US 20150096553A1

(19) United States
(12) Patent Application Publication
Kussul et al.
(10) Pub. No.: US 2015/0096553 A1
(43) Pub. Date: Apr. 9, 2015

(54) **SUPPORT DEVICE FOR SOLAR CONCENTRATOR WITH FLAT MIRRORS**

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(21) Appl. No.: **14/372,746**

(22) PCT Filed: **Jan. 31, 2013**

(86) PCT No.: **PCT/MX2013/000017**
§ 371 (c)(1),
(2) Date: **Jul. 16, 2014**

(30) **Foreign Application Priority Data**

Feb. 7, 2012 (MX) MX/A/2012/001598

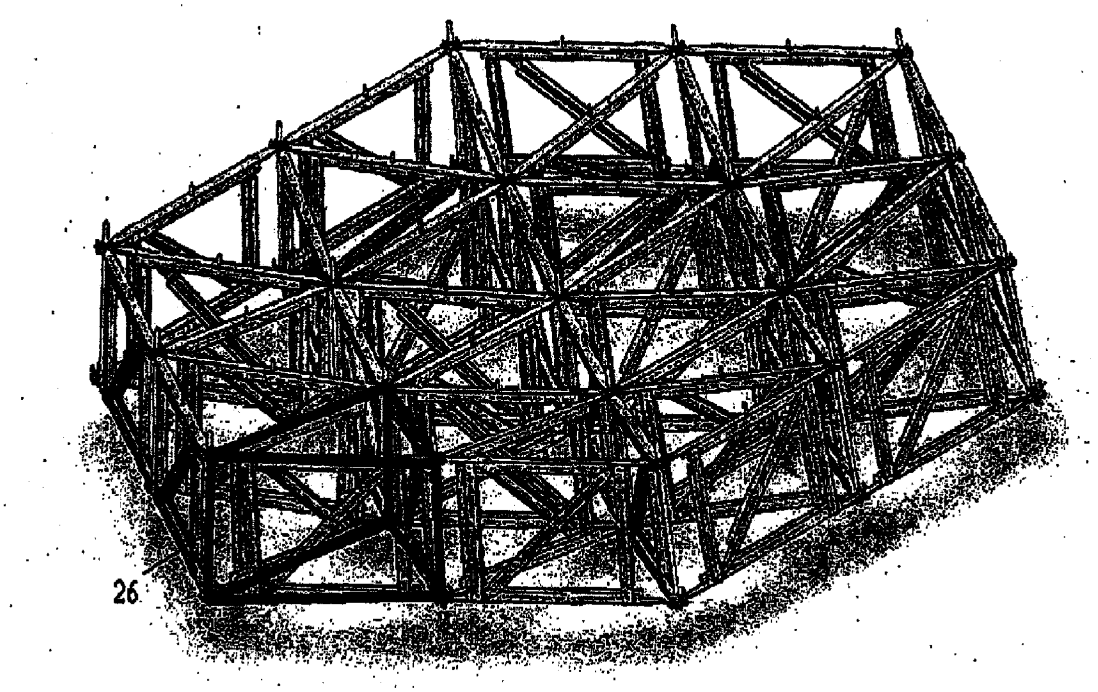
Publication Classification

(51) **Int. Cl.**
F24J 2/52 (2006.01)

(52) **U.S. Cl.**
CPC *F24J 2/5233* (2013.01); *F24J 2/5239* (2013.01)

(57) **ABSTRACT**

The invention relates to a hexagonal parabolic solar concentrator consisting of the union of different radial layers of support cells formed by two types of pre-assembled modules, wherein said pre-assembled modules are made up of bars and connecting elements. Using these pre-assembled modules significantly reduces the time for manufacture of the components and for parabolic concentrator assembling and the adjustment time for the flat mirrors supporting cells in order to generate the curve of parabola.



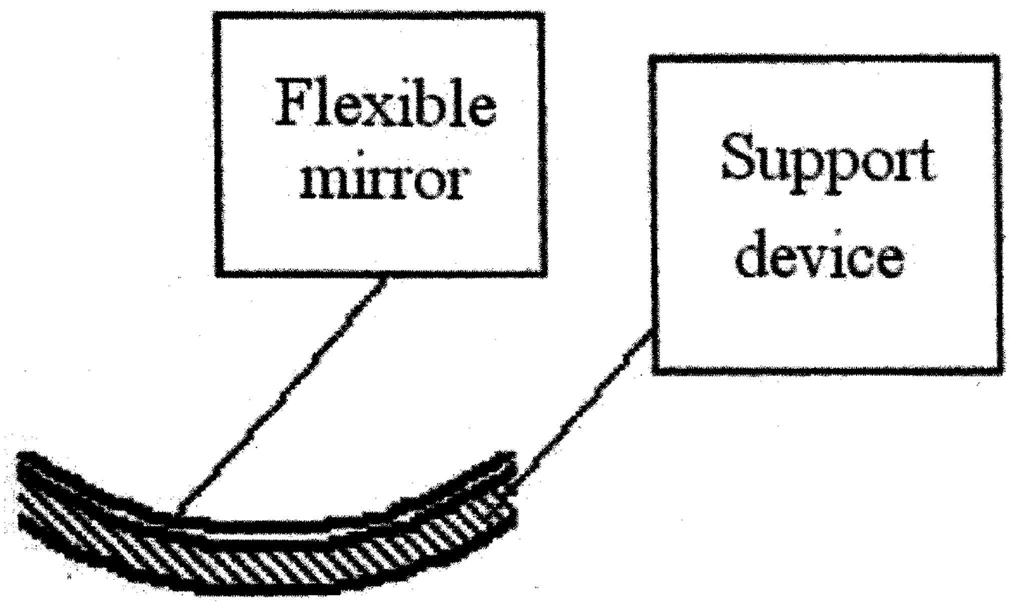


FIG. 1

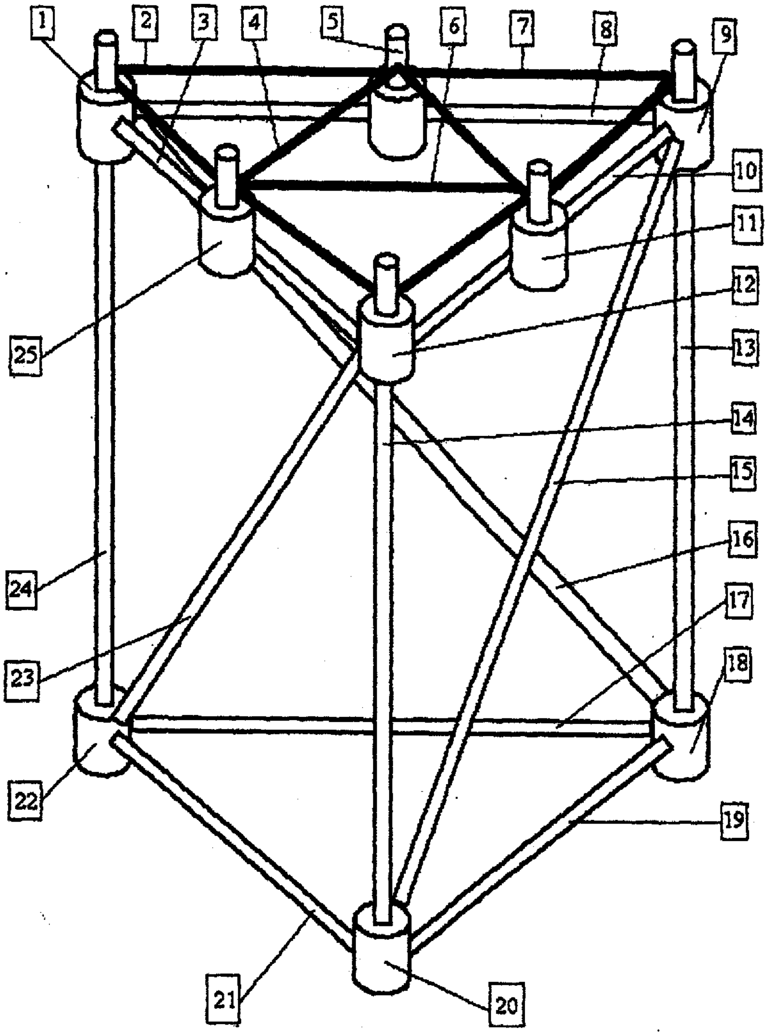


Fig 2

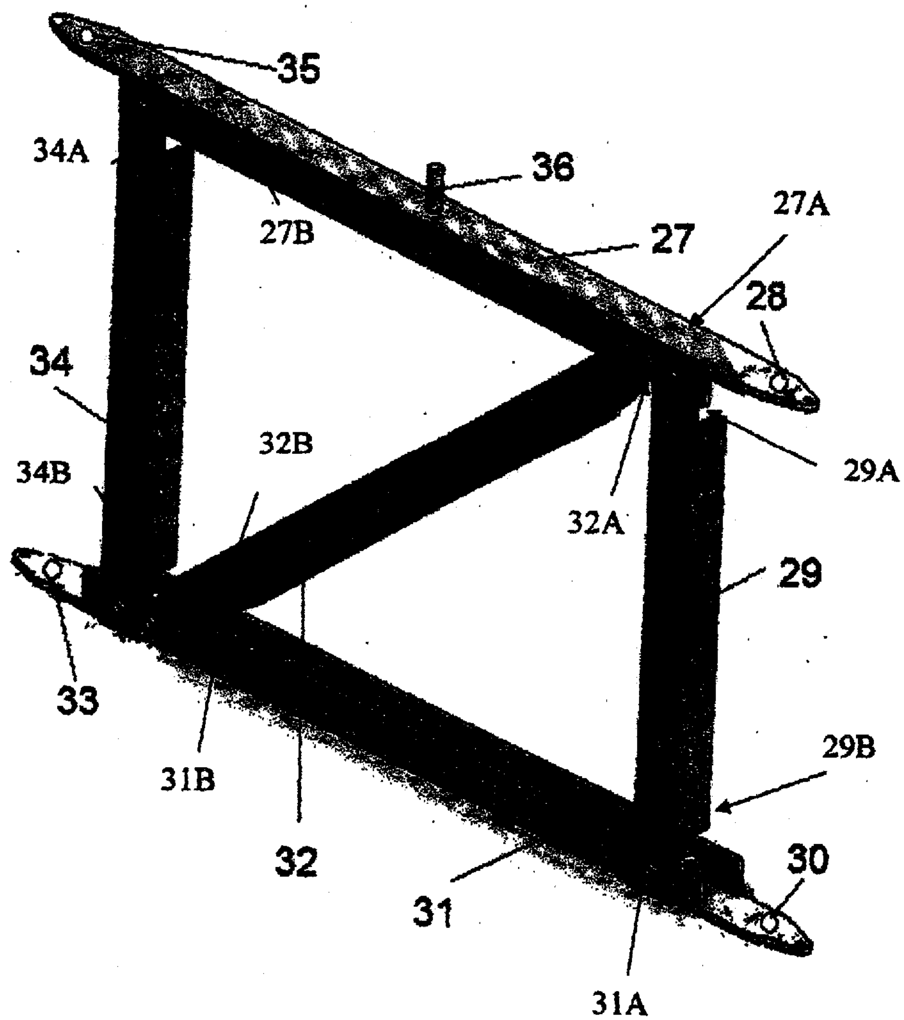

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Fig 3

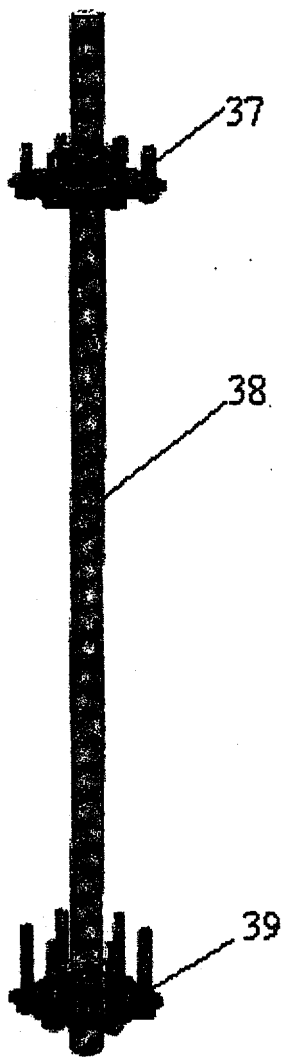

Fig 4

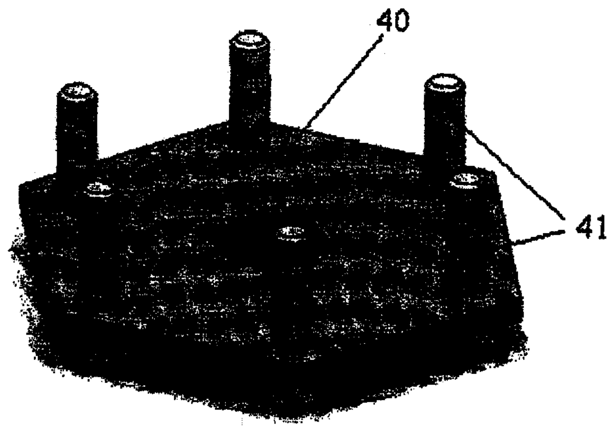

Fig 5

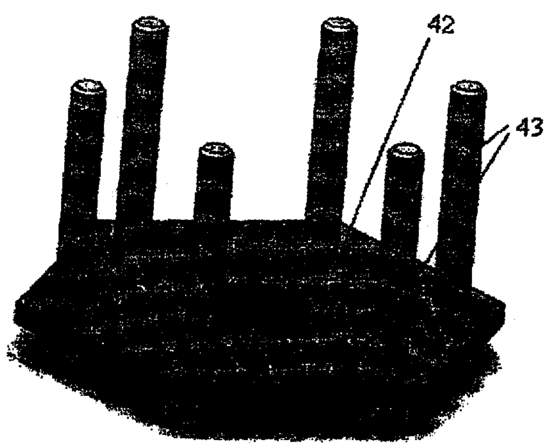

Fig 6

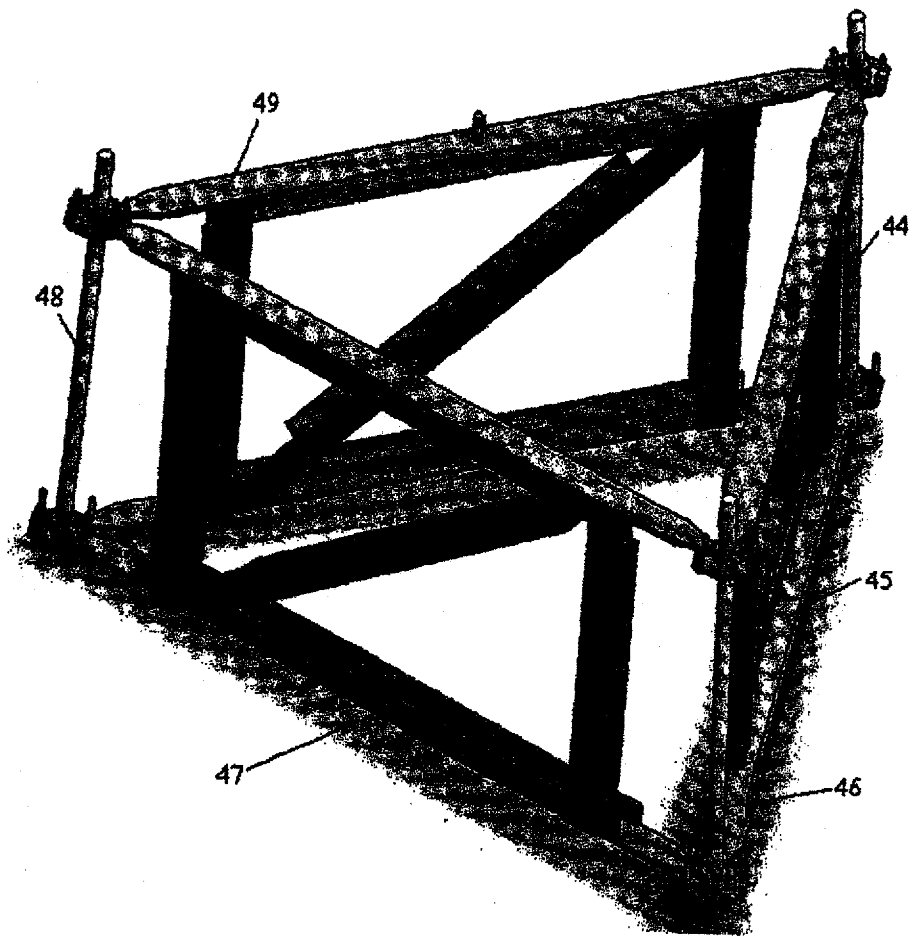

Fig 7

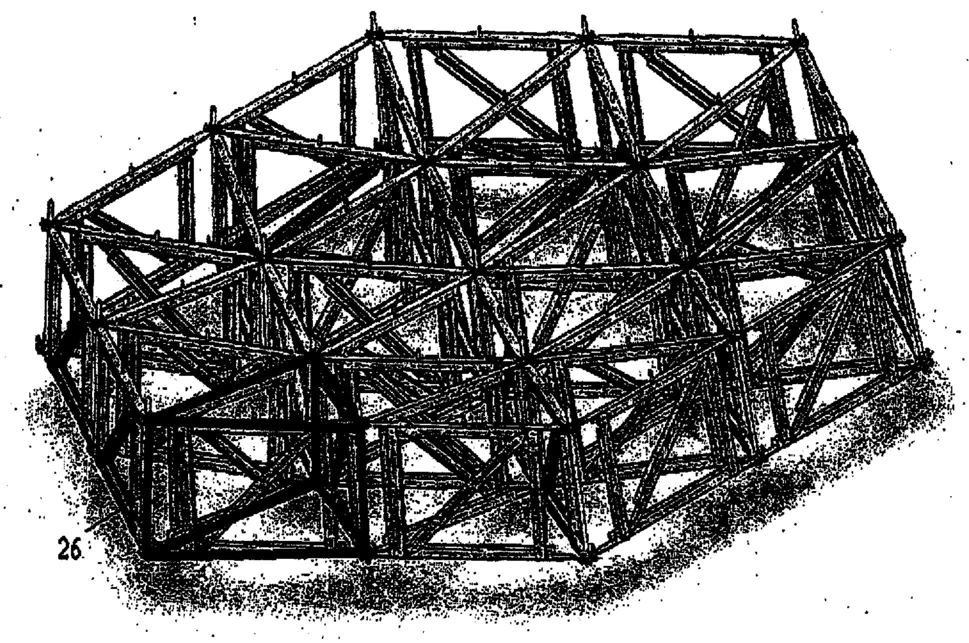

Fig. 8

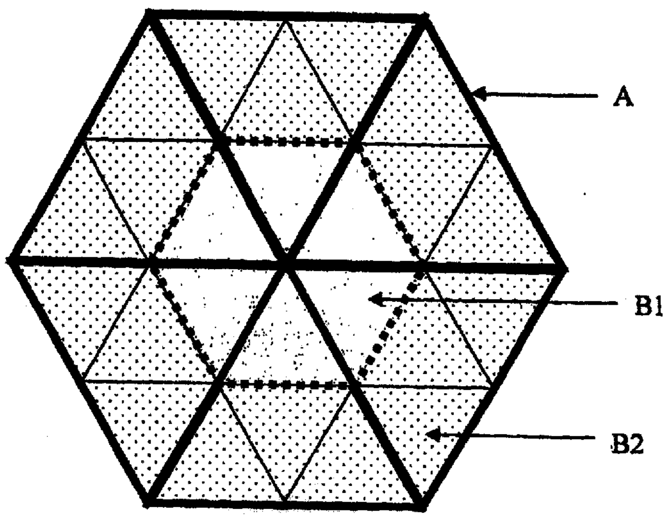

Fig 9

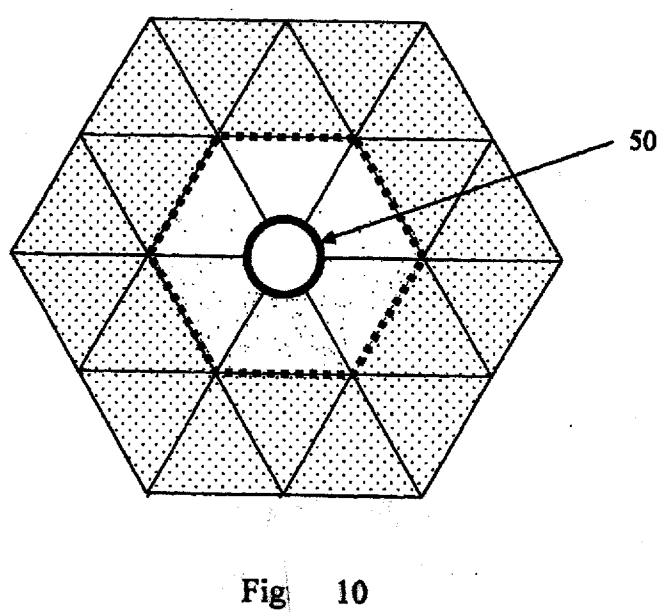

Fig 10

SUPPORT DEVICE FOR SOLAR CONCENTRATOR WITH FLAT MIRRORS

FIELD OF THE INVENTION

[0001] The present invention consists of a technology used to concentrate solar energy, specifically refers to a parabolic solar concentrator consisting of two types of pre-assembled modules, which are formed by bars and connecting elements, whose objective is to make the assembly of a structure of a parabolic concentrator.

BACKGROUND OF THE INVENTION

[0002] There are solar concentrators of different types [1]. Most of them are channel concentrators, concentrator towers and parabolic dish concentrators; channel concentrators do not allow obtaining a high concentration ratio; tower type concentrators have a complex control system and are relatively expensive; conventional parabolic dish concentrators are expensive because the parabolic surface is formed by two components: a rigid support and the flexible mirror (FIG. **1**), in addition, the flexible mirrors are made of high-cost special glass.

[0003] In the document [2], a proposal is made to approximate the parabolic surface with a large amount of spherical mirrors. The price of spherical mirrors is less than the parabolic mirrors.

[0004] Another technology relates to a parabolic dish concentrator that uses a large number of small flat mirrors that approximate a parabolic surface. This type of concentrator was developed by the Australian National University [3] and used in the solar power plant "White Cliffs" in Australia. This concentrator has a parabolic-shape support device made of fiberglass with over 2,300 flat mirrors with a size of 100×100 mm^2, which are adhered to the concave surface of this dish.

[0005] Literature describes the development of the flat minor solar concentrator with a support based on bars and nodes, as disclosed in documents [4] and [5]. The price of this type of concentrators is less than that of parabolic or spherical mirrors. Said concentrator uses a large number of small flat mirrors that approximate a parabolic surface. The limitation of the cell developed to support the solar concentrator (FIG. **2**) is that the assembly of such support is complicated, for example, the support of 24-cell device to support 96 flat mirrors, has 144 bars.

[0006] To assemble this device is necessary to find the positions of the two ends of each bar and fix these ends with assembly accessories, furthermore the access to some nodes is not easy due to the structure and/or elements design, which complicates the assembly process.

[0007] Said concentrator has the possibility to obtain a temperature up to 300 centigrade degrees, however to obtaining a higher temperature is necessary to increase the number of cells, which implies a more complicated assembly because the number of bars and bar unions with nodes are increasing.

[0008] Therefore, the assembly process of these type of devices has a strong impact on the manufacturing cost; hence, there is a need for concentrators that allow a cost-efficient assembly process.

BRIEF DESCRIPTION OF THE FIGURES

[0009] FIG. **1**. Shows a solar concentrator of the prior art with flexible mirrors (1) with support (2).

[0010] FIG. **2**. Shows the supporting cell for flat mirrors in a solar concentrator made of bars and nodes, the configuration of which is known in the prior art.

[0011] FIG. **3**. Shows a general view of one of the embodiments of the pre-assembled module of the first type.

[0012] FIG. **4**. Shows a general view of one of the embodiments of the pre-assembled module of the second type.

[0013] FIG. **5**. Shows an embodiment of the upper node of the pre-assembled module of the second type.

[0014] FIG. **6**. Shows an embodiment of the bottom node of the pre-assembled module of the second type.

[0015] FIG. **7**. Shows an embodiment of the supporting cell of the concentration device of the present invention using three pre-assembled modules of the first type and three pre-assembled modules of the second type.

[0016] FIG. **8**. Shows an embodiment of the supporting device of the solar concentrator consisting of 24 supporting cells made of pre-assembled modules of both types.

[0017] FIG. **9**. Shows a concentrator with a 6-cell layer and two mirror zones.

[0018] FIG. **10**. Shows a concentrator with a 6-cell layer, two mirror zones, and a modified module of the second type.

DETAILED DESCRIPTION OF THE INVENTION

[0019] In this invention, a parabolic solar concentrator is proposed consisting of cell layers constructed by pre-assembled modules of two types, which are shown in FIGS. **3** and **4**. The first type module has a trapezoidal shape (shown in FIG. **3**) and is constituted by a bottom horizontal bar (**31**), a upper horizontal bar (**27**) having an adjusting element (**36**) arranged in perpendicular form in its central part on the upper face, a first vertical bar (**29**), a second vertical bar (**34**) and a diagonal bar (**32**). The upper horizontal bar (**27**) has in its ends (**27**A) and (**27**B) two vertical last holes (**28**) and (**35**) respectively; in turn, the bottom horizontal bar (**31**) has in its ends two vertical last holes (**30**) and (**33**).

[0020] To form a pre-assembled module of the first type as shown in FIG. **3**, the end (**29**A) of the first vertical bar (**29**) is connected to the end (**27**A) of the top horizontal bar (**27**); the end (**29**B) of the first vertical bar (**29**) is connected to the end (**31**A) of the bottom horizontal bar (**31**); the end (**32**A) of the diagonal bar (**32**) is connected to the end (**27**A) of the top horizontal bar (**27**); the end (**32**B) of the diagonal bar (**32**) is connected to the end (**31**B) of the bottom horizontal bar (**31**); the end (**34**A) of the vertical bar (**34**) is connected to the end (**27**B) of the top horizontal bar (**27**); the end (**34**B) of the vertical bar (**34**) is connected to the end (**31**B) of the bottom horizontal bar (**31**).

[0021] It should be noted that in one of the embodiments of the present invention, the length of the top horizontal bar (**27**) is smaller than the length of the bottom horizontal bar (**31**); the difference between both lengths depends on the curvature of the concentrator. Vertical bars allow the pre-assembled module of the first-type to be rigid.

[0022] The second-type module (FIG. **4**) consists of a vertical bar (**38**), a top node (**37**) and a bottom node (**39**); the top node (**37**) of (FIG. **5**) consists of a plate (**40**) and six connecting elements (**41**) fixed and radially distributed in the outer area of the plate (**40**) with a 60° angle between them; the bottom node (**39**) of (FIG. **6**) contains the plate (**42**) and six connecting elements (**43**) radially distributed in the outer area of the plate (**42**) with a 60° angle between them.

[0023] In another embodiment of the invention, the length of the connecting elements (**43**) is bigger than the length of the connecting elements (**41**) to facilitate its assembly, either manually or by automatic systems.

[0024] The cell of FIG. **7** includes three modules of the first type (**45**, **47**, and **49**) and three modules of the second type (**44**, **46**, and **48**). Each module of the first type is connected to two modules of the second type assembled as follows: one end of the top horizontal bar of the module of the first type (**49**) is fixed on the connecting element of the top node of the module of the second type (**44**); one end of the bottom horizontal bar of the module (**49**) is fixed on one connecting element of the bottom node of the module of the second type (**44**);

[0025] one end of the top horizontal bar of the module of the first type (**45**) is fixed to the connecting element of the top node of the module of the second type (**44**); one end of the bottom horizontal bar of the module (**45**) is fixed on a connecting element of the bottom node of the module of the second type (**44**); the second end of the top horizontal bar of the module of the first type (**45**) is fixed to the connecting element of the top node of the module of the second type (**46**); the second end of the bottom horizontal bar of the module (**45**) is fixed to a connecting element of the bottom node of the module of the second type (**46**); the second end of the horizontal top bar of the module of the first type (**47**) is fixed to the connecting element of the top node of the module of the second type (**46**); one end of the horizontal bottom bar of the module (**47**) is fixed to a connecting element of the bottom node of the module of the second type (**46**); one end of the horizontal top bar of the module of the first type (**47**) is fixed to the connecting element of the top node of the module of the second type (**48**); the second end of the horizontal bottom bar of the module (**47**) is fixed to a connecting element of the bottom node of the module of the second type (**48**); finally, the second end of the horizontal top bar of the module of the first type (**49**) is fixed to the connecting element of the top node of the module of the second type (**48**); the second end of the bottom horizontal bar of the module (**49**) is fixed on a connecting element of the bottom node of the module of the second type (**48**).

[0026] The entire structure of the solar concentrator has a hexagonal shape as seen in the perspective of FIG. **8**, forming by the union of diverse supporting cells that define radial layers of supporting cells, enabling them to share modules of the first type and of the second type as illustrated in FIG. **9**, wherein a layer of six supporting cells A is shown, where each supporting cell includes 4 mirrors; although the number of mirrors in each cell can be 4^n as described in the patent application MX/a/2008/005063.

[0027] In the embodiment of the invention where each cell includes 4 mirrors, two mirror zones are formed: B**1** (grey layer) and B**2** (point layer) as illustrated in FIG. **9**.

[0028] In the embodiment of the invention where each supporting cell contains 16 mirrors, 4 mirror zones are formed.

[0029] The number of modules of the first type for the concentrator is calculated with the following equation:

$$M(1)=3c(3c+1)$$

[0030] The number of modules of the second type for the concentrator is calculated with the following equation:

$$M(2)=1+3c(c+1)$$

where "c" represents the number of cell layers of the concentrator.

[0031] The number of layers and zones depends on the type of application or the desired temperature of the collector. The total number of mirrors for a concentrator, is calculated by multiplying the number of mirrors per cell by the number of cells. It is possible for the cells to have cell arrays with different numbers of mirrors.

[0032] The first cell layer (A) consists of 6 cells, and the second cell layer consists of 18 cells; each successive cell layer increases by an arithmetic progression of twelve.

[0033] In another embodiment of the solar concentrator, 6 mirrors of the first mirror zone (B**1**) are omitted, as illustrated in FIG. **10**, since there always exists a shadow generated by the collector (**5**) on this central point. For example, for a concentrator with two cell layers with 4 mirrors in each cell, the number of total flat mirrors would be 90.

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[0035] [2] Lewandowski A., et al. Multi-facet concentrator of solar, U.S. Pat. No. 6,225,551, 2001.

[0036] [3] G. Johnston, Focal region measurements of the 20 m2 tiled dish at dic Australian National University, Solar Energy, Vol. 63, No.2, pp. 117-124, 1998.

[0037] [4] E. Kussul, T. Baidyk, O. Makeyev, F. Lara-Rosano, 3. M. Saniger, N. Bruce, Development of Micro Mirror Solar Concentrator, The 2-nd IASME/WSEAS International Conference on Energy and Environment (EE'07), Portoroz, (Portotose), Slovenia, May 15,17,2007, pp.294-299.

[0038] [5] E. Kussul, T. Baidyk, F. Lara-Rosano, 3. M. Saniger, N. Bruce, Support Frame for Micro Facet Solar Concentrator, The 2-nd IASME/WSEAS International Conference on Energy and Environment (EE'07), Portoroz (Portotose), Slovenia, May 15-17, 2007, pp.300-304.

[0039] [6] http:/www.anzses.orglGallery/Dish.html The Australian and New Zealand Solar Energy Society, White Cliffs Dish—20 m2 dish at ANU.

We claim:

1. A supporting device for a solar concentrator of flat mirrors conformed by one or more radial layers of supporting cells, characterized because said supporting cells consisting of modules of the first type with a trapezoidal shape, where each module is conformed by a bottom horizontal bar, one top horizontal bar, two vertical bars connecting the ends of the bottom and upper horizontal bars, and a diagonal bar connecting one end of the bottom horizontal bar with the opposite end of the top horizontal bar; and modules of the second type consisting of a vertical bar with a top node and a bottom node, where each node consists of a plate with six fixed connecting elements.

2. The device of claim **1**, characterized because the bottom horizontal bar (**31**) has a length bigger than the top horizontal bar (**27**) to form a trapezoidal geometry, where the difference between both lengths depends on the curvature of the concentrator.

3. The support device of claim **1**, characterized because the top horizontal bars have an adjustment element set up perpendicularly in the central part of their top face.

4. The support device of claim **1**, characterized because the connecting elements of the second-type modules are fixed perpendicularly to the top surface of the nodes.

5. The support device of claim **3**, characterized because said connecting elements are distributed radially in the outer area of the nodes.

6. The support device of claim **1**, characterized because the required number of modules of the first type is equal to [3c(3c+1)], where "c" represents the number of cell layers of the concentrator.

7. The support device of claim **1**, characterized because the number of modules of the second type is equal to [1+3c(c+1)], where "c" represents the number of cell layers of the concentrator.

* * * * *