APPARATUS FOR TRACKING SOLAR RADIATION

FIELD OF THE INVENTION

The present invention relates to a tracking apparatus for tracking solar radiation from the sun. The apparatus has particular application in rotating solar panels and other solar devices during a daytime period to maintain the efficiency of the device.

BACKGROUND OF THE INVENTION

Solar panels comprising arrays of photovoltaic cells for generating electricity from incident solar radiation are well known. However, the efficiency with which the electricity is generated varies as the angle of incidence of the solar radiation changes during the day. For maximum efficiency, the solar panel should be maintained substantially perpendicularly to the direction of the solar radiation. Similarly, other solar devices such as reflectors need to face the solar radiation for effective operation.

A tracking apparatus for tracking solar radiation is described in International Patent Application No. WO 2005/019542. That apparatus comprises a balance incorporating a frame pivotally mounted on a stand. A pair of spaced apart tanks partially filled with a liquid refrigerant are arranged on the frame. The interiors of the tanks are connected together through the passageway of a conduit. A shade panel lies alongside each side tank for shading the corresponding tank from behind. A reflective surface on a front side of each shade panel reflects heat onto the corresponding tank when the tank is facing the sun. The tanks are arranged such that in use, a first of the tanks is exposed to the sun to a greater degree than the other. As the first tank is heated by the sun the pressure of the refrigerant in the tank increases creating a pressure differential between the tanks causing refrigerant to progressively flow from the first tank to the other through the connecting conduit. As the refrigerant flows into the second tank the weight of that tank becomes heavier than the first causing the frame of the balance to pivot about a pivot axis. A drive shaft is rotated by the pivoting of the frame to drive rotation of a reflector in a westerly direction to substantially track the solar radiation.

At the end of the daylight period when the heat of the sun decreases, the pressure differential between the tanks reduces and the direction of flow of the refrigerant through the connecting conduit reverses. The return of the refrigerant causes the frame of the balance to progressively pivot about the pivot axis in an opposite direction and the reflector to thereby be progressively returned to its initial sunrise position.

SUMMARY OF THE INVENTION

It is an aim of the present invention to ameliorate one or more problems of the prior art or to at least provide a useful alternative.

In a first aspect of the present invention there is provided a tracking apparatus for tracking solar radiation from the sun, the device comprising:

first shade means rotatable about an axis of rotation;

second shade means rotatable about the axis of rotation;

a first reservoir for a fluid and which is arranged to one side of the axis of rotation;

a second reservoir for a fluid and which is arranged to an opposite side of the axis of rotation;

an actuating mechanism for rotating the first shade means about the axis of rotation;

a driving mechanism disposed for fluid communication with the fluid in the first reservoir and the fluid in the second reservoir, for driving the actuating mechanism to effect the rotation of the first shade means about the axis of rotation in one direction with the heating of the second reservoir by the solar radiation and in an opposite direction about the axis of rotation with heating of the first reservoir by the solar radiation; and

output drive means adapted for being coupled to a solar device to synchronously rotate the solar device with the first shade means when the first shade means is rotated in the one direction for tracking of the solar radiation by the solar device;

wherein the first shade means is arranged for progressive rotation in the one direction to shade the first reservoir with the heating of the second reservoir by the solar radiation, and the second shade means is arranged for rotation in the one direction from

an initial position with the first shade means to a final position for shading the second reservoir during a further daylight period to effect return of the first shade means and the second shade means in the opposite direction with heating of the first reservoir by the solar radiation during the further daylight period.

Typically, the driving mechanism will comprise first drive means responsive to the heating of the first reservoir by the solar radiation, second drive means responsive to heating of the second reservoir by the solar radiation, and a drive member arranged for being driven back and forth by the first drive means and the second drive means to drive the actuating mechanism.

Typically also, the first drive means and the second drive means will comprise respective bellows alternatively operable relative to one another.

Preferably, the actuating mechanism will comprise a lever arm pivotable about a pivot axis and a drive wheel for driving the first shade means about the axis of rotation with rotation of the drive wheel, the lever arm being arranged to be driven about the pivot axis by the drive member of the driving mechanism to drive the rotation of the drive wheel.

Preferably, the tracking apparatus further comprises a stop for stopping rotation of the second shade member about the axis of rotation in the one direction beyond the final position, the first shade member being free to continue to rotate in the one direction when the second shade is in contact with the stop.

Preferably, the second shade means rests on the first shade means when the second shade means is in the initial position and is adapted to rotate about the axis of rotation under the effect of gravity from the initial position to the final position with the rotation of the first shade means about the axis of rotation in the one direction, and wherein the second shade means is driven about the axis of rotation in the opposite direction by the first shade means.

Preferably, the output drive means will comprise an inner axle defining the axis of rotation and the first shade means will be mounted on the axle whereby the axle rotates with the first shade member.

Preferably, the tracking apparatus will further comprise an outer axle receiving the inner axle, the second shade means being mounted on the second axle.

Preferably, the tracking apparatus will also comprise a frame to which the first reservoir and the second reservoir are mounted, wherein the frame is adapted for being held in a fixed position during operation of the tracking apparatus.

The solar device may for example comprise a solar panel comprising photovoltaic cells for generating electricity, or a reflector for being rotated by the output drive means of the tracking apparatus for maintaining reflection of the solar radiation on a target object or space during the passing of the daylight period.

According to a second aspect of the present invention there is provided a tracking apparatus for tracking solar radiation from the sun, comprising:

a solar device arranged for being exposed to the solar radiation;

first shade means rotatable about an axis of rotation;

second shade means rotatable about the axis of rotation;

a first reservoir for a fluid and which is arranged to one side of the axis of rotation;

a second reservoir for a fluid and which is arranged to an opposite side of the axis of rotation;

an actuating mechanism for rotating the first shade means about the axis of rotation;

a driving mechanism disposed for fluid communication with the fluid in the first reservoir and the fluid in the second reservoir, for driving the actuating mechanism to effect the rotation of the first shade means about the axis of rotation in one direction with the heating of the second reservoir by the solar radiation and in an opposite direction about the axis of rotation with heating of the first reservoir by the solar radiation; and

output drive means for driving rotation of the solar device synchronously with the rotation of the first shade means when the first shade means is rotated in the one direction for tracking of the solar radiation by the solar device;

wherein the first shade means is arranged for progressive rotation in the one direction to shade the first reservoir with the heating of the second reservoir by the solar

radiation, and the second shade means is arranged for rotation in the one direction from an initial position with the first shade means to a final position for shading the second reservoir during a further daylight period to effect return of the first shade means and the second shade means in the opposite direction with heating of the first reservoir by the solar radiation during the further daylight period.

Typically, the daylight period in which the first shade means is rotated in the one direction will be on one day and the further period in which the first shade means is rotated in the opposite direction will be a morning period of the next day.

The fluid in the first reservoir and the second reservoir may be the same or different. Preferably, the fluid will be the same and most preferably, will be a refrigerant. However, it will be understood any suitable fluid for driving operation of the driving mechanism as described herein may be utilised.

According to another aspect of the present invention there is provided a tracking apparatus for tracking solar radiation from the sun, the device comprising:

first shade means rotatable about an axis of rotation;

second shade means rotatable about the axis of rotation;

a first reservoir for a fluid and which is arranged to one side of the axis of rotation;

a second reservoir for a fluid and which is arranged to an opposite side of the axis of rotation;

a driving mechanism disposed for fluid communication with the fluid in the first reservoir and the fluid in the second reservoir, for effecting rotation of the first shade means about the axis of rotation, a direction of rotation being dependent upon relative heating differences between the first and second reservoirs; and

output drive means adapted for being coupled to a solar device to synchronously rotate the solar device with the first shade means;

wherein the first and second shade means are arranged so as to cast a shading sequence onto the first and second reservoirs such that during a first daylight period the first shade means is driven by the driving mechanism so as to track incident solar

radiation and during a further daylight period the first and second shade means are returned to respective initial positions.

Preferably the first daylight period is on one day and the further daylight period is a morning period of the next day.

Throughout this specification the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Any discussion of documents, acts, materials, devices, articles or the like which have been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of this application.

The invention will now hereinafter be described by way of non-limiting, preferred embodiments and with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE ACCOMPANYING FIGURES

Figure 1 is a plan view of a tracking apparatus embodied by the present invention;

Figure 2 is an end view of the tracking apparatus of fig. 1;

Figure 3 is an opposite end view of the tracking apparatus of fig. 2; and

Figure 4 is a plan cross-sectional view of the driving mechanism taken through A-A of the tracking apparatus of fig. 3.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

The tracking apparatus 2 shown in fig. 1 comprises a frame 4 mounted on a rigid stand (see fig.2). The frame is orientated such that the longitudinal axis 6 of the frame is at an angle above horizontal equal to the latitude of the location at which the tracking

apparatus is positioned, with the elevated end of the longitudinal axis being further away from the earth's equator than the lower end of the longitudinal axis. The frame 4 comprises opposite frame members 8 and 10 between which is mounted reservoirs in the form of hollow side tanks 12 and 14. The frame 4 is further arranged with tank 12 toward the east and tank 14 toward the west. Each of the tanks is partially filled with a liquid refrigerant. The interior of the tank 12 is connected to first drive means in the form of flexible bellows 16 through the passageway of a conduit 18. The interior of the tank 14 is connected to second drive means in the form of flexible bellows 20 through the passageway of a further conduit 22.

An actuating mechanism 24 is secured to frame member 10 of the frame. The actuating mechanism comprises a further frame 26 to which the outer ends of bellows 16 and 20 are fastened. The inner ends of the bellows are connected by a drive member in the form of a rigid shaft 28 which is driven back and forth by the bellows 16 and 20 to effect rotation of drive wheel 30 of the actuating mechanism as described further below. The drive wheel is fixedly secured to an inner axle 32 comprising output drive means and defining the longitudinal axis 6, such that rotation of the drive wheel rotates the inner axle. The inner axle is received within an outer axle 34 extending through the opposite frame members of 8 and 10 of the frame 4 of the tracking apparatus.

First shade means comprising an elongate shade 36 and opposite inner and outer shade arms 38 and 40 to which the shade 36 is fixed, is mounted on the inner axle 32. The outer shade arm 40 is fixed to the drive wheel 30 for rotation of the shade with the drive wheel and the inner axle. Second shade means comprising a further elongate shade 42 lying parallel with respect to tank 14 and opposite inner and outer shade arms 44 and 46 to which that shade is fixed, is mounted on the outer axle 34.

As more clearly shown in Fig. 2, the activating mechanism further includes a lever arm 48 which pivots about pivot pin 50 of the stand 52 of the tracking apparatus. The lever 48 has slots 54 and 56 at its top and bottom ends which receive drive pin 58 of the shaft 28 and a rotational drive pin 60 of the drive wheel 30, respectively. The arrangement is such that lateral movement of the shaft 28 with operation of the bellows 16 or 20 is translated into rotational movement of the drive wheel 30 and the inner axle

32 about the longitudinal axis 6. It will be understood that the inner axle 32 and the outer axle 34 are free to rotate relative to one another.

Turning now to Fig. 3, a counter weight 62 is attached to the end of the inner shade arm 38 of the shade 36. A further counter weight 64 is attached to the end of the inner shade arm 44 of the shade 42.

At the start of the daylight period, shade 36 is parallel to tank 12 and overlies that tank such that the shadow cast by incident solar radiation from the sun is tangential to the top of the tank 12. The shade 42 lies parallel to tank 14 such that the shadow cast by that shade is tangential to the bottom of the tank 14. Both tanks 12 and 14 are thereby not shaded and so exposed to the solar radiation. Further, bellows 16 is extended and bellows 20 is contracted, and the rotational drive pin 60 of the drive wheel is in its most easterly position. As both of the tanks are exposed to the solar radiation they are heated equally. As a result, the refrigerant pressure in the tanks is equal and the bellows 16 remains extended and bellows 20 remains contracted.

As the sun rises, tank 12 is progressively shaded by shade panel 36 while tank 14 is heated by the solar radiation. The pressure of the refrigerant in tank 12 thereby decreases and the resulting differential refrigerant pressure between tank 12 and tank 14 causes bellows 20 to partially extend and bellows 16 to partially contract. The extension of bellows 20 and contraction of bellows 16 drives shaft 28 of the driving mechanism laterally forcing the lever arm 48 of the actuating mechanism to pivot about pivot pin 50 and the drive wheel 30 to rotate. The rotation of the drive wheel raises shade 36 in a westerly direction exposing tank 12 to the incident solar radiation. Both of the tanks are thereby heated equally once more, and the refrigerant pressure in the tanks equalises stopping rotation of the drive wheel.

As the sun rises further, tank 12 is again shaded by the shade 36 while tank 14 remains unshaded. The pressure of the refrigerant in the tank 14 therefore increases relative to the pressure of the refrigerant in tank 12 and the resulting pressure differential causes further expansion of bellows 20 and contraction of bellows 16 such that the shade 36 is further raised by the activating mechanism with rotation of the drive wheel 30. This process is sequentially repeated during the passing of the daylight period whereby the shade 36 is progressively moved in a westerly direction away from tank 12

toward tank 14. The inner axle is thereby rotated synchronously with the rotation of the shade panel 36.

As such, the inner axle can be coupled to a solar device such as a solar panel or reflector, to rotate the solar panel or reflector to track the solar radiation as the position of the sun in the sky changes with the progression of the daylight period to maintain efficiency of operation of the solar device.

Returning now to fig. 2, at the beginning of the daylight period, the inner shade arm 44 of the shade 42 rests on the inner shade arm 38 of the shade 36, holding the shade 42 in its initial position. With rotation of the shade 36 in the westerly direction as the sun rises, the counter weight 64 drives the simultaneous rotation of the shade 42 in the westerly direction under the effect of gravity. The shade 42 continues to rotate in the westerly direction with shade 36 to maintain the shadow cast by shade 42 tangential to the bottom of tank 14, until the inner shade arm 46 of the shade 42 contacts the stop 66 on the frame member 8 of the frame 4. The shade 42 is restrained in this position by the stop while shade 36 is free to continue to rotate. Stop 66 is located such that the position in which shade 42 is held shades tank 14 for a period in the morning of the next day. At the end of the current daylight period, shade 36 stops at its most westerly position.

At the beginning of the morning of the next day, tank 14 is fully shaded by shade panel 42 and tank 12 is exposed to incident solar radiation. The heating of tank 12 increases the pressure of the refrigerant in that tank to rise above the pressure of the refrigerant in tank 14. This causes bellows 16 to extend and bellows 20 to contract driving rotation of the shade 36 in an easterly direction. As the shade 36 returns to its most easterly position, the inner shade arm 38 of the shade panel contacts the inner shade arm 44 of shade 42, and progressively drives shade 42 about the longitudinal axis 6 to return it to its initial position. With both shade 36 and shade 42 in their most easterly positions, tanks 12 and 14 are again exposed to solar radiation from the sun and the operation cycle of the tracking apparatus 2 recommences for new daylight period.

In other words, the first and second shade means 36 and 42 are arranged so as to cast a shading sequence onto the first and second reservoirs 12 and 14 such that, during a first daylight period on one day, the first shade means 12 is driven by the driving mechanism from its initial position so as to track incident solar radiation. During a

further daylight period on the morning of the next day, the first and second shade means 12 and 14 are returned to their respective initial positions.

The refrigerant in tanks 12 and 14 may be any refrigerant deemed suitable, and may comprise mixtures of refrigerant. The refrigerant(s) in tanks 12 and 14 may also be the same or different. Typically, the same refrigerant will be used in each tank. Particularly preferred refrigerants include Freon although it will be understood that any suitable refrigerant or other fluid may be utilised.

Moreover, the inner axle 32 may be connected directly to the selected solar device or be coupled to the solar device through a flexible or rigid coupling member. The use of a flexible coupling member allows an upright solar device such as a reflector to be driven about an upright axis of rotation for tracking of the solar radiation by the reflector to effect heating of a target space or object throughout the daylight period. A reflector arrangement of this type is described in International Patent Application No. WO 2005/019542. Where the tracking apparatus is used in combination with a solar panel, the solar panel may be arranged on a tilt table for being rotated about the rotational axis of the tilt table synchronously with rotation of the inner axle 32 of the tracking apparatus to effect tracking of the solar radiation by the solar panel.

Although the present invention has been described hereinbefore with reference to a number of preferred embodiments, the skilled addressee will appreciate that numerous changes and modifications are possible without departing from the spirit or scope of the invention. The present embodiments described are, therefore, to be considered in all respects as illustrative and not restrictive.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A tracking apparatus for tracking solar radiation from the sun, the device comprising:

first shade means rotatable about an axis of rotation;

second shade means rotatable about the axis of rotation;

a first reservoir for a fluid and which is arranged to one side of the axis of rotation;

a second reservoir for a fluid and which is arranged to an opposite side of the axis of rotation;

an actuating mechanism for rotating the first shade means about the axis of rotation;

a driving mechanism disposed for fluid communication with the fluid in the first reservoir and the fluid in the second reservoir, for driving the actuating mechanism to effect the rotation of the first shade means about the axis of rotation in one direction with the heating of the second reservoir by the solar radiation and in an opposite direction about the axis of rotation with heating of the first reservoir by the solar radiation; and

output drive means adapted for being coupled to a solar device to synchronously rotate the solar device with the first shade means when the first shade means is rotated in the one direction for tracking of the solar radiation by the solar device;

wherein the first shade means is arranged for progressive rotation in the one direction to shade the first reservoir with the heating of the second reservoir by the solar radiation, and the second shade means is arranged for rotation in the one direction from an initial position with the first shade means to a final position for shading the second reservoir during a further daylight period to effect return of the first shade means and the second shade means in the opposite direction with heating of the first reservoir by the solar radiation during the further daylight period.

2. A tracking apparatus according to claim 1 wherein said driving mechanism comprises first drive means responsive to the heating of the first reservoir by the solar radiation, second drive means responsive to heating of the second reservoir by the solar

radiation, and a drive member arranged for being driven back and forth by the first drive means and the second drive means to drive the actuating mechanism.

3. A tracking apparatus according to claim 2 wherein the first drive means and the second drive means comprise respective bellows alternatively operable relative to one another.

4. A tracking apparatus according to claim 2 or 3 wherein the actuating mechanism comprises a lever arm pivotable about a pivot axis and a drive wheel for driving the first shade means about the axis of rotation with rotation of the drive wheel, the lever arm being arranged to be driven about the pivot axis by the drive member of the driving mechanism to drive the rotation of the drive wheel.

5. A tracking apparatus according to any one of the preceding claims wherein the tracking apparatus further comprises a stop for stopping rotation of the second shade member about the axis of rotation in the one direction beyond the final position, the first shade member being free to continue to rotate in the one direction when the second shade is in contact with the stop.

6. A tracking apparatus according to any one of the preceding claims wherein the second shade means rests on the first shade means when the second shade means is in the initial position and is adapted to rotate about the axis of rotation under the effect of gravity from the initial position to the final position with the rotation of the first shade means about the axis of rotation in the one direction, and wherein the second shade means is driven about the axis of rotation in the opposite direction by the first shade means.

7. A tracking apparatus according to any one of the preceding claims wherein the output drive means comprises an inner axle defining the axis of rotation and the first shade means is mounted on the axle whereby the axle rotates with the first shade member.

8. A tracking apparatus according to claim 7 further comprising an outer axle receiving the inner axle, the second shade means being mounted on the second axle.

9. A tracking apparatus according to any one of the preceding claims wherein the tracking apparatus comprises a frame to which the first reservoir and the second reservoir are mounted, wherein the frame is adapted for being held in a fixed position during operation of the tracking apparatus.

10. A tracking apparatus according to any one of the preceding claims wherein the solar device comprises a solar panel.

11. A tracking apparatus according to claim 10 wherein the solar panel comprisies photovoltaic cells for generating electricity.

12. A tracking apparatus according to claim 10 wherein the solar panel comprisies a reflector for being rotated by the output drive means of the tracking apparatus for maintaining reflection of the solar radiation on a target object or space during the passing of the daylight period.

13. A tracking apparatus for tracking solar radiation from the sun, comprising:

a solar device arranged for being exposed to the solar radiation;

first shade means rotatable about an axis of rotation;

second shade means rotatable about the axis of rotation;

a first reservoir for a fluid and which is arranged to one side of the axis of rotation;

a second reservoir for a fluid and which is arranged to an opposite side of the axis of rotation;

an actuating mechanism for rotating the first shade means about the axis of rotation;

a driving mechanism disposed for fluid communication with the fluid in the first reservoir and the fluid in the second reservoir, for driving the actuating mechanism to effect the rotation of the first shade means about the axis of rotation in one direction with the heating of the second reservoir by the solar radiation and in an opposite direction about the axis of rotation with heating of the first reservoir by the solar radiation; and

output drive means for driving rotation of the solar device synchronously with the rotation of the first shade means when the first shade means is rotated in the one direction for tracking of the solar radiation by the solar device;

wherein the first shade means is arranged for progressive rotation in the one direction to shade the first reservoir with the heating of the second reservoir by the solar radiation, and the second shade means is arranged for rotation in the one direction from an initial position with the first shade means to a final position for shading the second reservoir during a further daylight period to effect return of the first shade means and the second shade means in the opposite direction with heating of the first reservoir by the solar radiation during the further daylight period.

14. A tracking apparatus according to claim 13 wherein the daylight period in which the first shade means is rotated in the one direction is on one day and the further period in which the first shade means is rotated in the opposite direction is a morning period of the next day.

15. A tracking apparatus according to claim 13 or 14 wherein the fluid is a refrigerant.

16. A tracking apparatus for tracking solar radiation from the sun, the device comprising:

first shade means rotatable about an axis of rotation;

second shade means rotatable about the axis of rotation;

a first reservoir for a fluid and which is arranged to one side of the axis of rotation;

a second reservoir for a fluid and which is arranged to an opposite side of the axis of rotation;

a driving mechanism disposed for fluid communication with the fluid in the first reservoir and the fluid in the second reservoir, for effecting rotation of the first shade means about the axis of rotation, a direction of rotation being dependent upon relative heating differences between the first and second reservoirs; and

output drive means adapted for being coupled to a solar device to synchronously rotate the solar device with the first shade means;

wherein the first and second shade means are arranged so as to cast a shading sequence onto the first and second reservoirs such that during a first daylight period the first shade means is driven by the driving mechanism so as to track incident solar

radiation and during a further daylight period the first and second shade means are returned to respective initial positions.

17. A tracking apparatus according to claim 16 wherein the first daylight period is on one day and the further daylight period is a morning period of the next day.