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A THERMAL SOLAR ENERGY CONCENTRATOR SYSTEM

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(71) Applicant(s)
Dr. Vishwanath Karad MIT World Peace University;Anita Nene;S Ramachandran

(72) Inventor(s)
Nene, Anita;Ramachandran, S.

(74) Agent / Attorney
Saad Shaikh, Yudhister Singh, House No. 1156 Centre Road, Clarinda, VIC, 3169, AU

ABSTRACT

The present invention relates to a solar energy harnessing system. More particularly, the present invention relates to a thermal solar energy concentrator system with enhanced efficiency and reduced convective heat losses. The thermal solar energy concentrator system comprises a parabolic Scheffler reflector having a focal point, and configured for focusing solar rays, a convex conical receiver disposed in proximity of the focal point of the parabolic Scheffler reflector, and configured to receive the focused solar rays from the parabolic Scheffler reflector, a water pipe disposed in thermal communication with the convex conical receiver, and configured to facilitate flow and heating of water therethrough, wherein the convex conical receiver is tilted at a predetermined angle with respect to the horizontal axis of the convex conical receiver thereby facilitating increase in focal area which increases heat transfer thereby enhancing thermal efficiency of the system.

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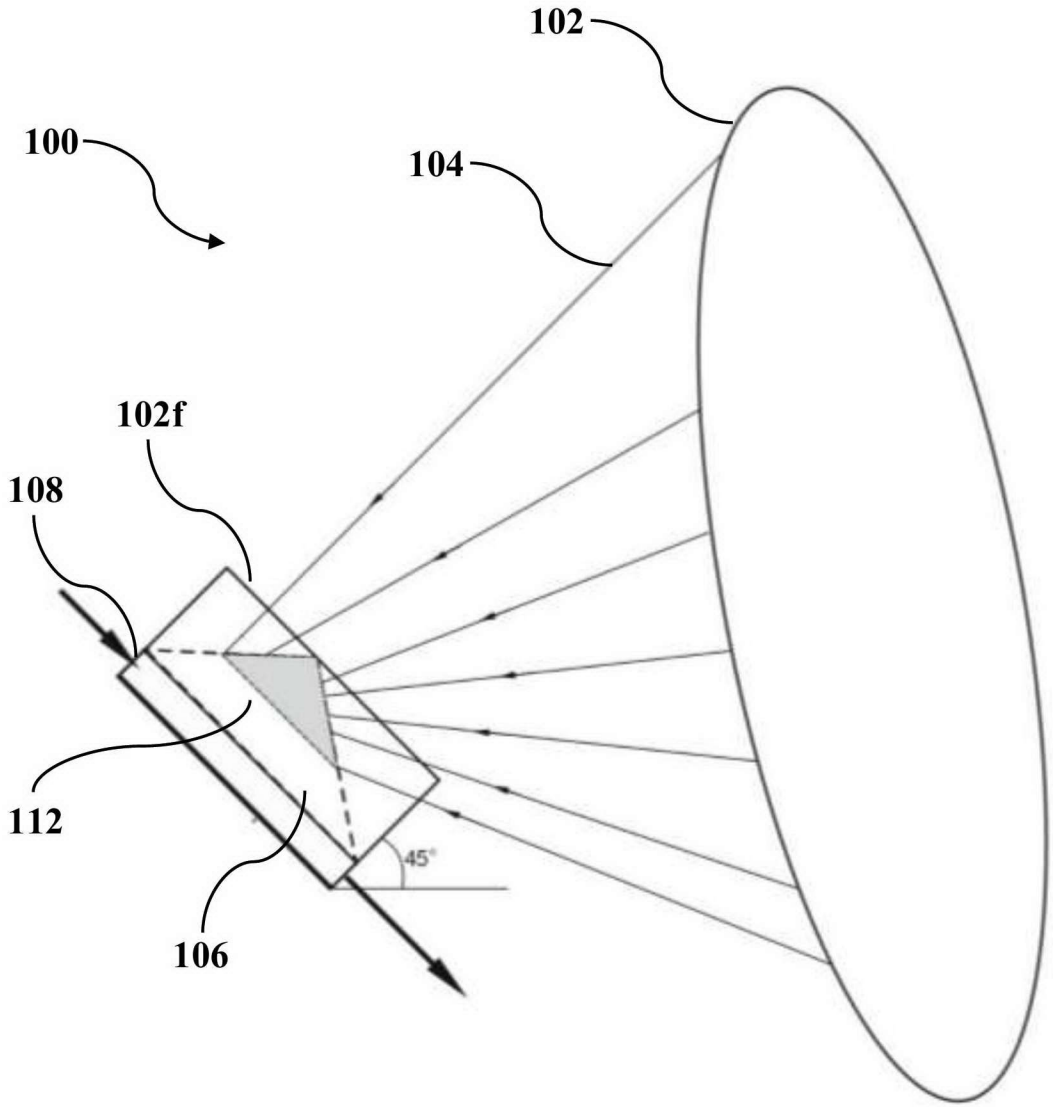

FIG. 1

TITLE

A THERMAL SOLAR ENERGY CONCENTRATOR SYSTEM

FIELD OF THE INVENTION

The present invention relates to a solar energy harnessing system. More particularly, the present invention relates to a thermal solar energy concentrator system with enhanced efficiency and reduced convective heat losses.

BACKGROUND OF THE INVENTION

In the contemporary world, demand for energy is ever-increasing. At present, for powering various machines, vehicles, and devices, fossil fuels are employed, which have had led to harmful effects on climate along with pollution.

It is therefore desired to have sources of energy which avoids the harmful effect on climate and pollution. That is, there is need of clean energy. One such source of clean energy is solar energy.

Attempts have been made to harness solar energy. There are two methods for harnessing the solar energy. The first one is to convert light or radiation in visible region to electricity, or photovoltaic, and the second one is to convert thermal energy contained in the solar radiations to electricity or any other useful form.

It is observed that the thermal energy conversion is most useful for heating and cooling applications pertaining to the industrial processes. More specifically, concentrated solar

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power technology (CSPT) is being developed and particularly Scheffler fixed focus concentrator under is one of the most promising type solar thermal energy convertor.

In countries like India where solar energy is amply available, there is a vast potential for solar power trapping. CSPT is comparatively new technology and is progressively used for most of the industrial heat applications to reduce CO_2 emissions.

In a typical solar power concentrator system, a cylindrical shaped receiver is commonly used with a Scheffler collector system. Receivers with other shape such as the conical shape receivers are also employed instead of the cylindrical shape.

For a given type of solar power concentrator system, the thermal efficiency thereof is influenced by parameters such as receiver shape, tilt angle, wind speed, and convection heat losses etc. Hence, improvement in the thermal efficiency of the solar power concentrator system can be achieved by reducing the convective heat losses.

Numerous attempts have been made, both experimental and numerical, for improving convective losses in downward-facing cylindrical cavity receivers and modified conical cavity receivers by considering the wind direction, wind speed, receiver configuration, and receiver orientation.

Among the different bottom reflective shapes, the conical cavity receiver with the bottom reflective cone has been found to exhibit higher optical performance but more convective losses. So, there is a need to improve the efficiency by reducing convective heat losses.

In the known art, there have been attempts to improve the efficiency by reducing the convective heat losses.

The US patent no. 4,030,477 titled solar collector with conical elements discloses a device for collecting radiant energy with a conical surface to convergently reflect rays toward an elongate energy absorbing structure which is disposed along a central focal axis. The conical surface has a relatively high reflectivity (rho) coefficient while the outer surface of the energy absorbing structure has a relatively high absorptivity coefficient and also is formed of a material having a relatively high thermal conductivity (k) for efficiently transferring thermal energy by convection to a heat exchange fluid. The energy absorbing structure comprises a hollow tube which is coiled in a helix about the focal axis, with a transparent cover enclosing the helix.

The US patent no. 9,383,122 B2, titled spiral concentrating collector with moving receiver discloses an improved solar energy concentrating system and to a preferred way of moving the receiver, along a curvilinear path above the mirror surface to the optimal location where the instantaneous concentration of reflected rays is the largest. The system comprises a fixed, trough concentrating collector formed with a concave curvature, shaped as a section of a spiral, oriented along the East-West axis, with a movable receiver, inclined facing South and capable of adjusting the angle of inclination periodically, preferably twice a year. The invention is capable of capturing more solar energy, on a more constant basis throughout the year and at a lower cost than the preferred, state-of the-art, trough parabolic concentrating collectors oriented along the North South axis.

The US patent no. 9,297,554 B2, titled Cavity receivers for parabolic solar troughs discloses a linear solar receiver comprising a solar radiation absorbing element having an outer surface configured to circumscribe an interior volume, said interior volume designed to contain a heat transfer medium, said solar radiation absorbing element designed to absorb an incident flux of solar radiation and transfer an absorbed flux of energy to said heat transfer medium, said heat transfer medium designed to receive and transport at least a portion of said absorbed flux of energy, said heat transfer medium when transporting at least a portion of said absorbed flux of energy being primarily in a fluid phase; In this way the conical cavity receiver maximizes thermal efficiency and an optical efficiency.

The Chines Patent Application no 103090555 A titled wedge structure cavity type solar energy discloses a wedge structure cavity type solar energy receiver and belongs to the technical field of solar energy high temperature heat utilization. The wedge structure cavity type solar energy receiver is formed by combination of a plurality of innovative designs namely a cylindrical cavity, a wedge type absorber and a cone-shaped reflector. The wedge structure cavity type solar energy receiver can operate in a disc type parabolic mirror solar energy system with 10000 of concentration ratio, achieve 66 kilowatts of heat exchanging amount in a limited heat exchanging space, enable heating medium gas to reach 1100° C of outlet temperature, and have technical feathers namely compactness, high efficiency and low flow resistance.

The Chinese Patent Application no. 103344048 A titled narrowing tube bundle structural cavity solar receiver discloses a narrowing tube bundle structural-cavity solar receiver, and belongs to the field of solar high-temperature heat utilization. A narrowing tube bundle heat

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absorber designed according to a light collection rule makes the receiver uniformly receive solar light rays, the difficult problem that energy in an existing receiver is not uniformly distributed is solved, an air channel structure formed by a truncated conical outer shell, cavity sealing glass, and a truncated conical inner cavity enables working media to flow uniformly in the receiver, accordingly energy flow is well matched, heat collection performance is well achieved. The receiver has the advantages of being compact, efficient and low in flow resistance, and has a significant meaning for improving competitiveness of a solar high-temperature heat utilization system, and making the solar receiver be high-temperature and efficient.

However, the known solar concentrator systems exhibit relatively high convective losses. Thus, there exists an acute need to improve the efficiency by reducing convective heat losses.

OBJECTS OF THE INVENTION

The some of the objects of the present invention of which at least one object is achieved by the present invention include:

An object of the present invention is to provide a thermal solar energy concentrator system which over comes one or more drawbacks associated with the conventional systems;

Another object of the present invention is to provide a thermal solar energy concentrator system with enhanced efficiency; and

Still another object of the present invention is to provide a thermal solar energy concentrator system with reduced convective heat losses.

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SUMMARY OF THE INVENTION

The present invention relates to a thermal solar energy concentrator system. The thermal solar energy concentrator system comprising a parabolic Scheffler reflector having a focal point, and configured for focusing solar rays, a convex conical receiver disposed in proximity of the focal point of the parabolic Scheffler reflector, and configured to receive the focused solar rays from the parabolic Scheffler reflector, a water pipe disposed in thermal communication with the convex conical receiver, and configured to facilitate flow and heating of water therethrough, wherein the convex conical receiver is tilted at a predetermined angle with respect to the horizontal axis of the convex conical receiver thereby facilitating increase in focal area which increases heat transfer thereby enhancing thermal efficiency of the system.

BRIEF DESCRIPTION OF THE INVENTION

FIG. 1 illustrates a schematic diagram of a thermal solar energy concentrator in accordance with the embodiments of the present invention;

FIG. 2 illustrates a schematic diagram of a top view of a convex conical receiver with a rim disposed there around;

FIG. 3 illustrates a schematic diagram of a side view of the convex conical receiver with the rim disposed there around of FIG. 2; and

FIG. 4 illustrates a schematic diagram of an isometric view of the convex conical receiver with the rim disposed there around of FIG. 2.

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DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a solar energy harnessing system and particularly to a thermal solar energy concentrator system with enhanced efficiency and reduced convective heat losses.

The solar energy concentrator system of the present invention is now described with reference to the accompanying drawings wherein FIG. 1 illustrates a schematic diagram of a thermal solar energy concentrator in accordance with the embodiments of the present invention, FIG. 2 illustrates a schematic diagram of a top view of a convex conical receiver with a rim disposed there around, FIG. 3 illustrates a schematic diagram of a side view of the convex conical receiver with the rim disposed there around of FIG. 2, and FIG. 4 illustrates a schematic diagram of an isometric view of the convex conical receiver with the rim disposed there around of FIG. 2.

Existing conventional receivers have cylindrical, spherical and conical cavity shapes. The receiver of the present invention differs from the conventional receivers in that the receiver of the present invention is convex conical in shape with 45° inclination, which the inventors of the present invention have observed to increase radiation heat transfer and increase the focal area of heat transfer.

Further, in contrast with the existing conventional thermal solar energy concentrators, a rim is attached on the circumference of the convex conical receiver to prevent airflow and hence to reduce the convective heat losses.

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The above mentioned two features have been observed to increase the overall thermal efficiency of the system.

The present invention is now described with reference to FIG. 1 through FIG. 4. More specifically, the thermal solar energy concentrator system (100) of the present invention comprises a parabolic Scheffler reflector (102) having a focal point (102f), and configured for focusing solar rays (104), a convex conical receiver (106) disposed in proximity of the focal point (102f) of the parabolic Scheffler reflector (102), and configured to receive the focused solar rays (104) from the parabolic Scheffler reflector (102), a water pipe (108) disposed in thermal communication with the convex conical receiver (106), and configured to facilitate flow and heating of water therethrough, wherein the convex conical receiver (106) is tilted at a predetermined angle with respect to the horizontal axis of the convex conical receiver (106) thereby facilitating increase in focal area (112) which increases heat transfer thereby enhancing thermal efficiency of the system.

In accordance with one embodiment of the present invention, the predetermined angle is 45°.

In accordance with one embodiment of the present invention, a rim (110) disposed around the convex conical receiver (106), which is configured to prevent air flow in and around the convex conical receiver (106) thereby reducing convection losses and enhancing thermal efficiency of the system.

In accordance with one embodiment of the present invention, the convex conical receiver (106) includes a rim, wherein both the convex conical receiver (106) and the rim (110) are titled at an angle of 45°.

In accordance with one embodiment of the present invention, the focal area (112) is elliptical in shape.

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The working of the system (100) is as follows:

The solar rays (104) from parabolic Scheffler reflector (102), are focused on the convex conical receiver (106) (see FIG. 1). Water is passed through a water pipe (108) inlet, wherein the water is allowed to get heated by the heat from the solar rays which are concentrated in and around the focal area (112) to generate steam which is received at the outlet of the water pipe (108), the steam being used for process applications.

The convex conical receiver (106) is tilted 45° to the horizontal axis of the receiver (106) so that its focal area (112) is increased which leads to more heat transfer to obtain more thermal efficiency. Also, the rim (110) around the receiver (106) prevents the air flow so that the convection heat losses due to surrounding air, are reduced which leads to increase the thermal efficiency. FIG. 2 illustrates a schematic diagram of a top view of a convex conical receiver with a rim disposed there around, wherein the convex conical receiver (106) with the rim (110) being inclined at 45°. The enlarged focal area (112) is in elliptical shape. The enlarged focal area (112) of the conical convex receiver (106) with the rim (110) increases the heat transfer and hence increases the thermal efficiency.

FIG. 3 illustrates a schematic diagram of a side view of the convex conical receiver with the rim disposed there around of FIG. 2; and FIG. 4 illustrates a schematic diagram of an isometric view of the convex conical receiver with the rim disposed there around of FIG. 2.

In accordance with one embodiment of the present invention, the convex conical receiver (106) have a diameter of 450 mm and a length of 50 mm length. To maintain optimum volume of 8 liter, the optimum axial length of the conical receiver is found to be 150 mm.

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The construction material is mild steel. The frontal area of the receiver is black coated to improve absorptive power to 91%. The receiver has a tilting arrangement equipped with an inclinometer to measure the tilting angle and set it as 45°.

The conical receiver with 450 mm diameter, length of 50 mm and the height of 150 mm with 45° tilting arrangement shows improved efficiency in Big Scheffler dish size of 9.7 m^2. To minimize the convection heat losses due to surrounding air, a rim of 450 mm diameter and 150 mm length and 6 mm thick is attached on the circumference of the conical receiver and it enormously reduces the convection heat losses. The 45° inclined convex conical receiver with the rim on the circumference increases the overall efficiency of the solar system.

To increase the area exposed to radiation heat transfer, the convex conical receiver is installed. To increase the more focus area of heat transfer, conical convex receiver is titled with 45° inclination. To prevent the air flow due to surrounding air and thereby reduce the convective heat losses, the rim is fitted around the circumference of the convex conical receiver. The above features increase the overall thermal efficiency of the Scheffler solar system.

Dimensions and parameters of a typical system (100) constructions in accordance with the embodiments of the present invention are listed in the table herein below:

Sr. No.	Title	Specification
1	Dimensions of Scheffler reflector	Model - 9.7 m^2 Ap - 6.5 m=

		Major Axis - 4.22 m Minor Axis -3.08 m Concentration ratio - 41	
2	Dimensions of convex conical receiver	Diameter – 450 mm Height – 150 mm Volume – 8 liters	
3	Dimension of rim disposed around the convex conical receiver	Diameter – 450 mm Height – 150 mm Thickness – 6 mm	
4	Convex conical receiver	Focal area	
		Without tilt	With tilt
		0.024 m^2	0.045 m^2

TECHNICAL ADVANTAGES

The thermal solar energy concentrator system of the present invention has the following advantages, wherein the system

1. is simple in construction;
2. is easy to install, operate, and maintain;
3. has increased efficiency; and
4. reduced convection loses.

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CLAIMS

1. A thermal solar energy concentrator system comprising:

   - a parabolic Scheffler reflector having a focal point, and configured for focusing solar rays;

   - a convex conical receiver disposed in proximity of the focal point of the parabolic Scheffler reflector, and configured to receive the focused solar rays from the parabolic Scheffler reflector;

   - a water pipe disposed in thermal communication with the convex conical receiver, and configured to facilitate flow and heating of water therethrough;

   wherein the convex conical receiver is tilted at a predetermined angle with respect to the horizontal axis of the convex conical receiver thereby facilitating increase in focal area which increases heat transfer thereby enhancing thermal efficiency of the system.

2. The system as claimed in claim 1, wherein the predetermined angle is 45°.

3. The system as claimed in claim 1, further includes a rim disposed around the convex conical receiver, which is configured to prevent air flow in and around the convex conical receiver thereby reducing convection losses and enhancing thermal efficiency of the system.

4. The system as claimed in claim 1, wherein the convex conical receiver includes a rim, wherein both the convex conical receiver and the rim are titled at an angle of 45°.

5. The system as claimed in claim 1, wherein the focal area is elliptical in shape.

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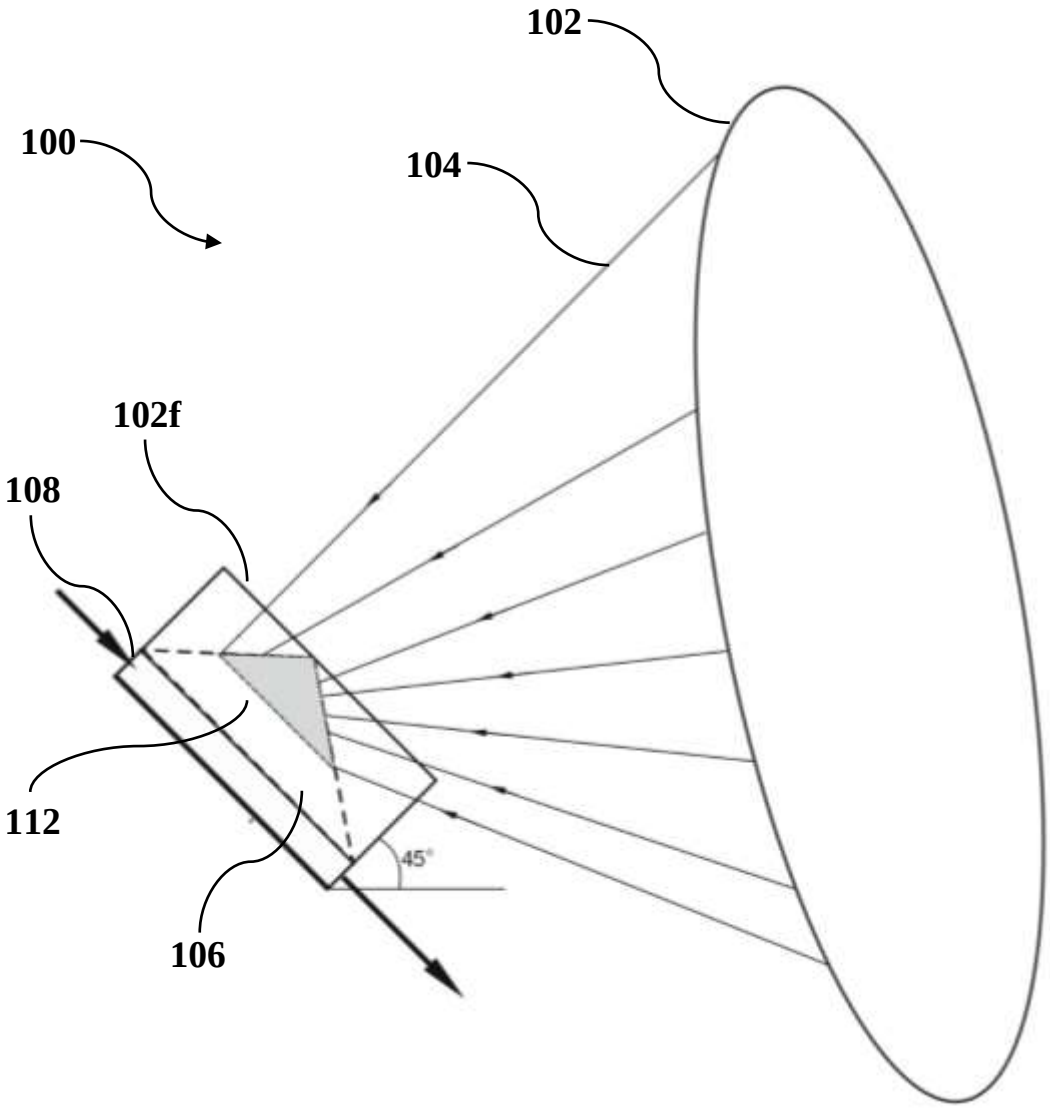

FIG. 1

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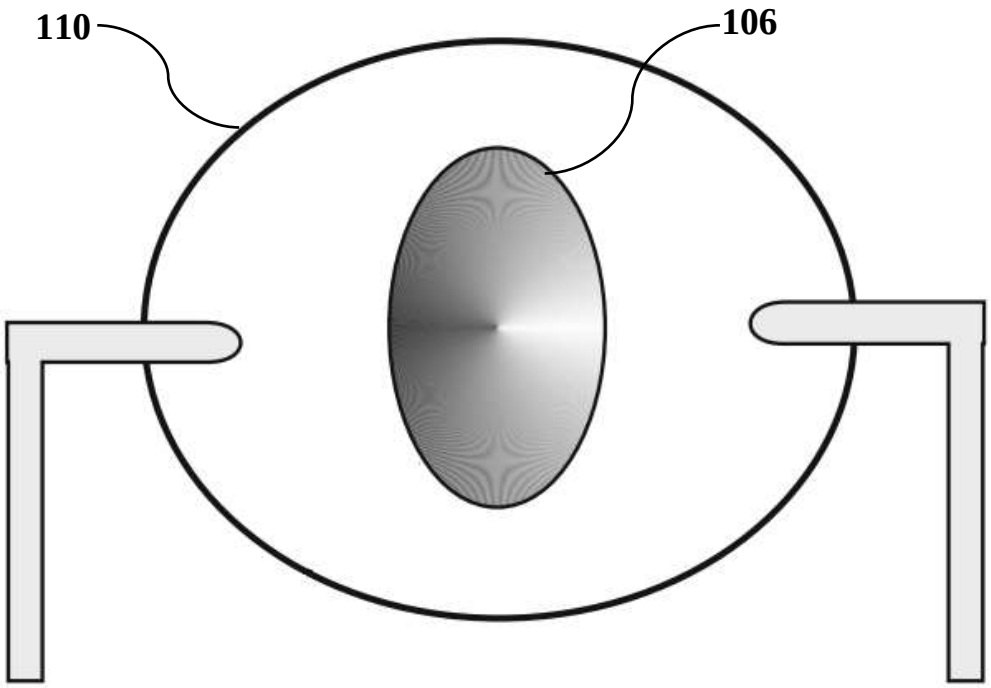

FIG. 2

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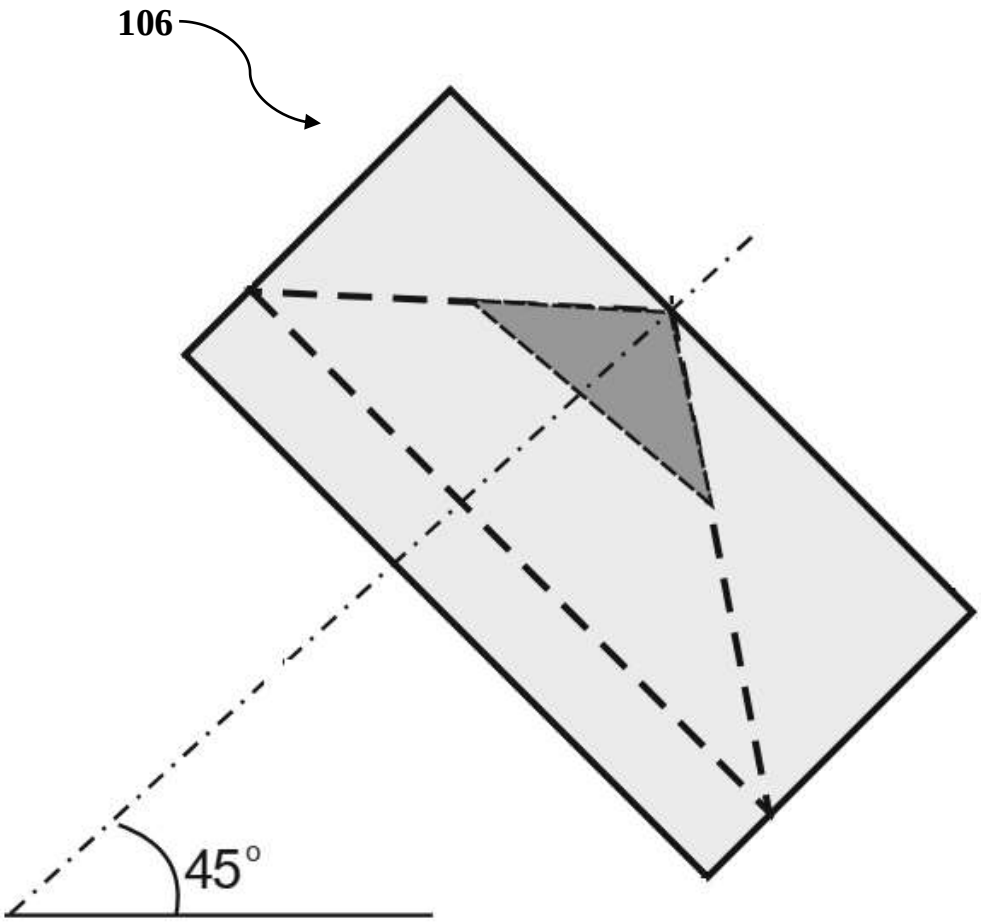

FIG. 3

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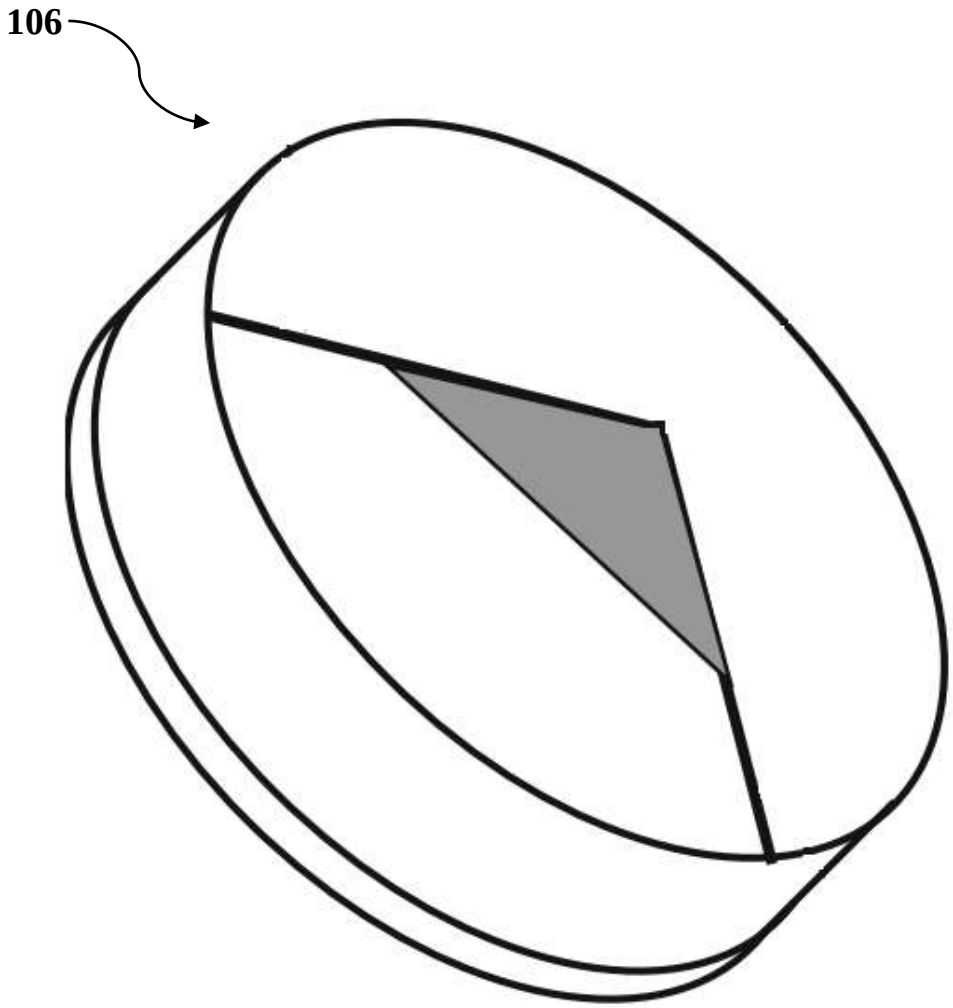

FIG. 4