

## **SOLAR POWER GENERATOR**

### **Field of the Invention**

**[0001]** The present invention generally relates to solar power technology, and in particular, to a solar power generator capable of automatic solar tracking and self-protection against adverse ambient conditions.

### **Background of the Invention**

**[0002]** Sunlight is an inexhaustible energy source in nature, which provides heat and light directly, and can be converted to produce electric power as well. Compared to conventional energy sources such as coal and natural gas, sunlight is a much cleaner energy source, with less emissions of air pollutants and greenhouse gases during the power generation process. Therefore, countries around the world are increasing their efforts to harness solar power as an essential alternative energy source, for the sake of environmental protection and sustainable economic development.

**[0003]** However, so far the use of sunlight for power generation, especially for electricity generation, is still limited for certain reasons. The construction cost of a solar power generator remains high. And due to inefficient energy conversion, of the excessive number of photovoltaic cells is required to meet certain energy supply, which not only increases the cost, but also leads to more space occupation. In addition, solar power generators are prone to wear and tear, in particular under harsh weathers, such as sandstorm, raining and snowing. The expense for frequent maintenance and repair contributes to additional operation cost.

**[0004]** In view of the above-mentioned problems, there is a need for a new generation of solar power generator, which is cost effective, high energy saving and durable.

### **Summary of the Invention**

**[0005]** The present invention provides a solar power generator, which comprises a support, a solar concentrator mounted on the support for reflecting and concentrating the incident sunlight, a plurality of photovoltaic cells for receiving the reflected light from the solar concentrator and converting the solar power into electric power, a mechanical system for regulating the position of the solar concentrator in both horizontal and vertical orientations, a solar tracking sensor for determining the relative orientation of the solar concentrator to the incident sunlight, a day/night sensor for detecting the transition from day to night, a rain/snow sensor for detecting rainfall and snowfall, and a control circuit for receiving and processing the signals from the solar tracking sensor, day/night sensor and rain/snow sensor, and actuating the mechanical system.

**[0006]** According to another aspect of the invention, there is provided a solar power generator, wherein the control circuit in response to the signal from the solar tracking sensor, is operable to actuate the mechanical system, so that the solar concentrator remains oriented towards the sun during the day.

**[0007]** According to yet another aspect of the invention, there is provided a solar power generator, wherein the control circuit is operable to actuate the mechanical system to rotate the solar concentrator to a first pre-determined position and to stop the solar tracking, when the day/night sensor signals the transition from day to night.

**[0008]** According to further another aspect of the invention, there is provided a solar power generator, wherein when the rain/snow sensor signals rainfall/snowfall, the control circuit is operable to actuate the mechanical system to rotate the solar concentrator to a second pre-determined position, so that the components mounted on the solar concentrator are shielded from the rain/snow.

**[0009]** The objectives and advantages of the present invention will become apparent from the following detailed description of embodiments thereof in connection with the accompanying drawings.

### **Brief Description of the Drawings**

**[0010]** Preferred embodiments according to the present invention will now be described with reference to the Figures accompanied herein, in which like reference numerals denote like elements.

**[0011]** FIG. 1 shows a side view of a solar power generator in accordance with one embodiment of the present invention.

**[0012]** FIG. 2 shows a front view of the solar power generator as illustrated in FIG. 1.

**[0013]** FIG. 3 shows a top view of the solar power generator as illustrated in FIG. 1.

**[0014]** FIG. 4 shows a cross sectional view of the light sensor as illustrated in FIG. 1.

**[0015]** FIG. 5 shows a circuit diagram of the control circuit in accordance with one embodiment of the present invention.

### **Detailed Description of the Invention**

**[0016]** The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

**[0017]** Now referring to FIG. 1, 2 and 3, there is provided a solar power generator **1** in accordance with one embodiment of the present invention. FIG. 1 is a side view of the solar power generator **1**; FIG. 2 a front view; and FIG. 3 a top view. The solar power generator **1** comprises a support **2**, a solar concentrator **3** mounted thereon for collecting and concentrating solar radiation, a plurality of photovoltaic cells **4** for converting the received radiation energy to electric power, a mechanical system **5** for regulating the orientation of the solar concentrator **3**, a sensing system **6** for detecting irradiance and ambient conditions, and a control circuit **7** (not shown in FIGs. 1-3) for receiving signals from the sensing system **6** and instructing the mechanical system **5** accordingly.

**[0018]** The support **2** has a base **21** for being secured to any supporting surface. An upright U-shaped support member **22** is mounted thereon via a bracket **23**. The upper end of the bracket **23** is welded to the bottom of the U-shaped support member **22**, whilst the lower end is rotably connected to the base **21**. The upright U-shaped support member **22** further has one horizontal structure **24** attached to the upper end of each arm to rotably support a horizontal shaft **25**.

**[0019]** The solar concentrator **3** has a frame **32** attached to the horizontal shaft **25**. A plurality of reflective mirrors **31** disposed on the frame **32** for receiving, reflecting and concentrating solar radiation energy. Between each two adjacent reflective mirrors **31**,

there is gap **33** for breaking the flow of the air over the surface of the reflective mirrors **31**, thereby reducing the impact of tangential force thereon.

**[0020]** In one embodiment of the frame, the frame **32** is arch-shaped as shown in FIG. 1 and 2. In another embodiment, the frame **32** is semi-spherical.

**[0021]** A support member **41** is mounted at the focal line of the solar concentrator **3**. The plurality of photovoltaic cells **4** are disposed thereon, for receiving solar radiation energy reflected by the solar concentrator **3** and converting the input solar energy to electric output. Electric wires may be connected to the photovoltaic cells **4** for transferring the generated electric power to a storage battery or to any electric appliance.

**[0022]** In one embodiment, the photovoltaic cells **4** are preferably disclosed in Chinese Patent Application No. 200310103395.X.

**[0023]** Still referring to FIG. 1, 2 and 3, the mechanical system **5** is provided for adjusting the orientation of the solar concentrator **3**, which has a first **51a** and a second **51b** worm gear sets for rotating the solar concentrator **3** in the horizontal and vertical orientation respectively. Each worm gear set **51** comprises a worm wheel **52**, a worm **53** meshing with the worm wheel **52** and a reversible motor **54** connected to the worm **53** for driving the rotation thereof. The first reversible motor **54a** is mounted on the base **21**; the first worm **53a** is attached to the output end of the first reversible motor **54a**; and the first worm wheel **52a** is coaxially installed on the lower end of the bracket **23**. When the first reversible motor **54a** is actuated, the rotary motion of the worm **53a** drives the rotation of the U-shaped support member **22** about the Z-axis as shown in FIG. 1, thus changing the horizontal orientation of the solar concentrator **3**. The second reversible motor **54b** is mounted on one arm of the U-shaped support member **22**; the second worm **53b** is attached to the output end of the second reversible motor **54b**; and the second worm wheel **52b** is coaxially installed on the horizontal shaft **25**. When the second reversible motor **54b** is actuated, the horizontal shaft **25** rotates about the X-axis, thus changing the vertical orientation of the solar concentrator **3**.

**[0024]** The actuation of the mechanical system **5** for position adjustment of the solar concentrator **3** is regulated by the control circuit **7** in response to signals generated by the sensing system **6**. The automatic self-regulation is designed to enable solar tracking for optimal solar collection in daytime, to disable solar tracking at night for energy saving, and

to shield from rain/snow the reflecting surface of the solar concentrator **3** and the other components mounted thereon.

**[0025]** Referring to FIG. 1, the sensing system **6** comprises a solar tracking sensor **61** installed on the support member **41** for measuring the irradiance of the sun so as to track the sun movement in a day, a day/night sensor **62** for sensing ambient light intensity so as to determine the transition from day to night, and a rain/snow sensor **63** for detecting exposure to fluid so as to identify rainfall/snowfall.

**[0026]** The day/night sensor **62** is installed at one side of the U-shaped support member **22**. In one embodiment, the day/night sensor **62** is a light dependent resistor. In another embodiment, the day/night sensor **62** is a photoelectric sensor.

**[0027]** The rain/snow sensor **63** is disposed on one of the upper ends of the U-shaped support member **22**. In one embodiment, the rain/snow sensor **63** is a fluid electrode. In another embodiment, the rain/snow sensor **63** is a temperature and humidity detector.

**[0028]** Now referring to FIG. 4, there is provided a cross sectional view of the solar tracking sensor **61** in accordance with one embodiment of the present invention. The solar tracking sensor **61** has a cylindrical body **611**, and four light sensing elements **612** evenly distributed in the four quadrants. The signals generated by the light sensing elements **612** cooperatively indicate the relative position of the solar concentrator **3** to the incident sunlight in the horizontal and vertical orientations.

**[0029]** In one embodiment, the light sensing elements **612** are photodiodes.

**[0030]** Now referring to FIG. 5, there is provided a diagram of the control circuit **7** in accordance with one embodiment of the present invention. The control circuit **7** has four sub-circuits **72a**, **72b**, **72c**, and **72d** for controlling the orientation of the solar concentrator **3** in relation to the east, west, south and north directions respectively. The input terminal of each sub-circuit is connected to one of the light sensing elements **612** that senses solar radiation in the corresponding direction. The output terminals of the sub-circuits **72a** and **72b** are connected to the first reversible motor **54a** for cooperatively controlling the on/off status and rotation direction thereof. Likewise, the output terminals of the sub-circuits **72c** and **72d** are connected to the second reversible motor **54b**. Each sub-circuit **72** further includes a constant voltage DC power supply; a signal regulating circuit for selectively transmitting and amplifying input signals, and outputting a regulated signal; and a logic

circuit **75** for processing the regulated signal and sending an output signal to the corresponding reversible motor **54**.

**[0031]** In the embodiment as shown in FIG. 5, each of the light sensing elements **612** is composed of an infrared photodiode **PD** and a photo coupler **PC**. And each of the logic circuit includes a plurality of diodes **D** and a transistor **Q** for signal processing, a reply **J** associated with one of the reversible motor **54** for actuating the rotation thereof, and a positioning transducer **K** for halting the rotation thereof once the solar concentrator **3** reaches a pre-determined limit position.

**[0032]** In view of the similarity in operation principles of the sub-circuits **72** for solar tracking, only the ones for adjusting the horizontal position of the solar concentrator **3** are describe herein. When only the photodiode **PD1** is incidentally illuminated, indicating the misalignment of the solar concentrator **3** with the incident sunlight, the photo coupler **PC1** is conducted due to the dramatically reduced resistance of the photodiode **PD1**. Sequentially, the transistor **Q1** is saturated; the relay **J1** is energized; and the first reversible motor **54a** is switched on to rotate in a first direction. As a result, the solar concentrator **3** is re-directed towards the incident sunlight. Likewise, when only the photodiode **PD2** is illuminated, the relay **J2** is energized and the relay **J1** remains de-energized. Consequently, the first reversible motor **54a** is switched on to rotate in a second direction. When the solar concentrator **3** is in alignment with the sunlight, both of the photodiodes **PD1** and **PD2** are of low resistance. Hence, both of the relays **J1** and **J2** are energized, which switches off the first reversible motor **54a**.

**[0033]** Still referring to FIG. 5, in this embodiment, the day/night sensor **62** is a light dependent resistor **LDR**, which is connected to the sub-circuit **72a** via a day/night differentiation circuit **76**. The day/night differentiation circuit **76** also includes the position transducer **K1**, and a photo coupler **PC5**. In operation, when the ambient light intensity reduces, the resistance of the light dependent resistor **LDR** rises. Once the resistance thereof exceeds a pre-determined value, the photo coupler **PD5** is conducted, indicating the transition of day to night. Sequentially, the transistor **Q1** is saturated, which cause the first reversible motor **54a** to rotate in the first direction so as to direct the solar concentrator **3** towards the east. Once the solar concentrator **3** reaches the pre-determined limit position, the position transducer **K1** is conducted, so that the first reversible motor **54a** is halted.

**[0034]** In addition, the rain/snow sensor **63** is connected to the sub-circuit **72c** for signaling. In this embodiment, the rain/snow sensor **63** is a fluid electrode **R**. During rainfall/snowfall, the fluid flowing over the surface of the fluid electrode **R** triggers an electric signal, which actuates the rotation of the second reversible motor **54b** to turn the solar concentrator **3** downward, thereby reducing the chances of damage to the components mounted on the solar concentrator **3**.

**[0035]** While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

### Claims

1. A solar power generator comprising:
  - a support;
  - a solar concentrator mounted on the support for reflecting and concentrating the incident sunlight;
  - a plurality of photovoltaic cells for receiving the reflected light from the solar concentrator and converting the solar power into electric power;
  - a mechanical system for regulating the position of the solar concentrator in both horizontal and vertical orientations;
  - a solar tracking sensor for determining the relative orientation of the solar concentrator to the incident sunlight;
  - a day/night sensor for detecting the transition from day to night;
  - a rain/snow sensor for detecting rainfall and snowfall; and
  - a control circuit for receiving and processing the signals from the solar tracking sensor, day/night sensor and rain/snow sensor, and actuating the mechanical system.
2. A solar power generator of claim 1, wherein the solar tracking sensor comprises four light sensing elements, corresponding to the east, west, south and north direction respectively.
3. A solar power generator of claim 2, wherein each light sensor comprises an infrared a photodiode and a photo coupler.
4. A solar power generator of claim 1, wherein the control circuit is operable to actuate the mechanical system in response to the signal from the solar tracking sensor, so that the solar concentrator remains oriented towards the sun during the day.
5. A solar power generator of claim 1, wherein the day/night sensor is a light dependent resistor.

6. A solar power generator of claim 1, wherein the control circuit is operable to actuate the mechanical system to rotate the solar concentrator to a first pre-determined position, when the day/night sensor signals the transition from day to night.
7. A solar power generator of claim 6, wherein the solar concentrator faces the east when rotated to the first pre-determined position.
8. A solar power generator of claim 1, wherein the rain/snow sensor is a fluid electrode.
9. A solar power generator of claim 1, wherein the rain/snow sensor is a humidity sensor.
10. A solar power generator of claim 1, wherein the control circuit is operable to actuate the mechanical system to rotate the solar concentrator to a second pre-determined position, when the rain/snow sensor signals rainfall/snowfall.
11. A solar power generator of claim 10, wherein the solar concentrator faces downward when rotated to the second pre-determined position.
12. A solar power generator of claim 1, wherein the support comprises:
  - a base for being secured to any supporting surface;
  - a vertical support member rotably mounted on the base; and
  - a horizontal shaft rotably supported by the vertical support member, wherein the solar concentrator is attached to the horizontal shaft.
13. A solar power generator of claim 12, wherein the mechanical system comprises:
  - a first worm gear set for rotating the solar concentrator in the horizontal orientation, which has a first worm wheel connected to the vertical support member, a first worm meshed with the first worm wheel, and a first reversible motor attached to the first worm for driving the rotation thereof; and

a second worm gear set for rotating the solar concentrator in the vertical orientation, which has a second worm wheel coupled to the horizontal shaft, a second worm meshed with the second worm, and a second reversible motor attached to the second worm for driving the rotation thereof.

14. A solar power generator of claim 13, wherein the control circuit comprises:
  - a first and a second sub-circuits for outputting signals to the first reversible motor so as to control the on/off status and rotation direction thereof; and
  - a third and a fourth sub-circuits for outputting signals to the second reversible motor so as to control the on/off status and rotation direction thereof;wherein
  - the day/night sensor is connected to one of the first or second sub-circuits
  - the rain/snow sensor is connected to one of the third or fourth sub-circuits;and
  - each sub-circuit is connected to the solar tracking sensor, and comprises a power supply, a signal regulating circuit for selectively transmitting and amplifying signals from the sensing system and generating a regulated signal, and a logic circuit for receiving and processing the regulated signal and sending output signal to the connected reversible motor;
15. A solar power generator of claim 1, wherein the solar concentrator comprises
  - a frame; and
  - a plurality of reflecting mirrors disposed on the frame;wherein there is a gap between each two adjacent reflecting mirrors.
16. A solar power generator of claim 1, wherein the photovoltaic cells are disposed on the focal line of the solar concentrator.
17. A solar power generator of claim 1, wherein the photovoltaic cell has the configuration as claimed in Chinese Patent Application Number 200310103395.X