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**Ritchey**

(54) **WATER CONDENSER**

(76) Inventor: **Jonathan Gale Ritchey**, Vernon (CA)

Correspondence Address:
**ANTONY C. EDWARDS**
**SUITE 200 - 270 HIGHWAY 33 WEST**
**KELOWNA, BC V1X 1X7 (CA)**

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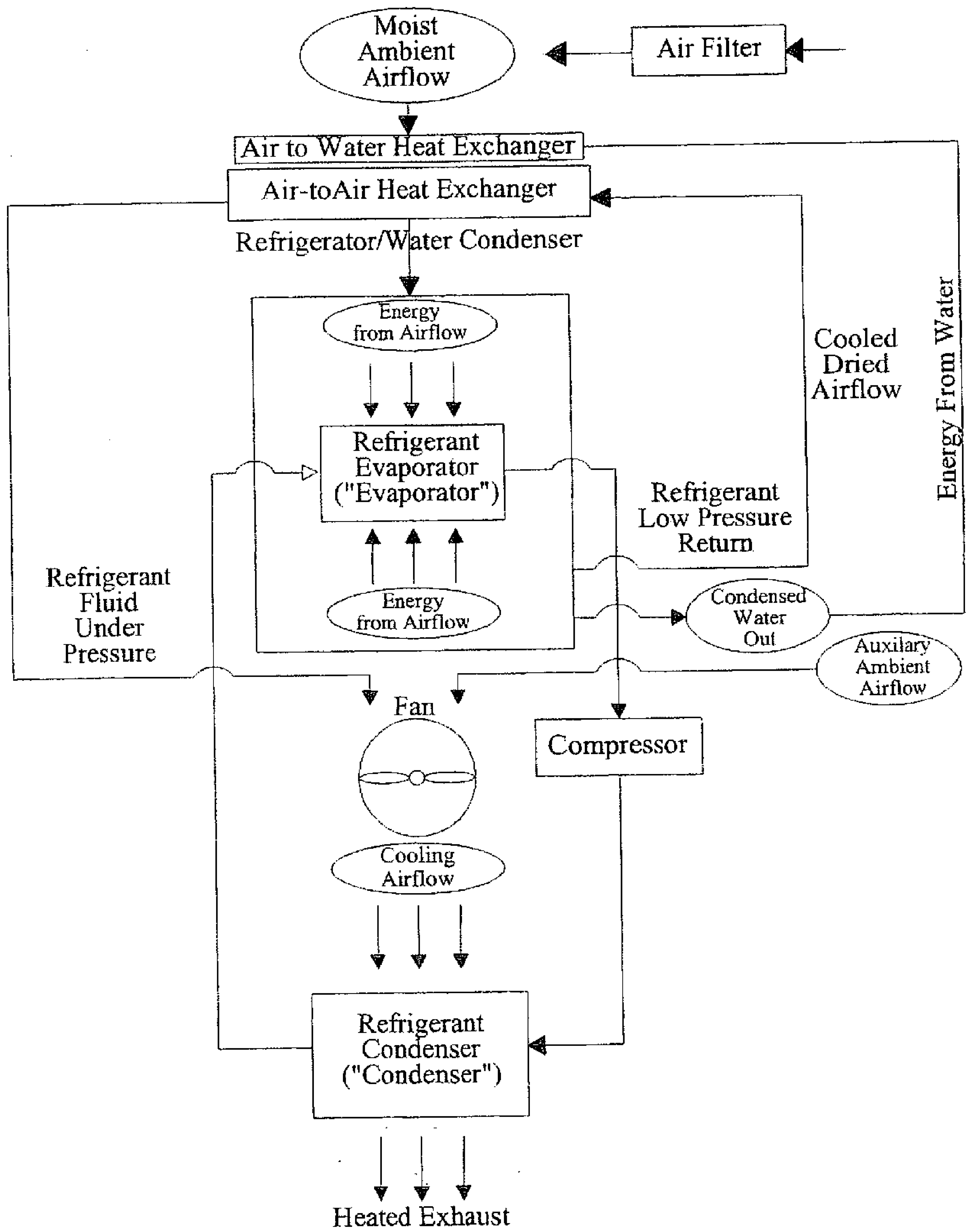
(57) **ABSTRACT**

A water condenser includes a fan which draws a primary airflow through an upstream refrigerant evaporator, through an air-to-air heat exchanger and in one embodiment also an air-to-water heat exchanger uses cold water collected as condensate from the evaporator, the airflow to the evaporator being pre-cooled by passing through the air-to-air heat exchanger and the air-to-water heat exchanger prior to entry into the evaporator wherein the airflow is further cooled to below its dew point so as to condense moisture onto the evaporator for gravity collection. The evaporator is cooled by a closed refrigerant circuit. The refrigerant condenser for the closed refrigerant circuit may employ the fan drawing the airflow through the evaporator or a separate fan, both of which drawing an auxiliary airflow separate from the airflow through the evaporator through a manifold whereby both the auxiliary airflow and the airflow through the evaporator, or just the auxiliary airflow are guided through the condenser and corresponding fan.



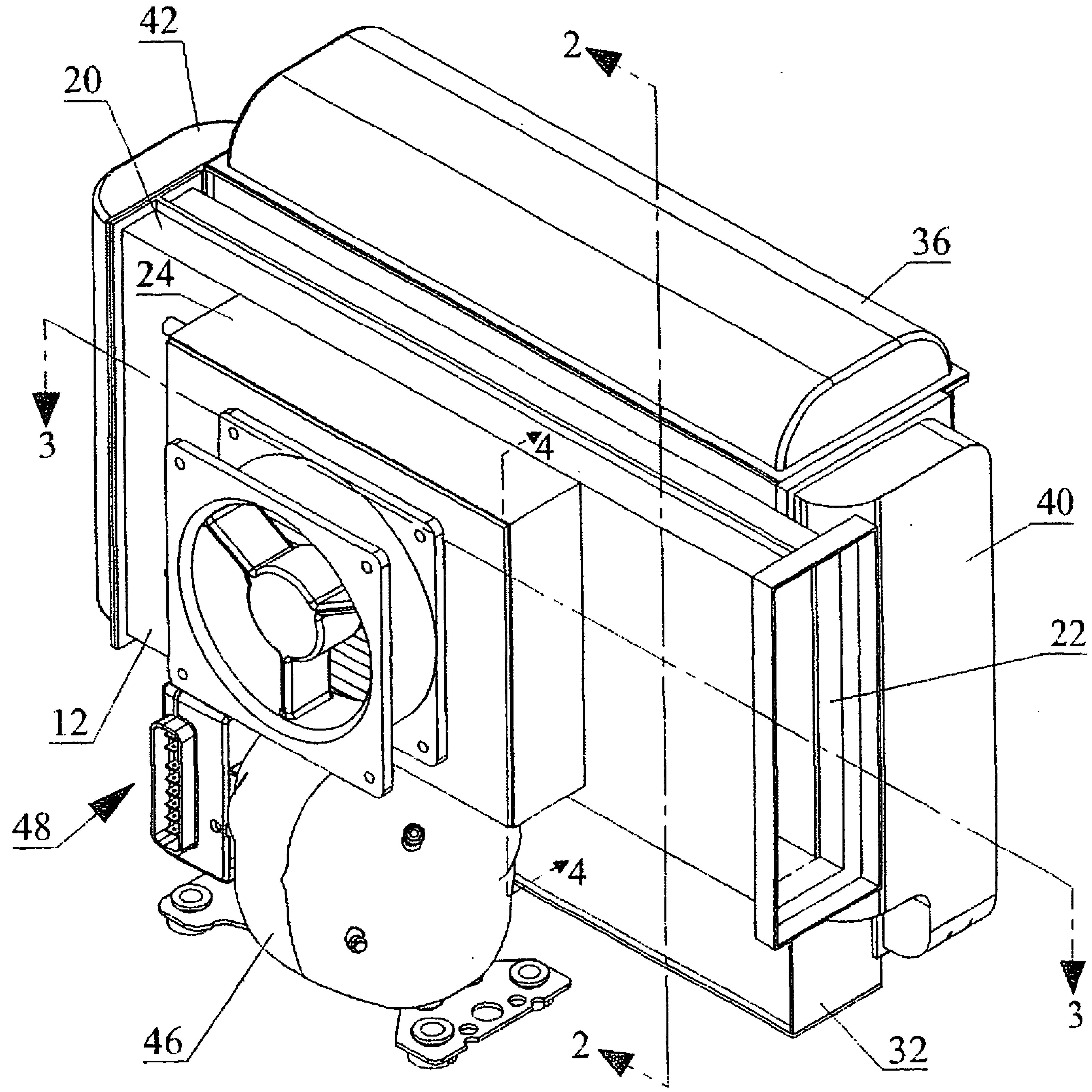



Fig 1

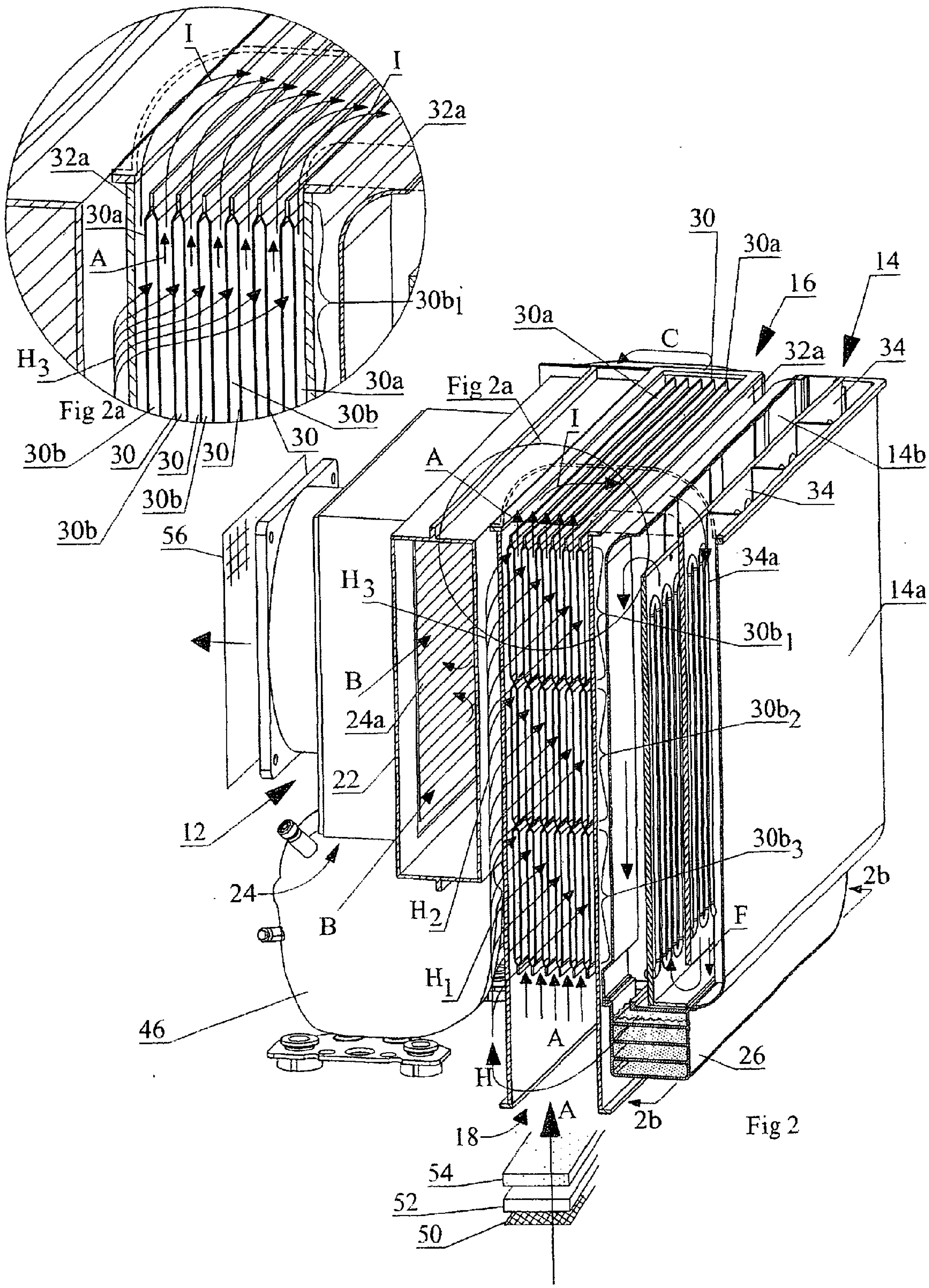

I
I
32a
32a
30a
A
30b1
H3
30a
Fig 2a
30b
30b
30
30
30
30
30b
30b
56
30
30a
16
14
30a
C
32a
34
Fig 2a
A
I
14b
34
34a
14a
H3
30b1
B
24a
30b2
22
12
30b3
24
B
H2
2b
F
H1
46
A
26
H
18
A
2b
54
52
50

Fig 2

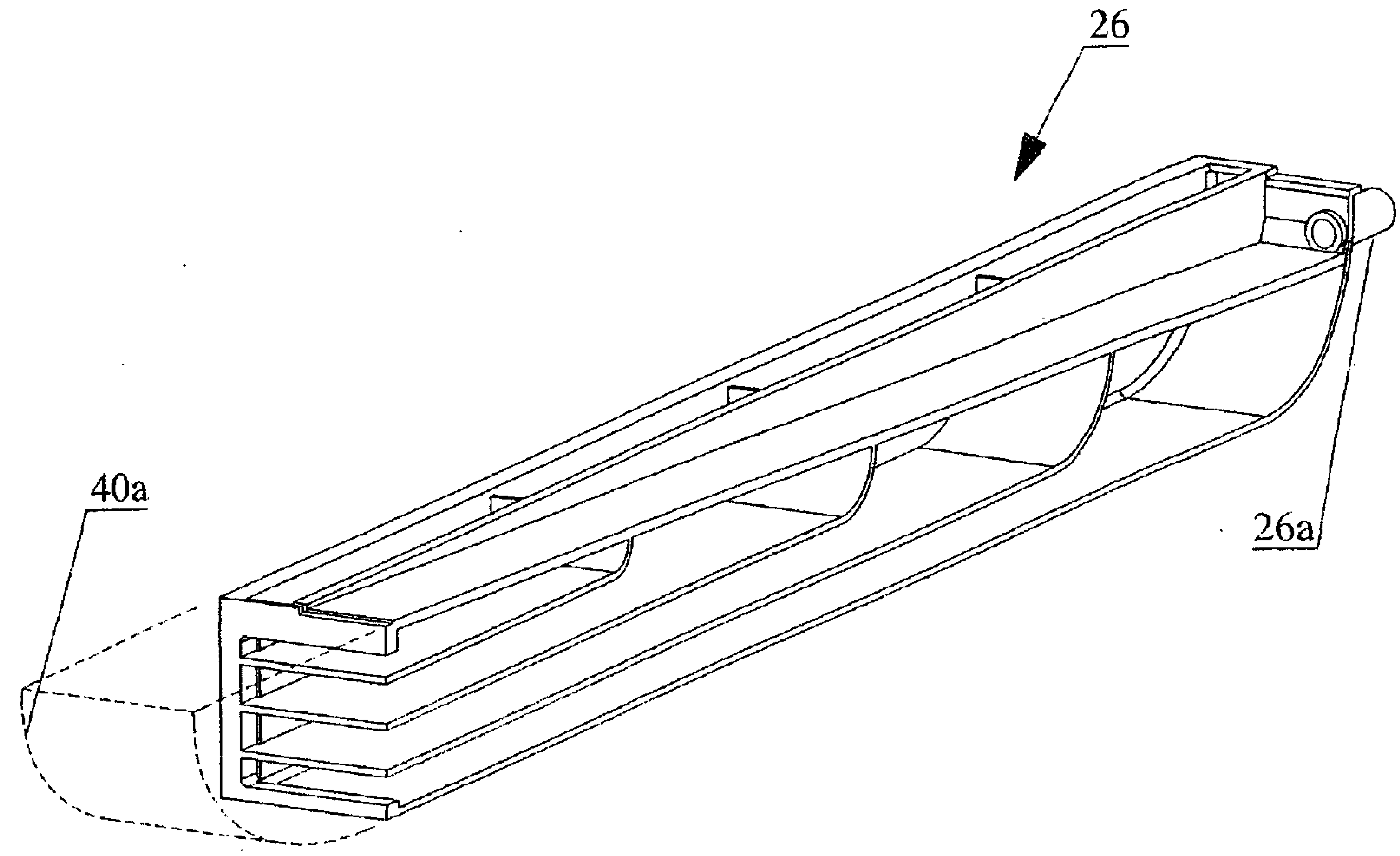
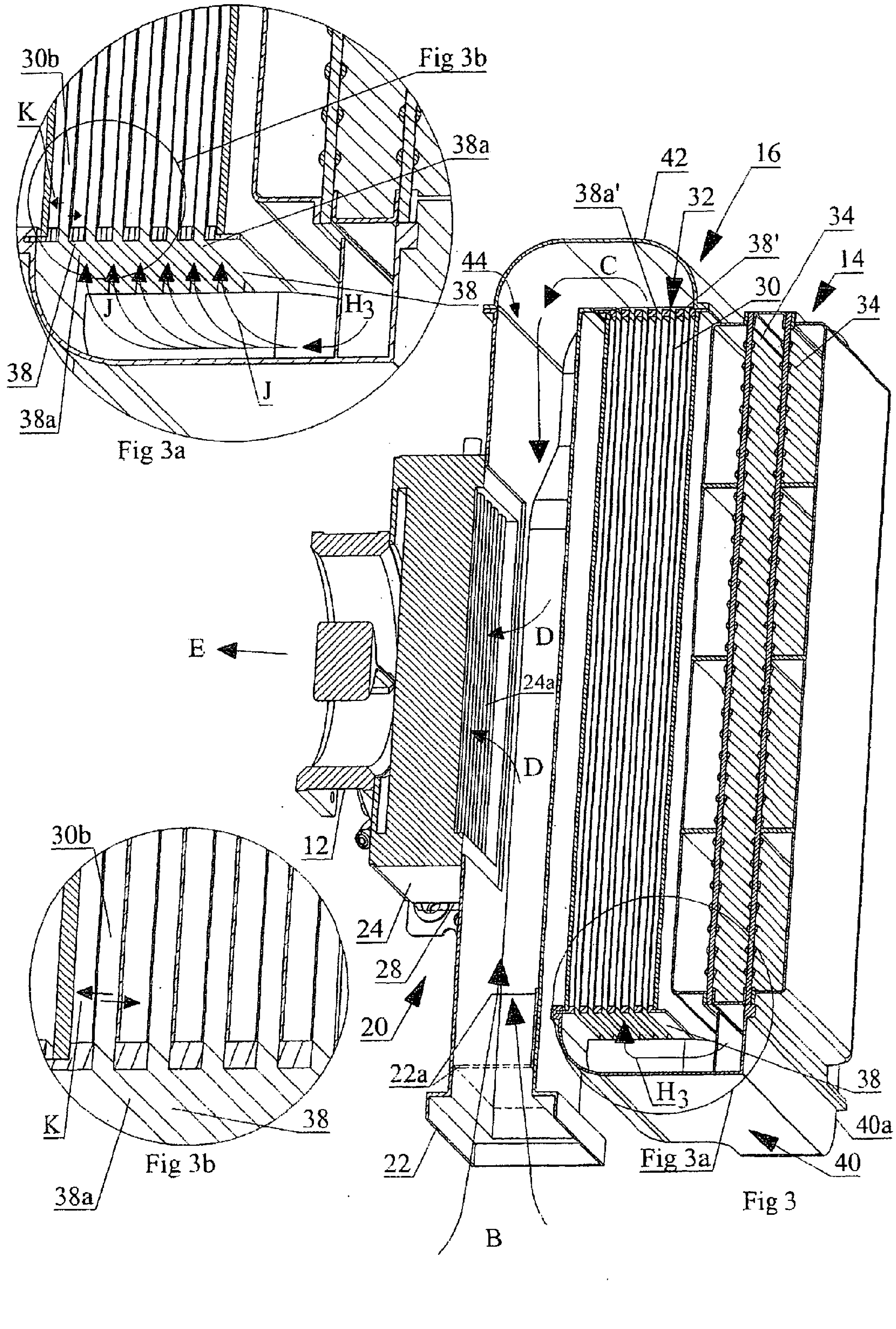



Fig 2b


30b
K
Fig 3b
38a
38
J
H3
38
38a
J
Fig 3a
42
16
38a'
32
34
38'
44
C
14
30
34
D
E
24a
D
12
30b
24
28
20
22a
38
H3
K
38
40a
22
Fig 3a
40
Fig 3b
38a
Fig 3
B

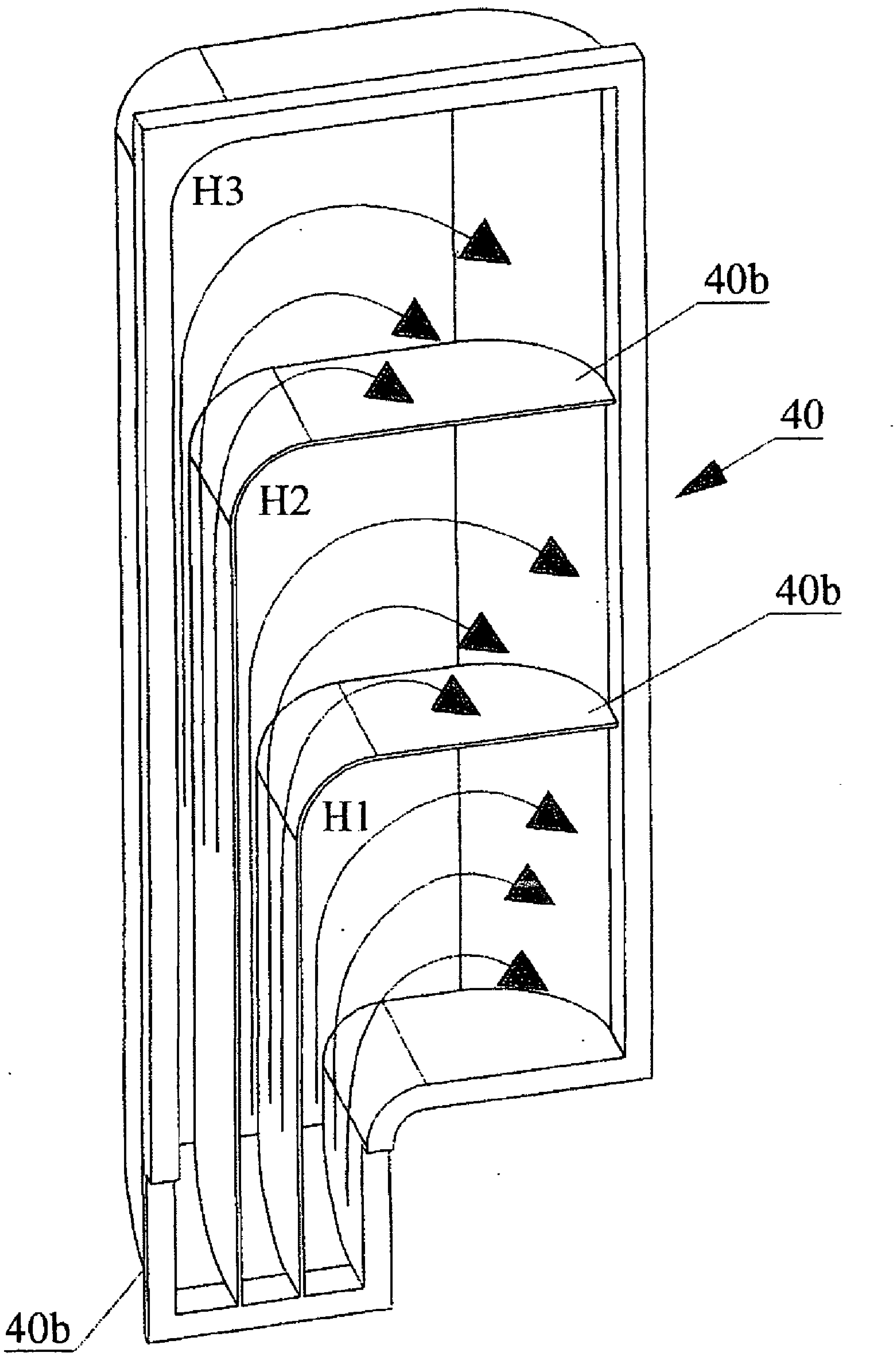



Fig 3c

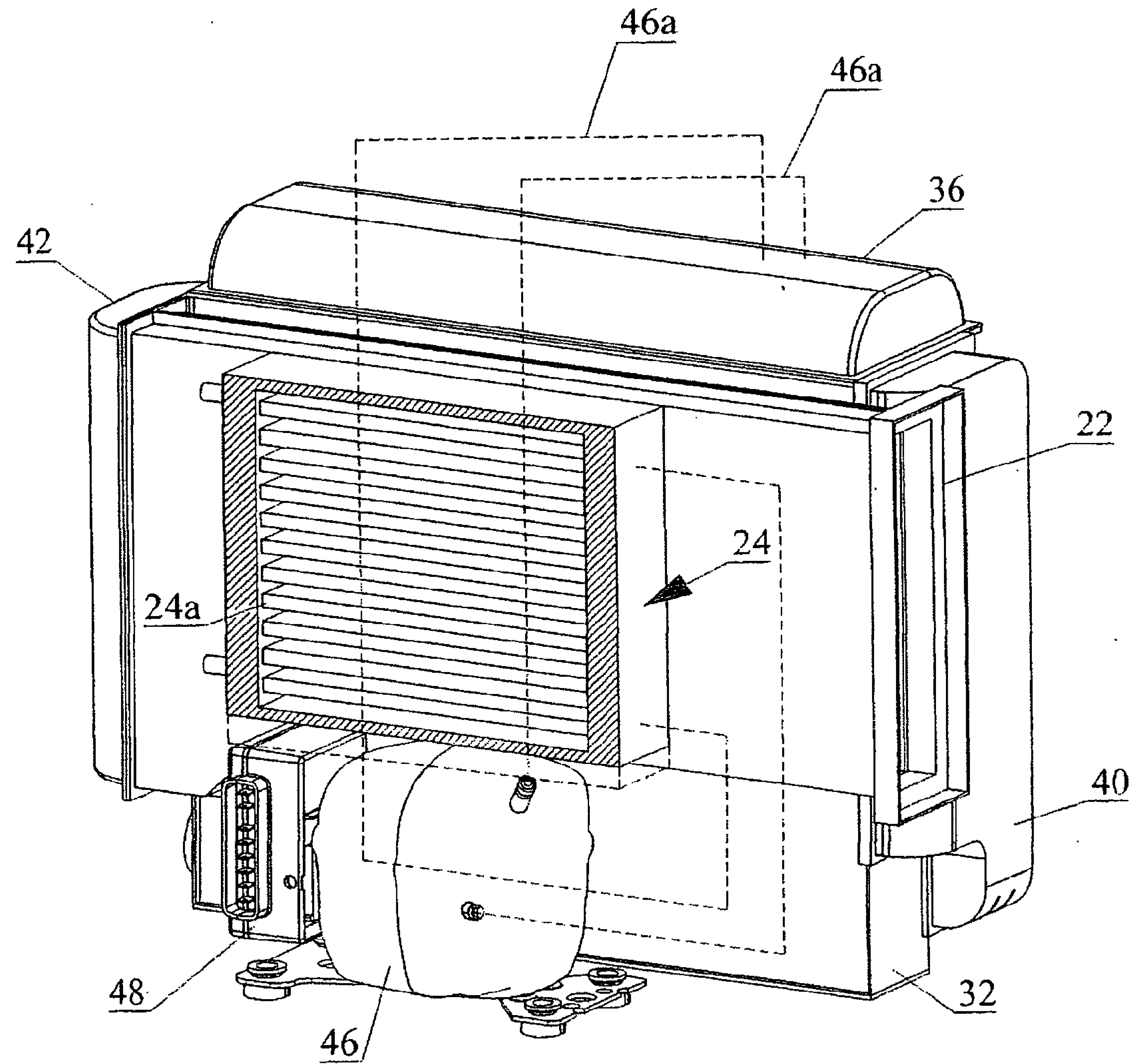



Fig 4

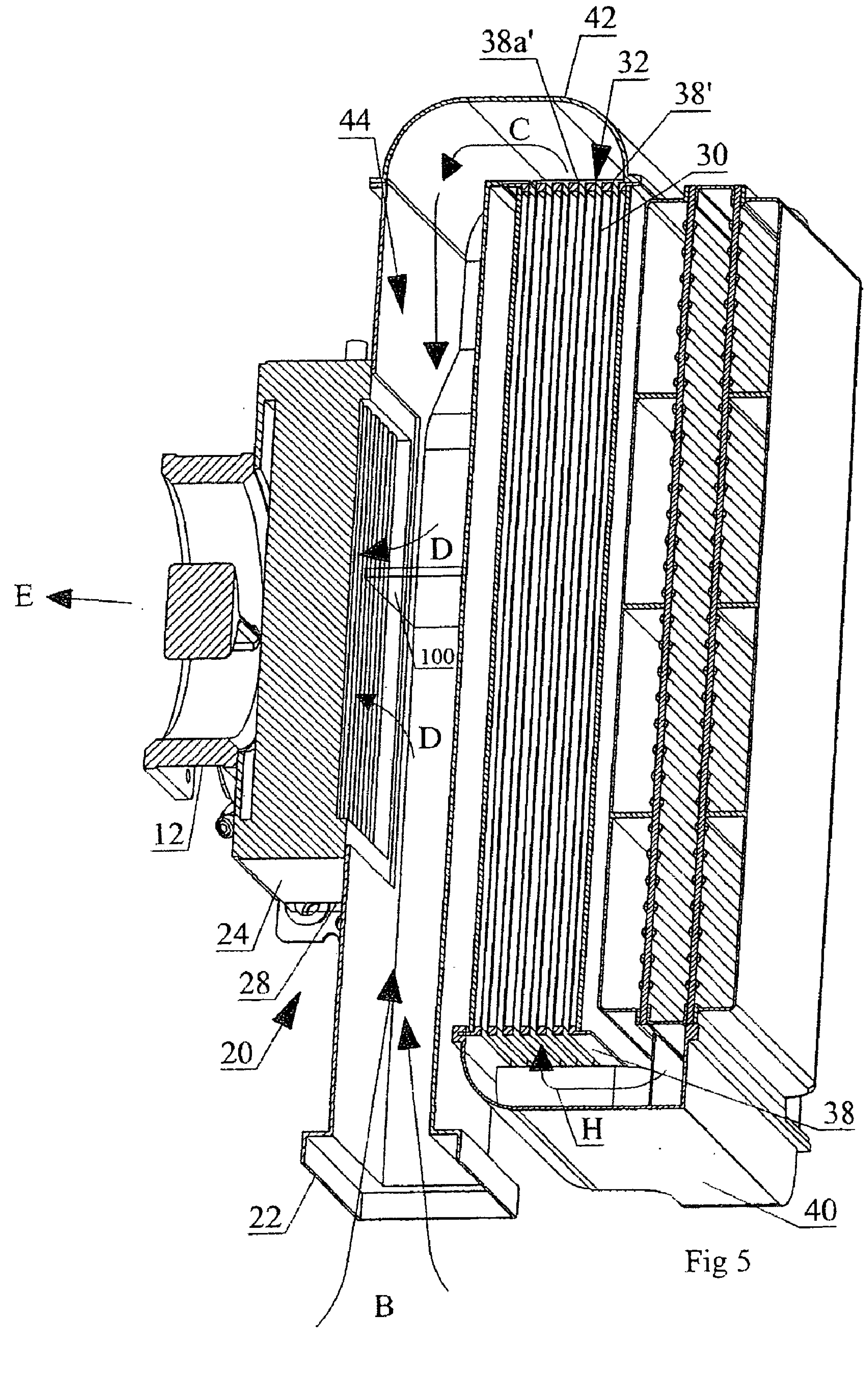



Fig 5

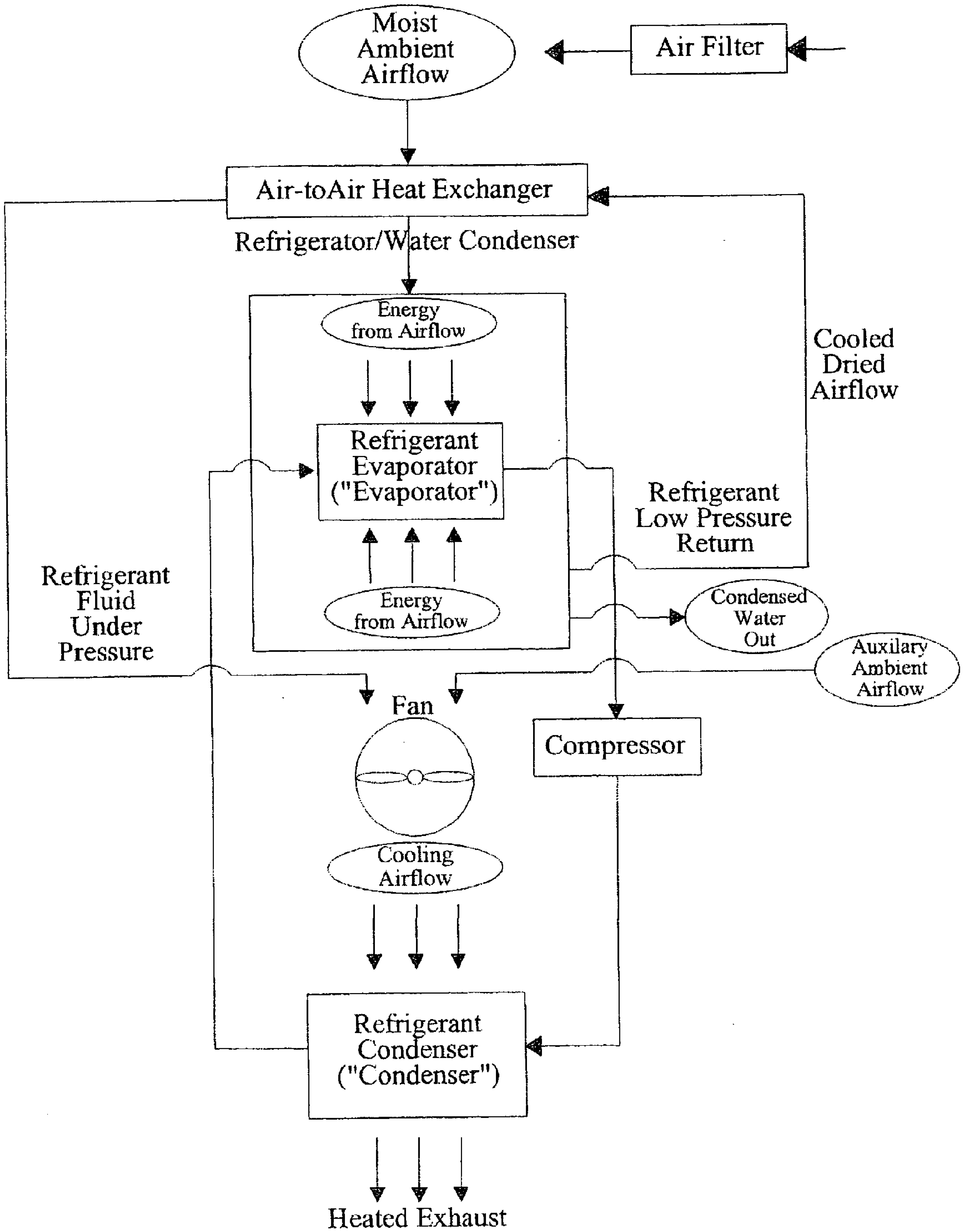
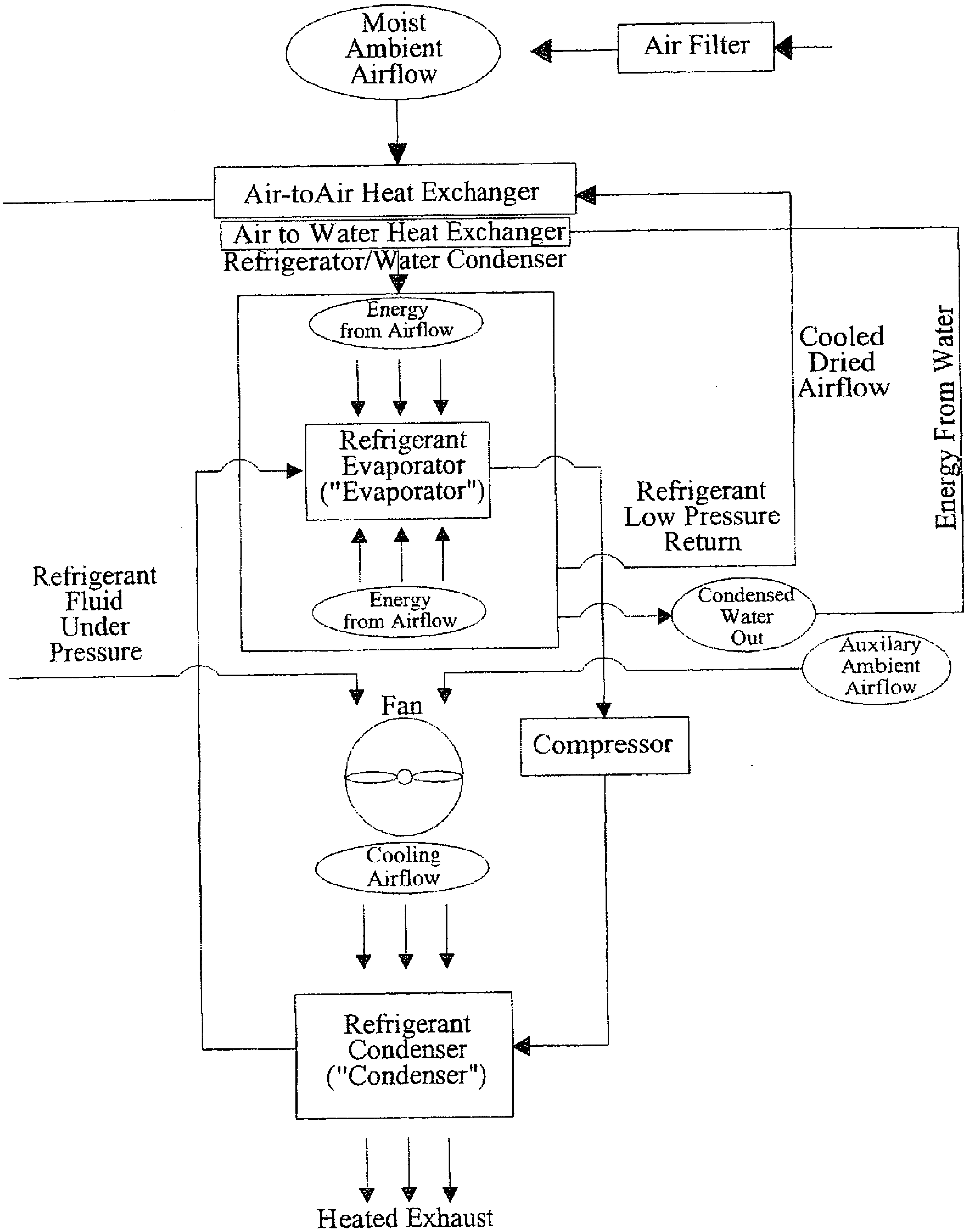

Moist Ambient Airflow
Air Filter
Air-toAir Heat Exchanger
Refrigerator/Water Condenser
Energy from Airflow
Refrigerant Evaporator ("Evaporator")
Energy from Airflow
Cooled Dried Airflow
Refrigerant Low Pressure Return
Refrigerant Fluid Under Pressure
Condensed Water Out
Auxilary Ambient Airflow
Fan
Compressor
Cooling Airflow
Refrigerant Condenser ("Condenser")
Heated Exhaust

Fig 6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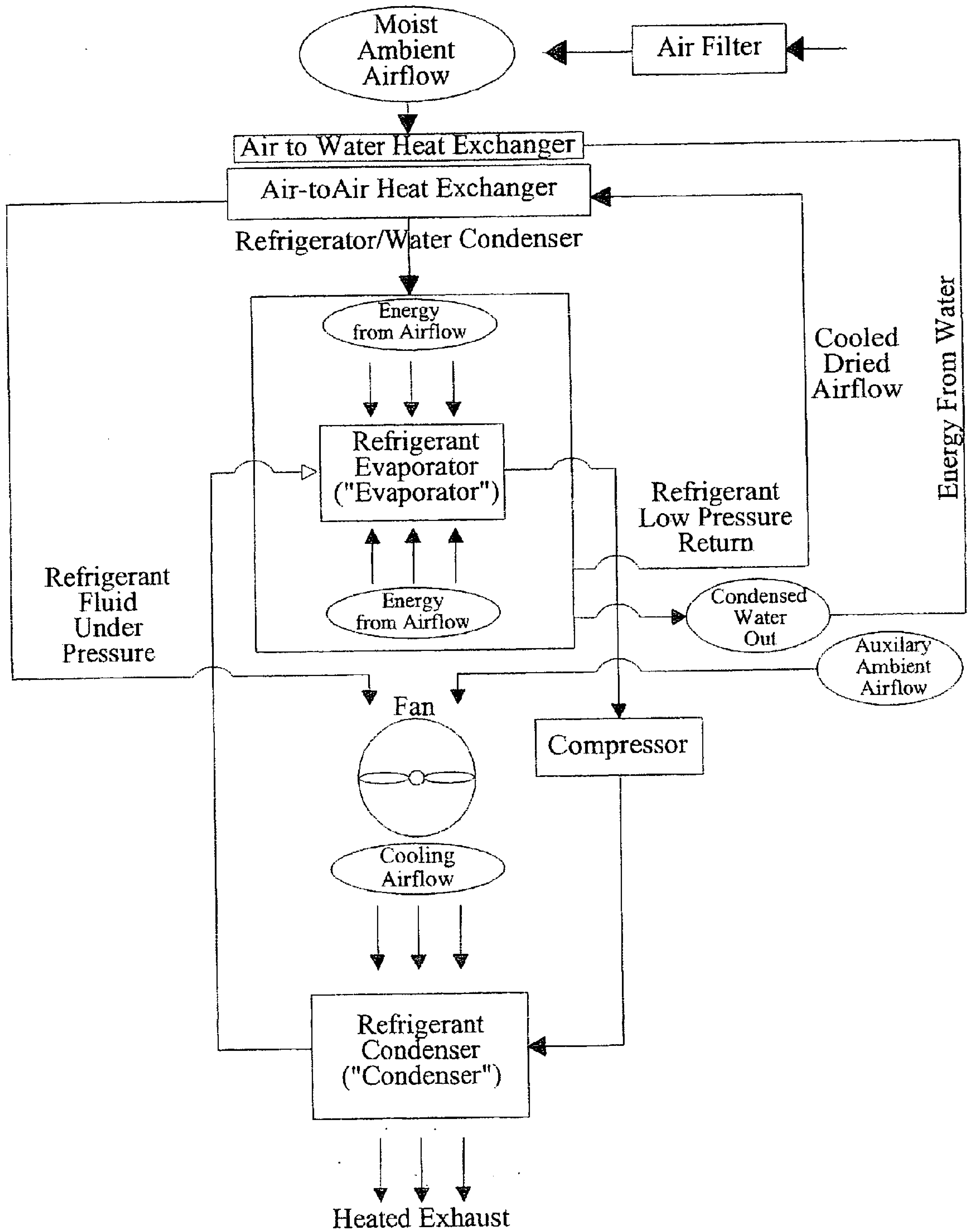
Refrigerant Fluid Under Pressure
Condensed Water Out
Auxilary Ambient Airflow
Fan
Compressor
Cooling Airflow
Refrigerant Condenser ("Condenser")
Heated Exhaust

Fig 6a



Moist Ambient Airflow
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Air to Water Heat Exchanger
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Condensed Water Out
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Compressor
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Heated Exhaust


Fig 6b

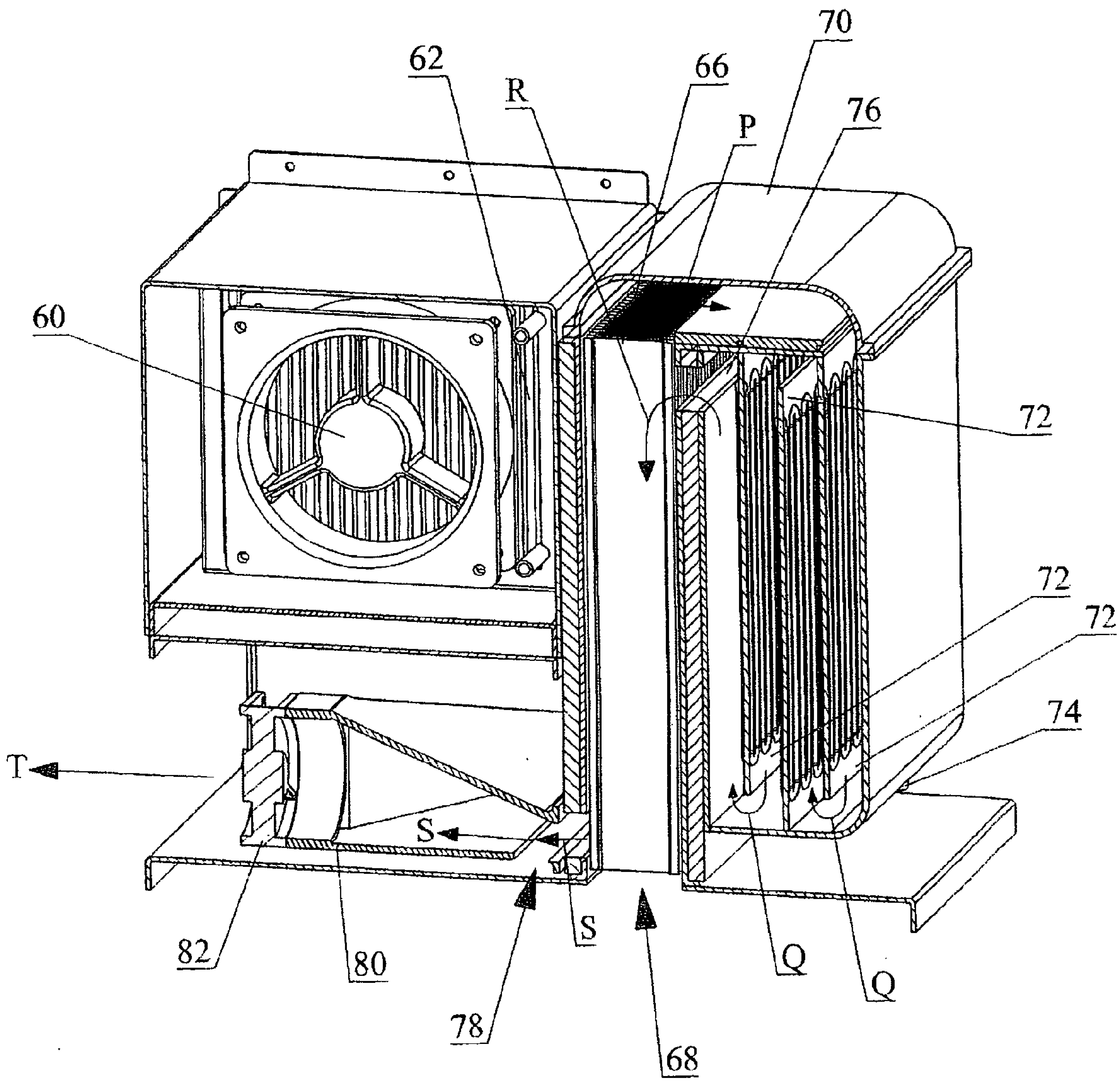


Fig 7

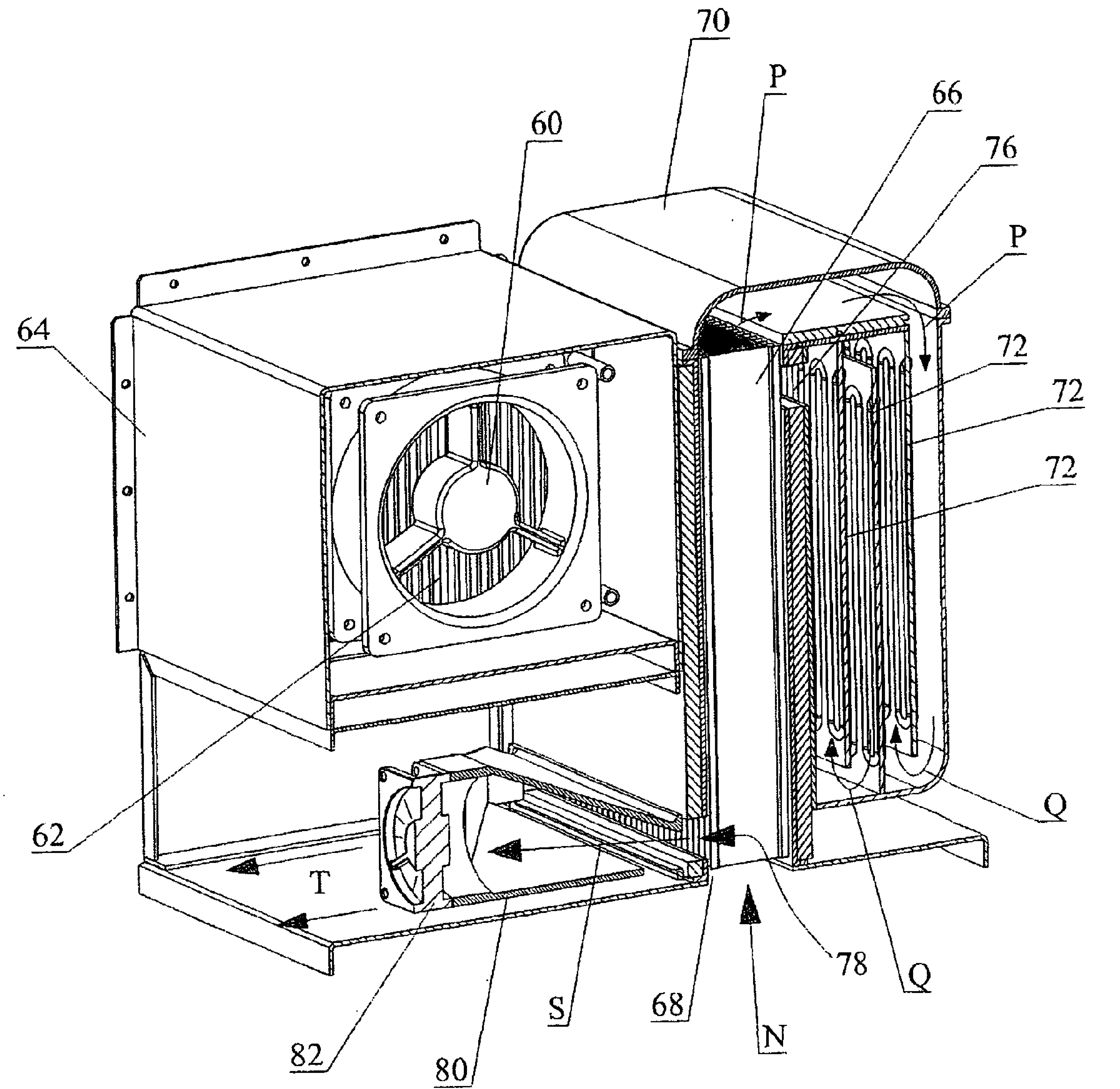


Fig 8

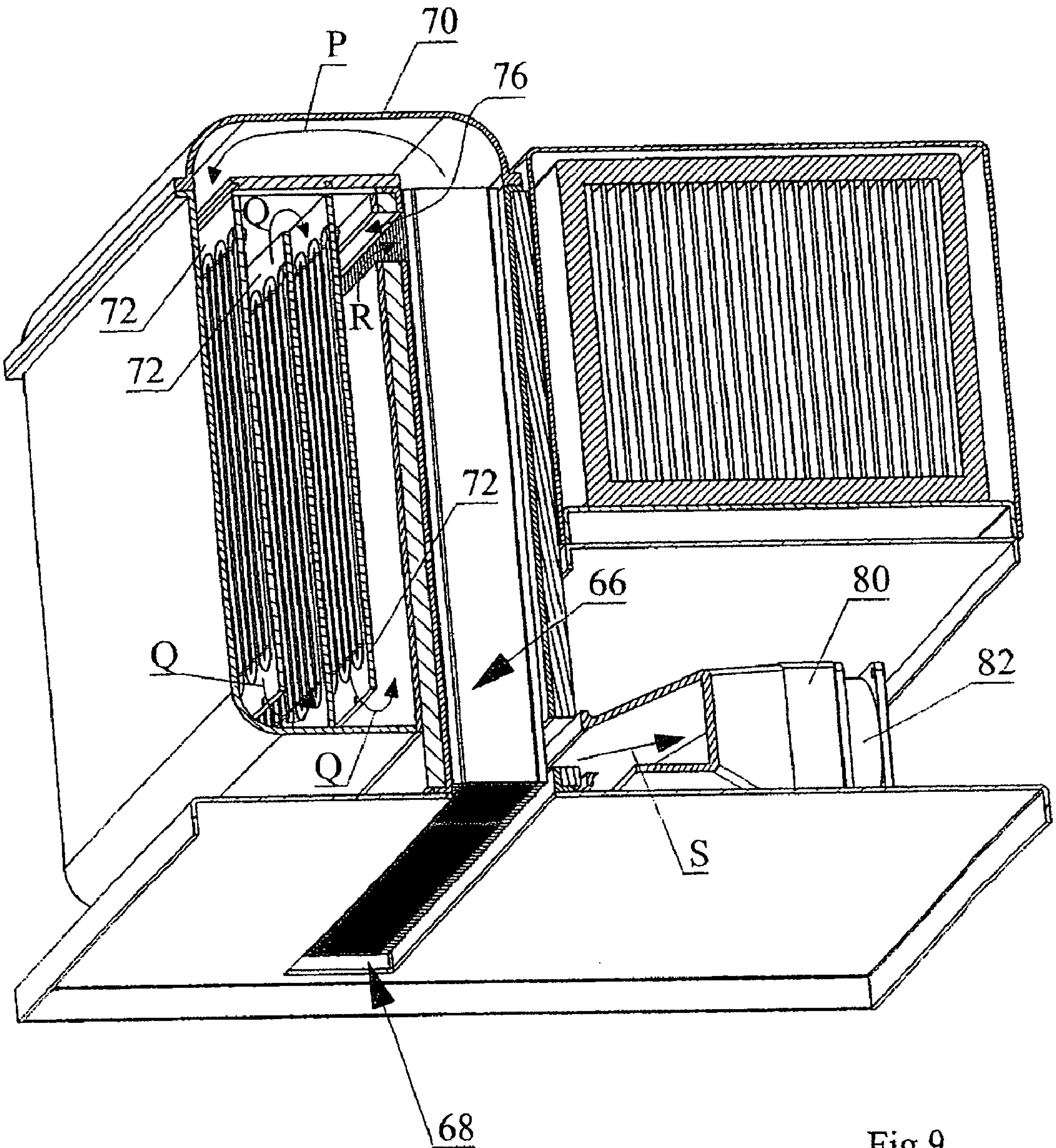


Fig 9

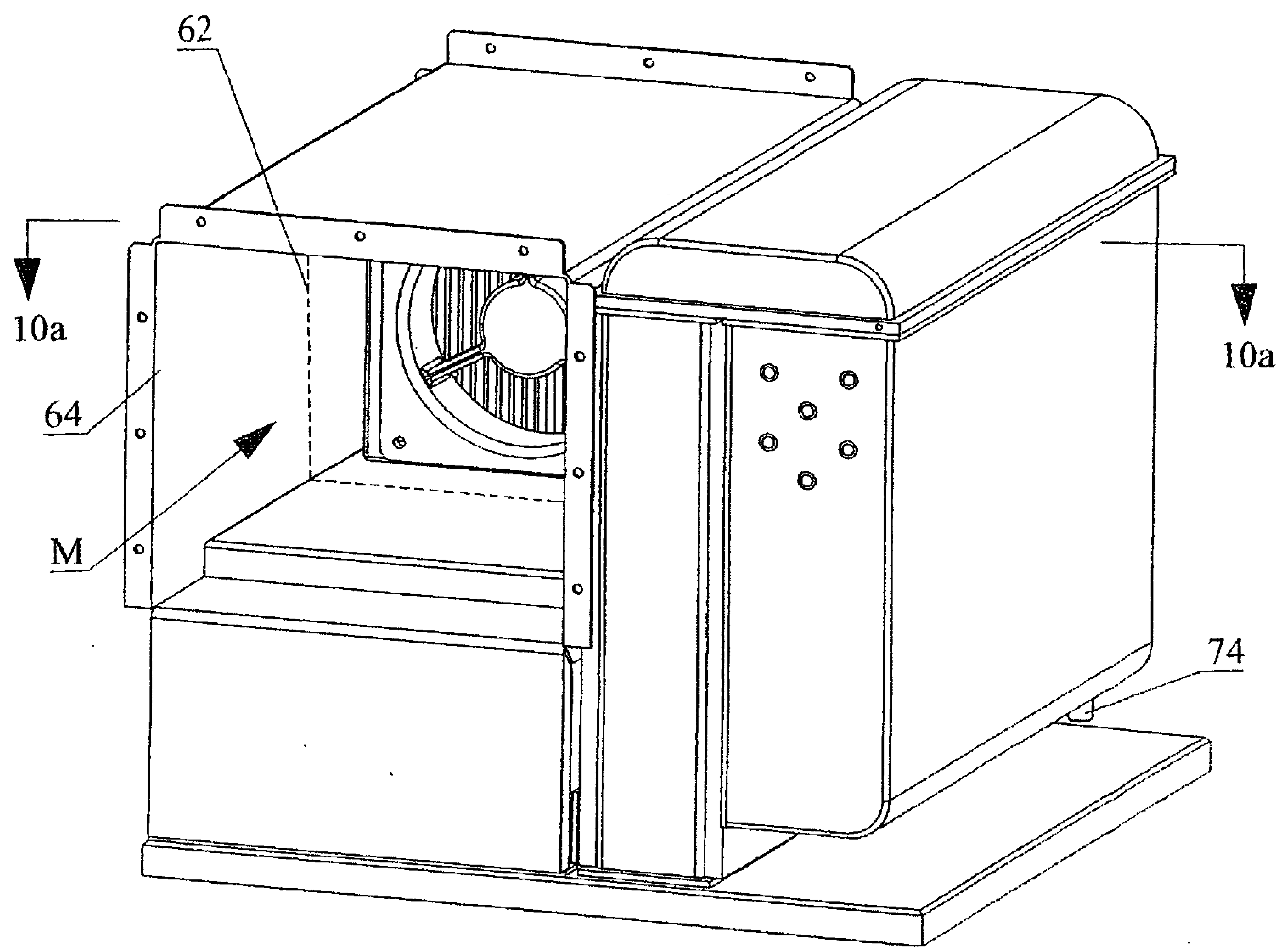


Fig 10

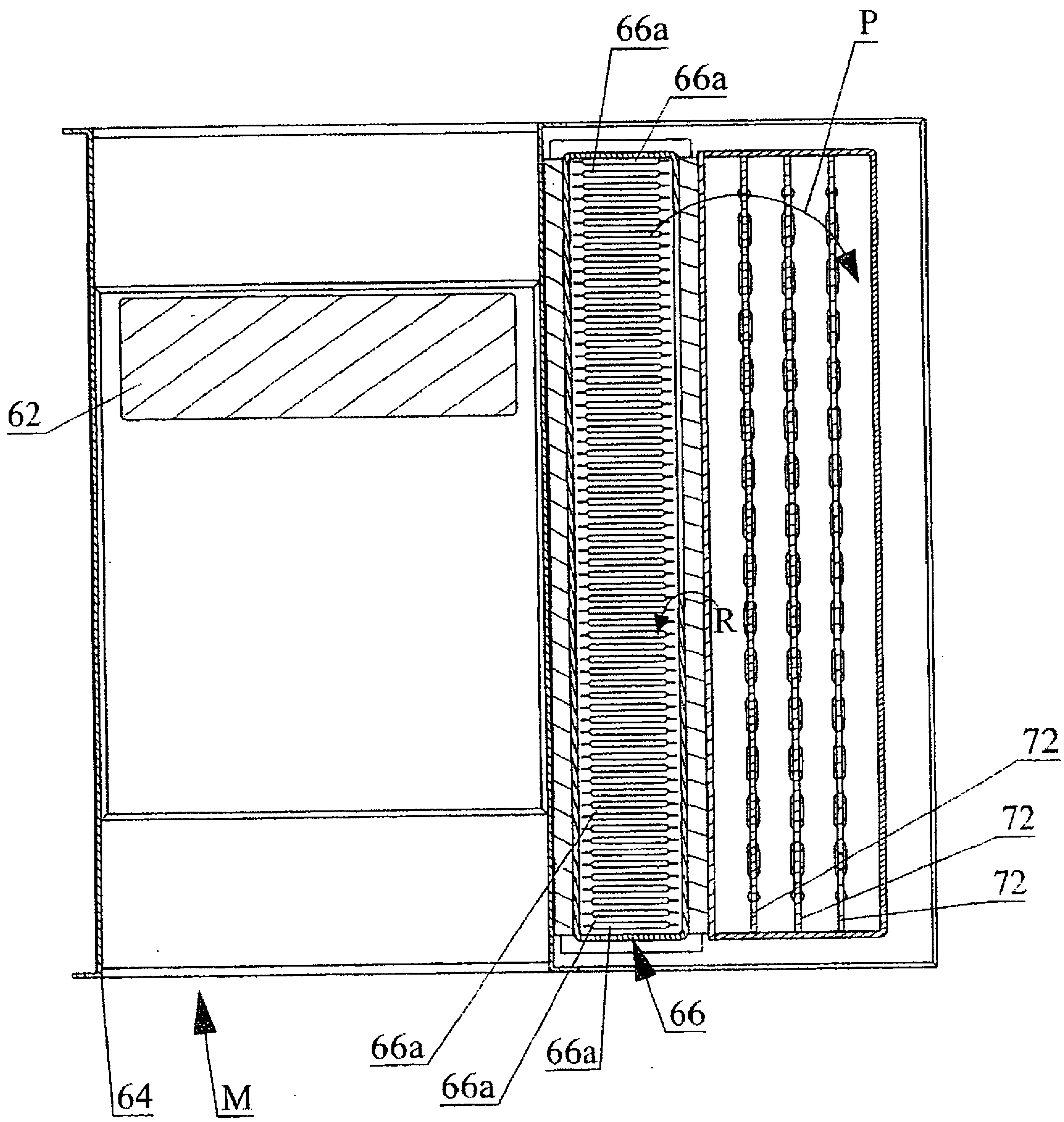


Fig 10a

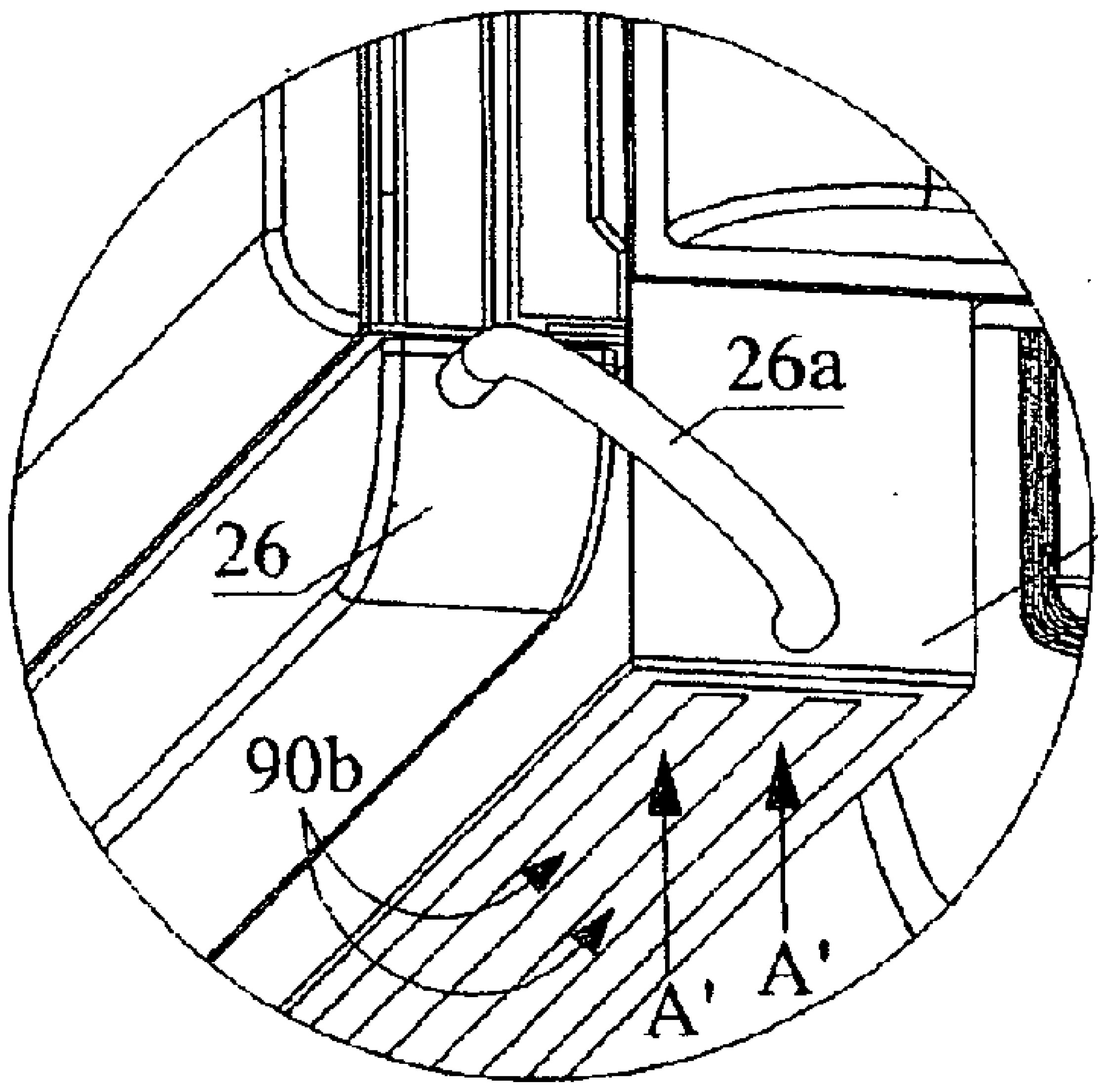


Fig 11a

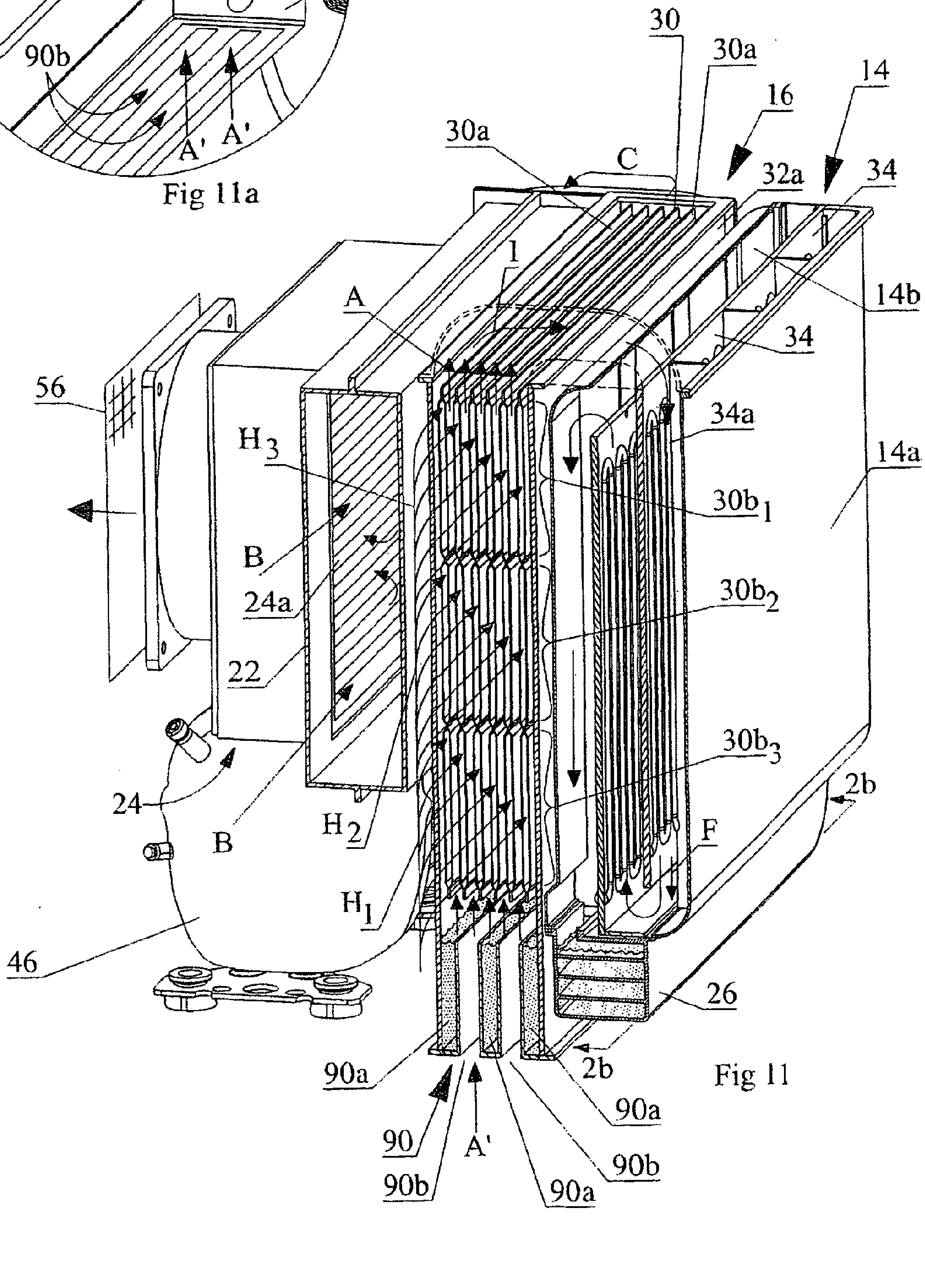


Fig 11

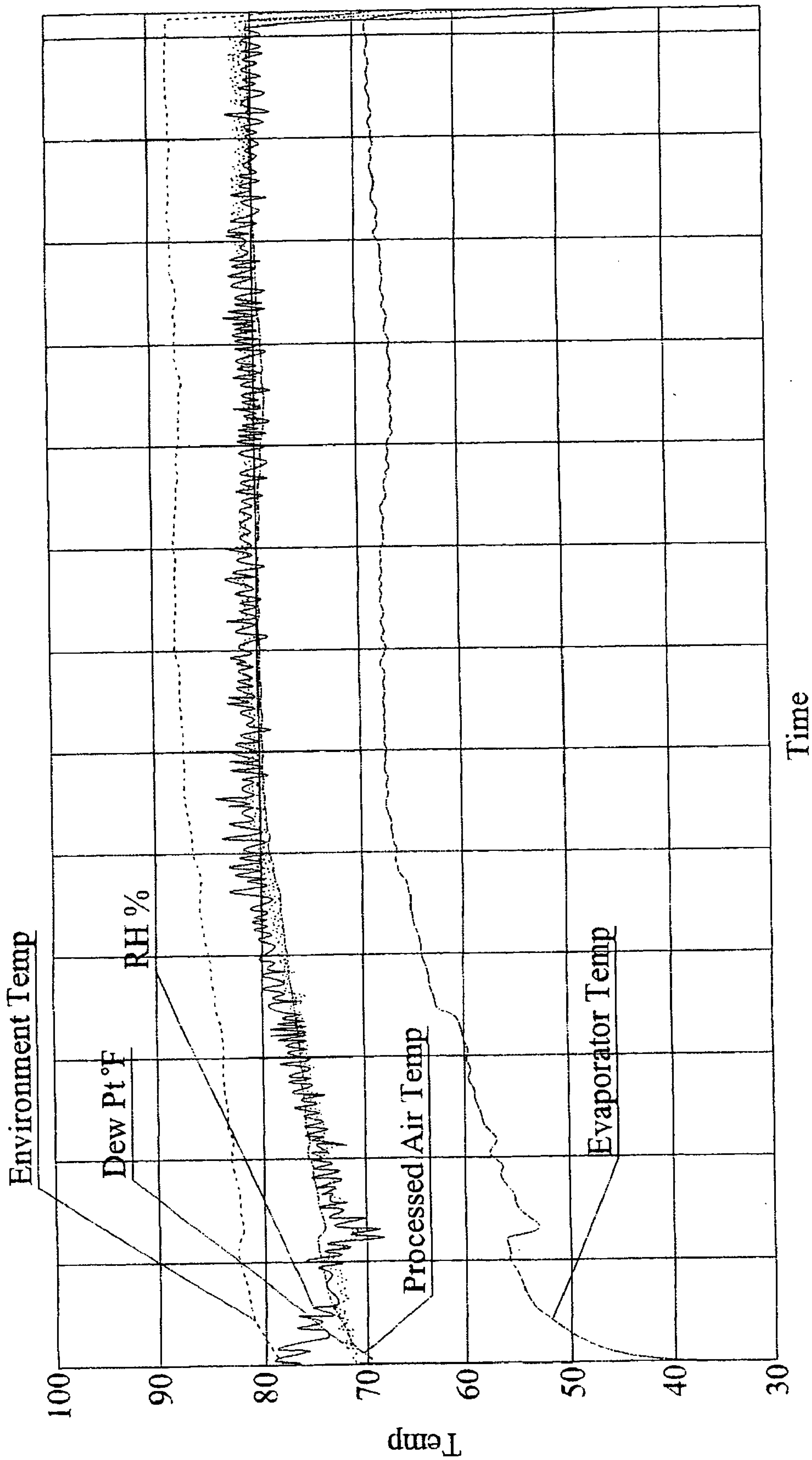
Environment Temp
Dew Pt °F
RH %
Processed Air Temp
Evaporator Temp
100
90
80
70
60
50
40
30
Temp
Time

Fig. 12

# WATER CONDENSER

## CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from U.S. Provisional Patent Application No. 60/632,077 filed Nov. 16, 2004 entitled Portable Potable Water Condenser.

## FIELD OF THE INVENTION

[0002] This invention relates to the field of water condensers generally, and in particular to a water condenser providing for optimized controlled cooling of an ambient airflow to its dew point temperature so as to condense moisture from the ambient air to provide potable water.

## BACKGROUND OF THE INVENTION

[0003] At any given moment the earth's atmosphere contains 326 million cubic miles of water and of this, 97% is saltwater and only 3% is fresh water. Of the 3% that is fresh water, 70% is frozen in Antarctica and of the remaining 30% only 0.7% is found in liquid form. Atmospheric air contains 0.16% of this 0.7% or 4,000 cubic miles of water which is 8 times the amount of water found in all the rivers of the world.

[0004] 0.16% of that 0.7% is found in the atmosphere

[0005] 0.8% of that 0.7% is found in soil moisture

[0006] 1.4% of that 0.7% is found in lakes

[0007] 97.5% of that 0.7% is found in groundwater

[0008] Nature maintains this ratio by accelerating or retarding the rates of evaporation and condensation, irrespective of the activities of man. It is the sole source and means of regenerating wholesome water for all forms of life on earth.

[0009] In addition, most of the world's fresh water sources are contaminated. A total of 1.2 billion people in the world lack access to safe drinking water and 2.9 billion people do not have access to proper sanitation systems (World Health Organization). As a result, about 3.4 million people, mostly children, die each year from water-related illnesses. According to the United Nations, 31 countries in the world are currently facing water stress and over one billion people lack access to clean water. Half of humanity lacks basic sanitation services and water-borne pathogens kill 25 million people every year. Every 8 seconds, a child dies from drinking contaminated water. Furthermore, unless we dramatically change our ways, by 2025, close to two-thirds of the world's population will be living with severe freshwater shortages.

[0010] There is a huge global need for cost effective and scalable sources of potable water. Current technologies require too much energy to operate efficiently and the resultant cost of treated water puts these technologies out-of-reach for the majority in need. Desalination plants exist in rich nations such as the United States and Saudi Arabia but are not feasible everywhere. The lack of infrastructure in developing nations makes large plants with high-volume production impractical, as there is no way to transport the water efficiently.

[0011] There is a need for small scalable water extraction plants that will meet the needs of individuals, communities and industries. This invention can responded to that need by developing an extraction unit that functions off-the-grid to make clean pure water, anywhere where the need exists.

[0012] The present invention is a device that extracts moisture vapor from atmospheric air for use as a fresh water source. The device may utilize the sun as the primary energy source thereby eliminating the need for costly fuels, hydro or battery power sources. The water collection device of the present invention provides flexibility over prior devices, allowing for productive installations in most regions of the world. As the water collection device's preferred power source is solar energy, the amount of available power for the device increases as installations of the device get closer to the equator where it is hotter year round.

[0013] The invention is designed to allow one small water cooler sized unit to provide cooking and drinking water for a family, simply by harvesting the water vapor from humid air. Private individuals, industries and communities could control their own water supply through the use of the device's technology. It is practical for many uses in domestic, commercial or military applications and offers ease of use and clean water of a highest quality anywhere, anytime. The modular design of these devices allow for increased capacity, simply by adding more modules.

[0014] In addition to domestic use larger units based upon the same basic technology will be appropriate for many other applications where larger water supplies are required. The 12 Volt compressor of the cooling system may be replaced with a larger 110 Volt compressor with appropriately sized components such as the evaporator and the condenser and the unit will be capable of condensing much larger quantities of water when electrical power is more readily available.

[0015] The devices solar water condenser technology may be applied to a variety of uses from residential to recreational and from commercial and agricultural to military and life saving in extreme water deprived regions of the world.

[0016] This invention may be used for obtaining pure drinking water, for cooking purposes or for other household uses such as cleaning or bathing. The system may also be used on boats or in vacation areas, on camping trips, trekking and places where drinking water delivery systems are not developed. The unit may be used to produce fresh water for bottling purposes or for larger commercial applications such as restaurants, offices, schools, hotel lobbies, cruise ships, hospitals and other public buildings. The system may also be used in playing fields and sports arenas.

[0017] Additionally, the technology may be used to augment the supply of water being used to irrigate selected crops using micro or drip irrigation systems. These systems deliver the right amount of water at the right time, directly to the roots of plants. As well, the technology may be used to for bottled water production or virtually any other application where water is needed.

[0018] The proposed technology provides an opportunity to end much suffering. The death and misery that flow from unsafe water is overwhelming. More than 5,000 children die daily from diseases caused by consuming water and food contaminated with bacteria, according to a recent study released by UNICEF, the World Health Organization (WHO) and the UN Environment Program (UNEP).

[0019] Currently, 1.2 billion people have no access to safe drinking water and that number is increasing steadily with forecasts of a potential 2.3 billion or one-third of the earth's population without access to safe water by 2025 (World Health Organization's statistics from World Commission on Water for the 21st Century). These at-risk children and their families are not restricted to rural areas in undeveloped nations. "Millions of poor urban dwellers have been left without water supply and sanitation in the rapidly growing cities of the developing world. The poor are often forced to pay exorbitant prices for untreated water, much of it deadly," reports William Cosgrove, director of World Water Vision, Paris. Our device can relieve much of this suffering.

[0020] A rapid increase in water demand, particularly for industrial and household use, is being driven by population growth and socioeconomic development. If this growth trend continues, consumption of water by the industrial sector will be double by 2025 (WMO).

[0021] Urban population growth will increase demand for household water, but poorly planned water and sanitation services will lead to a breakdown in services for hundreds of millions of people. Many households will remain unconnected to piped water.

[0022] The present invention offers a practical and affordable solution to many of the world's water supply problems.

[0023] It should be noted that while much of the prior art is simply extracting what it can from the air based upon a simplistic and uncontrolled process, some water will be extracted but with little concern for efficiency. This lack of efficiency can be explained by understanding the different types of heat that are used in the process of extracting water from air.

[0024] The heat that is used to bring air down to dew point is "specific heat". The heat used to bring the temperature of air below dew point is "latent heat" and represents a dynamic in the condensation process. The optimal condensation process uses as little "latent heat" as is possible.

[0025] For reference, specific heat means:

[0026] 1. The ratio of the amount of heat required to raise the temperature of a unit mass of a substance by one unit of temperature to the amount of heat required to raise the temperature of a similar mass of a reference material, usually water, by the same amount.

[0027] 2. The amount of heat, measured in calories, required to raise the temperature of one gram of a substance by one Celsius degree.

[0028] Latent heat means:

[0029] The quantity of beat absorbed or released by a substance undergoing a change of state, such as ice changing to water or water to steam, at constant temperature and pressure. This is also called heat of transformation.

[0030] In the optimal condensation process if too much air is drawn through the system the system cannot take enough of the total volume of air to a temperature below dew point and will therefore result in poor performance from the system.

[0031] If not enough air is drawn through the device the air temperature will drop to below dew point but as there is less air moving through the system, there is respectively less water available to be drawn from that air. There are as well other issues that arise when too little air is moved through the system such as freezing and wasted energy in the overuse of "latent" beat.

[0032] Therefore there is an optimal quantity of air that will travel through the system based upon a number of variables and that optimal quantity of air will change as the other variables change. It is therefore necessary to have a system that is monitored and reacts to the changes in temperature and humidity so as to ensure ongoing optimal operation is achieved.

## SUMMARY OF THE INVENTION

[0033] The water condenser according to the present invention is a device that may use various input source energy supplies to create a condensation process that extracts potable water from atmospheric air.

[0034] In one embodiment the water condenser is portable and the refrigeration cycle may be driven by a 12 Volt compressor that allows for an efficient condensation process for creating a potable water supply. The input source energy for the compressor may be supplied from many sources such as a wind turbine, batteries, or a photovoltaic panel. Additionally the design may be fitted with transformers to accommodate other power supplies such as 110 Volt or 220 Volt systems when such electrical power is available, or the device may be sized or scaled up so as to accommodate such electrical power sources directly. For example, the device might use a 110 Volt compressor and simply have the device's other components scaled-up to accommodate the larger compressor.

[0035] Rather than filtering water with conventional systems such as reverse osmosis or carbon filtration, the device filters the atmospheric air then provides a condensation process that lowers the temperature of that air to below dew point of the airflow. The air is then exposed to an adequate sized, cooled surface area upon which to condense, and the water is harvested as gravity pulls the water into a storage compartment.

[0036] The disclosed invention creates a high quality water supply through a process of filtering air rather than water. The device may be fitted with a screen to keep out larger contaminates. Downstream of the screen may be a pre-filter. The pre-filter may be removable for cleaning. Downstream of the pre-filter may be a high quality filter such as a HEPA filter to ensure the airflow is pure and depleted of contaminates that might impede upon the quality of water that is created by the condensation process downstream of the air filtration.

[0037] Rather than using a capillary tube metering mechanism for feeding refrigerant fluid into the refrigerant evaporator, such as is normally used for smaller refrigeration systems, the device according to the present invention may be fitted with an automatic suction valve so as to allow for the device to adapt to varying loads created by different environments. One object is that the condensation process is to provide efficient processing of atmospheric, that is ambient air. Thus the intake airflow downstream of the air filtration may be pre-cooled, prior to entering a refrigerant evaporator used to condense moisture out of the intake airflow, by passing the intake airflow through an air-to-air beat exchanger, itself cooled by cooled air leaving the evaporator. That is, the incoming airflow is cooled before it enters the refrigerant evaporator section by passing it in close proximity in the heat exchanger to the cooled air that is leaving the refrigerant evaporator. Air-to-air heat exchangers may be constructed to be very efficient, reaching 80% efficiency and therefore reducing the temperature of the incoming airflow towards the dew point of the airflow prior to entering the refrigerant evaporator reduces the temperature differential or temperature drop that must obtained by passing the air over cooled surfaces in the refrigerant evaporator to obtain the dew point temperature, and thus may have a significant impact upon the efficiency of the condensation process and thus the efficiency of the device. For example the device may thus be optimized to increase the airflow rate and still be able to reduce the airflow temperature to the dew point, or will be able to handle very hot inflow temperatures and still reduce the dew point temperature a reasonable airflow volume over time so as to harvest a useful amount of moisture. Sensors provide temperature, for example ambient, inlet temperatures, refrigerant evaporator inlet and refrigerant evaporator outlet temperatures, humidity, and fan speed or other air flow rate indicators to the processor to optimize and balance those variables to maximize harvested moisture volume. Embodiments of the present invention may thus include varying the flow of air through the system such that the device has a prescribed amount of air passing through the refrigerant evaporator and a different flow of air passing through the refrigerant condenser of the corresponding refrigerant circuit, allowing for optimized function.

**[0038]** In addition to the benefits described above our water condenser unit may add additional value in further processing. The harvested water may be further processed so as to increase the value of the water, for example by adding back inorganic minerals missing or only present in small amounts in the water so as to accommodate the perceived value of these minerals to the consumer. The process may also add organic minerals back into the water which are of benefit to the human body, rather than simply adding back inorganic minerals that the human body may not be able to properly assimilate.

**[0039]** There are numerous means by which to put back minerals and trace elements into the harvested water. For example, a small compartment with a hinged door allowing it to be easily accessed may be provided between a drip plate at the bottom of the refrigerant evaporator and a downstream water storage container so as to have all harvested water pass through this chamber. A provided mineral puck may inserted into this chamber by a user so that as harvested water drips over the mineral puck the puck dissolves thereby adding desired elements to the harvested water. The user thereby controls re-mineralization of the harvested water. Additional health remedies may also be added to the harvested water such as colloidal silver, water oxygenation additives, negatively ionized hydrogen ions or other health enhancing products.

**[0040]** In summary, the water condenser according to the present invention may be characterized in one aspect as including at least two cooling stages or first cooling a primary or first air flow flowing through the upstream or first stage of the two stages using an air-to-air heat exchanger, and feeding the primary airflow once cooled in the heat exchanger of one first stage in a refrigerant evaporator wherein the primary airflow is further cooled in the refrigerant evaporator to its dew point so as to condense moisture in the primary airflow onto cooled surfaces of the refrigerant evaporator, whereupon the primary airflow, upon exiting the refrigerant evaporator of the second stage, enters the air-to-air heat exchanger of the first stage to cool the incoming primary airflow, thereby reducing the temperature differential between the temperature of the incoming primary airflow entering the first stage and the dew point temperature of the primary airflow in the second stage. A secondary or auxiliary airflow, which in one embodiment may be mixed or joined (collectively referred to herein as being mixed) with the primary airflow, downstream of the first and second stages so as to increase the volume of airflow entering a refrigerant condenser in the refrigerant circuit corresponding to the refrigerant evaporator of the second stage. Thus if the primary or first airflow has a corresponding first mass flow rate, and the secondary or auxiliary airflow has a corresponding second mass flow rate, then the mass flow rate of the combined airflow entering the refrigerant condenser is the sum of the first and second mass flow rates, that is greater than the first mass flow rate in the two cooling stages. The two cooling stages may be contained in one or separate housings so long as the primary airflow is in fluid communication between the two stages. One housing includes a first air intake for entry of the primary airflow. The first air intake is mounted to the air-to-air heat exchanger.

**[0041]** The air-to-air heat exchanger has a pre-refrigeration set of air conduits cooperating at their upstream end in fluid communication with the first air intake. The first air intake thus provides for intake of the primary airflow into the pre-refrigeration set of air conduits. The air-to-air heat exchanger also has a post-refrigeration set of conduits arranged relative to the pre-refrigeration set of air conduits for heat transfer between the pre-refrigeration set of air conduits and the post-refrigeration set of air conduits.

**[0042]** A first refrigeration or cooling unit (hereinafter collectively a refrigeration unit) such as the refrigerant evaporator cooperates with the pre-refrigeration set of air conduits for passage of the primary airflow from a downstream end of the pre-refrigeration set of conduits into an upstream end of the first refrigeration unit. The first refrigeration unit includes first refrigerated or cooled (herein collectively or alternatively referred to as refrigerated) surfaces, for example one or more cooled plates, over which the primary airflow passes as it flows from the upstream end of the first refrigeration unit to the downstream end of the first refrigeration unit.

**[0043]** The already pre-cooled primary airflow is further cooled in the first refrigeration unit below a dew point of the primary airflow so as to commence condensation of moisture in the primary airflow onto the refrigerated surfaces for gravity-assisted collection of the moisture into a moisture collector, for example a drip late or pan mounted under or in a lower part of the housing. The downstream end of the first refrigeration unit cooperates with, for passage of the primary airflow into, an upstream end of the post-refrigeration set of air conduits, for example to then enter the air-to-air heat exchanger so as to pre-cool the primary airflow before the primary airflow engages the first refrigeration unit. Because of pre-cooling by the heat exchanger, condensate may be collected with minimal power requirements. A second air-to-air heat exchanger may further increase system performance. Collectively the pre-refrigeration and post-refrigeration sets of air conduits form the first cooling stage, and collectively the plate or plates of the refrigerant evaporator form the second cooling stage.

**[0044]** An air-to-water heat exchanger may be provided cooperating with the air-to-air heat exchanger for cooling the primary airflow wherein the primary airflow is passed through the air-to-water heat exchanger and the cold moisture from the moisture collector is simultaneously passed through the air-to-water heat exchanger so that the moisture cools the first airflow. The air-to-water heat exchanger may be either upstream or downstream of the air-to-air heat exchanger along the primary airflow.

**[0045]** In one embodiment a manifold or air plenum having opposite upstream and downstream ends cooperates in fluid communication with the downstream end of the post-refrigeration set of conduits. That is, the upstream end of the air plenum cooperates with the downstream end of the post-refrigeration set of conduits so that the primary airflow flows into the air plenum at the upstream end of the plenum. The plenum has a secondary or auxiliary air intake into the plenum for mixing of the auxiliary airflow with, or addition of the auxiliary airflow in parallel to, the primary airflow in the plenum so as to provide the combined mass flow rate into the refrigerant condenser, to extract heat from the refrigerant in the refrigerant circuit to re-condense the refrigerant for delivery under pressure to the refrigerant evaporator in the second cooling stage, the refrigerant pressurized between the refrigerant evaporator and condenser by a refrigerant compressor (herein referred to as the compressor). Thus the downstream end of the plenum cooperates in fluid communication with the refrigerant condenser. An airflow primer mover such as a fan or blower (herein collectively a fan) urges the primary airflow through the two cooling stages. In embodiments wherein both the primary and auxiliary airflows are directed into the refrigerant condenser (herein also referred to as the combined airflow embodiment), a single airflow prime mover, such as a fan on the refrigerant condenser may be employed, otherwise, where only the auxiliary airflow flows through the refrigerant condenser, separate airflow prime movers are provided for the primary and auxiliary airflows.

**[0046]** In the combined airflow embodiment, a selectively actuable airflow metering valve such as a selectively actuable damper may be mounted in cooperation with the auxiliary air intake for selectively controlling the volume and flow rate of the auxiliary airflow passing into the plenum. An automated actuator may cooperate with the metering valve for automated actuation of the metering valve between open and closed positions of the valve according to at least one environmental condition indicative of at least moisture content in the primary and/or auxiliary airflows (herein "and/or" collectively referred to by the bolean operator "or"). For example, the automated actuator may be a temperature sensitive bi-metal actuator or an actuator controlled by a programmable logic controller (PLC); for example the automated actuator may include a processor cooperating with at least one sensor, the at least one sensor for sensing the at least one environmental condition and communicating environmental data corresponding to the at least one environmental condition from the at least one sensor to the processor or PLC. The at least one environmental condition may be chosen from the group consisting of air temperature, humidity, barometric air pressure, air density, air mass flow rate. The air temperature conditioner may include the temperature of the ambient air at the primary airflow intake, and the temperature of the primary airflows entering and leaving the second cooling stage.

**[0047]** The processor regulates the first and/or second airflows, for example regulates the amount of cooling in the refrigeration unit, so that the air temperature in the first refrigeration unit is at or below the dew point of the primary airflow, but above freezing. The processor may calculate the dew point for the primary airflow based on the at least one environmental condition sensed by the at least one sensor.

**[0048]** The airflow prime mover may be selectively controllable and the processor may regulate the primary, auxiliary or combined airflow so as to minimize the air temperature of the primary airflow from dropping too far below the dew point for the primary airflow to minimize condensation within the heat exchanger, and so as to optimize or maximize the volume of moisture condensation in the refrigeration unit.

**[0049]** At least one filter may be mounted in cooperation with the water condenser housing. For example, at least one air filter such as a HEPA filter may be mounted in the flow path of the first airflow. A water filter may be provided for filtering water in the moisture collector. The air filters may include an ultra-violet radiation lamp mounted in proximity to, so as to cooperate with, the primary airflow path or the moisture collector. For example the air filter and the water filter may include a common ultra-violet radiation lamp mounted in proximity to so as to cooperate with both the primary airflow path and the moisture collector.

**[0050]** In upstream-to-downstream order, the first refrigeration unit may be adjacent the heat exchanger, the heat exchanger may be adjacent the plenum, the plenum may be adjacent the refrigerant condenser, and the refrigerant condenser may be adjacent the airflow prime mover. These elements may be inter-leaved in closely adjacent array.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0051]** **FIG. 1** is, in perspective view, one embodiment of the water condenser according to the present invention.

**[0052]** **FIG. 2** is a sectional view along line **2-2** in **FIG. 1**.

**[0053]** **FIG. 2*a*** is an enlarged view of a portion of **FIG. 2**.

**[0054]** **FIG. 2*b*** is a sectional view along line **2*b*-2*b*** in **FIG. 2**.

**[0055]** **FIG. 3** is a sectional view along line **3-3** in **FIG. 1**.

**[0056]** **FIG. 3*a*** is an enlarged view of a portion of **FIG. 3**.

**[0057]** **FIG. 3*b*** is an enlarged view of a portion of **FIG. 3*a***.

**[0058]** **FIG. 3*c*** is, in perspective view, the internal air conduits of the upstream side of manifold of the water condenser of **FIG. 1**.

[0059] **FIG. 4** is a sectional view along line **4-4** in **FIG. 1**.

[0060] **FIG. 5** is the view of **FIG. 3** in an alternative embodiment wherein the airflow manifold feeding the refrigerant condenser is partitioned between the primary and auxiliary airflows.

[0061] **FIG. 6** is a diagrammatic view of the pre-cooling and condenser cycle and closed loop refrigerant circuit according to the embodiment of **FIG. 1**.

[0062] **FIG. 6***a* is the view of **FIG. 6** showing an air-to-water heat exchanger downstream of the air-to-air heat exchanger.

[0063] **FIG. 6***b* is the view of **FIG. 6** showing an air-to-water heat exchanger upstream of the air-to-air heat exchanger.

[0064] **FIG. 7** is, in partially cut away front right side perspective view, an alternative embodiment of the present invention wherein two separate fans draw the primary and auxiliary airflows through the evaporator and condenser respectively.

[0065] **FIG. 8** is, in partially cut away front left side perspective view, the embodiment of **FIG. 7**.

[0066] **FIG. 9** is, in partially cut away rear perspective view, the embodiment of **FIG. 7**.

[0067] **FIG. 10** is a partially cut away rear perspective view of the embodiment of **FIG. 9**.

[0068] **FIG. 10***a* is a sectional view along line **10***a*-**10***a* in **FIG. 10**.

[0069] **FIG. 11** is, in partially cut away perspective view a further alternative embodiment of the present invention wherein the primary airflow passes through an air-to-water heat exchanger.

[0070] **FIG. 12** is a graph of Temperature vs. Time showing the interrelation of Evaporator Temperature, Processed Air Temperature, Relative Humidity (RH)%, Dew Point Temperature, and Environmental Temperature in the device of **FIG. 1**.

## DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0071] Applicant's U.S. provisional patent application No. 60/632,077 is incorporated herein by reference to the extent that it does not conflict with this disclosure.

[0072] With reference to the drawings wherein similar characters of reference denote corresponding parts in each view, in one preferred embodiment of the present invention, a fan **12** draws a primary airflow along an upstream flow path A through an upstream refrigerant evaporator **14**, through an air-to-air heat exchanger **16**, and in an alternative embodiment also through an air-to-water heat exchanger using cold water collected as condensate from evaporator **14** (better described below), cooperating with an air intake **18** of upstream flow path A, then through a manifold **20** where ambient air is drawn in as auxiliary airflow in direction B through auxiliary air intake **22**. The primary airflow enters manifold **20** in direction C upon leaving heat exchanger **16**. The primary and auxiliary airflows, in the embodiment of **FIG. 3**, mix in manifold **20** then flow in direction D through a downstream refrigerant condenser **24** and finally flow through fan **12** so as to be exhausted and heated exhaust in direction E.

[0073] The primary airflow is pre-cooled in the air-to-air heat exchanger, and also in the air-to-water heat exchanger in the alternative embodiment. Humidity in the ambient air drawn in as the primary airflow through intake **18** is condensed in refrigerant evaporator **14**. Water droplets which condense are gravity fed in direction F into a collection plate, pan or trough **26** for outflow through spout **26***a*. The addition of ambient air drawn in as the auxiliary airflow in direction B into manifold **20** provides the higher volumetric airflow rate needed to efficiently operate refrigerant condenser **24**.

[0074] In operation, the primary airflow is drawn in through the upstream air intake **18** of evaporator **14** in direction A and passes between the hollow air-to-air heat exchanger plates **30**. Depending on the embodiment of the present invention, an air-to-water heat exchanger **90** may cooperate with air-to-air heat exchanger **16** and there may be one, two, three or more plates **30** in heat exchanger **16**. Plates **30** are preferably parallel and are spaced apart to form flow channels therebetween, and between the outermost plates **30***a* and the walls **32***a* of the housing **32** of the heat exchanger. Within evaporator **14**, in the two evaporator plate embodiments illustrated, plates **34** are refrigerated by the evaporation of refrigerant flowing into cooling coils **34***a*. Plates **34** are optimally cooled to a temperature which will cool the primary airflow to just below its dew point such as seen plotted from experimental data in **FIG. 12** so as to condense water vapour in the primary airflow onto the surfaces of the plates and coils without causing the water vapour to form ice. For example, the primary airflow exiting evaporator **14** in direction H, so as to enter heat exchanger **16**, may be cooled to 40° Fahrenheit.

[0075] Once the primary airflow has passed between plates **30**, and between plates **30***a* and the walls **32***a* of housing **32** (collectively, generically the pre-refrigeration set of air conduits), the primary airflow is turned one hundred eighty degrees in direction I by and within an end cap manifold **36** which extends the length of the upper ends of plates **30**.

[0076] Plates **30** themselves are rigidly supported in parallel spaced apart array sandwiched by and between planar end plates **38**. The end plates have an array of apertures **38***a* therethrough. The apertures align with the open ends of sealed conduits **30***b* through the plates, as best seen in **FIGS. 3, 3***a* and **3***b*, so that, once the airflow has turned one hundred eighty degrees in direction H through upstream side manifold **40**, the airflow then passes in direction J through apertures **38***a* and along the length, of conduits **30***b* (the post-refrigeration set of air conduits) so as to exit from the corresponding apertures **38***a* downstream in the opposite end plate **38'**. In particular, side manifold **40** in the illustrated embodiment of **FIG. 3***c*, which is not intended to be limiting, segregates airflow in direction H into three flows $H_1$, $H_2$ and $H_3$ so as to enter into corresponding conduits **30***b*, themselves arranged in three banks $\mathbf{30}b_1$, $\mathbf{30}b_2$ and $\mathbf{30}b_3$ arranged vertically one on top of the other as seen in **FIG. 2**. Fences **40***b* divide airflows $H_1$, $H_2$ and $H_3$ from one another and align the airflows with their corresponding bank of sealed conduits **30***b*, so that airflows $H_1$, $H_2$ and $H_3$ are aligned for flow into, respectively, conduit banks $30b_1$, $30b_2$ and $30b_3$. Fences **40***b* also align with plates **34** so as to partially segregate the infeed to airflows $H_1$, $H_2$ and $H_3$ to come from, respectively, between the outside plate **34** and the outside wall **14***a*, between the inside and outside plates **34**, and between the inside plate **34** and the inside wall **14***b*. A lower cap **40***a* seals the end of pan **26** and channels moisture collected from side manifold **40** into pan **26**, better seen in **FIG. 2***b*. Air-to-air heat transfer in direction K occurs through the solid walls of plates **30** so that the primary airflow in conduits **30***b* cools the primary airflow between the plates.

[0077] Upon leaving the apertures **38***a*' in end plates **38'**, the airflow is again turned approximately one hundred eighty degrees in direction C by and within downstream side manifold **42** which extends the height of end plate **38'**. Side manifold **42** directs airflow into manifold **20** through a port **44** leading into the upstream end of manifold **20**. An ambient air intake **22** feeds ambient air in direction B into manifold **20** so as to, in one combined airflow embodiment, mix with the airflow from heat exchanger **16** with ambient air from auxiliary air intake **22**. The flow rate of the auxiliary airflow through intake **22** is selectively regulated by actuation of damper **20***a* (shown in **FIG. 3** in its closed position in dotted outline and in its open position in solid outline). The mixed airflow is then drawn in direction D into refrigerant condenser **24** so as to pass between the louvers **24***a* or coils or the like. Condenser **24** condenses refrigerant flowing in lines **46***a* (illustrated diagrammatically in dotted outline in **FIG. 4**) once compressed by compressor **46**. The combined airflow then enters the in-line fan **12** and exhausts from the fan in direction E.

[0078] Atmospheric air enters intake **18** in direction A through screen **50**, passing through pre-filter **52**, then through a high quality filter, such as HEPA filter **54**. Air flow leaving condenser **24** may pass through another filter **56**. Filter **56** inhibits contaminates from entering the fan and thus keeps contaminants from getting into evaporator **14**. Once the primary airflow has been processed through the two cooling stages of, respectively, heat exchanger **16** and refrigerant evaporator **14**, the primary airflow may not be sufficiently cool to assist in the refrigerant cooling in refrigerant condenser **24**. Thus the primary airflow may be exhausted entirely from the system without flowing through condenser **24** without significantly affecting performance or where the primary airflow is somewhat cool, it may be used to assist in cooling condenser **24**. If the air that has passed through the evaporator **14** and heat exchanger **16** is exhausted upstream of condenser **24**, the condenser **24** will draw its own air stream, that is the auxiliary airflow, directly from the ambient air outside the system. The use of the two air streams, primary and auxiliary has advantages in allowing a significant increase in airflow through the condenser versus the evaporator.

[0079] A controller **48** may do multiple tasks and the system may require multiple controllers if it is not beneficial or practical to build them all into the same unit. The controller **48** may be designed to accommodate a varying power input such as would be the case if the unit was hooked up directly to a photovoltaic panel. Controller **48** may also ensure that the refrigeration system pressures are maintained.

[0080] There are two pressures involved in a refrigeration system such as is employed in this design. These are the suction pressure (low side) and the discharge pressure (high side). For optimal performance the low side or suction pressure may be approximately 30 psi. The high side or discharge pressure is much harder to control and may be within the 120 psi to 200 psi range for optimal performance. With a normal refrigeration system the high side pressure is much easier to control using conventional refrigeration controls, and poses little concern. With a system such as this, that is under constant changing load with large fluctuations in both temperature and humidity, the pressures are prone to change and can quickly move outside of the optimal range. This can cause damage to the system as if the discharge pressure gets to high (over 250 psi) it may be very hard on the system and can cause internal damage to the valves in the compressor, the insulation on the electrical wiring, and may even cause the formation of waxes, as well as decreasing the overall efficiency of the system. These pressures may be controlled to some degree by controlling the pressures within the system and through controlling the flow of refrigerant. The high side or discharge may be controlled by regulating the quantity and temperature of the air that passes through the condenser. If the discharge pressure is too low (below 120 psi) the cooling system becomes compromised and functions below its capability. In this case the controller is designed to turn the fan off and allow the pressure to rise. If the pressure gets too high the controller will turn the fan on and the pressure will drop. This is a simple and inexpensive way to control the system discharge pressure.

[0081] Controller **48** may also find the optimal airflow rate through the condenser so as to moderate the discharge (also called backpressure) to an acceptable range (150 psi may be optimal). In this design the fan is kept at the optimal speed rather than turning off and on, so as to ensure proper system pressures and optimal operation of the refrigeration system.

[0082] In ensuring that an ideal operation of the device is maintained, different systems may be employed. They are as follows.

[0083] The ideal location within the system will be determined for where the internal airflow should be reaching its dew point. This location might be between the heat exchanger and the evaporator plates (first pass). A controller with sensors monitors environmental conditions and calculates internally what the dew point is. Sensors are placed within the system such as mentioned above, that allow the controller to monitor the sensors, thereby determining where the temperature is with respect to dew point. Thus, if optimal system function is to create dew point at this sensor the controller will slow down or speed up the fan in a continual effort to optimize the system. In another embodiment a pressure differential gauge may be used to offer feedback to the controller assisting in its function to optimize the airflow. The present system is designed to keep the airflow just below dew point and to track, dew point continuously as conditions change. As seen in the test data set of **FIG. 12**, the dew point is continuously tracked by the processed air temperature ensuring optimal operation.

[0084] In an alternative embodiment as seen in **FIGS. 7-10** and **10***a* the primary and auxiliary airflows are entirely separate. Whereas in the previously describe embodiment, the primary airflow after passing through the air-to-air heat exchanger wherein the lowered temperature of the primary airflow leaving the refrigerant evaporator is used to pre-cool the incoming primary airflow rather than be wasted, and the primary airflow then flowing into the manifold wherein it is mixed with the auxiliary airflow so as to provide the increased mass flow volume for the refrigerant condenser, in this embodiment, control of the primary airflow is provided by a separate fan for increased accuracy of control of the primary airflow through the two cooling stages namely the heat exchanger and refrigerant evaporator.

[0085] Thus as may be seen in the illustrations, fan **60** draws auxiliary airflow through refrigerant condenser **62** in direction M via intake **64**. As before, the refrigerant condenser is in the same refrigeration circuit as the refrigerant evaporator, that is, is in the same refrigeration circuit as the second cooling stage. As before, an air-to-air heat exchanger provides the first cooling stage. Thus the primary airflow, as before, enters the heat exchanger prior to entry into the refrigerant evaporator. In particular, primary airflow enters air-to-air heat exchanger **66** in direction N through a lower intake **68** having passed through air filters as previously described (not shown). The primary airflow passes through hollow conduits **66***a* across the width of the heat exchanger, exiting conduit **66***a* in direction P so as to be turned one hundred eighty degrees in end manifold **70**. The primary airflow then flows between refrigerant evaporator plates **72** in direction Q wherein the primary airflow is cooled below it's dew point without freezing. Moisture thus condenses out of the primary airflow onto plates **72** and is harvested through a spout **74** into a collection pan or the like (not shown).

[0086] The primary airflow exits from the refrigerant evaporator through slot **76** and travels in direction R downwards between conduits **66***a* so as to exit heat exchanger **66** in direction S through slot **78**. The primary airflow is then drawn through fan housing **80** and fan **82** so as to exit as exhaust from fan **82** in direction T.

[0087] The de-linking of the primary and auxiliary airflows so as to require separate fans, respectively fans **82** and **60**, provide for condenser **62** functioning at a greater capacity without affecting optimization of the balance of the cooling between the first and second cooling stages of, respectively, the heat exchanger **66** and the evaporator plates **72**. Thus the lower volume fan **82** may be controlled by a processor (not shown) to determine the current environmental conditions affecting optimization of cooling and condensation for example by varying the power supplied to fan **82** to thereby control the velocity and mass flow rate of the primary airflow through the two cooling stages. Thus the primary airflow may be drawn through the cooling stages at a velocity which is not so high as to affect the maximum condensation of moisture, and not too low so as to waste energy in cooling the primary airflow too far below the dew point. Thus by monitoring environmental conditions, for example the humidity and temperature, the fan speed of fan **82** may be selectively controlled to optimize production of condensation regardless of ambient environmental conditions. Thus in a very humid environment, fan **82** will be powered to draw a higher mass flow rate of the primary airflow through the two cooling stages, whereas in lower humidity conditions the primary airflow will require more time to optimize the condensation and thus slower fan speeds may be used to provide for optimized condensate production.

[0088] In the further embodiment of **FIG. 5 a** partition **100** partitions manifold **20** so that the primary and secondary airflows do not mix. For example, partition **100** may bisect the intake into refrigerant condenser **24**. Otherwise, partition **100** may be mounted relative to the intake into refrigerant condenser **24** so as to provided for a greater volume of auxiliary airflow in direction D' flowing through condenser **24**. The air speed velocity and mass flow rate of the primary airflow through the two cooling stages of the heat exchanger and refrigerant evaporator respectively, may be, for example, controlled by selectively positioning the position of partition **100** relative to condenser **24** or otherwise by, in conjunction with, the use of airflow dampers or other selectively controllable airflow valves.

[0089] The appropriate processing of ambient air provides for optimal operation of the condenser unit. While conventional condensers may simply drive high volumes of air through a cooling system (typically just an evaporator without a heat exchanger), these systems have not accommodated a system designed for power efficiency as is in the present invention which employs techniques to extract the maximum quantity of water with the least power requirements. This may be accomplished in a number of ways, as follows.

[0090] Environmental conditions are monitored by the system and at an appropriate point in the system, such as between the heat exchanger and the evaporator (first pass) the temperature relative to dew point is monitored. If the air at this point is too far above dew point the fan that draws air through this section of the unit may decrease its speed thus slowing the air and allowing more time for the air to cool prior to reaching the evaporator plates. If the air at this point is below dew point then the system may increase the fan speed and continue to optimize the airflow stream. Other conditions throughout the device may be monitored as well and this information may be used by controller **48** to further tune the device. Humidity levels leaving the system may be used as a means to determine exactly how much water has been extracted from the air and with this information, the system may modify its configuration thus ensuring optimal performance.

[0091] In the alternative embodiment of **FIGS. 6***b*, **11** and **11***a*, air-to-water heat exchanger **90** is mounted upstream of the air-to-air heat exchanger along the primary airflow. Water collected in moisture collector **26** is directed for example by conduit **26***a* into water reservoir **90***a* from which the water may be collected for end use. The water in reservoir **90***a* is chilled, having just been condensed into and recovered from the evaporate plates. Thus the primary airflow passing through air conduits **90***b* in direction A' is cooled by the water cooling the conduits **90***b* before the primary airflow enters the air-to-air heat exchanger for further pre-cooling as described above. This further improves the efficiency of the condenser as it takes advantage of the cold temperature of the collected water.

[0092] In one embodiment, various parts and components of the unit may be either constructed with Titanium Dioxide or my simply be coated with Titanium Dioxide. Using this material to construct various parts for the device, or using this material as a coating on these parts, will ensure that these components are kept clean and free of contaminates and that the water source created by the device is kept free of unwanted contaminates. Virtually any of the internal components may be made of this inexpensive and abundant material. In addition, either all the material that composes the storage container or just the inner lining may be made of this material as a means to ensure that that water source is kept clean and free of unwanted contaminates.

**[0093]** This material may be used as an antimicrobial coating as the Photocatalytic activity of titania results in a thin coating of the material exhibiting self cleaning and disinfecting properties under exposure to ultra-violet (UV) radiation. These properties make the material ideal for application in the construction of our water condensation system helping to keep air and water sources clean and free of contaminates while as well offering the benefits of self repair should a surface be scratched or compromised.

**[0094]** Titanium dioxide, also known as titania, is the naturally occurring oxide of titanium, chemical formula $TiO_2$. Approved by the food testing laboratory of the United States Food and Drug Administration (FDA), Titanium Dioxide is considered a safe substance and harmless to humans.

**[0095]** Scientific studies on photocatalysis have proven this unique but abundant substance to be anti-bacterial, anti-viral and fungicidal making it ideal for self cleaning surfaces and may be used for deodorizing, air purification, water treatment, and water purification.

**[0096]** As Titanium dioxide is a semiconductor and is chemically activated by light energy, appropriate lighting sources may be added at various strategic points throughout the device to ensure that the air and water sources are kept clean and free of unwanted substances. Some of the most beneficial places throughout the system that might use this $TiO_2$ exposed to UV radiation are the heat exchanger, evaporator plates, and the storage container, however virtually all surfaces that come in contact with either the air or the water source may be constructed with Titanium Dioxide. One strategic place for the lighting source might be between the heat exchanger and the evaporator plates using reflective material to ensure that the light radiates through both theses sections of the device made, or coated with $TiO_2$.

**[0097]** As a pure titanium dioxide coating is relatively clear, this substance may be used for the inner lining of tubing that carries the water from the evaporator plates to the storage container and may become part of the UV purification system. This material has an extremely high index of refraction with an optical dispersion higher than diamond so in order to enhance its desired effects, coiled tubing that surrounds the light source, may be encased in a reflective material so as to ensure that light is given an adequate opportunity to come in contact with the surface of the material and thus create the desired effect.

**[0098]** In applications where this UV and Titanium purification system is used inside of a storage container of some sort, an opening may be situated at the bottom of the reflective encasement such that light will escape to offer these same desire effects to occur within the storage container. Alternatively, a separate light may be used within the storage container assuming it is not practical for various applications to use only one light to serve this purpose.

**[0099]** As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

What is claimed is:

**1**. A water condenser comprising:

a housing having a first air intake for entry of a first airflow,

said first air intake mounted to an air-to-air heat exchanger having a pre-refrigeration set of air conduits cooperating in fluid communication with said first air intake; for intake of said first airflow into said pre-refrigeration set of air conduits,

said heat exchanger having a post-refrigeration set of air conduits arranged relative to the pre-refrigeration set of air conduits for beat transfer between said pre-refrigeration set of air conduits and said post-refrigeration set of air conduits,

a refrigeration unit cooperating with said pre-refrigeration set of air conduits for passage of said first airflow from a downstream end of the pre-refrigeration set of air conduits into an upstream end of said refrigeration unit, wherein said refrigeration unit includes refrigerated surfaces over which said first airflow passes as it flows from said upstream end of the refrigeration unit to a downstream end of said refrigeration unit, said first airflow cooled in said refrigeration unit below a dew point of said first airflow so as to condense moisture from said first airflow onto said refrigerated surfaces for gravity-assisted collection of the first moisture into a moisture collector mounted under said refrigeration unit,

an air-to-water heat exchanger cooperating with said air-to-air heat exchanger for cooling said first airflow wherein said first airflow is passed through said air-to-water heat exchanger and said first moisture from said moisture collector is simultaneously passed through said air-to-water heat exchanger so that said first moisture, cools said first airflow,

said downstream end of said refrigeration unit cooperating with, for passage of said first airflow into, an upstream end of said post-refrigeration set of air conduits, said first airflow exhausting from a downstream end of said post-refrigeration set of air conduits, wherein said first airflow in said post-refrigeration set of air conduits pre-cools said first airflow in said pre-refrigeration set of air conduits, control means for controlling the temperature of said first airflow in said pre-refrigeration set of air conduits so that it remains above a dew point temperature of said first airflow when in said pre-refrigeration set of air conduits and for controlling the temperature of said first airflow in said refrigeration unit so that it drops below a dew point temperature of said first airflow when in said refrigeration unit without freezing,

an airflow mover urging said first airflow into said first air intake, along said pre-refrigeration set of air conduits, through said refrigeration unit, and along said post-refrigeration set of air conduits.

2. The device of claim 1 further comprising an air plenum having upstream and downstream ends, said upstream end of said air plenum cooperating with said downstream end of said post-refrigeration set of air conduits so that said first airflow flows into said air plenum at said upstream end of said plenum,

said plenum having an auxiliary air intake into said plenum, for intake of an ambient second airflow into said plenum, said downstream end of said plenum cooperating in fluid communication with a refrigerant condenser in a refrigeration circuit including said first and second airflows exhausting from a downstream end of said refrigerant condenser,

wherein said airflow mover urges said first and second airflows through said plenum and said refrigerant condenser.

3. The device of claim 1 wherein said refrigeration unit is a refrigerant evaporator.

4. The device of claim 2 further comprising a selectively actuable airflow metering valve mounted in cooperation with said auxiliary air intake for selectively controlling the volume and flow rate of said second airflow passing into said plenum.

5. The device of claim 4 further comprising an automated actuator cooperating with said metering valve for automated actuation of said metering valve between open and closed positions of said valve according to at least one environmental condition indicative of moisture content in said first airflow.

6. The device of claim 5 wherein said automated actuator is a bi-metal actuator and wherein said at least one environmental condition includes ambient air temperature external to said housing.

7. The device of claim 5 wherein said automated actuator includes a processor cooperating with at least one sensor, said at least one sensor for sensing said at least one environmental condition and communicating environmental data corresponding to said at least one environmental condition from said at least one sensor to said processor.

8. The device of claim 3 further comprising a processor cooperating with at least one sensor, said at least one sensor for sensing said at least one environmental condition and communicating environmental data corresponding to said at least one environmental condition from said at least one sensor to said processor, wherein at least one environmental condition of said at least one environmental condition is chosen from the group consisting of: ambient air temperature, first airflow temperature of said first airflow, humidity, barometric air pressure, air density, airflow velocity, air mass flow rate, temperature of said refrigerated surface.

9. The device of claim 8 wherein said at least one sensor senses said at least one environmental condition in or in proximity to said first airflow.

10. The device of claim 9 wherein said first airflow temperature environmental condition includes air temperatures in said pre-refrigeration and post-refrigeration sets of air conduits.

11. The device of claim 9 wherein said first airflow temperature environmental condition includes air temperature in said refrigeration unit.

12. The device of claim 11 wherein said at least one sensor senses said at least one environmental condition in said heat exchanger, and wherein said processor regulates said first airflow in said first refrigeration unit so that said air temperature in said refrigeration unit is below said dew point of said first airflow, but above freezing.

13. The device of claim 11 wherein said processor calculates said dew point for said first airflow based on said at least one environmental condition sensed by said at least one sensor.

14. The device of claim 11 wherein said airflow mover is selectively controllable and wherein said processor regulates said first airflow so as to minimize said air temperature of said first airflow from dropping below said dew point for said first airflow while in said heat exchanger to minimize condensation within said heat exchanger.

15. The device of claim 9 wherein said airflow mover is at least one fan in a flow path containing said first airflow.

16. The device of claim 15 wherein said at least one fan includes a fan downstream of said heat exchanger.

17. The device of claim 15 further comprising at least one air filter in said flow path.

18. The device of claim 17 further comprising a water filter for filtering water harvested from said refrigeration unit.

19. The device of claim 17 wherein said at least one air filter includes an ultra-violet radiation lamp mounted in proximity to so as to cooperate with said flow path.

20. The device of claim 17 wherein said water filter includes an ultra-violet radiation lamp mounted in proximity to so as to cooperate with said moisture collector.

21. The device of claim 17 wherein said at least one air filter and said water filter include a common ultra-violet radiation lamp mounted in proximity to so as to cooperate with said flow path and said moisture collector.

22. The device of claim 1 wherein said refrigeration unit includes a plate condenser having at least one plate.

23. The device of claim 22 wherein said at least one plate is a plurality of plates.

24. The device of claim 23 wherein said plurality of plates are mounted in substantially parallel spaced apart array.

25. The device of claim 2 where, in upstream-to-downstream order, said refrigeration unit is adjacent said heat exchanger, said heat exchanger is adjacent said plenum, said plenum is adjacent said refrigerant condenser, and said refrigerant condenser is adjacent said airflow mover.

26. The device of claim 25 wherein said refrigeration unit, said heat exchanger, said plenum, said refrigerant condenser, and said airflow mover elements are inter-leaved in closely adjacent array.

27. The device of claim 2 wherein said first airflow has a corresponding first mass flow rate, and wherein said second airflow has a corresponding second mass flow rate, and wherein a combined airflow of said first and second airflows is the sum of corresponding first and second mass flow rates so that a combined mass flow rate of said combined airflow is greater than said first mass flow rate.

28. The device of claim 1 wherein said air-to-water heat exchanger is upstream of said air-to-air heat exchanger along said first airflow.

29. The device of claim 1 wherein said air-water heat exchanger is downstream of said air-to-air heat exchanger along said first airflow.

**30**. The device of claim 1 wherein elements including said housing, said first air intake, said air-to-air heat exchanger, said sets of air conduits, said refrigeration unit, said moisture collector, said air-to-water heat exchanger, moisture conduits, or said airflow mover include titanium dioxide as a constituent component.

**31**. The device of claim 30 wherein said titanium dioxide is a coating on at least internal surfaces of said elements.

**32**. The device of claim 30 further comprising at least one source of radiation is mounted within said housing so as to irradiate internal surfaces of at least one of said elements.

**33**. The device of claim 32 wherein said at least one source of radiation is a source of ultra-violet radiation.

**34**. The device of claim 32 wherein said source of radiation is mounted between said heat exchanger and said evaporator.

**35**. The device of claim 34 further comprising a reflector mounted adjacent said source of radiation to reflect radiation onto internal surfaces of said heat exchanger and said evaporator.

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