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Faqih

(54) PRODUCTION OF POTABLE WATER AND FRESHWATER NEEDS FOR HUMAN, ANIMAL AND PLANTS FROM HOT AND HUMID AIR

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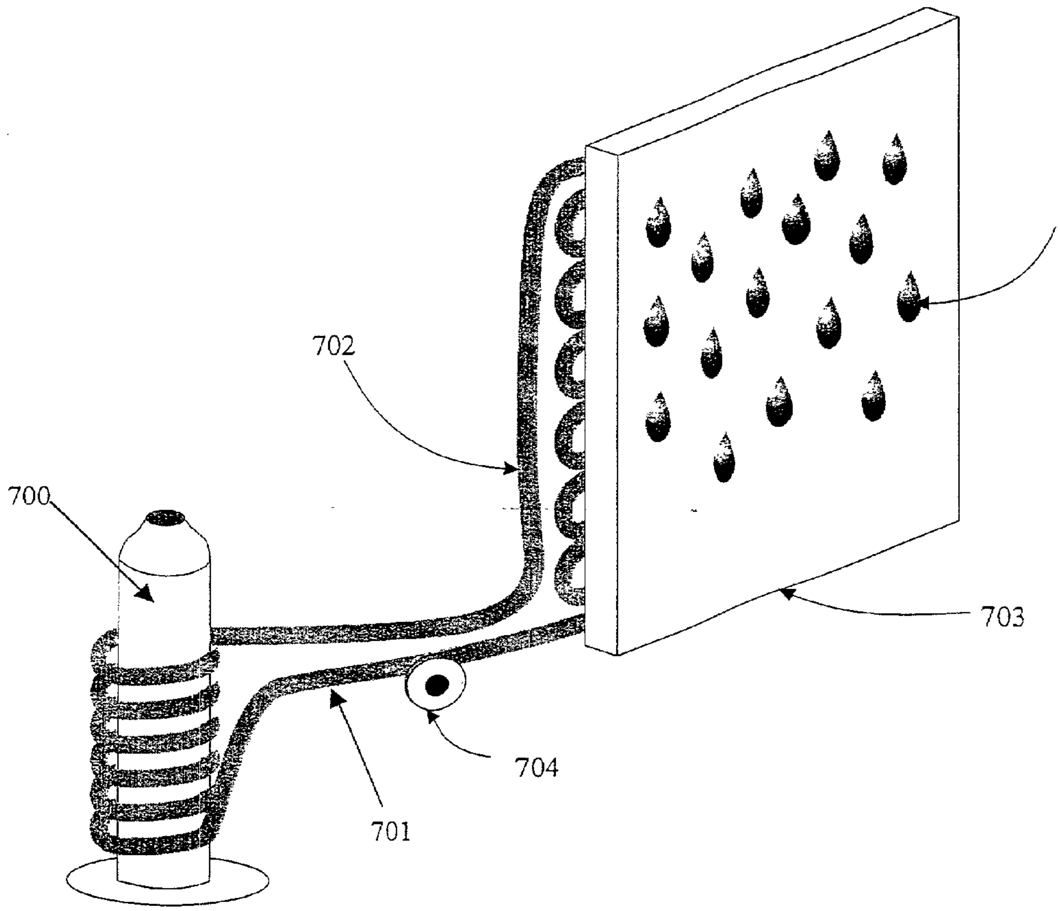
(57) **ABSTRACT**

Systems and methods are disclosed for extracting freshwater from atmospheric humidity in extremely hot and humid climates and supplying freshwater to a small group of people, a building, a farm, or forestation area. The freshwater is treated to provide drinking water by disinfecting to eliminate microorganisms and filtration to remove suspended particulates from air, erosion or corrosion products, and disinfected waste. Compact units provide drinking water for individuals, passengers in cars, vans, trucks, or recreational boats, or crewmembers on a seagoing cargo ship whether from atmospheric humidity or from moisture-laden gases. Furthermore, systems are disclosed for the ample supply of freshwater with minimal treatment for small- to large-sized buildings in a manner that alleviates the heat load on buildings. Collection of freshwater from hot humid ambient air is also provided for other uses, such as irrigation and farm animal drinking. Various methods are used for condensation of water vapor suspended in the air as alternative to conventional refrigeration cycles using CFC refrigerants. Devices are disclosed using naturally occurring brackish cold water, circulation of cooling water cooled by thermoelectric cooling or thermoacoustic refrigeration as well as evaporative cooling and transpiration cooling. Water produced by the systems may flow under gravitational forces entirely or with the assistance of boasting pumps.



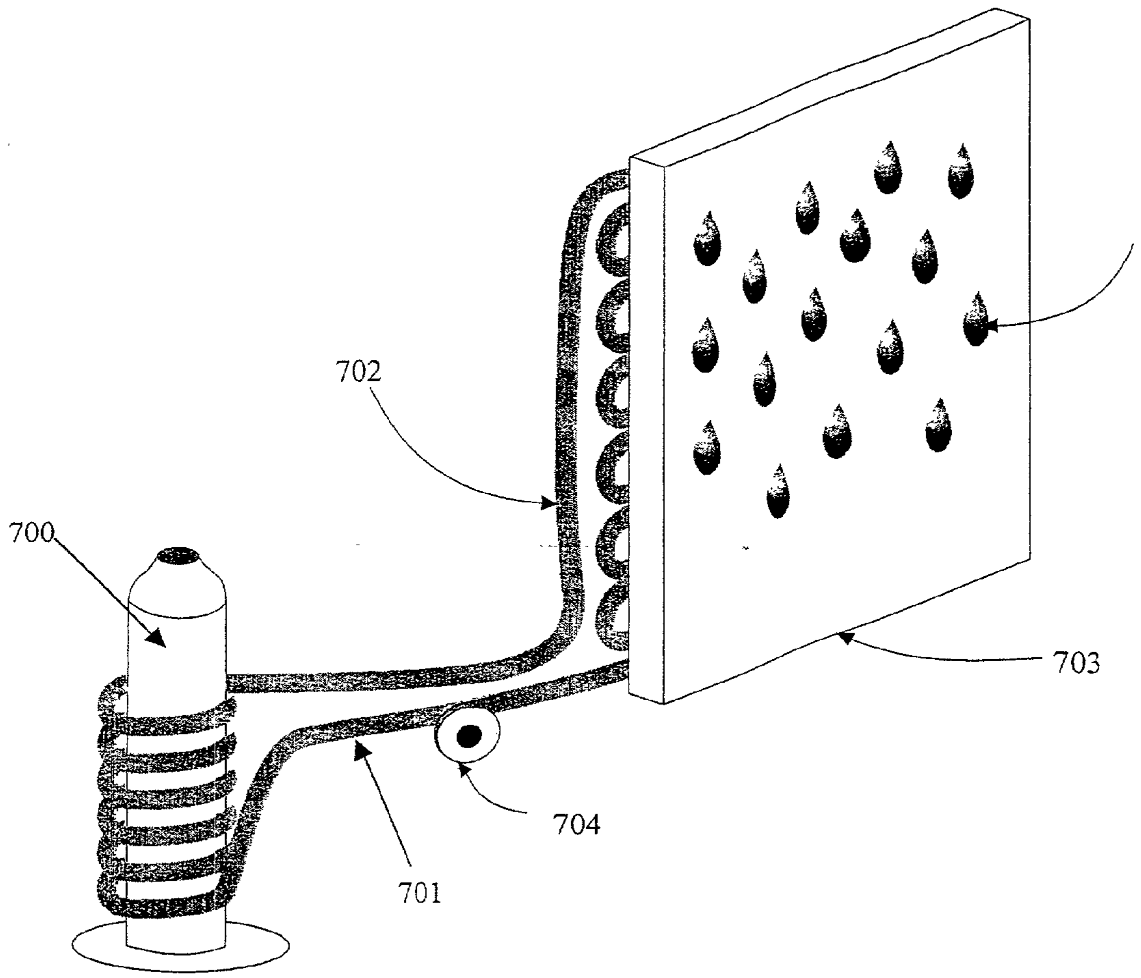


Figure 1

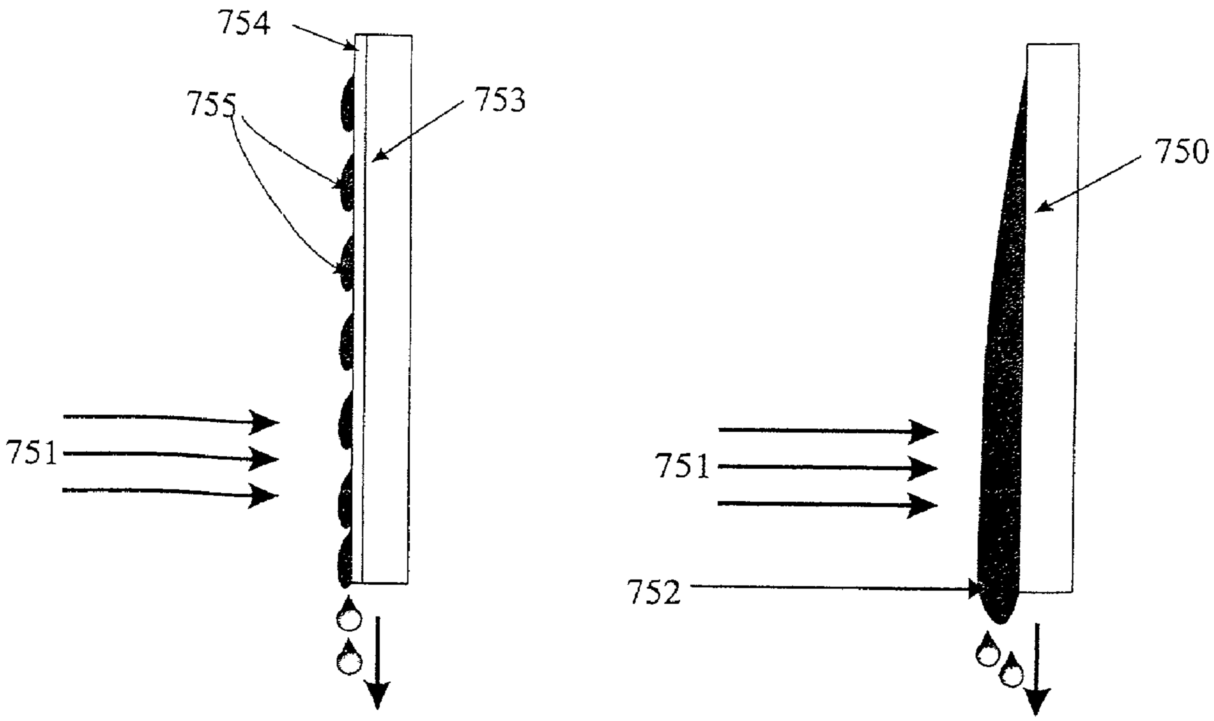


Figure 2a

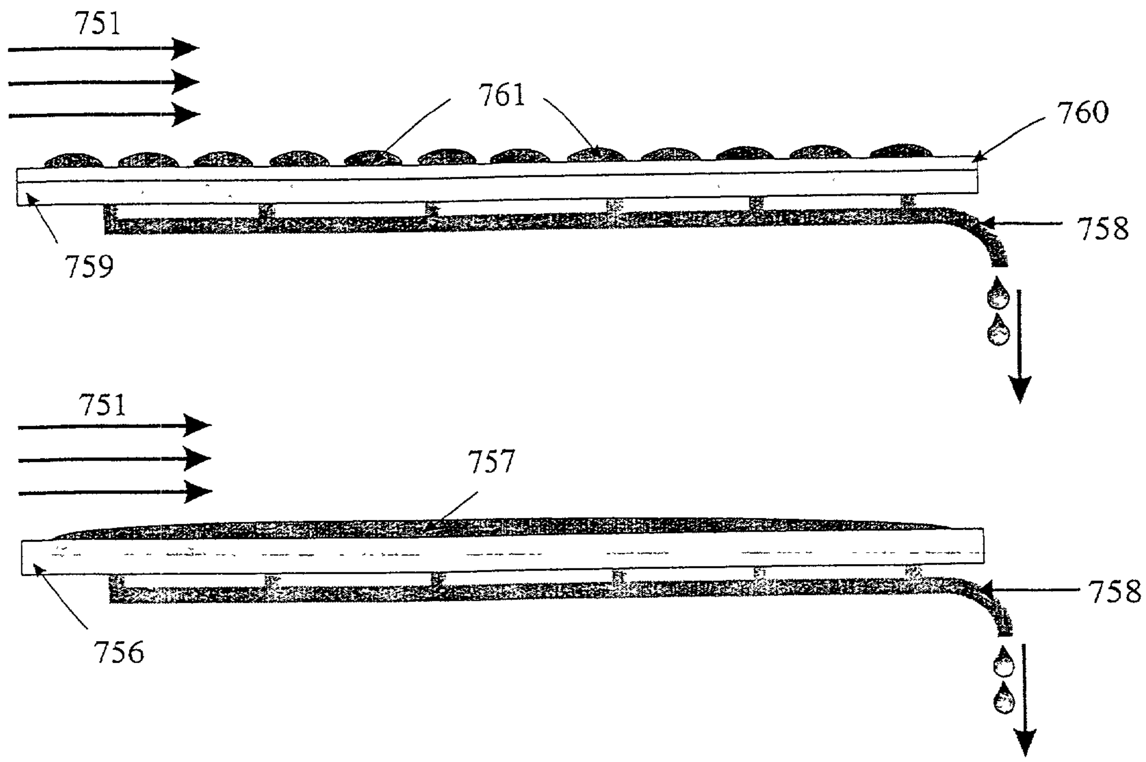
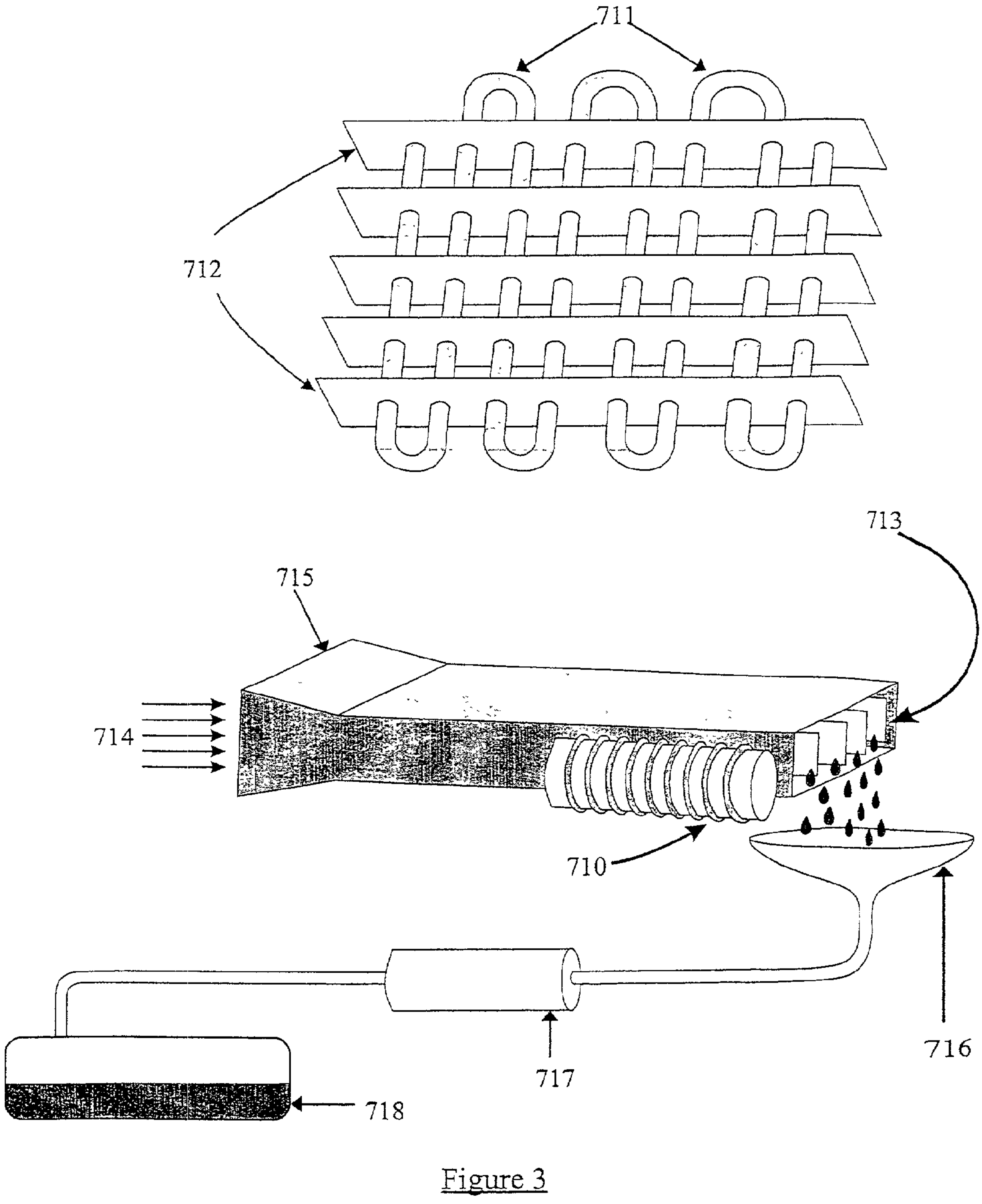


Figure 2b



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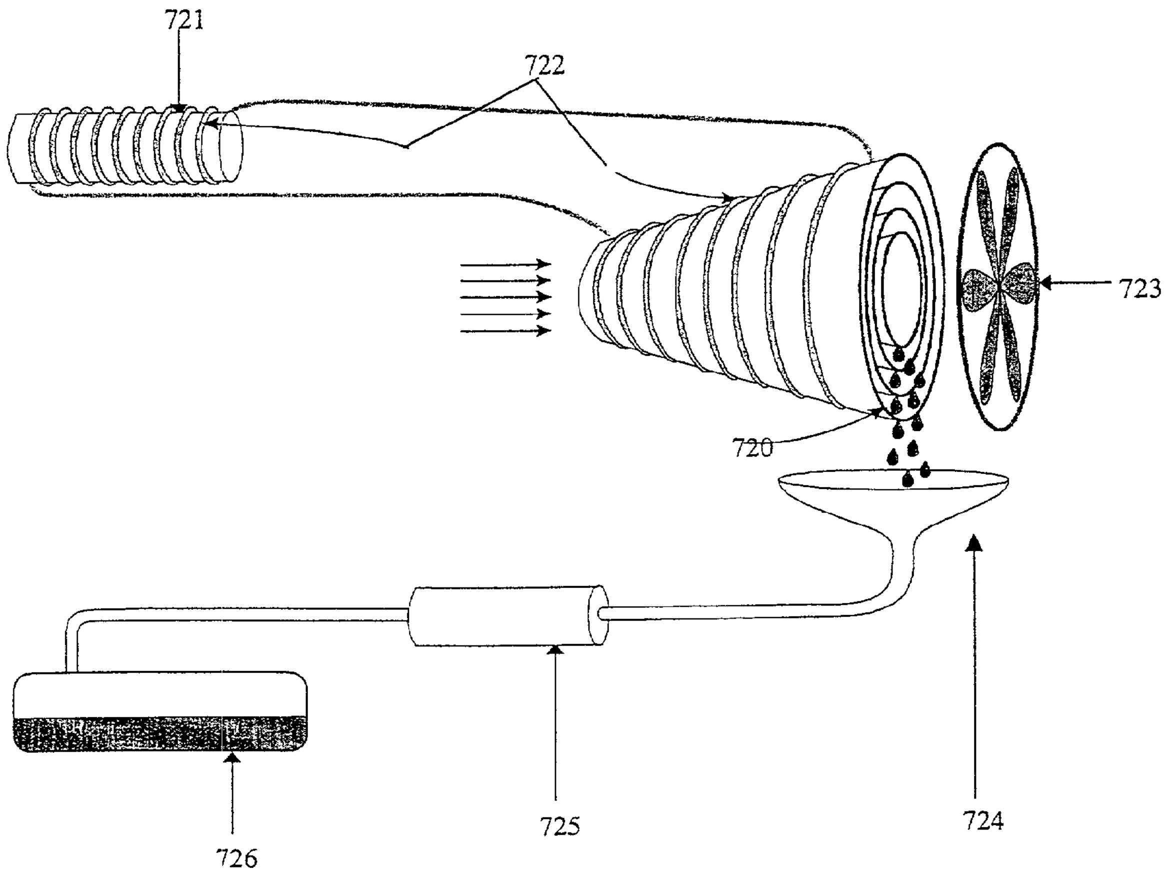

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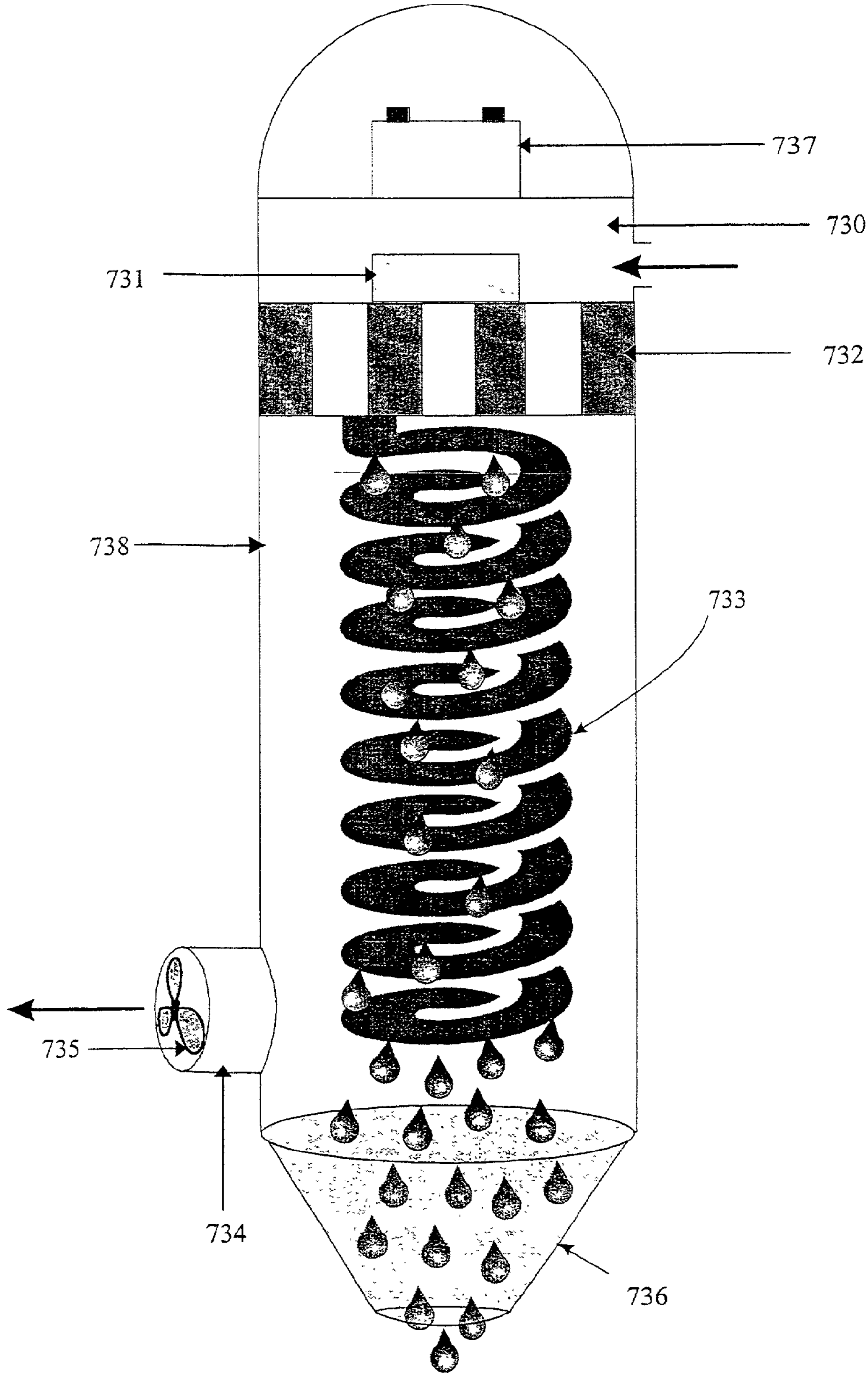

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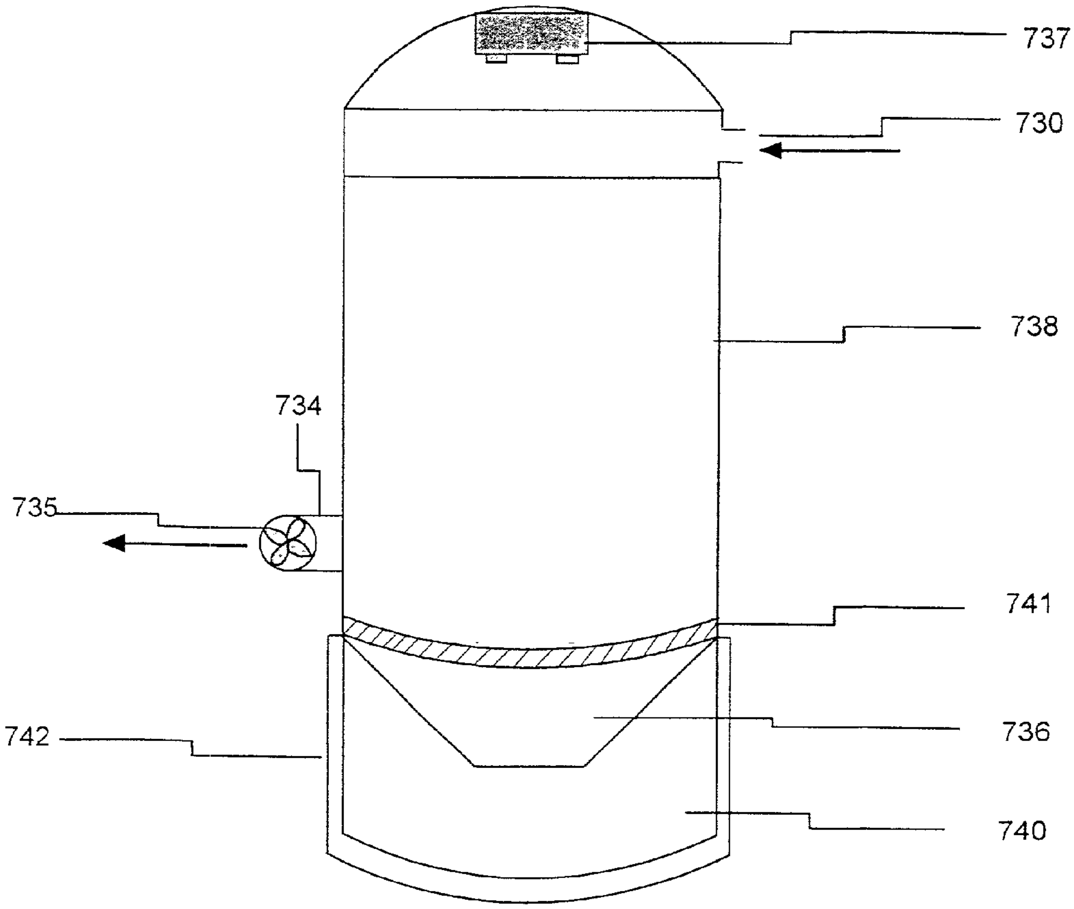

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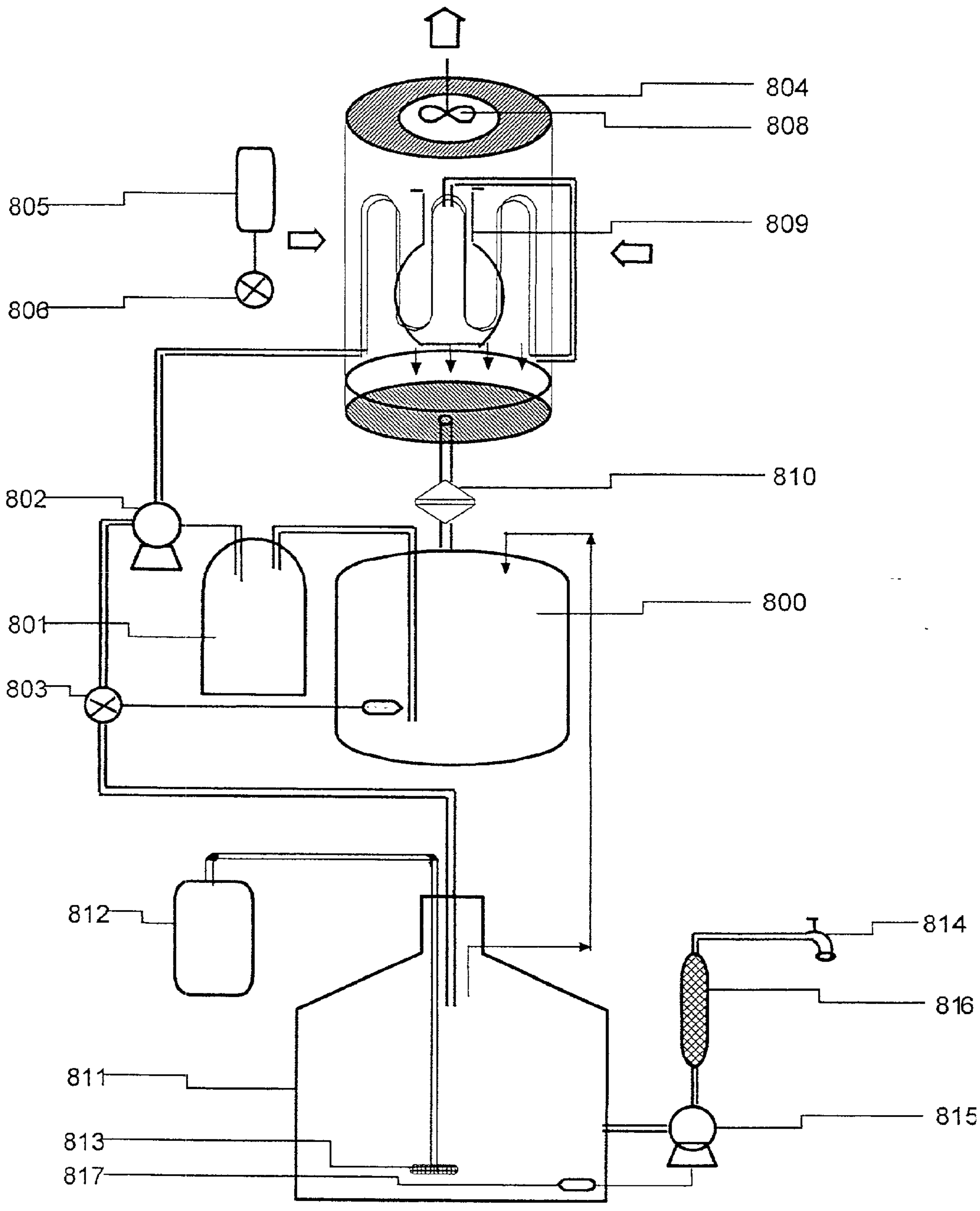
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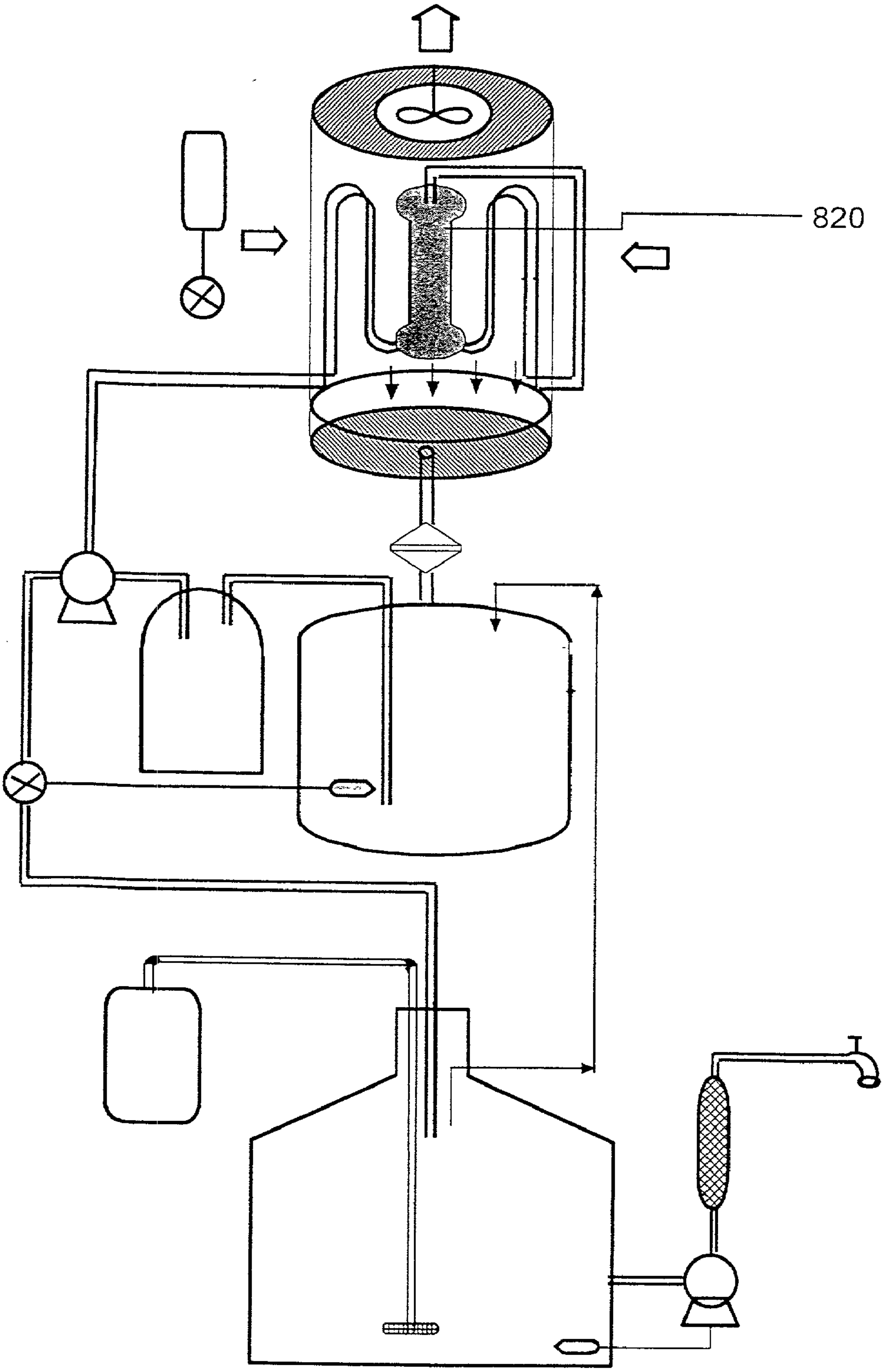
Figure 7



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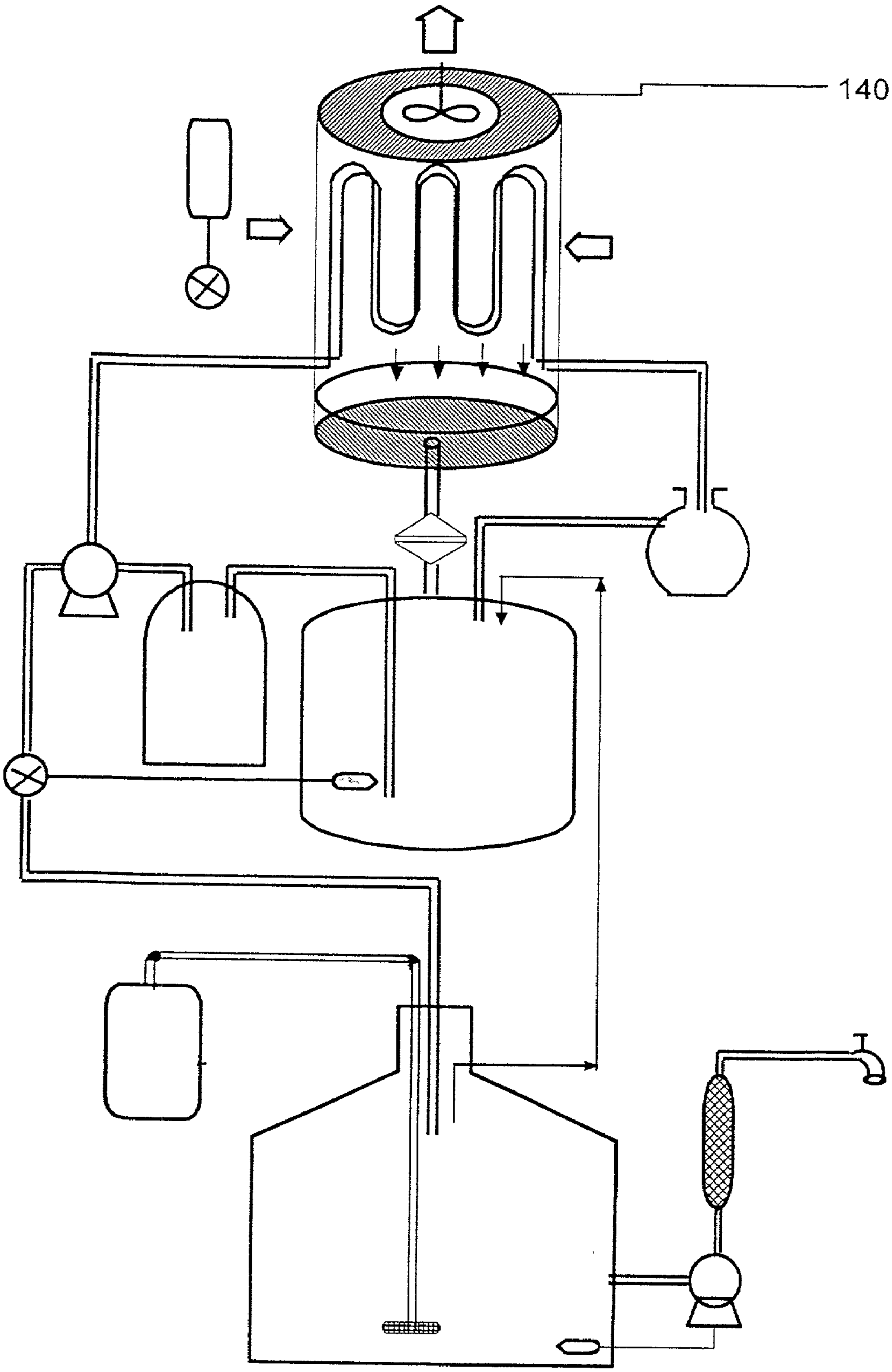

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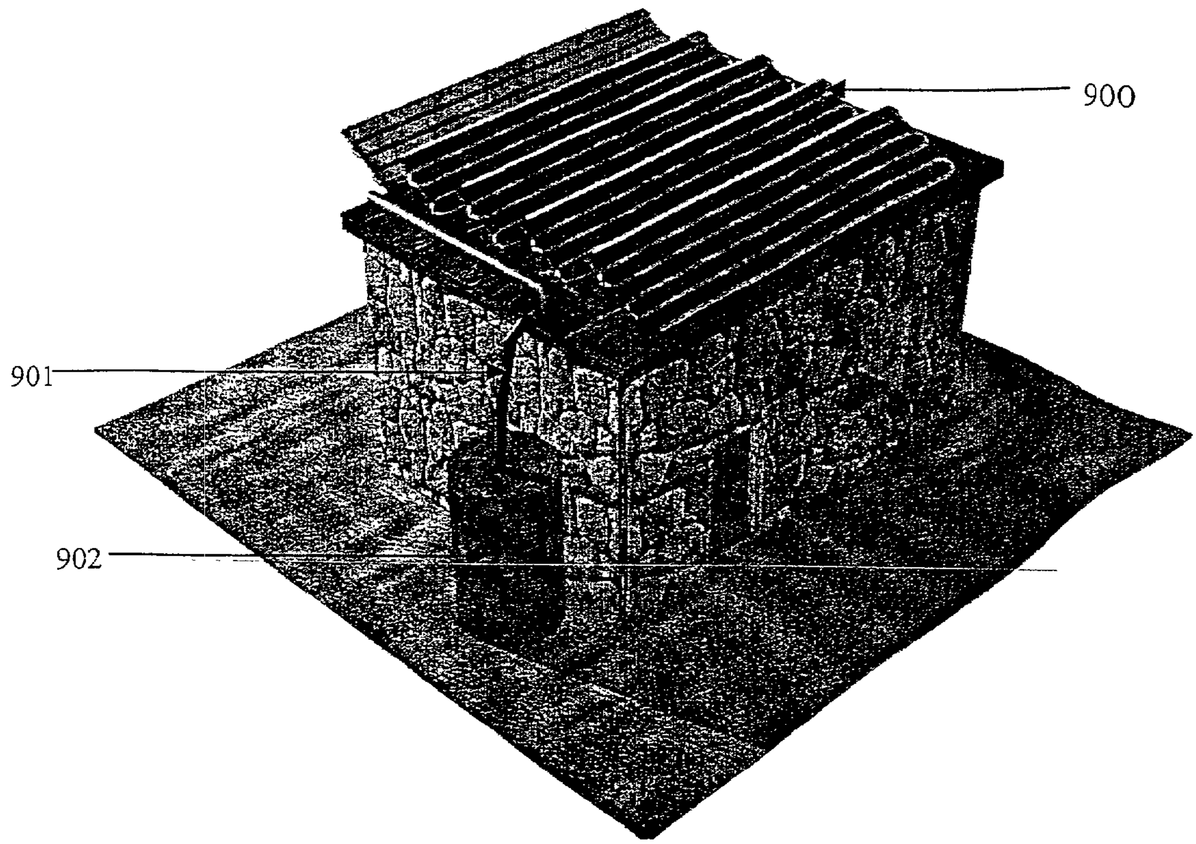

Figure 10

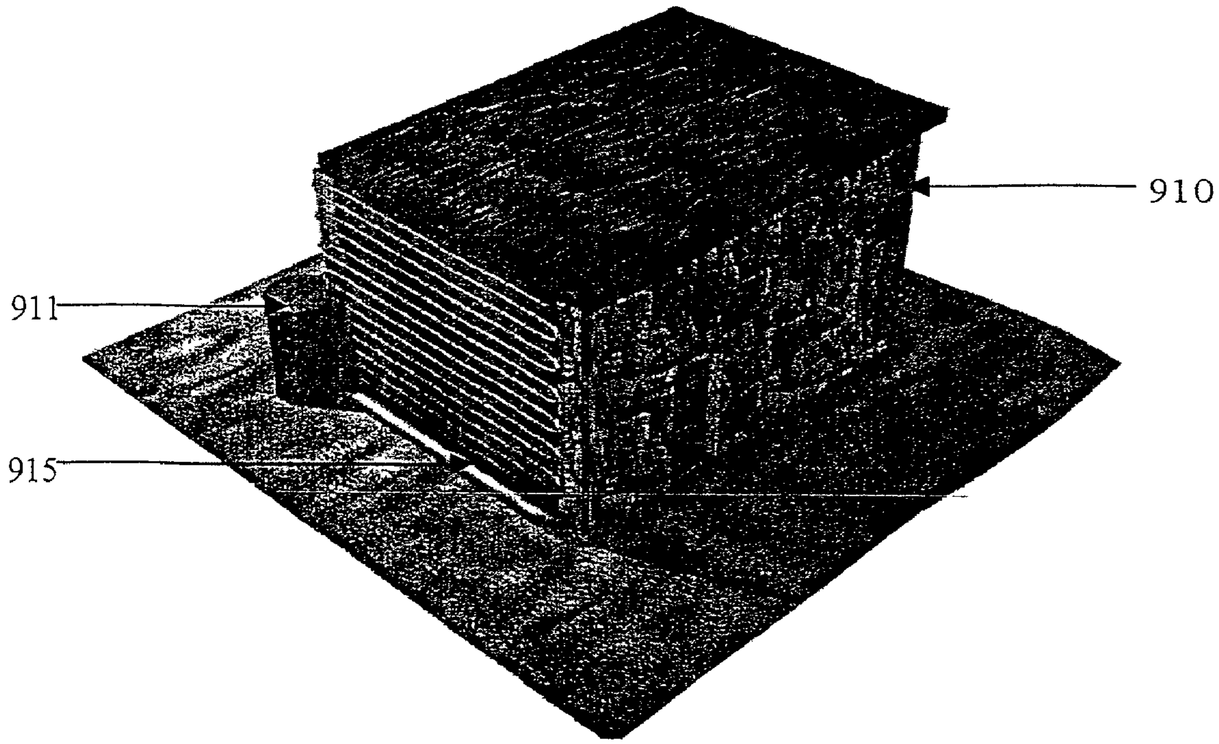

Figure 11a

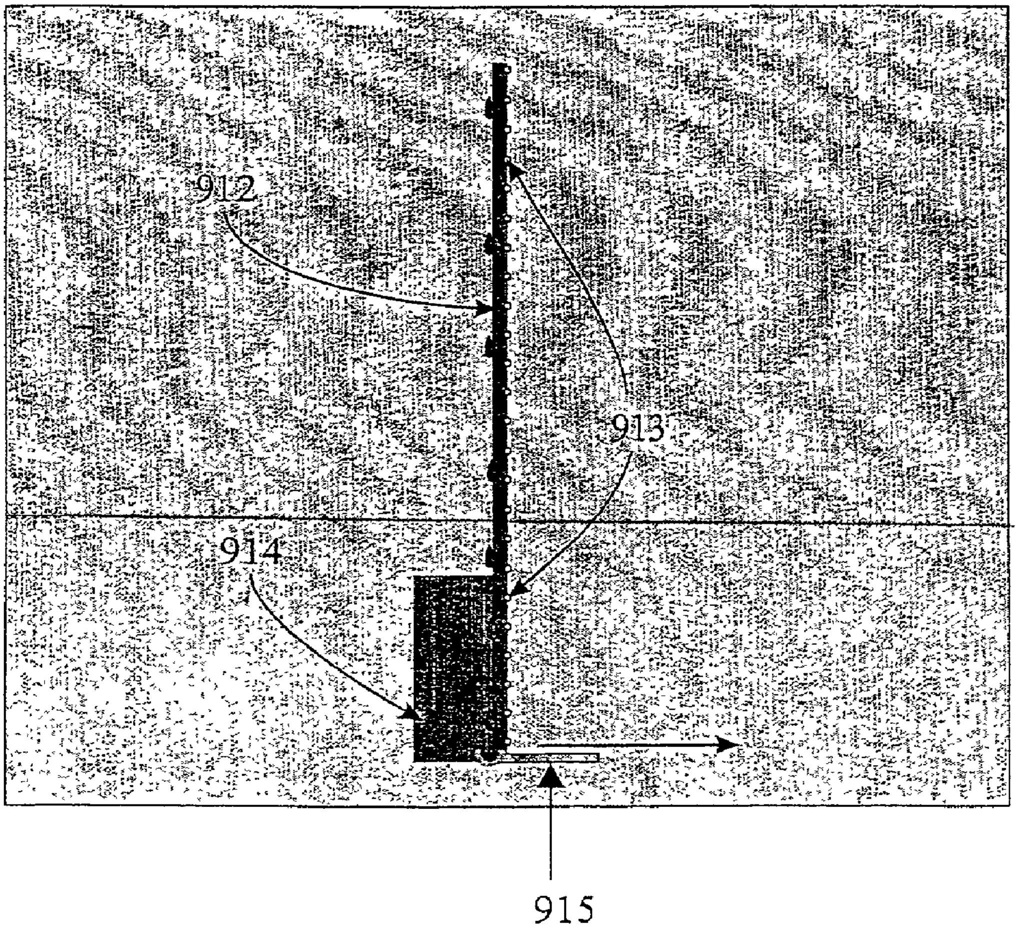

Figure 11b

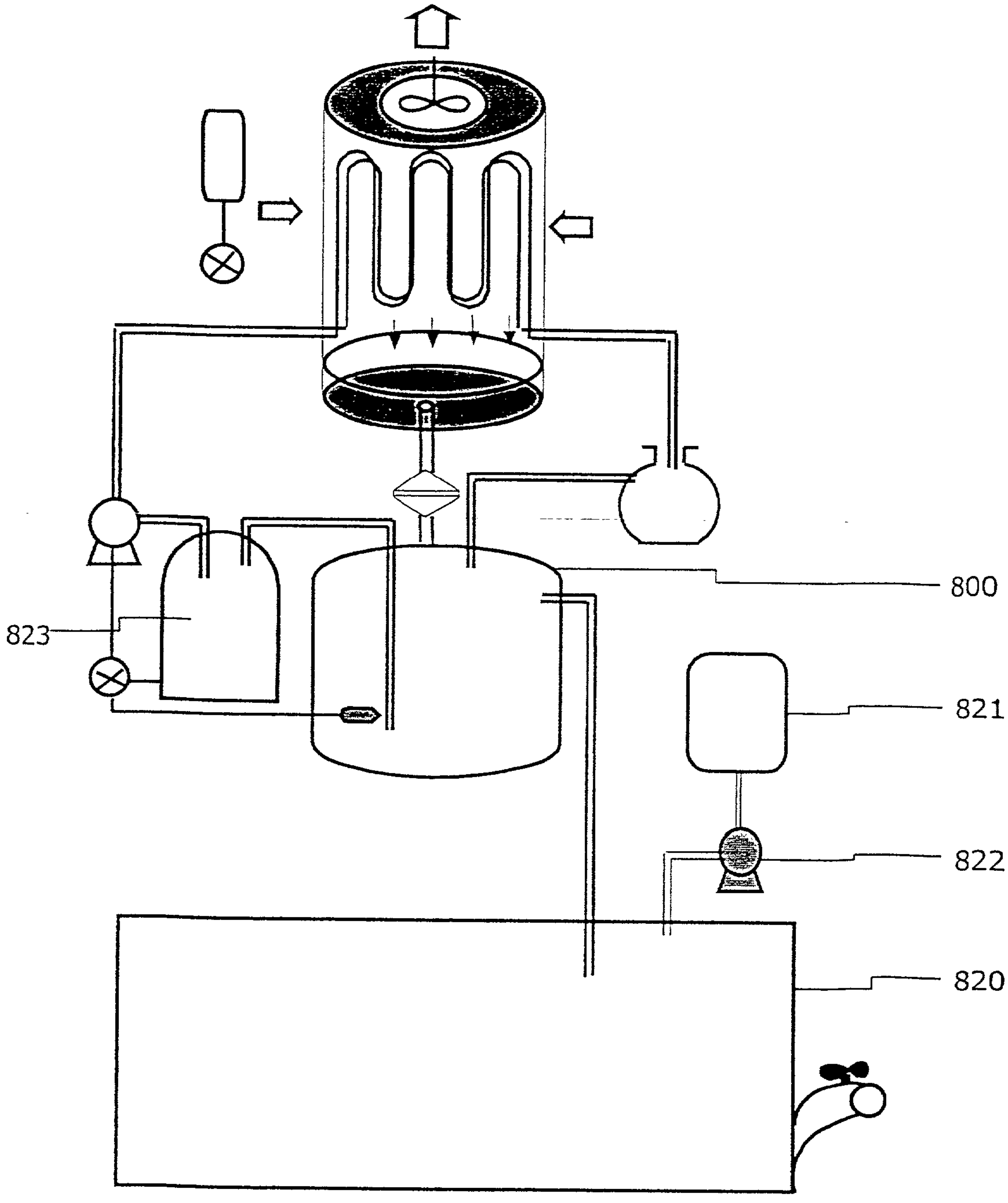

Figure 12

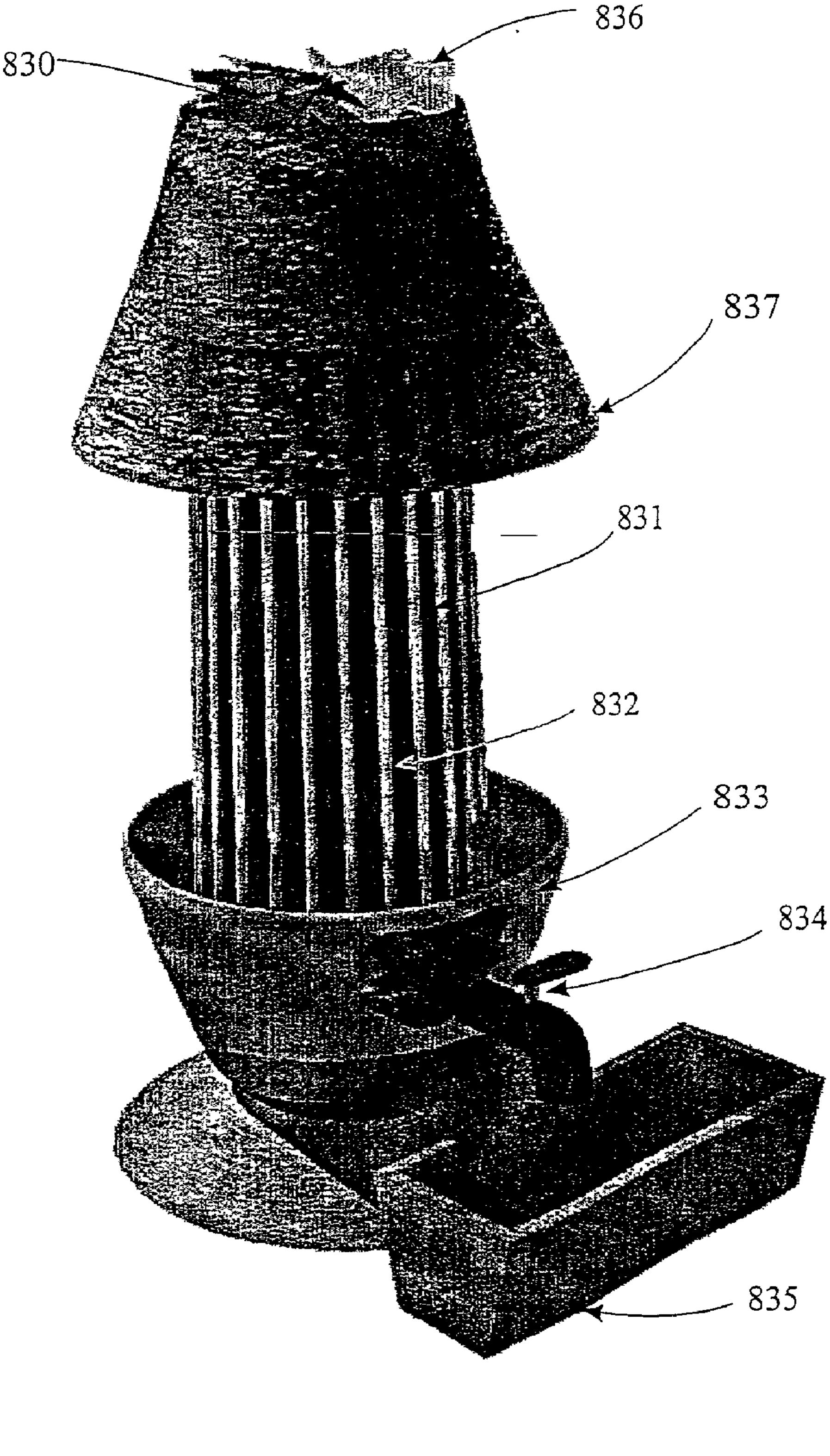

Figure 13

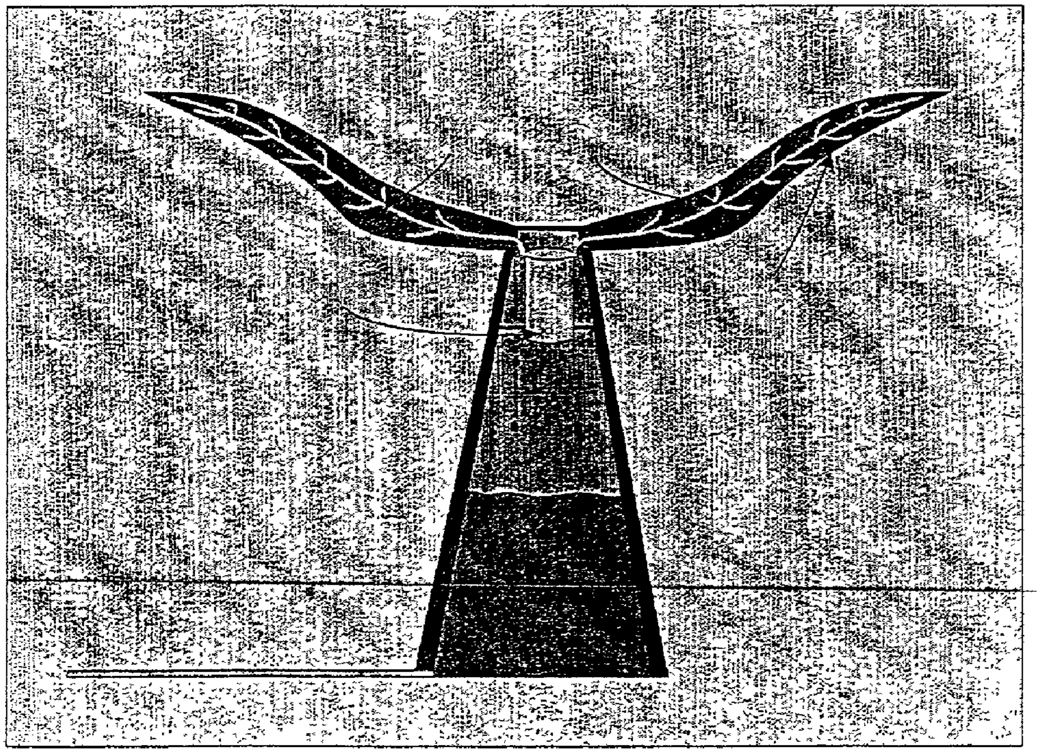

Figure 14

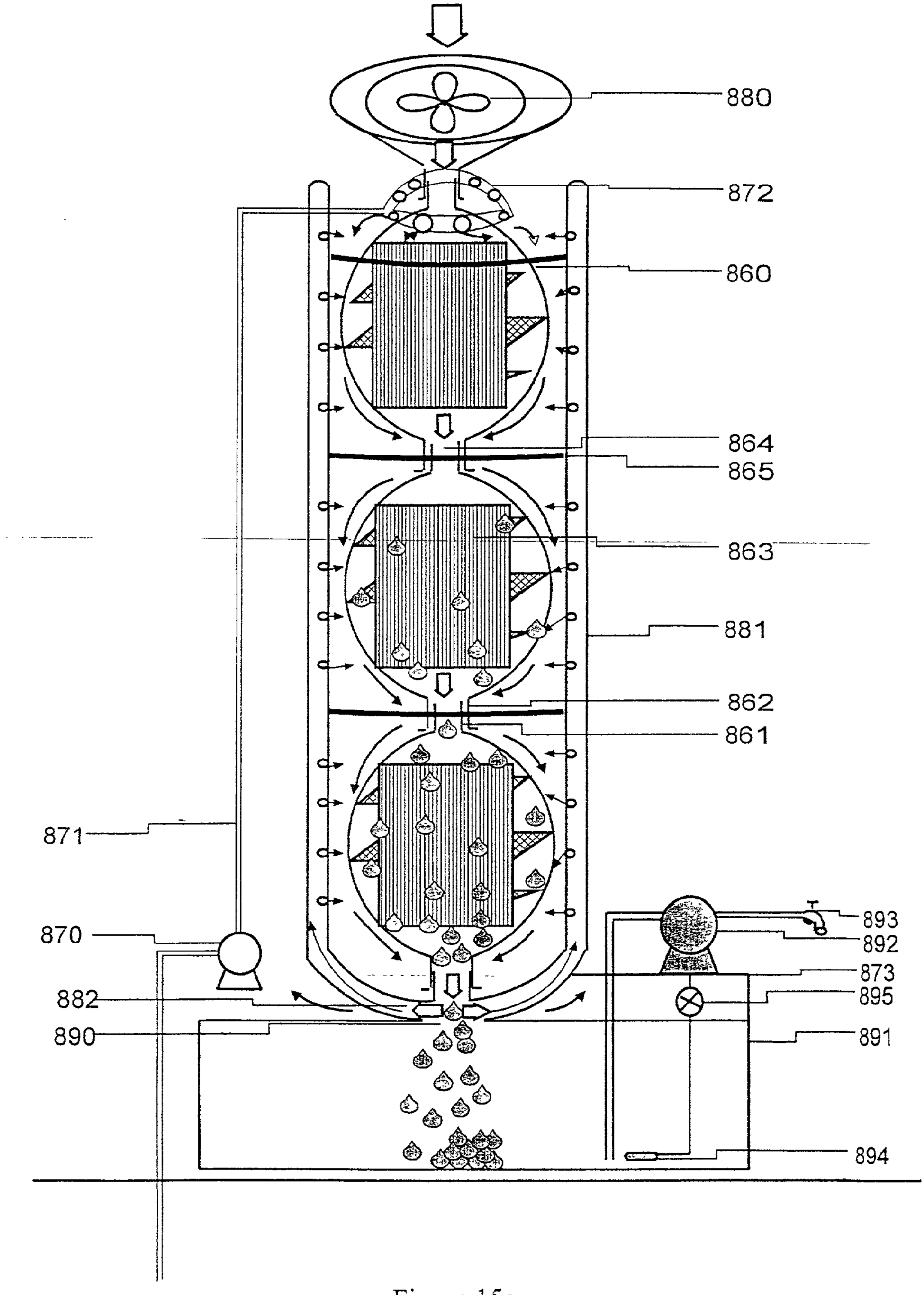
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Figure 15a

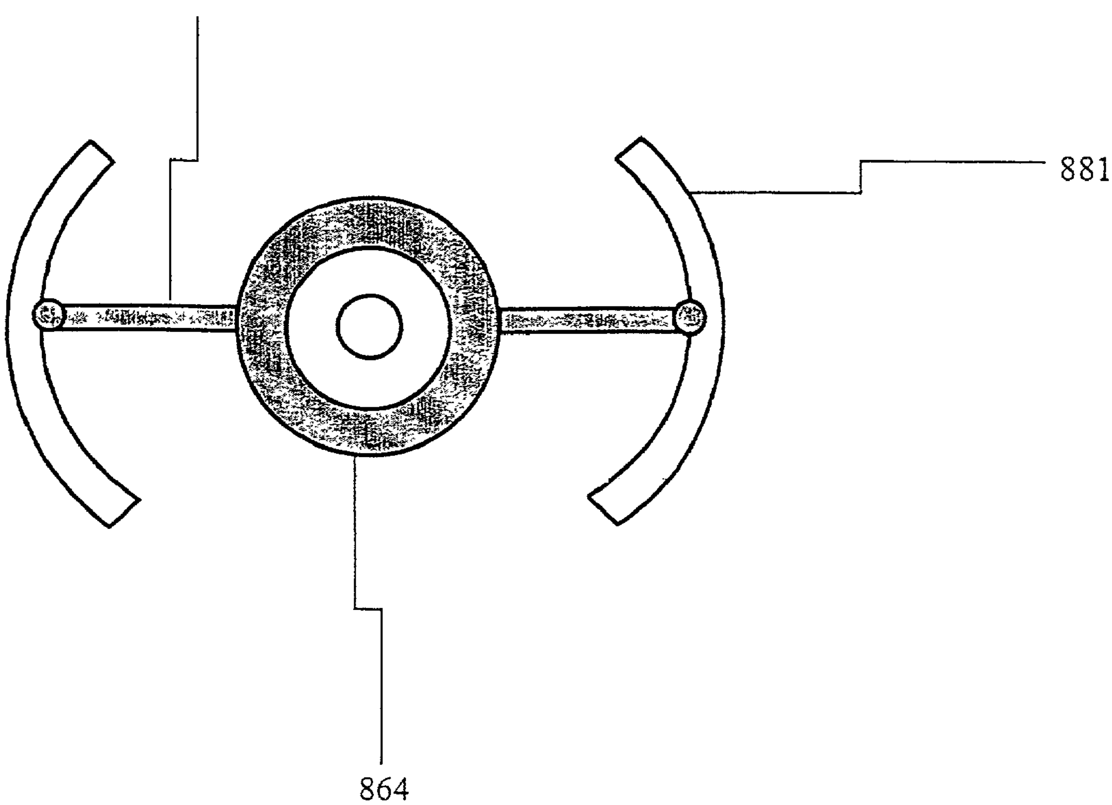

Figure 15b

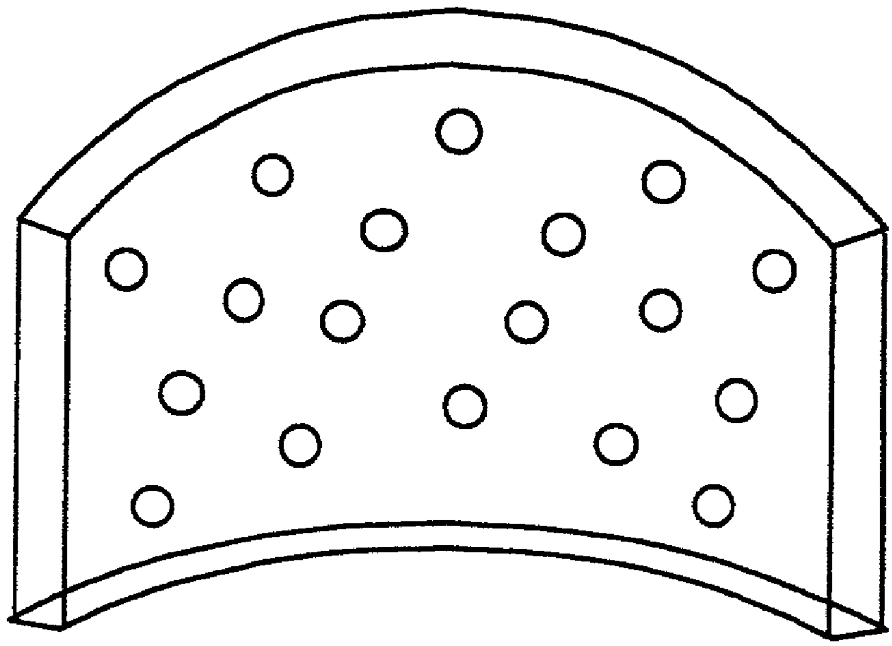

Figure 15c

PRODUCTION OF POTABLE WATER AND FRESHWATER NEEDS FOR HUMAN, ANIMAL AND PLANTS FROM HOT AND HUMID AIR

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The invention relates generally to harvesting freshwater from atmospheric humidity in regions suffering from freshwater shortage compounded with extended periods of extremely high temperature and very high humidity to supply potable water as well as freshwater for other human uses, irrigation, and animal and poultry farms and to alleviate the heat loading for buildings. The invention also relates to collection of water from moisture rich gases in situations of emergency and when trusted freshwater is lacking.

SUMMARY OF THE INVENTION

[0002] Extreme heat in tropical regions is usually accompanied by extremes of high humidity, especially at low altitude where bayous, marshlands, swamps, shallow lakes, heavy vegetations, and forests are abundant; tropical islands, such as the Caribbean Islands; arid land and deserts nearby ocean shorelines or seashores; such as the regions in the Arabian Peninsula near the Red Sea and the Gulf. The absolute humidity in regions by and near the shores of oceans and seas could reach up to twenty-five (25) grams of water per cubic meter of air.

[0003] Generally, natural freshwater resources are scarce or limited in very hot and humid deserts and arid lands due to low precipitation and high salinity of surface and underground water. Heat strokes are also common in areas where there is no shade and building material does not provide proper protection from brunt of the harsh climate. Rural and nomadic life conditions are deteriorating due to environmental changes caused by expanding developments elsewhere.

[0004] Shortage in supply of potable water and freshwater is increasing at a vast rate, as deserts expand and overtake fertile land and as many of the natural ground water-resources are being depleted. Shift in patterns of the global climate throughout time resulted in a drop in the rate of rainfall in many areas. Hunger and starvation is spreading in Africa because of shortage of freshwater to raise domestic animals and crops for food.

[0005] Sparse population and scattered population pockets in many areas make the application of water desalination and treatment technologies uneconomical due to the law demand and the high cost of water distribution from a central system over a wide stretch of land. Transportation of loads of freshwater is costly and exposes water to contamination en route and during handling and storage.

[0006] Accordingly, there is a need for localized production of fresh water to provide water for human drinking and freshwater for raising animals and for irrigation as well as other human uses. There is also need for means to alleviate the heating load of dwellings for human and animal.

[0007] In addition, atmospheric moisture is an excellent natural source of water regardless of the amount of water vapor content of the air. The lower layer of the atmosphere surrounding the earth contains over three trillion (3×10^{12}) cubic meter of renewable water, which is about one-thousandth (0.001) of the water stored on the surface of the earth. In comparison, the daily drinking water consumption of the earth population is about two hundred twelve million cubic meter (2.12×10^{8}), which is a very modest portion of the water entrapped in the atmosphere. That is, free atmospheric water accessible to all mankind on the earth can satisfy all drinking water needs anywhere and anytime with a lot to spare for irrigation and raising farm animals. The atmospheric moisture reserve will not be depleted by excessive extraction of water since the water vapor is continuously replenished by evaporation of surface water and the surface of the mountains and valleys due to the flow of hot air.

[0008] Accordingly, there is a need for systems to harvest moisture entrapped in ambient air for provision of potable water for human and freshwater for agricultural uses including rearing of animal farms for food.

[0009] Additionally, many resorts and vacationing places are located in hot humid regions deprived from drinking water and freshwater since they are on spreads of arid lands by shorelines wherein groundwater is brackish and rainfall is rare. In spite of the popularity of those areas, construction of desalination plants to produce freshwater for tourists is not economically viable due to the briefness of the tourism seasons and decline of demand most of the year. Reliance on bottled water is expensive for the average consumer while this source will not provide freshwater for other uses.

[0010] Accordingly, there is a need for systems for local water production from atmospheric humidity to supply fresh water to cabins, camping areas and tourist areas during tourism seasons in regions characterized by humid hot weather throughout the busy seasons. Systems compatible with tourist regions should reduce expenditure on drinking water and provide excess water for other human uses as long as the weather conditions are appropriate.

[0011] Travel across arid lands and deserts exposes travelers to shortage of water, or lack of trusted sources of water. Loading sufficient potable water on land vehicles could be cumbersome and may be impossible in some situations. Similarly, passengers on recreation boats or seagoing ships can be exposed to the risk of water shortages during their excursions.

[0012] Accordingly, there is a need for portable freshwater producing systems that can supply freshwater and potable water on land vehicles and seagoing vehicles, utilizing available water resources, such as atmospheric humidity and moisture-laden exhaust gases from internal combustion engines.

[0013] Installing large freshwater tanks over land vehicles for long trips across vast stretches of desert is impractical. Similarly, carrying sufficient freshwater supply or installation of desalination units or water reuse units aboard large seagoing boats reduces cargo space and minimizes the benefit from surface areas on the boat and increases the load.

[0014] Accordingly, there is a need for lightweight and freshwater producing systems characterized by small footprints that can supply freshwater and potable water on large land vehicles and seagoing ships.

[0015] In situations of emergency, water supply systems may be contaminated or interrupted by natural disasters or man made catastrophes and shortage of clean freshwater and potable water can lead to spread of diseases.

[0016] Accordingly, there is a need for mobile and portable water production equipment that can supply non-contaminated freshwater and potable water for a small or larger group of people on temporary basis until the main supply of water resumes operation.

[0017] Thermoacoustic refrigeration engines have been developed and are in use in the US National Laboratories, the US Department of Energy and the National Institute of Science and Technology, the US Department of Commerce. The machines are currently used for crycooling in special experiments.

[0018] In recent years concerns with the ozone depletion and global warming problems have become additional focal points of the Heating Ventilation Air Conditioning and Refrigeration (HVAC&R) research programs. Approximately one-third of the chlorofluorocarbons (CFCs) consumed in the U.S. are used in refrigeration and air-conditioning. CFCs are considered a major factor in ozone depletion and global warming problems. The changeover from CFCs to alternative refrigerants impacts equipment design and have a significant impact on energy use.

[0019] In the latest development in refrigeration, high-intensity sound waves are used to create superhot gas molecules. The gas molecules transfer their heat to inert coils and then expand and cool; effectively creating a refrigerator that can be adjusted by a volume-control knob. Advantages over conventional refrigerators include the elimination of ozone-destroying gases, reduction of components to a single moving part, and the ability to precisely control the cooling cycle. Thermoacoustic cooling has been used in space shuttles, and it remains a future hope for automobile air conditioners and refrigerators in homes and boats. Accordingly, intensive efforts are expended in application of such capabilities in development of air conditioning units for automobiles to replace current devices that use Freon and other CFC refrigerants, which are harmful to the environment. A thermoacoustic cooling device was manufactured to cool drinks in tin containers.

[0020] Harvesting the water carried by atmospheric moisture enhances the utilization of natural resources in areas of scarce water supply and in applications where the transport of water poses a problem, such as the case of potable water supply as well as in maintenance of trees and greenery in tropical arid regions. The use of an environmentally benign cooling capability makes the exploitation of this water source attractive. Dependent on the amount of water needed the thermoacoustic engine can be used indoors. Extraction of humidity from the air provides cooling which can substitute for energy-intensive air conditioning systems, since the effective temperature increases with the increase in humidity of the air intake. A laboratory test of a thermoacoustic cooler, 227 W of acoustic power was used to provide 419 W of useful cooling power, corresponding to a coefficient of performance of 1.85. Taking into account the 54% electro-acoustic efficiency of the loudspeakers, the thermoacoustic cooler provided 1 W of cooling for each watt of electrical power input.

[0021] Accordingly, there is a need to develop systems that utilize energy-efficient environmentally benign thermoacoustic cooling to produce freshwater from hot humid air for supply of potable water and freshwater for different uses.

[0022] Harvesting of moisture from ambient air has been an old art. Two thousand years ago, the Nabatian Arabs, whose Kingdom embraced the Northern part of Saudi Arabia, harnessed, stored and conveyed water through an extensive system of public and private, wells, reservoirs, pipelines and channels. They gained fame for sophisticated hydraulic works such as dams and water channels. For areas close to water bodies, they collected water from the atmospheric moisture using caves in the mountains. The relatively warm air was allowed to pass through special man-made openings carved in the rocks. The water vapor condenses on the cold walls and flows by gravity in conduits or grooves in the stone walls. The produced fresh water is then collected by cisterns and stored in reservoirs below the collection areas. Near the Red Sea, they tunneled wide deep caverns under the mountains for condensation of water vapor carried by the air. Currently, there is a farm in that area, near Petra, that quite successfully imitates the old ways.

[0023] A passive system being used from ancient times in desert regions consists of a massive beehive-shaped block of concrete or stone pierced with many holes. A complex cycle involving radiation into the clear night sky of the desert allowed small amounts of water to be recovered from a very dry atmosphere. In tropical areas, such a device is very productive if the night sky is not often overcast.

[0024] Archaeologists have discovered that the ancient city of Theodosia, situated in one of the driest sections of Crimea, Ukraine, was abundantly supplied with water 2,300 years ago by taking water from the air instead of the earth. A beehive structures on hill draws moisture from atmosphere and holds it in reservoir. Thirteen great heaps of broken limestone were loosely piled on a nearby hilltop. Ducts led moisture condensing from the air within these piles to the fountains of the city, and there is no record that they ever ran dry.

[0025] On the coast of Oman large cold surfaces were placed on the top of a coastal mountain ridge to collect water from the early morning water vapor.

[0026] Very low technological approaches have been utilized from the earliest times. For example, caverns near the Red Sea wherein dew and fog would condense on the cool walls and be collected in "gutters" carved into the walls. However, attempts to do this on a larger scale and/or with more modern artificial cooling have not yet materialized on a wide scale.

[0027] A semi-active moisture/condensation system produces potable water simply by sucking the air through an array of underground pipes plumbed into the house's cold water system. The system is mounted in the basement or crawlspace of an otherwise conventional home. The chill of the earth causes sub-cooling of humid air entering the basement from grade level, condensing some of the moisture.

[0028] In St. Croix, the Virgin Islands, cold water was brought up from the deep ocean, run through condensation coils to extract fresh water from the atmosphere. Then the nutrient rich seawater was used in an aquaculture system.

[0029] Prior art encompasses inventions that utilize chemical adsorbents to extract moisture from atmospheric air or moisture-laden gases to produce fresh water or drinking water after appropriate treatment. The adsorbent is then regenerated and recycled for reuse. The use of adsorbents may be necessary in cases wherein insignificant amount of moisture is present in the atmosphere whereas in the case of extremely hot and humid environments the use of chemicals seems to be a nuisance and would require additional steps for extraction of water and regeneration of the chemicals. In addition, such systems require technical care in operation and maintenance, unlikely to avail the people and areas in dire need for water.

DESCRIPTION OF THE PRIOR ART

[0030] U.S. Pat. No. 1,816,592 discloses an aerial well comprising: a dome-like, perforated shell of stone and mortar, with a thickness of 2.5 to 3 meters to prevent the penetration of the sun's heat; a mushroom like inner core of concrete, pierced with numerous ducts for the circulation of air; a central pipe with its upper opening above the top of the outer dome. At night, cold air pours down the central pipe and circulates through the core as shown in the diagram. By morning, the whole inner mass is so thoroughly chilled that it will maintain its reduced temperature for a good part of the day. Warm, moist outdoor air enters the Central chamber, as the daytime temperature rises, through the upper ducts in the outer wall. It immediately strikes the chilled core, which is studded with rows of slates to increase the cooling surface. The air chilled by the contact, gives up its moisture upon the slates. As it cools, it gets heavier and descends, finally leaving the chamber by way of the lower ducts. Meanwhile the moisture trickles from the slates and falls into a collecting basin at the bottom of the well. By this principle, it is possible to obtain as much as 22,710 liter of water daily for every 93 square meter of condensing surface. This patent was implemented over half a century ago in southern France for extracting water from the air to irrigate fields and vineyards. Towering 12 meters above a hilltop overlooking the little town of Trans en Provence, the structure resembles nothing more than a monstrous beehive. Its grayish-white walls of stone are perforated with scores of openings. Warm outdoor air entering through these ducts is systematically stripped of its moisture by contact with the chilly interior, much as dew condenses on a pitcher of ice water.

[0031] U.S. Pat. No. No. 4,313,312, for example, discloses a water producing air conditioning system comprising a water producing apparatus that adsorbs moisture in the ambient air on an adsorbent or absorbent and evaporates water adsorbed on the adsorbent or absorbent by heating it and condenses steam to obtain water. A heat exchanger exchanges heat between ambient air and hot dry air discharged from the water producing system during adsorbing moisture on the adsorbent or absorbent. An evaporation-cooling system is used for forming a cold wet air by evaporating water and cooling it by contacting water with a dry air at the ambient temperature passed through the heat exchanger. The hot air heated by the heat exchanger or the cold air obtained from the evaporation-cooling system is utilized for the air conditioning. The system can be used for comfortable living in a severe condition such as a desert by the effective combination of the evaporation-cooling apparatus with the water-producing device utilizing high efficiency heat-exchange. Evaporative cooling was used in this disclosure as the main method for air-cooling, however evaporative cooling was not used, as an assistive means for supplementing cooling by convection of a cold-water steam was not mentioned.

[0032] In addition, U.S. Pat. No. 5,601,236 teaches an autonomous plant watering device and a method for promoting plant growth for arid climatic regions. The device includes an absorption cycle atmospheric vapor condensation unit that may be solar powered, to deliver water and accumulate the collected water in a storage tank. The stored water is supplied to a subsurface, site-specific delivery system located intimately with a target plant. To assure growth enhancement, the apparatus utilizes fuzzy logic supervision provided with local sensing means and historical vapor pressure maps to control and predict water usage while controllably supplementing the delivered water with nutrients and anti-transpirants as needed. The device disclosed by this patent is used for site specific watering intimately incorporated with the target plant, which is not the case with the present invention.

[0033] The aforementioned inventions and others that may fall under the same category do not relate to the present invention since they are based on the use of adsorbents, desiccants and hygroscopic material, and mostly address hot low humidity climate conditions; which is not of concern to the present invention.

[0034] Heat pipes are used in some inventions to cool a condensing surface below dew point to precipitate the water vapor from the atmosphere. Heat pipes are also used to control indoor environment. However, the present invention is not based on this type of technology exploitation and inventions.

[0035] Prior art has also encompassed processes that rely upon heat convection in large structures and the control of the process to obtain freshwater from atmospheric humidity. Tropical and subtropical regions having high ambient temperatures and relative humidity can be locally subjected to cooling and dehumidification according to U.S. Pat. No. 4,182,132, by a tower in which, upon a post or other vertically extending support, a pair of vertically aligned spaced apart air guides are provided. The lower air guide includes the cooler that can simultaneously condense moisture from the air while the upper air guide can include a heat dissipater of a refrigeration cycle. The air guides are associated with blowers and inducing ambient air into the air guide at a location between them and displacing the air through the air guides into heat exchanging relationship. The tower can also be used to collect potable (drinking) water by condensation from the atmosphere.

[0036] U.S. Pat. No. 4,433,552 describes a system for recovering atmospheric moisture utilizing a wind driven electrical generator for powering a mechanical refrigeration system for condensing atmospheric moisture. A turbine is mounted on a housing forming an atmospheric duct. The turbine is driving a connected electrical generator. The refrigeration system includes an evaporator positioned in the atmospheric duct whereon water vapor is condensed. Electrical current is generated from wind to power the refrigeration system, which includes the evaporator. Atmospheric moisture is condensed on the evaporator and collected.

[0037] U.S. Pat. No. 4,080,186 describes a device to extract useful energy and fresh water from moist air, with an associated removal of pollutant particles entrained in the extracted water. The device comprises an enclosure with a tall stack and an extended base that has means for the creation and utilization of a contained tornado, which is powered by the energy release associated with the rapid condensation of water from the incoming moist air. This patent is based on atmospheric conditions that do not pertain to the present invention.

[0038] The above inventions that rely upon heat convection in large structures in extraction of freshwater from the atmosphere and cooling or dehumidification of local open space do not relate to the present invention, which is based on processes that are mostly performed within relatively compact structures.

[0039] In contrast, very limited production of water for irrigation was disclosed in U.S. Pat. No. 4,315,599 that describes a method and a device for automatically watering vegetation whereby the water requirement is constantly monitored. A cooled condensation surface selectively condenses water vapor out of the atmosphere and collects the condensed moisture for application onto the soil containing vegetation. Various accessories are provided to automatically feed the vegetation and distribute water to the soil containing the vegetation. The device uses thermoelectric principles to provide the required watering requirements, however, the patent does not disclose a hand-held or a portable device for providing potable water during emergencies.

[0040] Domestic central air conditioning units used to cool homes or any other buildings operate in combination with air directing units that produce a quantity of waste condensate. The water formed by condensation taken out of the air was utilized in a lawn watering system that was disclosed in U.S. Pat. No. 4,134,269. A device is designed for continually collecting the waste condensate from the central air conditioning unit. The water is stored in a holding tank. At a predetermined level in the tank, a pump is switched on to deliver the water to a hose system in the lawn. The system intermittently and automatically distributes the condensate throughout a region to be irrigated. The device comprises a holding tank for collecting the waste condensate; a drainage conduit for directing the waste condensate from the air conditioning unit to the holding tank; a depth sensing device is used indicating the level of the waste condensate collected in the tank; a pump that is automatically turned on by the depth sensing device to pump collected waste condensate from the holding tank when the depth sensing device indicates that the level of condensate in the tank has reached a predetermined maximum and automatically turned off by the depth sensing device when the depth sensing device indicates that the level of condensate in the tank has reached a predetermined minimum thus allowing the condensate to refill the tank to the predetermined maximum level; a discharge conduit associated with the pump; and an irrigation system for directing the waste condensate from the holding tank throughout the region to be irrigated.

[0041] Prior art on thermoacoustic cooling and refrigeration is concerned with different types of design of the thermoacoustic-cooling engine. Examples are, U.S. Pat. No. 5,456,082 that describes a pin stack array for thermoacoustic energy conversion, U.S. Pat. No. 5,295,791 that discloses a tapered fluid compressor and refrigeration apparatus, U.S. Pat. No. 5,275,002 teaches a pulse tube refrigerating system, U.S. Pat. No. 5,174,130 discloses a refrigeration system having standing wave compressor, and U.S. Pat. No. 4,584,840 describes a cooling machine or heat pump having a thermoacoustic work system that has a heat source and a heat sink coupled with at least one thermoacoustic drive system of like construction. In addition, an acoustic cryocooler with no moving parts is formed from a thermoacoustic driver driving a pulse tube refrigerator through a standing wave tube was disclosed in U.S. Pat. No. 4,953,366. Only U.S. Pat. No. 5,165,243 discloses a compact acoustic refrigerator for cooling electronic components.

[0042] None of the prior art references benefit from thermoacoustic refrigeration or thermoelectric cooling using water as a cooling fluid to cool the condensation surfaces and provide potable water on a small or large scale. In addition, the use of combinations of natural cold brackish water, transpiration cooling and evaporation cooling to condensate atmospheric humidity was not disclosed in prior art.

[0043] Furthermore, none of the prior inventions discloses devices or means for utilization of building architecture to provide an aesthetically acceptable system to provide freshwater from hot humid outdoor ambient air while reducing the heat load on the structure. Integration of water production from air moisture for human use, irrigation, or animal farms and the environment is one of the unique features of the present invention.

[0044] According to the present invention, thermoacoustic refrigeration is used to cool freshwater circulating in pipes and coils to cool condensation surfaces of different topologies to temperatures below dew point to produce freshwater and drinking water by condensation of water vapor from atmospheric humidity in high temperature and high humidity climates. In a second aspect of the invention, devices for production of freshwater and drinking water use condensation of water vapor from moisture-laden gases such as the exhaust of internal combustion engines. In a third aspect of the invention, thermoelectric cooling was used to cool freshwater for condensation of water vapor from hot humid gas to supply a limited quantity of freshwater. In a fourth aspect of the invention, cooled water and evaporation cooling were used to condensate and cool freshwater condensates from atmospheric moisture. In a fifth aspect of the invention, the water vapor condensation surfaces were integrated with building structures to produce ample quantities of water from outdoor air and alleviate the heat loads. In a sixth aspect of the invention, aesthetically accepted systems are provided for supplying water to animal farms and to forested areas. In a seventh aspect of the invention, a modular system was provided for collection of water from the atmosphere using natural brackish water cooling supplemented by transpiration cooling and evaporative cooling.

[0045] It is an object of the present invention to provide a device and a process for condensation of water vapor entrained in hot humid air by flat condensation plates surfaces of varying surface areas. Surface areas of the plates can be expanded from small limited areas, to cover large wide areas dependent on the desired quantity of condensate.

[0046] It is another object of the present invention to provide a device for freshwater production, using condensation surfaces that can condensate large quantities of water vapor per unit surface area, wherein special coatings are applied with some degree of surface roughness.

[0047] It is a third object of the present invention to provide a freshwater producing device using thermoacoustic cooling and parallelopiped sectioned condensation chamber to condense atmospheric humidity.

[0048] It is a fourth object of the present invention to provide a freshwater producing device using thermoacoustic cooling and conical multi-layer condensation chamber to condense atmospheric humidity.

[0049] It is a further object of the present invention to provide a thermoelectric device using cylindrical condensation chamber to condense atmospheric humidity for supply of freshwater to a small group of people.

[0050] It is a still further object of the present invention to provide a thermoelectric device using cylindrical condensation chamber to condense atmospheric humidity for supply an individual with potable water.

[0051] It is yet a further object of the present invention to provide a device and a process for producing cold potable water for a large number of people using cold water to cool condensation fins in a cylindrical configuration as well as evaporative cooling.

[0052] It is a still further object of the present invention to provide a system for supply of freshwater to a building through condensation of moisture from outdoor ambient air by a condensating roof structure that also alleviates the heat loading on the living space.

[0053] It is a still further object of the present invention to provide a system of condensating surfaces attached to the exterior walls of a building for supply of freshwater through condensation of moisture from outdoor ambient air.

[0054] It is a still further object of the present invention to provide a system for supply of freshwater to a building through condensation of moisture from outdoor ambient air by condensating surfaces integrated into the architecture of the building.

[0055] It is a still further object of the present invention to provide a device for supplying drinking water to poultry and farm animals produced from atmospheric moisture.

[0056] It is a still further object of the present invention to provide an irrigation system blending with the surroundings for watering trees in a forested area produced from atmospheric moisture.

[0057] It is a still further object of the present invention to provide a modular system for collection of freshwater from the atmosphere to supply potable water for human and fresh water for irrigation and drinking water for farm animals using natural cold brackish underground water to cool condensation surfaces with the assistance of transpiration cooling and evaporative cooling.

[0058] It is a still further object of the present invention to provide a modular system for collection of freshwater from the atmosphere to supply potable water for human and fresh water for other human usage using natural cold brackish deep cold seawater to cool condensation surfaces with the assistance of transpiration cooling and evaporative cooling.

[0059] In a first embodiment of the invention, a thermoacoustic refrigeration engine continuously cools water circulating in a closed tube-coil arrangement by a water pump. The cooling water flows through a tubing and a set of coils in a plane configuration rigidly connected to a rough metallic plate coated by a material that enhances drop-wise condensation of water vapor. By cooling the plates to a temperature below the dew point, heat exchange between the plates and the hot humid air naturally flowing in contact with the surface of the plates strips the air from humidity and cools it. Condensate from water vapor condensating on the cold surfaces is collected as freshwater. The quantity of production of freshwater depends on the surface area of the plates, providing the temperature of the surface is kept below the dew point. In principle, any quantity of water can be produced by scaling up the surface area of the plates. The footprint of the system can be reduced by stacking several plates and subjecting their coated surfaces to the prevailing wind or air moving direction.

[0060] The first aspect of the invention also relates to forcing the flow of ambient air to blow within the vicinity of and in intimate contact with the cooled condensation surfaces. This is accomplished by placing the condensation surfaces in a closed chamber wherein hot humid ambient air is blown by an air blower inside the chamber entering from one side and exiting from an opposite side.

[0061] In another embodiment of the first aspect of the invention the condensation chamber is a two section elongated box with a large rectangular air entrance and a smaller rectangular air exhaust. The condensation surfaces are provided by thin wide fins placed on the circumferences of the cooling coils. Condensate is collected by a conical funnel and pumped through a filter to a storage and supply tank.

[0062] In a different embodiment of the first aspect of the invention, the condensation chamber is constructed from layers of concentric metallic sheets forming a cone wrapped with cooling coils. Hot humid air is drawn from the wide mouth of the chamber to force it through the narrow mouth.

[0063] The two-section rectangular box-shaped and the conical condensation chambers are used in the second aspect of the invention to condensate water, vapor from the exhaust of an internal combustion engine by directing the exhaust with a blower to the interior of the chamber in the water producing device. In hot humid climates the moisture-laden exhaust gas will be mixed by hot humid ambient air.

[0064] In the third aspect of the invention, hot humid air, engine exhaust or a mixture of both is drawn through a condensation chamber containing a spiral of cooling coils as the condensation surfaces. In another embodiment of the third aspect of the invention, condensation is enhanced by placing fins on the circumference of the coils. Cooling water is supplied by a thermoelectric cooler powered by a bank of chargeable batteries for a device that supplies a limited quantity of freshwater from condensate collected and filtered in a small storage tank.

[0065] A size of a device as small as a hiking canteen or a thermos to supply drinking water in emergencies for one individual is provided in a different embodiment of the third aspect of the invention. The bottom of the device allows the attachment or screw of a cup or a small container to fill it with filtered water for drinking. The cup can be thermally insulated or wetted for coolness of water.

[0066] In the fourth aspect of the invention, cooling freshwater produced by a refrigeration system is supplied by tubes and coils to a cylindrical condensation unit formed from finned surfaces and coils. The condensation surfaces condensate atmospheric moisture to produce freshwater. Further cooling of the water leaving the condensation coils is achieved by evaporative cooling. The collected condensate is stored in a tank wherein the water is treated by ozonation and filtered before dispensation. The water flow is driven by pumps and controlled by valves and water level sensors. In one of the embodiment of the fourth aspect of the invention, evaporation cooling is provided by a pot in the middle of the condensation unit wherein the cooling water terminates after cooling the condenser and thus carrying the heat reject from the hot humid air. Other embodiments include using a small water tower, and placement of the pot outside the condensation unit. The pots and the tower are fabricated from porous material such as ceramics or non-glazed clay. The evaporative cooling of water filled containers is caused by the relatively dry cool air resulting from the heat exchange of the humid hot air with the condensation surfaces. Cooling is provided by thermoelectric cooler. Alternately, thermoacoustic cooling or gas refrigerants may be used.

[0067] In a different embodiment of the fourth aspect of the invention, the system is used to provide separate large basins for irrigation water and drinking water for farm animals. Untreated product water is drained in each basin and nutrients and appropriate chemicals are added.

[0068] In the fifth aspect of the invention, water vapor condensation surfaces were integrated with building structures to produce ample quantities of water from hot humid outdoor ambient air and to alleviate heat loads from the hot humid weather and from the irradiation by direct sunrays. In one of the embodiments of this aspect of the invention, the roof is covered by densely placed staggered metallic sheets having grooves with a slope leading to gutters and draining spouts to collect the condensate and direct it to a water distribution facility. Pipes of cooling water are used to cool the condensation surfaces wherein water is circulated by pumps and cooled by a thermoacoustic cooler. In a second embodiment of the fifth aspect of the invention, metallic sheets cooled by pipes of circulating cold water are placed on the external sidewalls in an arrangement that promotes condensation of water vapor from outside ambient air. The condensation sheets are aesthetically arranged to blend with the building architecture. Conduits, pipes and spouts collectively direct product water to the distribution facility. The roof coverage and the sidewall condensation sheets are combined to provide larger supply of freshwater and more protection from the heat in a third embodiment of the fifth aspect of the invention. Natural cold-water sources may be used in place of thermoacoustic cooling wherever available.

[0069] In an embodiment of the sixth aspect of the invention, a system is provided for supplying farm raised animals and poultry with drinking water, using thermoacoustic cooling engine to cool water for circulation in a vertically assembled cylindrical arrangement of water pipes with fins for condensating water vapor. Ambient hot humid air is directed downward by air blowers to have an intimate contact with the surfaces of the fins. A shading cover protects the pipes from the sun and help directing the hot humid air downward. The condensate is drained into a container at the bottom of the cylindrical assembly wherein nutrients and solutions of preventive medicine are added to the drinking water. The water is then dispensed on demand to the farm animals or poultry.

[0070] The other embodiment of the sixth aspect of the invention provides a sculpture of an artificial wooden tree with an outer surface made from natural bark for watering a forestation area. The artificial tree trunk is equipped with a thermoacoustic cooling engine, a storage tank, a water distribution system, and pipes for communicating cooling water to the condensation surfaces provided by metallic wide leaves with thin branching tubes for cooling. Fur-like fins cover the artificial leaves. The condensate collected from water vapor entrained in hot humid air drains in the storage tank inside the trunk. Nutrients and chemicals are added to the water as needed for health growth of the trees. The water is distributed through buried plastic pipes that resemble the roots of a tree to deliver water on demand to natural trees. The water supply system is located in a manner that allows free flow of hot humid air around the leaves, and is aesthetically integrated with the wooded area.

[0071] In the seventh aspect of the invention, a modular system is provided for collection of water from the atmosphere using natural cold brackish water from a natural source such as a deep well, for cooling condensation units formed from coils, plates and fins. The cooling water is pumped to the top of an assembly of a stack of modular containers, manufactured from ceramics or metal covered with water absorbing material. The cooling water flows downward by gravity outside the containers and through the coils. Hot humid air is blown inside the containers for condensation of the water vapor content and the product condensate fall by gravity through the containers to a holding tank for treatment and distribution of freshwater. The wetted containers are cooled by cold air driven through an air radiator causing evaporative cooling of the outside surface of the containers. When ceramic containers are used, transpiration cooling plays a supplementary role in the cooling process. The number of containers depends on the quantity of freshwater required and the amount of coolness provided by the brackish water. The product freshwater can be used for irrigation, for animal drinking, or for production of potable water and other human usages.

[0072] In another embodiment of the seventh aspect of the invention, the modular system uses deep seawater as coolant to provide potable water and freshwater aboard ships. For potable water supply proper water treatment is necessary and is dependent on sources of pollution and contamination of the air and the product water.

BRIEF DESCRIPTION OF THE DRAWINGS

[0073] **FIG. 1** shows a simple apparatus for condensation of water vapor from hot humid ambient air using a thermoacoustic refrigeration engine to produce chilled water flowing through coils that cool an extended condensation surface.

[0074] **FIG. 2*a*** presents a comparison between drop-wise condensation and film condensation of water vapor on a vertical condensation surface.

[0075] **FIG. 2*b*** presents a comparison between drop-wise condensation and film condensation of water vapor on a horizontal condensation surface.

[0076] **FIG. 3** displays the configuration of a device for extraction of water content in hot humid gas whether the gas is air, an exhaust gas from an internal combustion engine of a land vehicle or a seagoing boat, or a mixture of air and exhaust gas using a prism enclosed condensation surfaces cooled by a thermoacoustic refrigeration engine.

[0077] **FIG. 4** shows a conical device similar to the device of **FIG. 3**.

[0078] **FIG. 5** shows a thermoelectric device for condensation of water vapor entrained in humid air or gas.

[0079] **FIG. 6** shows a device similar to the device of **FIG. 5** for supplying drinking water for one individual using water collected from humid air or gas.

[0080] **FIG. 7** presents the structure of a system for production of cold potable water from hot humid ambient air by condensation of water vapor entrained in hot humid air on surfaces cooled by freshwater combined with evaporative cooling.

[0081] **FIG. 8** shows a modification of the system of **FIG. 7**, using evaporative cooling tower.

[0082] **FIG. 9** shows a modification of the system of **FIG. 7**, using an evaporative cooling pot located outside the cylindrical condensation configuration.

[0083] **FIG. 10** shows a configuration of a system of corrugated cold surfaces for condensation of humidity from hot humid atmosphere, wherein condensation surfaces are installed on the roof of a building in a manner that allows flow and distribution of freshwater and provision of a protective cooling shield for the building.

[0084] **FIG. 11***a* shows a configuration of a system of corrugated cold surfaces for condensation of humidity from hot humid atmosphere, wherein condensation surfaces are installed on the sides of a building in a manner that allows flow and distribution of freshwater and provision of a protective cooling shield for the building.

[0085] **FIG. 11***b* shows the cooling and water production equipment of the system of **FIG. 11***a*.

[0086] **FIG. 12** shows the configuration of a system for production and distribution of fresh water for animal and fowl farms, based on the system of **FIG. 9**.

[0087] **FIG. 13** shows a system for production and distribution of fresh water from hot humid air for animal and fowl farms, using thermoacoustic cooling for water vapor condensation surfaces.

[0088] **FIG. 14** shows a system for production and distribution of freshwater from hot humid air for irrigation, using thermoacoustic cooling for water vapor condensation surfaces.

[0089] **FIG. 15***a* shows a system for production of fresh water from hot humid air for irrigation or supply of drinking water aboard ships, using evaporation cooling of salty water.

[0090] **FIG. 15***b* shows a cross-section of the air radiation component of the system of **FIG. 15***a*.

[0091] **FIG. 15***c* shows the method of connecting the units of the system of **FIG. 15***a*.

DETAILED DESCRIPTION OF THE INVENTION

[0092] **FIG. 1** shows the configuration and components of a simple apparatus for condensation of water vapor from the atmosphere wherein a thermoacoustic refrigeration engine **700** is used to cool freshwater flowing through the tubing **701** directly connected and feeding a plurality of coils **702** in intimate contact with a flat condensation plate **703**. The coils **702** may be soldered to the flat plates **703**. The water pump **704** drives the water flow and circulates the cooling water in the combined tube **701** and coils **702** path to provide and maintain continuous cooling of the plate **703**. As the moisture-laden ambient air passes in intimate contact with the plate **703**, heat exchange takes place between the hot humid air stream and the cold surface and freshwater condensates drips down by gravity. To enhance the rate of condensation, air may be blown across the surface at a slow speed and to prevent air stagnation by the surface in case of calm airflow. Air blowers blow a stream of hot humid ambient air across the plate **703**, in case of using the apparatus indoors or in a place wherein airflow is not sufficient. The amount of cooling, required to condensate the moisture from the air, is small since the temperature of the condensating plate **703** has to drop only a few degrees under ambient air temperature to reach the dew point. The surface of the condensating plate **703** must be rough, corrugated and may be covered with hair like fins to enhance condensation of water vapor. Preferably, a thin film of silicon or teflon or any other material of similar texture is used to coat the condensating plate **703**. The coating promotes drop-wise condensation and prevent the formation of a thin water film on the surface that could hinder the continuation of the condensation process as shown in **FIG. 2***a*, for a vertically oriented condensation surface and **FIG. 2***b*, for horizontal orientation of the condensation surface.

[0093] In **FIG. 2***a*, the vertical condensation surface **750** is smooth and wet and hence the moisture carried by the stream of hot humid air **751** condensates forming a thin water film that flows down by gravity as continuous sheets of freshwater. In contrast, the condensation surface **753** is coated with a layer **754** that promotes dropwise condensation and hence water vapor condensates from the hot humid air **751** flow as droplets **755**.

[0094] In **FIG. 2***b*, the horizontal condensation surface **756** is wet and smooth and hence the hot humid air **751** condensates as a thin film **757** and flows by gravity to water collector **758**. In contrast, the horizontal condensation surface **759** is coated with a layer **760** that promotes drop-wise condensation and hence water vapor condensates from the hot humid air **751** as droplets **761** that drip by gravity to water collector **758**.

[0095] The condensation surface **703** of the apparatus of **FIG. 1** is flexible to expand as much as the space allows. In principle, the condensation of any large quantity of freshwater is possible, since the quantity of condensate that can be collected from the air at any time is proportionate to the quantity of moisture entrained in the air and the condensation surface area. However, the plate does not have to be constructed as one continuous surface. Connected segments or modular units can be used for production of large quantities of freshwater.

[0096] The formed condensate drips by gravity to accumulate freshwater where it can be collected, treated by appropriate disinfection and filtration methods, then distributed and supplied to consumers as potable water or freshwater.

[0097] **FIG. 3** shows a compact device for condensation of water vapor entrained in hot humid ambient air using a thermoacoustic engine **710** to cool freshwater flowing in cooling coils **711** that provide cooling to rigidly attached fins in the form of thin metallic plates **712**. The fins **712** enhance the heat transfer between hot humid air and the cooling surfaces and act as condensating surfaces as well. The coils **711** with the joined fins **712** form a condensation unit contained in a two-section condensation chamber in the form of a funnel-shaped jacket **713**. One section is formed from a short prism with trapezoid sides, a wide rectangular mouth as an inlet, and connected on the other side by a narrower rectangular outlet with the second section, which is a long rectangular parallelopiped. The jacket **713** draws hot humid air **714** at the wide mouth inlet **715** by a suction fan. The hot humid air moves through the two sections of the chamber passing by the condensation surfaces and leaves the narrow outlet of the jacket **713** free from atmospheric humidity while the condensate drips by gravity to a funnel collector **716**. The open collector **716** will assist in removing any volatile organic particulates. The collected water is treated by the filtration unit **717** to remove suspended particulates. The product freshwater is then stored in a tank **718**. Unit **717** may include a disinfection stage if potable water is required. However, in situations of emergency, simple filtration can be sufficient if the water intake is for a limited time only.

[0098] In another embodiment, **FIG. 4** shows the configuration of an apparatus for condensation of water vapor entrained in hot humid ambient air using conical condensating chamber **720** constructed from concentric metallic layers of condensation surfaces. A thermoacoustic engine **721** cools the water in the coil **722** that surrounds the conical condensating chamber **720**. Hot humid air rushes at the narrower mouth of the cone **720** under the effect of a suction fan **723**, that draws the hot humid air to the wider mouth outlet, leaving behind the water vapor that condensates on the condensating layers. The condensate drips down by gravity in the big mouth funnel collector **724**. The collected water flows to a filtration unit **725** and then to a storage tank **726**.

[0099] The components of the condensation devices of **FIGS. 1, 3**, and **4** are lightweight and small compared to any other devices of similar capacities, using other refrigeration cycles. Thermoacoustic engines have no fast rotating mechanical equipment. The device, however, has blowers and fans to drive the air over the condensation surfaces. When pumps are needed to drive the flow of water in large systems, only booster bump are required. This makes the arrangements ideal for water production from moisture-laden gases. Examples are the water-vapor rich exhaust of automobiles, vans, trucks and boats or a combination of humid air and exhaust gases from internal combustion engines. The size of the devices can be made very small so that the condensating chambers can be fitted to the exhaust system of a vehicle to collect freshwater, providing appropriate filtration of the exhaust is used. Furthermore, reduction of the condensation surfaces and plates makes it possible to construct devices of limited capacity to provide a single person, two people or more with drinking water.

[0100] The apparatus of **FIG. 5** uses thermoelectric cooling in condensation of atmospheric humidity. Thermoelectric chillers and cooling devices are produced by Thermoelectric Cooling America Corp.™ (TECA), Chicago, Ill.; Melcor Corp.™, Trenton, N.J.; Tellurex Corp.™, Traverse City, Mich.; Farrar Scientific™, Raleigh, N.C.; Supercool U.S., Inc.™, San Rafael, Calif.; or any equivalent.

[0101] Hot humid ambient air enters from an inlet **730** by the action of a suction air fan **735** located at the outlet duct **734**. The water pump **731** circulates the cooling water through a thermoelectric cooler **732**. The cooling water circulates through the condensation spiral coils **733** to condensate the water vapor entrained in the hot humid ambient air as it passes in contact with the condensation surfaces. The coils may be fitted with thin fins to enhance heat exchange with the hot humid air. The condensate drips by gravity through the bottom of the apparatus after treatment and filtration by treatment unit **736**. In case of supply of emergency water, no treatment is required other than filtration. The water production apparatus is powered by a bank of chargeable batteries **737**.

[0102] All the components of the apparatus can be packed inside a relatively compact container **738**. Accordingly, the apparatus can be constructed at a reduced size and capacity to provide potable water sufficient for the daily supply of one person as shown in **FIG. 6**, wherein the water production apparatus is attached to the top of a thermos, canteen or thermally insulated cup **740** which can be strapped to the apparatus with a belt **741**. When the container **740** is filled, it can be released for use of the potable water or replaced by another. A spongy cloth can be used to wrap the container **740** to cool the water in the container by evaporative cooling.

[0103] The thermoelectric apparatus of **FIGS. 5 and 6** are ideal for collecting water from the exhaust of internal combustion engines in case of emergency providing appropriate filtering of the exhaust moisture-laden gases is used to eliminate sod and organic and inorganic particulates.

[0104] The water production process of **FIG. 7** starts with filling the thermally insulated collection tank **800** and the thermoelectric water cooler **801** with a priming charge of freshwater. The outside surface of the tank **800** is padded with thermal insulation material in a manner sufficient for the water inside to keep its cold temperature all the time. The thermoelectric water cooler **801** cools the cooling water of the condensation unit **804** to a few degrees below ambient temperature since the temperature of the condensation surfaces need to be maintained just below dew point of the air moisture.

[0105] In the implementation of this aspect of the patent, the stainless-steel water chiller **801** is a commercial water cooler manufactured by Canaletas S.A.™, Barcelona, Spain and modified by Advanced Thermoelectric Products™, Nashua, N.H., USA. Other drinking water coolers may be used; for example Koolatron™, Rochester, England UK, Pure Earth Technology™, Marietta, Ga., USA, or equivalent. In addition, coolers that use a conventional CFC cycle such as freon may be used, such as Oasis™, Columbus, Ohio, or Larco, Inc.™, Harrisville, N.H., USA; Sunroc Gas™, Maryland, USA, Tianjin Tahoe Cooler™, Tianjin, China, or any equivalent.

[0106] The condensation process does not start until the priming water charge is cooled in the cooler **801**. At that time, water is drawn from the cooler **801** by a pumping unit **802** combining a plurality of a switch, valve, and water pump of appropriate capacity. The water valve **803** is actuated to direct the flow of the cold water to the coils of the cylindrical condensation unit **804** to condensate the incoming hot humid ambient air.

[0107] The water valve **803** allows water to flow either to the unit **804** or to the storage tank **811**. When the temperature and relative humidity measured by the sensor **805** are such that the specific humidity drops under a level at which condensation of moisture from the air becomes uneconomical the interrupter **806** interrupts the power supply to stop the air fan **808**. The signal from the sensor **805** opens the valve **803** to direct the flow to the storage tank **811**, and switch the pumping unit **802** to pump water to the storage tank **811**.

[0108] The air fan **808** draws hot humid air from the atmosphere from the sides of the unit **804** in the direction of the coils such that the incoming air loses its moisture by heat transfer with the cold fins and coils of unit **804**. As the hot humid air gets cooler and drier, it moves up passing by the porous pot **809** located at the center of the coils in its way to the air outlet of the unit **804**.

[0109] The cold water driven by the pump **802** and flowing through the coils of unit **804** terminates into the porous pot **809** through its open mouth as relatively warmer water. The pot is a specially shaped and fabricated from porous non-glazed baked clay or ceramics. Ceramic pots are preferred for their durability. The porosity of the pot induces evaporative cooling of the water contained inside, as it flows through the pot, by the drier air flowing upward. Evaporative cooling reduces power consumption (in terms of kWh per liter of produced freshwater) in the cooling process that adjusts the temperature of the cooling water.

[0110] The dripping of condensate from the coils of unit **804** and pot **809** as well as the water from the pot drain to the bottom of unit **807** and fall by gravity to a preliminary filter **810** down to the collection tank **800**. Accumulated cold water in the tank **800** flows to the cooler **801**, or can flow directly to the storage tank **811** through valve **803**.

[0111] The preliminary filter **810** removes any suspended dust, fine sand or suspended particulates. The filter **810** is a column combining active carbon and ion exchange resin. In the implementation of this aspect of the invention, a Britta™ filter, or equivalent may be used. This type of filter is commonly used at home for tap water purification for drinking and use in preparation of food and drinks. Among the commercial filters that can be used are those produced by Omni™, Pûr™, and Rubber Maid™, USA.

[0112] In special cases wherein ultrapure water is needed two ion exchange columns may be used one for cation-exchange and another for anion exchange to eliminate negative as well as positive ions. The length of the residence time in the filtration unit is such that the water will have enough time for effective filtration.

[0113] The water in the storage tank **811** is disinfected by ozonation to oxidize microorganisms. The ozonation is most effective in cold water and a small quantity of ozone will be required for disinfection. The ozone generator **812** feeds ozone to the tank **811** through the stone outlet **813** that releases and distributes ozone throughout the stored water.

[0114] Ozone generators and ozonators of different capacities are commercially available and can be customized to the application according to specifications. Ozonators are produced by Ozomax™, Montreal, Quebec, Canada; Water Ozonator™, Sota Instruments™, British Columbia, Canada; and Ozoteck™, Yreka, Calif., USA, or any equivalent. Active carbon filters are produced by Rubbermaid™, Cameron Carbon, Inc., Baltimore, Md.; or Hermotz™ filter, Plymouth, Minn., USA or any equivalent.

[0115] Drinking water is dispensed through the faucet **814** which actuates an on-demand pump **815** that pumps water from the storage tank **811** through an activated carbon filter **816** to remove suspended particulates, contaminants and oxidized waste from the ozonation process; from the water before use. To avoid cavitation of the pump **815**, a float sensor **817** is used to interrupt the dispensing operation when the tank **811** is empty or below a certain level by shutting off the pump **815** and the ozone generator **812**.

[0116] The length of the residence time in the disinfection and filtration processes is such that the water will have enough residence time in the units for effective disinfection and filtration.

[0117] The pump **815** is manufactured by SureFlo™, Browly, West Sussex, UK or any equivalent. When all faucets are locked and no drinking water is drawn, the pressure in the system rises and the pump **815** stops. This feature increases the lifetime of the pump and stretches its use. The pump **815** operates on twelve volt and continuous current and hence it is connected to a current transformer to step down the voltage from 110 Volt or 220 Volt continuous current to 12 Volt continuous current. The transformer is supplied by Bicron Electronics™ or any equivalent. At the start of operation 10 amperes are needed, however as the operation starts, only 6 volts are required for operation. It is necessary to stop the pump **815** when the tank **811** is empty, otherwise the pump **815** will continue operating at no load until enough water fills the tank **811** which may take long time if the ambient air is mild and has low humidity. Stopping the pump at that time will reduce power consumption and increases the useful life of the pump.

[0118] Since the condensate collected from the atmosphere is free from useful minerals and has characteristics similar to distilled water in purity and tendency to react with the surfaces of water passages, mineral addition may be necessary to provide the nutrition value of natural water and to prevent chemical reactions with the containers.

[0119] In subsequent operations of the system, the priming charge is not necessary and water from the storage tank **811** can be pumped back to the collecting tank **800**. This is needed when the weather changes, and the condensation process is stopped and the cooler **801** is depleted of water.

[0120] The pot **809** may be replaced by a small cooling water tower **820** as shown in **FIG. 8**. The water tower **820** may be constructed from porous non-glazed baked clay or ceramics to provide additional evaporation surface to further cool the warm water leaving the cooling coils if unit **804**. Alternately, construction of the water tower **820** from galvanized metal will provide cooling by convection. Use of plastics will provide cooling by evaporation as well as convection. However, porous ceramics would provide the most cooling.

[0121] Alternately the pot **809** may be located outside the unit **804** as shown in **FIG. 9**. This will allow dry air to freely flow outside the system. In that case, the relatively cool air may be directed to cool a closed space such as the interior of a tent or cabin.

[0122] In **FIG. 10, a** system is provided for production of water from atmospheric humidity appropriate for integration with the architecture of the structure of a building such as a small commercial building, a residence or home. The roof of the building is covered with a layer of corrugated condensation sheets **900** tilted to one sides of the roof to allow runoff of condensate. The condensation sheets **900** are made of sections of rough surfaced conductive non-corrosive material and can be placed on a flat top roof if it is supported in a manner that provides a steep slope on one side or on both sides as used in ranch-style homes. The condensation sheets **900** are cooled by cold water circulating in tubes attached to the bottom.

[0123] The corrugated structure provides grooves for condensate collection, and is connected to troughs and gutters that drain into one pipe **901** that pours the collected water in a tank **902** by a sidewall of the house. The pipe **901** can be directed to a tank inside the house. Alternatively, the water can be pumped from the tank **902** to a storage tank over the roof of the house.

[0124] Hot humid ambient air flows by natural convection carried by prevailing winds. Orientation of the roof in a manner that allows the sweeping air to move from the low side to the top of the condensation surface structure would provide longer residence time and closer contact between the air and the surfaces. As air contacts the cold surfaces, water vapor is condensated on the surfaces and the condensate is slowly drained through the gutters. The maximum freshwater production will be the highest during early mornings and throughout high humidity nights. The high temperature of the direct sun radiation will heat the surfaces in the middle of the day and very little of water vapor will be condensated if any at all, since any condensate will be immediately evaporated and lifted by the passing air unless the air in the vicinity of the roof reaches saturation. Nevertheless, a quantity of water will be collected during hours of low solar radiation, especially during the night wherein nocturnal cooling takes place and the surface radiates to the open sky. The quantity of freshwater produced depends on the extent of the condensation surface, the surface area of the roof and the average absolute humidity present in the air.

[0125] To enhance nocturnal cooling, a shallow water basin may be constructed under the condensation roof. In addition, the condensation sheets may be constructed from plastic impregnated with conductive copper chips or from porous light color ceramic shingles. The water basin can be a source of hot water during the day if freshwater is circulated in the basin.

[0126] Sufficient freshwater can be produced by cooling the condensation surfaces with cold brackish ground water, if available. In this case, cold water is pumped to a plurality of coils connected to the bottom of the condensation sheets **900**.

[0127] A high flow of product freshwater can be achieved using a thermoacoustic refrigeration engine to cool freshwater for circulation in pipes and coils connected to the condensation layers **900**. Cooling the surfaces just a few degrees under the dew point will continuously condensate the water on the cold surfaces and the water will be drained fast enough before evaporation which does not easily occur in high humidity environment regardless of the rise in atmospheric temperature.

[0128] Thermoelectric refrigeration may also be used to supply coolness to the condensation surfaces, however the effectiveness will depend on the size of structure to be cooled. While thermoelectric refrigeration is ideal for small configurations, thermoacoustic refrigeration is preferred for large systems.

[0129] The tank **902** can be constructed as a water unit for supply of potable water by providing a water treatment facility for disinfection and filtration and dispensation of the drinking water. Disinfection can be achieved by ultraviolet radiation if the amount of production is limited otherwise chlorination and ozonation are preferred for the water stored in the tank. Filtration can be done when dispensing of the potable water. In addition, a pre-filtration stage may be useful for the water before it reaches the tank **902** and can be attached to the end of the spout of the pipe **901**.

[0130] An alternate implementation of the invention is shown in **FIG. 11***a,* wherein vertical condensation sheets **910** cover the external walls of the building unit with cooling water pipes distributed between the wall and the condensation sheets **910**. The condensate from water vapor accumulates in the water unit **911** and then is treated and supplied to the resident by the distribution unit **915**. The surfaces have to accommodate for openings in the structure, such as windows and doors and become an integral part of the architecture.

[0131] The components for the water preparation components are shown in **FIG. 11***b* that include condensation surfaces **912**, cold-water coils **913**, the water treatment unit **914** and the distribution unit **915**.

[0132] The sidewall arrangement is preferred over roof top condensation due to the ability to avoid direct solar radiation all day around to all the condensation surfaces. However, proper orientation of the surfaces to minimize the solar radiation flux is only possible in new housing construction. The coolness of the condensation surfaces is provided in the same manner as in the case of the roof structure.

[0133] The arrangement of sidewall condensation of **FIG. 11** and roof condensation of **FIG. 10** collection can be combined to provide high rate of freshwater production. The exact arrangement of the combined structure will vary according to the requirements of the owner of the building and the architecture's creativity. In the combined architecture the assemblage of the condensation surface can provide aesthetic effects as well as coolness inside the building.

[0134] The system of **FIG. 12** includes an adaptation and modification of the water production unit of **FIG. 9** for providing drinking water for grazing animals, and animal and poultry farms. Most treatment and cooling components are eliminated and a large tank **820** with dispensation capabilities is added to provide ample supply of water when the need rises with climatic changes such as rise in ambient temperature.

[0135] In **FIG. 12, a** provision is also provided for adding nutritional material to the water supply from a hopper **821** to be dispensed by a dosing pump **822**.

[0136] The function of the cooler **823** is limited to chilling the cooling water for condensation to maintain the temperature of the condensation surfaces below the dew poing. The insulated tank **800** and the pot **809** will assist in maintenance of cold temperature of the cooling water. Dependent on the capacity of the system, the cooler **823** can be cooled by thermoacoustic or thermoelectric refrigeration. Furthermore, the cooler **823** can be replaced by a large porous ceramic jar and other means to promote cooling by evaporative, perspiration or transpiration cooling. Alternately the system can utilize cold ground water if available as cold brackish water.

[0137] Furthermore, the system of **FIG. 12** can be implemented to provide freshwater for irrigation providing the system relies completely on evaporation cooling or on cold brackish ground water to be cost effective in collecting water from the atmosphere. This will depend on the climate conditions in the area to be cultivated and the water requirements for irrigation.

[0138] In this case, easy to dissolve fertilizers or plant nutrients can be mixed with the produced freshwater.

[0139] Furthermore, wind energy or solar energy can be used in supplying power for operation of the system, if used for irrigation, in place of expensive electric power that may not be easily accessed in the region of implementation, which may be deprived of water and power resources. The use of such alternative energy sources depends on the solar insolation and the frequency and speed of the prevailing wind in the region. The system can operate continuously day and night without the consumption of much power. Furthermore, the coolness can be stored in rocks for use in cooling of the condensation surfaces.

[0140] The system shown in **FIG. 13** is designed for providing drinking water for animals and poultry, wherein the thermoacoustic cooler **830** produces chilled water that circulates in cold water pipes **831** to cool the finned surfaces of a condensation cylinder **832**. The condensate accumulates on the fins and drops by gravity to a container **833** where the drinking water is dispensed by the spout **834** to the drinking basin **835**. The hot humid air is blown by the air fan **836** close to the fins of the condensation cylinder **832**. The top cover **837** is provided to protect the chilled water pipes **831** from the direct sun radiation during the day and to help in directing the stream of hot humid air through in contact with the condensation surfaces **832**.

[0141] Nutrients and medicinal chemicals can be added to the container **833** or to the basin **835** in doses proportionate to the water consumption rate. The system is of modular nature and can be constructed in different locations in a poultry farm. Alternately water can be produced at main locations and distributed to basins for providing drinking water to small groups of chicken or to stalls for use by animals. The drinking system can be integrated into the structure of a poultry farm or a barn in a manner compatible with the layout.

[0142] For watering of trees using water from atmospheric humidity, the system of **FIG. 14** is specially provided to assure efficiency in the use of irrigation water and to provide aesthetic appeal. The system is constructed to blend with natural trees growing within the vicinity of the water supply system and hence is shaped in the form of an artificial man-made vascular tree and is manufactured from wood. A hollow tree trunk may be used as the main component. The artificial trunk is covered with bark from natural trees.

[0143] The system is formed by wide leaflike condensation surfaces **851**; running through it cooled branching tubes **852** similar to leaf vessels. The condensation surface **851** is designed to expose the surfaces to the hot humid air stream for condensation of the water vapor entrained in the hot humid ambient air. The water-cooling unit **853** is placed at the top of the treelike trunk to supply cold water to the condensation surfaces **851**. The condensate falls by gravity and accumulates at the bottom part of the trunk in a tank **854** or at the distribution point **855**. Fertilizers can be added to the water in the tank **854** or at the point of distribution **855**, which feeds a distribution system that supplies water to the roots of the trees around. The extent of piping and the number of trees to be watered by one system depends on the water requirements of the specific trees and the quantity of water that can be condensated in each unit.

[0144] **FIG. 15***a* shows the components of a modular system using a combination of natural convection water-cooling, transpiration cooling and evaporative cooling for harvesting water from atmospheric humidity. The system is suitable for seashore regions and areas with abundant underground water resources that provide relatively cold brackish water or water containing high dissolved solids contents and not suitable for drinking. Simpler versions of the system are appropriate for production of potable water on seagoing vessels or small islands in the middle of the sea.

[0145] Each condensation module or stage **860** is in the form of a pot with two differently shaped necks. A narrow neck **861** of one pot can tightly fit into the opening of the wider neck **862** of another to form a stack of pots. The two necks can be locked into each other.

[0146] In one embodiment, the pot is fabricated from a porous ceramic material, while the interior wall is covered with a thin metallic layer. The pot can be also fabricated from metal for durability with a layer of porous material covering the outer surface. The pot is coated by a material that can absorb water and to the saturation level, such as padded cotton, wool, sponge, corrugated cellulose or natural animal skin (untreated leather) with a surface of thick hair. Inside each container, there is a set of coils and metallic condensation surfaces **863** with fins to promote heat exchange between the hot humid air and the cooled condensation surfaces.

[0147] After locking each pair of pots, the necks are tied up with a strong choker **864** that can be fabricated from leather or metal, strapped by a strap **865** connected to an air radiator **881** that surrounds the stacked pot assembly, as shown in **FIG. 15***b*. The air radiator is constructed from a hollow cylinder with wide orifices to allow the flow of air from inside to outside, as shown in **FIG. 15***c*.

[0148] The operation of the system involves drawing brackish water from a natural water source using the pump **870** that pumps the water into the pipe **871** and sprays it over the outer skin of the pots with the sprayer **872** to dampen the porous surface and the coating to saturation. The sprayed water falls by gravity to the disposal basin **873** where it can return to the open sea or to the well.

[0149] Upon saturation of the porous surfaces with water, the water evaporates by heat transfer between the relatively dry air surrounding the outer surfaces of the pots resulting in cooling of the interior of the pots **860** as well as the condensation surfaces and fins **863**. The hot humid air is blown inside the pot assembly by the air blower **880** located at the top of the assembly. The water vapor entrained in the hot humid air condensates as it strikes the cold fins **863**. This process takes place in stages, as the hot air enters and gets cooler and dryer, the colder air, flows down the assembly. At the pot in the bottom of the assembly, air is directed by the duct **862** to flow upward through the air radiator **881**. The condensate forming in the interior surfaces of the pots drips through the drain **890** to a storage tank **891**, where freshwater can be dispensed by the water pump **892** for distribution through the dispenser **893**. To avoid cavitation, the pump **892** is controlled by the level meter **894** and the switch **895** to operate only when sufficient water level is achieved in the tank **891**.

[0150] In a different embodiment, the pots are fabricated from porous ceramics. The porosity of the interior as well as the exterior promotes transpiration cooling through the outer skin of the pots. This will add to the cooling effect produced by evaporation cooling and promote condensation of the water vapor from hot humid air on the surfaces contained in the pot.

[0151] When the system of **FIG. 15** is used for irrigation, several units can be installed with multiple pots and distributed in the field in a manner that maintains aesthetics of the region.

[0152] For application in providing potable water aboard a seagoing ship, deep seawater is used for cooling. The number of pots will depend on the water requirements and the effluent of the seawater can be returned to the open sea, since it is not subject to any contamination. However, disinfection and filtration of the product freshwater is necessary prior to use. Ozonation in this case is the preferred means of disinfection.

[0153] While the present invention has been described with references to several embodiments, it will be appreciated by those skilled in the art that the invention may be practiced otherwise than as specifically described herein without departing from the spirit or the scope of invention. It is, therefore, to be understood that the spirit and scope of the invention be limited only by the appended claims.

What is claimed is:

1. A small apparatus for supplying a limited quantity of freshwater and drinking water to meet urgent water needs in emergency situations by condensing water vapor entrained in a high humidity, high temperature gas; said apparatus comprising:

a thermoacoustic refrigeration unit for cooling freshwater;

a freshwater connection pipe for circulating a stream of cold freshwater cooled by said thermoacoustic refrigeration unit through a plurality of cooling coils;

a water pump for driving the flow of water in said freshwater connection pipe and said plurality of cooling coils;

regulator means for regulating the circulation of cold freshwater stream in said freshwater connection pipe and said plurality of cooling coils;

condensation means for condensing water vapor from a high humidity, high temperature gas stream;

collection means for collecting the condensate dripping from said condensation means as freshwater;

filtration means for removing suspended particulates from the freshwater collected by said collection means;

storage means for storing the filtered freshwater; and

dispensing means for distributing the freshwater from said storage means.

2. The apparatus of claim 1, wherein said high humidity, high temperature gas stream is high humidity, high temperature ambient air.

3. The apparatus of claim 1, wherein said high humidity, high temperature gas stream is a mixture of high humidity, high temperature ambient air and high temperature moisture-laden exhaust from an internal combustion engine.

4. The apparatus of claim 1, wherein said high humidity, high temperature gas stream is high temperature moisture-laden exhaust of an internal combustion engine.

5. The apparatus of claim 1, wherein said condensation means comprises:

a rough condensation surface coated with a coat of material that promotes drop-wise condensation, said rough condensation surface in communication with, and cooled by said plurality of cooling coils;

an air blowing means for blowing said high humidity, high temperature gas stream over said rough condensation surface; and

an air filtering means for removing suspended particulates from high humidity, high temperature gas stream.

6. The apparatus of claim 1, wherein said condensation means comprises:

a plurality of cooling fins forming an integral part with said plurality of cooling coils for promoting a heat exchange between said high humidity, high temperature gas and condensate-entrained water vapor;

a duct including an oblique prism section having substantially rectangular-shaped faces and substantially trapezoidal-shaped lateral faces and a substantially rectangular-shaped parallelopiped section, said duct enclosing said plurality of cooling coils and said plurality of cooling fins;

air suction means for admitting said high humidity, high temperature gas stream through an open substantially rectangular-shaped inlet of said duct, said air suction means directing said high humidity, high temperature gas stream over said plurality of coils and said plurality of cooling fins and discharging said high humidity, high temperature gas stream through a narrow substantially rectangular-shaped outlet of said duct;

air filtering means for removing suspended particulates from said high humidity, high temperature gas stream at said open substantially rectangular-shaped inlet of said duct; and

tilted passage means positioned at a bottom surface of said duct for draining condensate dripping from said plurality of cooling fins.

7. The apparatus of claim 1, wherein said condensation means comprises:

a substantially conical-shaped duct including a plurality of concentric substantially conical-shaped condensation surfaces, an outer surface of said substantially conical-shaped duct being covered by said plurality of cooling coils;

air suction means for admitting said high humidity, high temperature gas stream through an inlet end of said substantially conical-shaped duct, said air suction means directing said high humidity, high temperature gas stream over said plurality of concentric substantially conical-shaped condensation surfaces and discharging said high humidity, high temperature gas stream upon drying and cooling said high humidity, high temperature gas stream from an outlet end of substantially conical-shaped duct;

air filtering means for removing suspended particulates from said high humidity, high temperature gas stream at said inlet end of said substantially conical-shaped duct; and

a tilted passage means at the bottom of said substantially conical-shaped duct to drain condensate dripping from said plurality of concentric conical condensation surfaces.

8. A process for the emergency supply of freshwater through the condensation of water vapor from hot moisture-laden gas, said process comprising the steps of:

cooling a charge of freshwater flowing in a pipe by thermoacoustic refrigeration;

circulating substantially cold freshwater by a water pump through a plurality of cooling coils connected to said pipe;

providing a plurality of condensation surfaces;

cooling said plurality of condensation surfaces with said plurality of cooling coils;

regulating the flow of the substantially cold freshwater through said pipe;

directing high humidity, high temperature gas to said condensation surfaces;

directing said high humidity, high temperature gas over said plurality of condensation surfaces;

condensing water vapor contained in said high humidity, high temperature gas on said plurality of condensation surfaces;

collecting condensate from said plurality of condensation surfaces as freshwater;

disinfecting the freshwater collected from said plurality of condensation surfaces;

filtering the disinfected freshwater to obtain a supply of potable water;

storing the potable water; and

dispensing the potable water.

9. The process of claim 8, wherein the step of cooling the plurality of condensation surfaces further comprises the steps of providing a metallic plate having a back surface and a front surface having a substantially rough surface coated with a material that promotes drop-wise condensation, and positioning said plurality of cooling coils on said back surface.

10. The process of claim 8, wherein the step of cooling the plurality of condensation surfaces further comprises the steps of:

placing a plurality of fins on a surface of said plurality of cooling coils, said plurality of cooling coils serving to cool the fins; and

providing a duct for enclosing said plurality of cooling coils and said plurality, said duct directing the flow of high humidity, high temperature gas.

11. The process of claim 8, wherein the step of cooling said plurality of condensation surfaces further comprises wrapping an outer surface of said plurality of condensation surfaces with said plurality of cooling coils.

12. A portable device for collecting freshwater from hot moisture-laden gas and supplying potable water to a limited number of passengers on a transport vessel, said device comprising:

inlet means for directing the hot moisture-laden gas inside a chamber;

a filter for essentially eliminating solid particulates contained in the hot moisture-laden gas before the hot moisture-laden gas enters into said chamber;

outlet passage means for discharging dry gas from said chamber after moisture is removed from the hot moisture-laden gas;

an air fan for drawing the hot moisture-laden gas from said inlet means through said chamber an into said outlet passage means;

a thermoelectric cooler for cooling a circulating stream of cold freshwater;

a plurality of spiral condensation coils for condensing moisture from the hot moisture-laden gas when the hot moisture-laden gas comes into contact with said plurality of spiral condensation coils to produce drippings of condensate that fall by gravity from the surfaces of said plurality of spiral condensation coils;

a water pump for circulating the stream of cold freshwater through said plurality of spiral condensation coils;

condensate collection means for collecting a freshwater product from the drippings of condensate that fall from the surfaces of said plurality of spiral condensation coils;

treatment means for disinfecting and filtering the freshwater product to produce potable water;

potable water holding means for storing said potable water;

dispensing means for drawing said potable water from said potable water holding means; and

power supply means for supplying electric power to said device.

13. The portable device of claim 12, wherein said hot moisture-laden gas is high humidity, high temperature ambient air.

14. The portable device of claim 12, wherein said hot moisture-laden gas is a mixture of high humidity, high temperature ambient air and exhaust from an internal combustion engine.

15. The portable device of claim 12, wherein said hot moisture-laden gas is the exhaust from an internal combustion engine.

16. The portable device of claim 12, wherein said power supply means is a diesel generator.

17. A portable device for collecting and supplying freshwater from moisture-laden air and being sized to be transported by a single individual, said portable device comprising:

inlet means for directing high humidity, high temperature ambient air inside a chamber;

outlet air passage means for discharging dry air from said chamber after moisture is removed from the high humidity, high temperature ambient air;

an air fan for drawing air from said inlet means through said chamber and into said outlet air passage means;

a thermoelectric cooler for cooling a stream of substantially cold freshwater;

a plurality of spiral condensation coils for condensing moisture from said high humidity, high temperature ambient air as the high humidity, high temperature ambient air comes into contact with said plurality of spiral condensation coils;

a water pump for circulating the stream of substantially cold freshwater through said plurality of spiral condensation coils;

condensate collection means for collecting a freshwater product produced from the drippings of condensate that fall from the surfaces of said plurality of spiral condensation coils;

filtration means for filtering said freshwater product to produce potable water;

potable water holding means for holding said potable water for dispensing; and

a battery for supplying electric power to said portable device.

18. The portable device of claim 17, wherein said potable water holding means comprises:

a container for drinking of potable water; said container having a top surface and a bottom surface; and

attachment means for attaching said top surface of said container to the said filtration means to allow the water to flow into said container by gravity.

19. The portable device of claim 18, wherein said container also comprises a canteen having an insulating layer for maintaining the temperature of the water contained in said canteen.

20. The portable device of claim 18, wherein said container comprises thermos.

21. A method for producing freshwater and potable water from the atmospheric humidity in very hot and humid climates and supplying the freshwater and potable water to at least one individual, said method comprising the steps of:

producing electric power from a rechargeable battery bank;

pumping freshwater through a thermoelectric cooler for cooling the freshwater and circulating cold freshwater through a plurality of spiral condensation coils for condensing water vapor entrained in high humidity, high temperature ambient air;

drawing the high humidity, high temperature ambient air from the atmosphere and forcing the high humidity, high temperature ambient air to flow into contact with said plurality of spiral condensation coils and then discharging the high humidity, high temperature ambient air into the atmosphere;

collecting; condensate as a freshwater product;

filtering collected freshwater;

dispensing the filtered water into a separate container for drinking; and

insulating the drinking cup to maintain the water temperature.

22. A system for producing freshwater and potable water from high humidity, high temperature outdoor ambient air drawn from outside of buildings and man-made structures, said system comprising:

water vapor condensation means for condensing water vapor contained in the high humidity, high temperature outdoor ambient air and using freshwater for cooling said water vapor condensation means to a temperature below the dew point;

outdoor ambient air drawing means for drawing the high humidity, high temperature outdoor ambient air to pass through and around said water vapor condensation means and discharging the high humidity, high temperature outdoor ambient air upon the removal of water vapor;

air filtering means for removing environmental pollutants contained in the high humidity, high temperature outdoor ambient air when drawn by said outdoor ambient air drawing means;

controller means for controlling and regulating the operation of said water vapor condensation means according to the ambient temperature and relative humidity of the high humidity, high temperature outdoor ambient air;

freshwater cooler means for cooling freshwater that is used to cool said water vapor condensation means and for supplying of cold potable water;

cold freshwater feed means for feeding the cold freshwater from said freshwater cooler means to said water vapor condensation means;

a water pump for driving said cold freshwater in said cold freshwater feed means;

freshwater recovery means for recovering the cold freshwater from said water vapor condensation means after elevation of the temperature of said cold freshwater feed;

evaporation means for re-cooling return freshwater flowing from said freshwater recovery means through evaporative cooling by surrounding air, wherein said return freshwater stays in said evaporation means a sufficient time to cool;

freshwater collection means for collecting condensate produced by said water vapor condensation means by condensing the water vapor contained in the high humidity, high temperature outdoor ambient air;

condensate transport means for assisting the flow of condensate from said freshwater collection means;

water filtration means for removing suspended particulates in freshwater flow;

water holding means for temporarily storing filtered water flowing out of said water filtration means, said water holding means being thermally insulated by thermal insulation material to maintain the temperature of the water in said water holding means;

freshwater flow means for pumping freshwater from said water holding means to said freshwater cooler means;

flow controller means for regulating said freshwater flow means;

water storage means for storing the freshwater and removing sediments contained in freshwater;

water directing means for directing the water from said freshwater cooler into said water storage means;

ozone generation means;

a release valve for releasing and distributing ozone in said water storage means for disinfecting the water in said water storage means;

ozone controller means for controlling the release of ozone in said water storage means;

relief means for venting residual ozone from said water storage means;

final polishing means for removing oxidation products from ozonation and suspended particulates in the water before use as potable water;

a water supply pump for pumping water to said final polishing means;

water drawing means for dispensing potable water; and

water return means for returning excess water from said water storage means to said water holding means.

23. The system of claim 22, wherein said water vapor condensation means comprises:

cylindrical surfaces means constructed from metallic sheets for condensing the water vapor contained in the high humidity, high temperature outdoor ambient air;

a plurality of finned coils for promoting the heat transfer between the high humidity, high temperature outdoor ambient air and said plurality of finned coils in condensing water vapor contained in the high humidity, high temperature outdoor ambient air; and

driving means for driving the flow of cold water from said cold freshwater feed means through said plurality of finned coils.

24. The system of claim 23, wherein said evaporation means comprises a porous ceramic pot located in the middle of said water vapor condensation means;

recovered freshwater flow means for directing recovered substantially warm water by said freshwater recovery means to said porous ceramic pot for cooling; and

overflow means for directing freshwater from said porous ceramic pot to said freshwater collection means.

25. The system of claim 23, wherein said evaporation means comprises a porous ceramic pot located outside of said water vapor condensation means;

recovered freshwater flow means for directing recovered relatively warm water by said freshwater recovery means to said porous ceramic pot for cooling; and

an overflow means for directing freshwater from said porous ceramic pot to said water holding means.

26. A process for producing freshwater and potable water from high humidity, high temperature outdoor ambient air using freshwater to cool condensation surfaces below the dew point to condensate water vapor contained in the high humidity, high temperature outdoor ambient air through evaporative cooling, said process comprising the steps of:

drawing outdoor high humidity, high temperature outdoor ambient air;

measuring the ambient temperature and relative humidity of said high humidity, high temperature outdoor ambient air;

estimating the absolute humidity of the high humidity, high temperature outdoor ambient air;

condensing water vapor from said high humidity, high temperature outdoor ambient air using freshwater to cool condensation surfaces;

estimating the lower limit of absolute humidity of said high humidity, high temperature outdoor ambient air under which condensating water vapor from said high humidity, high temperature outdoor ambient air becomes uneconomical;

controlling the step of condensating water vapor from said high humidity, high temperature outdoor ambient air based upon comparing the absolute humidity estimates and a lower limit of absolute humidity;

collecting condensate in a freshwater collecting container;

flowing the freshwater from said freshwater collecting container;

filtering the flowing freshwater from said freshwater collecting container;

storing the filtered water in a thermally insulated holding tank;

cooling the freshwater in a cooler;

drawing the water from said thermally insulated holding tank to said cooler; and

pumping the water from said cooler.

27. The process of claim 26, wherein the step of condensating water vapor comprises:

pumping from an external source an initial charge of freshwater in excess of the capacity of said thermally insulated holding tank;

drawing the excess freshwater from said thermally insulated holding tank to said cooler;

cooling the freshwater in said cooler to produce cooling freshwater;

regulating the flow of said cooling freshwater;

pumping the cool freshwater in condensation finned coils to form a cylindrical condensation unit having condensation surfaces;

replenishing the cooling freshwater in said cooler from said thermally insulated holding tank;

drawing said high humidity, high temperature outdoor ambient air from the sides of said cylindrical condensation unit;

condensing water vapor carried by said high humidity, high temperature outdoor ambient air as said high humidity, high temperature outdoor ambient air passes by said condensation finned coils and said condensation surfaces;

directing said high humidity, high temperature outdoor ambient air to the top of said cylindrical condensation unit after drying and cooling said high humidity, high temperature outdoor ambient air;

terminating the flow of said cooling freshwater in said condensation finned coils by pouring the cooling freshwater in a porous container;

re-cooling the cooling freshwater in said porous container by evaporative cooling as the external surface of said is exposed to said dry and relatively cold air before leaving to the outdoors;

returning the cooling freshwater after re-cooling in said porous container to said thermally insulated holding tank; and

dripping the condensate from said porous container in said freshwater collecting container.

28. The process of claim 26, further comprising the steps of:

directing the freshwater flow from said thermally insulated holding tank to a storage tank;

controlling the flow from said storage tank;

ozonating water inside said storage tank;

filering of ozonated water from disinfection products; and

dispensing the cold potable water.

29. A system for producing freshwater from atmospheric humidity in shoreline regions where brackish underground water is plentiful, said system comprising:

a cylindrical condensation unit constructed from a plurality of connected surfaces and finned coils;

drawing means for drawing high humidity, high temperature outdoor ambient air and directing the high humidity, high temperature outdoor ambient air through said cylindrical condensation unit from the sides for condensation of water vapor and exhausting cooler drier air from the top;

a pump for lifting cold brackish water from a natural water source to an intermediate brackish water holding tank;

flow driving means for driving the flow of said cold brackish water through said finned coils for cooling the cylindrical condensation unit and terminating the flow of said cold brackish water after the temperature of said cold brackish water becomes higher into a porous ceramic pot for evaporative cooling on the exterior through contact with cooler drier air exiting from the top of said cylindrical condensation unit;

recovery means for returning the brackish water from said porous ceramic pot to said intermediate brackish water holding tan;

collection means for collecting condensate from said cylindrical condensation unit;

filtration means for removing contaminants and suspended particulates from freshwater collected in said collection means;

storage means for storing the freshwater; and

supply means for dispensing thefreshwater.

30. A process for producing freshwater from atmospheric humidity in shoreline regions wherein brackish underground water is plentiful, said process comprising the steps of:

driving high humidity, high temperature outdoor ambient air inside a limited space to enter from the sides and leave at the top;

measuring the ambient temperature and relative humidity of said high humidity, high temperature outdoor ambient air;

estimating the absolute humidity based on the ambient temperature and relative humidity measurements;

condensating water vapor from said high humidity, high temperature outdoor ambient air using freshwater;

collecting condensate from said condensation surfaces in a freshwater collecting container; and

flowing freshwater from said freshwater collecting container by gravity to a large capacity storage tank.

31. The process of claim 30, wherein the step of condensating water vapor comprises:

pumping the cold brackish water from a natural source;

directing said high humidity, high temperature outdoor ambient air inside said limited space to flow through a cylindrical condensation unit;

directing said cold brackish water through a plurality of coils with tightly spaced fins to promote the heat transfer between said fins and air, said plurality of coils being connected to layers of condensation surfaces to form an integral part of said cylindrical condensation unit;

condensing water vapor carried by said high humidity, high temperature outdoor ambient air as said high humidity, high temperature outdoor ambient air comes into contact with said cylindrical condensation unit;

collecting the condensate from said cylindrical condensation unit into said freshwater collecting container; and

directing the cold brackish water leaving said plurality of coils to a porous ceramic pot for re-cooling by evaporative cooling.

32. The process of claim 30, further comprising the steps:

disinfecting freshwater in said large capacity storage tank by ozonation;

filering the water drawn from said large capacity storage tank to remove oxidized particulates; and

dispensing the potable water on demand.

33. The process of claim 30, further comprising the steps of:

adding doses of nutrients and preventive medication to the water in said large capacity storage tank; and

directing fortified drinking water to drinking basins of animals.

34. The process of claim 30, further comprising the steps of:

adding doses of nutrients, pesticides, herbicides and other plant growing and protection materials to the water contained in said large capacity storage tank; and

directing the water to an irrigation system.

35. A system for supply of freshwater from hot humid outdoor ambient air and for easing the indoor temperature in a building unit that can be a small house or commercial building, comprising:

cooling supply means to providing a stream of cooling water;

pump means for driving and circulating the stream of cooling water from said cooling supply means to a plurality of distribution pipes,

transferring cooling water from said plurality of connection pipes to said plurality of distribution pipes then to a plurality of cooling coils forming an integral part with the bottom of a plurality of corrugated metallic sheet sections for condensing the water vapor contained in naturally flowing outdoor ambient air, said sheet sections covering the roof of said building unit in a staggered manner for providing an overall large condensation surface area and for allowing flow paths for condensate;

insulation means for thermally insulating said cooling coils from said roof;

a plurality of down pipes to return relatively warm cooling water to said supply means;

a plurality of gutters to collect runoff condensate from said sheet sections;

draining means for flowing the freshwater collected in said plurality of gutters by gravity;

external freshwater storage means for storing drained freshwater and precipitate sediments and suspended particulates;

water treatment means for preventing the growth of bacteria, bio-contaminants and microorganisms in the freshwater contained in the external freshwater storage means by in-situ treatment;

distribution means for distributing the freshwater in said building unit;

filtration means for removing disinfected waste, suspended particulates, dust, and sand from the water;

pumping means for forcing the flow of freshwater from said external freshwater storage means through said filtration means to said distribution means;

drawing means for drawing freshwater from said distribution means;

potable water preparation means; and

dispensation means for dispensing potable water from said potable water preparation means.

36. The system of claim 35, wherein said cooling supply means comprises:

a thermoacoustic refrigeration engine; and

make-up means for replenishing the cooling water during circulation.

37. The system of claim 35, wherein said cooling supply means comprises a deep underground brackish water well.

38. A system for supplying freshwater from high temperature, high humidity outdoor ambient air and for lowering the indoor temperature of an enclosed structure, said system comprising:

cooling supply means for providing a stream of cooling water;

pump means for driving and circulating said stream of cooling water from said cooling supply means to a plurality of connection pipes to transfer cooling water to a plurality of cooling coils forming an integral part with the backside of a plurality of corrugated metallic vertical sheet sections for condensation of water vapor entrained in naturally flowing outdoor ambient air, said sheet vertical sections cover the walls of said building unit in a staggered manner that provides an overall large condensation surface area;

insulation means for thermally insulating said cooling coils from the structure of the walls of said building unit;

a plurality of pipes for returning relatively warm cooling water to said supply means;

a plurality of conduits with an incline to collect runoff condensate from said sheet sections and allow condensate to flow by gravity;

a draining means for flow of freshwater collected in said plurality of conduits by gravity;

external freshwater storage means for storing drained freshwater and precipitate sediments and suspended particulates;

water treatment means for in-situ treating freshwater in said external freshwater storage means to prevent the growth of bacteria, bio-contaminants and microorganisms in the freshwater;

distribution means for distributing freshwater to said building unit;

filtration means for removing disinfected waste, suspended particulates, dust, and sand from the water;

pumping means for forcing the flow of freshwater from said external freshwater storage means through said filtration means to said distribution means;

drawing means to draw freshwater from said distribution means to supply freshwater or to prepare potable water;

potable water preparation means; and

dispensation means for dispensing potable water from said potable water preparation means.

39. The system of claim 38, wherein said cooling supply means comprises:

a thermoacoustic refrigeration engine; and

make-up means for replenishing the cooling water during circulation.

40. The system of claim 38, wherein said cooling supply means comprises a deep underground brackish water well.

41. The system of claim 38, further comprising:

a plurality of distribution pipes for circulation of said stream of cooling water from said cooling supply means by said pump means;

a plurality of connection pipes for transferring cooling water from said plurality of distribution pipes upward to a plurality of cooling coils forming an integral part with the bottom of a plurality of corrugated metallic sheet sections for condensation of water vapor entrained in naturally flowing outdoor ambient air, said sheet sections cover the roof of said building unit in a staggered manner that provides an overall large condensation surface area and allow rundown paths for condensate;

insulation means for thermally insulating said cooling coils from the roof structure;

a plurality of down pipes to return relatively warm cooling water to said supply means;

a plurality of gutters to collect runoff condensate from said sheet sections; and

draining means for flowing the freshwater collected in said plurality of gutters by gravity to said external freshwater storage means.

42. A system for providing clean freshwater for drinking of farm animals and poultry from atmospheric humidity in hot humid climate, said system comprising:

a thermoacoustic refrigeration engine for supplying cooling freshwater by gravity to a plurality of conducting tubes in intimate contact with a vertical cylindrical condensation surfaces with a plurality of longitudinal fins to promote heat transfer with hot humid ambient air in the surroundings;

an air fan for driving said hot humid ambient air and form an air stream flowing around said plurality of longitudinal fins;

a conical cover for protecting the condensation surfaces and directing the air stream driven by said air fan;

a collection cistern for catching condensate falling by gravity from said condensation surfaces;

means for supplying drinking water from said cistern to drinking basins; and

means for supplying of doses of nutrients and preventive medicine solutions to said drinking water supply means.

43. A system for providing freshwater to watering trees in wooded areas from atmospheric humidity in hot humid climate, said system comprising:

thermally insulated container means containing cooling means, collection means and distribution means, said thermally insulated container means being formed from a hollow conical-shaped tank in the form of a tree trunk and having an outer surface covered with bark for added insulation;

metallic condensation means for condensing water vapor contained in hot humid ambient air carried by winds flowing by natural convection, said metallic condensation means collecting and draining condensate, said metallic condensation means having a metallic sheet shaped like a rubber plant leaf and rigidly connected to said container means such that said sheet is tilted at an angle towards said container means to drain condensate, plurality of metallic condensation means are located in proximity of sites, of trees to be watered without being shaded by trees or sheltered from the prevailing wind or hot humid ambient air stream;

a plurality of cooling means to convey said cooling freshwater throughout, said and to said metallic condensation means, said plurality of cooling means are embedded in said metallic condensation means for cooling, and are formed from vascular-like thin tubes branching from a main thick tube in the middle of said metallic condensation means to thinner capillary tubes with passages narrowing as they reach the tip of said metallic condensation surfaces; and

a plurality of watering means for distribution of irrigation water to the roots of natural trees, said plurality of watering means are metallic roots-like pipes extending in the ground.

44. The system of claim 43, wherein said thermally insulated tree trunk-like tank comprises:

a thermoacoustic refrigeration engine to supply cooling freshwater to said plurality of tubes by the force of a water pump;

a collection means to collect accumulated condensate from the lower part of said condensation means at the bottom of said trunk-like tank;

an dosing means to add nutrients and plant protection chemicals to the freshwater in said collection means; and

a pumping means to direct the water from said collection means to a watering distribution means to distribute water to the roots of the natural trees; said distribution means are shaped like roots.

45. A process for watering trees in a limited wooded area by freshwater from atmospheric humidity in hot humid climates, said process comprising the steps of:

supplying coolness by a thermoacoustic refrigeration engine to a cooling water stream;

circulating said cooling water stream in a closed loop connecting said refrigeration engine, a pump and vascular-shaped tubes embedded in metallic condensation surfaces for cooling said metallic condensation surfaces to a temperature below dew point of hot humid ambient air;

condensating of water vapor from hot humid ambient air blowing around and in contact with said metallic condensation surfaces;

enhancing free-falling of condensate accumulated on said metallic condensation surfaces to a storage tank located at the bottom a thermally insulated container;

adding nutrients and plant protective additives to water in said storage tank; and

driving fortified water from said storage tank through extended buried piping to watering locations on demand.

46. A modular system for production of freshwater from atmospheric humidity in hot humid seashore regions, said modular system comprising:

a condensation means constructed from a plurality of coils connected to the surface of condensation sheets with fins for condensation of hot humid air;

a hollow sphere module to contain said condensation means, said hollow sphere module has an open mouth and a neck at each of its ends, the circumference of the neck at top is wider than the neck of the bottom end;

an air fan to create a stream of hot humid ambient air that enters in the wide mouth at the top of said hollow sphere module, passes through the interior in contact with said condensation means and exits at the bottom through the narrow mouth at the bottom of said hollow sphere module;

an assembly including a plurality of said of hollow sphere modules;

an air radiation means surrounding said assembly, constructed from cylindrical metallic sheet containing orifices to allow relatively cooler and drier air to move upward in a draft;

an air directing means to direct said cooler and drier air exiting from the narrow mouth at the bottom of said assembly to the interior of said air radiation means after being relieved from humidity and heat;

a cooling water source of cooling brackish water;

a drawing means to draw said cooling brackish water from said cooling water source and lift to the top of said assembly;

a spraying means to spray said cooling brackish water lifted to the top of said assembly over the exterior of said module;

a brackish water collection means to collect the free-falling said cooling brackish water at the bottom of said assembly to return it to said cooling water source;

a holding tank means to collect free-falling condensate from the interior of said assembly;

a delivery means to pump freshwater from said holding tank;

a control means to regulate the operation of said delivery means; and

a distribution means to distribute freshwater from said holding tank.

47. The modular system of claim 46, wherein said hollow sphere module comprises:

a metallic cooling jug; and

an outer jacket to cover the exterior of said jug to promote evaporative cooling, said outer jacket is fabricated from water absorbent material such as cotton sponge, natural leather with thick hair, or corrugated cellulose.

48. The modular system of claim 46, wherein said hollow sphere module comprises:

a porous ceramic cooling jug to promote transpiration cooling; and

an outer jacket to cover the exterior of said jug to promote evaporative cooling, said outer jacket is fabricated from water absorbent material such as cotton sponge, natural leather with thick hair, or corrugated cellulose.

49. The modular system of claim 46, wherein said assembly comprises:

a stack of said hollow sphere modules assembled by fitting the narrow neck of the top module in the opening of the wider neck of the lower module;

a leak prevention means to prevent leakage of air or condensate from the interior of said hollow sphere modules to the outside and intrusion of cooling brackish water from the outside to the interior of said hollow sphere modules; and

a tying means to firmly tie said hollow sphere modules to said air radiation means.

50. The modular system of claim 46, wherein said distribution means comprises:

a filtration means to remove suspended particulates from freshwater; and

a dispensation means to draw freshwater.

51. The modular system of claim 46, wherein said distribution means comprises:

a large basin to provide irrigation water;

a piping means to connect said holding tank means to said large basin; and

an irrigation means to supply water to plants.

52. The modular system of claim 46, wherein said distribution means comprises:

a large basin to provide drinking water to farm animals; and

a piping means to connect said holding tank means to said large basin.

53. The modular system of claim 46, wherein said cooling water source comprises cold brackish water well.

54. The modular system of claim 46, wherein said cooling water source comprises sea water.

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