EFFICIENCY COOLING AND HEATING APPARATUS

RELATED APPLICATIONS

[0001] This application claims priority and herein incorporates by reference U.S. provisional patent application 61/007,866, filed Dec. 17, 2007.

BACKGROUND OF THE INVENTION

[0002] Maintaining a comfortable temperature; cooling in hot ambient environments and heating in colder climates, is essential for human comfort and safety. This becomes critical when the space is limited and regular household or industrial AC power is unavailable. This is especially true for a moving vehicle where is not desirable to have an engine belt driven air conditioner. For example, the crew compartment in any Army Vehicle, such as a Tank which is heavily armored. In hot whether conditions, like in desert operations, the crew chamber gets extremely hot and to make matters worse, the hatch must be kept closed for safety and security reasons. Another example is in a stationary application such as a "Watchman" or observer cabin in a remote areas where a battery powered electric air conditioner is desirable to maintain a comfortable interior temperature in spite of any vagaries in outside temperature fluctuations. Also, in offshore oil platforms, the need for air conditioning to keep the crew members comfortable is clear. A problem with some prior art air conditioning systems is that they require significant power requirements and are generally heavy and bulky.

[0003] Weight is a big issue especially in applications such as those listed above where weight and space is limited.

[0004] Prior art "Vapor Compression" air conditioners are built to operate at a maximum ambient temperature of 113° F. (45° C.). In this condition the condensing temperature of refrigerant is about 120° F. (49° C.). If the ambient temperature rises beyond 113° F., then the condensing temperature also raises past 120° F. This makes the Compressor to shut off temporarily. When the ambient temperature drops, the compressor restarts automatically.

[0005] In the desert, the ambient may reach 130° F. (55° C.). In addition to the ambient heat load, there are other heat loads like engine, personnel emitting heat and the apparatus they use inside their chamber. The condensing temperature may reach 150° F. (65° C.). For prior art refrigerants, this temperature level is abnormal and ordinary compressors quit working.

[0006] Another problem is that the regular AC power may not be available in remote areas like cabins, off-shore oil platforms and in vehicles like military tanks. Air conditioners must be designed which will operate on battery power (DC power source). Also, the refrigerant condensing temperature must be brought down.

SUMMARY OF THE INVENTION

[0007] A high efficiency cooling and heating apparatus comprises an outdoor condensing unit having a high speed fan disposed within a housing. Also disposed with the housing is a micro compressor run by a high speed brushless DC motor with a custom winding to increase efficiency and decrease weight. A control circuit allows the motor to operate at high speeds almost instantaneously. The fan pulls air across a dual condenser coil disposed within the housing. An indoor evaporative unit also houses a high speed fan along with a control circuit to allow an operator to select cooling or heating an air flow. The indoor and out door units are connected with hoses to provide heat exchange. The apparatus can be operated at a much higher ambient temperature than conventional air cooling and heating systems.

[0008] Other features and advantages of the instant invention will become apparent from the following description of the invention which refers to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a circuit diagram for a high efficiency cooling and heating apparatus according to an embodiment of the present invention.

[0010] FIG. **2** is a perspective drawing of an outdoor condenser unit according to an embodiment of the present invention.

[0011] FIG. **3** is a perspective drawing of an indoor unit according to an embodiment of the present invention.

[0012] FIG. **4** is a side view of the outdoor condenser unit shown in FIG. **2**.

[0013] FIG. **5** is a side view of the indoor unit shown in FIG. **3**.

DETAILED DESCRIPTION OF THE INVENTION

[0014] In the following detailed description of the invention, reference is made to the drawings in which reference numerals refer to like elements, and which are intended to show by way of illustration specific embodiments in which the invention may be practiced. It is understood that other embodiments may be utilized and that structural changes may be made without departing from the scope and spirit of the invention.

[0015] Referring to FIG. **1**, a circuit diagram of a high efficiency cooling and heating apparatus is shown having a compressor switch **102** in electrical communication with a thermostat **106** connected to a bus. A heating switch **104** is provided for heating operation. An evaporator fan **108** is a high output type for efficient movement of air across the evaporative coils. A condenser fan **114** is also provided to efficiently move air across the condenser coils.

[0016] Again condenser fan **114** is a high efficiency type fan. A mini circuit breaker **112** is provided to prevent damage to the system. A solenoid **116** is provided to allow operation in cooling mode or heating mode. An on/off switch **110** is provided to operate the unit. A speed controller **120** controls operating speed of the unit. A mini compressor with DC brushless motor **118** is provided to allow high speed operation at greatly improved efficiency.

[0017] Referring now to FIGS. **2** through **4**, a high efficiency cooling and heating apparatus **200** is shown having a housing **210** having a plurality of air openings **220** for allowing air to travel across a dual row of condensing coils **225**. A high speed and powerful fan **230** is used to pull air through coils **225** which greatly lowers the refrigerant condensing temperature which leads to much greater range of operating temperatures than is possible with prior art devices. A micro compressor **235** provides the necessary compression of a super efficient refrigerant such as Ikon B or R132a. Ikon B is a non-flammable, non-ozone depleting and ultra efficient refrigerant compared with R22 and other refrigerants which are extensively used in today's air conditioning industry. The use of Ikon B increases the system efficiency by additional

25%. Micro compressor **235** is made of aluminum to reduce weight and to increase thermal efficiency.

[0018] A high speed brushless DC motor **240** is used to operate micro compressor **235**. Motor **240** is designed with a custom winding to achieve higher RPMs (Revolutions per Minute) of up to 7,600. This causes about a 35% reduction in size and about a 50% reduction in its weight. Higher RPMs results in the reduction of amount of refrigerant displacement per one rotation. This reduced displacement allows compressor **235** to be more compact.

[0019] A control circuit and power source **245** is provided to control the operation of high efficiency cooling and heating apparatus **200**. Control circuit **245** utilizes advanced electronics to cause motor **240** to operate at very high speed as soon as the unit is switched-on. This enables micro compressor **235** to operate at higher efficiency.

[0020] An indoor evaporative unit **300** is shown having a housing **310**, containing a plurality of air louvers **320** which can be positioned to direct cool or warm air as selected by a user. Switches **330** provide control such as on/off, cool/heat air flow speed, etc. A plurality of connectors **340** are used to connect inside unit **300** with outside unit **200** with hoses (not shown).

[0021] Indoor unit **300** has heat exchanger **350** mounted within housing **310**. A high speed DC fan **360** causes air to flow through air louvers **330**. Air will either be cooling or heating depending on the user selection of solenoid **116** that directs the direction of flow.

[0022] Specific Examples of Prototypes.

[0023] 1. Out Door Unit (Heat Exchanger)

[0024] Body: Stainless Steel (1.00 mm thick)

[0025] Dimensions=15.0 (Left to Right)×12.25 (Front to Back)×12.5 (Top to Bottom) in Inches b) Weight=35.0 Pounds c) Interior: Contains Heat exchanger with 30,000 Hours brush less D.C. Fan and

[0026] Hermitically sealed DC micro compressor; capable of both heating and cooling.

[0027] 2. Indoor Unit: (Heat Exchanger)

[0028] Body: Stainless Steel (1.00 mm thick) Dimensions=15.5 (Left to Right)×13.0 (Front to Back)×7.0 (Top to Bottom) in Inches) Weight=20 Pounds

[0029] Interior Unit: Contains Heat exchanger with 30,000 Hour D.C. Fan

[0030] 3. Electrical:

[0031] Input Voltage=24 Volts, D.C. (22 to 28 Volts Range)

[0032] Operating Current=33.84 Amp. D.C. (MAX: 38.83 A)

[0033] Operating Power=812 Watts (MAX: 919.2 W)

[0034] 4. Air Flow, BTUs and Temperature:

[0035] From Indoor Unit=470 Cubic Meter per Hour

[0036] Air Temp from Indoor Unit=Approx 70 F

[0037] Cooling Capacity=8,100 BTU/hr

[0038] Heating Capacity **32** 10,000 BTU/hr

[0039] Operating Temperature=10 F to 140 F (−12.8 C to +60 C)

[0040] 5. Mechanical:

[0041] Out door unit is mechanically fastened with the Welded Brackets and supported by springs

[0042] Indoor Unit is attached to the inside wall by 1.0 Inch Steel Screws. Any other suitable mechanical fastening may be adopted if necessary.

[0043] 6. Supplemental Personal Cooling System:

[0044] Three individual Cell Phone size "Solid State Cooling" devices are available any time to get cold relief via rapid cooling of forehead, cheeks and neck area. These wirelesses devices come with self recharging batteries. They are placed on recharging stands, thus they are recharged when not in use. The crew or its passengers may just pick up these devices from the stand and press a red button on it. This makes the "Cold and Smooth" blue disc reach almost freezing temperatures in less than 30 seconds. Gently press this smooth disc against cheeks, forehead and neck to get instant cool relief. After using, replace it on its charging stand. This allows the personal cooler to be charged and ready for use whenever desired.

[0045] HEAT LOAD CALCULATION for Use in Vehicle (Military Tank):

[0046] 1. Conduction and Convection: The heat infiltration through the insulated Crew Cabin walls due to both conduction and convection from all its 6 sides (Qc): From 140 degree F. ambient (Max) to Cabin's interior temp 70 degree F.:

$$Q_c = \frac{A \times DT}{x/k + 1/h}$$

[0047] Where:

[0048] Qc=Heat Flow in BTU/hour

[0049] A=Total area of all 6 sides in square feet

[0050] DT=Temperature difference between ambient and interior of crew compartment in degree F.

[0051] x=thickness of insulation in feet* (1.0+0.02)/12=0.085 Ft.

[0052] k=Thermal conductivity in BTU/(hr ft^2 F) (for example: Polyisocyanurate, k=0.01)

[0053] h=Thermal convection coefficient (For Turbulent air, h=15 to 20)

*Super insulation: Polyisocyanurate has an 'R' value of 8 (Per Inch Thickness). In addition to this, a 20 mil thick (0.02 inch) coat of Ceramic paint called "Supertherm®" (Energy Star Rated Green) is sprayed on external walls of crew compartment. This enhances the insulation capacity, anticorrosion as well as serving as a sound barrier. This paint's color is transparent. Any die may be added to get a particular color if so desired.

[0054] These super insulations are approved by FDA and used in Food Storage and deep freezing.

Example

[0055] Insulation: Polyisocyanurate Super Insulation Thickness "x"=1.0 inch=0.083 ft+20 mil Supertherm® Ceramic Spray.

[0056] Where A=420.3 ft^2.

[0057] DT=(140° F.−70° F.)=70° F.

[0058] k=0.01 (R−Factor: R=1/12k=1/12×0.01=8.3)

[0059] h=20 (for Turbulent Air)

[0060] x=1.02/12=0.085 ft

$$Q_c = \frac{420.3 \times 70}{\left(\frac{0.085}{12} + \frac{1}{20}\right)}$$

[0061] Q_c=3,442 BTU/hr

[0062] 2. Heat Infiltration Due to Radiation: $Q_r=(\sigma)(A)(\epsilon)(T_h^4-T_c^4)$

[0063] Where:

[0064] Q_r=Heat flow due to radiation in BTU/hr

[0065] σ=Stefan-Boltzmann Constant=1.71 4×10^{-9} BTU/(hr-ft^2-$^0R^4$)

[0066] ϵ=Emissivity Min=0 (Example: Smooth light surface)

[0067] Max=1 (Black Body, non-smooth surface) 0.030 (approx) for tank's steel surface

[0068] A=Area of exposed surface in ft^2

[0069] T_h=Absolute temperature of warmer surface in °R (459.67+140)

[0070] T_c=Absolute temperature of colder surface in °R (459.67+70)

[0071] R=Rankine Absolute Zero Temperature=(459.67+°F.)

[0072] $Q_r=(1.714\times10^{-9})(420.3)(0.030)((599.67)^4-(529.67)^4)$

[0073] Q_r=1,098 BTU/hr

[0074] 3. Heat Load Due to Active Crew Members (Q_h)

[0075] Every Active adult human being generates about 200 BTU/hr on the average. Three crew members=600 BTU/hr +Energy Dissipated by Meters +Misc=400 BTU/hr

[0076] Q_h=1,000 BTU/hr

[0077] 4. Heat Infiltration through the back wall due to Main Engine (Q_e)

[0078] Main Engine is rated at about 1050 HP (Mounted in rear).

[0079] Approximately 30% of useful Mechanical Power is derived from this I.C. engine.

[0080] Wasted heat is =70%=0.7 ×1050 HP=735 HP=735×746×3.41 Wasted heat=1,869,737 BTU/hr

[0081] High volume air blower mounted at the rear will blast all most all of the heat to the tail end side of the tank, away from front end.

[0082] Giving an allowance of one-tenth of one percent of heat will still infiltrate into crew through the insulated back wall, then:

[0083] Heat Load due to main engine=(0.1/100)×1,869,737=1,869.7 BTU/hr

[0084] In the trial application if this allowance seems not enough then we may have to increase the back wall insulation. But this is highly unlikely.

[0085] Q_e=1,870 BTU/hr

[0086] Total BTU's of heat that must be removed per hour:

[0087] $Q_t=Q_c+Q_r+Q_h+Q_e$

[0088] Total heat load:

[0089] Q_t=3,442+1,098+1,000+1,870

[0090] Q_t=7,410 BTU/hr

[0091] This is the amount of heat that must be removed from the crew cabin to maintain the interior temperature around 70° F.

[0092] Although the instant invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art.

What is claimed is:

1. A high efficiency cooling and heating apparatus comprises:
- a first housing;
- a condenser coil disposed within said first housing;
- a fan mounted in front of said condenser coil;
- said fan arranged to pull air through said condenser coil;
- a high speed brushless DC motor disposed within said first housing;
- a micro compressor disposed within said first housing and driven by said high speed brushless DC motor;
- a heat exchanging unit in thermodynamic communication with said micro compressor; and
- a control circuit in electrical communication with said fan and said high speed brushless motor.

2. The high efficiency cooling and heating apparatus according to claim **1** wherein said first housing is made of aluminum.

3. The high efficiency cooling and heating apparatus according to claim **1** wherein said high speed brushless DC motor is designed with a custom winding to achieve up to 7,600 revolution per minute.

4. The high efficiency cooling and heating apparatus according to claim **3** wherein said control circuit is adapted to allow said high speed brushless DC motor to operate at a high speed as soon as unit is switched on.

5. The high efficiency cooling and heating apparatus according to claim **1** wherein said condenser coil is filled with a super efficient refrigerant.

6. The high efficiency cooling and heating apparatus according to claim **5** wherein said super efficient refrigerant is Ikon B.

7. The high efficiency cooling and heating apparatus according to claim **5** wherein said super efficient refrigerant is R132a.

8. The high efficiency cooling and heating apparatus according to claim **1** further comprising a switching means for switching said high efficiency cooling and heating apparatus from operating in a cooling or heating mode.

9. The high efficiency cooling and heating apparatus according to claim **8** wherein said switching means is a solenoid.

10. The high efficiency cooling and heating apparatus according to claim **1** wherein said high speed brushless DC motor has a coefficient of performance of approximately 3.5.

11. The high efficiency cooling and heating apparatus according to claim **1** wherein said heat exchanging unit further comprises:
- a second housing;
- a heat exchanging coil disposed within said second housing; and
- a DC powered fan mounted in front of said heat exchanging coil.

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