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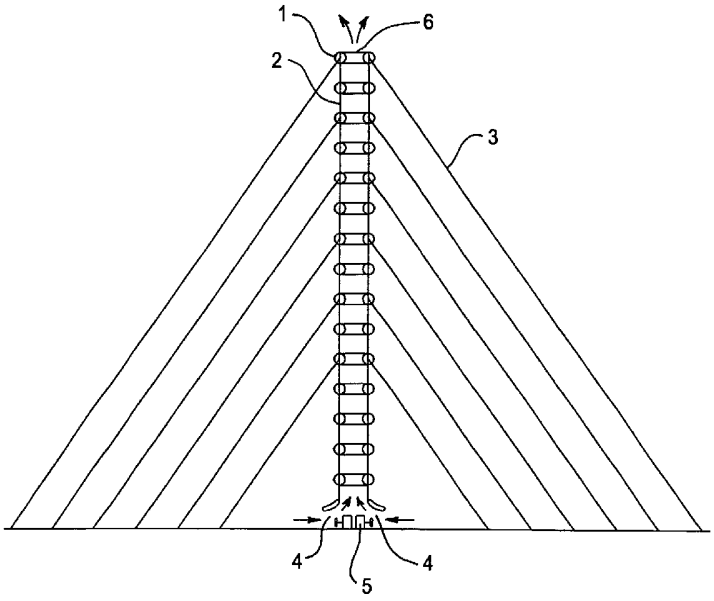

(57) Abstract: The present invention relates to improved solar towers (or solar chimneys) for the generation of power, that can be constructed of low cost, light weight materials. The towers of the present invention remain substantially upright mainly due to the inclusion of a lighter-than-air gas in the structure, or in a chamber attached to the structure. The solar towers of the present invention are therefore able to be built to great heights. Where flexible materials are used, the structure is able to bend in response to a wind force. The ability to bend provides augmentation of the normal flow of air through the tower by utilising ground wind, and the natural negative pressure that develops at the upper end of the tower. The invention also provides methods for generating power using the towers described.

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SOLAR TOWER

FIELD

The present invention relates to improved apparatus and methods for the generation of power using solar towers.

BACKGROUND

The generation of energy using solar towers (or solar chimneys) is well known. The tower generates energy by exploiting three principles: the tower, the greenhouse and the windmill. The "draw" that sustains an open-hearth fire exploits the temperature differential between the warm room and the cooler outside air, which is greatest on cold nights. Warm air rises, creating a convective flow. In the atmosphere, temperatures fall by 1°C per 100m of altitude, so the air at the top of a 1km-tall solar tower is about 10°C cooler than at the base. This differential may be amplified by feeding heated air into the tower from a vast greenhouse "skirt" around its base. The addition of a greenhouse to a solar tower raises the ambient temperature by another 10-20°C providing a total temperature differential of 20-30°C. This produces a convective airflow moving at 35km/h to 50km/h that is able to spin 32 wind turbines mounted about 40m above ground level, generating a peak output of 200MW. Power output is determined by the height of the tower, the size of the greenhouse roof and the extent to which it is glazed (single or double). The relationships are roughly proportional, i.e. doubling the height of the tower or doubling the width of the roof doubles output.

A major problem of solar towers relates to the limitations associated with building such large structures. In order to attain a practical temperature differential the tower must be at least 1,000 metres tall. At these heights wind poses a significant engineering problem, and so solar towers have been designed to withstand the associated forces. In light of this, solar towers of the prior art have generally been very expensive to construct.

One recent estimate of the total capital cost of a concrete solar tower came to AUD600-700m, including AUD270m for the collector and AUD230m for the tower. In order to lower costs, lighter weight structures built from thin-walled concrete have been proposed. Even if cost were not a consideration, structures built form traditional building materials such as concrete simply cannot be engineered to great heights.

Another attempt at designing a solar tower of alternative construction is shown in United States Patent 5,266,837 (KINOSHITA). This document discloses a tower having a wall composed of interconnected gas filled chambers constructed from a lightweight membrane. The chambers are filled with gas at pressure leading to a structure of some rigidity. A problem of this design is that the solar tower would still not be sufficiently rigid to resist winds at altitudes to which these structures need be constructed.

It is an aspect of the present invention to alleviate a problem of the prior art by providing a cost-efficient structure that is able to reach great heights and not be adversely affected by wind.

The discussion of documents, 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 or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed in Australia before the priority date of each claim of this application.

SUMMARY OF THE INVENTION

In one aspect the present invention provides an apparatus for generating an air current comprising a tower, when in use, the tower having an opening at a lower end and an opening at an upper end, the tower being adapted to allow an air current to flow through the tower between the two openings wherein the tower remains substantially upright mainly by the upward force created by

a chamber containing a lighter than air gas.

Throughout the description and the claims of this specification the word "comprise" and variations of the word, such as "comprising" and "comprises" is not intended to exclude other additives, components, integers or steps.

In another aspect the present invention provides an apparatus for generating an air current comprising a tower, when in use, the tower having an opening at a lower end and an opening at an upper end, the tower being adapted to allow an air current to flow through the tower between the two openings wherein the tower is substantially non-rigid or flexible

The applicants have surprisingly found that solar towers of great height may be constructed from unconventional building materials such as flexible plastics. This is achieved by using a lighter than air gas to provide the upward lift to maintain the structure substantially upright. The use of unconventional materials also provides a structure of a high flexibility. The flexibility of the tower provides low resistance to the wind, allowing the structure to bend when sufficient wind force is applied.

The flexibility may also be provided by the manner in which the tower is anchored to the ground. Accordingly, another aspect of the present invention provides an apparatus for generating an air current comprising a tower, when in use the tower having an opening at a lower end and an opening at an upper end, the tower being adapted to allow an air current to flow between the two openings, wherein the tower is capable of pivoting at a point proximal to the ground.

It should be understood that the invention includes various combinations of the features included in apparatus described herein.

Also provided by the present invention is a method of generating energy from an air current, the method including the use of an apparatus as described

herein. The method relies substantially on the tower height for generating the air current.

In a further aspect the present invention provides a method of maintaining a substantially consistent air current in a solar tower, the method comprising sensing an inconsistency in the air current and implementing a second source of air current if an inconsistency is detected.

In yet a further aspect the present invention provides a method of selling energy at a profit, the method including the steps of buying a energy at a first price, utilising the energy purchased at the first price as input energy to a solar tower energy generating system, and later selling the extra energy resulting from the input energy generated by the solar tower energy system at a second higher price.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a lateral view of a solar tower constructed of annular balloons, and flexible material, including stay wires. The direction of air movement is indicated with arrows.

Figure 2 shows a solar tower having a wind vane and swiveling base. The force of the wind acts to align the tower so that ground level wind is channeled into the tower. This arrangement also assists in drawing air out of the tower, thereby increasing air current through the turbine. The direction of air movement is indicated with arrows.

Figure 3 shows a solar tower that is pivoted at the base. Tilting of the tower due to wind force, acts to admit ground level wind to the base. The direction of air movement is indicated with arrows.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In one aspect the present invention provides an apparatus for generating an air current comprising a tower, when in use, the tower having an opening at a

lower end and an opening at an upper end, the tower being adapted to allow an air current to flow through the tower between the two openings wherein the tower remains substantially upright mainly by the upward force created by a chamber containing a lighter than air gas. The tower is anchored to the ground at one end and is buoyantly suspended below one or more lighter-than-air chambers attached to the upper end of the tower and/or attached at various points up the height of the tower.

In another aspect the present invention provides an apparatus for generating an air current comprising a tower, when in use, the tower having an opening at a lower end and an opening at an upper end, the tower being adapted to allow an air current to flow through the tower between the two openings wherein the tower is substantially non-rigid or flexible

The applicant has discovered that a flying lighter-than-air solar tower having the features described herein has a number of advantages. In contrast to the substantially rigid towers described in the prior art, the tower of the present invention has flexibility provided along the length of the tower or by virtue of a flexible anchorage mechanism, for example. This arrangement provides a tower of minimal wind resistance that is able to lay virtually horizontal if necessary. This means of constructing solar towers is in direct contravention to the teachings of the prior art that the tower must have sufficient rigidity to resist movement. The applicant has discovered that it is possible to provide a flexible structure that is able to perform the wind generating function required of a solar tower, while still being able to be built of lightweight materials and of a great height.

Construction difficulties and costs of building rigid towers in such designs out of concrete or steel tends to limit their height to presently around 1 kilometer. The advantage of the flying lighter-than-air tower as proposed in the present invention is that it allows a tower height of 2 to 3 kilometers or more in height and at lower construction costs.

The solution stemmed from an appreciation of the true function of the tower. To establish a solar tower effect, the tower merely needs to be capable of thermally separating air inside the tower from air outside the tower. This function does not require the structural strength of traditional building materials. Some structural strength is however required toward the base, where there is an air pressure differential between air inside and outside the tower. This pressure differential is greatest at the base and decreases to zero at the top of the tower. The pressure differential is created by the 'draw' or lower air pressure created at the base as the relatively warmer air within the tower rises and in doing so leaves a slight vacuum to draw more air in to replace it as it rises up.

Preferably the apparatus provides low resistance to the wind. A key advantage of the present invention is that it allows for the effect of strong winds that are especially problematic at higher altitudes. The flexible nature of the solar tower of the present invention allows it to flex with the wind and therefore provides low resistance to wind forces. This allows the tower to be constructed of inexpensive, flexible and lightweight materials.

In a preferred form the apparatus is used for generating power and comprises means for harnessing the kinetic energy of the air current. Many forms of harnessing energy from an air current are known to the skilled artisan. In a preferred form of the invention the means for harnessing the kinetic energy is a turbine capable of generating electricity. It is contemplated however that kinetic energy from the air current could be harnessed by any means currently known, or yet to be developed.

In one form of the invention the tower comprises one or more gas filled chambers. Preferably the chambers are filled with a lighter-than-air gas.

As discussed above, the invention requires that the solar tower be substantially non-rigid or flexible. However, in order to operate as a solar tower, the tower should remain substantially upright for at least a proportion

of the day to allow the warm air to rise from the lower end and exit at the upper end. One way of achieving this is to include one or more gas filled chambers that contain a lighter-than-air gas thereby providing an upward force. The chambers may be any size or shape, so long as they are capable of containing sufficient gas to keep the tower substantially upright in low wind conditions for at least a proportion of the day.

Preferably the tower has a height of at least about 500 metres. More preferably the tower has a height of at least about 2000 metres. In still a more highly preferred form of the invention the tower has a height of at least about 3000 metres. In some embodiments, the tower may reach a height up toward the edge of space. The final height achievable by a solar tower off the present invention depends on the materials used and the volume of lighter-than-air gas included in the structure. The height actually used for a given application will depend on many variables including the power output required, the climate of the site where the solar tower is to be located, and whether a greenhouse is used to name a few. It is well within the ability of the skilled artisan to calculate the final height necessary for a given application.

In a particularly preferred apparatus, the one or more chambers are substantially annular. With a substantially non-rigid or flexible structure as described herein, the natural tendency of warm air rising within such a tower would be to draw inwards the outer flexible walls until the tubular shape collapsed under the higher outside air pressure. Well known ribbing and/or bracing means can be utilized to prevent such collapse. Alternatively, to reduce weight and cost, multiple annular chambers could in one preferred form replace such ribbing and/or bracing. Thus one role of the annular chambers spaced throughout the height of the tower is to minimize such collapse. Preferably the annular chambers are capable of maintaining the tower in a substantially tubular form. In this embodiment donut-shaped balloon segments are inflated with helium gas under pressure to form components spaced up and throughout the tower to assist in maintaining the structure in a substantially tubular form as well as provide the required

buoyancy to hold the tower aloft. As the flexible sheeting from which the tower is formed must carry the tensile forces of it's own weight suspended below the buoyant element/s and the forces between the bouncy elements and the ground tethering point, such tensile forces can be minimized by multiple buoyancy elements being distributed up the height of the flexible tube, each only suspending the weight of smaller portions of sheeting. Alternatively the solar tower could be flatter and shaped like the tail plane of an aircraft to present less frontal area to the wind, and the inflated balloon ribs could be shaped like small protruding wings to provide lift to the entire tower as wind passes over them.

A further use for the donut balloon segments would be as potential anchoring points from which guy wires may be attached to limit the movement of the tower against wind forces. While a key feature of the tower of the present invention is its flexibility, it may be necessary to limit this flexibility in some circumstances.

Figure 1 shows a preferred embodiment of the invention. The tower is composed of a plurality of annular chambers **1** connected together with a flexible material **2**. The annular chambers are filled with a lighter-than-air gas, thereby providing buoyancy to the structure as a whole and allowing the structure to remain substantially upright. In this embodiment, there is provided means for limiting the movement of the structure by the use of a plurality of stay wires **3**. In use, air is drawn into the tower via the openings **4** thereby driving the turbines **5** resulting in the generation of electricity. The air continues up the tower until it exits at the opening **6**.

In a preferred form of the invention, in the case that the tower has one chamber, the chamber is physically connected to the ground using a flexible material. The apparatus may simply consist of one chamber to which is attached the flexible material which is attached to the ground. Alternatively by way of a further example the form may take that of a single lifting balloon at the very top of the tower from which a lightweight flexible tube of material

hangs down to the tethering point. In such a case the tubular form of the flexible tube may preferably be maintained by ribbing or light wire or other material formed into rings to hold the tube open, not dissimilar to a typical vacuum cleaner's ringed flexible hose, or spoked wheel-like structures could hold the tube open against collapse. Thus, in this form of the invention the gas-filled chamber performs only a buoyancy function, having no structural function.

The flexible material may be any substantially non-rigid or flexible material that is substantially air-tight. Materials available to the makers of blimps and of modern sails are preferable. Preferably the flexible material is selected from the group including a plastic material, a woven glass material, a Kevlar material, or any other sheet or laminate material which is strong yet light while being substantially air-tight and tear resistant. Woven glass cloth is cheap, strong, flexible, non-conductive and fire resistant. It is also long lived when exposed to the sun and other elements and is not unduly effected by ultraviolet light such as plastics are. In order to make it airtight it may be doped or laminated with some form of sealant, preferably on the inner side, which may be better protected from the elements. Such doping or laminating could be renewed over the life of the flying tower if such sealant breaks down faster over time than the glass cloth. Such re-doping may be achieved by simply spraying the glass cloth. The flexible material may be any color, or more than one color. For example, any region of the tower may be black so as to absorb heat from the sun and thereby further increasing the temperature of the internal air within the tower giving it an even greater ability to rise resulting in a greater air current.

Preferably the flexible material is capable of inhibiting heat transfer between air interior to the tower and air exterior to the tower. Given that the efficiency of a solar tower depends on the temperature differential between the top and the bottom of the tower it is preferable to provide thermal insulation in the wall of the tower. This is especially desired at the upper regions of the tower where the cold air outside the tower could cool the rising warm air inside the

tower. Of course, cooling the rising air will cause disruption or even cessation of the air current in the tower leading to a decreased ability of the tower to generate power. The thermal insulation could be provided by the flexible material itself, or by the use of multiple layers of flexible material in the wall of the tower.

In a preferred form of the invention, in the case that the tower has two or more chambers, at least two of the two or more chambers are physically connected to each other using a flexible material.

The solar tower may be connected to a solar collector, such as a greenhouse. Because air is typically around 1 degree Celsius cooler for every 100 meters of altitude, solar towers seek to use 1 kilometer high towers to provide a 10 degree Celsius differential in temperature of the air between the top and bottom of the tower. To increase this differential solar heat collectors in the form of greenhouses may be used to raise the temperature of the air at the bottom by a further 20 degrees Celsius or so. This makes the temperature differential around 30 degrees Celsius. However, the inclusion of a solar collector is strictly unnecessary in solar towers of the present invention given the great heights achievable by implementing a substantially non-rigid or flexible construction. By achieving these extreme heights the temperature differential of 30 degrees Celsius is achieved without the need for the expensive and land consuming solar collector greenhouses around the base of the tower.

In one form of the invention the upper opening of the tower has means for restricting the flow of hot air exiting the upper opening. One simple form of restriction could be inflatable bags that with greater inflation further restrict the area within the tower preferable at or near the top. The more this airflow is restricted the more the tower becomes like one large hot air balloon, providing even more buoyancy than that provided simply by the helium gas filled balloon segments. Such extra buoyancy may be useful in countering strong winds that may otherwise try to blow the tower over against it's natural

tendency to stand upright. In fact even the normal wind turbine generators at the base used to draw off power could be switched to being driven from the electric power grid and become fans to blow air up into the tower. In rare times of very high winds this would help to firm up the structure, especially if the outflow of air at the top of the tower is restricted.

Preferably, the solar tower comprises means for dissipating electrical energy. A solar tower may be hit from time to time by lightning and a lightning conducting cable could preferably be held by non-conducting guidelines so as to run down the centre of the tower tube. Lightning rods could extend outward from this cable and pass through the outer tube via the use of heat and electricity insulators. Indeed, such lightning conducting cable could be weaved into a flat or tubular loose form such that it heats up when conducting lightning and like a radiator element dissipates some of that lightning energy as heat into the rising air within the tower, adding to the power generation. Alternatively, if the flying tower is stayed by guy wires then these could be used as lightning conductors.

Figure 2 shows a preferred form of the invention where the solar tower comprises a base **1** and a rigid or flexible skirt **2** fitted between the tower and the ground capable of capturing wind at ground level. The wind capturing opening **3** of such a skirt could be larger and more enhanced than shown in the Figure. This would preferably add the additional power source of wind to that of the thermal rising air power that the flying tower is primarily designed to convert into electrical power. Such a skirt at the base may be attached to the solar tower and the ground by a sliding means **4** such that it may direct the opening **3** into any prevailing wind. Such directional control of the skirt may be by automatic powered means, controlled by a computer, wind sensors and actuators. Alternatively such directional control could be achieved manually or by a wind-vane effect by attaching wind-vanes **5** to the skirt so that wind pressure directs the sliding of the skirt so as to direct it's opening towards the oncoming wind.

The solar tower may also comprise a wind enhancing directional vent **6** at the top of the structure as shown in Figure 2. Such a directional vent would also capture the additional energy of any wind at the top of the flying tower to aid in drawing out exhaust air from the top of the flying tower by aerodynamic means. Such a directional vent may be rigidly attached to the flying tower and the flying tower would be pivotally attached to the ground. This arrangement would allow the entire tower and directional vent to align itself with prevailing winds at the top of the tower (either by automated powered means similar to the skirt as above, or alternatively by wind-vane effect) such that the vent exhaust opening faces away from the oncoming wind. Alternatively the directional vent may be attached by sliding means to the top of the flying tower such as to allow it to rotate directionally and freely from the flying tower. Such directional control of the directional vent may also be by automated or by wind-vane means. As the wind passes about the directional vent then the aerodynamically induced lower air pressure, on the downwind exhaust vent opening side of the directional vent, helps draw air out of the flying tower faster than may otherwise occur, adding to the energy the flying tower may convert into electricity.

In a further aspect the present invention provides an apparatus for generating an air current comprising a tower when in use the tower having an opening at a lower end and an opening at an upper end, the tower being adapted to allow an air current to flow between the two openings, wherein the tower is capable of pivoting at a point proximal to the ground. Figure 3 shows a solar tower demonstrating this embodiment. The solar tower may be constructed so that its anchor point **1** provides flexibility to the structure as a whole. This could be achieved for example by a gimbal and airtight surrounding boot (not shown). This arrangement would allow the tower to lay over in strong wind even if land based or attached atop a rigid tower.

Where the tower is pivotally attached to the ground or other anchorage point it may lean over in the wind and swing about the anchorage point thereby acting as a wind vane. This would allow the flying solar tower to transition

between being a purely thermal solar tower in calm, still air to that of effectively a ducted wind powered wind turbine. Such can be seen in Figure 3. To aid in this capacity the top **2** and bottom **3** of the solar tower may be trumpet-shaped so as to help direct additional wind into and draw rising air out of the tower as it lays over on it's pivotal support. It will be understood that in this embodiment of the invention it is not necessary for the shaft of the tower to be non-rigid or substantially flexible. Indeed, the apparatus described in United States Patent 5,266,837 could be used in this form of the invention provided that it utilizes sufficient lighter-than-air gas in the chambers so that the shaft of the tower as a whole is buoyant in air.

When a pivotally anchored solar tower lays over in the wind it will reach a state of equilibrium at a position where lifting forces equals the wind force. Such lifting forces arise from the lift of the helium filled balloon sections plus the lift of a slight hot air balloon effect as the warmer air within the lain over solar tower, especially near the top, provides an upper vector force on the upper inner side of the tower. Additional lift can come from aerodynamic surfaces or forms being added to the solar tower, which engage with any wind passing over or about the solar tower. As wind force tries to push the tower over such wing or kite shaped surfaces at or near the top and other sections of the tower could advantageously provide a lifting force on the tower. Such wings or aerodynamic surfaces may be static or manually/automatically movable to produce optimum lift so as to provide an up-righting effect on the tower to counteract leaning over in wind.

In another aspect the present invention provides a method of generating energy from an air current, the method including the use of an apparatus described herein. It is anticipated that the method typically relies on an air current flowing from the lower opening to the upper opening. However, the method is not so limited and may also include utilising an air current generated by cold air entering the upper opening and exiting the lower opening.

In a preferred form of the method the solar tower is land-based or sea-based. The solar tower may be sea-based either tethered to an underwater structure or anchored barge or similar. This has the added advantage that in large storms substantially non-rigid or flexible tower structure if unstayed could be blown over even to the extent of touching the sea, but be designed to withstand this without any damage. An advantage of positioning the tower over or near a body of water is that the electrical power it produces could be used to electrolyze water so as to produce hydrogen gas or oxygen gas. These gases could be compressed and cooled on-site from stores or directly from the electrolysis process by cryogenic processes so as to produce liquid hydrogen and or liquid oxygen to be piped or shipped from the site for such use as hydrogen powered cars. The waste heat from such cryogenic compression and cooling of the gases into their liquid form could be directed up the solar tower so as to be substantially reclaimed. The management of when electrolysis and or cryogenic activity occurs at the site could preferably be controlled by automated and computerized systems to optimize the efficient power production of the tower with regard to time of day, ambient wind speeds and ambient temperatures etc. Thus cryogenic activity may preferably occur say more at night when the waste heat could maintain up-flow through the solar tower for example.

The method may include the use of ancillary structures such as a green house to warm incoming air. Additionally gas, coal, or oil could be burned so as to vent warm air into the base of the tower to provide additional updraft up the solar tower. These could be dedicated fires or the heat and exhaust could be secondary to some other primary use such as gas fired electricity generation or industrial steam generation etc or any other waste heat source, such a that given off by the cryogenic process of compressing and cooling natural gas into it's liquid form.

Preferably the method relies substantially on the tower height for generating the air current. Because the construction of the solar tower described herein allows for a tower of great height, large temperature differentials between the

lower and upper openings may be generated. This leads to structures such as green houses being inessential.

In one form of the method, the method comprises movement of the tower from a substantially upright position to a position wherein a substantially acute angle is defined between a wall of the tower and the ground thereby increasing the air current through the tower. Because a solar tower of the present invention may have minimal wind resistance, it is possible that the tower will substantially lean over, and possibly even touch the ground. Preferably the mechanism for increasing air current through the tower is the venturi effect or a venturi-like effect. An advantage of the venturi effect is that air is drawn out of the tower faster, thereby increasing efficiency of the soar tower.

In another aspect the present invention provides a method of maintaining a substantially consistent air current in a solar tower, the method comprising sensing an inconsistency in the air current and implementing a second source of air current if an inconsistency is detected. It is contemplated that a solar tower may experience inconsistency in air current flow through the tower, leading to a "stall" of the thermal flow. This may occur in cold overnight conditions for example. In response to this undesirable scenario the tower's wind generators may (either by manually or by automatic control via computers, programming and sensors) draw power from the electricity grid (purchased preferably at low off peak prices) and become fans to blow air up the tower to maintain the thermal flow and prevent it from stalling. Equally the solar tower could draw power from the grid to spin its turbines at off peak prices just before the morning changeover to peak power needs as industry and commerce begin the days activity.

In another aspect the present invention provides a method of selling energy at a profit, the method including the steps of buying a energy at a first price, utilising the energy purchased at the first price as input energy to a solar tower energy generating system, and later selling the extra energy resulting

from the input energy generated by the solar tower energy system at a second higher price. The turbines may be used as fans to boost the tower's thermal up-flow of air at off-peak energy rates so that the energy can be redrawn in peak power time from that extra airflow to provide higher priced power for sale. Thus the inertial forces of the up-flow of air within the tower acts as a store of energy to be redrawn, thereby providing a profitable outcome.

CLAIMS

1. An apparatus for generating an air current comprising a tower, when in use, the tower having an opening at a lower end and an opening at an upper end, the tower being adapted to allow an air current to flow through the tower between the two openings wherein the tower remains substantially upright mainly by the upward force created by a chamber containing a lighter than air gas.

2. An apparatus for generating an air current comprising a tower, when in use, the tower having an opening at a lower end and an opening at an upper end, the tower being adapted to allow an air current to flow through the tower between the two openings wherein the tower is substantially non-rigid or flexible

3. An apparatus according to claim 2 wherein the flexibility of the tower provides low resistance to the wind.

4. An apparatus according to claim 1 or 2 comprising means for harnessing the kinetic energy of the air current.

5. An apparatus according to claim 1 or 2 comprising one or more gas filled chambers.

6. An apparatus according to claim 5 wherein the chambers are filled with a lighter-than-air gas.

7. An apparatus according to claim 1 or 2 wherein the tower has a height of at least about 500 metres.

8. An apparatus according to claim 1 or 2 wherein the tower has a height of at least about 2000 metres

9. An apparatus according to claim 1 or 2 wherein the tower has a height of at least about 3000 metres.

10. An apparatus according to claim 1 or 2 wherein the tower has a height toward the edge of space.

11. An apparatus according to claim 5 wherein the one or more chambers are substantially annular.

12. An apparatus according to claim 11 wherein the annular chambers are capable of maintaining the tower in a substantially tubular form.

13. An apparatus according to claim 5 wherein, in the case that the tower has one chamber, the chamber is physically connected to the ground using a flexible material.

14. An apparatus according to claim 5 wherein, in the case that the tower has two or more chambers, at least two of the two or more chambers are physically connected to each other using a flexible material.

15. An apparatus according to claim 13 or 14 wherein the flexible material is selected from the group including a plastic material, a woven glass material, and a Kevlar material.

16. An apparatus according to claim 13 or 14 wherein the flexible material is capable of inhibiting heat transfer between air interior to the tower and air exterior to the tower.

17. An apparatus according to claim 1 or 2 comprising a solar collector.

18. An apparatus according to claim 1 or 2 wherein one opening of the tower has means for restricting the flow of air exiting the opening.

19. An apparatus according to claim 1 or 2 comprising a base or a skirt fitted between the tower and the ground.

20. An apparatus for generating an air current comprising a tower, when in use the tower having an opening at a lower end and an opening at an upper end, the tower being adapted to allow an air current to flow between the two openings, wherein the tower is capable of pivoting at a point proximal to the ground.

21. A method of generating energy from an air current, the method including the use of an apparatus according to any one of claims 1, 2 or 20.

22. A method according to claim 21 wherein the method relies substantially on the tower height for generating the air current.

23. A method according to claim 21 wherein the method comprises movement of the tower from a substantially upright position to a position wherein a substantially acute angle is defined between a wall of the tower and the ground thereby increasing the air current through the tower.

24. A method according to claim 23 wherein the mechanism for increasing air current through the tower is the venturi effect or a venturi-like effect.

25. A method of maintaining a substantially consistent air current in a solar tower, the method comprising sensing an inconsistency in the air current and implementing a second source of air current if an inconsistency is detected.

26. A method of selling energy at a profit, the method including the steps of buying a energy at a first price, utilising the energy purchased at the first price as input energy to a solar tower energy generating system, and later selling the extra energy resulting from the input energy generated by the solar tower energy system at a second higher price.

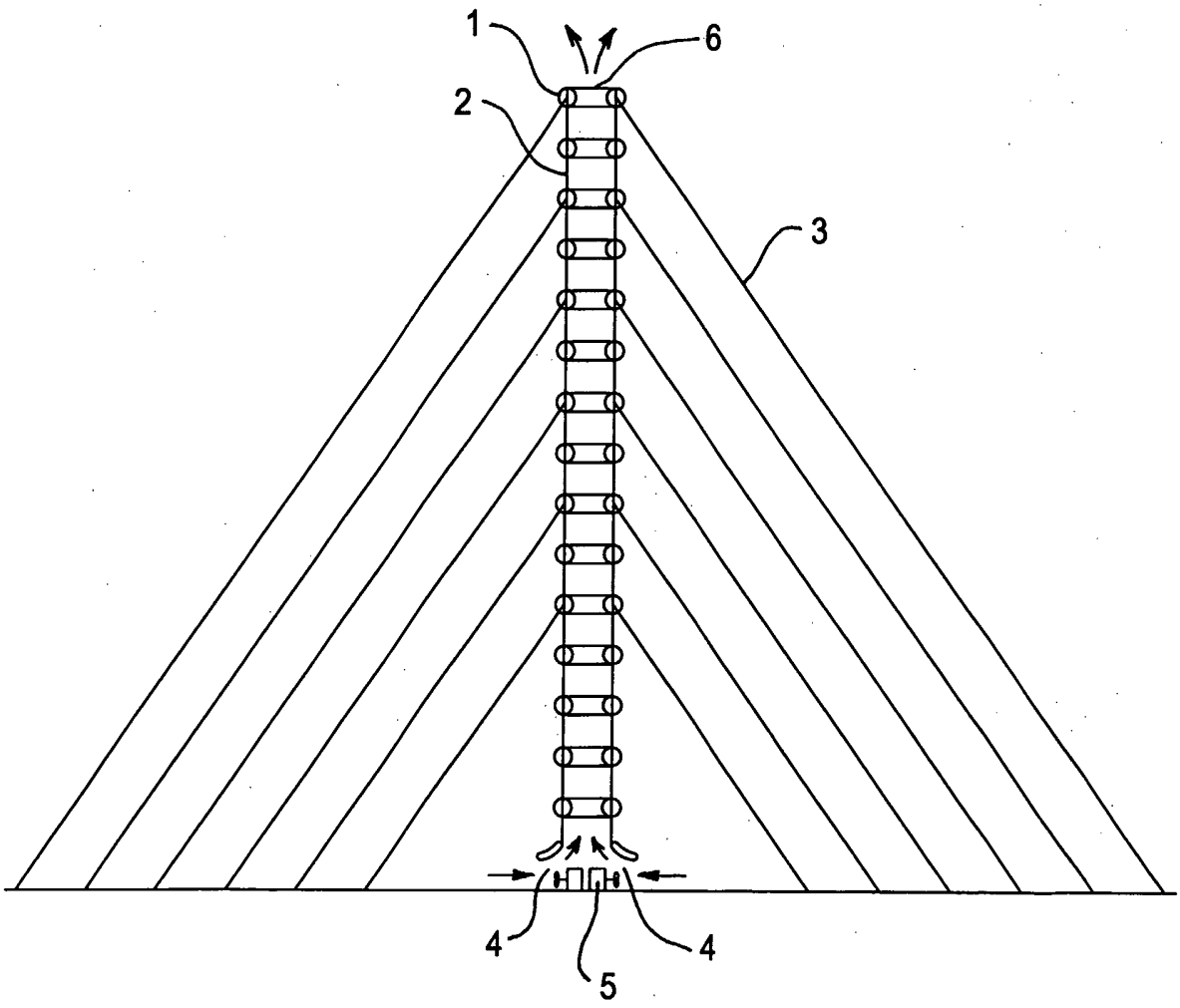
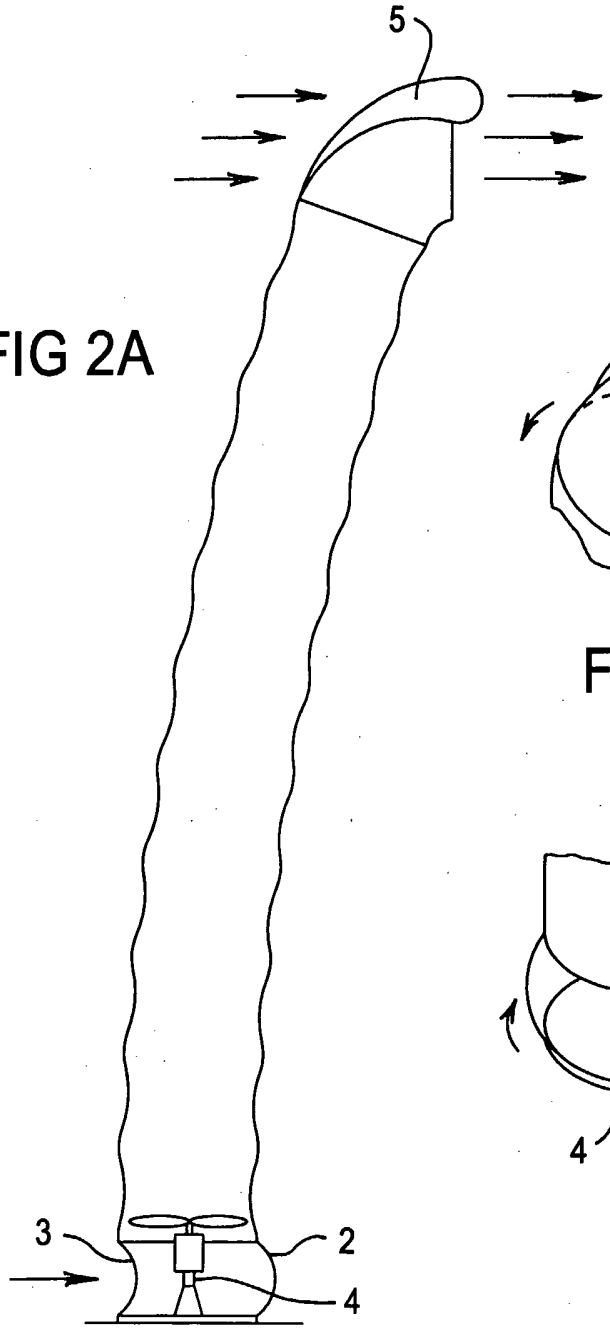


FIG 1

FIG 2A



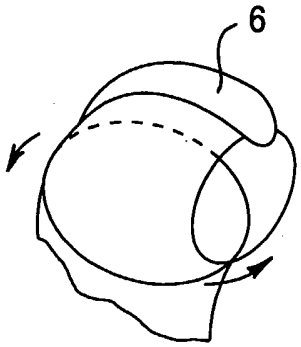


FIG 2C

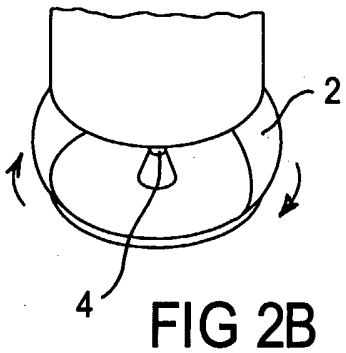


FIG 2B

FIG 3B

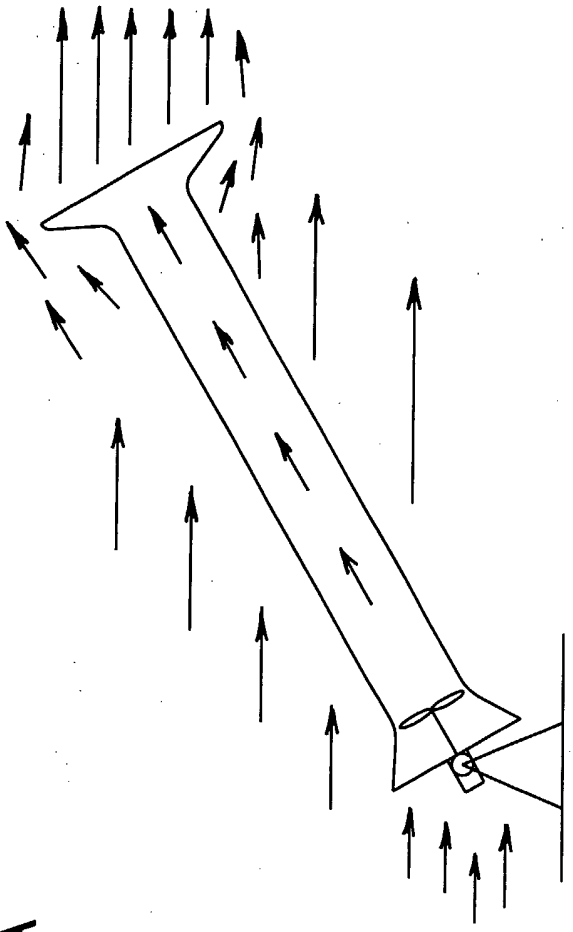
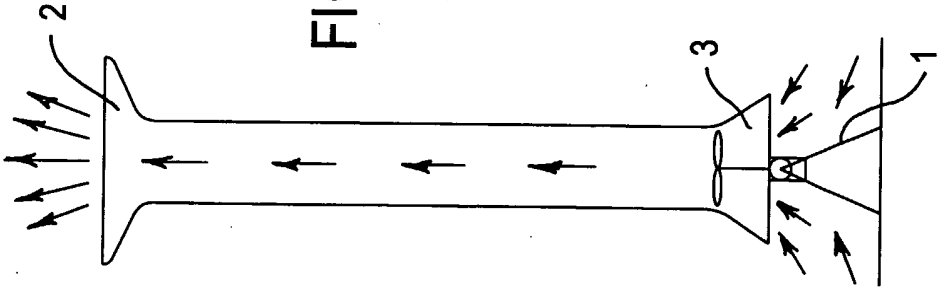


FIG 3A



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/01362

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: F03G 7/04, 6/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC F03G 7/04, 6/04

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI IPC F03D, F03G & keywords: air, solar, chimney, tower, flue.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 5266837 A (KINOSHITA) 30 November 1993	
X	Whole document	1 - 19, 21 - 23
Y	Whole document	24
	DE 29622549 U1 (DRABNER) 7 May 1997	
X	Whole document	1 - 12, 17 - 19 21 - 23
Y	Whole document	24
	DE 3918764 A (KERN) 10 January 1991	
X	Whole document	1 - 12, 17 - 19 21 - 23
Y	Whole document	24

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 November 2003	23 DEC 2003
Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	**B. NGUYEN** Telephone No : (02) 6283 2306

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/01362

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 01/96740 A (DRUCKER) 20 December 2001 Page 4 lines 15 - 24, Fig 2	24

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/01362

Box I Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos :

because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos :

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos :

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

As reasoned on the extra sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1 - 24

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/01362

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No:

The different inventions are:

1. Claim 1 directed to an apparatus for generating an air current comprising a tower characterised by the tower remaining upright mainly by the upward force created by a chamber containing a lighter than air gas.

2. Claims 2 to 19 directed to an apparatus for generating an air current comprising a tower characterised by the tower being substantially non-rigid or flexible.

3. Claims 20 to 24 directed to an apparatus for generating an air current comprising a tower wherein the tower is capable of pivoting at a point proximal to the ground.

4. Claim 25 directed to a method of maintaining a substantially consistent air current in a solar tower.

5. Claim 26 directed to a method of selling energy at a profit.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU03/01362

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	5266837	JP	5280462				
DE	29622549	NONE					
DE	3918764	NONE					
WO	01/96740	AU	67224/01	BR	0111846	CA	2412686
		EP	1290342				

END OF ANNEX