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(54) **SOLAR RADIATION MODULAR COLLECTOR**

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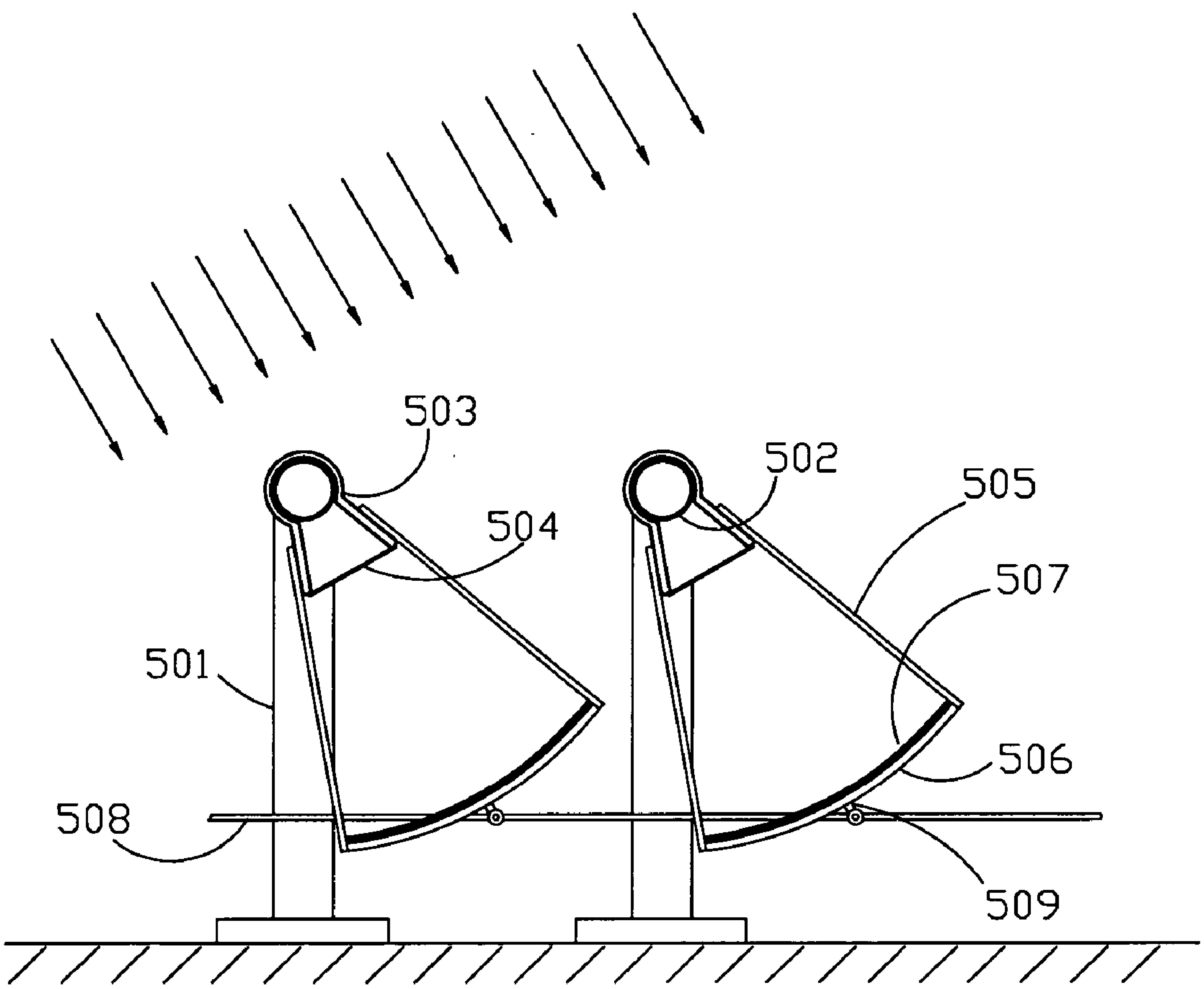
(57) **ABSTRACT**

The invention relates to the field of solar radiation collectors intended to convert energy of solar radiation into thermal energy, specifically, to the solar radiation collectors constructed as the combination of a concentrated solar radiation receiver, a single-curvature or compound-curvature concentrator and a tracking mechanism. A thermal insulation of the concentrated solar radiation receiver and the concentrated solar radiation receiver itself play a role of parts in the tracking mechanism.



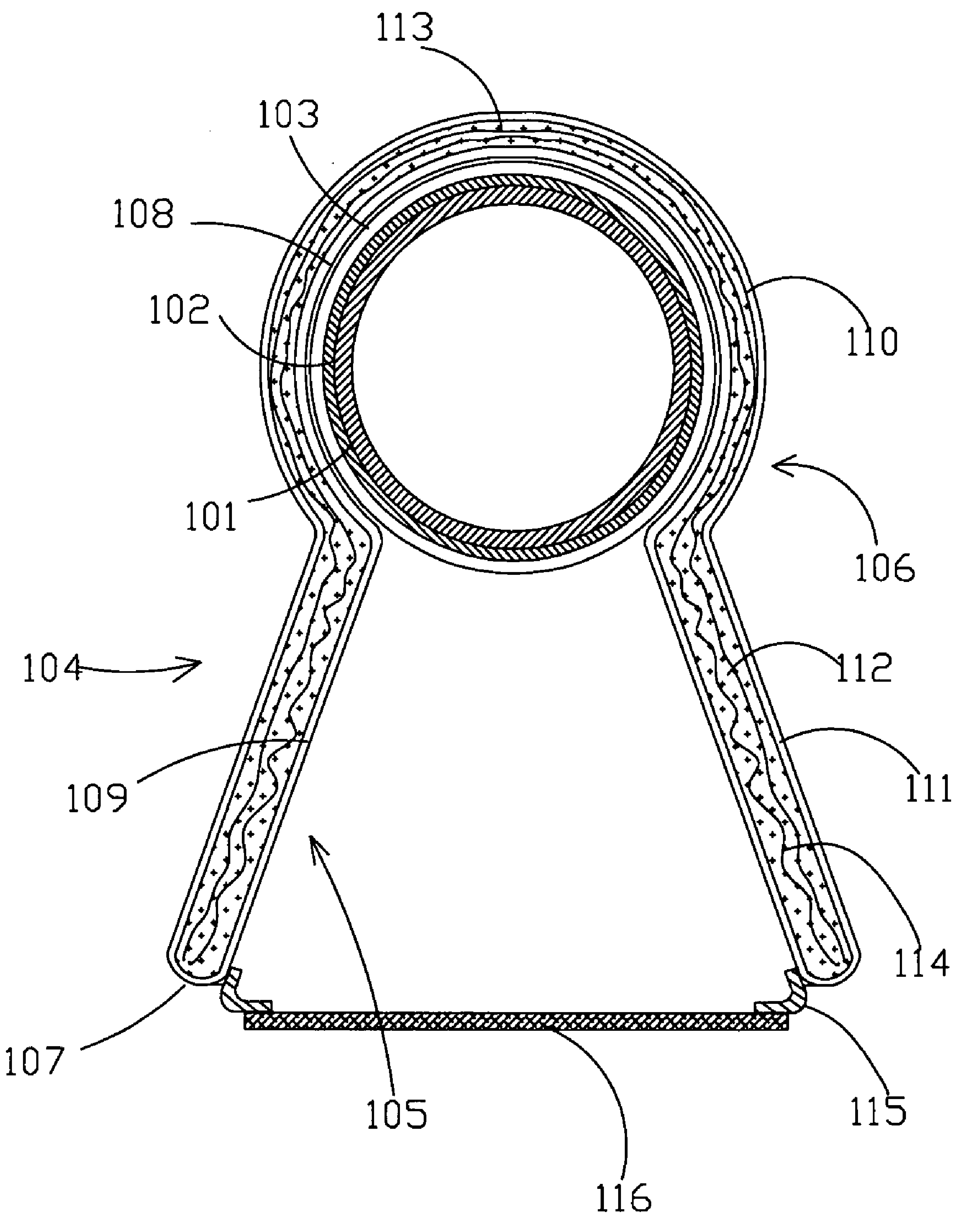


FIG. 1a

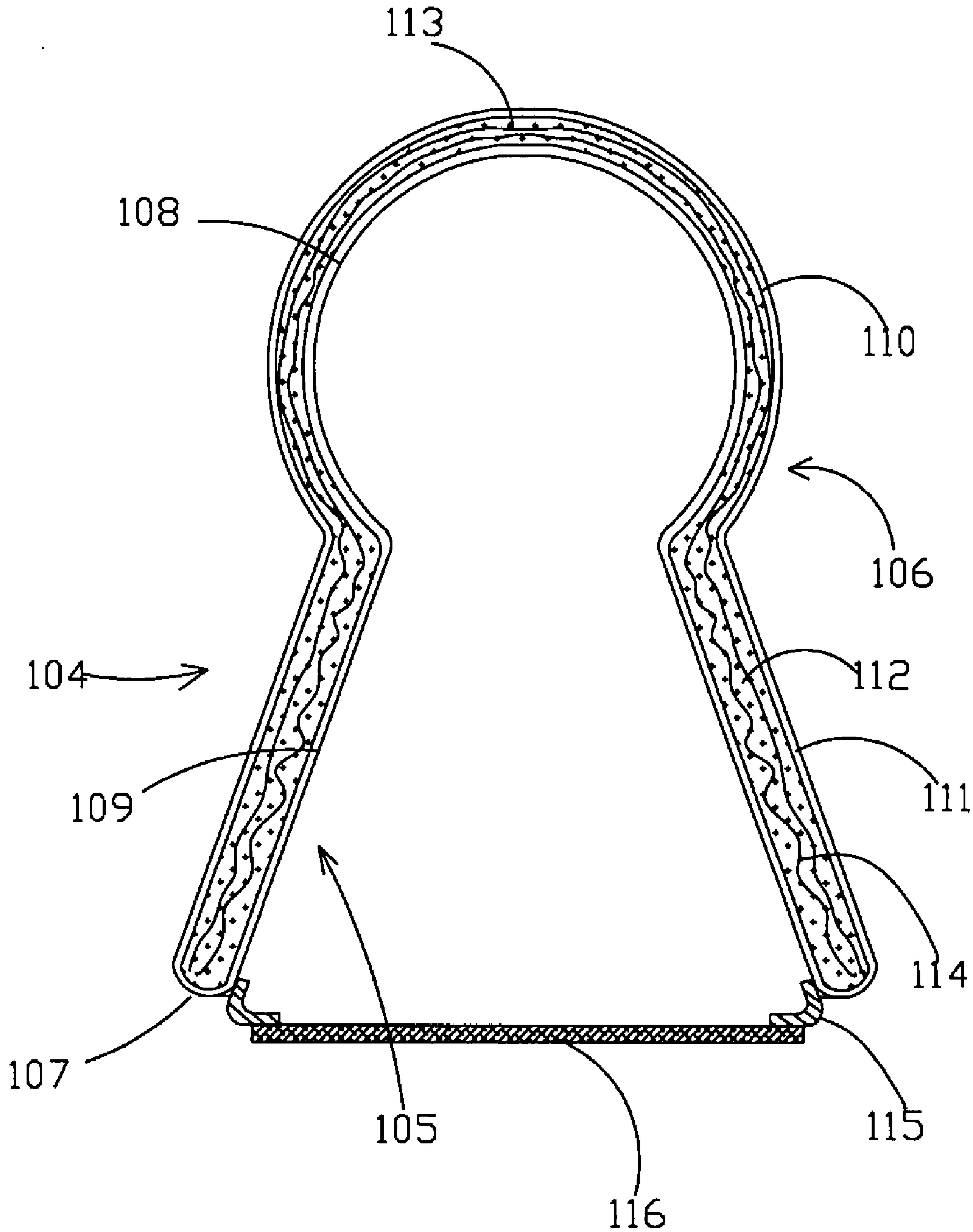


FIG. 1b

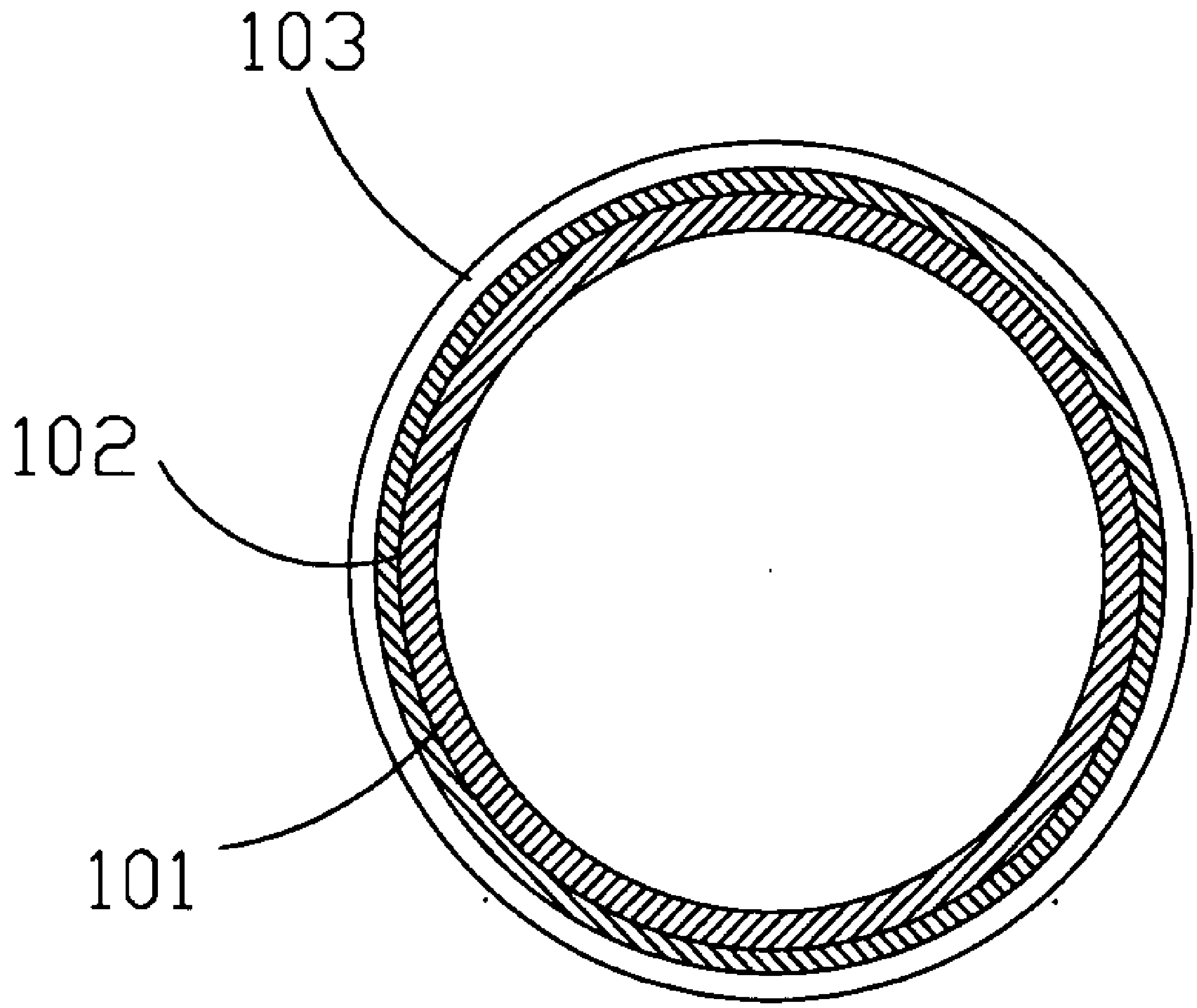


FIG. 1c

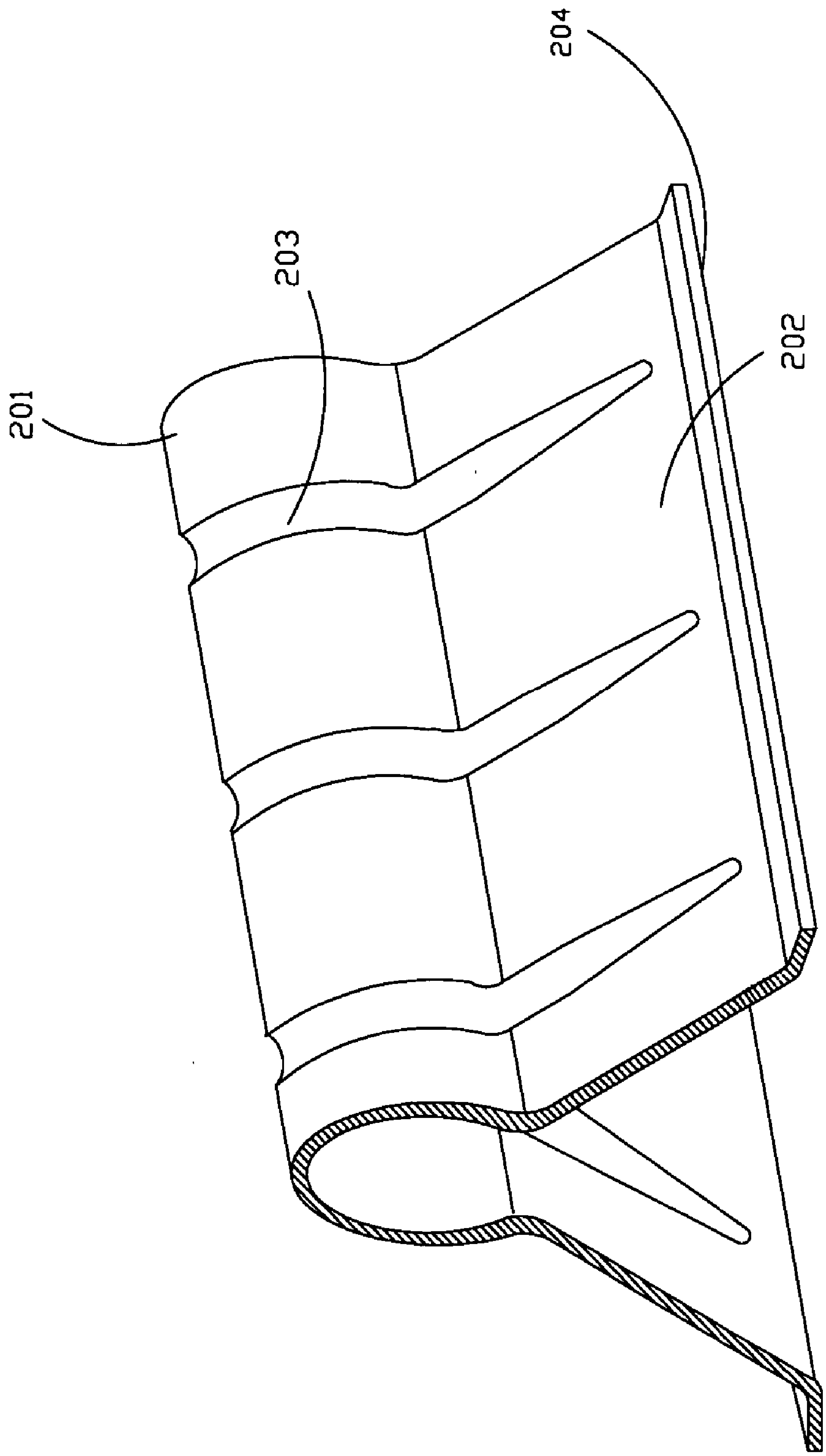


FIG. 2

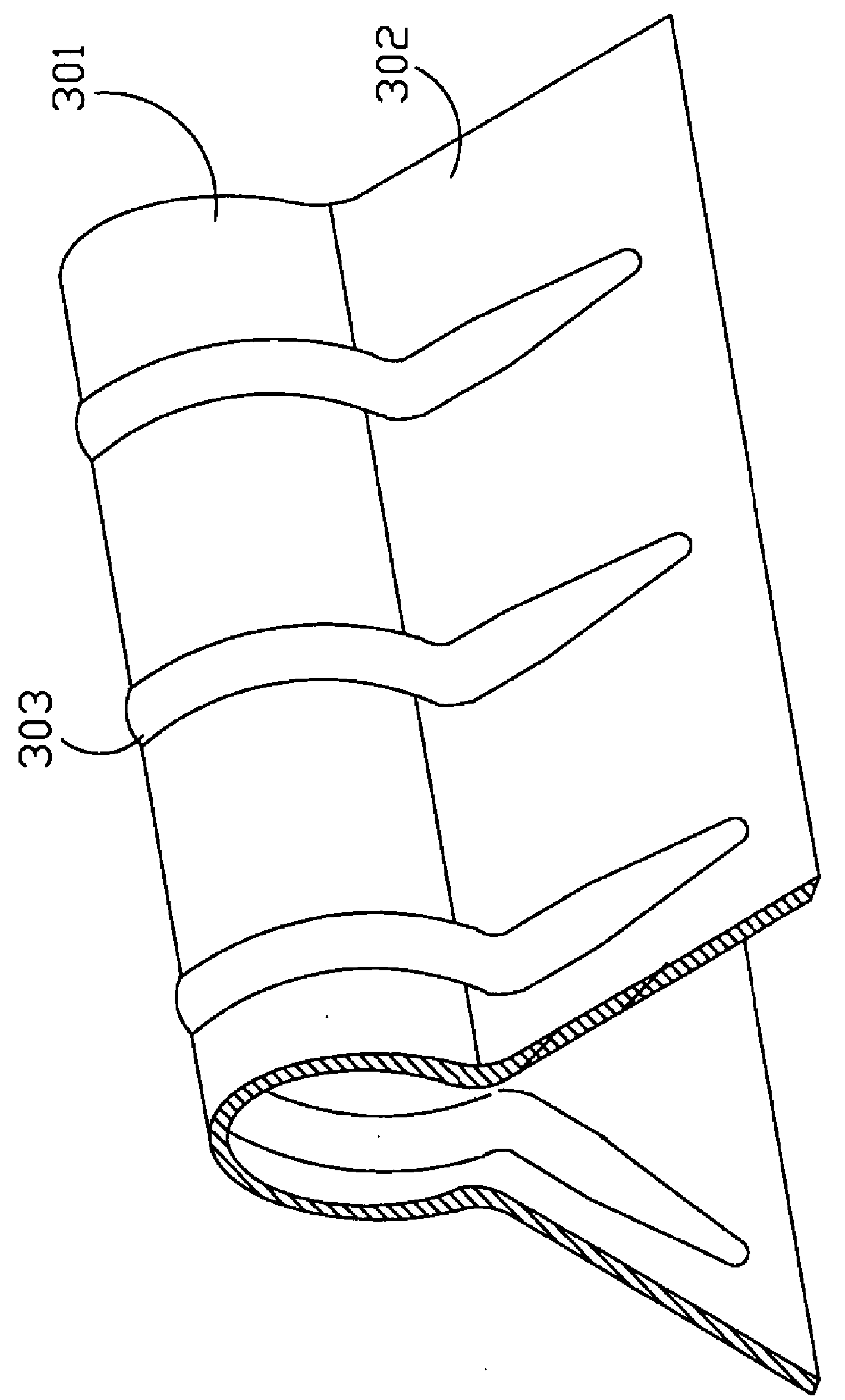


FIG. 3

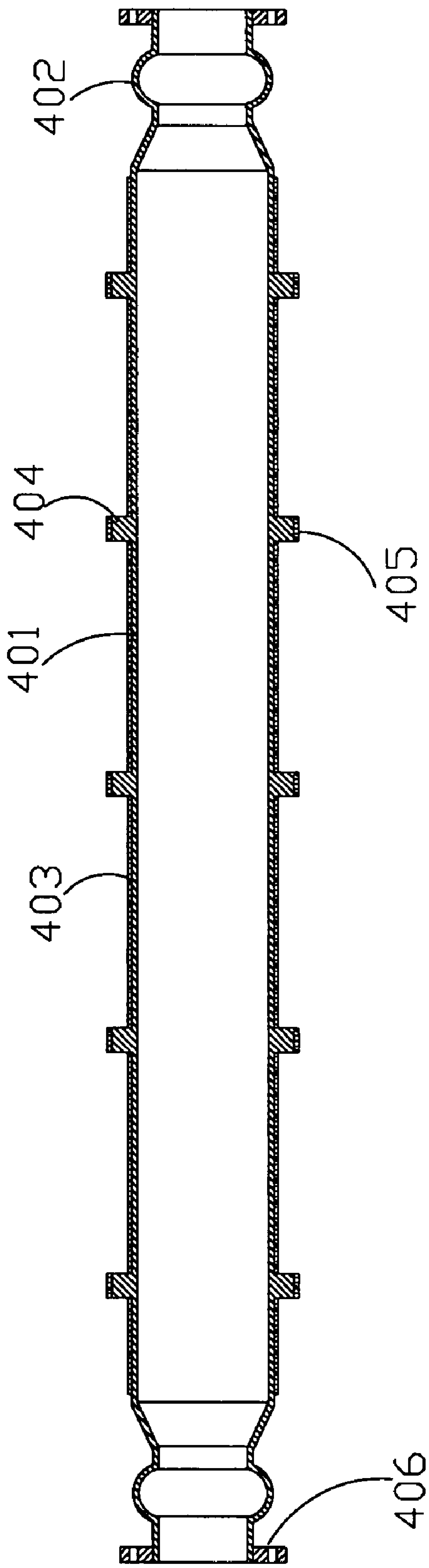


FIG. 4

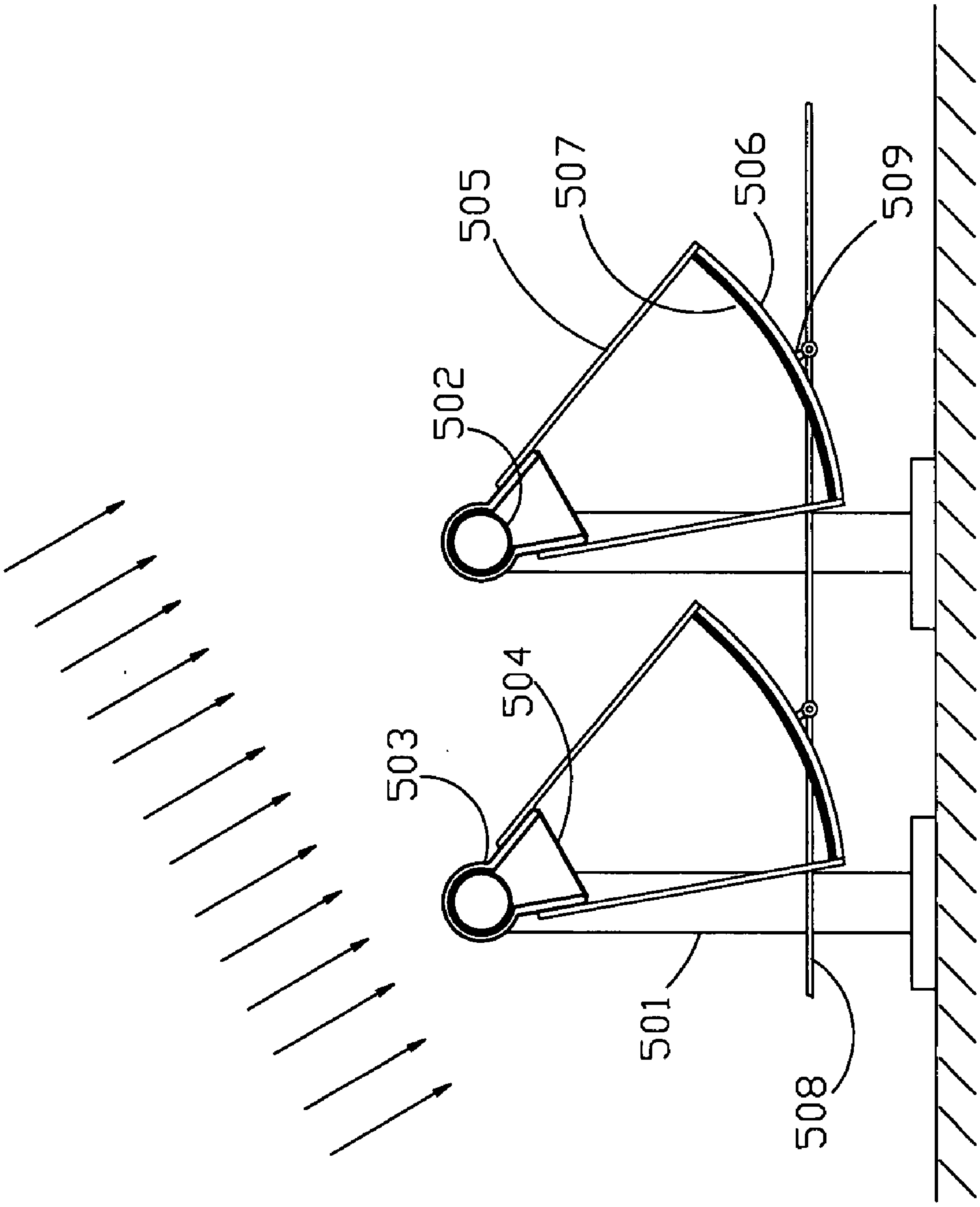


FIG. 5

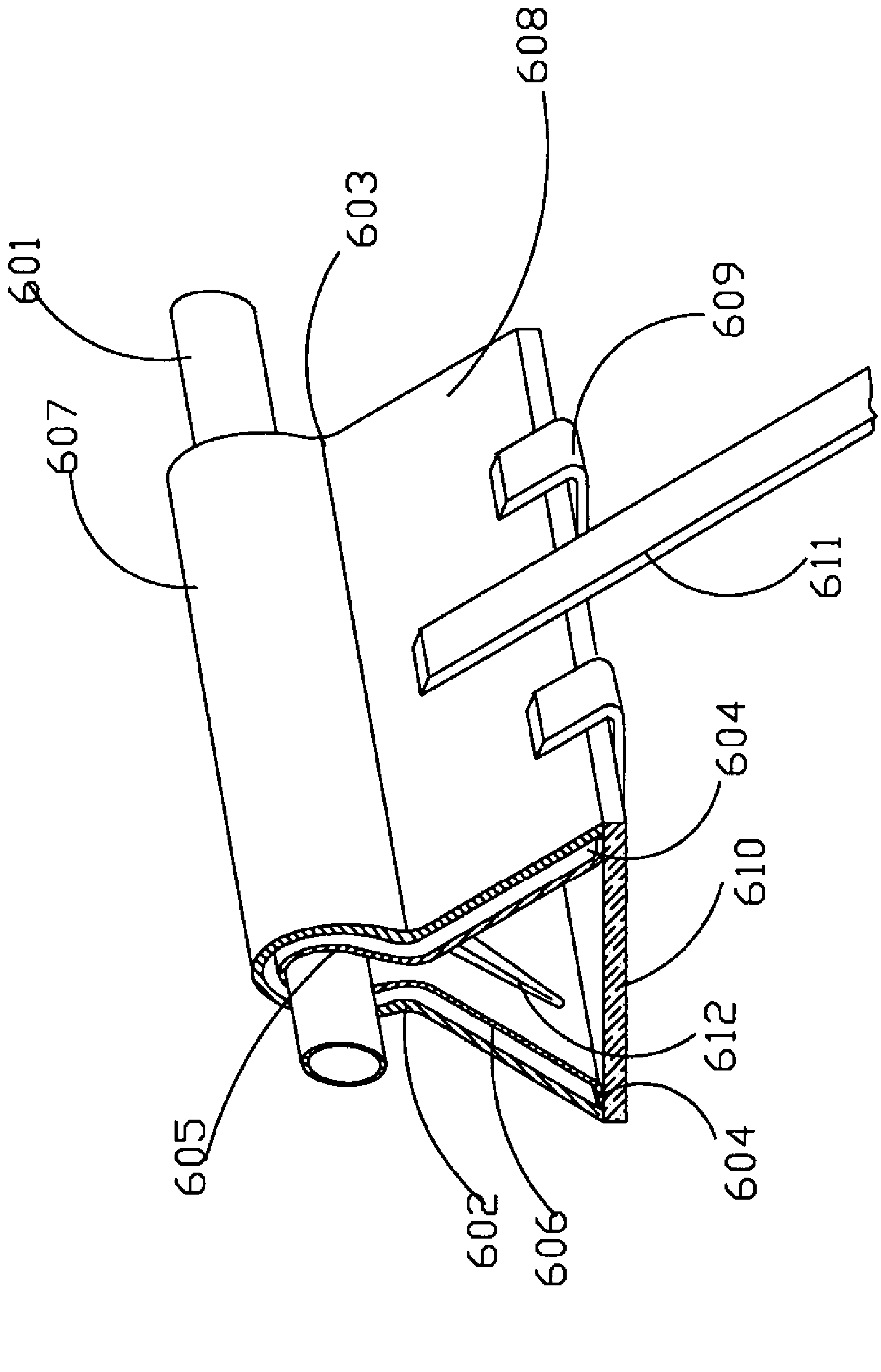


FIG. 6

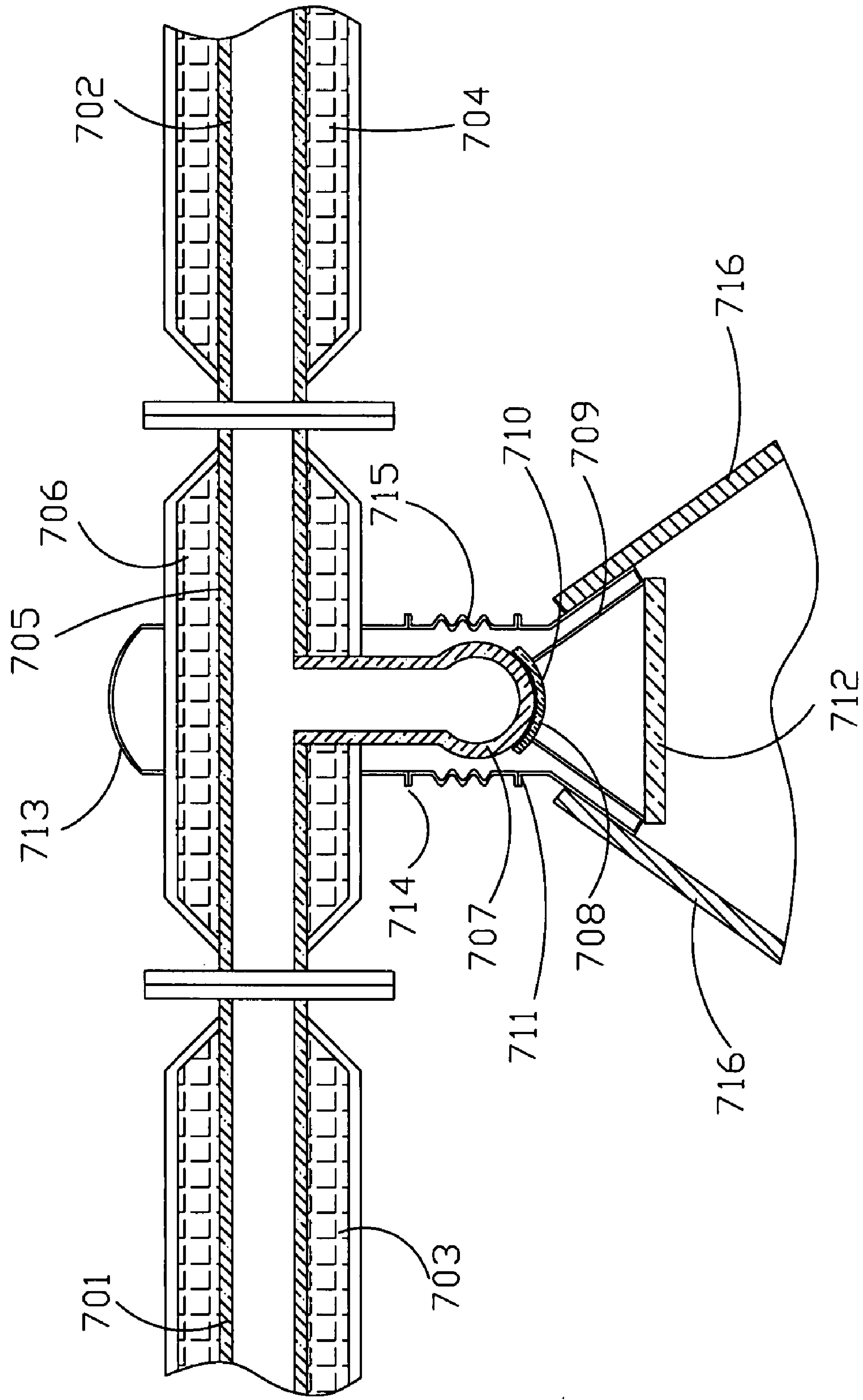

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FIG. 7

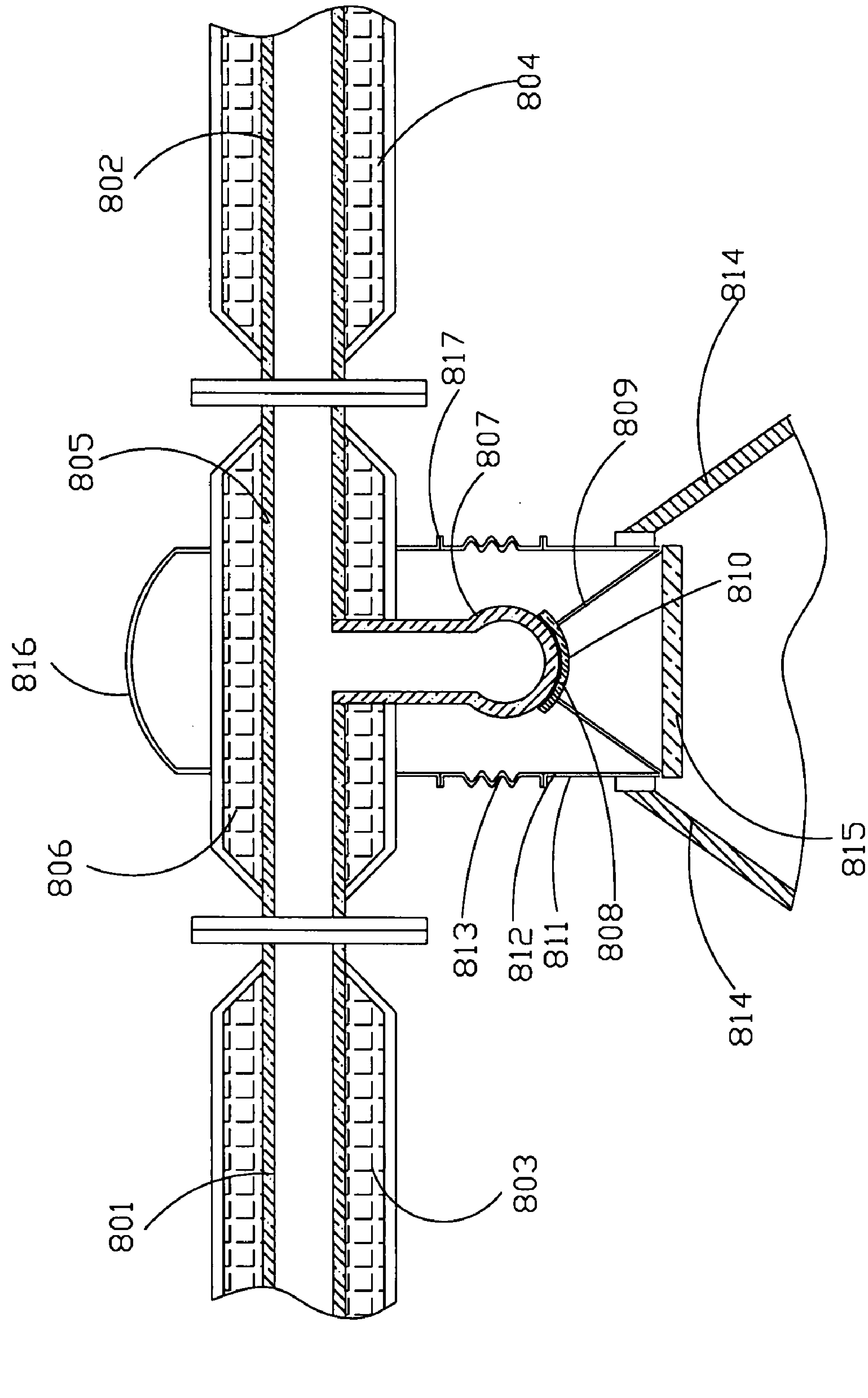

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FIG. 8

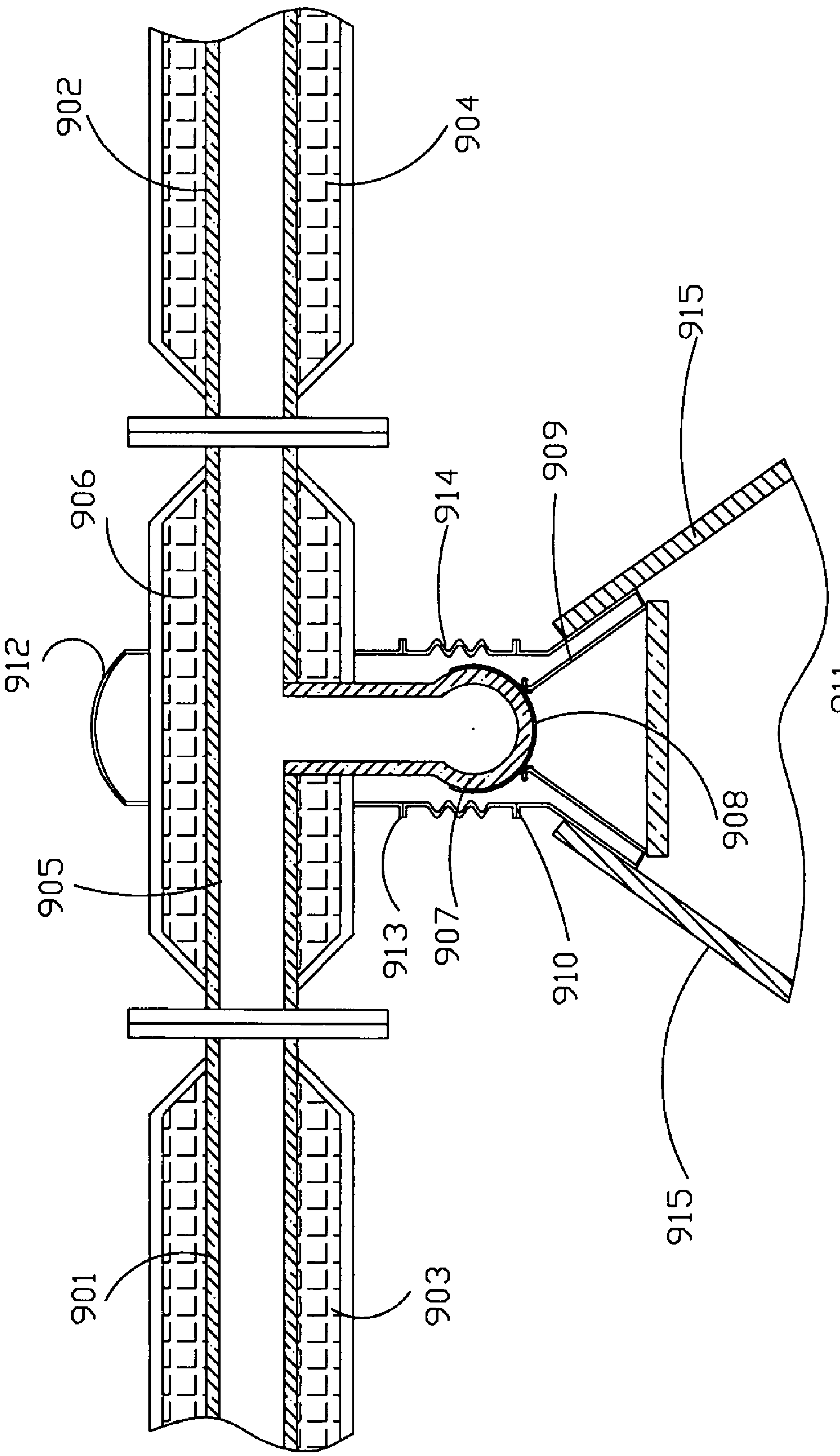

FIG. 9

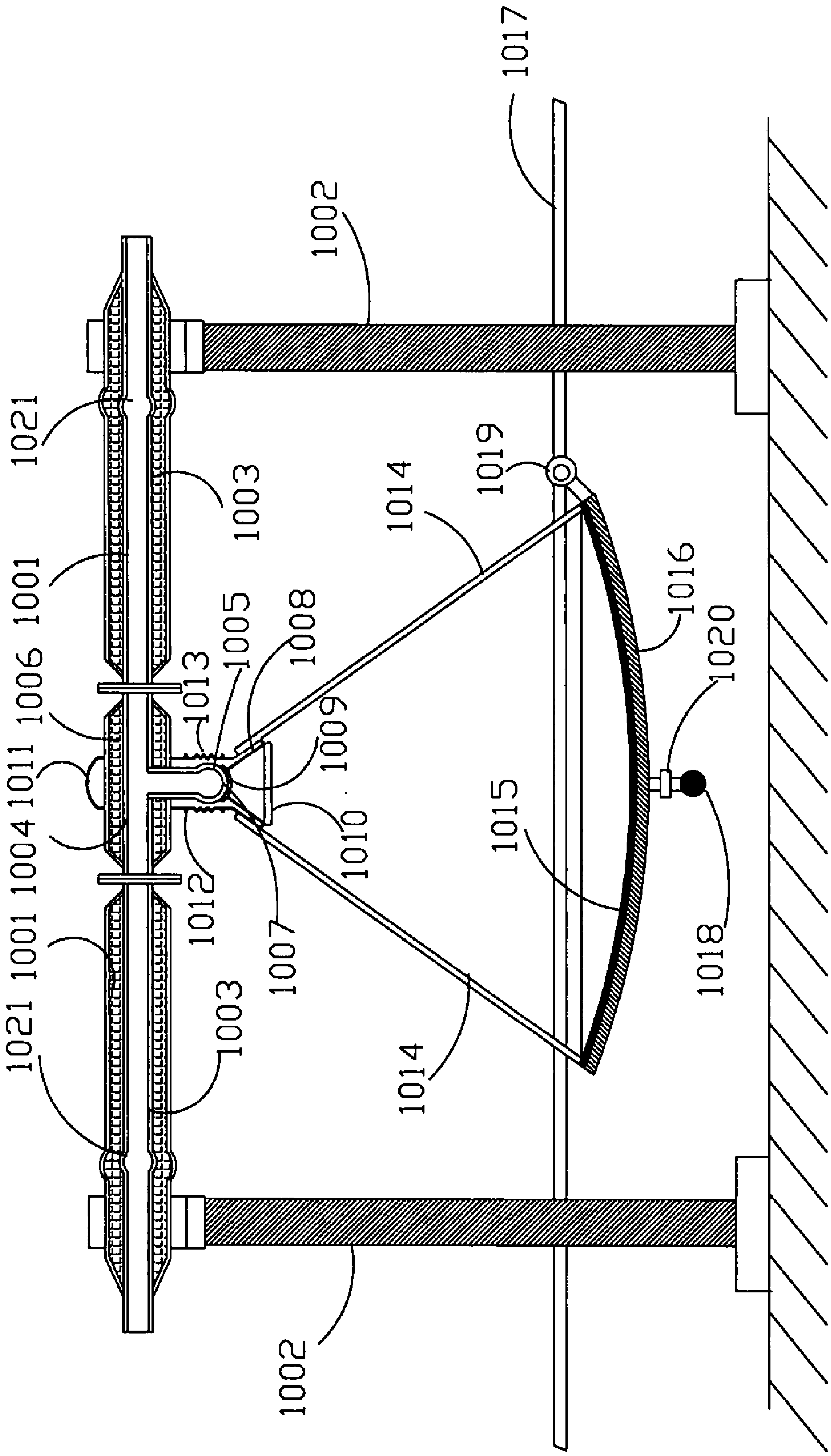
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FIG. 10

SOLAR RADIATION MODULAR COLLECTOR

[0001] This Application is a Continuation-in-Part Application of U.S. patent application Ser. No. 11/081,406 filed on 17 Mar. 2005, which is hereby incorporated by reference as if fully set forth herein.

FIELD OF THE INVENTION

[0002] The present invention relates to the field of solar radiation collectors intended to convert energy of solar radiation into thermal energy.

BACKGROUND OF THE INVENTION

[0003] Solar radiation collectors which convert energy of solar radiation into thermal energy are known. Some types of such collectors include those which incorporate single-curvature or compound-curvature concentrators.

[0004] If single-curvature parabolic mirrors are used as the concentrators, the modular solar radiation collector is constructed as a combination of an elongated receiver, the single-curvature concentrator and a tracking mechanism, which ensures steady positioning of the elongated receiver in the focal zone of the single-curvature concentrator.

[0005] It is known that such solar collectors can result in temperatures of a working fluid which are significantly higher than 100° C.; this in turn gives the possibility of applying the obtained thermal energy to different industrial processes or to convert this thermal energy into electricity with sufficiently high efficiency. In the most cases, the single-curvature concentrator is constructed as a trough-wise parabolic mirror or a single-curvature Fresnel lens.

[0006] The elongated receiver is usually constructed as a pipe with an outer coating intended to absorb concentrated and direct solar radiation, and a transparent (glass) elongated envelope positioned around the pipe. The transparent envelope is sealed with the pipe at its ends and the gap between the pipe and the elongated envelope is vacuum-insulated in order to suppress convective losses of thermal energy from the outer surface of the pipe.

[0007] There are some drawbacks of this construction, a few of which are listed below.

[0008] 1. Concentrated solar radiation illuminates only a part of the whole surface of the radiation receiving pipe; at the same time, heat loss by radiation occurs from the entire outer surface of this pipe.

[0009] 2. Sealing the metal pipe of the receiver with the glass envelope is very expensive and complicated from the technological point of view.

[0010] 3. It is impossible to insulate thermally the radiation receiving pipe in a modular manner.

[0011] 4. Low strength of the glass envelope does not permit this glass envelope to be used as a carrying element of the construction of a solar collector.

[0012] These same drawbacks are also true for solar collectors which feature compound-curvature dish-type concentrators.

[0013] There are some US patents related to the area of this invention, none of which completely solve the above problems. U.S. Pat. No. 4,078,549 to McKeen describes a solar energy collector which concentrates the sun's rays on a liquid medium that is used to power a mechanical energy device such as a positive displacement steam engine. A reflective surface of the solar energy collector is made from an arcuate portion of a circle having a trough-like surface to reflect and concentrate the sun's rays in a plane. A collector having a liquid medium flowing therethrough is located in the plane. The collector is constructed to extend across the entire plane for complete absorption by the liquid medium of the sun's rays reflected from the reflective surface. The collector and reflective surface are connected together for pivotal movement by an appropriate tracking apparatus so that the sun's rays are continually reflected during normal daylight hours through the plane in which the collector is located.

[0014] However, this patent has numerous drawbacks, a few of which are listed below It does prevent heat loss from the receiving pipe due to infrared radiation.

[0015] It does not permit enclosure of the majority of the receiving pipe by the thermo-insulating envelope (in fact, the thermo-insulating envelope encloses less than 50% of the surface of the receiving pipe).

[0016] It does not permit the internal reflecting surface of the envelope to be used as a secondary non-imaging concentrator.

[0017] U.S. Pat. No. 4,048,982 to Pei describes a bulb-type solar energy collector comprising a hollow glass body shaped with a parabolic interior surface that is coated with specular finish of a metal, e.g. silver, and includes an apex aperture and integral hollow yoke. A hollow glass, bulb-shaped absorber element is exteriorly coated with a wave length selective coating. The bulb-shaped element includes a tubular hollow stem dependent from the bulbar portion and fixed in the yoke of the glass body so that the central axis of the stem and bulbar end portion is along the focal axis of the parabolic reflecting surface. A cover plate is sealed over the enlarged end of the reflecting surface enclosing the interior mirror surface in a chamber which is evacuated to substantial vacuum, e.g. 10^{-4} torr or greater vacuum. A working liquid is circulated from a source in a manifold through the interior volume of the absorber element to remove the solar energy absorbed thereby as heat and the media is returned to the manifold. The solar energy laden liquid is available for heating, cooling or power generating uses.

[0018] Pei does not teach any technical solution of tracking the reflector after the sun motion.

BRIEF SUMMARY OF THE INVENTION

[0019] The background art does not teach or suggest a solar collector device for both providing sufficient insulation of a solar radiation receiver so as to decrease significantly or prevent heat loss (thereby increasing efficiency of collection of solar energy) and also for most efficiently tracking the sun in order to obtain the most efficient amount of solar exposure.

[0020] The present invention overcomes these deficiencies of the background art by providing (in a first embodiment) a solar radiation modular collector with a concentrating unit of the single-curvature type (one-axis sun tracking concentrator) and with a receiver of concentrated solar radiation in the form of a radiation receiving pipe.

[0021] The radiation receiving pipe is provided with a thermal insulation layer which is preferably in the form of a metal envelope, which may optionally be vacuum-insulated and/or filled with material with low thermal conductivity. In addition, the internal cavity of this metal envelope may optionally feature one or more radiant shields from metal foil with high reflection coefficient in the infrared range. The single-curvature concentrator can optionally be constructed as a parabolic trough-wise reflector, or alternatively as a single-curvature Fresnel mirror.

[0022] The metal envelope insulates most of the outer surface of the radiation receiving pipe with significant reduction of heat losses caused by convection and radiation from this part of the outer surface.

[0023] The metal envelope of the radiation receiving pipe is preferably constructed from two elongated internal and external sections, which are joined by two elongated connection straps and sealed at their ends by face planes.

[0024] The internal elongated section comprises a cylindrical sub-section, which encloses a significant part of the radiation receiving pipe; this cylindrical sub-section is transformed at its longitudinal margins to flat or single-curved strips with a certain angle of convergence with respect to the cylindrical sub-section. In such a way, the cross-section of the internal section is somewhat similar to the vertical cross-section of a jug. The external section encloses the internal one.

[0025] The internal cavity between the internal and external sections of the metal envelope is preferably evacuated (to form a vacuum) in order to suppress convective loss of heat. In addition, this space can be filled with a porous material and/or layers of metal foil in order to diminish heat loss by radiation.

[0026] It is possible to apply filling the internal cavity of the metal envelope with a gas having low thermal conductivity, for example, krypton.

[0027] The gap between the elongated connection straps is preferably glazed in order to diminish heat losses, which occur from the part of the radiation receiving pipe that is not enclosed by the cylindrical sub-section of the internal elongated section.

[0028] According to preferred embodiments, a plurality of metal envelopes may optionally be installed sequentially around a radiation receiving pipe in place of a single envelope. Each such envelope is preferably constructed as described previously. This simplifies the manufacturing process of the metal envelopes.

[0029] Without wishing to be limited by a single hypothesis, thermal losses in the proposed construction of the thermal insulation may be expected to occur one of three ways:

[0030] By thermal conductivity of the walls of the metal envelope.

[0031] By radiation from the illuminated surface of the radiation receiving pipe.

[0032] By convection via the internal cavity between the internal flat strips, the glazing and the radiation receiving pipe.

[0033] By way of example only and without wishing to be limited in any way, the above problems may optionally be solved as follows. The optional but preferred glazing of the internal cavity between the internal flat strips significantly reduces thermal losses occurring by convection. In addition, the glazing may optionally be provided with a transparent coating, which reflects back infrared radiation from the radiation receiving pipe.

[0034] The limited thermal conductivity of the walls of the metal envelope may cause temperature gradient to occur within the envelope and in turn this can cause deformation of the metal envelope.

[0035] In order to prevent this, the internal and external sections of the metal envelope are optionally and preferably provided with corrugations, which decrease in dimension to zero (ie are narrowed) in the vicinity of the connection straps. These corrugations can be directed inwards or outwards with respect to the internal cavity of the metal envelope.

[0036] The outer surface of the external section of the metal envelope can be coated with a coating, for example by being painted with black paint or pigment, and/or with paint or pigment having a very low emittance coefficient in the infrared range; it enables the temperature of the external section of the metal envelope to be raised due to the direct solar radiation falling on its surface. It in turn diminishes heat losses caused by thermal conductivity of the metal envelope and by radiation and thermal conductivity through the internal cavity of the metal envelope.

[0037] The proposed receiver of the solar radiation may optionally be rigidly joined by a set of truss struts with the single-curvature concentrator, which should be rotated by a tracking mechanism in accordance with the sun motion. In this case, the receiver rotates by turning the single-curvature concentrator.

[0038] According to some embodiments of the present invention, the mechanical strength of the metal envelope also optionally and preferably enables the modular solar collector to feature a stationary metal radiation receiving pipe. In this case, the metal envelope with the single-curvature concentrator is rigidly joined to the metal envelope by the truss struts and is rotated around the metal radiation receiving pipe by the tracking mechanism. In such a way, the radiation receiving pipe plays the role of a bearing element and an axle.

[0039] The radiation receiving pipe may optionally be provided in this case with a set of ribs in order to prevent contact of the internal surface of the metal envelope with the black or selective coating of the radiation receiving pipe. In addition, the cylindrical surface of these ribs may optionally be provided with an antifriction coating.

[0040] The proposed construction of the thermal insulation of the radiation receiving pipe allows the solar radiation collector to be assembled in a modular manner without requiring complicated and expensive sealing means between a glass cylindrical envelope and the radiation receiving pipe, as is known in the art.

[0041] According to other preferred embodiments of the present invention, a plurality of solar radiation modular collectors may optionally be located in parallel rows and provided with common tracking mechanisms.

[0042] According to another embodiment of the solar collector according to the present invention, compound-curvature concentrators and, particularly, dish-type parabolic mirrors, are used as the concentrators of solar radiation.

[0043] If the compound-curvature concentrators are in the form of the dish-type mirrors, a module of the present invention preferably features a bearing pipe that is mounted on vertical posts. A heat transfer medium (working fluid) flows in the bearing pipe. The bearing pipe is provided with a layer of thermal insulation.

[0044] A plurality of T-pieces are built into the bearing pipe, i.e. the bearing pipe comprises a set of tubular sections with T-pieces installed between two neighboring tubular sections to connect them. The lower branch of each T-piece is sealed by a metal convex spherical cap and at least a portion of the outer surface of the T-piece is covered with a layer of thermal insulation.

[0045] In addition, there is a solar radiation receiving member, which is constructed from a dish-type plate and a double-wall funnel. The upper side of the dish-type plate has the concave surface in the form of a spherical segment with the radius almost identical to that of the metal convex spherical cap. In such a way, the pair of the spherical cap of the T-piece and the concave surface of the dish-type plate together presents a spherical joint. The lower surface of the dish-type plate is preferably covered with a layer of a solar radiation absorption coating.

[0046] The upper surface of the dish-type plate and the outer surface of the metal convex spherical cap may optionally be provided with antifriction coating.

[0047] The upper edge of the internal wall of the double-wall funnel is joined with the edge of the dish-type plate and the edge of its outer wall is provided with a flange.

[0048] The distal (lower) aperture of the double-wall funnel can be glazed in order to diminish heat losses via its internal cavity. In addition, this glazing can be provided with a transparent coating, which reflects back infrared radiation from the layer of the solar radiation absorption coating of the dish-type plate.

[0049] The internal surface of the internal wall of the double-wall funnel is preferably constructed of one or more materials with the property of high reflectivity for solar radiation; in such a way, this internal wall plays a role of an additional non-imaging concentrator of the solar radiation.

[0050] There is a bearing housing with a split lower flange and two longitudinal slots; this housing is mounted on the thermal insulation of the T-piece. The open sections of the longitudinal slots are closed by a clamp. The flanges of the bearing housing and the outer wall of the double-wall funnel are joined by a flexible joint, which plays at the same time a role of a thermal insulator.

[0051] The outer wall of the double-wall funnel serves at the same time for mounting truss struts, which serve in turn for installation of a dish-type concentrating mirror with its frame.

[0052] The frame of the dish-type mirror is joined through cylindrical hinges with tracking rods.

[0053] The internal cavity between the walls of the double-wall funnel and between the flexible joint and the lower branch of the T-piece may optionally be filled with thermo-insulating material with low thermal conductivity.

[0054] It should be noted that heat transfer from the internal surface of the spherical cap to the working medium is performed mainly by natural convection, conduction and boiling. In order to diminish temperature drop between this internal surface and the working medium, the internal surface of the spherical cap may be provided with fins and/or a porous coating from metal powder; this porous coating has open porosity.

[0055] It is possible to use a funnel with a single wall instead of the aforementioned double-wall funnel; in this case the lower edge of the funnel is joined with a connecting branch with a flange; this connecting branch is joined in turn with the lower flange of the flexible joint. The truss struts are joined in this case with the connecting branch.

[0056] In addition, it is possible to obviate use of the dish-type plate. The outer surface of the metal convex spherical cap is provided in this embodiment with a radiation absorption coating. This coating is preferably stable against friction with the upper edge of the aforementioned double- or single-wall funnel.

[0057] A solar radiation collector may optionally be assembled from a plurality of solar radiation modular collectors, which are described above; this plurality of solar radiation modular collectors is preferably placed in the form of parallel rows and bearing pipes are interconnected in series in each row.

[0058] Solar radiation modular collectors, which are positioned in parallel and/or belong to one set of interconnected serial bearing pipes, preferably have common tracking units.

[0059] Without wishing to be limited to a single set of advantages, it should be noted that the technical solutions described above have a number of advantages, a few of which are listed below.

[0060] In the first described embodiment of the proposed solar collector with a trough-wise concentrator, the metal thermal insulation of the receiver has a number of functions, which are not known in the background art:

[0061] It serves as an non-imaging concentrator;

[0062] Its corrugations prevent its thermal deformation and serve as elements of the tracking mechanism;

[0063] It is supporting the concentrators.

[0064] This is true as well regarding the receiver, which also has some additional functions:

[0065] It is a bearing element for the thermal insulation and for the concentrators;

[0066] It is an element in a tracking mechanism.

[0067] In the second embodiment of the invention with a dish-wise concentrator, T-pieces with their caps of the bearing pipe also have a variety of functions:

[0068] 1. They are bearing elements for double-wall funnels and the concentrators;

[0069] 2. They serve for heat transfer to a medium flowing in the bearing pipes;

[0070] 3. They serve as elements in the tracking mechanism.

[0071] On the other hand, the double-wall funnels with their dish-type plates also have additional functions:

[0072] Their dish-type plates serve for heat transfer to the spherical caps of the T-pieces;

[0073] The double-wall funnels serves as non-imaging concentrators;

[0074] The double-wall funnels with their dish-type plates are elements in the tracking mechanism;

[0075] The double-wall funnels are the bearing elements for the dish-type concentrators.

BRIEF DESCRIPTION OF THE DRAWINGS

[0076] FIG. **1***a* is a transverse cross-section of a receiver of a concentrated solar radiation collector module with a concentrating single-curvature unit.

[0077] FIG. **1***b* is an exploded transverse cross-section of the metal envelope of the receiver and its glazing.

[0078] FIG. **1***c* is an exploded transverse cross-section of a radiation receiving pipe of the receiver.

[0079] FIG. **2** is an isometric view of an internal section of a metal envelope of the receiver, which is shown in FIG. **1***a* and FIG. **1***b*, with corrugations directed inwards.

[0080] FIG. **3** is an isometric view of an external section of the metal envelope of the receiver, which is shown in FIG. **1***a* and FIG. **1***b*, with corrugations directed outwards.

[0081] FIG. **4** is an axial cross-section of the radiation receiving pipe of the receiver, which is shown in FIG. **1***a* and FIG. **1***c*.

[0082] FIG. **5** is a transverse cross-section of the solar radiation collector modules for concentrating single-curvature units and with some elements of a tracking mechanism.

[0083] FIG. **6** demonstrates an isometric view of the section of the receiver of concentrated solar radiation for the case of application a concentrating single-curvature mirrors.

[0084] FIG. **7** is a cross-section of a combined unit: a T-piece—solar radiation receiver with application of a double-wall funnel and a dish-type radiation absorption plate.

[0085] FIG. **8** is a cross-section of a combined unit: a T-piece—solar radiation receiver with application of a single-wall funnel and a dish-type radiation absorption plate.

[0086] FIG. **9** is a cross-section of a combined unit: a T-piece—solar radiation receiver with application of a metal convex spherical cap for absorption of concentrated solar radiation.

[0087] FIG. **10** is a longitudinal cross-section of the solar radiation collector module with a concentrating compound-curvature unit and with some elements of a tracking mechanism.

DETAILED DESCRIPTION OF THE INVENTION

[0088] FIG. **1***a*, FIG. **1***b* and FIG. **1***c* show the transverse cross-sections of the receiver of concentrated solar radiation for the embodiment of the present invention featuring a concentrating single-curvature unit. The figures show an exploded transverse cross-section of the metal envelope of the receiver and its glazing and an exploded transverse cross-section of a radiation receiving pipe of the receiver.

[0089] This embodiment of the device according to the present invention includes a radiation receiving pipe **101** with a selective coating **102** of its outer surface and low circular ribs **103**, and a metal envelope **104**. Preferably coating **102** is made of selective coating material (preferably absorbing strongly in the visible range but only weakly emitting in the infra-red range of light). As previously described, radiation receiving pipe **101** receives radiation and is insulated by metal envelope **104**.

[0090] Metal envelope **104** includes an internal elongated section **105** and an external elongated section **106**, which are joined by two elongated connection straps **107** and sealed at their ends by face planes; the internal elongated section **105** comprises in turn a cylindrical sub-section **108**, which encloses a significant part of the radiation receiving pipe **101** for insulating it from heat loss. Cylindrical sub-section **108** features at its longitudinal margins a plurality of flat strips **109** with a defined angle of convergence with respect to the cylindrical sub-section **108**.

[0091] The external elongated section **106** comprises a cylindrical sub-section **110**, which encloses the cylindrical sub-section **108**; cylindrical sub-section **110** features at its longitudinal margins a plurality of flat strips **111** with the same angle of convergence as for flat strips **109**. The angle of convergence preferably enables additional radiation reflected from the surface of the flat strips **109** to be collected by the radiation receiving pipe **101** and also for heat to be maintained in the area of the radiation receiving pipe **101**, further increasing the efficiency of energy collection.

[0092] Two elongated connection straps **112** join the flat strips **109** and flat strips **111**.

[0093] The internal space between the internal and external sections (**108** and **110**, respectively) is preferably evacuated in order to reduce convective losses of heat. In addition, this space may optionally be filled with a porous filler **113** to further reduce heat loss.

[0094] In addition, radiation shields in the form of metal foils **114** are situated in the internal cavity of the metal envelope **104** to reduce heat loss and to increase the efficiency of energy collection.

[0095] The flat strips **109** are provided with longitudinal clamps **115**, which serve for fastening glazing **116**. Glazing **116** preferably increases the efficiency of energy collection and also reduces radiant and convective heat loss.

[0096] FIG.**2** shows an isometric view of the internal section of the metal envelope alone according to an optional embodiment with corrugations directed inwards.

[0097] It comprises a cylindrical sub-section **201**, which features flat strips **202** at the longitudinal margin as previously described.

[0098] The cylindrical sub-section **201** and the flat strips **202** are preferably provided with corrugations **203**, which decrease in dimension at their lower margins. These corrugations **203** are preferably directed inwards with respect to the cylindrical sub-section **201**. The lower edges of the flat strips **202** are provided with elongated connection straps **204**. Dimensions of corrugations **203** are a function of the mechanical properties of the envelope (material and dimensions) and also depends on the temperature differential. Corrugations **203** preferably are constructed so as to prevent distortion due to a temperature gradient on the metal envelope and mechanical stresses caused by this temperature gradient, as previously described.

[0099] FIG. **3** is an isometric view of an external section of the metal envelope alone according to an embodiment featuring corrugations directed outwards.

[0100] It comprises a cylindrical sub-section **301**, which also features flat strips **302** as previously described.

[0101] The cylindrical sub-section **301** and the flat strips **302** are preferably provided with corrugations **303**, which decrease in dimension at their lower margins. Corrugations **303** are directed outwards with respect to the cylindrical sub-section **301**.

[0102] FIG. **4** shows an axial cross-section of an embodiment of the radiation receiving pipe alone. It comprises a metal pipe **401** that is provided with two bellows **402** at its extreme sections. Bellows **402** are intended to compensate thermal expansion of the metal pipe **401**. The outer surface of the metal pipe **401** is provided with a selective coating **403** which preferentially absorbs solar radiation and has a low emittance of infra-red energy. Selective coating **403** may optionally cover only the part of the outer surface of pipe **401**, which is irradiated by the concentrated solar radiation. In addition, the metal pipe **401** is preferably provided with low ribs **404**, which prevent immediate contact of the selective coating **403** with the surface of the internal section of the metal envelope (not shown) when the envelope rotates around the metal pipe **401**. The cylindrical surfaces of the low ribs are preferably coated separately with antifriction coating **405** also to prevent friction during rotation.

[0103] Flanges **406** are installed on the ends of the metal pipe **401**.

[0104] Bellows **402** may optionally be made of the same material as metal pipe **401**; the material is preferably selected according to the dimensions of bellows **402** and the plasticity of the material.

[0105] FIG. **5** is a transverse cross-section of two solar radiation collectors positioned in parallel with a common tracking rod and with a concentrating single-curvature unit.

[0106] It shows posts **501** with pipes **502** installed on their upper sections. A metal envelope **503**, which is provided with glazing **504**, is situated on pipe **502** and can rotate around pipe **502**. Truss struts **505** serve for fastening frames **506**, which in turn serve for installation of parabolic troughwise mirrors **507**. A common tracking rod **508** is joined by hinged units **509** with frames **506**. This enables the unit to follow the motion of the sun through movement by a common tracking unit (not shown; may optionally employ a motor to power movement of the unit). Pipes **502**, metal envelope **503** and glazing **504** preferably operate together are as for FIG. **1**. Metal envelope **503** also collects energy through heating due to some radiation falling onto it. Glazing **504** preferably diminishes heat loss through natural convection.

[0107] FIG. **6** demonstrates an isometric view of the section of the receiver of concentrated solar radiation for the embodiment featuring a single-curvature concentrating mirror.

[0108] It comprises: a radiation receiving pipe **601** with a selective coating, and a metal envelope that includes an internal elongated section **602** and an external elongated section **603**. These sections **602** and **603** are joined together to elongated connection straps **604**. The internal elongated section **602** comprises, in turn, a cylindrical sub-section **605**, which encloses a majority of the radiation receiving pipe **601**; this cylindrical sub-section **605** is transformed at its longitudinal margins to flat strips **606** with a certain angle of convergence with respect to the cylindrical sub-section **605**.

[0109] The external elongated section **607** comprises a cylindrical sub-section **608**; this cylindrical sub-section **608** is transformed at its longitudinal margins to flat strips **609** with the same angle of convergence as the flat strips **606**.

[0110] The internal space between the internal and external sections (sections **602** and **603** respectively) is preferably evacuated in order to reduce convective losses of heat.

[0111] The flat strips **609** are provided with clamps **600**, which serve for installation of glazing **611**.

[0112] The cylindrical sub-section **605** and the flat strips **606** are provided with corrugations **612**, which decrease in dimension at their lower margins. These corrugations **612** are directed inwards with respect to the internal elongated section **602**.

[0113] Truss struts **613** are installed on the outer surface of the flat strip **609**.

[0114] The function of these elements is similar to that of the corresponding elements of FIGS. **1-5**.

[0115] FIG. **7** demonstrates a cross-section of a combined unit (which is another embodiment according to the present invention), featuring a T-piece—solar radiation receiver with a double-wall funnel and a dish-type radiation absorption plate.

[0116] It comprises: bearing pipes **701** and **702** with insulting layers **703** and **704**, and a T-piece **705** with an insulating layer **706**. The lower branch of this T-piece **705** is sealed by a metal convex spherical cap **707**. In addition, there is a solar radiation receiving member, which is constructed from a dish-type plate **708** and a double-wall funnel **709**.

[0117] The upper side of the dish-type plate **708** has a concave surface in the form of a spherical segment with the radius almost identical to that of the metal convex spherical cap **707**. In such a way, the metal convex spherical cap **707** of T-piece **705** and the concave surface of the dish-type plate **708** together forms a spherical joint.

[0118] The lower surface of the dish-type plate **708** is covered with layer **710** of solar radiation absorption coating.

[0119] The upper edge of the internal wall of the double-wall funnel **709** is joined with the edge of the dish-type plate **708** and the edge of its outer wall is provided with flange **711**.

[0120] The distal (lower) aperture of the double-wall funnel **709** is glazed with glazing **712**.

[0121] There is a bearing housing **713** with a split lower flange **714** and two longitudinal slots; this bearing housing **713** is mounted on the thermal insulation **706** of T-piece **705**.

[0122] Flanges **714** and **711** of the bearing housing **713** and of the outer wall of the double-wall funnel **709** are joined by a flexible joint **715**, which plays at the same time a role of a thermal insulator.

[0123] The outer wall of the double-wall funnel **709** serves at the same time for mounting truss struts **716**, which in turn serve for installation of a dish-type concentrating mirror with its frame.

[0124] FIG. **8** shows a cross-section of a combined unit of a T-piece—solar radiation receiver with application of a single-wall funnel and a dish-type radiation absorption plate.

[0125] It comprises bearing pipes **801** and **802** with insulting layers **803** and **804**; and T-piece **805** with an insulating layer **806**. The lower branch of T-piece **805** is sealed by a metal convex spherical cap **807**. In addition, there is a solar radiation receiving member, which constructed from a dish-type plate **808** and a single-wall funnel **809**.

[0126] The upper side of the dish-type plate **808** has the concave surface in the form of a spherical segment with the radius almost identical to that of the metal convex spherical cap **807**. In such a way, the combination of the metal convex spherical cap **807** of the T-piece and the concave surface of the dish-type plate **808** together form a spherical joint.

[0127] The lower surface of the dish-type plate **808** is covered with layer **810** of a solar radiation absorption coating.

[0128] The lower edge of the single-wall funnel **809** is joined with a connecting branch **811** with flange **812**, which is joined in turn with the lower flange of a flexible joint **813**. Truss struts **814** are joined in this case with the connecting branch **811**, which serve in turn for installation of a dish-type concentrating mirror with its frame (not shown).

[0129] The distal (lower) aperture of the single-wall funnel **809** is glazed with glazing **815**.

[0130] There is a bearing housing **816** with a split lower flange **817** and two longitudinal slots; this bearing housing **816** is mounted on the thermal insulation **806**. The split lower flange **817** of the bearing housing **816** is joined with the flexible joint **813**, which plays at the same time a role of a thermal insulator serving in turn for installation of a dish-type concentrating mirror with its frame (not shown).

[0131] FIG. **9** is a cross-section of a combined unit featuring a T-piece—solar radiation receiver with application of a metal convex spherical cap for absorption of concentrated solar radiation.

[0132] It comprises bearing pipes **901** and **902** with insulting layers **903** and **904**; T-piece **905** with an insulating layer **906**, the lower branch of T-piece **905** is sealed by a metal convex spherical cap **907**.

[0133] The outer surface of the metal convex spherical cap **907** is provided with a radiation absorption coating **908**.

[0134] There is a double-wall funnel **909**; the upper edge of this double-wall funnel is in immediate contact with the radiation absorption coating **908** of the metal convex spherical cap **907**, and the double wall funnel **909** can be turned in two directions around this metal convex spherical cap **907**.

[0135] In such a way, the combination of the metal convex spherical cap **907** of T-piece **905** and the double-wall funnel **909** forms a spherical joint.

[0136] The outer edge of the outer wall of the double-wall funnel **909** is. provided with flange **910**.

[0137] The distal (lower) aperture of the double-wall funnel **909** is glazed with glazing **911**.

[0138] There is a bearing housing **912** with a split lower flange **913** and two longitudinal slots; this bearing housing **912** is mounted on the thermal insulation **906** of T-piece **905**.

[0139] Flanges **913** and **910** of the bearing housing **912** and of the outer wall of the double-wall funnel **909** are joined by a flexible joint **914**, which plays at the same time a role of a thermal insulator. The outer wall of the double-wall funnel **909** serves at the same time for mounting truss struts **915**, which serve in turn for installation of a dish-type concentrating mirror with its frame.

[0140] FIG. **10** shows a longitudinal cross-section of the solar radiation collector module with a concentrating compound-curvature unit and with some elements of a tracking mechanism.

[0141] It comprises bearing pipes **1001** with expansion units **1021**, which are mounted on vertical posts **1002**. A working medium flows in the bearing pipes **1001**. The bearing pipes **1001** are provided with layers **1003** of a thermal insulation.

[0142] T-piece **1004** is built into the bearing pipes **1001**. The lower branch of T-piece **1004** is sealed by a metal convex spherical cap **1005**.

[0143] T-piece **1004** is covered with layer **1006** of a thermal insulation.

[0144] In addition, there is a solar radiation receiving member, which constructed from a dish-type plate **1007** and a double-wall funnel **1008**.

[0145] The upper side of the dish-type plate **1007** has the concave surface in the form of a spherical segment with the radius almost identical to that of the metal convex spherical cap **1005**. In such a way, the combination of the metal convex spherical cap **1005** and the concave surface of the dish-type plate **1007** forms a spherical joint.

[0146] The lower surface of the dish-type plate **1007** is covered with layer **608** of a solar radiation absorption coating.

[0147] The upper edge of the internal wall of the double-wall funnel **1008** is joined with the edge of the dish-type plate **1007** and the edge of its outer wall is provided with flange **1009**.

[0148] The distal (lower) aperture of the double-wall funnel **1008** is glazed by glazing **1010** in order to diminish heat losses via its internal cavity.

[0149] There is a bearing housing **1011** with a split lower flange **1012** and two longitudinal slots; this bearing housing **1011** is mounted on the thermal insulation **1006** of T-piece **1004**.

[0150] The open sections of the longitudinal slots of the bearing housing **1011** are closed. The flanges **1012** and **1009** of the bearing housing **1011** and of the outer wall of the double-wall funnel **1008** are joined by a flexible joint **1013**, which plays at the same time a role of a thermal insulator.

[0151] The outer wall of the double-wall funnel **1008** serves at the same time for mounting truss struts **1014**, which in turn serve for installation of a dish-type concentrating mirror **1015** with its frame **1016**.

[0152] Frame **1016** of the dish-type concentrating mirror **1015** is joined through cylindrical hinges **1019** and **1020** with tracking rods **1017** and **1018**.

[0153] Other embodiments and configurations may be devised without departing from the spirit of the invention and the scope of appended claims.

What is claimed is:

1. A solar radiation modular collector comprising:

a concentrating unit of the single-curvature type;

a receiver of concentrated solar radiation, said receiver comprising: a metal pipe with inlet and outlet connections, with a black or selective coating of the outer surface of said metal pipe;

a thermal insulation intended to insulate thermally at least a portion of said metal pipe; said thermal insulation comprising a metal envelope with a vacuum-insulated internal cavity; said metal envelope comprising elongated internal and external sections, which are joined by two elongated connection straps and sealed at their ends by face planes; said internal elongated section comprising a cylindrical sub-section, which encloses a significant part of said metal pipe; said cylindrical sub-section featuring flat or single-curved strips with a certain angle of convergence with respect to said cylindrical sub-section;

wherein said elongated external section encloses said metal pipe and the internal cavity between said elongated internal and external sections is evacuated in order to suppress convective and conductive losses of heat from said metal pipe;

wherein the gap between the distal longitudinal margins of said flat or single-curved strips is glazed by a glazing;

wherein said internal and external sections of said metal envelope are provided with corrugations, which decrease in dimension in the vicinity of said connection straps; and

wherein said receiver is positioned in the zone of the focal line of said single-curvature concentrator; and

a set of truss struts joining said concentrating unit with said metal envelope.

2. A solar radiation modular collector of claim 1, wherein said metal pipe is provided at end sections with a plurality of flexible sections in order to compensate for thermal expansion.

3. A solar radiation modular collector of claim 1, wherein said metal pipe is provided with a set of low circular ribs in order to prevent immediate contact of said black or selective coating with the inner surface of said elongated internal section.

4. A solar radiation modular collector of claim 3, wherein the cylindrical surfaces of said circular ribs are provided with an antifriction coating.

5. A solar radiation modular collector of claim 1, wherein the ends of said metal pipe are provided with flanges.

6. A solar radiation modular collector of claim 1, further comprising an auxiliary means for installation of said concentrating unit, said metal pipe and said metal envelope.

7. The collector of claim 6, wherein said metal pipe is installed on two posts, which serve as said auxiliary means, and said metal envelope can rotate around said metal pipe.

8. A solar radiation modular collector of claim 1, wherein the outer surface of said external section of said metal envelope is provided with a selective coating, which absorbs concentrated solar radiation.

9. A solar radiation modular collector of claim 1, wherein reflecting shields from metal foil are positioned in said internal cavity of said metal envelope.

10. A solar radiation modular collector of claim 9, wherein said internal cavity of said metal envelope is filled with gas.

11. A solar radiation modular collector of claim 10, wherein said gas has low thermal conductivity.

12. A solar radiation modular collector of claim 1, wherein said internal cavity is filled with powdered solid material.

13. A solar radiation modular collector of claim 1, wherein the extreme sections of said metal pipe are provided with threads instead of said flanges.

14. A solar radiation modular collector of claim 1, wherein there are some said metal envelopes situated around one said metal pipe, and, correspondingly, there are some said concentrating units, which are joined with said metal envelopes.

15. A solar radiation modular collector of claim 1, further comprising a tracking unit for tracking the sun by said concentrating unit.

16. A solar radiation collector system comprising a plurality of said solar radiation modular collectors of claim 1; said plurality solar radiation modular collectors are placed in the form of parallel rows and said metal pipes are interconnected in series in each said row.

17. A solar radiation collector system of claim 16, further comprising a common tracking unit for said collectors.

18. A solar radiation modular collector comprising:

a concentrating unit of the compound-curvature type with a frame;

a bearing pipe with an inlet and outlet connections and flexible joints at its extreme sections for compensation of its thermal expansion, for transport of heat by a working medium; wherein said bearing pipe is provided with a thermal insulation layer;

posts for mounting said bearing pipe;

wherein said bearing pipe comprises tubular members and

T-pieces, installed between each pair of the neighboring tubular members; wherein the lower branch of each said T-piece is sealed by a metal convex spherical cap and a part of its outer surface of the T-piece is covered with a thermal insulation layer;

a solar radiation receiving unit, which is constructed from a dish-type plate and a double-wall funnel; wherein the upper side of said dish-type plate has the concave surface in the form of a spherical segment with the radius commensurate with that of said metal convex spherical cap, thereby forming a spherical joint; wherein the lower surface of said dish-type plate is covered with a layer of solar radiation absorption coating; wherein the upper edge of the internal wall of said double-wall funnel is joined with the edge of said dish-type plate and the edge of its outer wall is provided with a flange;

a glazing of the distal (lower) aperture of said double-wall funnel;

a bearing housing with a split lower flange and two longitudinal slots; said bearing housing being mounted on said thermal insulation layer of said T-piece;

a clamp, which closes the open sections of said bearing housing;

a flexible joint that joins said split lower flange of said bearing housing and said flange of said double-wall funnel; and

a tracking unit for tracking the sun by said concentrating unit of the compound-curvature type; said tracking unit comprising tracking rods, which are joined by hinges with said frame.

19. A solar radiation modular collector of claim 18, wherein the internal surface of said internal wall of said double-wall funnel has a high value of light reflection coefficient.

20. A solar radiation modular collector comprising:

a concentrating unit of the compound-curvature type with a frame;

a bearing pipe with an inlet and outlet connections and flexible joints at its extreme sections for compensation of its thermal expansion, for transport of heat by a working medium; wherein said bearing pipe is provided with a thermal insulation layer;

posts for mounting said bearing pipe;

wherein said bearing pipe comprises tubular members and T-pieces, installed between each pair of the neighboring tubular members; wherein the lower branch of each said T-piece is sealed by a metal convex spherical cap and a part of its outer surface of the T-piece is covered with a thermal insulation layer;

a solar radiation receiving unit, which is constructed from a double-wall funnel; wherein the upper side of said dish-type plate has the concave surface in the form of a spherical segment with the radius commensurate with that of said metal convex spherical cap, thereby forming a spherical joint; wherein the lower surface of said dish-type plate is covered with a layer of solar radiation absorption coating; wherein the upper edge of the internal wall of said double-wall funnel is joined with the edge of said dish-type plate and the edge of its outer wall is provided with a flange; and wherein the outer surface of said metal convex spherical cap is provided with a radiation absorption coating and said radiation absorption coating is stable against friction with the upper edge of said double-wall funnel;

a glazing of the distal (lower) aperture of said double-wall funnel;

a bearing housing with a split lower flange and two longitudinal slots; said bearing housing being mounted on said thermal insulation layer of said T-piece;

a clamp, which closes the open sections of said bearing housing;

a flexible joint that joins said split lower flange of said bearing housing and said flange of said double-wall funnel; and

a tracking unit for tracking the sun by said concentrating unit of the compound-curvature type; said tracking unit comprising tracking rods, which are joined by hinges with said frame.

21. A solar radiation modular collector comprising,

a concentrating unit of the compound-curvature type with a frame;

a bearing pipe with an inlet and outlet connections and flexible joints at its extreme sections for compensation of its thermal expansion, for transport of heat by a working medium; wherein said bearing pipe is provided with a thermal insulation layer;

posts for mounting said bearing pipe;

wherein said bearing pipe comprises tubular members and T-pieces, installed between each pair of the neighboring tubular members; wherein the lower branch of each said T-piece is sealed by a metal convex spherical cap and a part of its outer surface of the T-piece is covered with a thermal insulation layer;

a solar radiation receiving unit, which is constructed from a dish-type plate and a single-wall funnel; wherein the upper side of said dish-type plate has the concave surface in the form of a spherical segment with the radius commensurate with that of said metal convex spherical cap, thereby forming a spherical joint; wherein the lower surface of said dish-type plate is covered with a layer of solar radiation absorption coating;

a glazing of the distal (lower) aperture of said double-wall funnel;

a bearing housing with a split lower flange and two longitudinal slots; said bearing housing being mounted on said thermal insulation layer of said T-piece;

a clamp, which closes the open sections of said bearing housing;

a flexible joint that joins said split lower flange of said bearing housing and said flange of said double-wall funnel; and

a tracking unit for tracking the sun by said concentrating unit of the compound-curvature type; said tracking unit comprising tracking rods, which are joined by hinges with said frame;

wherein the lower edge of said single-wall funnel is joined with the lower flange of said flexible joint; said truss struts are joined in this case with said connecting branch.

22. A solar radiation collector system comprising a plurality of said solar radiation modular collectors of claim 18; wherein said plurality of solar radiation modular collectors are in parallel rows; said bearing pipes are interconnected in series in each said row; said solar radiation modular collectors, which are positioned in parallel or belong to said one set of interconnected serial bearing pipes have common tracking units.

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