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(54) Title: ENVIRONMENT CONTROLLED MULTI SPAN STRUCTURED GREEN HOUSES FOR COST EFFECTIVE FOOD PRODUCTION

(57) Abrégé/Abstract:
The present invention relates to the environment controlled multi span structured greenhouses equipped with the modules Z1 to Z7 and plurality of sensors. Z1 comprises a capture manifold, a compressor, tanks T1, T2 and Ta, and a release manifold, Z2 comprises an earth tube heat exchanger for low cost heating and cooling of greenhouses in cold/hot locations, substantially reducing fossil fuel use, Z3 maintains greenhouse air relative humidity at a defined set point, Z4 harnesses bio-thermal energy, Z5 reduces global warming by preventing the greenhouse carbon dioxide release into atmospheres, Z6 uses activated, nutrients' solutions substantially reducing input cost, Z7 comprises a film fixed to the greenhouse roof and to the external sides and automated 0 to 100% roll-on-closed and roll-off-open thermal cum shading curtains wherein the greenhouse does not comprise gutters.

ABSTRACT

The present invention relates to the environment controlled multi span structured greenhouses equipped with the modules Z1 to Z7 and plurality of sensors. Z1 comprises a capture manifold, a compressor, tanks T1, T2 and Ta, and a release manifold, Z2 comprises an earth tube heat exchanger for low cost heating and cooling of greenhouses in cold/hot locations, substantially reducing fossil fuel use, Z3 maintains greenhouse air relative humidity at a defined set point, Z4 harnesses bio-thermal energy, Z5 reduces global warming by preventing the greenhouse carbon dioxide release into atmospheres, Z6 uses activated, nutrients' solutions substantially reducing input cost, Z7 comprises a film fixed to the greenhouse roof and to the external sides and automated 0 to 100% roll-on-closed and roll-off-open thermal cum shading curtains wherein the greenhouse does not comprise gutters.

ENVIRONMENT CONTROLLED MULTI SPAN STRUCTURED GREEN HOUSES FOR COST EFFECTIVE FOOD PRODUCTION

FIELD OF THE INVENTION

The present invention relates to the environment generally and, more particularly, to controlled structured greenhouses for cost effective food production.

BACKGROUND OF THE INVENTION

Conventional greenhouses suffer from numerous problems of which so far no tangible solutions exist and as such cost effective food production cannot be achieved using conventional greenhouses.

In conventional greenhouses, it is difficult to maintain in the greenhouse the air relative humidity at a defined relative humidity point independent of the greenhouse air temperature defined temperature point. In this regard, water molecules evaporate into the greenhouse air until equilibrium is reached. If the greenhouse air temperature increases, then the greenhouse air expands and can hold more water and thus the greenhouse air relative humidity reduces. Conversely, if the greenhouse air temperature decreases, the greenhouse air contracts and can hold less water. As long as water does not condense out of the greenhouse air, the greenhouse air relative humidity increases. With any further temperature decrease, the concentration of water in the greenhouse air rises above the saturation point and condenses, dew point forming large drops of water on the interior surfaces of the greenhouse cover film and on the interior surfaces of the gutters which drip on to plants and may cause injury. Condensation also reduces light transmission into the greenhouse.

Several foliar diseases are directly related to the greenhouse air high relative humidity, especially Botrytis and Powdery mildew. Powdery mildew spores germinate best at 95% or higher greenhouse air relative humidity.

Another problem in conventional greenhouses is mist. A very fine continuous layer of moisture, which can form on the interior surfaces of the greenhouse cover film during cold early mornings, when the greenhouse air temperature decreases and the greenhouse air relative humidity reaches saturation point. A dense fog can form in the greenhouse which also reduces sunlight transmission into the greenhouse.

It is difficult to maintain the greenhouse at a defined temperature point, particularly in relatively hot geographical locations wherein so far there is no option to use a fan/pad or a fogger

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evaporative cooling system which increases the greenhouse air relative humidity. The defined temperature point cannot be controlled and maintained because the higher the greenhouse air relative humidity the less effective is evaporative cooling. Furthermore, supplementary cooling cost in relatively hot geographical locations is very high.

Also, in relatively cold geographical locations, there is a high cost associated with greenhouse supplementary heating, induced mostly by burning fossil fuel, which emits substantial air pollutants, which contribute to global warming.

Due to the fact that during dark hours, plants release carbon dioxide and are in need of an oxygen rich environment to rejuvenate the health of the plants, and to maximize tolerance of the plants to disease and the like.

Due to carbon dioxide released by the plants during dark hours, or due to residual carbon dioxide available after the carbon dioxide enrichment, events of the sunlight hours the carbon dioxide content in the greenhouse are much higher than desired (compared to a defined carbon dioxide content point). Traditionally, greenhouse excess carbon dioxide content is released into the atmosphere, which contributes to global warming and also incurs a cost in relation to carbon credits.

Another problem with conventional greenhouses is that the air relative humidity, the air temperature and carbon dioxide content in the greenhouse vary due to horizontal and vertical gradients and hot or cold pockets are formed therein. This is further augmented by moisture production of the plants which is driven by leaf temperature of the plants and the greenhouse air vapor pressure deficit.

In conventional greenhouses, during winter, horizontal air fans are run continuously to improve the greenhouse air relative humidity and the greenhouse air temperature uniformity, and to prevent hot or cold pockets from being formed. However, the cost benefit is minimal.

The intensity of solar radiation all over the world, at ground level, is unevenly distributed.

This is due to variables such as solar altitude, which is associated with the latitude, seasons, atmospheric conditions, cloud coverage, degree of pollution and elevation above sea level.

Climatic conditions are characterized by either low or high atmospheric air temperature during winter and summer.

In the conventional greenhouses, a thermal screen may be installed at the interior level of the gutters for retaining heat, for reducing heat loss from the greenhouse and the associated thermal energy cost. However, it is difficult to maintain an air tight thermal screen for reducing heat loss from below the thermal screen to above the thermal screen. Furthermore, during snow storms, the thermal screen is switched-off to allow the heat below the thermal screen to reach the greenhouse roof in order to melt snow. The sudden exposure of the plants to the cold environment, which until then were in a suitably warm environment, can be detrimental to the health of the plants. Furthermore, this method of melting snow is not adequate.

In many conventional greenhouses, in relatively cold geographical locations, a double layer inflated film is used for covering the greenhouse for reducing heating cost. However, it is difficult to maintain optimal insulation between the two layers of inflated film which is critical for increased heating efficiency in order to minimize heat loss and thermal energy cost. Another problem associated with such greenhouse cover film is isolating leaking holes.

In relatively hot geographical locations separate shading curtains may need to be used during the sunlight hours for reducing

a) Greenhouse air temperature,

b) Unwanted heat gain, and

c) Greenhouse supplementary cooling cost.

So far no cost effective tangible solutions exist to control the daily light photoperiod, which is a vital factor influencing the growth of a plant. Plants that are grown in conditions of varying daily light photoperiod patterns cannot settle into a regular life cycle and tend to grow poorly.

Another problem with conventional greenhouses is that of gutter connected multi span structured greenhouses. It is unviable to install gutters of adequate volume to handle very heavy downpours of rain in multi span structured greenhouses.

Heavy downpours of rain often overflows the roofs, along the sides and into the multi span structured greenhouses which can damage crops. There are further problems related to gutters such as blocking incoming sunlight into the greenhouse, condensation or mist on the interior surfaces of the gutters and snow accumulation in the gutters.

Another problem is snow accumulation on the exterior surfaces of the film covering the greenhouse roof and the four external sides of the greenhouse.

Yet another problem is dust and dirt accumulation on the exterior surfaces of the film covering the greenhouse roof and the four external sides of the greenhouse and in the gutters which also promotes growth of fungi and algae because the dust and dirt serve as soil and mineral elements.

Dust, dirt and the like cause a substantial reduction in the transmitted solar radiation into the greenhouse. Within a few weeks after installation, the dust and dirt can render the greenhouse cover film almost opaque rather than transparent, which substantially reduces light transmission into the greenhouse.

Another problem is that of fire hazards, which may occur because of highly inflammable greenhouse cover film, curtains, insect nettings, screens and the like.

Yet another problem is food production in relatively cold geographical locations, wherein life exists but is very sunlight deficient.

Another problem in existing greenhouses is the very high capital cost, labor intensive requirements, use and maintenance of complicated equipment and component. Further to this, the following must be completed:

i) Mixing, activating and drip dosing a drip dosing a activated nutrient solution,

ii) Mixing and drip dosing a drip dosing a crop treatment solution,

iii) Warming the i) and ii) solutions to a defined temperature in order to maintain temperature of the roots of the crop at a defined temperature point,

iv) Mixing, activating and foliar dosing a foliar dosing activated nutrient solution,

v) Mixing and a foliar dosing a foliar dosing crop treatment solution,

vi) Warming the iv) and v) solutions to a defined temperature equal to the greenhouse air temperature,

vii) Greenhouse evaporative cooling in relatively hot geographical locations,

viii) Greenhouse, humidification in relatively hot geographical locations,

ix) Dust and/or dirt wash off from exterior surfaces of the film covering the greenhouse roof and the four external sides, and

x) Firefighting.

Also, as of now, for roll-on and roll-off curtains and screens very high cost large wall thickness C-class, large diameter galvanized iron pipes are used to keep the curtains and screens and the like weighted down to retain them tightly in place, and to prevent them from blowing in the wind. Such solutions are very expensive.

Basic needs to overcome the problems of conventional greenhouses for cost effective food production are:

1) Substantial reduction in capital and operating costs of a greenhouse,

2) Maintaining the greenhouse air relative humidity at a defined relative humidity point,

3) Maintaining the greenhouse air temperature at a defined temperature point,

4) Preventing greenhouse carbon dioxide from being released into the atmosphere, the carbon dioxide released by the plants during dark hours and/or the residual carbon dioxide available after the carbon dioxide enrichment events of sunlight hours, which otherwise contributes to global warming and incurs a cost in relation to carbon credits,

5) Maintaining in the greenhouse the carbon dioxide content at a defined carbon dioxide content point,

6) Providing an oxygen rich environment during dark hours to rejuvenate the health of a plant and to maximizes tolerance of the plants to disease and the like,

7) Reducing use and thus the cost of nutrients, pH adjustments agents and of crop protection agents,

8) Minimizing greenhouse supplementary heating and cooling cost in respective relatively cold and hot geographical locations,

9) Sourcing a cost effective material to serve as a thermal and shading for "an all in one solution for all seasons and in all geographical locations",

10) Increasing the deficient sunlight energy together with or without artificial lighting energy into the greenhouse to be sufficient for food production,

11) Stopping heavy downpour of rain overflowing on the roofs, along the sides and into the multi span structured greenhouses,

12) Reducing the dust and dirt accumulation on the exterior surfaces of the film covering the greenhouse roof and the four external sides of the greenhouse which will lead to an increase in the light transmission into the greenhouse,

13) Providing an efficient method to combat fire hazards which may occur because of highly inflammable greenhouse cover film, curtains, insect netting, screens and the like,

14) Facilitating melting of snow on the exterior surfaces of the film covering the greenhouse roof and the four external sides of the greenhouse,

15) Facilitating crop root zone aeration, and maintaining the crop root zone temperature at a defined temperature point,

16) Facilitating low cost integrated pest management,

17) Obviating ventilation need for maintaining the carbon dioxide and oxygen balance during winters, rain and snow when conventional greenhouses are maintained closed,

18) Facilitating food production in a greenhouse in relatively cold geographical locations, wherein life exists but is very sunlight deficient and wherein food production even in a greenhouses has not so far been achieved, and

19) Reducing the cost of galvanized iron pipes that are used for weighing down roll-on and roll-off curtains and screens to retain them tightly in the place and to prevent them from blowing in the wind.

OBJECTS OF THE INVENTION

One problem addressed is the very high and ever rising prices of fossil fuel. A substantial portion of the global total area excluding the oceans are relatively colder geographical locations wherein heating of the greenhouses needs burning substantial amounts of fossil fuels. This also emits substantial amounts of atmospheric pollutants, most of which contribute to global warming. If heating of the greenhouses can be enabled by some other cost effective means, then fossil fuel use would be drastically reduced.

The present invention provides innovative solution to reduce the use of fossil fuel by enabling heating of the greenhouses by providing an earth tube heat exchanger. The following illustrates an example of an earth tube heat exchanger that may be used with the present invention. In general, with soil strata between 2-3 meters depth, a temperature regime is constant (thermal constant).

Earth Tube Heat Exchanger Fundamental

Soil strata between 2 - 3 metre depth

Temp regime is constant (thermal constant)

Temp in this strata displays no diurnal fluctuation

It does display annual fluctuation but amplitude is small

At Ahmedabad India 23. 03° N Latitude

Average Thermal Constant 27° C

Sharan G., R. Jadhav, 2002. Soil Temperature Regime at Ahmedabad. Journal of Agricultural Engineering 39 [1], January-March.

The use of earth tube heat exchanger substantially reduces the greenhouse supplementary heating cost in relatively cold geographical locations and the greenhouse supplementary cooling cost in relatively hot geographical locations, by conditioning cooler greenhouse air to warmer temperatures in relatively cold geographical locations and by conditioning warmer greenhouse air to cooler temperatures in relatively hot geographical locations maintaining the greenhouse air temperature equal to the average thermal constant temperature of the geographical location.

Before installation of an earth tube heat exchanger, the soil strata depth can be measured wherein the most suitable average thermal constant temperature of a geographical location can be found.

Another low cost means is geothermal energy which involves low investment cost over other renewable energy sources. Furthermore, geothermal energy does not depend upon energy markets, and only relies on providing a geothermal energy harnessing automated equipment. Harnessing geothermal energy also coproduces carbon dioxide which is used for enrichment during the sun light hours for maximizing the yield.

Another problem addressed by the present invention is carbon dioxide released by the plants during dark hours or due to the residual carbon dioxide available after carbon dioxide enrichment events of the sunlight hours. The excess carbon content in the greenhouse can be much higher than a desired and a defined carbon dioxide content point. Traditionally, greenhouse excess carbon dioxide is released into the atmosphere which contributes to global warming and also incurs a cost in relation to carbon credits.

Similarly, industrial co-produced carbon dioxide also escapes into the atmosphere, which also contributes to global warming.

The present invention may offer a tangible method and/or apparatus to alleviate global warming by preventing the greenhouse carbon dioxide from being released into the atmosphere; by capturing, compressing, dehumidifying, storing and utilizing the greenhouse carbon dioxide for enrichment during the sunlight hours for maximizing the yield of the plants. This results in very low cost food production.

The present invention also alleviates global warming by preventing the industrial co-produced carbon dioxide from escaping into the atmosphere by using a compressor with the manifold inlets that are positioned around carbon dioxide co-producing sources.

The delivery pipes of the compressors are installed in a very deep water bores, which are tightly filled with thick soil and sealed. This maintains the carbon dioxide dissolved in water which may be converted into hydrocarbons in due course.

Another problem addressed by the present invention is that land on earth planet is limited, yet the population continues to increase. In a world with a burgeoning population, the fight against hunger and famine cannot be over emphasized.

Apart from food security, another graver problem is the cost of food production which is rising fast due to high and increasing costs of inputs. Therefore, in the coming decades, even if food is available, most of the population of the world (particularly in the undeveloped and the developing countries) will not be able to afford such food and will starve. As such, it is essential to search for innovative solutions for low cost food production.

The present invention may offer a tangible method and/or apparatus for reducing the cost of food production:

1) Food production in a greenhouse

i) Providing an environmentally friendly, extremely efficient greenhouse for very cost effective food production that addresses various problems with conventional greenhouses. These solutions can be retrofitted into existing greenhouses so that low cost food production can be facilitated.

ii) Very substantially reducing the greenhouse supplementary heating cost in relatively cold geographical locations and the greenhouse supplementary cooling cost in relatively hot geographical locations which can be achieved by:

a) Providing a low cost earth tube heat exchanger which maintains greenhouse air temperature equal to the thermal constant temperature of the geographical location.

b) Providing 0-100% roll-on-close and roll-off-open automated thermal and shading curtains on the greenhouse roof and on the four internal sides of the greenhouse for maximizing heat gain, sensible and latent, for minimizing the greenhouse supplementary heating cost in relatively colder geographical locations and for minimizing unwanted heat gain for minimizing the greenhouse supplementary cooling cost in relatively hot geographical locations.

c) Providing an automated equipment for harnessing geothermal energy for further supplementary heating of the greenhouses in relatively colder geographical locations after the earth tube heat exchanger has maintained the greenhouse air temperature equal to the thermal constant temperature of the geographical location. This equipment also serves numerous other needs for hot air and also provides carbon dioxide which is used for carbon dioxide enrichment during sun light hours for maximizing the yield and also provides high quality sterilized compost.

iii) Facilitating food production in a greenhouse in relatively cold geographical locations where life exists but is very deficient sunlight energy and wherein food production even in a greenhouse has not so far been realized. Food production is facilitated by increasing deficient sunlight together with artificial light by using an earth tube heat exchanger together with a geothermal energy harnessing automated equipment.

2) Optimizing the yield by

i) Utilizing the greenhouse carbon dioxide for carbon dioxide enrichment during sunlight hours,

ii) Facilitating in relatively hot geographical locations, the carbon dioxide enrichment during sunlight hours,

iii) Increasing sunlight energy together with or without artificial lighting energy to be sufficient for food production,

iv) Providing low cost artificial lighting during the dark hours for maximizing the photoperiod,

v) Using growing media beds wherein yield is much higher and all benefits of the bags can be realized at much lower cost, and

vi) Maintaining the temperature of the roots of the crops at a defined temperature point which facilitates efficient uptake of nutrients, and Maximizing pollination of plants (like tomatoes, bell peppers, and the like). Pollination is directly linked to the yield. During the pollination hours, release pressure of the release manifold is suitably increased.

3) Minimizing use and cost of crop protection agents and cost of sprayers by

i) Rejuvenating health of plants and maximizing the resistance of plants to diseases organisms, bacteria, pathogens, fungi, viral infection, harmful insect pests and the like, by releasing into the greenhouse oxygen rich greenhouse air during dark hours,

ii) Facilitating integrated pest management by the greenhouse efficiently preventing ingress of pathogens, harmful insect pests and the like into the greenhouse for efficient biological control, and

iii) Facilitating maintaining the greenhouse air relative humidity at about 80% which helps in minimizing the pressure of disease and the like.

4) General cost savings

i) Facilitating a more economically viable greenhouse by selling the carbon credits which are not used because the greenhouse carbon dioxide is prevented from being released into the atmosphere,

ii) Facilitating realization of all the benefits of a tall greenhouse in a shorter greenhouse leading to a much more economically viable greenhouse with reduced capital cost, greater energy efficiency and reduced operating cost,

iii) Foliar dosing of activated nutrient solutions which substantially reduce operational use and input cost of nutrients, enhances their use efficiency, and eliminates the cost associated with leaching diammonium phosphate activated solution foliar dosing during transplanting or seed drilling,

iv) Eliminating the need of horizontal air fans and thereby saving their capital and operating cost, and

v) Facilitating switching-off a drip dosing irrigation and a drip dosing fertigation event on the first few drops of drained off water or leachate for optimal watering and nutrition thus saving substantial cost of nutrients.

5) Food production in open field

i) Foliar dosing of activated nutrient solutions which substantially reduce operational use and input cost of nutrients, enhances use efficiency of nutrients, and eliminates the cost associated with leaching diammonium phosphate activated solution foliar dosing during transplanting or seed drilling, and

ii) All standing horticulture, food grains crops and the like to be provided artificial lighting for a total daily photo period of 16 to 22 hours, including day light hours.

A collateral benefit of the invention is a very substantial alleviation of global warming.

SUMMARY OF THE INVENTION

In accordance with an aspect of the present invention, there is provided a greenhouse equipped with a solar radiation sensor, a temperature sensor, a relative humidity sensor and a carbon dioxide sensor.

In accordance with another aspect of the present invention, there is provided a greenhouse equipped with a basic first module which comprises a compressor, a first tank, a second tank, a third tank, a capture manifold and a release manifold, wherein the capture manifold captures dark hours carbon dioxide rich greenhouse air and sunlight hours oxygen rich greenhouse air which is compressed and stored in the first tank or the second tank. The third tank stores and dehumidified atmospheric compressed air.

In accordance with another aspect of the present invention, a second module measures the average thermal constant temperature of a geographical location by stepwise placement of a probe of a thermistor in bores of various depths commencing at about 2.5 meters below ground level until the most suitable average thermal constant temperature of a geographical location is found.

In accordance with another aspect of the present invention, a greenhouse equipped with a low cost material earth tube heat exchanger which conditions greenhouse relatively cooler air to relatively warmer in relatively cold geographical locations and conditions relatively warmer greenhouse air to relatively cooler in relatively hot geographical locations.

In accordance with another aspect of the present invention, a greenhouse equipped with a greenhouse air relative humidity sensor which functions together with the components of the first module and with an earth tube heat exchanger of the second module to maintain greenhouse air relative humidity at a defined relative humidity point.

In accordance with another aspect of the present invention, a greenhouse equipped with a geo-thermal fourth module comprising geo-thermal neat and clean automated equipment for generating geo-thermal energy for greenhouse supplementary heating and for numerous other needs in relatively cold geographical locations.

In accordance with another aspect of the present invention, there is provided a method for preventing greenhouse carbon dioxide and residual carbon dioxide after sunlight hours carbon dioxide (1000-1500 ppm) enrichment events, traditional release into atmosphere and instead capturing compressing dehumidifying storing and utilizing the greenhouse carbon dioxide for enrichment during sunlight hours for optimizing the yield and to reduce global warming.

In accordance with another aspect of the present invention, there is provided a cost effective method to reduce the input cost of nutrients by using activated solutions and obviating the use of toxic crop protection agents, saving cost of the agents, spraying labour, health hazards and facilitating non-toxic food production.

In accordance with another aspect of the present invention, there is provided a fifth module comprising two greenhouse roof sprinkler manifolds, two gable sides' sprinkler manifolds and two long sides' sprinkler manifolds for maintaining the exterior surfaces film covering the greenhouse free of dust / dirt.

In accordance with another aspect of the present invention, there is provided an efficient firefighting system to combat fire hazards which may occur due to highly inflammable greenhouse cover film, insect netting and screens etc.

In accordance with another aspect of the present invention, there is provided a system using growing media beds which comprises preventing crop root zone contact with soil strata wherein harmful pests may exist which may harm the crops. By using growing media beds, yield is much higher and all benefits of bags can be realized much better at much lower cost. Furthermore growing media beds' serves other needs as well like crop root zone aeration, maintaining crop root zone temperature at a defined temperature point and drained off leachate automated collection which bags do not offer and also saving substantial cost of growing media bags.

In accordance with another aspect of the present invention, a greenhouse is equipped with a greenhouse roof cover film and gutters interior surfaces heating manifold when the atmospheric air temperature sensor senses that the atmospheric air temperature is approaching 0°C, the atmospheric air temperature senses switches-on pressurized hot air injections into heating manifold for heating interior surfaces of the greenhouse roof cover film and interior surfaces of gutters. The snow melts and slides off.

In accordance with another aspect of the present invention, a sixth module comprises 0 to 100% convertible roll-on / off automated thermal shading curtains on the greenhouse roof and internal curtains on the four sides of the greenhouse which, substantially reduce the greenhouse supplementary heating cost in relatively cold geographical locations and the greenhouse supplementary cooling cost in relatively hot geographical locations and which also serve as most efficient photoperiod control.

In accordance with another aspect of the present invention, the sixth module increases deficient sunlight and / or the deficient artificial light and produces red, blue and white light.

In accordance with another aspect of the present invention, the sixth module facilitates food production in a greenhouse in relatively cold geographical locations wherein life exists but is very sunlight deficient. Food production is facilitated by increasing deficient sunlight together with artificial lighting energy and using the earth tube heat exchanger together with the geothermal energy harnessing automated equipment.

In accordance with another aspect of the present invention, the greenhouse efficiently prevents ingress of disease organisms, pathogens, fungi, harmful insect pests, and the like into the greenhouse. This facilitates efficient biological control.

In accordance with another aspect of the present invention, the sixth module being equipped with cost effective tangible means and/or by cost effective tangible methods to eliminate gutters altogether with all gutters' related problems in a multi-bay greenhouse leading to no blocking of incoming sunlight energy into the greenhouse, no condensation, no mist on gutters' interior surfaces, no water drop dripping on to plants, no plant injury, no snow accumulation in gutters, no very heavy down pour of water, overflowing on greenhouse roofs and along sides, no entry of rain water into greenhouse, no damage to crops inside, no dust/dirt accumulation in gutters, and no algae or fungi growth in gutters.

In accordance with another aspect of the present invention, there is provided a tangible method to maintain optimal insulation between two layers of inflated double layer polythene greenhouse cover film and isolating leaking holes.

In accordance with another aspect of the present invention, the sixth module maintains optimal insulation between the two layers of inflated double layer film for covering the greenhouse and also isolates leaking holes.

In accordance with another aspect of the present invention, the sixth module further comprises a system that employs smaller wall thickness and, smaller diameter, cheaper galvanized iron pipes filled with sand (ends sealed to ensure no escape of sand) are used, in place of costly large wall thickness C-class, large diameter costly galvanized iron pipes which serves same need and saving their considerable cost for keeping the curtains, the screens and the like weighed down for retaining them tightly in place and preventing them from blowing in the wind.

In accordance with another aspect of the present invention, there is provided a method for controlling the environment in a multi bay structured greenhouse wherein the method includes equipping the greenhouse with a first module, a second module and a third module, wherein the first module comprises:

a capture manifold suitable for capturing carbon dioxide rich greenhouse air during dark hours, and oxygen rich greenhouse air during sunlight hours;

a compressor suitable for compressing the captured greenhouse air;

a first dehumidifying tank, and a second dehumidifying tank suitable for optimal dehumidification of or for maintaining the compressed greenhouse air almost dry;

a release manifold suitable for releasing into the greenhouse at cultivation level the carbon dioxide rich dehumidified or almost dry conditioned greenhouse air during the sunlight hours, and the oxygen rich dehumidified or almost dry conditioned greenhouse air during the dark hours, and

a third tank which is suitable for storing and dehumidifying compressed atmospheric air, for release into the greenhouse to maintain a balance between carbon dioxide and oxygen,

characterized in that the second module comprises an earth tube heat exchanger, which functions with the capture manifold, the compressor, the first and second dehumidifying tanks and the release manifold of the first module; wherein the earth tube heat exchanger comprises four separate compartments; wherein:

a first compartment that stores the first and second tanks' dehumidified carbon dioxide rich greenhouse air,

a second compartment that stores the first and second tanks' dehumidified oxygen rich greenhouse air,

a third compartment that stores the first and second tanks' almost dry carbon dioxide rich greenhouse air, and

a fourth compartment that stores the first and second tanks' almost dry oxygen rich greenhouse air, and

wherein the earth tube heat exchanger is suitable for conditioning relatively cooler greenhouse air to relatively warmer greenhouse air in relatively cold geographical locations and for conditioning relatively warmer greenhouse air to relatively cooler greenhouse air in relatively hot geographical locations and wherein the earth tube heat exchanger maintains the greenhouse air temperature at a defined temperature point which is equal to an average thermal constant temperature of the geographical location,

wherein the third module comprises a carbon dioxide sensor which functions with the components of the first module and the earth tube heat exchanger of the second module for reducing the global warming by preventing the greenhouse carbon dioxide from being released into atmosphere by capturing, compressing, dehumidifying, storing and utilizing the greenhouse carbon dioxide for enrichment during sunlight hours for maximizing the yield and maintaining the greenhouse carbon dioxide content at a defined carbon dioxide content point that is equal to the atmospheric carbon dioxide content point,

wherein when the greenhouse carbon dioxide content is higher than the defined carbon dioxide content point due to carbon dioxide released by plants during dark hours and/or due to residual carbon dioxide available after carbon dioxide enrichment events of the sun light hours, the method comprises the steps of:

switching-on the said components of the first module and the said component of the second module using the greenhouse carbon dioxide sensor;

capturing carbon dioxide rich greenhouse air using the capture manifold;

compressing the captured carbon dioxide rich greenhouse air using the compressor; dehumidifying the compressed carbon dioxide rich greenhouse air in the tanks; storing the carbon dioxide rich dehumidified greenhouse air into the first compartment; and

releasing into the greenhouse, using the release manifold, at the cultivation level, the oxygen rich dehumidified conditioned greenhouse air already stored in the second compartment; for maintaining the greenhouse carbon dioxide content at a defined carbon dioxide content point which is equal to the atmospheric carbon dioxide content.

In accordance with another aspect of the present invention, the method further comprises the step of: maintaining the greenhouse air relative humidity at a defined relative humidity point; wherein when the greenhouse air relative humidity is higher than a defined relative humidity point, the method comprises the steps of:

switching-on the components of the first module and the component of the second module using the greenhouse air relative humidity sensor;

capturing the humid stale carbon dioxide rich greenhouse air during dark hours, and oxygen rich greenhouse air during sunlight hours, using the capture manifold;

compressing the captured greenhouse air using the compressor; maintaining the compressed greenhouse air almost dry in the first and second tanks;

storing the almost dry carbon dioxide rich and the oxygen rich greenhouse air into the third and fourth compartments, respectively; and

releasing into the greenhouse using the release manifold, at cultivation level:

the almost dry carbon dioxide rich conditioned greenhouse air stored in the third compartment during the sunlight hours, and

the almost dry oxygen rich conditioned greenhouse air already stored in the fourth compartment during the dark hours, for maintaining the greenhouse air relative humidity at the defined relative humidity point, and

wherein when the greenhouse air relative humidity is lower than a defined relative humidity point; the greenhouse air relative humidity sensor switching-on the evaporative cooling for maintaining the greenhouse air relative humidity at the defined relative humidity point.

In accordance with another aspect of the present invention, there is provided an environment controlled multi span structured greenhouse comprising:

a first module comprising the following components:

a capture manifold for capturing a carbon dioxide rich greenhouse air during non-sunlight hours and an oxygen rich greenhouse air during sunlight hours;

a compressor for compressing the carbon dioxide rich greenhouse air during non-sunlight hours and the oxygen rich greenhouse air during sunlight hours;

a first tank and a second tank, for alternately filling up with the compressed carbon dioxide rich greenhouse air during non-sunlight hours and with the compressed oxygen rich greenhouse air during sunlight hours, the first and second tanks for optimal dehumidification of, or for maintaining relatively dry, the compressed carbon dioxide rich greenhouse air and the compressed oxygen rich greenhouse air;

a release manifold for releasing into the greenhouse at a cultivation level, the carbon dioxide rich dehumidified or relatively dry conditioned greenhouse air during the sunlight hours and the oxygen rich dehumidified or relatively dry conditioned greenhouse air during non-sunlight hours; and

a third tank for storing and dehumidifying compressed atmospheric air, for release into the greenhouse for maintaining a balance between carbon dioxide and oxygen,

a second module comprising an earth tube heat exchanger, which functions with the components of the first module, wherein the earth tube heat exchanger comprises:

a first compartment that stores the dehumidified carbon dioxide rich greenhouse air from the first and second tanks, a second compartment that stores the dehumidified oxygen rich greenhouse air from the first and second tanks,

a third compartment that stores the relatively dry, carbon dioxide rich greenhouse air from the first and second tanks, and

a fourth compartment that stores the relatively dry, oxygen rich greenhouse air of the first and second tanks,

and wherein the earth tube heat exchanger conditions relatively cold greenhouse air to relatively hot greenhouse air in a relatively cold weather geographical location and conditions relatively hot greenhouse air to relatively cold greenhouse air in a relatively hot weather geographical location and further wherein the earth tube heat exchanger maintains the greenhouse air temperature at a defined temperature point which is equal to an average thermal constant temperature of the geographical location;

a fifth module comprising a greenhouse carbon dioxide sensor which functions together with the components of the first module and the earth tube heat exchanger of the second module, for reducing global warming by preventing the greenhouse carbon dioxide from being released into the atmosphere by capturing, compressing, dehumidifying storing and utilizing the greenhouse carbon dioxide for enrichment during sunlight hours for maximizing the yield of, and for maintaining, the greenhouse carbon dioxide content at a defined carbon dioxide content point that is equal to the atmospheric carbon dioxide content point,

wherein when the greenhouse carbon dioxide content is higher than the defined carbon dioxide content point due to carbon dioxide released by plants during non-sunlight hours or due to residual carbon dioxide available after carbon dioxide enrichment events of the sunlight hours, the greenhouse carbon dioxide sensor switches on the components of the first module and the earth tube heat exchanger of the second module, the capture manifold captures the carbon dioxide rich greenhouse air, the compressor compresses the captured carbon dioxide rich greenhouse air, the first and second tanks dehumidify, or maintain relatively dry, the compressed carbon dioxide rich greenhouse air, the dehumidified, or relatively dry, carbon dioxide rich greenhouse air is stored into the first and third compartments, and the release manifold releases into the greenhouse, at a cultivation level, the oxygen rich dehumidified or relatively dry conditioned greenhouse air already stored in the second and fourth compartments, for maintaining the greenhouse carbon dioxide content at a defined carbon dioxide content point which is equal to the atmospheric carbon dioxide content point.

In an embodiment of the present invention, the environment controlled multi span structured greenhouse as described above further comprises:

a heating manifold for melting snow on exterior surfaces of a film covering the roof of the greenhouse and in the gutters of the greenhouse, together with:

a weather station comprising:

(i) an atmospheric solar radiation sensor;

(ii) an atmospheric air temperature sensor; and

(iii) a rain detector,

wherein when the atmospheric air temperature sensor senses that the atmospheric air temperature is approaching 0°C, the atmospheric air temperature sensor switches on pressurized hot air injections into the heating manifold for heating the interior surfaces of the film covering the roof of the greenhouse and the interior surfaces of the gutters of the greenhouse, for melting the snow.

In an embodiment of the present invention, each of the first, second and third tanks comprises a moisture drain off valve for draining off moisture content for optimal dehumidification of, or for maintaining relatively dry, greenhouse air in the first and second tanks and the dehumidified atmospheric air in the third tank and wherein the moisture drain off valve of each of the first, second and third tanks is switched on by a greenhouse air relative humidity sensor.

In an embodiment of the present invention, the environment controlled multi span structured greenhouse as described above further comprises:

a fourth module comprising the following components of a geothermal energy harnessing automated equipment:

two geothermal energy harnessing tanks;

a first fresh dosing tank;

a second spent dosing tank;

a hot air storing tank; and

a carbon dioxide storing tank,

wherein the geothermal energy harnessing automated equipment function with the compressor of the first module for pressurized air need and with a water transfer pump of a sixth module for pressurized water need, for harnessing the geothermal energy.

In an embodiment of the present invention, the sixth module functions together with the hot air storing tank of the fourth module, for hot air need, and wherein the sixth module further comprises:

a drip dosing manifold;

a water transfer pump;

a drip dosing nutrient solution dosing system, a drip dosing crop root zone treatment dosing system,

a drip dosing irrigation system;

a fogger manifold;

a high pressure pump;

a foliar dosing system;

a drip dosing tank; and

a foliar dosing tank,

wherein the following processes are carried out in the drip dosing tank: (i) mixing, activating, maintaining relatively hot, and drip dosing, a drip dosing activated nutrient solution, and (ii) mixing, maintaining relatively hot, and drip dosing, a drip dosing crop root zone treatment solution, and

wherein the following processes are carried out in the foliar dosing tank: (i) mixing, activating, maintaining relatively hot, and foliar dosing, a foliar dosing activated nutrient solution and (ii) mixing, maintaining relatively hot and foliar dosing a foliar dosing crop treatment solution.

In an embodiment of the present invention, the sixth module further comprises: two greenhouse roof sprinkler manifolds, two greenhouse gable sides sprinkler manifolds and two greenhouse long sides sprinkler manifolds for maintaining the exterior surfaces of the film covering the greenhouse free from dust / dirt and for efficient firefighting, wherein:

(i) during sunlight hours and intervals based upon the dust / dirt status of a geographical location, the atmospheric solar radiation sensor switches on : two greenhouse roof sprinkler manifolds, two greenhouse gable sides sprinkler manifolds and two greenhouse long sides sprinkler manifolds for throwing pressurized water onto all the exterior surfaces of the film covering the greenhouse for removing all the dust / dirt and

(ii) on smoke detection, the greenhouse roof, gable sides and long sides sprinkler manifolds are switched on for throwing pressurized water onto the greenhouse roof, onto the two gable sides and onto the two long sides of the greenhouse, to extinguish the fire.

In an embodiment of the present invention, the environment controlled multi span structured greenhouse as described above further comprises a seventh module comprising:

a film fixed to the greenhouse roof and to the four sides of the greenhouse, together with 0 to 100%convertible roll-on / off automated thermal shading curtains on the greenhouse roof and, or the automated thermal shading internal curtains on the four sides of the greenhouse, wherein the greenhouse does not comprise a gutter,

wherein (i) interior and exterior surfaces of the thermal shading curtains function as solid barriers between a greenhouse air temperature environment, and an atmospheric air temperature environment, and (ii) the interior surfaces absorb and retain relatively hot or relatively cold greenhouse air trying to escape into the atmosphere and the exterior surfaces absorb and retain relatively hot or relatively cold atmospheric air trying to enter into the greenhouse and wherein the automated thermal shading curtains also serve as an efficient photoperiod control.

In an embodiment of the present invention, the seventh module further comprises: mirrors; compact fluorescent lamps; fluorescent tubes alternately red, blue and white; and aluminum foil,

wherein the compact fluorescent lamps and the fluorescent tubes are hung from a bottom of a truss at defined elevations and are movable to adjust their height,

wherein the compact fluorescent lamps and the fluorescent tubes are installed staggered at defined square meters centered around a horizontal width center of a row of a growing media bed or bag, wherein the mirrors and the aluminum foil are at defined square meters centers,

wherein the elevations of the compact fluorescent lamps and of the fluorescent tubes are adjusted as the plants grow in height, and

wherein sunlight and/or artificial light striking the mirrors, the shades of the compact fluorescent lamps and the aluminum foil, is reflected repeatedly to increase, and to produce, red, blue and white light.

In an embodiment of the present invention, the second module measures an average thermal constant temperature of a geographical location, wherein a probe of a thermistor is placed at the bottom end of a bore commencing at about 2.5 meters below ground level,

wherein after placement of the probe, the bore is tightly filled with soil and sealed,

wherein the probe of the thermistor continuously measures and records the temperature of a bore location until the temperature stabilizes and remains constant for a few days,

wherein this constant temperature is the average thermal constant temperature of the bore location, and

wherein similar treatment of other bores located about 20 square meters apart with stepwise depth increments of about 0.5 meter in each subsequent bore based upon average thermal constant temperature at 2.5 meter or more or less in each subsequent bore based upon average thermal constant temperature at 2.5 meter depth and thermistor probe placement until the most suitable average thermal constant temperature of a bore location is found.

In an embodiment of the present invention, the greenhouse air temperature is maintained at a defined temperature point,

wherein in relatively hot weather geographical locations, during sunlight hours, when the greenhouse air temperature is higher than the defined temperature point, the greenhouse solar radiation sensor provides shade by adjusting positions of 0 to 100% convertible roll-on/off automated thermal shading curtains on the greenhouse roof and/or automated thermal shading internal curtains on the four sides for admitting into the greenhouse only a defined deficient solar radiation for minimizing needless heat gain and for minimizing a greenhouse supplementary cooling cost; and

wherein when the greenhouse air temperature remains higher than the defined temperature point during sunlight and/or non-sunlight hours, a greenhouse sensor switches on an evaporative cooling together with the components of the first module and the earth tube heat exchanger of the second module; the capture manifold captures the carbon dioxide rich greenhouse air during non-sunlight hours and the oxygen rich greenhouse air during sunlight hours, the compressor compresses the captured carbon dioxide rich greenhouse air and the oxygen rich greenhouse air; the compressed carbon dioxide rich greenhouse air and the oxygen rich greenhouse air are, maintained relatively dry, in the first and second tanks; the relatively dry carbon dioxide rich greenhouse air and the relatively dry oxygen rich greenhouse air, are stored into the respective third and fourth compartments of the earth tube heat exchanger and the release manifold releases into the greenhouse at cultivation level:

the relatively dry conditioned carbon dioxide rich greenhouse air already stored in the third compartment during sunlight hours, and the relatively dry conditioned oxygen rich greenhouse air already stored in the fourth compartment during non-sunlight hours, for optimal evaporative cooling until the greenhouse air temperature equals the defined temperature point.

In an embodiment of the present invention, the greenhouse air temperature is maintained at a defined temperature point;

wherein in a relatively cold weather geographical location, when the greenhouse air temperature is lower than the defined temperature point, the greenhouse air temperature sensor switches on the components of the first module and the earth tube heat exchanger of the second module, the capture manifold captures the carbon dioxide rich greenhouse air during non-sunlight hours, and the oxygen rich greenhouse air during sunlight hours, the compressor compresses the captured carbon dioxide rich greenhouse air and the captured oxygen rich greenhouse air, the compressed carbon dioxide rich greenhouse air and the oxygen rich greenhouse air are dehumidified in the first and second tanks, the dehumidified carbon dioxide rich and the oxygen rich greenhouse air are stored into the respective first and second compartments and, the release manifold releases into the greenhouse at cultivation level, relatively hot air, until the greenhouse air temperature equals the defined temperature point.

In an embodiment of the present invention, the environment controlled multi span structured greenhouse as described above further comprises a greenhouse air relative humidity, sensor wherein the green house air relative humidity is maintained at a defined relative humidity point,

wherein when the greenhouse air relative humidity is higher than a defined relative humidity point, the greenhouse air relative humidity sensor switches on the components of the first module and the earth tube heat exchanger of the second module, the capture manifold captures the humid stale carbon dioxide rich greenhouse air during non-sunlight hours, and the oxygen rich greenhouse air during sunlight hours, the compressor compresses the captured carbon dioxide rich greenhouse air and the oxygen rich greenhouse air, the compressed carbon dioxide rich greenhouse air and the oxygen rich greenhouse air, wherein the captured greenhouse air are maintained relatively dry in the first and second tanks, the relatively dry carbon dioxide rich greenhouse air and the relatively dry oxygen rich greenhouse air are stored into the respective third and fourth compartments, and the release manifold releases into the greenhouse at a cultivation level:

the relatively dry conditioned carbon dioxide rich greenhouse air already stored in the third compartment during sunlight hours, and the relatively dry conditioned oxygen rich greenhouse air already stored in the fourth compartment during non-sunlight hours until the greenhouse air relative humidity equals the defined relative humidity point, and

wherein when the greenhouse air relative humidity is lower than a defined relative humidity point, the greenhouse air relative humidity sensor switches on the evaporative cooling until the relative humidity of the greenhouse air equals the defined relative humidity point.

BRIEF DESCRIPTION OF THE FIGURES

Embodiments of the invention will be apparent from the following detailed description and the appended claims and drawings in which:

FIG. 1 is a diagram of the first and second modules;

FIG. 2 is a diagram of the fourth module; and

FIG. 3 is a diagram of the fifth module.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the term 'defined temperature point' can be interchangeable with the term 'defined air temperature set point'.

As used herein, the term 'defined relative humidity point' can be interchangeable with the term 'defined air relative humidity set point'.

As used herein, the term 'defined carbon dioxide content point' can be interchangeable with the term 'defined carbon dioxide content set point'.

As used herein, the term 'defined solar radiation point' can be interchangeable with the term 'defined solar radiation set point'.

According to an embodiment of the present invention, a greenhouse is equipped with an atmospheric weather station comprising of an atmospheric solar radiation sensor, an atmospheric air temperature sensor and a rain detector.

Now turning to FIG. 1, according to another embodiment of the present invention, the greenhouse is equipped with a first module comprising a capture manifold (2), a compressor (4), a first tank (6), a second tank (8), a release manifold (10), and a third tank (12). The capture manifold (2) captures carbon dioxide rich greenhouse air during dark hours and oxygen rich greenhouse air during sunlight hours. The captured greenhouse air is compressed by the compressor (4) and stored into the first tank (6) or the second tank (8). The greenhouse air relative humidity sensor switches-on the moisture drain off valve of the first tank (6) or the second tank (8) for draining off moisture content for optimal dehumidification or for draining off moisture content for maintaining almost dry greenhouse air in the first tank (6) and the second tank (8). Dehumidified carbon dioxide rich greenhouse air, dehumidified oxygen rich greenhouse air, almost dry carbon dioxide rich greenhouse air and almost dry oxygen rich greenhouse air are stored into the respective first (14), second (16), third (18) and fourth (20) compartments of an earth tube heat exchanger (22) of the second module.

The release manifold (10) releases the dehumidified or almost dry conditioned carbon dioxide rich greenhouse air already captured and stored in the first (14) and third (18) compartments, respectively, into the greenhouse at the cultivation level, during the sunlight hours. During dark hours, the release manifold (10) releases into the greenhouse the dehumidified (or almost dry) conditioned oxygen rich greenhouse air already captured and stored in the respective second (16) and fourth (20) compartments.

The third tank (12) stores compressed atmospheric air and also serves to dehumidify the stored atmospheric air. The greenhouse air relative humidity sensor maintains the compressed atmospheric air in the third tank (12) at optimal dehumidification which can be released into the greenhouse for maintaining carbon dioxide and oxygen balance. When the capture manifold (2) is not operating, the compressor (4) compresses the atmospheric air to maintain optimal atmospheric air stock in the third tank (12).

According to another embodiment of the present invention, the second module measures the average thermal constant temperature of a geographical location. In an embodiment, the second module is located approximately 2.5 meters below ground level.

According to another embodiment of the present invention, the greenhouse is equipped with a second module comprising an earth tube heat exchanger (22) and a greenhouse air temperature sensor. The second module functions with the capture manifold (2), the compressor (4), the first (6) and second (8) dehumidifying tanks and the release manifold (10) of the first module and maintains the greenhouse air temperature equal to the average thermal constant temperature of the geographical location.

The earth tube heat exchanger (22) comprises four separate compartments: a first compartment (14) that stores dehumidified carbon dioxide rich greenhouse air from the tanks (6) and (8), a second compartment(16) that stores dehumidified oxygen rich greenhouse air from the tanks (6) and (8), a third compartment (18) that stores almost dry carbon dioxide rich greenhouse air from the tanks (6) and (8), and a fourth compartment (20) that stores almost dry oxygen rich greenhouse air from the tanks (6) and (8).

The earth tube heat exchanger (22) substantially reduces the greenhouse supplementary heating cost in relatively cold geographical locations, and the greenhouse supplementary cooling cost in relatively hot geographical locations. It should be clear that the use of the earth tube heat exchanger (22) results in a much more economically viable greenhouse by reducing the use and reliance upon costly conventional thermal energy sources fossil fuel in relatively cold geographical locations and by using less electric power in relatively hot geographical locations. This is achieved by maintaining the greenhouse air temperature equal to the average thermal constant temperature of the geographical location.

In an example operation, when the greenhouse is installed in a relatively cold geographical location and the air temperature of the geographical location is lower than the defined temperature set point, the greenhouse air temperature sensor switches-on the components of the first module and the components of the second module. The capture manifold (2) captures the carbon dioxide rich greenhouse air during the dark hours and the oxygen rich greenhouse air during the sunlight hours. The captured greenhouse air is compressed and released into the first tank (6) or the second tank (8) for optimal dehumidification. Carbon dioxide rich dehumidified greenhouse air of the first tank (6) and the second tank (8) is stored into the first compartment (14). Oxygen rich dehumidified greenhouse air of the first tank (6) and the second tank (8) is stored into the second compartment (16).

The release manifold (10) releases into the greenhouse, at cultivation level, hot air until the greenhouse air temperature equals the defined temperature set point. The cultivation level defines the upper surface of the growing media in beds or bags where from the bottom portion of a stem of a plant emerges.

In an example operation when the greenhouse is located in a relatively hot geographical location, during sunlight hours, even after optimal shading has been provided. If the greenhouse air temperature still remains higher than a defined temperature set point, during the sunlight hours and/or during the dark hours, the greenhouse air temperature sensor switches-on the evaporative cooling together with the components of the first module and the component of the second module. The capture manifold (2) captures, humid stale carbon dioxide rich greenhouse air during the dark hours and the oxygen rich greenhouse air during the sunlight hours. The captured greenhouse air is compressed and released into the first tank (6) or the second tank (8). The

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greenhouse air relative humidity sensor maintains almost dry greenhouse air in the first tank (6) or the second tank (8). The first and second tanks (6) and (8) store the almost dry carbon dioxide rich greenhouse air into the third compartment (18) during dark hours. The first and second tanks (6) and (8) store the almost dry oxygen rich greenhouse into the fourth compartment (20) during sun light hours.

The release manifold (10) releases into the greenhouse at cultivation level (i) during sunlight hours the almost dry carbon dioxide rich conditioned greenhouse air already captured and stored in the third compartment (18), and (ii) during dark hours the almost dry oxygen rich conditioned greenhouse air already captured and stored in the fourth compartment (20) for optimal evaporative cooling until the greenhouse air temperature equals the defined temperature point.

As such, it is very easy to adjust and maintain the greenhouse air temperature at a defined temperature point which assists in significantly improving the timing of crops, especially of flowers.

Hunting (+) (-) 2.5%

By way of example, when the greenhouse air defined temperature point is 20° C, then a temperature correction event may switch-on when the greenhouse air temperature rises even to about 20.1° C and also when the greenhouse air temperature drops even to about 19.9° C. Without the present invention, this can cause problems with almost simultaneous switch-on and switch-off temperature correction events.

In the present invention, trend logic to track and/or adjust the greenhouse air temperature rising or dropping is used. For instance, when the greenhouse air temperature rises at a rising trend, then the event would switch-on at 20.5°C and maintain the greenhouse air temperature at 19.5°C and vice versa. This alleviates the problem of almost simultaneous switch-on and switch-off temperature correction events.

A similar process is used for maintaining the greenhouse air relative humidity at a defined relative humidity point.

According to another embodiment of the present invention, the greenhouse is equipped with a greenhouse air relative humidity sensor that functions with the components of the first module and the component of the second module to maintain the greenhouse air relative humidity at a defined relative humidity point. When the greenhouse air relative humidity is higher than the defined relative humidity point then the greenhouse air relative humidity sensor switches-on the components of the first module and the component of the second module. The capture manifold (2) captures the humid stale carbon dioxide rich greenhouse air during the dark hours and the

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oxygen rich greenhouse air during the sunlight hours. The captured greenhouse air is compressed and stored into the first tank (6) or the second tank (8). The greenhouse air relative humidity sensor maintains almost dry greenhouse air in the first tank (6) or the second tank (8). The almost dry carbon dioxide rich greenhouse air of the first and second tanks (6) and (8) is stored into the third compartment (18) during dark hours. The almost dry oxygen rich greenhouse air of the first and second tanks (6) and (8) is stored into the fourth compartment (20) during sun light hours.

At the cultivation level of the greenhouse, the release manifold (10) (i) releases into the greenhouse during the sunlight hours the almost dry carbon dioxide rich conditioned greenhouse air already captured and stored in the third compartment (18), and (ii) during the dark hours, the almost dry oxygen rich conditioned greenhouse air already captured and stored in the fourth compartment (20) for mixing with the greenhouse humid air until the greenhouse air relative humidity equals the defined relative humidity point.

When the greenhouse air relative humidity is lower than the defined relative humidity point, the greenhouse air relative humidity sensor switches-on evaporative cooling until the greenhouse air relative humidity equals the defined relative humidity point.

The present invention provides a method for maintaining the greenhouse air relative humidity at a defined relative humidity point, without manipulating the greenhouse air temperature

Example operation during sunlight hours

At the cultivation level of the greenhouse, the release manifold (10) releases into the greenhouse:

i) the dehumidified carbon dioxide rich conditioned greenhouse air already captured and stored in the first compartment (14),

ii) the almost dry carbon dioxide rich conditioned greenhouse air already captured and stored in the third compartment (18), for maintaining:

   a) the greenhouse air relative humidity at a defined relative humidity point, without manipulating the greenhouse air temperature, and

   b) the greenhouse air temperature at a defined temperature point by optimal evaporative cooling in relatively hot geographical locations,

iii) hot air in relatively cold geographical locations,

iv) additional carbon dioxide for enrichment during sunlight hours for maximizing the yield, and

v) the compressed atmospheric air stored in the third tank (12) for maintaining the carbon dioxide and the oxygen balance in the greenhouse.

Example operation during dark hours

At the cultivation level of the greenhouse, the release manifold (10) releases into the greenhouse

i) the dehumidified oxygen rich conditioned greenhouse air already captured and stored in the second compartment (16),

ii) the almost dry oxygen rich conditioned greenhouse air already captured and stored in the fourth compartment (20), for maintaining:

a) the greenhouse air relative humidity at a defined relative humidity point without manipulating the greenhouse air temperature, and

b) the greenhouse air temperature at a defined temperature point by optimal evaporative cooling in relatively hot geographical locations,

iii) hot air in relatively cold geographical locations, and

iv) the compressed atmospheric air stored in the third tank (12) for maintaining the carbon dioxide and the oxygen balance in the greenhouse.

The release of greenhouse air by the release manifolds (10) into the greenhouse at the cultivation level leads to:

i) create multiple combinations of horizontal and vertical flows, and air circulation cycles around the plants for uniform mixing of the released greenhouse air with the existing greenhouse air thus maximizing air circulation around the plants facilitating much higher crop density,

ii) push up the stale greenhouse air from the cultivation level to above the plants,

iii) obviate horizontal or vertical gradients by controlling and maintaining in the greenhouse at all vertical and horizontal locations:

a) an uniform air relative humidity at a defined relative humidity point, and

b) an uniform air temperature at a defined temperature point,

iv) obviate the need of horizontal air fans and therefore saves capital and operating cost of the horizontal fans,

v) prevents escape into the atmosphere the stored carbon dioxide rich greenhouse air and/or the additional carbon dioxide released at the cultivation level for enrichment during

vi) sunlight hours because of being released at cultivation level is readily taken up by the plants. This saves:

   a) the cost of the carbon dioxide which could have escaped into the atmosphere, and

   b) contributed to global warming.

vii) strengthens and harden the stems of the plants, and

viii) pollinate tomato plants, bell pepper plants and the like. To maximize pollination during the pollination hours the release pressure of the release manifold (10) is suitably increased.

Other benefits

i) facilitates carbon dioxide enrichment in relatively hot geographical locations also during the sunlight hours for maximizing the yield,

ii) creates a more economically viable greenhouse wherein instead of purchasing high cost carbon credits, substantial revenue is generated by selling the carbon credits that are not used because the greenhouse carbon dioxide is prevented from being released into the atmosphere,

iii) minimizes pressure of disease and the like and use of crop protection agents by releasing into the greenhouse the oxygen rich greenhouse air during the dark hours, which:

   a) rejuvenates the health of the plants, and

   b) maximizes the resistance of plants to diseases organisms, bacteria, pathogens, fungi, viral infection, harmful insect pests and the like,

iv) facilitates maintaining the greenhouse air relative humidity at about 80% which helps in minimizing the pressure of diseases and the like, and

v) achieves all the benefits of a tall greenhouse in a shorter greenhouse therefore leading to a more economically viable greenhouse with reduced capital cost, greater energy efficiency and reduced operating cost.

Now turning to FIGS. 2 and 3, according to another embodiment of the present invention, the greenhouse is equipped with a fourth module which comprises a geothermal energy harnessing automated equipment that functions with the compressor (4) of the first module for the pressurized air need and with a water transfer pump (24) of a fifth module for the pressurized water need for harnessing geothermal energy for the greenhouse supplementary heating and for numerous other needs in relatively cold geographical locations.

The fourth module comprises two identical geothermal energy harnessing tanks, a first fresh dosing tank (26) which receives pressurized air from the compressor (4) of the first module and pressurized water from the water transfer pump (24) of the fifth module, a second spent dosing tank (28), a hot air tank (30) which provides hot air to warm irrigation water and activated nutrient solutions, to the heating manifold (27) to melt snow and to the release manifold (10), and a carbon dioxide tank (32) which provides carbon dioxide to the release manifold (10).

The fourth module harnesses geothermal energy for various needs such as:

i) greenhouse supplementary heating,

ii) warming equal to a defined temperature for maintaining the temperature of the roots of the plants at a defined temperature point.

  a) drip dosing irrigation water,

  b) drip dosing activated nutrient solution, and

  c) drip dosing crop treatment solution,

iii) warming equal to the greenhouse air temperature,

  a) foliar dosing activated nutrient solution, and

  b) foliar dosing crop treatment solution,

iv) melting snow on the exterior surfaces of the film covering the greenhouse roof and in the gutters by injecting hot air onto the interior surfaces of the film covering the greenhouse roof and onto the interior surfaces of gutters, and

v) injecting pressurized hot air of a defined temperature into root zone of plants during each drip dosing irrigation and drip dosing fertigation event.

The fourth module provides carbon dioxide for enrichment during the sun light hours and also provides high quality sterilized compost. The fourth module needs about 7 square meters space.

According to another embodiment of the present invention, the greenhouse is equipped with a third module which comprises a greenhouse carbon dioxide sensor and functions with the components of the first module and the component of the second module for reducing global warming by preventing the greenhouse carbon dioxide from being released into the atmosphere, by capturing, compressing, dehumidifying, storing and utilizing the greenhouse carbon dioxide for enrichment during the sunlight hours for maximizing the yield.

The third module further maintains in the greenhouse carbon dioxide content at a defined carbon dioxide content point.

When the greenhouse carbon dioxide content is higher than a defined carbon dioxide content point, due to the carbon dioxide released by the plants during the dark hours, or due to residual carbon dioxide available after the carbon dioxide enrichment events of the sunlight hours, then the greenhouse carbon dioxide sensor switches-on the components of the first module and the component of the second module.

The capture manifold (2) captures carbon dioxide rich greenhouse air which is compressed and released into the first tank (6) or second tank (8) for dehumidification. The dehumidified carbon dioxide rich greenhouse air of the first tank (6) and the second tank (8) is stored into the first compartment (14).

The release manifold (10) releases into the greenhouse at the cultivation level the dehumidified oxygen rich conditioned greenhouse air already captured and stored in the second compartment (16), until the greenhouse carbon dioxide content equals the defined carbon dioxide content point which is equal to the atmospheric carbon dioxide content point.

According to another embodiment of the present invention, the greenhouse is equipped with a fifth module which comprises a water inlet (42) from a tubewell, a filter (44), a water storage tank (46), a drip dosing tank (38), a foliar dosing tank (40), a water transfer pump (24), a drip manifold (34), a fogger manifold outlet for evaporative cooling and an outlet for crop treatment foliar dosing (60), an activated nutrient solution dosing system, a crop root zone treatment dosing system, and a drip dosing irrigation system.

The processes of mixing, activating warming and drip dosing a drip dosing activated nutrient solution and mixing warming and drip dosing a drip dosing crop treatment solution are completed in the drip dosing tank (38). The processes of mixing, activating warming and foliar dosing a foliar dosing activated nutrient solution and mixing warming and foliar dosing a foliar dosing crop treatment solution are completed in the foliar dosing tank (40). Using activated nutrient solutions substantially reduces the operational use and the input cost of the nutrients.

According to another embodiment of the present invention, the fifth module further comprising two greenhouse roof sprinkler manifolds two gable sides sprinkler manifolds and two long sides sprinkler manifolds for maintaining exterior surfaces of the film covering the greenhouse clean and free from dust / dirt. The inlets of the sprinkler manifolds are connected to an outlet of a high pressure water pump (36). During the defined sunlight hours, and intervals based upon the dust / dirt status of a geographical location, the atmospheric solar radiation sensor switches-on roof, gable sides and long sides sprinkler manifolds for throwing pressurized water onto all the exterior surfaces of the film covering the greenhouse to wash off all the dust / dirt.

According to another embodiment of the present invention, the fifth module further comprises an efficient firefighting system for combating fire hazards, that may occur because of highly inflammable greenhouse cover film, curtains, insect netting, screens and the like. On smoke detection, all sprinkler manifolds are switched-on for throwing pressurized water onto greenhouse roof, onto two gable sides and onto two long sides of the greenhouse to extinguish fire at the earliest. The main benefit is minimal damage to the greenhouse cover film, and the crops inside the greenhouse.

According to another embodiment of the present invention, the fifth module uses growing media beds wherein the yield is much higher and wherein all the benefits of bags like preventing contact of the roots of the plants with the soil strata can be realized at much lower cost. A thermal sheet is fixed to the surfaces of the bottom ends of the growing media beds at about 30 centimeters depth and about 30 centimeters along four internal vertical sides with about 7 centimeters overlap on horizontal surfaces of four external sides. The bottom end surface of growing media beds is provided with another layer of a film which is provided holes for leachate drain off and in between the two layers are provided plastic perforated pipes. Pressurized hot air of a defined temperature is injected into the pipes during each drip dosing irrigation and drip dosing fertigation event for:

i) aerating the roots of the plants,

ii) maintaining the temperature of the roots of the plants at a defined temperature point which helps in efficient uptake of nutrients, and

iii) facilitating switching - off the drip dosing irrigation or drip dosing fertigation event on first few drops of drained off leachate for facilitating optimal watering and nutrition without any danger of plants collapsing due to water logging which is very beneficial in general and in hydroponics in particular. The best method is to use diluted activated nutrients solutions which further increases use efficiency and obviate separate irrigation and fertigation.

Similar benefits can also be derived in a growing media bags system wherein a thermal tube having a width equal to 3/4th width of the growing media bag is placed under the rows of the bags. The upper surface of the tube is provided holes for leachate drain off.

Plastic perforated pipes are provided at the center of the tube in between the two layers.

According to another embodiment of the present invention, the fifth module melts snow on the exterior surfaces of the film covering the greenhouse roof by equipping the greenhouse with a heating manifold (27). When the atmospheric air temperature sensor senses that the atmospheric air temperature is approaching 0°C, the atmospheric air temperature sensor switches-on pressurized hot air injections into the heating manifold (27) for heating the interior surfaces of the film covering the greenhouse roof, and the interior surfaces of the gutters.

According to another embodiment of the present invention, the sixth module comprises a film fixed to the greenhouse roof and to the four sides of the greenhouse together with 0 to 100% convertible roll-on / off automated thermal shading curtains on the greenhouse roof and internal curtains on the four sides of the greenhouse. It will be appreciated that the thermal and shading curtains are the curtains that provides both thermal insulation and shade. The interior and exterior surfaces of the thermal shading curtains function as solid barriers between the greenhouse air temperature environment and the atmospheric air temperature environment. The interior surfaces of the curtains absorb and retain the greenhouse hot or cold air trying to escape into the atmosphere, and the exterior surfaces of the curtains absorb and retain the atmospheric cold or hot air trying to enter into the greenhouse.

The heat energy accumulated on the interior surfaces of the curtains on the greenhouse roof and on the interior surfaces of the internal curtains on the four sides of the greenhouse, saves substantial heating cost and helps to prevent the greenhouse air from cooling down. During the winter, cold evenings, nights and mornings the greenhouse remains warm and there is little chance of moisture condensation or mist formation on the interior surfaces of the film covering the greenhouse.

Sunlight energy and heat energy being linked, in relatively hot geographical locations during sunlight hours, when the greenhouse air temperature is higher than a defined temperature point, the greenhouse solar radiation sensor switches-on optimal shade by adjusting positions of the 0 to 100% convertible roll-on / off automated thermal shading external curtains on the greenhouse roof and / or of internal curtains on the four sides of the greenhouse, for admitting into the greenhouse only a defined deficient solar radiation for:

i) minimizing the needless heat gain, and

ii) minimizing the greenhouse supplementary cooling cost.

In relatively cold geographical locations, commencing sunrise until sunset, the greenhouse solar radiation sensor maintains switched-off the curtains on the greenhouse roof and internal curtains on the four sides of the greenhouse for:

i) maximizing heat gain, sensible and latent, and

ii) minimizing the greenhouse supplementary heating cost.

In relatively hot geographical locations, during early morning sunrise, overcast sky hours, at sunset, and as and when solar radiation into the greenhouse is less than the defined solar radiation point, the atmospheric solar radiation sensor, maintains switched-on the curtains on the greenhouse roof and internal curtains on the four sides of the greenhouse for minimizing needless heat gain for reducing the greenhouse supplementary cooling cost.

Thus the 0 to100% convertible roll-on/ off automated thermal shading curtains substantially reduce the greenhouse supplementary heating cost in relatively cold geographical locations, and the greenhouse supplementary cooling cost in relatively hot geographical locations, and comprises an all in one solution for all the seasons and in all geographical locations.

After sunset or after the defined photoperiod hours, the atmospheric solar radiation sensor switches-on the curtains on the greenhouse roof and internal curtains on the four sides of the greenhouse.

According to another embodiment of the present invention, the sixth module increases deficient artificial lighting in the greenhouse. This reduces capital and operating cost by reducing the electric energy required for artificial lighting, and require installation of fewer lights. The sixth module also increases deficient sun light energy.

Compact fluorescent lamps and fluorescent tubes are hung from a bottom of a truss at defined elevations and are movable to adjust their height.

The fluorescent tubes alternately red, blue and white; and aluminium foil wherein compact fluorescent lamps and fluorescent tubes are installed staggered at defined square meter centers around a horizontal width center of rows of growing media beds or bags. at the defined square meters centers, and are hung from a bottom of a truss at defined elevations above tops of the plants. The fluorescent tubes and the compact fluorescent lamps may be raised as the plants grow in height.

The mirrors and the aluminium foil are at defined square meters centers.

Sunlight and/or artificial light striking the mirrors, compact fluorescent lamp shades and aluminium foil is reflected repeatedly to increase and to produce red, blue and white light.

The sixth module also increases deficient sunlight into the greenhouse to be sufficient for food production in geographical locations wherein sunlight energy is not deficient but is reduced due to dust / dirt accumulation on the exterior surfaces of the film covering the greenhouse and, or due to condensation or mist formation on the interior surfaces of the film covering the greenhouse.

The sunlight is increased by equipping the greenhouse with mirrors and aluminum foil. These mirrors and aluminum foil are installed at defined square meters centers. Incoming sunlight or artificial light striking mirrors, lamp shades and aluminum foil is reflected to the other mirrors, lamp shades and aluminum foil, to increase by repeated light reflecting and produces red, blue and white light. The mirrors and aluminum foil also spread light more uniformly.

According to another embodiment of the present invention, the sixth module facilitates food production in relatively cold geographical locations, wherein life exists but is very sunlight deficient. This is achieved by increasing deficient sunlight energy together with artificial lighting energy to be sufficient for food production and using the earth tube heat exchanger (22) together with the geothermal energy harnessing automated equipment.

According to another embodiment of the present invention, the sixth module comprises a film fixed to the greenhouse roof and to the four sides of the greenhouse such that the greenhouse efficiently prevents ingress of insect pests, pathogens and the like into the greenhouse facilitating efficient biological control.

According to another embodiment of the present invention, the sixth module comprises a method for eliminating the need for gutters in a multi span structured greenhouse. As such, this eliminates problems related to the gutters such as:

a) blocking of incoming sunlight into the greenhouse,
b) condensation or mist on the interior surfaces of the gutters,
c) water drops dripping on to the plants causing injury to the plants,
d) snow accumulation in the gutters,
e) very heavy down pour of rain overflowing on the multi span structured greenhouse roofs, along the sides and into the greenhouse, causing damage to the plants inside, dust and dirt accumulation in the gutters, and
f) algae or fungi growth in the gutters.

According to another embodiment of the present invention, the sixth module further maintains optimal insulation between two layers of inflated double layer greenhouse cover film which is critical for increased thermal efficiency, and for reducing the heat loss and the associated thermal energy cost. The total area of a double layer greenhouse cover film is divided into alternate horizontal and vertical segments of about 2 square meters and of about 3 square meters respectively. Thermal sealing is completed after each segment is inflated to ensure that the segment which is being inflated is fully insulated from all other adjoining segments. Leaking segment can be visually identified and easily repaired.

According to another embodiment of the present invention, the sixth module also comprises a method to employ smaller wall thickness, smaller diameter, cheaper galvanized iron pipes filled with sand. The ends of the pipes are sealed so that the sand cannot escape. These pipes replace the large wall thickness C-class, large diameter costly galvanized iron pipes for weighting down the curtains, the screens and the like to keep them tightly in place and to prevent them from blowing in the wind. They both serve the same objective thus, considerable cost is saved.

The above description is to understand the invention and in no way to limit the scope of the invention which is amendable to various modifications and improvements within the scope of the present invention which will be evident to those skilled in the art. The present invention is not restricted to the greenhouse applications only.

CLAIMS

1. An environment controlled multi span structured greenhouse having a roof, two gable sides and two long sides, the greenhouse comprising:

a first module, a second module, and a third module, wherein the first module comprises the following components:

a capture manifold for capturing a carbon dioxide rich greenhouse air during dark hours and an oxygen rich greenhouse air during sunlight hours;

a compressor for compressing the captured carbon dioxide rich and oxygen rich greenhouse air;

a first tank and a second tank for dehumidifying, or for maintaining relatively dry, the compressed carbon dioxide rich and oxygen rich greenhouse air;

a release manifold for releasing into the greenhouse at cultivation level, the dehumidified or relatively dry carbon dioxide rich greenhouse air during the sunlight hours, and the dehumidified or relatively dry oxygen greenhouse air during the dark hours; and

a third tank for storing and dehumidifying compressed atmospheric air for release into the greenhouse to maintain a balance between carbon dioxide and oxygen,

wherein the second module comprises an earth tube heat exchanger and a greenhouse air temperature sensor which functions with the capture manifold, the compressor, the first tank, the second tank and the release manifold, wherein the earth tube heat exchanger comprises a first compartment for storing the dehumidified carbon dioxide rich greenhouse air, a second compartment for storing the dehumidified oxygen rich greenhouse air, a third compartment for storing the relatively dry carbon dioxide rich greenhouse air, and a fourth compartment for storing the relatively dry oxygen rich greenhouse air and wherein, in relatively cold weather geographical locations, the earth tube heat exchanger conditions relatively cooler greenhouse air to relatively warmer greenhouse air and, in relatively hot weather geographical locations, the earth tube heat exchanger conditions relatively warmer greenhouse air to relatively cooler greenhouse air,

wherein the earth tube heat exchanger maintains the greenhouse air temperature at a predetermined temperature set point which is equal to an average thermal constant temperature of the geographical location of the greenhouse,

wherein the third module comprises a carbon dioxide sensor which functions together with the components of the first module and with the earth tube heat exchanger of the second module, for reducing global warming by preventing the greenhouse carbon dioxide from being released into the atmosphere by capturing, compressing, dehumidifying, storing and utilizing the greenhouse carbon dioxide for enrichment during the sunlight hours for maximizing the yield of plants growing in the greenhouse and for maintaining the greenhouse carbon dioxide content at a predetermined carbon dioxide content set point that is equal to the atmospheric carbon dioxide content,

wherein when the greenhouse carbon dioxide content is higher than the predetermined carbon dioxide content set point due to carbon dioxide released by the plants during the dark hours or due to residual carbon dioxide available after carbon dioxide enrichment events during the sunlight hours, the greenhouse carbon dioxide sensor switches on the components of the first module and the earth tube heat exchanger of the second module, and the capture manifold captures the carbon dioxide rich greenhouse air, the compressor compresses the captured carbon dioxide rich greenhouse air, the compressed carbon dioxide rich greenhouse air is dehumidified in the first and second tanks and, the carbon dioxide rich dehumidified greenhouse air is stored into the first compartment and the release manifold releases into the greenhouse, at a cultivation level, the oxygen rich dehumidified conditioned greenhouse air stored in the second compartment for maintaining the greenhouse carbon dioxide content at a predetermined carbon dioxide content set point which is equal to the atmospheric carbon dioxide content point.

2. The environment controlled multi span structured greenhouse of claim 1, further comprising a heating manifold for melting snow on exterior surfaces of a film covering the roof of the greenhouse, wherein the greenhouse further comprises a weather station comprising (i) an atmospheric solar radiation sensor, (ii) an atmospheric air temperature sensor and (iii) a rain detector, wherein when the atmospheric air temperature sensor senses that the atmospheric air temperature is approaching 0°C, the atmospheric air temperature sensor switches on pressurized hot air injections into the heating manifold to heat interior surfaces of the film for melting snow on the exterior surfaces of the film.

3. The environment controlled multi span structured greenhouse of claim 1, wherein each of the first tank, the second tank, and the third tank comprises a moisture drain off valve for draining off moisture from each of the first tank, the second tank, and the third tank wherein the moisture drain off valves are switched on by a greenhouse air relative humidity sensor.

4. The environment controlled multi span structured greenhouse of claim 1, wherein bio-thermal energy is harnessed for supplementary heating of the greenhouse in relatively cold weather geographical locations using automated equipment of a fourth module, the fourth module comprising the following components:

two bio-thermal energy harnessing tanks;

a first fresh dosing tank;

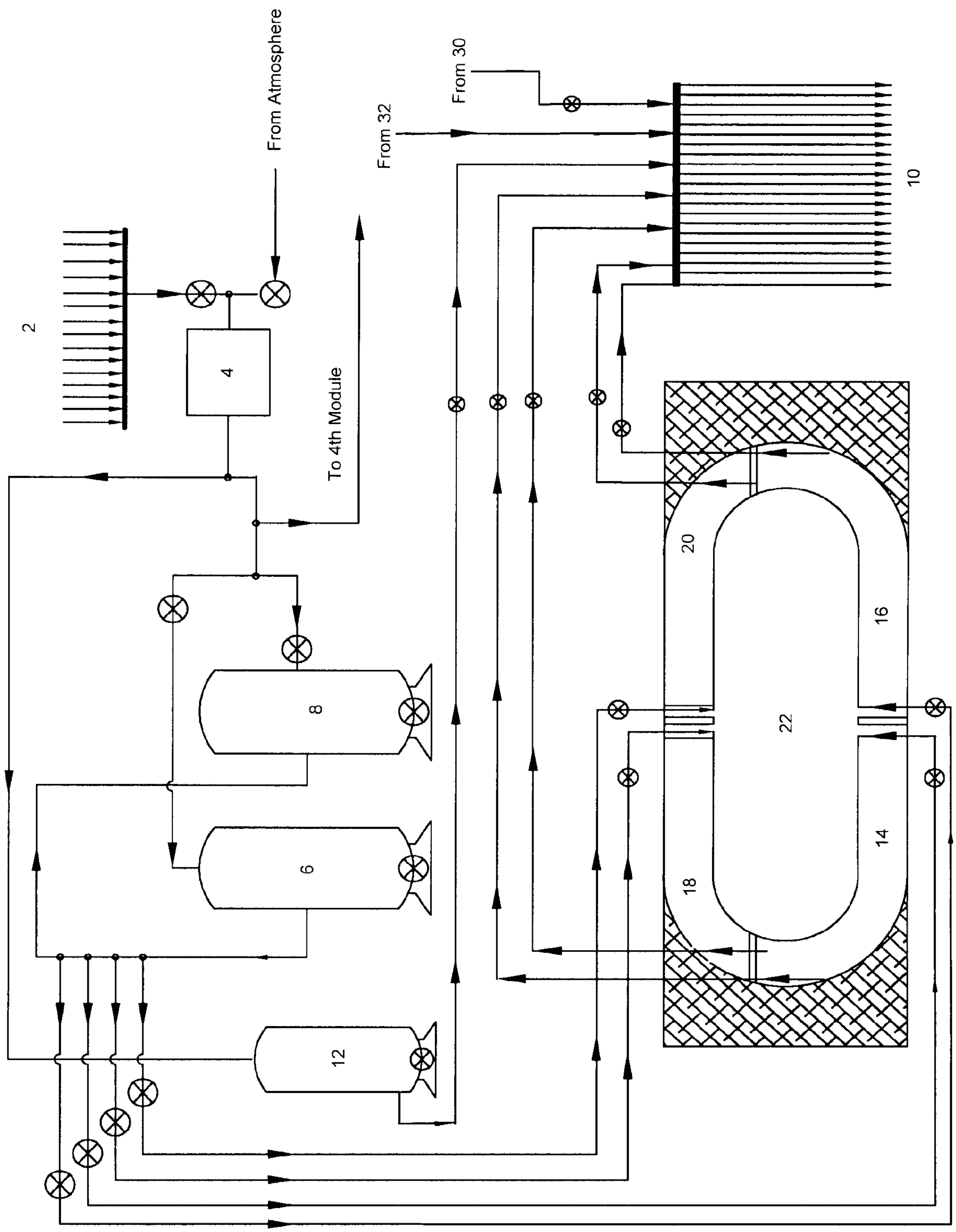
a second spent dosing tank;

a hot air storing tank; and

a carbon dioxide storing tank,

wherein the components of the fourth module function with the compressor of the first module for providing pressurized air and with a water transfer pump of a fifth module for providing pressurized water for harnessing the bio-thermal energy.

FIG. 1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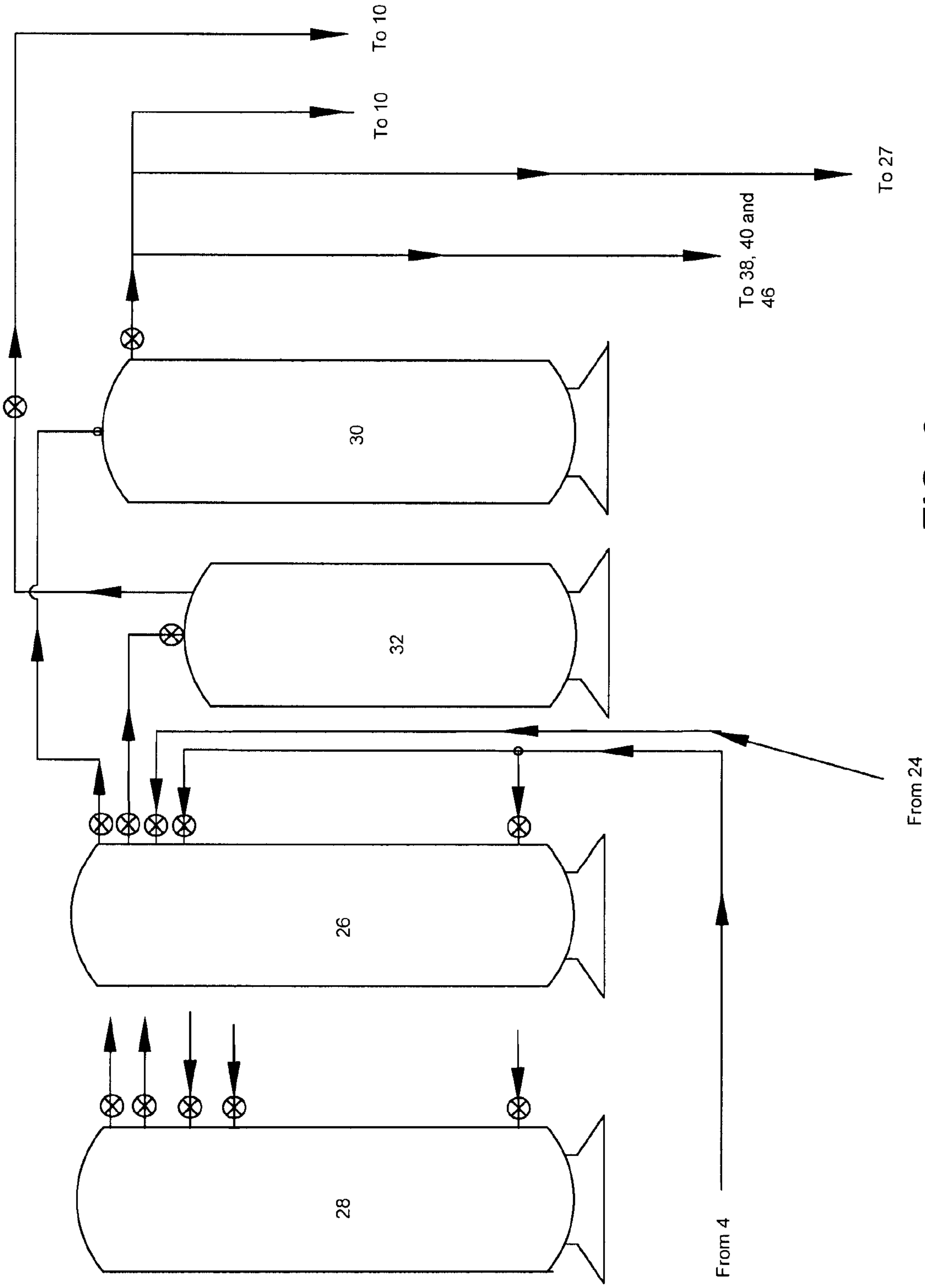

FIG. 2

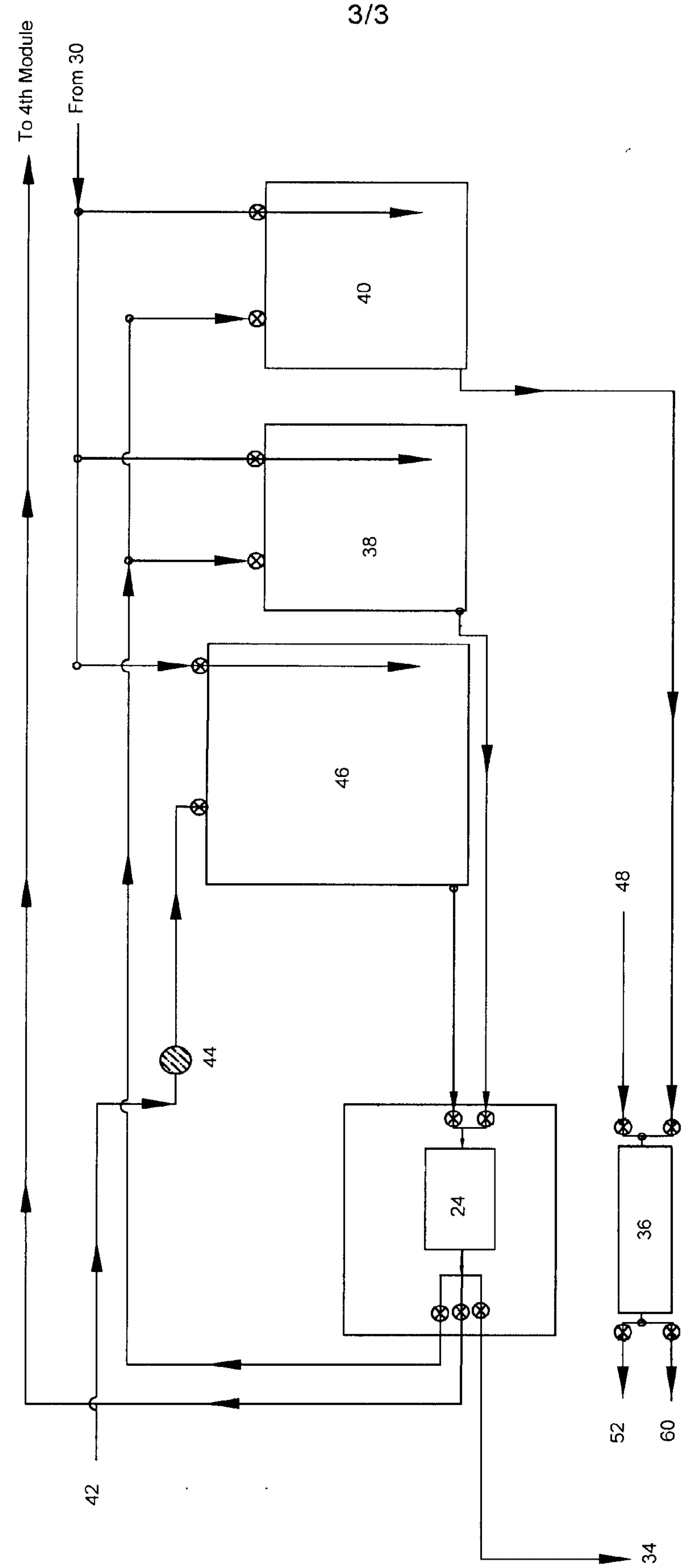

FIG. 3