

**AN IMPROVED SOLAR ENERGY CONCENTRATING SYSTEM  
HAVING A NOVEL FOCAL COLLECTION ZONE**

**5    TECHNICAL FIELD**

The present invention relates to an improved solar energy concentrating system and to a preferred novel focal collection zone for such a system. In general, the system comprises a moveable linear solar energy collector supported above a  
10    cylindrically arcuate solar energy concentrating reflector. The solar energy collector has a compound parabolic cross section, preferably based on non-imaging optics. In a preferred embodiment, instead of positioning the collector to rotate about the center of curvature of the reflector and to extend down halfway between the center of curvature and the reflector, in the present invention, the solar energy  
15    collector extends further down according to a particular algorithm.

**RELATED APPLICATIONS**

20        The present invention can be made in a modular form as described in an application entitled "A Roof Having an Integral Solar Energy Concentrating System", filed concurrently herewith, and incorporated by reference hereto.

25        The present invention also can incorporate the use of replaceable solar energy concentrating reflectors as described in an application entitled "An Improved Solar Energy Concentrating System Having Replaceable Reflectors", filed concurrently herewith, and incorporated by reference hereto.

The present invention also can incorporate the use of an automatic safety means for the secondary collector as described in an application entitled "An Improved Solar Energy Concentrating System Having An Automatic Safety Means", filed concurrently herewith, and incorporated by reference hereto.

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### **BACKGROUND ART**

In the past, solar energy concentrating systems have used a variety of approaches for achieving a maximum collection of solar energy from a combination of a cylindrically arcuate primary concentrating reflector and a movable secondary solar energy collector. For example, U.S. 4,602,613 to Barr, discloses a combination of a stationary cylindrically arcuate primary collector and a moveable secondary collector. However, the secondary collector is a flat plate collector that moves in a horizontal direction.

In another traditional configuration, described in U. S. 3,868, 823, a simple conduit is used as a secondary solar energy collector in combination with a circular primary collector formed from a plurality of longitudinal slats arranged in a circular arcuate fashion. The conduit is pivoted about the center of curvature for the primary reflector. The conduit is placed on a rotating member that extends up from the center of curvature. The length of that member extends anywhere from one to one half the radius of curvature of the reflector.

Compound parabolic optics have been used to collect solar energy. The seminal work of Dr. Roland Winston embodies this work, as seen in U. S. 4,230,095; U. S. 4,359,265; U.S. 4,387,961; and U.S. 5,289,356. (For the purposes of the present invention, the phrases "compound parabolic" and "non-imaging optics" include the definitions set forth in Dr. Winston's work.) However, in all of these disclosures, a compound parabolic optically based concentrator has

always been used alone as a primary solar energy concentrator, never in tandem as a secondary solar energy concentrator paired with a primary reflector.

5 **DISCLOSURE OF THE INVENTION**

The present invention relates to an improved solar energy concentrating system with a greater solar collection efficiency. All the elements of the present invention may have been used in the prior art. The novelty of the present  
10 improvement lies in the unexpected benefits in changing the relationship among the elements, in particular, pairing a compound parabolic solar collector as a secondary solar energy collector in tandem with a cylindrically arcuate solar energy concentrating reflector as a primary collector.

15 In the present invention, a primary solar energy reflector has a concave and cylindrically arcuate configuration of up to about 220 degrees, a lower edge, an upper edge and curved lateral edges. (For the purposes of this invention, "lower" and "upper" do not express, necessarily, a relative position between the edges. For example, if the reflector has a 180 degrees configuration mounted in a level  
20 fashion, then these edges may be equidistant from a supporting surface for the reflector.) The skyward surface of the reflector is the concave surface. A structural support means is disposed beneath the reflector. It is dimensioned and configured to support the weight of at least the reflector, a solar energy collector, and a collector support means. A collector support means spans across the  
25 reflector, from the upper edge to the lower edge. The collector support means is connected to a compound parabolic solar energy secondary solar energy collector and either the reflector, the structural support means, or a supporting surface that underlies the structural support means. The collector support means is dimensioned and configured so to support a solar energy collector and allow it to  
30 move arcuately so as to stay within a focal collection zone above the primary

reflector.

A linear compound parabolic solar energy secondary collector extends lengthwise across the reflector, from one curved lateral edge to another curved lateral edge. The collector is located by and disposed on the collector support means so as to move arcuately within a predetermined focal zone for collecting solar energy reflected from the reflector. The focal zone position can vary, depending upon the exact compound parabolic cross section used for the collector. Typically, the zone would be located at about one half the radius of the center of curvature for the primary reflector. The collector is dimensioned and configured to receive reflected solar energy into a conduit through which an energy transfer fluid can flow.

Also included in preferred embodiments of the present invention is a means for positioning the collector. Connected to the collector support means, the positioning means places the collector in an optimal position within the focal collection zone for collecting solar energy throughout a defined solar cycle, such as the diurnal cycle.

The final element is a fluid transport means which connects the conduit to a thermal energy use means or an energy storage means. When the sun shines, solar energy bounces off the reflector towards the concentrator, where it is impinged upon the conduit. The fluid within the conduit of the collector is heated. The fluid transport means circulates the heated fluid through either the thermal energy use means or the energy storage means.

In a preferred embodiment using a non-imaging compound parabolic secondary collector, the present invention comprises the collector pivoting about the center of curvature of the reflector, while the collector is located down from the center of curvature by a distance  $L$  plus or minus 5% according to the formula:  $L =$

$(R * 1.1)/2$ ; where R equals the radius of the curvature of the solar energy concentrating reflector. By using such a position, one can achieve a greater accumulation of reflected solar energy than at previous known locations, including the prior art mounting of the collector at the halfway position.

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### **BRIEF DESCRIPTION OF THE DRAWINGS**

FIGURE 1 is a sectional view of the present invention.

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FIGURE 2 is an isometric view of the present invention.

### **BEST MODES FOR CARRYING OUT THE INVENTION**

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A preferred embodiment of the present invention is shown in FIGURE 1. A solar energy concentrating primary reflector (10) having a concave and cylindrically arcuate configuration of about 60 degrees has a lower edge (12), an upper edge (14), and curved lateral edges (16). Suitable materials for the reflector include polished metals or reflectorized materials having deposited or laminated coatings. In one preferred embodiment, the reflector comprises an ultraviolet-stabilized plastic or polymer having a reflectorized surface of aluminum deposited thereon. The skyward surface of the reflector is the concave surface. In another preferred embodiment, a first reflector can be adjacent to a second reflector, either along its curved lateral edges or its lower edge. In the latter case, the lower edge of a first reflector is adjacent along the entire lower edge to the lower edge of a second reflector, each reflector having a cylindrically arcuate configuration of up to about 90 degrees, the pair forming a cylindrically arcuate configuration of up to about 180 degrees.

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A structural support means (20), such as a space truss, is disposed beneath the reflector. The structural support means is dimensioned and configured to support the weight of at least the reflector, a compound parabolic secondary solar energy collector, and a solar energy collector support means, as well as  
5 conventional live loads and dead loads. A number of alternative configurations can be designed by those of ordinary skill in the art. A collector support means spans lengthwise across and above the reflector, as defined by the axis extending from the upper edge (14) to the lower edge (12). The collector support means comprises two arches (22), a bearing means (24) disposed on each arch, a drive shaft member  
10 (26) connected to the bearing means (so as to comprise a rotating means), and two downward spacing members (28). The rotating means is located at the center of curvature for the reflector, as shown by the circular path (29) in FIGURE 1. The downward spacing members are dimensioned such that the collector is located down from the center of curvature by a distance L plus or minus 5% according to  
15 the formula:

$$L = (R * 1.1)/2;$$

where R equals the radius of the curvature of the reflector. The above arrangement of elements allows the secondary collector to move within a predetermined and defined focal zone for collecting solar energy reflected from the primary reflector.  
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The compound parabolic, non-imaging solar energy collector (30) is connected to the structural support means (20) by the collector support means. Attachment points (32) are located adjacent to both the upper edges and the lower edges of the reflector, the attachment points also being connected to the arches  
25 (22). Alternatively, the collector support means could have been connected to a supporting surface that underlies the structural support means. The collector support means is dimensioned and configured so to support the collector and allow it to move arcuately, and thus, alternative designs are known to those of ordinary skill in the art.

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In some preferred embodiments, the collector is oriented lengthwise within 30 degrees of a true East-West axis, such as in the embodiment shown in FIGURE 1. However, if the non-reflective panel (40) in FIGURE 1 is replaced with a reflector, then one could orient the collector lengthwise within 30 degrees of a true North-South axis.

Preferably, a means for positioning the solar energy collector (34) is connected to the drive shaft member (26). The positioning means can comprise a number of conventional means including a hydraulic motor driven by a hydraulic pump and control means, an electrical step motor, or a mechanical chain/gear or cable/pulley means. In any of these forms, the positioning means keeps the collector in an optimal position for collecting solar energy throughout a defined solar cycle, preferably the diurnal cycle. Thus, a microprocessor can be part of the positioning means, calculating periodically the optimal solar energy gathering position according to an algorithm that takes into account the latitude, the time of year, and the time of day. Such algorithms are known to those of ordinary skill in the art.

The collector is dimensioned and configured to receive reflected solar energy into an interior conduit through which an energy transfer fluid can flow. Preferred cross sectional embodiments for compound parabolic secondary collectors to be used with cylindrically arcuate reflectors are disclosed in U. S. 5,274,497 or U. S. 5,289,356. Suitable fluids for use in the collector conduit include commercially available heat transfer fluids. A fluid transport system, not shown, connects the conduit of the collector to a thermal energy use means or a thermal energy storage means. The fluid transport means circulates the solar energy-heated fluid. The fluid transport means can be of conventional designs known to those of ordinary skill in the art.

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All publications or unpublished patent applications mentioned herein are hereby incorporated by reference thereto.

Other embodiments of the present invention are not presented here which  
5 are obvious to those of ordinary skill in the art, now or during the term of any patent issuing from this patent specification, and thus, are within the spirit and scope of the present invention.

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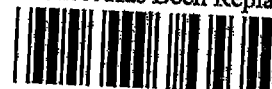
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## CLAIMS



## 1. An improved solar energy concentrating system having:

- 5           a) at least one solar energy primary concentrating reflector having a concave and cylindrically arcuate configuration of up to about 220 degrees, a lower edge, an upper edge, and curved lateral edges, the skyward surface of the reflector being the concave surface;
- 10          b) a structural support means disposed beneath and attached to the reflector, said support means being dimensioned and configured to support the weight of at least the reflector, a compound parabolic secondary solar energy collector, and a collector support means;
- 15          c) a collector support means spanning across and above the reflector, said collector support means being connected to a solar energy collector and either the structural support means or a supporting surface that underlies the structural support means, and said collector support means being dimensioned and configured so as to support the solar energy collector and allow it to move arcuately;
- 20          d) a linear secondary solar energy collector having a compound parabolic cross-section, said collector extending laterally across the reflector, said collector being located and disposed so as to move arcuately within a predetermined focal zone for collecting reflected solar energy from the reflector, and said collector being dimensioned and configured to receive the reflected solar energy into a conduit through which an energy transfer fluid flows, said fluid being heated by the reflected solar energy;
- 25          e) a means for positioning the collector in an optimal position within the focal collection zone throughout a defined solar cycle, said positioning means being connected to the collector support means; and
- 30          f) a fluid transport means which connects the conduit of the collector to a thermal energy use means or an energy storage means, wherein the fluid





transport means circulates the solar energy-heated fluid through the conduit.

2. The solar energy concentrating system of Claim 1 wherein the positioning  
5 means is controlled by a microprocessor which periodically calculates an optimal position within the focal collection zone for the collector to receive the reflected solar energy from the reflector.
3. The solar energy concentrating system of Claim 1 wherein the collector is  
10 oriented lengthwise within 30 degrees of a true East- West axis.
4. The solar energy concentrating system of Claim 1 comprising two reflectors, wherein a first reflector is adjacent along the entire lower edge to the lower edge of a second reflector, each reflector having a cylindrically arcuate configuration of up  
15 to about 110 degrees.
5. The solar energy concentrating system of Claim 1 wherein the collector support means includes at least two collector support members, each being disposed at either end of the collector.  
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6. The solar energy concentrating system of Claim 4 wherein the collector is oriented lengthwise within 30 degrees of a true North -South axis.
7. An improved solar energy concentrating system having:  
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  - a) at least one solar energy concentrating reflector having a concave and cylindrically arcuate configuration of up to about 220 degrees, a lower edge, an upper edge, and curved lateral edges, the skyward surface of the reflector being the concave surface;
  - b) a structural support means disposed beneath and attached to the  
30 reflector, said support means being dimensioned and configured to





support the weight of at least the reflector, a solar energy collector, and a collector support means;

- 5 c) a collector support means spanning across and above the reflector, said collector support means being connected to a solar energy collector and either the structural support means or a supporting surface that underlies the structural support means, and said collector support means being dimensioned and configured so as to support the solar energy collector and allow it to move arcuately;
- 10 d) a linear secondary solar energy collector having a compound parabolic cross section, said collector extending laterally across the reflector, said collector being located and disposed so as to move within a predetermined focal zone for collecting reflected solar energy from the reflector, and said collector being dimensioned and configured to receive the reflected solar energy into a conduit through which an
- 15 energy transfer fluid flows, said fluid being heated by the reflected solar energy;
- e) a means for positioning the collector in an optimal position within the focal collection zone throughout a defined solar cycle, said positioning means being connected to the collector support means; and
- 20 f) a fluid transport means which connects the conduit of the collector to a thermal energy use means or an energy storage means, wherein the fluid transport means circulates the solar energy-heated fluid through the conduit;

wherein the improvement comprises the collector pivoting about the center of curvature of the reflector, and the collector being located down from the center of curvature by a distance L plus or minus 5% according to the formula:

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$$L = (R * 1.1)/2;$$

where R equals the radius of the curvature of the solar energy concentrating reflector.

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8. The solar energy concentrating system of Claim 7 wherein the positioning means is controlled by a microprocessor which periodically calculates an optimal position within the focal collection zone for the collector to receive the reflected solar energy from the reflector.

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9. The solar energy concentrating system of Claim 7 wherein the collector is oriented lengthwise within 30 degrees of a true East- West axis.

10. The solar energy concentrating system of Claim 7 comprising two reflectors, wherein a first reflector is adjacent along the entire lower edge to the lower edge of a second reflector, each reflector having a cylindrically arcuate configuration of up to about 110 degrees.

11. The solar energy concentrating system of Claim 7 wherein the collector support means includes at least two collector support members, each being disposed at either end of the collector.

12. The solar energy concentrating system of Claim 10 wherein the collector is oriented lengthwise within 30 degrees of a true North -South axis.

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