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WITNESS my hand this
Twenty-seventh day of August 2007

PETER SCHLAEFER
TEAM LEADER EXAMINATION
SUPPORT AND SALES

2006904540 21 Aug 2006

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Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: **DEVICE FOR GENERATING ELECTRICITY FROM SOLAR POWER**

Applicant: **Pure Solar Power (IP) Pty Ltd**

The invention is described in the following statement:

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DEVICE FOR GENERATING ELECTRICITY FROM SOLAR POWER

Field of the Invention

The present invention relates to the field of electricity generation and, in a particularly preferred form, the present invention relates to a device for generating electricity from solar power.

Background of the Invention

Various means for generating electricity from solar power have been conceived and developed. The generation of electricity using solar towers, otherwise known as solar chimneys, is one such means. Solar towers generate electricity by harnessing energy from air heated by the sun. The "draw" that is associated with an open-hearth fire relies on the difference in temperature between the air in the room and the air outside. The relatively warm air in the room rises up through a chimney to rise above the denser, relatively cold air outside and in doing so creates a current of air up through the chimney to the cold air outside. This behaviour of air is commonly known as convection.

Similarly, the solar tower exploits the same principle by providing a hollow tower in the order of hundreds of meters high to exploit the difference in temperature between the air at ground level and at altitude. In the atmosphere, air temperature decreases in the order of 1°C for every 100 metres of altitude such that in the case of a 500 metre tall solar tower the temperature at the top is 5°C cooler than at the base. The difference in temperature can be enhanced by providing a green house like structure around the base. In this case, the air surrounding the tower is heated by the green house canopy to a temperature that may be greater than the ambient temperature at ground level. The heated air at ground level flows up through the tower and exits the top of the tower in an effort to rise above the relatively colder air at altitude. The solar tower seeks to harness the kinetic energy in the flow, or current, of air up through the tower by converting it into electricity.

The solar tower may have a turbine attached to a generator that is placed in the path of the air current. The moving air passes over the turbine blades and causes the turbine to spin. The generator, which is attached to the turbine, converts the rotation of the turbine into electrical power for supply to an electricity grid for domestic, commercial or industrial use.

The amount of electrical power generated by the solar tower is dependent on the velocity of the air current the solar tower generates. The velocity of the air current up through the tower is determined by various factors such as the height of the tower and the surface area and efficiency of the green house canopy at the base of the tower. These variables influence the velocity of the air current up through the tower by affecting the temperature differential between the air at the base and at the top of the tower.

Existing efforts to increase the temperature differential between the air at the base and at the top of the tower have focused on ways of increasing the height of the tower and of increasing the efficiency of the green house canopy in heating the air at the base of the tower. Efforts to increase green house canopy efficiency have included: increasing the surface area of the canopy, in some cases to areas in the order of tens of square kilometres; and advancements in materials and construction of the green house canopy that enhance transmission of solar energy striking the upper surface canopy to the air beneath the canopy and that prevent heated air from escaping through the canopy, thus, ensuring that substantially all of the heated air is directed towards the base of the solar tower.

Although solar energy is abundant and inexhaustible it is not, however, continuously available at any given location on earth. In other words, the sun's energy can only be harnessed directly during the daylight hours. In the case of devices that generate electricity directly from solar energy this is a major hurdle. Electricity grids require a base-load of electrical power to be constantly available as electricity is used for domestic, commercial and industrial purposes 24 hours a day. This presents a serious problem for the use of solar towers for the production of base-load electrical power as the amount of electrical power solar towers produce may be seriously restricted outside of daylight hours.

The above discussion of acts, materials, devices, articles and the like is included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any of these matters are known, form part of the prior art base or are common general knowledge in the field relevant to the present invention at the priority date of each claim of this application.

Summary of the Invention

The present invention seeks to ameliorate the drawbacks associated with the production of electrical power from solar energy by providing a device for generating electricity from solar energy including:

an air passage having a bottom opening and a top opening, the top opening being at a relatively higher altitude than the bottom opening, for a current of air to flow through the air passage from the bottom opening to the top opening;

a turbine generator located in the air current for generating electricity therefrom; and

a solar energy absorbing and storage means for absorbing and storing solar energy in the form of thermal energy and supplying the thermal energy to an air heater for heating the air that flows through the air passage from the bottom opening to the top opening.

An advantage of the invention is that it exploits the propensity for hotter air at a lower altitude to rise above colder air at a higher altitude, otherwise known as convection, to generate electricity. Another advantage of the invention is that it captures and stores solar energy in the form of thermal energy for conversion into heated air for use by the device to generate electricity as well as control of the conversion of the stored solar energy into heated air and generated electricity. In other words, the invention may provide an electricity generating device that absorbs and stores solar energy that can be used, when required, to generate electricity. Thus, the device, although using solar energy to generate electricity, is not necessarily dependent on the availability of the sun at a given time to generate electricity.

In one form, the solar energy absorption and storage means is located remotely from the air heater. In a particularly preferred form, the solar energy and absorption and storage means is a solar pond that includes a body of water having: a top layer with a low salt content; a bottom layer with a high salt content that is heated by absorbing solar energy; and an intermediate insulating layer with a salt gradient for setting up a density gradient that prevents convective heat exchange from the bottom layer to the top layer for enabling the bottom layer to store the absorbed solar energy in the form of thermal energy.

Such forms of the device of the invention provide a means for absorbing and storing solar energy in the form of thermal energy for subsequent use, when required, by the device to heat air when the sun may not be available to do so, thereby setting up the air current through the air passage that enables the device to generate electricity. The invention may also provide a device that enables a steady base load of electricity to be generated using solar energy which is a highly desirable outcome electrical power generation technologies employing renewable energy sources such as solar energy.

In one form, the air heater includes a thermal energy exchanger for exchanging the stored thermal energy into heat in the air that flows through the air passage from the bottom opening to the top opening. Preferably, the stored thermal energy is transmitted to the thermal energy exchanger by means of fluid that absorbs the stored thermal energy from the solar energy absorbing and storage means and emits the thermal energy via the thermal energy exchanger into the air that flows through the air passage from the bottom opening to the top opening. In one form, the thermal energy exchanger includes a thermal radiator for radiating the thermal energy emitted from the fluid to the air that flows through the air passage from the bottom opening to the top opening. More preferably, the fluid moves between the solar energy absorbing and storage means and the thermal energy exchanger through a continuous pipe through which the fluid is pumped.

Such forms of the invention provide a mechanism for the use of thermal energy stored in the solar energy absorbing and storage means to heat the air that flows through the air passage from the bottom opening to the top opening that, through convection, sets up an air current in the air passage of the device as the heated air seeks to move through the air passage to the relatively cooler air at higher altitude at the top opening, with some of the kinetic energy in the current of air being harnessed by the turbine generator of the device by conversion into electricity.

In a particularly preferred form, the movement of fluid between the solar energy absorbing and storage means in the thermal energy exchanger is controllable. In this form, the invention enables control of the degree, if any, to which the stored solar energy, in the form of stored thermal energy, is converted by the device into heated air that flows through the air passage from the bottom opening to the top opening and hence into electricity.

In one form, the air heater includes a base spaced apart from a cover for defining a volume of the air that flows through the air passage from the bottom opening to the top opening and for directing the air current to the bottom opening of the air passage. The cover acts as a greenhouse-like structure that transmits solar energy striking the cover to heat the air beneath the cover the air that flows through the air passage from the bottom opening to the top opening, substantially contain that air beneath the cover while it is heated and direct it towards the bottom opening of the air passage. Preferably, the base is adapted to absorb solar energy and radiate that energy as heat into the air that flows through the air passage from the bottom opening to the top opening and the cover is adapted to transmit solar energy striking the cover to the base. More preferably, the base and the cover surround the bottom opening of the air passage and the cover extends continuously from the bottom opening of the air passage. Preferably the cover is formed from a substantially transparent material and the cover may include insulation for reducing the transmission of thermal heat through the cover. In one form, the base may be an area of ground and the cover may be inclined towards the bottom opening of the air passage.

Such forms of the invention provide a greenhouse-like structure around, and extending from, the bottom opening of the air passage. Solar energy striking the cover of the greenhouse-like structure is transmitted through the cover and absorbed by the low altitude air beneath the cover and by the base that, in turn, radiates the solar energy into the air between the cover and the base as heat. The hotter the air that flows through the air passage from the bottom opening to the top opening moves in a current, as a result of the natural convection process, towards and into the bottom opening of the air passage at, passes up through the air passage and out the top opening of the air passage at the relatively higher altitude where the air in the atmosphere is relatively colder. These forms of the invention enable the turbine generator of the device to generate electrical power from solar energy during daylight hours when sunlight is available independently to, or in combination with or supplementary to, the action of the solar energy absorbing and storage means and the air heater.

Brief Description of the Drawings

It will be convenient to hereinafter describe the invention in detail with reference to the attached drawings that illustrate a preferred embodiment of a device for generating electricity from solar energy according to the invention. It should be appreciated, however, that the generality of the preceding portion of the specification is not to be superseded by the specifics of the following description.

Figure 1 illustrates a side section of a preferred embodiment of the device for generating electricity from solar energy according to the invention.

Figure 2 illustrates a side section of a preferred embodiment of the solar energy absorbing and storage means feature of the invention in the form of a solar pond.

Detailed Description

Referring to Figure 1 there is illustrated a preferred embodiment of the device 10 for generating electricity from solar energy of the invention. The device 10 includes an air passage 20 having a bottom opening 25 and a top opening 30 and a passageway 35 therebetween. An air heater 40 is located adjacent to the bottom opening 35 of the air passage 20. The air heater 40 includes a thermal heat exchanger 50, a base 60 and a cover 70 spaced apart from the base 60 so as to define a volume 80 containing air. The air heater 40 operates to heat the air contained in the volume 80 and direct the heated air towards the bottom opening 25 of the air passage 20, that due to convection, seeks to rise upwards through the passageway 35 of the air passage 20 towards the relatively cooler air surrounding the top opening 30 of the air passage 20 and exit therefrom. Air that exits the top opening 30 of the air passage 20 is replaced by air entering the volume 80 of the air heater 40 through an air heater inlet 45 that is defined by the extremities of the base 60 and cover 70 located distally from the bottom opening 25 of the air passage 20.

As is illustrated in Figure 1, air enters the air inlet 45 into the volume 80 defined between the base 60 and cover 70 of the air heater 40. The air is then heated and drawn, by natural convection, into the bottom opening 25 of the air passage 20 thus setting up a current of air in the volume 80 between the cover 70 and the base 60. A turbine 90 is located such that the current of air strikes blades 95 of the turbine that in turn causes the turbine 90 to spin. The turbine 90 is connected to a generator (not shown) that converts the rotation of the turbine 90 into electricity. The electricity may be channelled to a power grid for commercial, domestic or industrial use. The turbine 90 is located in the space between the cover 70 and the base 60 of the air heater 40 so that the current of air in the volume 80 strikes the blades 95 of the turbine 90 prior to reaching the bottom opening 25 of the air passage 20. Thus, the blades 95 of the turbine 90 are oriented substantially perpendicularly to the base 60 and the cover 70 and the current of air travels substantially perpendicularly to the orientation of the blades 95 of the turbine 90. In other words, the current of air travels in a direction substantially parallel to the base 60 and the cover 70 from the air inlet 45 of the air heater 40 towards the bottom opening 25 of the air passage 20 where the current of air substantially changes direction to enter the bottom opening 25 and travel generally upwardly through the passageway 35 of the air passage 20 towards the relatively cooler air surrounding the top opening 30 of the air passage 20 and exiting therefrom. In another form, the turbine 90 may be located to take advantage of the current of air as it moves in the upward direction through the passageway 35 of the air passage 20. The turbine 90 may be located within the passageway 35 at some point between the bottom opening 25 and the top opening 30 with the blades 95 of the turbine 90 oriented substantially perpendicularly to the direction of movement of the current of air through the passageway 35 and the passageway 35 itself. In this form, additional support means may be required for suspending the turbine 90 and the generator above the level of the base 60 within the passageway 35 of the air passage 20.

The cover 70 of the air heater 40 may be formed from transparent material such as glass, a transparent polymer or other synthetic material that transmits solar energy that strikes the upper surface 72 of the cover 70 through to the air contained in the volume 80. Preferably, the cover is formed from a plurality of modular cover sections (not shown). Each cover section is constructed from a transparent cover and a spaced apart absorbing plate. Fins are connected to the absorbing plate. Solar energy is conducted through the transparent cover and absorbed by the absorbing plate as heat energy. The heat energy is then transferred from the absorbing plate and the fins connected to the absorbing plate to the air contained in the volume 80 at the underside of the absorbing plate by radiation and convection. Forced convective currents are developed to move the heated air away from the absorbing plate and fins.

The dimensions of the spacing between the transparent cover and absorbing plate are such as to suppress the development of convective currents and suppress radiation so as to establish a relatively stagnant zone between the transparent cover and absorbing plate. The stagnant zone acts as an insulating layer to the absorbing plate to encourage conduction of the solar energy through the absorbing plate, rather than back to the transparent cover and/or into the air in the stagnant zone.

Each cover section may also include turbulence inducers which is a protrusion extending from the absorbing plate into the air contained in the volume 80 at the underside of the absorbing plate. The turbulence inducers cause moving air in the volume 80 that hits the turbulence inducers to move away from the absorbing plate.

The heat that is transmitted by the cover 70 of the air heater 40 is absorbed by the air contained in the volume 80 between the cover 70 and the base 60. The heated air tends to move, due to convection, into the bottom opening 25, up through into the passageway 35 and out the top opening 30 of the air passage 20, as mentioned above, and the kinetic energy of the heated air is used by the turbine 90 to generate electricity.

The cover 70 of the air heater 40 is inclined slightly in the direction from the air heater inlet 45 or extremities of the cover towards the bottom opening 25 of the air passage 20. Accordingly, when the air contained in the volume 80 between the cover 70 and the base 60 of the air heater 40 is heated it tends to rise and the inclination of the cover 70 deflects the rising air in a direction towards the bottom opening 25 of the air passage 20. By deflecting the rising air in this way, the inclination of the cover 70 may propagate and/or add to the current of heated air towards the bottom opening 25 of the air passage 20, that due to convection, rises upwards through the passageway 35 of the air passage 20 towards the relatively cooler air surrounding the top opening 30 of the air passage 20 and exiting therefrom.

Located remotely from the air heater 40 is a solar energy absorbing and storage means in the form of a solar pond 100. The constituents of the solar pond 100 are illustrated in more detail in Figure 2. The solar pond 100 is a body of water having three layers, a top layer 110, an intermediate layer 120 and a bottom layer 130, that are located in a container 102 that may be a concave depression in the ground lined by a waterproof membrane (not illustrated). The top layer 110 has a relatively low salt content. The bottom layer 130 has a relatively high salt content and the intermediate layer 120 has a salt gradient from a higher salt concentration towards the bottom layer 130 to a lower salt concentration towards the top layer 110. The relative salt concentrations of the top layer 110 and the bottom layer 130 and the salt gradient of the intermediate layer 120 are illustrated by the graph X-Y which is incorporated in Figure 2. The X axis of the graph indicates increasing salt content and the Y axis of the graph indicates reducing depth.

The salt gradient of the intermediate layer 120 acts to prevent convective heat exchange from the bottom layer 130 to the top layer 110. Thus, solar energy that strikes the top surface 115 of the solar pond 100 and is transmitted through the top layer 110 and intermediate layer 120 is absorbed by the bottom layer 130 and stored in the bottom layer 130 in the form of thermal energy.

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Accordingly, while the ambient air temperature above the top surface 115 of the solar pond may be, say, 30°C and the temperature of the top layer 110 of the solar pond 100 may also be, say, 30°C the temperature of the bottom layer 130 may be, say, 90°C. Without the intermediate layer 120 the relatively warmer water of the bottom layer 130 would rise towards the top layer 110 due to the tendency for warmer liquid to rise above cooler liquid, otherwise known as the natural phenomenon of convection. In turn, the cooler water of the top layer 110 would tend to fall towards the bottom layer 130. Figure 2 illustrates diagrammatically that convection currents exist within the bottom layer 130 and the top layer 110 independently, however, no such convection current exists in the intermediate layer 120 due to the salt gradient. Accordingly, the solar pond 100 acts as a means for absorbing and storing solar energy striking the top surface 115 of the solar pond 100.

The stored solar energy, in the form of thermal energy stored in the bottom layer 130 of the solar pond 100, may be used in the invention to heat air contained in the volume 80 between the cover 70 and the base 60 of the air heater 40. Relatively warm liquid from the bottom layer 130 of the solar pond 100 is transported through a supply pipe 140 to the thermal heat exchanger 50 which is in the form of a thermal radiator and back to the bottom layer 130 of the solar pond 100 by a return pipe 142. The direction of movement of liquid through the supply pipe 140 and the return pipe 142 is illustrated by arrows in Figure 1. When the heated liquid reaches the thermal heat exchanger 50 the liquid emits its thermal energy via the thermal heat exchanger 50 into the air contained in the volume 80 between the upper surface 72 and base 60 of the air heater 40. A pump 145 is located in series with the supply pipe 140 to pump the heated water from the bottom layer 130 of the solar pond 100 through the supply pipe 140 and the thermal heat exchanger 50 and back via the return pipe 142 to the bottom layer 130 of the solar pond 100.

The thermal heat exchanger 50 may include a plurality of rows and/or columns of fluid passages through which the heated water from the solar pond 100 may pass. The fluid passages within the thermal heat exchanger 50 may have a total length that is sufficient for the heated water, which travels at a predetermined velocity through the fluid passages, to spend a sufficient amount of time within the fluid passages such that the heat in the water is transmitted through the walls of the fluid passages to the air contained in the volume 80 between the upper surface 72 and base 60 of the air heater 40. The walls of the fluid passages may be formed of a material that is suitable for efficiently transmitting heat from water located within the fluid passages to air located outside the fluid passages. The material of the fluid passages, and indeed the supply pipe 140 and return pipe 142 and pump 145 would be resistant to corrosion resulting from contact with the salty heated water from the bottom layer 130 of the solar pond 100.

The liquid contained in the solar pond 100 is preferably water that is supplied from a local aquifer (not shown) via an aquifer feed pipe 150 and an aquifer feed pipe pump 152 located in series with the aquifer feed pipe 150. The aquifer feed pipe pump 152 can be turned on to supply water from the aquifer to the solar pond 100 when it is required to replenish or supplement the water contained in the solar pond 100 as some may be lost through various ways including evaporation.

As mentioned above, the solar pond 100 includes a body of water located in a container 102 that may be a concave depression in the ground lined by a waterproof membrane. The purpose of the waterproof membrane is to prevent water in the solar pond 100 from leeching into the ground surrounding the solar pond 100 and, hence, to prevent the loss of water and salt into the surrounding ground. The solar pond 100 may include a thin selectively permeable membrane (not shown) between the separate layers 110, 120, 130 of the solar pond 100 to separate the layers 110, 120, 130 and prevent salt passing through the membrane between layers. This can assist in maintaining the relative salt concentrations in each of the layers 110, 120, 130 of the solar pond. A membrane could also be placed on the top surface 115 of the solar pond 100 to assist in reducing water loss from the solar pond 100 due to evaporation and to reduce disturbance to the solar pond 100 due to external environmental effects such as wind, plants and animals.

By incorporating a solar energy absorbing and storage means such as a solar pond 100 located remotely from the air heater 40 the device 10 of the invention can absorb solar energy when it is available, such as during daylight hours, and store the energy as thermal energy so that when the sun is not available to directly heat the air contained in the volume 80 between the cover 70 and the base 60 of the air heater 40 the stored solar energy in the solar pond 100 can be utilised to replace and/or supplement the direct action of the sun to heat the air contained in the volume 80 between the cover 70 and the base 60 of the air heater 40. As such, when the sun is not available, for example at night, the device can use the stored solar energy in the solar pond 100 to heat the air in the volume 80 so that, as a result of convection, the heated air tends to move towards the bottom opening 25 of the air passage 20, through the passageway 35 and out the top opening 30 to a relatively higher altitude where the ambient air temperature is relatively lower. Thus, the invention enables the stored solar energy to generate an air current when the sun may be unavailable or insufficient such that the turbine 90 and generator of the device 10 may generate electricity for transmission to a grid for domestic, commercial or industrial use.

Accordingly, the device of the invention may overcome one of the main drawbacks associated with renewable energy generating devices powered by the sun in that it may enable electricity to be generated from solar energy when sunlight is not available, such as at night, or is insufficient to generate an amount of electricity sufficient for a base load electricity requirement.

Various alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the spirit and/or ambit of the invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A device for generating electricity from solar energy including:

an air passage having a bottom opening and a top opening, the top opening being at a relatively higher altitude than the bottom opening, for a current of air to flow through the air passage from the bottom opening to the top opening;

a turbine generator located in the air current for generating electricity therefrom; and

a solar energy absorbing and storage means for absorbing and storing solar energy in the form of thermal energy and supplying the thermal energy to an air heater for heating the air that flows through the air passage from the bottom opening to the top opening.

2. The device of claim 1, wherein the solar energy absorption and storage means is located remotely from the air heater.

3. The device of either claim 1 or claim 2, wherein the solar energy absorption and storage means includes a solar pond.

4. The device of any one of the preceding claims, wherein the solar energy absorption and storage means includes a body of water having: a top layer with a low salt content; a bottom layer with a high salt content that is heated by absorbing solar energy; and an intermediate insulating layer with a salt gradient for setting up a density gradient that prevents convective heat exchange from the bottom layer to the top layer for enabling the bottom layer to store the absorbed solar energy in the form of thermal energy.

5. The device of claim 4, further including a thin selectively permeable membrane to separate the layers and prevent salt passing between the layers.

6. The device of any one of the preceding claims, wherein the air heater includes a thermal energy exchanger for exchanging the stored thermal energy

into heat in the air that flows through the air passage from the bottom opening to the top opening.

7. The device of claim 6, wherein the stored thermal energy is transmitted to the thermal energy exchanger by means of fluid that absorbs the stored thermal energy from the solar energy absorbing and storage means and emits the thermal energy via the thermal energy exchanger into the air that flows through the air passage from the bottom opening to the top opening.

8. The device of claim 7, wherein the thermal energy exchanger includes a thermal radiator for radiating the thermal energy emitted from the fluid to the air that flows through the air passage from the bottom opening to the top opening.

9. The device of any one of claims 6 to 8, wherein the fluid moves between the solar energy absorbing and storage means and the thermal energy exchanger and the movement is controllable.

10. The device of any one of claims 7 to 9, wherein the fluid moves between the solar energy absorbing and storage means and the thermal energy exchanger through a continuous pipe.

11. The device of claim 10, wherein the fluid is pumped through the continuous pipe.

12. The device of any one of the preceding claims, wherein the air heater includes a base spaced apart from a cover for defining a volume of the air that flows through the air passage from the bottom opening to the top opening and for directing the air current to the bottom opening of the air passage.

13. The device of claim 12, wherein the cover is adapted to absorb solar energy and radiate that energy as heat into the air that flows through the air passage from the bottom opening to the top opening.

14. The device of claim 12 or 13, wherein the base and the cover surround the bottom opening of the air passage and the cover extends continuously from the bottom opening of the air passage.

15. The device of any one of claims 12 to 14, wherein the cover is formed from a substantially transparent material spaced apart from a solar energy absorbing material.

16. The device of any one of claims 12 to 15, wherein the cover includes insulation for reducing heat loss through the cover from the volume of the air that flows through the air passage from the bottom opening to the top opening.

17. The device of any one of claims 12 to 16, wherein the base is an area of ground.

18. The device of any one of claims 12 to 17, wherein the cover is inclined towards the bottom opening of the air passage.

19. A device for generating electricity from solar energy, substantially as herein described with reference to any one of the accompanying drawings of embodiments of the invention.

Figure 1

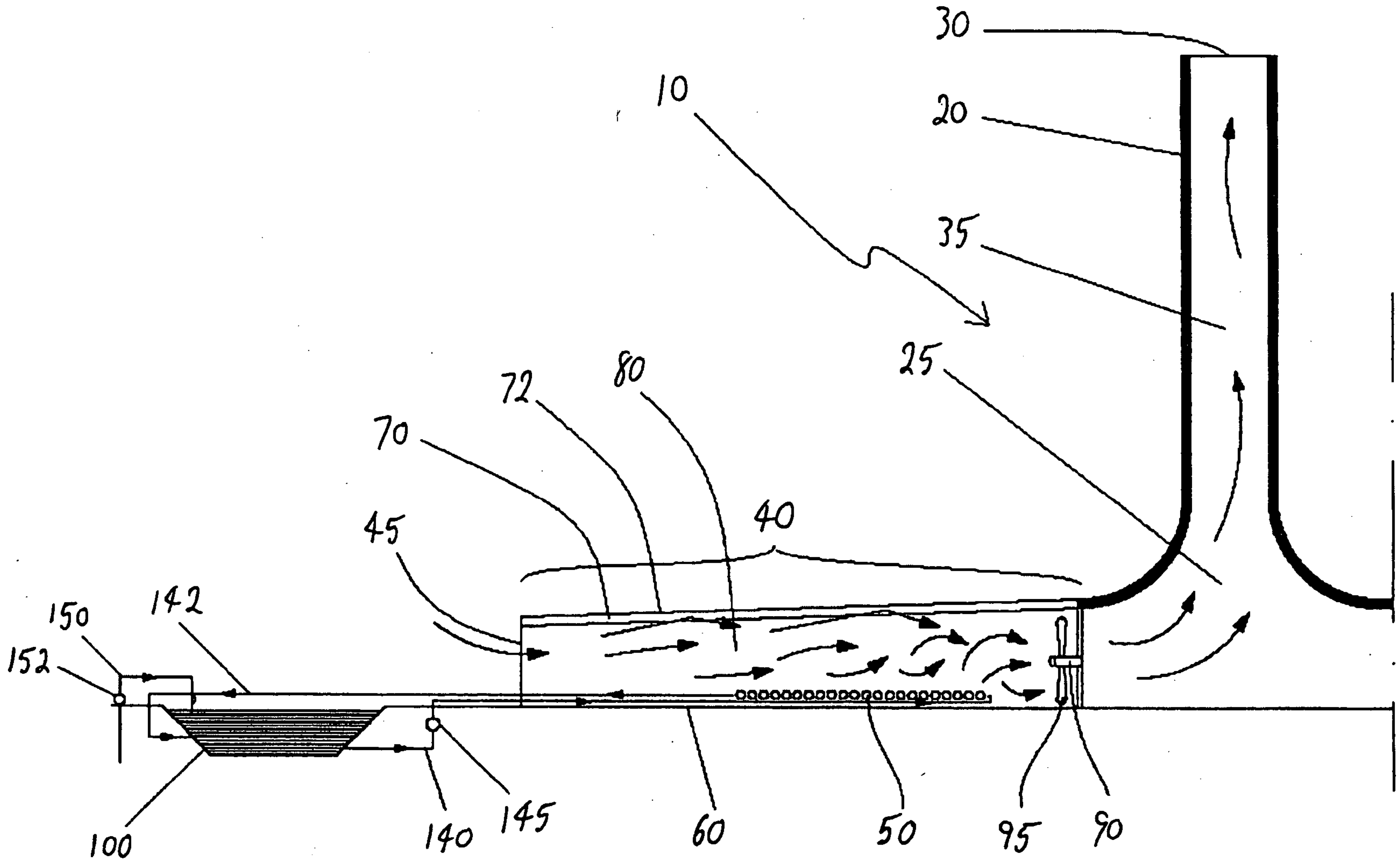

Figure 2