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**KUSSUL**(10) **Pub. No.: US 2011/0041836 A1**(43) **Pub. Date: Feb. 24, 2011**(54) **SOLAR CONCENTRATOR**(30) **Foreign Application Priority Data**(75) Inventor: **Ernst KUSSL, TIALCOLIGIA**  
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**F24J 2/12** (2006.01)(52) **U.S. Cl.** ..... **126/690**(57) **ABSTRACT**(73) Assignee: **UNIVERSIDAD NACIONAL**  
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Ciudad Universitaria (MX)(21) Appl. No.: **12/864,615**(22) PCT Filed: **Apr. 15, 2009**(86) PCT No.: **PCT/MX2009/000035**§ 371 (c)(1),  
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The invention relates to a novel design for a solar concentrator formed by: a first upper bushing, a second upper bushing, a third upper bushing, a fourth upper bushing, a fifth upper bushing, a sixth upper bushing, a first lower bushing, a second lower bushing, a third lower bushing, a first upper bar, a second upper bar, a third upper bar, a first lower bar, a second lower bar, a third lower bar, a first vertical bar, a second vertical bar, a third vertical bar, a first diagonal bar, a second diagonal bar, a third diagonal bar, a first mirror, a second mirror, a third mirror and a fourth mirror. The solar concentrator is formed by small flat mirrors which can be adjusted using nuts in order to obtain the desired parabolic curvature, thereby providing a higher concentration coefficient.

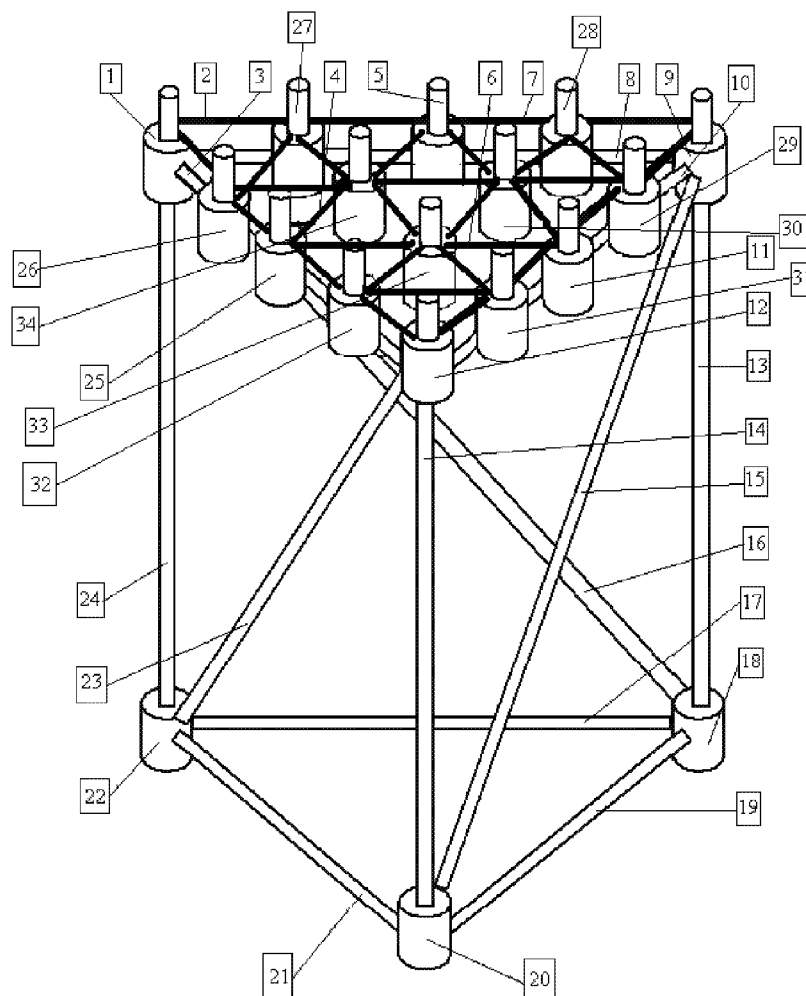


Figure 1

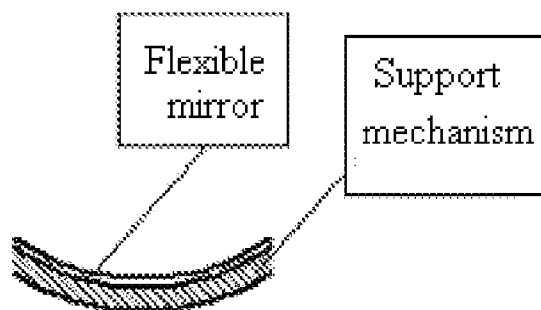


Figure 2

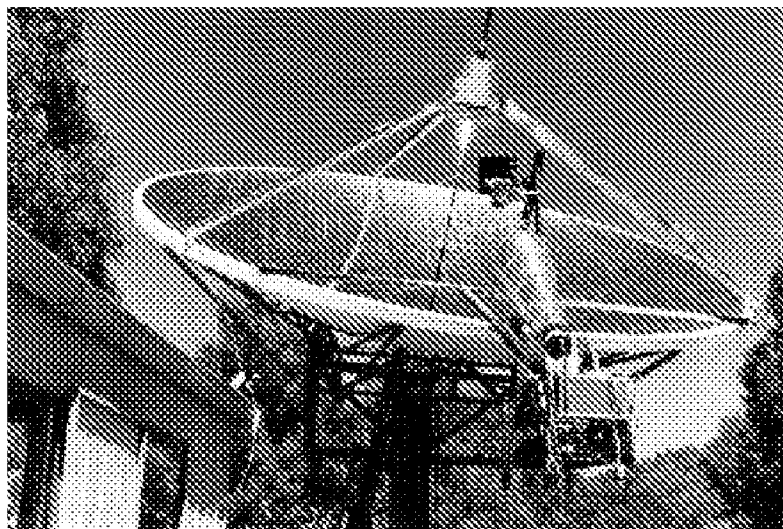


Figure 3

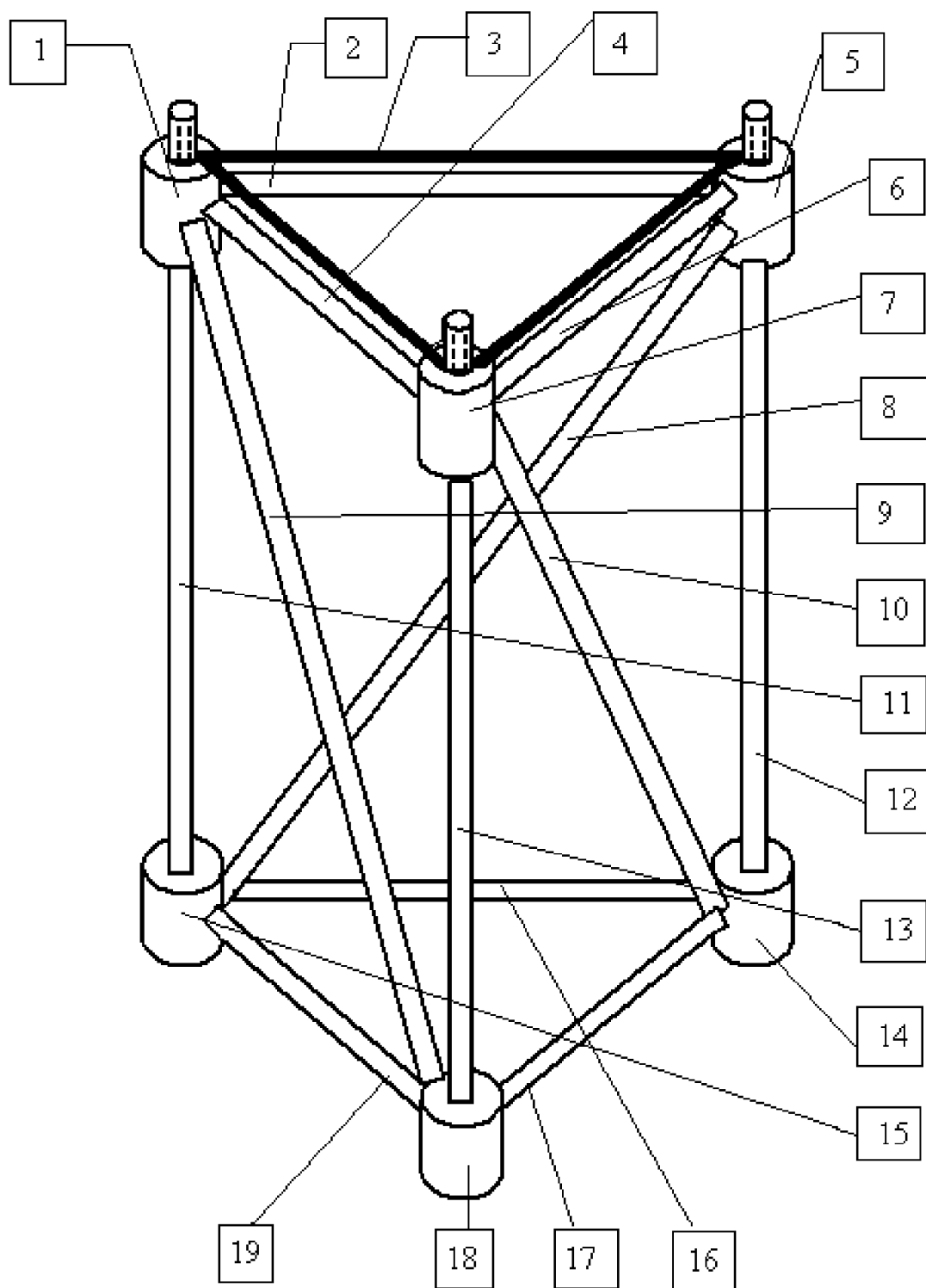


Figure 4

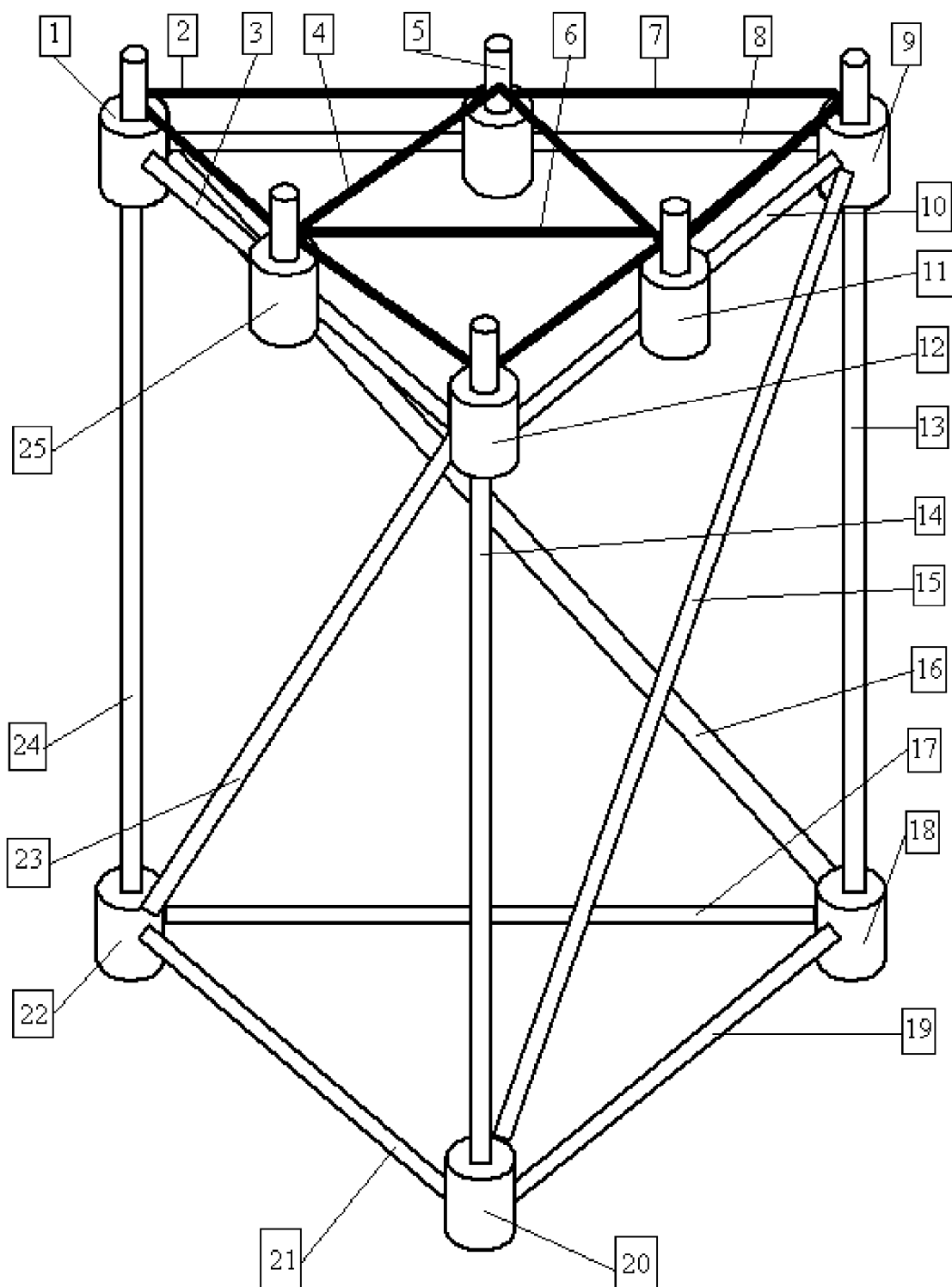


Figure 5

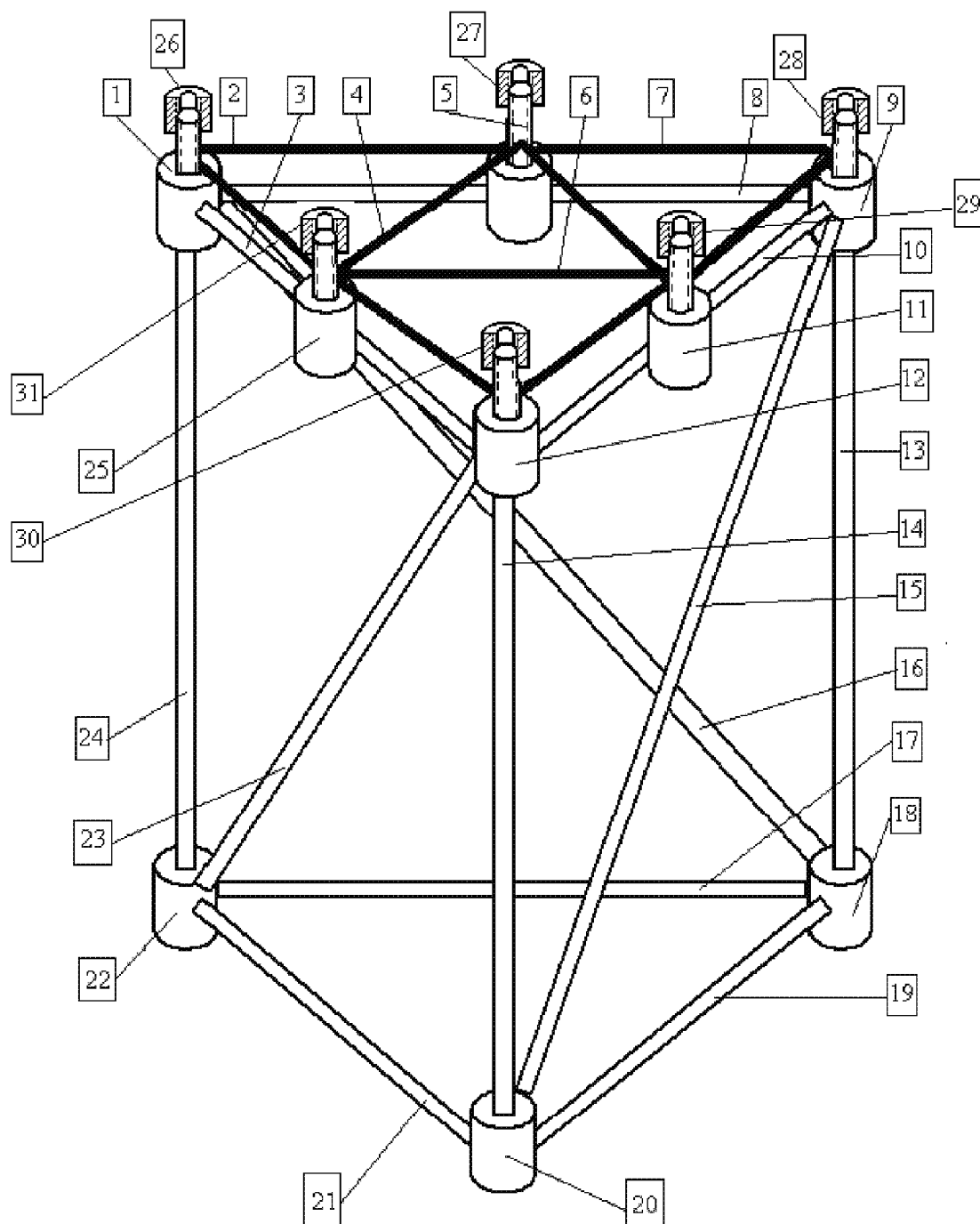


Figure 6

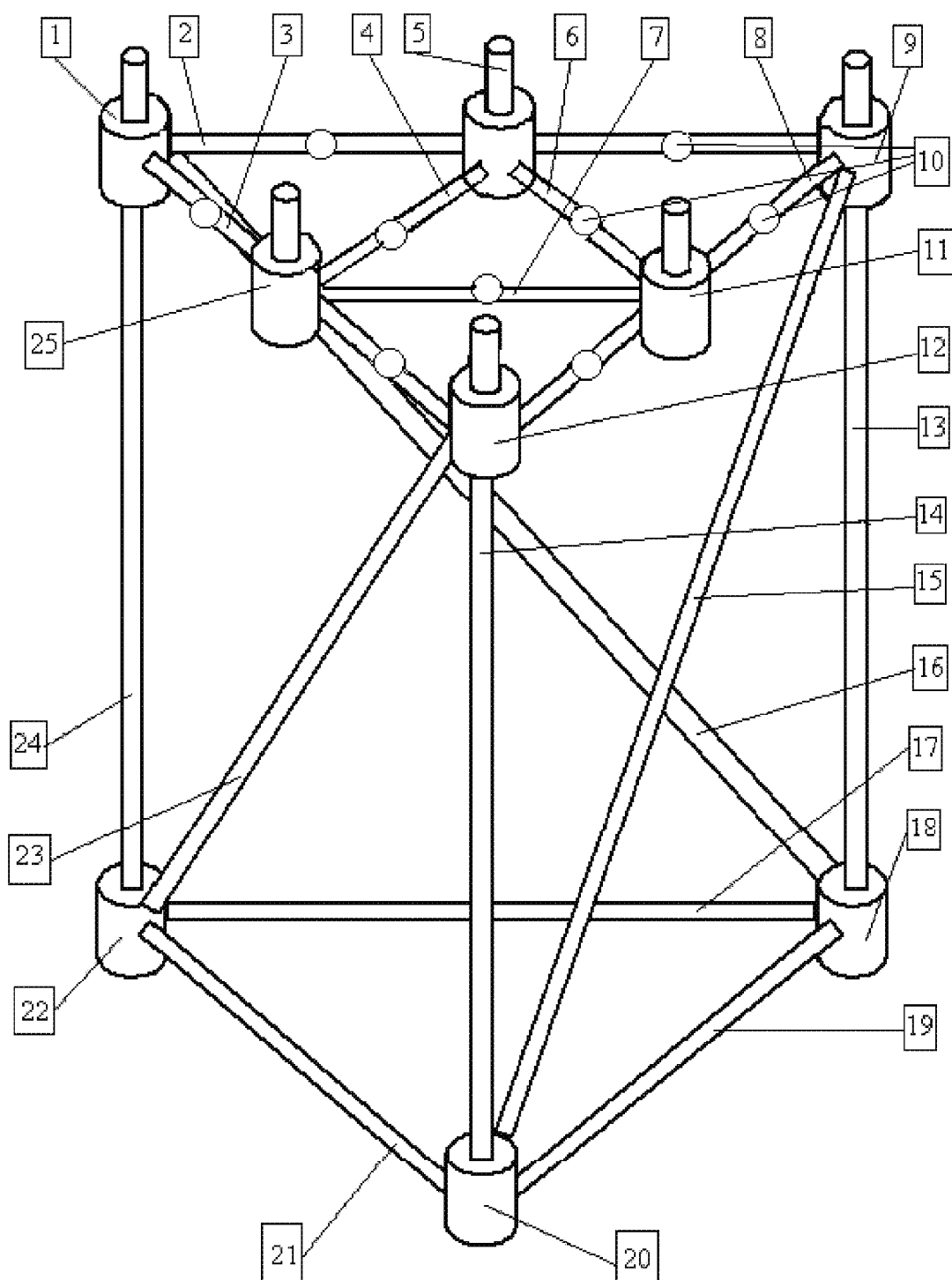
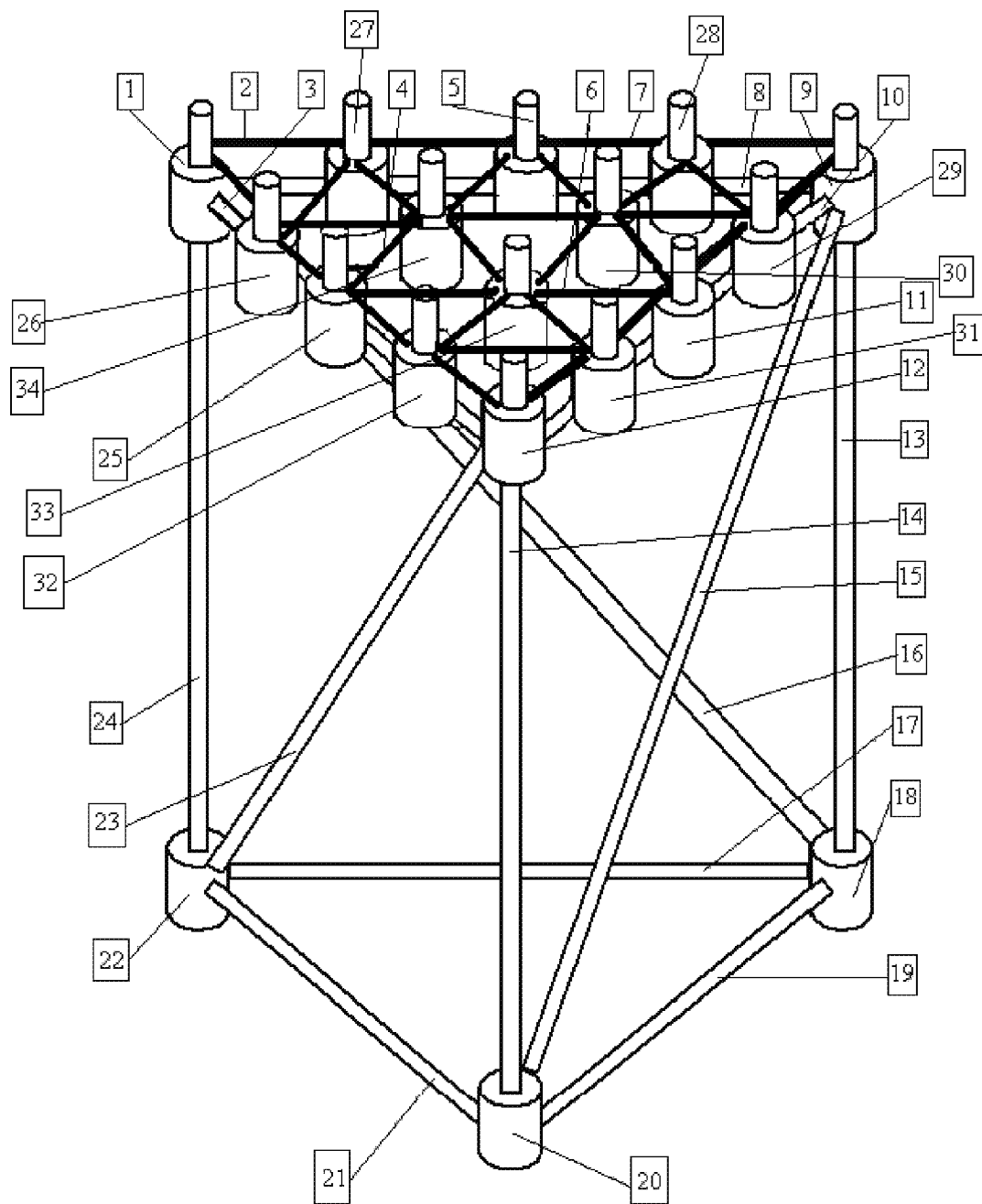


Figure 7



## SOLAR CONCENTRATOR

### FIELD OF THE INVENTION

**[0001]** The present invention consists of a technology to harvest solar energy to be used as an alternative energy source.

### BACKGROUND OF THE INVENTION

**[0002]** There are solar concentrators of various types [1]. The most commonly used are channel, tower-type, and parabolic concentrators. Channel concentrators do not provide a high concentration coefficient. The tower-type concentrators use a complex control system and are also expensive. Conventional parabolic concentrators are expensive because the parabolic surface comprises two components: a rigid and a flexible mirror (FIG. 1).

**[0003]** Flexible mirrors are made of a special high-cost glass.

**[0004]** It is proposed to approximate the parabolic surface with a large number of spherical mirrors [2]. The cost of spherical mirrors is cheaper than that of parabolic mirrors though still high.

**[0005]** There is a concentrator that uses a large number of small flat mirrors, which approximate a parabolic surface [2] [3] [4] [5] [6]. This type of concentrator was developed by the Australian National University [5] and was used in the solar power plant "White Cliffs" in Australia. This concentrator device had a dish-shaped holder made of fiberglass. More than 2,300 flat mirrors of 100×100 mm are glued to the concave surface of the dish (FIG. 2).

**[0006]** This solar concentrator had the peak concentration coefficient of 970 suns [5]. Its disadvantages are on one hand the high cost of the fiberglass support and on the other, the glue used to stick the flat mirrors reduces the accuracy of the solar concentrator.

**[0007]** Literature describes the solar concentrator of flat mirrors with support rods and nodes [3] [4]. The cell support is presented below.

**[0008]** The support device cell of the solar concentrator (FIG. 3) contains the first upper bushing (1), the second upper bushing (5) and the third upper bushing (7), the first lower bushing (15), the second lower bushing (14) and the third lower bushing (18), the first upper bar (2), the second upper bar (6) and the third upper bar (4), the first lower bar (16), the second lower bar (17) and the third lower bar (19), the first vertical bar (12), the second vertical bar (13) and the third vertical bar (11), the first diagonal bar (8), the second diagonal bar (10) and the third diagonal bar (9), the mirror (3).

**[0009]** The first terminal of the first upper bar is connected to the first upper bushing, and the second terminal of this bar is connected to the second upper bushing. The first terminal of the second upper bar is connected to the second upper bushing, and the second terminal of this bar is connected to the third upper bushing. The first terminal of the third upper bar is connected to the third upper bushing, and the second terminal of this bar is connected to the first upper bushing. The first terminal of the first lower bar is connected to the first lower bushing, and the second terminal of this bar is connected to the second lower bushing. The first terminal of the second lower bar is connected to the second lower bushing, and the second terminal of this bar is connected to the third lower bushing. The first terminal of the third lower bar is connected to the third lower bushing, and the second terminal of this bar

is connected to the first lower bushing. The first terminal of the first vertical bar is connected to the second lower bushing, and the second terminal of this bar is connected to the second upper bushing. The first terminal of the second vertical bar is connected to the third lower bushing and the second terminal of this bar is connected to the third upper bushing. The first terminal of the third vertical bar is connected to the first lower bushing and the second terminal of this bar is connected to the first upper bushing. The first terminal of the first diagonal bar is connected to the first lower bushing and the second terminal of this bar is connected to the second upper bushing. The first terminal of the second diagonal bar is connected to the second lower bushing and the second terminal of this bar is connected to the third upper bushing. The first terminal of the third diagonal bar is connected to the third lower bushing and the second terminal of this bar is connected to the first upper bushing. The first vertex of the mirror is connected to the first upper bushing, the second vertex of the mirror is connected to the second upper bushing, the third vertex of the mirror is connected to the third upper bushing.

**[0010]** The disadvantage of this prototype is that the cell supports only one flat mirror. The object of the invention is to increase the number of flat mirrors in a support cell, preserving the possibility to approximate the parabolic surface.

### BRIEF DESCRIPTION OF THE FIGURES

**[0011]** FIG. 1. Shows a diagram of a solar concentrator with a flexible mirror support.

**[0012]** FIG. 2. Describes the dish of "White Cliffs" [5], which is an example of a solar concentrator with square flat mirrors glued to the support with epoxy glass.

**[0013]** FIG. 3. The support cell for flat mirrors is observed in a conventional concentrator, the architecture of a support cell for a known solution of the construction of the solar concentration support.

**[0014]** FIG. 4. Displays a support cell for flat mirrors in the proposed concentrator where one can observe the architecture of a support cell for the new array of the support construction for the solar concentrator.

**[0015]** FIG. 5. Shows the support cell for flat mirrors in a proposed concentrator with adjusting nuts to position the flat mirrors to approximate the parabolic surface.

**[0016]** FIG. 6. Shows a solar concentrator cell with three additional bars and the placement of new bars, which allows increasing the number of flat mirrors up to 16.

**[0017]** FIG. 7. Shows a support cell for 16 flat mirrors; each cell can be used to support 16 flat mirrors; here each mirror can be divided by four prior smaller mirrors, obtaining up to 16 flat mirrors.

### DETAILED DESCRIPTION OF THE INVENTION

**[0018]** The present invention consist of approximate the parabolic surface with a large amount of flat mirrors [3] [4].

**[0019]** The cost of flat mirrors is less than that of parabolic or spherical mirrors. There is a concentrator that uses a large number of small flat mirrors that approximate a parabolic surface [3] [4]. This type of concentrator was developed at UNAM, Mexico, in 2007. This concentrator comprises a bar and nodes support device. Each support cell of this concentrator supports a triangular flat mirror of 50 mm width (FIG. 3).

**[0020]** To increase the number of flat mirrors and the solar concentration factor and decrease the cost of the solar con-

centrator support we propose a new design of solar concentrator cell that supports four flat mirrors instead of one flat mirror in the known array. We have two options with this new array:

a) First Array

**[0021]** Each of the four mirrors has the same size as a mirror known array. Here, we obtain a larger concentration surface and relatively increase the concentration power while preserving the consumption of metallic materials (bars and nodes) to the same level as that of the known array.

b) Second Array

**[0022]** The cell size does not change; we obtain four smaller mirrors than in the known array and achieve a better adjustment of the parabolic surface and a better solar concentration coefficient.

**[0023]** The main difference of the new array is that each upper bar of the cell contains in its center an additional upper bushing to support additional flat mirrors. This array is novel and allows the placement of four flat mirrors instead of one of the known array. This array maintains the same number of bars and nodes and can increase the number of flat mirrors four times. This feature of the new array allows an improvement of the solar concentration factor maintaining or lowering the cost preserving however, the concentration factor.

**[0024]** The cell proposed for the device to support the solar concentrator (FIG. 4) comprises the first upper bushing (1), the second upper bushing (9), the third upper bushing (12), the fourth upper bushing (5), the fifth upper bushing (11), the sixth upper bushing (25), the first lower bushing (22), the second lower bushing (18), the third lower bushing (20), the first upper bar (8), the second upper bar (10), the third upper bar (3), the first lower bar (17), the second lower bar (19), the third lower bar (21), the first vertical bar (13), the second vertical bar (14), the third vertical bar (24), the first diagonal bar (16), the second diagonal bar (15), the third diagonal bar (23), the first mirror (2), the second mirror (7), the third mirror (4), the fourth mirror (6).

**[0025]** The first terminal of the first upper bar is connected to the first upper bushing, and the second terminal of this bar is connected to the second upper bushing. The first terminal of the second upper bar is connected to the third upper bushing, and the second terminal of this bar is connected to the second upper bushing. The first terminal of the third upper bar is connected to the third upper bushing, and the second terminal of this bar is connected to the first upper bushing. The first terminal of the first lower bar is connected to the first lower bushing, and the second terminal of this bar is connected to the second lower bushing. The first terminal of the second lower bar is connected to the second lower bushing, and the second terminal of this bar is connected to the third lower bushing. The first terminal of the third lower bar is connected to the third lower bushing, and the second terminal of this bar is connected to the first lower bushing. The first terminal of the first vertical bar is connected to the second lower bushing, and the second terminal of this bar is connected to the second upper bushing. The first terminal of the second vertical bar is connected to the third lower bushing, and the second terminal of this bar is connected to the third upper bushing. The first terminal of the third vertical bar is connected to the first lower bushing, and the second terminal of this bar is connected to the first upper bushing. The first terminal of the first diagonal

bar is connected to the second lower bushing, and the second terminal of this bar is connected to the first upper bushing. The first terminal of the second diagonal bar is connected to the third lower bushing, and the second terminal of this bar is connected to the second upper bushing. The first terminal of the third diagonal bar is connected to the first lower bushing, and the second terminal of this bar is connected to the third upper bushing. The fourth upper bushing is connected to the center of the first upper bar. The fifth upper bushing is connected to the center of the second upper bar. The sixth upper bushing is connected to the center of the third upper bar. The first vertex of the first mirror is connected to the first upper bushing; the second vertex of the first mirror is connected to the fourth upper bushing; the third vertex of the first mirror is connected to the sixth upper bushing. The first vertex of the second mirror is connected to the fourth upper bushing; the second vertex of the second mirror is connected to the second upper bushing; the third vertex of the second mirror is connected to the fifth upper bushing. The first vertex of the third mirror is connected to the sixth upper bushing; the second vertex of the third mirror is connected to the fourth upper bushing; the third vertex of the third mirror is connected to the fifth upper bushing. The first vertex of the fourth mirror is connected to the sixth upper bushing, the second vertex of the fourth mirror is connected to the fifth upper bushing; the third vertex of the fourth mirror is connected to the third upper bushing.

**[0026]** To adjust the mirror positions, the solar concentrator with four flat mirrors contains bushings; each bushing contains a bolt and nut (FIG. 5). Nuts and bolts have the numbers 26, 27, 28, 29, 30, 31 (FIG. 5).

**[0027]** Is possible to increase the number of mirrors in a cell to 16 instead of four. For this purpose, we add three additional bars (FIG. 6). The bars that existed before are numbers 2, 3, 8, and new additional bars are numbers 4, 6, 7.

**[0028]** Using these additional bars we add nine additional bushings at the positions marked with circles (as examples, number 10 in FIG. 6), with the opportunity to place 16 flat mirrors in a cell.

**[0029]** With additional bars (FIG. 6) the cell can support 16 flat mirrors. In FIG. 7 the cell is shown with 16 flat mirrors in the proposed concentrator. The nine bushings are presented in FIG. 7 with the following numbers: 26, 27, 28, 29, 30, 31, 32, 33, 34.

**[0030]** Continuing this method it is possible to divide each triangular mirror in four smaller mirrors using the following equation:

$$F(n)=4^n$$

where  $F(n)$  is the number of mirrors in a support cell,  $n$  is the integral number and  $n=0, 1, 2, 3 \dots$  etc., each  $n$  corresponding to a new array,  $n=0$  is the known array,  $n=1$  corresponding to the proposed array, for the purposes of this patent application (FIG. 4),  $n=2$  corresponding to the second proposal (FIG. 7).

Formula of the Invention.

**[0031]** The cell proposed for the device to support the solar concentrator (FIG. 4) comprises the first upper bushing (1), the second upper bushing (9), the third upper bushing (12), the fourth upper bushing (5), the fifth upper bushing (11), the sixth upper bushing (25), the first lower bushing (22), the second lower bushing (18), the third lower bushing (20), the first upper bar (8), the second upper bar (10), the third upper bar (3), the first lower bar (17), the second lower bar (19), the

third lower bar (21), the first vertical bar (13), the second vertical bar (14), the third vertical bar (24), the first diagonal bar (16), the second diagonal bar (15), the third diagonal bar (23), the first mirror (2), the second mirror (7), the third mirror (4), the fourth mirror (6), the first terminal of the first upper bar is connected to the first upper bushing, and the second terminal of this bar is connected to the second upper bushing; the first terminal of the second upper bar is connected to the second upper bushing, and the second terminal of this bar is connected to the third upper bushing; the first terminal of the third upper bar is connected to the third upper bushing, and the second terminal of this bar is connected to the first upper bushing; the first terminal of the first lower bar is connected to the first lower bushing, and the second terminal of this bar is connected to the second lower bushing; the first terminal of the second lower bar is connected to the second lower bushing, and the second terminal of this bar is connected to the third lower bushing; the first terminal of the third lower bar is connected to the third lower bushing, and the second terminal of this bar is connected to the first lower bushing; the first terminal of the first vertical bar is connected to the second lower bushing, and the second terminal of this bar is connected to the second upper bushing; the first terminal of the second vertical bar is connected to the third lower bushing, and the second terminal of this bar is connected to the third upper bushing; the first terminal of the third vertical bar is connected to the first lower bushing, and the second terminal of this bar is connected to the first upper bushing; the first terminal of the first diagonal bar is connected to the first lower bushing, and the second terminal of this bar is connected to the second upper bushing; the first terminal of the second diagonal bar is connected to the second lower bushing, and the second terminal of this bar is connected to the third upper bushing; the first terminal of the third diagonal bar is connected to the third lower bushing, and the second terminal of this bar is connected to the first upper bushing; the first vertex of the mirror is connected to the first upper bushing; the second vertex of the mirror is connected to the second upper bushing; the third vertex of the mirror is connected to the third upper bushing, which is distinguished: the cell contains the fourth upper bushing, the fifth upper bushing, the sixth upper bushing, the first flat mirror, the second flat mirror, the third flat mirror and the fourth flat mirror; the fourth upper bushing is connected to the center of the first upper bar; the fifth upper bushing is connected to the center of the second upper bar; the sixth upper bushing is connected to the center of the third upper bar; the first vertex of the first mirror is connected to the first upper bushing; the second vertex of the first mirror is connected to the fourth upper bushing; the third vertex of the first mirror is connected to the sixth upper bushing; the first vertex of the second mirror is connected to the fourth upper bushing; the second vertex of the second mirror is connected to the second upper bushing; the third vertex of the second mirror is connected to the fifth upper bushing; the first vertex of the third mirror is connected to the sixth upper bushing; the

second vertex of the third mirror is connected to the fourth upper bushing; the third vertex of the third mirror is connected to the fifth upper bushing; the first vertex of the fourth mirror is connected to the sixth upper bushing; the second vertex of the fourth mirror is connected to the fifth upper bushing; the third vertex of the fourth mirror is connected to the third upper bushing.

1-13. (canceled)

14. Solar concentrator characterized because the proposed cell for the support device of the solar concentrator it is conformed by: a first upper bushing, the second upper bushing, the third upper bushing, the fourth upper bushing, the fifth upper bushing, the sixth upper bushing, the first lower bushing, the second lower bushing, the third lower bushing, the first upper bar, the second upper bar, the third upper bar, the first lower bar, the second lower bar, the third lower bar, the first vertical bar, the second vertical bar, the third vertical bar, the first diagonal bar, the second diagonal bar, the third diagonal bar, the first mirror, the second mirror, the third mirror, the fourth mirror.

15. Solar concentrator in accordance with claim 14, characterized because each bushing includes a bolt and nut for adjusting the positions of the mirrors.

16. Solar concentrator in accordance with claim 14, characterized because each cell has three additional bars, nine additional bushings in the support and 16 flat mirrors.

17. Solar concentrator in accordance with claim 16, characterized because each bushing includes a bolt and nut for adjusting the positions of 16 flat mirrors.

18. Solar concentrator in accordance with claim 14, characterized because the mirrors that conform the parabola are a plurality of small mirrors that together form a large parabolic surface.

19. Solar concentrator in accordance with claim 14, characterized because each support cell of the solar concentrator supports a triangular flat mirror of 50 mm by side.

20. Solar concentrator in accordance with claim 14, characterized because each cell has a new cell design that supports four flat mirrors.

21. Solar concentrator, in accordance with claim 14, characterized because the concentration surface becomes larger.

22. Solar concentrator in accordance with claim 14, characterized because the power from the concentrator increases.

23. Solar concentrator, in accordance with claim 14, characterized because metallic materials are present by means of bars and nodes.

24. Solar concentrator in accordance with claim 14, characterized because to increase the number of mirrors additional bars are supplied.

25. Solar concentrator in accordance with claim 24, characterized because bushings are added.

26. Solar concentrator in accordance with claim 14, characterized because the number of mirrors is in multiples of four at  $n F (n)=4^n$ , where  $n=0, 1, 2, 3, \dots$  etc.

\* \* \* \* \*