Saleable Rainwater

Many people have considered recovering potable water from humid air but have always run up against the constraints of capital or energy costs.

The attached patent suggests a somewhat different path to that objective. The inventor believes that this may be a "niche" application to supply water to a bottling plant that could advertise that they were selling "pure rain water" as their product. This will allow the water to be sold at a much higher price than if were to be sold as "tap water".

Your task is to evaluate the patent and to come up with cost per liter for producing potable water via this process proposed in the patent. Work product includes:

- Site Recommendation
- Process Flow Diagram
- Mass and Energy Balance
- Equipment Sizing
- Plot Plan
- Utilities Requirement
- Capital Cost
- Operating Cost
- Cost per liter of produced water

The required completion date for this work is the end of November 2015.

A.M. Center
Project Sponsor

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your provisional patent has been filed!

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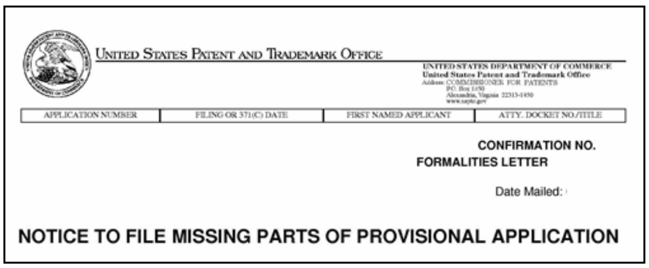
The Atmospheric Water Generator is officially "patent pending" with Provisional Patent Application Number 62/180,688

The US Patent Office will send an official letter to your correspondence address within a few weeks. Save the letter when it comes as it is physical evidence of your provisional patent application.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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE

CONFIRMATION NO.
FORMALITIES LETTER

Date Mailed:

NOTICE TO FILE MISSING PARTS OF PROVISIONAL APPLICATION

If you receive a letter with the heading <u>Notice to File Missing Parts</u> or <u>Notice to Correct Application Papers</u> (see example on the left), contact your consultant and provide a copy of the letter. This indicates the US Patent Office needs something corrected and we will help you take care of this.

What does the provisional patent filing allow?

- The invention disclosed in this application is legally patent pending for the next 12 months.
- If you file a non-provisional patent within 12 months, the non-provisional patent will enjoy the filing date of this provisional patent.

Where can I go from here?

1. With a filing date secured, have confidence in marketing your invention or pitching it to investors and companies.
2. File a non-provisional patent application within 12 months to enjoy the filing date of the provisional patent application. If the non-provisional patent is granted, your invention will have patent protection for 20 years.

Should you have any questions, please contact me at your convenience.

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Provisional Patent Application Number 62/180,688

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Title of Invention	Atmospheric Water Generator
Listed Inventors	Robert Nelson Garcia
Docket Number	TPP24489
Receipt Date	17-JUN-2015
Time Stamp	11:53:34
Application Type	Provisional
Documents Filed	Specification Drawings – only black and white line drawings Micro Entity Status Certification Provisional Cover Sheet Fee Worksheet

Atmospheric Water Generator

FIELD OF THE INVENTION

The present invention relates generally to devices that converts water vapor in the atmosphere into liquid water. More specifically, the present invention is a device that utilizes the main components of an axial compressor, turbo expander, honeycomb flow straightener and a gas/liquid separator to generate mass quantities of water from the atmosphere. Given the proper baseline atmospheric conditions, the present invention should be able to produce on the order of 1 million gallons of liquid water per 24-hour period.

BACKGROUND OF THE INVENTION

Atmospheric water generators provide an environmentally sustainable and responsible water supply solution in regions that have high moisture content in the air. At any given moment, the atmosphere contains a staggering 37.5 million billion gallons of water in vapor form, therefore there is no shortage of water in the atmosphere. Atmospheric water generators can be placed virtually anywhere and provide the benefits of producing water where there is no conventional water source. There are several types of atmospheric water generators that are in use today. However, these machines are typically smaller and have a limited capacity to produce water. Additionally, these smaller machines utilize components such as evaporator coils, condenser coils and refrigerants that are typically found in refrigeration and air conditioning units. These types of generators have several disadvantages such as a high cost given their low capacities and they operate with huge inefficiencies. Further, the use of Freon and similar refrigerants in such systems have been controversial due to environmental and safety concerns.

The present invention aims to address the problems of existing atmospheric water generators as mentioned above. Given the proper baseline atmospheric conditions of 86 degrees Fahrenheit and 100% relative humidity, the present invention should be able to produce on the order of 1 million gallons of liquid water per 24-hour period. The present invention, also referred to as the “Celesteau Machine” in its full-sized version will use four axial compressor feeding air into four turbo expanders to process four million cubic feet of air per minute. Four million cubic feet of air contains approximately 116,000 ounces of water, which translates into 906 gallons per minute. This in turn translates into a potential 54,375 gallons of water per hour, for a total of about 1,305,000 gallons of water in a 24- hour period that would be available for extraction. The present invention will utilize the main components of an axial compressor, turbo expander, honeycomb flow straightener and a gas/liquid separator to convert mass quantities of moist atmospheric air into liquid water. The present invention will run at a much higher efficiency than existing machines and will not utilize refrigerants such as Freon which may be harmful to the environment and people.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the flow of the moisture-laden atmospheric air through the various components of the present invention

FIG. 2 shows the functions of each of the aforementioned components

FIG. 3 shows how additional components such as booster compressors, generators and compressors may be added to the present invention to facilitate the flow of air as well as to recapture some of the expended energy

FIG. 4 shows how the dry exhaust air may be redirected to recapture some of the expended energy

FIG. 5 is a sectional view of an axial compressor

FIG. 6 is a sectional view of a combination turboexpander and compressor assembly

FIG. 7 is a perspective view of a honeycomb flow straightener showing the flow of the water vapor

FIG. 8 depicts a flow straightener configured vertically onto the inlet of a gas/liquid separator

1. Honeycomb flow straightener
2. Gas/liquid separator

FIG. 9 depicts a possible configuration of the present invention, showing the flow of air through the various components

1. Air filter
2. Axial compressor #1
3. Turboexpander (Turboexpander-compressor combination unit)
4. Axial compressor #2
5. Honeycomb flow straightener
6. Gas/liquid separator
7. Water filter
8. Water storage tank
9. Secondary boost compressor (Turboexpander-compressor combination unit)
10. Pump, piping and spray to add water to a point above the honeycomb flow straightener

DETAIL DESCRIPTIONS OF THE INVENTION

All illustrations of the drawings are for the purpose of describing selected versions of the present invention and are not intended to limit the scope of the present invention.

The present invention, also referred to as the "Celesteau Machine" will be able to produce approximately 1 million gallons of water in a 24-hour period from the moist atmospheric air. In conditions of 86 degrees Fahrenheit and 100% relative humidity (typically found in areas such as South Florida), every cubic foot of air contains approximately 0.029 ounces of water in vapor form. The present invention in its full-sized version will utilize four axial compressors feeding air into four turbo expanders to process four million cubic feet of air per minute. Under these conditions, those four million cubic feet of air contains about 116,000 ounces of water, which translates into 906 gallons per minute. This in turn translates into a potential 54,375 gallons of water an hour, for a total of about 1,305,000 gallons of water in a 24-hour period that would be available for extraction. The present invention should be able to perform reasonably well even in areas where the temperature and humidity are not under optimal conditions such as Dubai, where the near-constant average atmospheric conditions are at a temperature of 80 degrees Fahrenheit and a relative humidity of 80%. Alternatively, in atmospheric conditions of temperatures in the range of 95-100 degrees Fahrenheit and 100% relative humidity (such as tropical regions), the present invention may produce as much as 50% more water from the atmosphere. This system solely relies on compressing and expanding the air to form condensation which will be separated and collected. There will be no need for components used in refrigeration systems such as condenser coils, evaporator coils and potentially harmful refrigerants. The primary purpose of the present invention will be to produce near-pure water for human consumption.

The present invention is an atmospheric water generator that comprises an air filter, axial compressors, a turbo expander, Y-ducts or manifolds, a honeycomb flow straightener, a gas/liquid separator, a water filter and a storage tank. The present invention is not limited to any specific type of axial compressor, turboexpander, gas/liquid separator, etc. Such components are well known in the industry, therefore will be described as components within the overall system itself rather than detailing each component. The focus will be on the arrangement and the functionality of each of the aforementioned components in relation to one another within the system. The key to the present invention is that it is capable of moving massive amounts of air through the system. Axial compressors use motor-driven turbine-like blades to move massive quantities of gas under pressure. A depiction of an axial compressor is shown in **FIG. 5**. It is preferable to use an axial compressor that utilizes magnetic bearings as they are better for non-contamination purposes when compared to traditional bearing systems that need lubricants such as oil that may end up contaminating the system. The largest axial compressors presently available have the capacity to move 1 million cubic feet of air per minute. A first axial compressor will suck in the moisture-laden air from the atmosphere and force it through a turbo expander. Prior to entering the first axial compressor, the air will pass through an air filter. The air filter will prevent dust, insects and other particulate matter from entering the machine.

The turbo expander will supercool the air via expansion. The pressurized air exiting the axial compressor will be forced over a rotating impeller and then through a funnel-shaped duct, thereby expanding the gas. Physically expanding the gas causes it to cool. Turbo expanders are typically used in air separation plant to cool air to temperatures low enough to produce liquid nitrogen and liquid oxygen. The present invention however, does not require the temperature to be cooled to such extremes. A target temperature of 40 degrees Fahrenheit will be more than sufficient enough to case the water vapor in the moisture-laden atmospheric air to condense into a liquid form. Because the turboexpander cools the air to such extreme temperatures, a second axial compressor will be needed to pull in warm air. The outlet of the turboexpander will be connected to an inlet of the Y-duct. A second axial compressor will be connected to the other inlet of the Y-duct. The single outlet is then arranged to the inlet of the honeycomb flow straightener. The purpose of this configuration is to warm the super cooled air exiting the turboexpander to a temperature around the dew point for condensation. It may be necessary to have more than one axial compressor to sufficiently warm the super cooled air to the appropriate temperature. As shown in **FIG. 1**, a third axial compressor may be added to the system to further warm the super cooled air. In this case, the Y-duct will be replaced with a 3-way duct or manifold for the third axial compressor unit attach to. Although not mentioned, components such as an intermediate booster compressor, generators and additional compressors may be added to the machine to facilitate the flow of air as well as recapture expended energy. For example, an electric generator or an additional compressor may be connected to the impeller shaft of the turbo expander to recapture some of the energy expended by the machine, as depicted in **FIG. 3**. Depicted in **FIG. 6** is a combination turboexpander and compressor unit. In this configuration, the turboexpander and compressor are connected on a single shaft where the turboexpander is the power unit and the compressor is the driven unit. Meaning, the turboexpander extracts the potential heat energy from the air stream, causing it to cool dramatically which the extracted energy is then converted to mechanical energy to rotate the shaft to the compressor end of the turboexpander. As shown in **FIG. 9**, a portion of the exhaust air from the gas/liquid separator enters a Y-duct and into the compressor while the rest is expelled into the atmosphere. If the compressor unit on the turboexpander is replaced with an electric generator, it will be unnecessary to redirect the air. Instead, the air will be discharged from the gas/liquid separator.

As the processed air flows through the turbo expander and mixes with the warm air within the duct, it is equalizes to a temperature of about 40 degrees Fahrenheit, where the water vapor will condense into liquid form as it touches a substrate surface such as the impeller on the turbo expander and the ducting walls. In order to promote the highest degree of condensation, the surface area contacted by the water vapor must be maximized. This is accomplished by forcing the cooled air out of the turbo expander and through the honeycomb flow straightener. The hexagonal shape of the honeycomb flow straightener is important due to the minimal frontal surface area, while providing a large lateral surface area within the honeycomb cell walls. The minimal frontal surface area provides the least amount of air resistance and the lateral surface area will act as the substrate surface for the air molecules to contact and condense upon. It is preferred to orient the honeycomb flow straightener in the vertical direction as gravity will aid in pulling the condensation down and into the gas/liquid separator.

The water droplet-entrained stream of air is then forced through a gas/liquid separator. The present invention is not limited to any specific type of gas/liquid separator as one may be more effective than the other based on the orientation of the components. However, it is most beneficial to utilize a gas/liquid separator with a vertical inlet so that the vertically oriented honeycomb flow straightener can be placed directly on top, as depicted in **FIG. 8**. The moisture-laden air will enter the inlet of the gas/liquid separator where it is deflected into a centrifugal motion. The entrained solids and moisture droplets are then separated from the air by a reduction in velocity of the flow. The moisture droplets and dry air are then expelled through separate outlets, effectively separating the moisture-laden air. The moisture droplets, or liquid water, is then pumped into a storage tank. Prior to entering the storage tank, the liquid water will flow through a water filtration system where it will be further purified to render it potable. The dry air will be expelled out of the system. However, if feasible, the exhausted air may be forced into the turbo expander compressor unit to provide recapture additional energy, as depicted in

FIG. 4. Booster compressors may be added to an intermediate point or at the end of the machine's ducting in order to keep the air flowing through the apparatus at a high velocity, as depicted in **FIG. 3**. The flow of the moisture-laden atmospheric air is depicted in **FIG. 1** and their respective functions within the system is depicted in **FIG. 2**.

The interior surfaces of the machine, as well as the storage tanks will be constructed from food-grade stainless steel to provide a high level of purity. Additionally, the entire interior surface of the present invention may be coated in a super hydrophobic coating to promote the coalescing of water droplets into a spherical form, which aids in the transporting of water droplets as they "roll" along the surface rather than sticking to it. The super hydrophobic coating will also prevent the water droplets from "standing" or collecting in parts of the machine and its ducting which would be undesirable. This would also prevent ice from forming inside the machine. The super hydrophobic coating may have a negative impact on the purity of the water as the coating may run off of the interior surface, contaminating the water. It is understood that there are a variety of ways to provide a super hydrophobic coating-like surface to the interior of the machine. For example, alternative methods include etching the stainless steel that gives a super hydrophobic coating feel as well as methods including chemical etching. Therefore, the present invention is no limited to any specific method.

An additional method of facilitating condensation is to add water to a point above the honeycomb flow straightener. In nature, precipitation forms when water vapor coalesces around CCNS, or cloud condensation nuclei. CCNs are small particles on which water vapor condenses. When the water droplets are large enough, instead of evaporating, they being to attract more water vapor that condenses on these drops, which allows them to grow larger and fall. This principle will be used to facilitate condensation. In this configuration, the gas/liquid separator will further comprise a pump, piping and sprayer. A small pipe will be arranged to the bottom of the gas/liquid separator, where a small amount of collected water will be recirculated and pumped to a point above the honeycomb flow straightener, as depicted in **FIG. 9**. The water is then sprayed via the sprayer into the air stream prior to entering the honeycomb flow straightener. The recirculated water droplets being sprayed back into the airstream must be large enough to overcome the "curvature effect" of water droplets, allowing the droplets to coalesce further and grow in size. By having the duct and honeycomb surfaces coated or etched for super hydrophobicity, many large droplets will bounce around, entrained in the air stream, providing more opportunity for the water vapor to contact something to transfer its latent heat of evaporation onto, thereby causing more condensation to form.

FIG. 9 depicts a possible layout of the present invention, showing the flow of air through the various components of the system. As shown in the figure, the axial compressor unit comprises a horizontal inlet to bring in the moisture-laden air from the atmosphere and a vertical outlet connected to the vertical inlet of the turboexpander unit. The horizontal outlet of the turboexpander unit is connected to one inlet of the Y-duct to mix with the incoming air from the second compressor unit. The second compressor unit brings in warmer air to mix with the super cooled air exiting the turboexpander. The mixed air, having a temperature of about 40 degrees Fahrenheit, will then flow into the honeycomb flow straightener. The honeycomb flow straightener is connected to the vertical inlet of the gas/liquid separator where the moisture-laden air is separated. The water drains from the bottom of the gas/liquid separator, through a water filter and into a water storage tank. In this configuration, a portion of the dry air is redirected into the compressor attached to the turboexpander-compressor combination unit. Additionally, in this configuration, the interior from point A to point B is etched for super hydrophobicity and a small pump and sprayer unit redirects some of the collected water back into the system to facilitate condensation. Note that the components are not drawn to scale.

Although the invention has been explained in relation to its preferred embodiment, it is to be understood that many other possible modifications and variations can be made without departing from the spirit and scope of the invention.

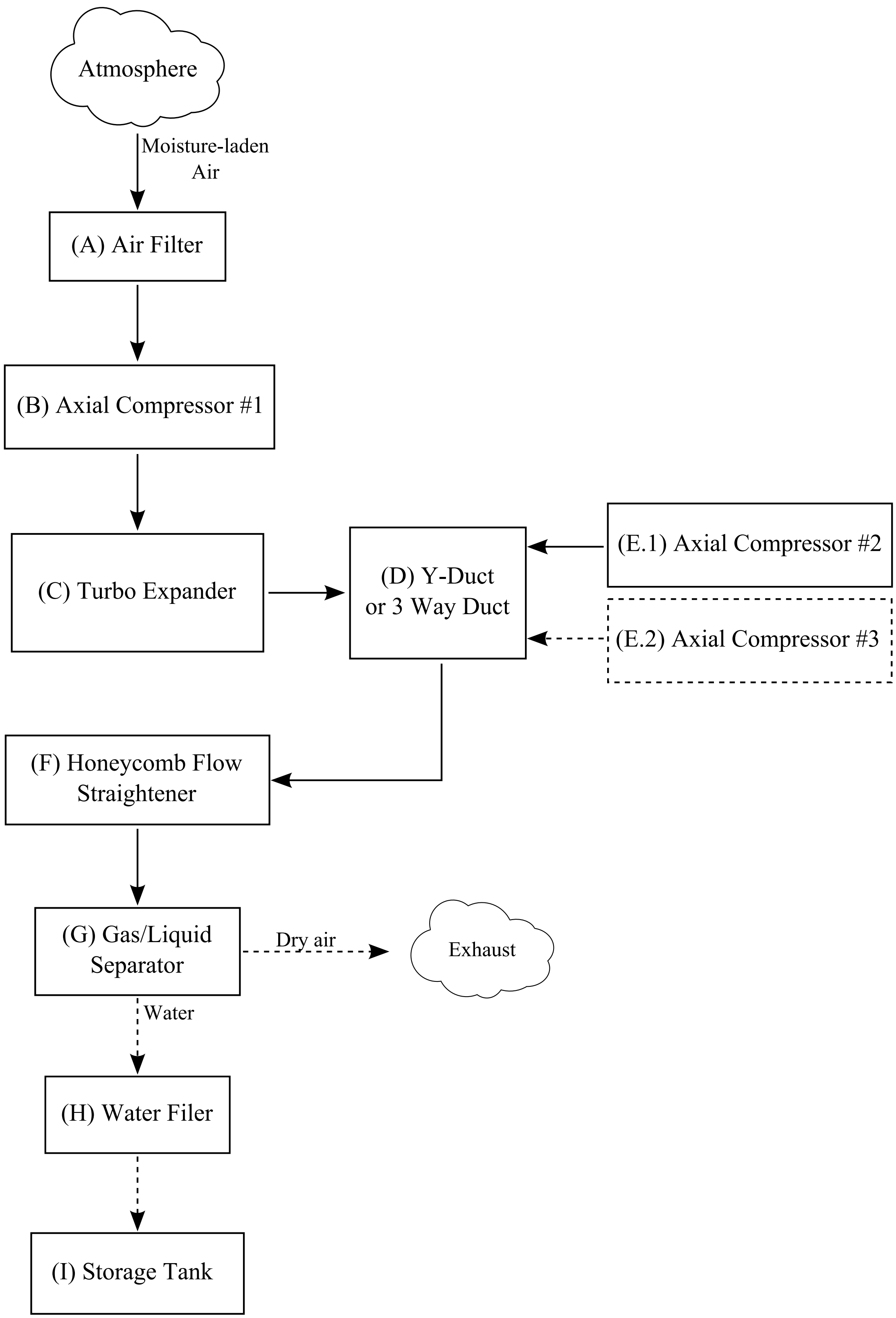

Atmosphere
Moisture-laden Air
(A) Air Filter
(B) Axial Compressor #1
(C) Turbo Expander
(D) Y-Duct or 3 Way Duct
(E.1) Axial Compressor #2
(E.2) Axial Compressor #3
(F) Honeycomb Flow Straightener
(G) Gas/Liquid Separator
Dry air
Exhaust
Water
(H) Water Filer
(I) Storage Tank

FIG. 1

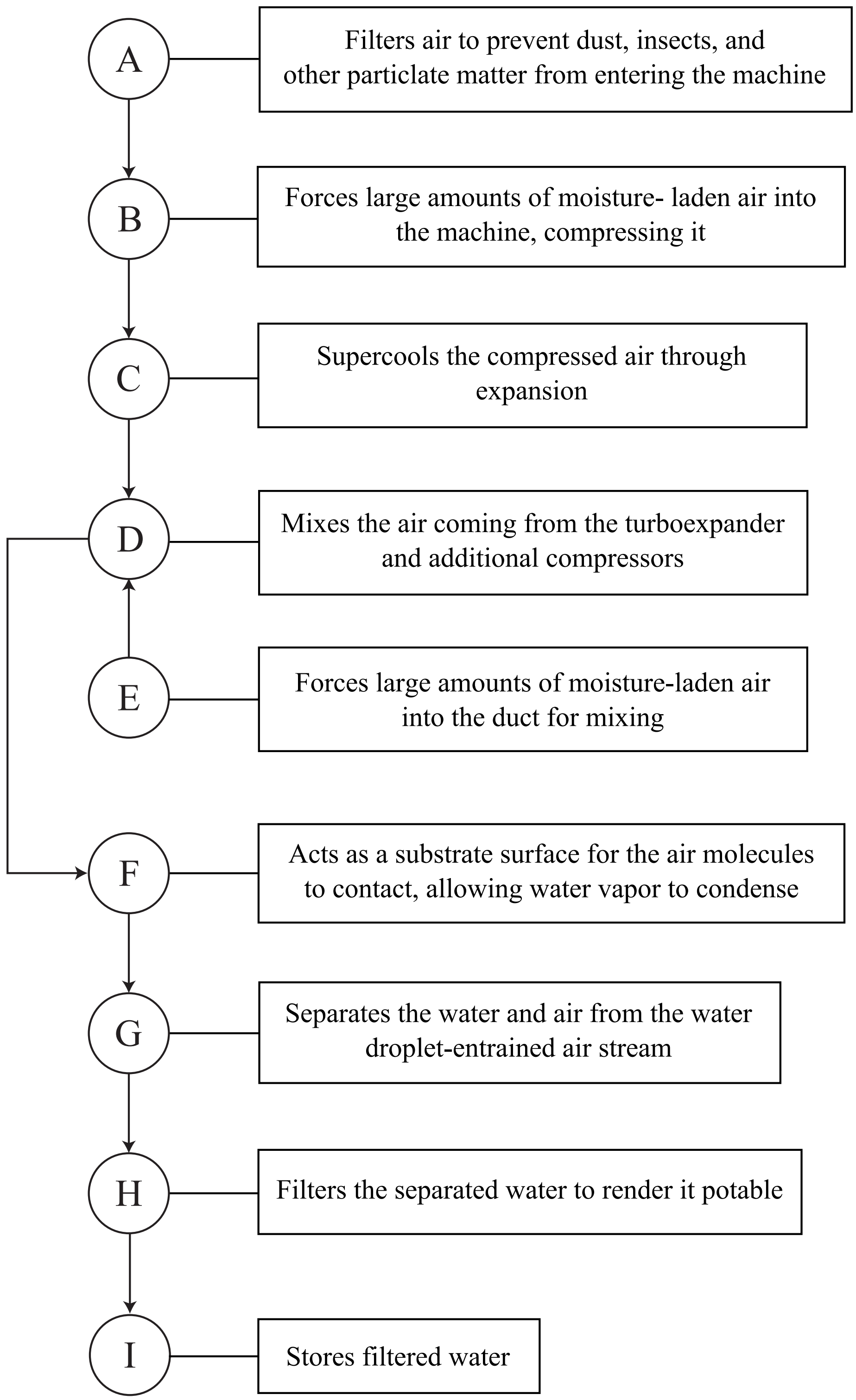

A
Filters air to prevent dust, insects, and other particulate matter from entering the machine
B
Forces large amounts of moisture- laden air into the machine, compressing it
C
Supercools the compressed air through expansion
D
Mixes the air coming from the turboexpander and additional compressors
E
Forces large amounts of moisture-laden air into the duct for mixing
F
Acts as a substrate surface for the air molecules to contact, allowing water vapor to condense
G
Separates the water and air from the water droplet-entrained air stream
H
Filters the separated water to render it potable
I
Stores filtered water

FIG. 2

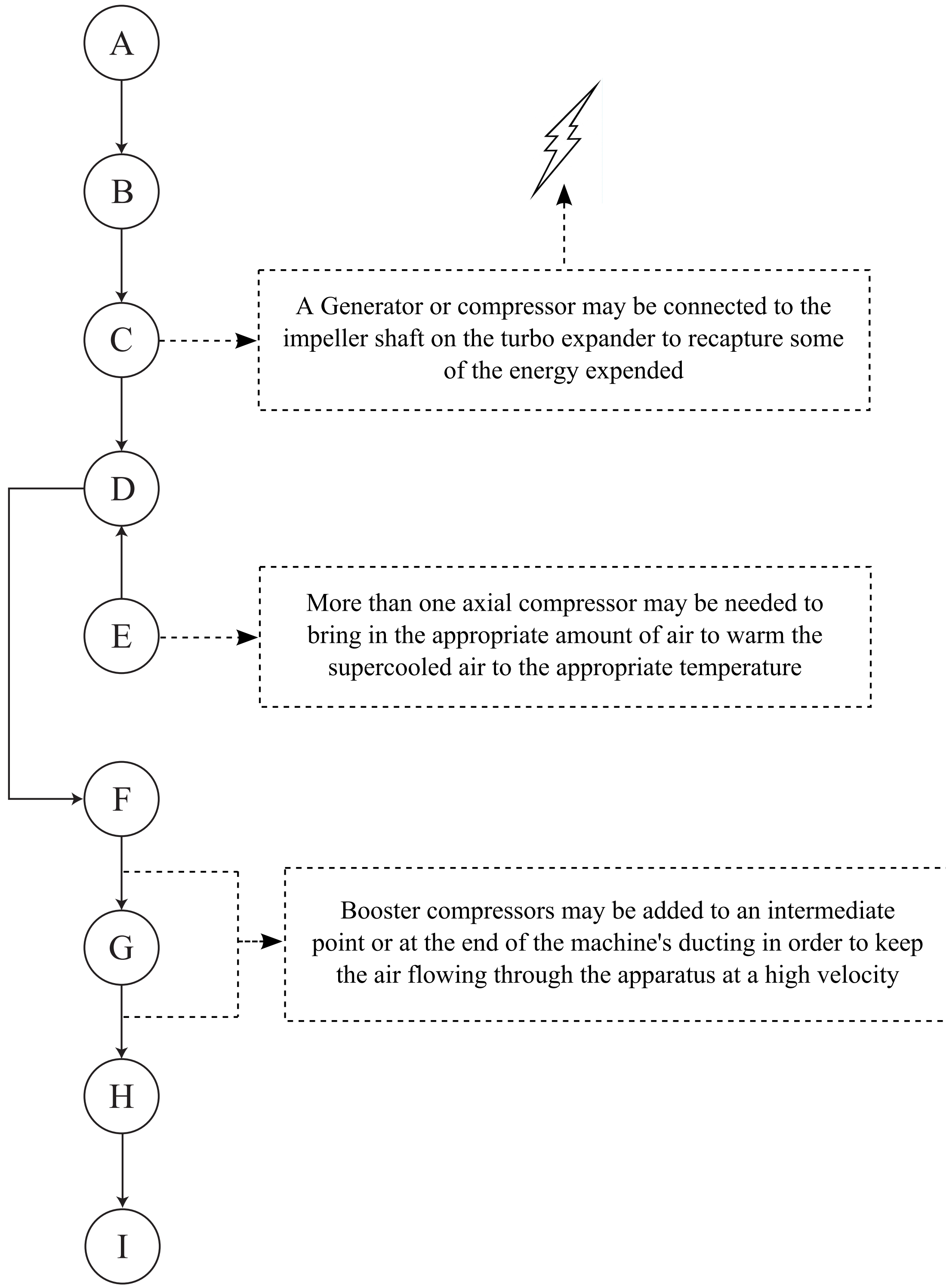

A
B
C
D
E
F
G
H
I
A Generator or compressor may be connected to the impeller shaft on the turbo expander to recapture some of the energy expended
More than one axial compressor may be needed to bring in the appropriate amount of air to warm the supercooled air to the appropriate temperature
Booster compressors may be added to an intermediate point or at the end of the machine's ducting in order to keep the air flowing through the apparatus at a high velocity

FIG. 3

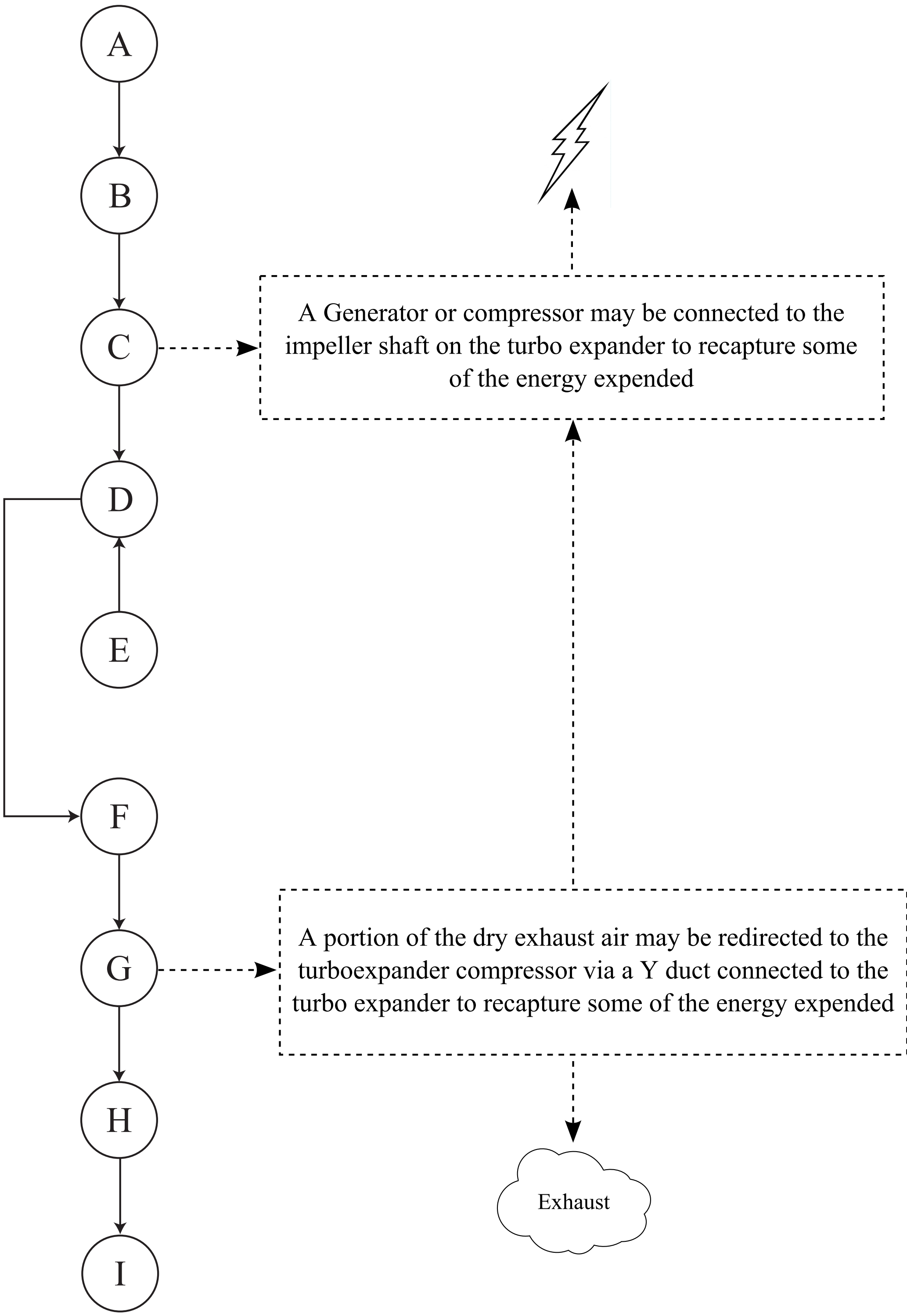

A
B
C
D
E
F
G
H
I
A Generator or compressor may be connected to the impeller shaft on the turbo expander to recapture some of the energy expended
A portion of the dry exhaust air may be redirected to the turboexpander compressor via a Y duct connected to the turbo expander to recapture some of the energy expended
Exhaust

FIG. 4

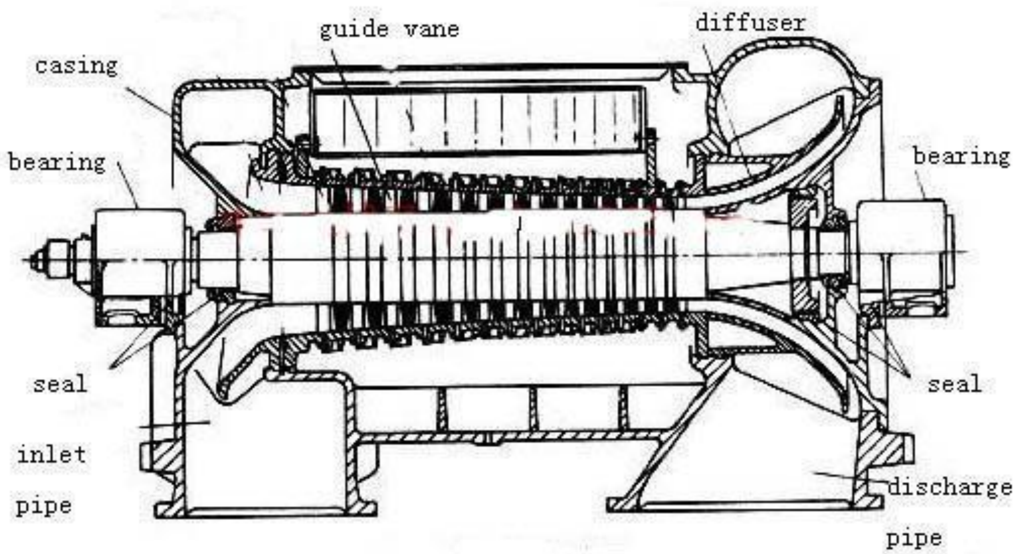

guide vane
diffuser
casing
bearing
bearing
seal
seal
inlet
pipe
discharge
pipe

FIG. 5

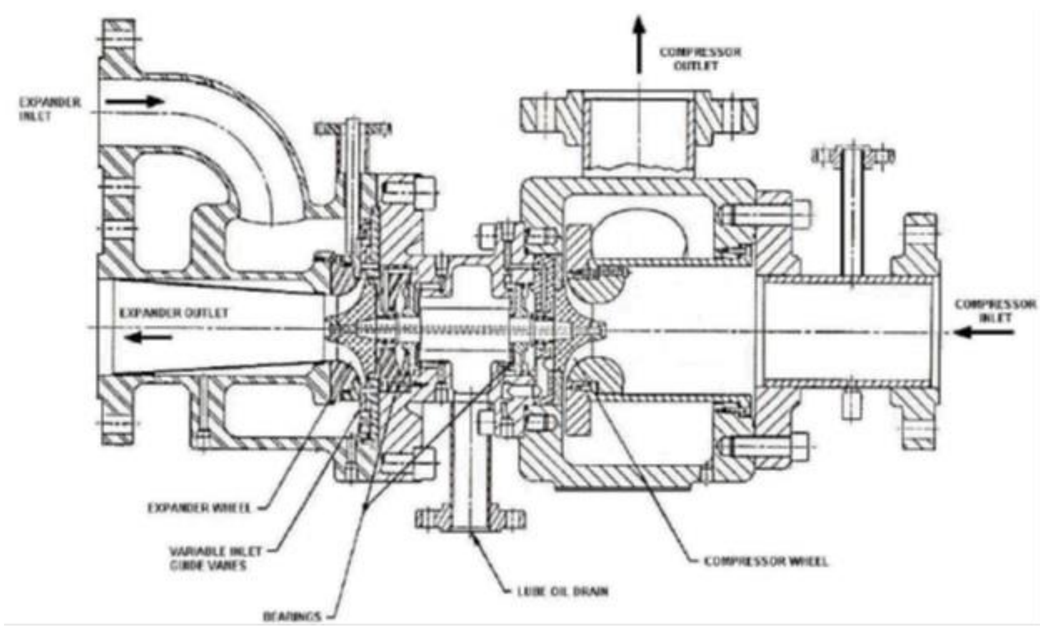

COMPRESSOR OUTLET
EXPANDER INLET
EXPANDER OUTLET
COMPRESSOR INLET
EXPANDER WHEEL
VARIABLE INLET GUIDE VANES
BEARINGS
LUBE OIL DRAIN
COMPRESSOR WHEEL

FIG. 6

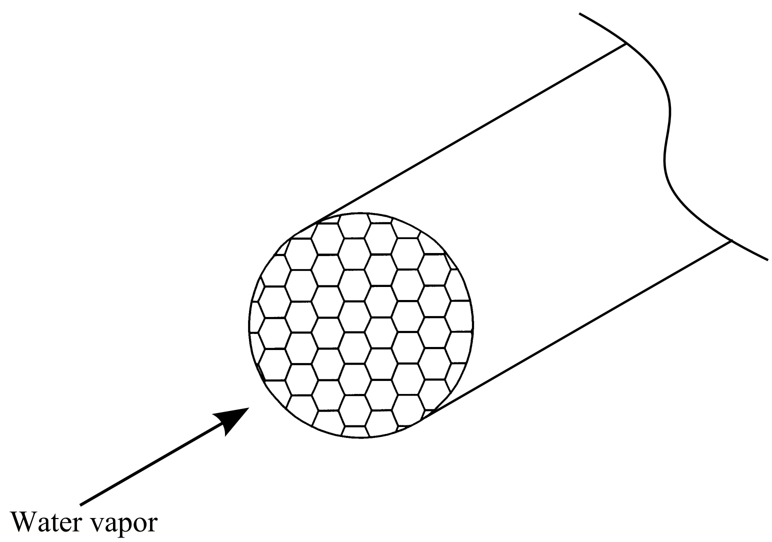


FIG. 7

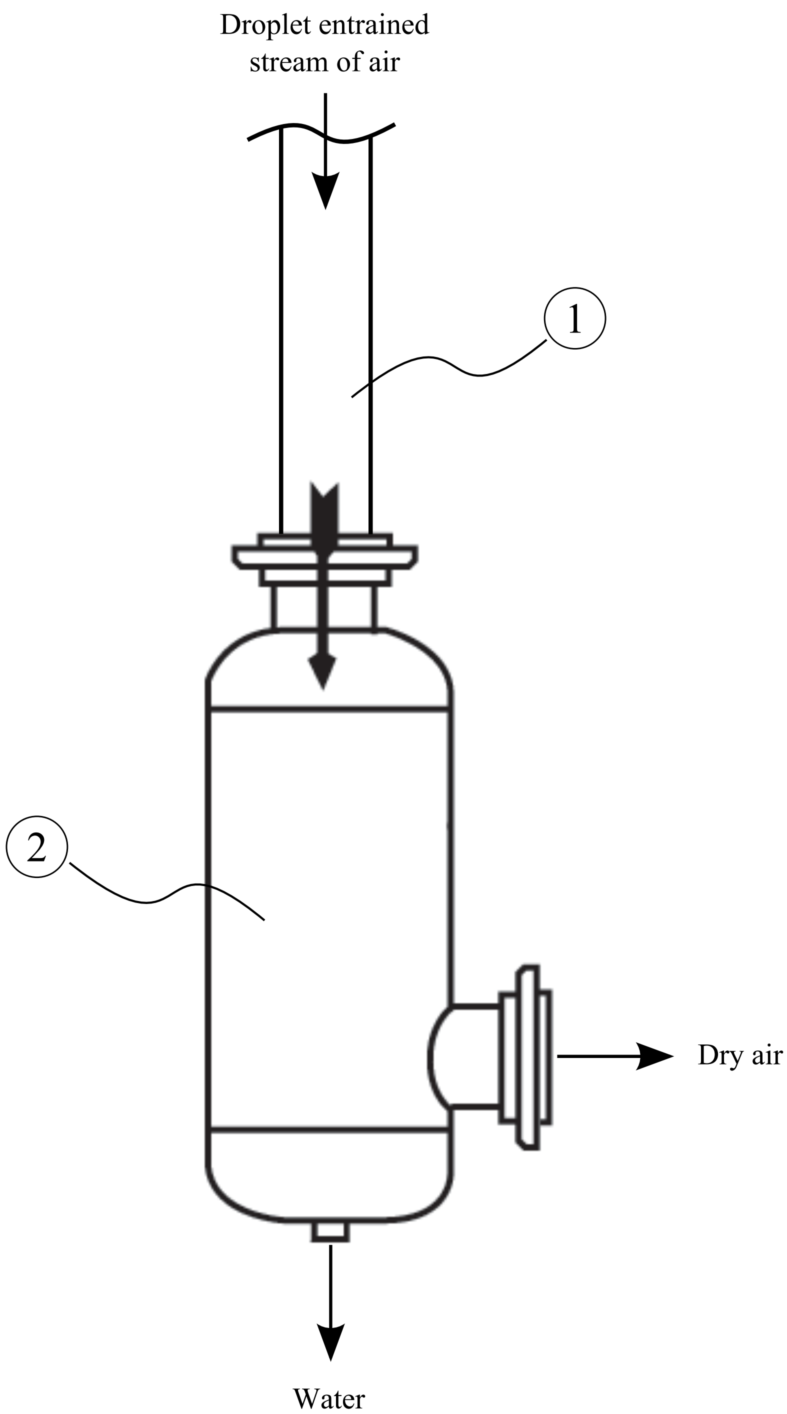
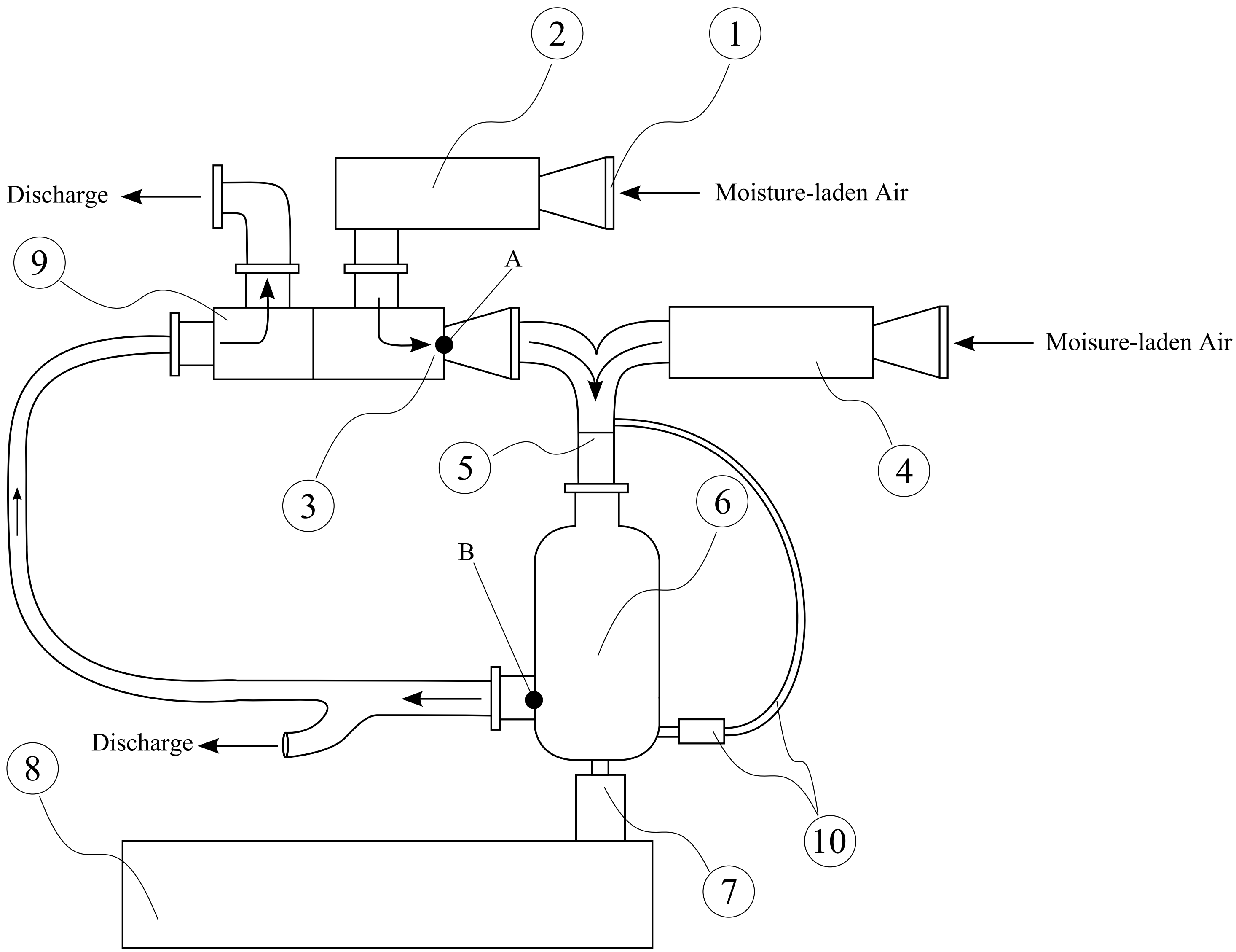


FIG. 8



1
2
Moisture-laden Air
Discharge
9
A
Moisure-laden Air
3
5
4
6
B
Discharge
8
7
10

FIG. 9