

SOLAR COLLECTOR

FIELD OF THE INVENTION

The present invention relates broadly to a solar collector and a solar powered heat exchanger. The invention also relates to a solar tracking apparatus and a combination
5 solar collector/tracking apparatus.

BACKGROUND OF THE INVENTION

Solar hot water systems of a conventional construction include a solar collector connected to a storage cylinder containing stored water. The solar collector is fabricated from an arrangement of heat absorbing pipes or tubes layed out in a parallel or serpentine
10 arrangement. In one form the tubes are formed in a black heat absorbing mat which can be placed on a rooftop to capture the sunlight. In another form the pipes are housed within an enclosure having a glass pane front which is exposed to sunlight and the efficiency of heating is improved under the influence of the greenhouse effect. The system may provide direct heating where the stored water itself is circulated through the
15 solar collector. Alternatively, indirect heating may be provided where for example a glycol mixture is recirculated through the solar collector and an associated solar circuit which passes through the storage cylinder. The storage cylinder includes a heat exchanger for indirect heating of the stored water utilising the heat of the glycol mixture in the solar circuit. In either case of direct or indirect heating, the stored water or glycol
20 mixture is pumped through the solar collector until the temperature of the stored water is equal to or approaches that of the liquid in the solar collector.

Conventional solar collectors absorb short wave radiation which is transferred by conduction into the fluid being heated. As the fluid temperature rises so does the temperature of the collector surface. Heat energy is lost from the collector by re-radiation
25 from the heated collector surface in the form of long wave radiation, and the higher the collector surface temperature the more heat energy is re-radiated (or lost) from the collector. Because of this effect, efficiency of conventional collectors declines rapidly as the temperature of the heated fluid rises until eventually the long wave radiation losses from the collector surface equal the short wave radiation being absorbed by the collector

and no further heating can occur. The maximum fluid temperature that can be achieved with conventional collectors is about 85 to 90 degC.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided a solar collector

5 comprising:

a collector housing having a translucent or transparent surface and being sealed to permit at least partial evacuation or reduction in pressure within the housing below atmospheric pressure; and

10 a collector tank located within the collector housing and having a solar absorbent surface located adjacent the translucent or transparent surface, the collector tank being adapted to contain a heat transfer fluid which, on exposure of the solar collector to sunlight, is heated via solar energy which penetrates the translucent or transparent surface and, with the increased efficiency provided by the sealed and at least partially evacuated housing, is absorbed onto the solar absorbent surface which transfers heat to the heat transfer fluid.

15 Preferably the sealed collector housing defines a chamber between at least the translucent or transparent surface and the absorbent surface of the collector tank. More preferably the housing includes an evacuation valve which permits evacuation of the sealed chamber for drawing at least a partial vacuum within the chamber. Even more preferably the sealed chamber surrounds the collector tank which is separated from the collector
20 housing on opposing internal surfaces by flexible spacers.

Preferably the solar collector includes an adjustable mounting assembly to which the collector housing is mounted, the mounting assembly being adapted to provide reorientation of the solar collector to increase exposure of the absorbent surface to sunlight. More preferably the adjustable mounting assembly effects seasonal

25 reorientation of the solar collector by rotation about a first axis. Even more preferably the adjustable mounting assembly is effective in tracking the sun by pivoting about a second axis arranged generally transverse to the first axis. Still more preferably the first axis is the altitude axis and the second axis the azimuth axis.

According to another aspect of the invention there is provided a solar powered heat
30 exchanger comprising:

a solar collector including a collector housing having a translucent or transparent surface, the collector housing being sealed to permit at least partial evacuation or reduction in

pressure within the housing below atmospheric pressure, and a collector tank located within the collector housing and being adapted to contain a heat transfer fluid; a heat accumulator operatively coupled to the solar collector for storing the heat transfer fluid heated by exposure of the solar collector to sunlight wherein solar energy penetrates the translucent or transparent surface and, with the increased efficiency provided by the sealed and at least partially evacuated housing, is absorbed onto the solar absorbent surface which transfers heat to the heat transfer fluid; and a heat exchanger operatively coupled to the heat accumulator and being arranged for transferring heat to an external device utilising the heat of the heat transfer fluid from the heat accumulator or the solar collector.

Preferably the heat exchanger includes a heat exchange chamber in heat exchange communication with the external device, the heat exchange chamber being connected to the heat accumulator via a feed line which provides the heat transfer fluid from the accumulator. More preferably the heat exchange chamber is also connected to the accumulator via a return line for returning the heat transfer fluid to the accumulator after said fluid has exchanged its heat with the external device. Even more preferably the heat exchanger also includes an expansion tank connected to the heat exchange chamber and being designed to allow the heated fluid to expand as its temperature rises thus maintaining a relatively constant and low hydrostatic pressure within the heat exchanger. Still more preferably the heat exchanger further includes a pump connected to the return line to promote flow of the heat transfer fluid from the heat exchange chamber to the heat accumulator.

Preferably the heat accumulator includes an accumulator chimney connected to a supply line connected to the outlet of the collector tank, the accumulator chimney being positioned within the accumulator to convey the heat transfer fluid from the outlet of the collector tank. Additionally, the heat exchanger includes a heat exchange chimney connected to the feed line which interconnects the heat accumulator and the heat exchanger, the heat exchange chimney being positioned within the heat exchange chamber to convey the heat transfer fluid from the heat accumulator.

Preferably the solar powered heat exchanger also comprises a recirculation line connected between the heat accumulator and the solar collector for recirculation of the heat transfer fluid. More preferably the collector tank includes an inlet connected to the recirculation line, and an outlet coupled to the heat accumulator, the outlet being elevated relative to

the inlet to effect a flow of the heat transfer fluid from the inlet to the outlet and recirculation of the heat transfer fluid through the recirculation line by a thermal siphon effect at the inlet. Even more preferably the collector tank includes a plurality of internal baffle plates being arranged to support the tank and oriented to promote the flow of the heat transfer fluid from the inlet to the outlet.

Preferably the solar powered heat exchanger further comprises a temperature control system operatively coupled to the heat exchanger to control the flow of the heat transfer fluid to the heat exchanger and thus the amount of heat exchanged with the external device. More preferably the temperature control system includes a control valve connected to the feed line, and a temperature sensor connected to the external device, the temperature sensor being operatively coupled to the control valve whereby, depending on the temperature of the external device, the control valve is throttled to control the flow of the heat transfer fluid to the heat exchanger.

Preferably the heat transfer fluid is a liquid such as glycol or a water/glycol mixture.

Accordingly to a further aspect of the invention there is provided a solar tracking apparatus comprising:
a base being adapted to mount to a solar collector;
a shading member connected to the base at a fixed and predetermined angle;
a pair of light sensitive elements mounted on the base on respective opposing sides of the shading member; and

an actuator operatively coupled to the pair of light sensitive elements whereby in operation the light sensitive elements, dependent of their relative exposure to sunlight as controlled by the shading member, drive the actuator to effect movement of the solar collector.

Preferably the base is planar and the shading member is fixed substantially perpendicular to the planar base. More preferably the shading member includes a generally straight lower portion fixed to the base, and an upper portion extending from the lower portion at an obtuse angle. Even more preferably the upper portion includes a reflective surface on its lower face and directed toward one of the light sensitive elements.

Preferably, the light sensitive elements are each in the form of a light dependent resistor.

Preferably the solar tracking apparatus also comprises an actuator circuit including the light dependent resistors which dependent on their exposure to sunlight are configured to drive the actuator. More preferably the actuator circuit includes a voltage comparator having voltage inputs from the light dependent resistors and a reference voltage,

5 respectively, whereby differential voltage applied to the inputs of the voltage comparator causes it to conduct driving the actuator. Even more preferably an output of the voltage comparator is connected to a transistor which is electrically coupled to and actuates a relay whereby the application of differential voltage to the comparator causes the comparator and the transistor to conduct and close the relay which in turn powers the
10 actuator. Still more preferably the relay includes an electromagnetic relay connected to a normally-open relay contact.

Preferably the actuator is in the form of a drive motor. More preferably the drive motor is electrically coupled to the pair of light sensitive elements via the actuator circuit.

According to yet another aspect of the invention there is provided a combination of a
15 solar collector and a solar tracking apparatus as disclosed in the preceding aspects, the tracking apparatus being connected to the solar collector and designed for reorientation of the collector to optimise its exposure to sunlight.

Preferably the solar tracking apparatus is arranged to rotate the solar collector about an azimuth axis to effectively track the sun and optimise daily exposure to sunlight. More
20 preferably the tracking apparatus is one of a pair of said apparatuses, the other solar tracking apparatus being designed to permit rotation or tilting of the solar collector about an altitude axis to optimise its seasonal exposure to sunlight.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to achieve a better understanding of the nature of the present invention a
25 preferred embodiment of a solar collector, solar powered heat exchanger, and solar tracking apparatus will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of a solar powered heat exchanger of an embodiment of one aspect of the invention;

30 **Figure 2** is a sectional view taken through A-A of the solar collector of figure 1;

Figure 3 is another sectional view taken through B-B of the accumulator and heat exchanger of figure 1; and

Figure 4 is a further sectional view taken through C-C of the heat exchanger of figure 3;

Figure 5 is a plan and elevational view of the solar powered heat exchanger of Figure 1
5 together with an adjustable mounting assembly;

Figure 6 is a side elevational view of a solar powered heat exchanger together with a solar tracking apparatus of an embodiment of a further aspect of the invention;

Figure 7 is a plan and elevational view of a tracker sensor of the solar tracking apparatus of Figure 6;

10 Figure 8 is a circuit diagram of the solar tracking apparatus of Figure 6; and

Figure 9 is a schematic illustration of the tracker sensor showing its rotational movement about the azimuth axis.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in figure 1 there is a solar powered heat exchanger designated generally as 10
15 comprising a solar collector 12, a heat accumulator 14, and a heat exchanger 16. The solar collector 12 is operatively coupled to the heat accumulator 14 via a supply line 18 and a recirculation line 20. The heat accumulator 14 is in turn operatively coupled to the heat exchanger 16 via a feed line 22 and a return line 24.

The solar collector 12 includes a collector housing 26 having a translucent or transparent
20 surface in the form of a glass pane 28. The solar collector 12 also includes a collector tank 30 located within the collector housing 26 and in operation being adapted to contain a heat transfer fluid such as glycol or a water/glycol mixture. The water/glycol mixture is heated by the solar collector 12 and circulates by a thermosiphon effect between the solar collector 12 and the heat accumulator 14 via the supply and the recirculation lines 18 and
25 20, respectively. The solar heated water/glycol mixture flows from the heat accumulator 14 to the heat exchange 16 via the feed line 22 and transfers heat to an external device 32 which is in heat communication with the heat exchanger 16. The water/glycol mixture is then returned to the heat accumulator 14 via the return line 24 either by pump of thermosiphon.

As best shown in figure 2, the solar collector 12 is of a generally flat and cuboidal configuration wherein the collector housing 26 includes a rectangular perimeter frame 34 sandwiched between a rear opaque plate 36 and the front glass pane 28. The glass pane 28 and the rear plate 36 are fixed to the perimeter frame 34 via a sealant 38. This arrangement provides a sealed chamber 40 within the collector housing 26 which is specifically designed to permit a reduction in pressure within the housing below atmospheric pressure, or preferably a full vacuum. The collector tank 30 includes a solar absorbent surface 41 which faces the glass pane 28 for exposure to sunlight, and is shaped and coloured (preferably matt black) for maximum solar absorption.

- 10 It is understood that by evacuating the sealed chamber 40 between the solar absorbent surface 41 and the translucent covering or glass pane 28, radiation losses from the absorbent surface 41 (which are long wave) are reduced or eliminated because heat transfer by convection away from the solar absorbent surface 41 to the exterior is eliminated and long wave radiation cannot travel through the glass pane 28. Therefore the efficiency of the evacuated/ sealed chamber 40 is fairly uniform regardless of fluid temperature, and much higher temperatures can be achieved.

The sealed collector housing 26 houses the collector tank 30 which is of a complementary shape to the sealed pressure reduction chamber 40. The sealed chamber 40 surrounds all faces of the collector tank 30 which is spaced from the glass pane 28 and the rear plate 36 by respective internal flexible spacers such as 42 and 44. The collector tank 30 has an inlet 46 and an outlet 48 diagonally spaced and located in opposite perimeter walls and connected to the recirculation line 20 and the supply line 18, respectively. The collector tank 30 also includes a series of internal baffle plates such as 50 which in this example are equally spaced transversally and arranged generally parallel to one another. The solar collector 12 is oriented so that the collector tank outlet 48 is elevated relative to its inlet 46 to provide a flow of the water/glycol mixture through the collector tank 30 with a thermal siphon effect at the inlet 46. The internal baffle plates such as 50 are, as best shown in figure 1, oriented relative to the inlet 46 and outlet 48 to further promote this flow of the heat transfer fluid.

- 30 The solar collector 12 is designed to permit at least partial evacuation of the sealed chamber 40 about the collector tank 30. The collector housing 26 or perimeter frame 34 of this embodiment includes an evacuation valve 51 which permits evacuation of the sealed chamber 40 for drawing a vacuum within the chamber 40. The flexible spacers such as 42

and 44 maintain the separation between the collector housing 26 and the collector tank 30 whereas the baffle plates such as 50 provide support for the relatively thin walled collector tank 30. The supply and recirculation lines 18 and 20 pass through insulating glands such as 52 located within openings in the perimeter frame 34 aligned with the tank inlet and outlet 46 and 48. This arrangement allows the collector tank 30 to expand or contract relative to the collector housing 26 under differential temperature conditions.

As shown in figure 3, the heat accumulator 14 includes a cylindrical accumulator tank 54 laid on its side, and an accumulator chimney 56 extending radially across the tank 54 from its circumferential wall. The accumulator chimney 56 is connected to the supply line 18 and is disposed in a generally upright position. The accumulator chimney 56 is in this disposition designed to allow the heated fluid to rise by convection from the collector 12 into the top of the accumulator 14. The chimney 56 is insulated to reduce heat transfer from the rising heated fluid to cooler fluid stored in the accumulator 14. The accumulator tank 54 is of a size and volume dependent on the heating requirements. For example, if heating is required for extended periods outside effective sunlight hours then the accumulator tank 54 will be relatively large. The accumulator tank 54 is insulated with known cladding (not shown) to minimise heat losses from the heat transfer fluid. The recirculation line 20 extends within the accumulator tank 54 with its mouth or entrance 58 at a height dependent on the maximum volume of heat transfer fluid to be retained in the heat accumulator 14. The feed line 22 is connected to the accumulator tank 54 and generally aligned coaxially with the accumulator chimney 56. The feed line 22 is flared outwardly in a frusto-conical form 60 at its connection to the accumulator tank 54. It is understood that this flared connection immediately adjacent the accumulator tank 56 increases the rate at which the heat transfer fluid or water/glycol mixture can flow into the heat accumulator 14.

The heat exchanger 16 of this embodiment includes a heat exchange chamber 62 within which the heat exchange device 32 is partly housed. The heat exchanger 16 also includes a heat exchange chimney 64 connected to the feed line 22 and arranged upright within the heat exchange chamber 62 to allow hot fluid to rise to the top of the exchanger 16. The feed line 22 includes a control valve in the form of a throttle valve 66 for controlling the flow of the water/glycol mixture to the heat exchanger 16 depending on the heating requirements of the external device 32. The heat exchanger 16 is also provided with a temperature sensor 68 operatively coupled to the external device 32 and designed, dependent on the external device 32 temperature, to control throttling of the control

valve 66. The heat exchanger 16 further includes an expansion tank 70 connected to the heat exchange chamber 62 via a relatively small pipe 72 and designed to allow for expansion of the heat transfer fluid within the heat exchanger 16. The expansion tank 70 has a loose fitting lid to allow atmosphere to leave or enter the tank 70 according to the level of fluid in the tank 70. The water/glycol mixture having exchanged its heat within the heat exchanger 16 is returned to the heat accumulator 14 via the return line 24. The return line 24 of this example includes a pump 76 designed to promote the flow of heat transfer fluid from the heat exchanger 16 to the heat accumulator 14. Alternatively, a thermosiphon effect may eliminate the need for a pump.

Figure 4 shows in cross section the external device 32 with which the solar powered heat exchanger 10 of this embodiment exchanges heat. The external device 32 includes another chamber 76 which contains a separate fluid to be heated. Heat transfer fluid in the heat exchange chamber 62 transfers heat by conduction through the walls of the other chamber 32 into the separate fluid to be heated. As the transfer fluid cools it falls by thermosiphon to the bottom of the heat exchange chamber 62 and then flows via the return line 24 back to the accumulator 14.

In order to further facilitate an understanding of this embodiment of the solar powered heat exchanger 10, the general steps involved in its operation are as follows:

1. solar energy is absorbed by the solar collector 12 which effectively heats the heat transfer fluid or the water/glycol mixture;
2. the water/glycol mixture is caused to flow into the collector tank 30 of the solar collector 12 and rises upwardly through the accumulator chimney 56;
3. depending on the load and heating requirements, the solar heated water/glycol mixture rises into the heat exchanger 16 via the heat exchange chimney 64 at a volume/flow rate dictated by the control valve 66;
4. as the relatively hot heat transfer fluid enters the top of the accumulator 14, cooler fluid retained in the accumulator 14 falls by thermosiphon towards the bottom of the accumulator 14 and by thermosiphon returns via the recirculation line 20 to the bottom of the collector 12;

5. the water/glycol mixture rising into the heat exchange chamber 62 of the heat exchanger 16 exchanges heat with, and effectively heats, the external device 32; and

6. the heat depleted water/glycol mixture is returned to the heat accumulator 14 via
5 the return line 24 under the assistance of the pump or by a thermosiphon action.

As shown in figure 5, and in order to increase the exposure of the solar collector 12 to sunlight, the solar collector 12 includes an adjustable mounting assembly 90 to which the collector housing 26 is mounted. The adjustable mounting assembly 90 includes a mechanical actuator and lock arrangement 92 having a lever 94 at one end being fixed to a
10 shaft 96, and releasably lockable to a fixed seasonal reference point. The lever 94 includes a retractable pin (not shown) which in this example engages one of three (3) holes 100A to C in the plate 98 which are angularly displaced depending on the season, summer, spring/autumn, and winter respectively. The mounting assembly 90 also includes a drive
15 motor 102 connected to a drive shaft or spindle 104 which in turn is fixed to the solar collector 12. The drive motor 102 thus rotates the solar collector 12 to track the sun and maximise daily exposure to sunlight.

The adjustable mounting assembly 90 is thus effective in providing either continuous or intermittent seasonal reorientation of the solar collector 12 by re-inclination or orientation about a primary or altitude axis. The adjustable mounting assembly 90 may also permit
20 pivoting about a secondary or azimuth axis, arranged generally transverse to the primary axis, and designed to have the solar collector 12 effectively track the sun during daylight hours.

Figure 6 illustrates a variant of the solar powered heat exchanger of figure 1 together with an embodiment of a solar tracking apparatus 110 of a further aspect of the invention. The
25 solar tracking apparatus 110 of this embodiment is one of a pair of these apparatuses 110 and 110' being designed for rotation of the solar collector 12' about an azimuth axis 112 and an altitude axis 114, respectively.

The solar collector 12' (preferably together with the accumulator and heat exchange not shown) is elevated above ground via a fixed support column or pedestal 116. The
30 pedestal 116 is at an upper end rotationally mounted to an intermediate mounting assembly 118 for tilting or re-inclination of the solar collector 12' about the altitude axis 114. The intermediate mounting assembly 118 provides mounting for a drive motor 120

having a shaft 122 defining the azimuth axis 112 about which the solar collector 12' is rotated. The shaft 122 is rotatable about the intermediate support assembly 118 and fixed to a mounting bracket 124 which in turn is secured to an underlying surface of the solar collector 12'.

- 5 The solar tracking apparatus 110 for rotation of the solar collector 12' about the azimuth axis 112 includes the drive motor 120 together with an azimuth sensor 126. The other solar tracking apparatus 110' includes an altitude drive motor 128 having a shaft fixed to the intermediate mounting assembly 118 for tilting of the solar collector 12' about the altitude axis 114, and an altitude sensor 130. The azimuth and altitude sensors 126 and
10 130 are mounted coplanar with and at opposing sides of the solar collector 12' facing the sun.

Figure 7 shows in elevation and plan the tracker sensors 126 and 130 of the apparatus of figure 6. The azimuth sensor 126 for example includes a base plate 132 to which a generally upright shading member or arm 134 is fixed at right angles. The shading arm
15 134 is at its upper end formed continuous with a reflector 136 ranged at an obtuse angle to the shading arm 134. Importantly, the tracker sensor 126 includes a pair of light sensitive elements in the form of light dependent resistors (LDR) 138 and 140 mounted to an upper face of the base plate 132 on opposing sides of the shading arm 134. The shading arm 134 together with the reflector 136 control the relative exposure of the opposing LDRs 138 and
20 140 to sunlight.

In order to better understand the solar tracking apparatus, its operation will now be described with reference to figures 8 and 9.

The opposing LDRs 138 and 140 are as the name suggests light dependent and have a relatively high electrical resistance in low and zero light, and relatively low resistance in
25 bright light. Therefore, with reference to the actuator circuit 150 of figure 8, with equal intensity of light falling on both LDRs 138/140 (normal condition) the voltage at V1 is half the supply voltage. If the intensity of light on LDR1 138 rises above that on LDR2 140 then the voltage at the one rises above half the supply voltage. Conversely, if the intensity of light on LDR1 138 falls below that on LDR2 140 then the voltage at V1 falls
30 below half the supply voltage.

The actuator circuit 150 of the embodiment includes a voltage divider provided by resistors R1 152 and R2 154 which provides a reference voltage at V2 equal to half the

supply voltage. The circuit 150 also includes a voltage comparator A1 or 156 having positive and negative inputs to which the respective voltages V1 and V2 are applied. The circuit 150 further includes another voltage comparator 158 having positive and negative inputs to which the respective voltages V2 and V1 are also applied.

5 In operation and with equal light falling on both LDRs 138/140 neither of the voltage comparators 156 or 158 conduct. With increased light on, for example, LDR1 138 an output of the comparator A1 or 156 is relatively high whereas an output of the other voltage comparator A2 or 158 remains relatively low. The voltage comparator A1 or 156 is electrically connected to a transistor Q1 or 160 which under these conditions is caused
10 to conduct which in turn energises an electromagnetic relay R1 or 162 to which it is connected. The energised relay R1 or 162 causes associated relay contacts CR1 or 164 to close and apply a normal voltage polarity to the actuator or, for example, azimuth drive motor 120.

If on the other hand LDR2 or 140 is exposed to increased light this causes the output of
15 the voltage comparator A2 or 158 to be relatively high whilst the voltage output of the other comparator A1 or 156 remains relatively low. Under these conditions, another transistor Q2 or 166 which is connected to the output of the comparator A2 or 158 conducts to energise an electromagnetic relay R2 or 168. The energised relay 168 closes relay contacts 170 which apply a reversed voltage polarity to the drive motor 120.

20 As schematically illustrated in figure 9, the tracker sensor 126 of this example 130 provides effective rotation of the solar collector about the azimuth axis 112 to maximise its daily exposure to sunlight. With equal light falling on LDR1 or 138 and LDR2 or 140 the drive motor 120 for the azimuth rotation is not energised. If light falling on the LDR1 or 138 is higher in intensity than that falling on the LDR2 or 140 then the drive motor 120
25 rotates in one direction or *vice versa*.

As shown in figure 9 the solar tracking apparatus rotates the solar collector about the azimuth axis 112 in the following stages:

1. with the sun vertically above the plane of the base 132 and the collector, both of the LDRs 138/140 receive equal light intensity and the azimuth drive motor 120 is
30 off;

2. as the sun moves towards the west the reflector 136 shades the LDR2 or 140 which now receives less light than the LDR1 or 138 and the drive motor is energised and the associated solar collector rotated about its azimuth axis 112;
3. the shadow cast by the reflector 136 leaves the LDR2 140 and both LDRs 138/140 receive equal light and the motor is de-energised so that the solar collector is directly facing the sun; and
4. at sunset the solar collector panel is facing west and the solar collector remains stationary overnight until the sun rises the next morning and light from the eastern horizon is reflected by the reflector 136 onto the LDR2 or 140 which receives a higher light intensity than the LDR1 or 138 and the drive motor is energised in the opposite direction to rotate the solar collector on its azimuth axis 112 until the solar collector is facing the sun and the LDRs 138/140 are receiving equal light intensity.

It will be appreciated that tracking of the sun during daylight hours is then continued or repeated as outlined in stages 1-3 above. The sensitivity of the solar tracking apparatus can be adjusted by the height of the shading arm such as 134 whereby increasing its height increases the apparent speed with which the shadow of the shading arm 134 falls on the LDR2 or 140. It will also be appreciated that the other solar tracking apparatus 110' of figure 6 operates in a similar manner wherein the altitude drive motor 128 rotates or tilts the solar collector 12' about its altitude axis 114. The altitude sensor 130 is generally oriented perpendicular to the azimuth sensor 126 in that it has its shading arm disposed in an east-west direction so as to maintain the solar collector 12' facing the track of the sun as its altitude varies between summer and winter.

The solar powered heat exchanger 10 of this embodiment has application in the heating of water where, for example, the external device 32 contains a domestic potable water supply. In another application, the solar powered heat exchanger 10 is used as a heat source for driving an apparatus designed to produce water from ambient air. The specification of the applicant's Australian provisional application No. 2003904488 describes an apparatus of this type, and the disclosure of this specification is included herein by way of reference. In yet another application, heat from the solar powered heat exchanger 10 may be used in an absorption system to drive a refrigerator or an air-conditioner.

Now that a preferred embodiment of the present invention has been described in some detail it will be apparent to those skilled in the art that the solar collector, the solar powered heat exchanger, or the solar tracking apparatus have the following advantages:

1. the solar collector, having a sealed collector housing within which at least a partial vacuum can be drawn, provides efficient absorption of solar energy for heating of the heat transfer fluid and allows higher temperatures to be achieved;
2. the configuration of the solar collector and orientation of its inlet and outlet provides an effective flow of the heat transfer fluid promoted by a thermosiphon effect at the inlet of the collector tank;
3. the solar powered heat exchanger utilises density differences in the heat transfer fluid between the bottom of the collector (cooler and higher density) and the top of the heat exchanger (hotter and lower density) wherein the heat transfer fluid heated in the collector becomes less dense and rises by natural convection forces to the highest point of the heat exchange system whereas as the fluid cools in the heat exchanger it becomes more dense and falls to the bottom of the system; and
4. the solar tracking apparatus is effective in tracking the sun daily and/or seasonally to preferably provide maximum sunlight exposure for the solar collector.

Those skilled in the art would appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. For example, the specific construction of the solar collector may vary from that described provided the heat transfer fluid is effectively heated within the solar collector. The control mechanisms by which the flow of heat transfer fluid is controlled to the heat exchanger may also vary. Likewise, the construction and control of the adjustable mounting assembly for the solar collector may be different from that described.

All such variations and modifications are to be considered within the scope of the present invention and nature of which is to be determined from the foregoing description.

CLAIMS

1. A solar collector comprising:

a collector housing having a translucent or transparent surface and being sealed to permit at least partial evacuation or reduction in pressure within the housing
5 below atmospheric pressure; and

a collector tank located within the collector housing and having a solar absorbent surface located adjacent the translucent or transparent surface, the collector tank being adapted to contain a heat transfer fluid which, on exposure of the solar collector to sunlight, is heated via solar energy which penetrates the translucent or
10 transparent surface and, with the increased efficiency provided by the sealed and at least partially evacuated housing, is absorbed onto the solar absorbent surface which transfers heat to the heat transfer fluid.

2. A solar collector as defined in claim 1 wherein the sealed collector housing defines a chamber between at least the translucent or transparent surface and the
15 absorbent surface of either of the collector tank.

3. A solar collector as defined in either of claims 1 or 2 wherein either of the housing includes an evacuation valve which permits evacuation of the sealed chamber for drawing at least a partial vacuum within the chamber.

4. A solar collector as defined in any one of the preceding claims wherein the sealed
20 chamber surrounds the collector tank which is separated from the collector housing on opposing internal surfaces by flexible spacers.

5. A solar collector as defined in any one of the preceding claims also comprising an adjustable mounting assembly to which the collector housing is mounted, the mounting assembly being adapted to provide reorientation of the solar collector to
25 increase exposure of the absorbent surface to sunlight.

6. A solar collector as defined in claim 5 wherein the adjustable mounting assembly effects seasonal reorientation of the solar collector by rotation about a first axis.

7. A solar collector as defined in claim 6 wherein the adjustable mounting assembly is effective in tracking the sun by pivoting about a second axis arranged generally transverse to the first axis.
8. A solar collector as defined in claim 7 wherein the first axis is the altitude axis and the second axis the azimuth axis.
9. A solar collection as defined in any one of the preceding claims wherein the heat transfer fluid is a liquid including glycol or a water/glycol mixture.
10. A solar powered heat exchanger comprising:
 - a solar collector including a collector housing having a translucent or transparent surface, the collector housing being sealed to permit at least partial evacuation or reduction in pressure within the housing below atmospheric pressure, and a collector tank located within the collector housing and being adapted to contain a heat transfer fluid;
 - a heat accumulator operatively coupled to the solar collector for storing the heat transfer fluid heated by exposure of the solar collector to sunlight wherein solar energy penetrates the translucent or transparent surface and, with the increased efficiency provided by the sealed and at least partially evacuated housing, is absorbed onto the solar absorbent surface which transfers heat to the heat transfer fluid;
 - a heat exchanger operatively coupled to the heat accumulator and being arranged for transferring heat to an external device utilising the heat of the heat transfer fluid from the heat accumulator or the solar collector;
11. A solar powered heat exchanger as defined in claim 10 wherein the heat exchanger includes a heat exchange chamber in heat exchange communication with the external device, the heat exchanger chamber being connected to the heat accumulator via a feed line which provides the heat transfer from the accumulator.

12. A solar powered heat exchanger as defined in claim 11 wherein the heat exchange chamber is connected to the accumulator via a return line for returning the heat transfer fluid to the accumulator after said fluid has exchanged its heat with the external device.
- 5 13. A solar heat powered heat exchanger as defined in either of claims 11 or 12 wherein the heat exchanger also includes an expansion tank connected to the heat exchange chamber and designed to allow the heated fluid to expand as its temperature rises thus maintaining a relatively constant and low hydrostatic pressure within the heat exchanger.
- 10 14. A solar powered heat exchanger as defined in any one of claims 12 to 13 wherein the heat exchanger further includes a pump connected to the return line to promote flow of the heat transfer fluid from the heat exchange chamber to the heat accumulator.
- 15 15. A solar powered heat exchanger as defined in any one of claims 11 to 14 wherein the heat exchanger includes a heat exchange chimney connected to a feed line which interconnects the heat accumulator and the heat exchanger, the heat exchanger chimney being positioned within the heat exchange chamber to convey the heat transfer fluid from the heat accumulator.
- 20 16. A solar powered heat exchanger as defined in any one of claims 10 to 15 wherein the heat accumulator includes an accumulator chimney connected to a supply line connected to the outlet of the collector tank, the accumulator chimney being positioned within the accumulator to convey the heat transfer fluid from the outlet of the collector tank.
- 25 17. A solar powered heat exchanger as defined in any one of claims 10 to 16 also comprising a recirculation line connected between the heat accumulator and the solar collector for recirculation of the heat transfer fluid.
- 30 18. A solar powered heat exchanger as defined in claim 17 wherein the collector tank includes an inlet connected to the recirculation line, and an outlet coupled to the heat accumulator, the outlet being elevated relative to the inlet to effect a flow of the heat transfer fluid from the inlet to the outlet and recirculation of the heat transfer fluid through the recirculation line by a thermalsiphon effect at the inlet.

19. A solar powered heat exchanger as defined in claim 18 wherein the collector tank includes a plurality of internal baffle plates being arranged to support the tank and oriented to promote the flow of the heat transfer fluid from the inlet to the outlet.
- 5 20. A solar powered heat exchanger as defined in any one of the claims 10 to 19 further comprising a temperature control system operatively coupled to the heat exchanger to control the flow of the heat transfer fluid to the heat exchanger and thus the amount of heat exchanged with the external device.
- 10 21. A solar powered heat exchanger as defined in claim 20 wherein the temperature control system includes a control valve connected to the feed line, and a temperature sensor connected to the external device, the temperature sensor being operatively coupled to the control valve whereby, depending on the temperature of the external device, the control valve is throttled to control the flow of the heat transfer fluid to the heat exchanger.
- 15 22. A solar powered heat exchanger as defined in any one of claims 10 to 21 wherein the heat transfer fluid is a liquid such as glycol or a water/glycol mixture.
23. A solar tracking apparatus comprising:
- a base being adapted to mount to a solar collector;
- a shading member connected to the base at a fixed and predetermined angle;
- 20 a pair of light sensitive elements mounted on the base on respective opposing sides of the shading member; and
- an actuator operatively coupled to the pair of light sensitive elements whereby in operation the light sensitive elements, dependent of their relative exposure to sunlight as controlled by the shading member, drive the actuator to effect
- 25 movement of the solar collector.

24. A solar tracking apparatus as defined in claim 23 wherein the base is planar and the shading member is fixed substantially perpendicular to the planar base.
25. A solar tracking apparatus defined in either of claims 23 or 24 wherein the shading member includes a generally straight lower portion fixed to the base, and an upper portion extending from the lower portion at an obtuse angle.
26. A solar tracking apparatus as defined in claim 25 wherein the upper portion includes a reflective surface on its lower face and directed toward one of the light sensitive elements.
27. A solar tracking apparatus as defined in any one of claims 23 to 26, wherein the light sensitive elements are each in the form of a light dependent resistor.
28. A solar tracking apparatus as defined in claim 27, wherein the solar tracking apparatus also comprises an actuator circuit including the light dependent resistors which dependent on their exposure to sunlight are configured to drive the actuator.
29. A solar tracking apparatus as defined in claim 28, wherein the actuator circuit includes a voltage comparator having voltage inputs from the light dependent resistors and a reference voltage, respectively, whereby differential voltage applied to the inputs of the voltage comparator causes it to conduct thereby driving the actuator.
30. A solar tracking apparatus as defined in claim 29 wherein an output of the voltage comparator is connected to a transistor which is electrically coupled to and actuates a relay whereby the application of differential voltage to the comparator causes the comparator and the transistor to conduct and close the relay which in turn powers the actuator.
31. A solar tracking apparatus as defined in claim 30, wherein the relay includes an electromagnetic relay connected to a normally-open relay contact.
32. A solar tracking apparatus tracking apparatus as defined in any one of claims 28 to 31 wherein the actuator is in the form of a drive motor.
33. A solar tracking apparatus as defined in claims 32 wherein, the drive motor is electrically coupled to the pair of light sensitive elements via the actuator circuit.

34. A combination of a solar collector, as defined in any one of claims 1 to 9 and a solar tracking apparatus as defined in any one of claims 23 to 33, the tracking apparatus being connected to the solar collector and designed for reorientation of the collector to optimise its exposure to sunlight.
- 5 35. A combination of a solar collector and a solar tracking apparatus as defined in claims 34 wherein the solar tracking apparatus is arranged to rotate the solar collector about an azimuth axis to effectively track the sun and optimise daily exposure to sunlight.
- 10 36. A combination of a solar collector and a solar tracking apparatus as defined in claim 35 further comprising an additional solar tracking apparatus, as defined in any one of claims 23 to 33, the additional solar tracking apparatus being designed to permit rotation or tilting of the solar collector about an altitude axis to optimise its seasonal exposure to sunlight.