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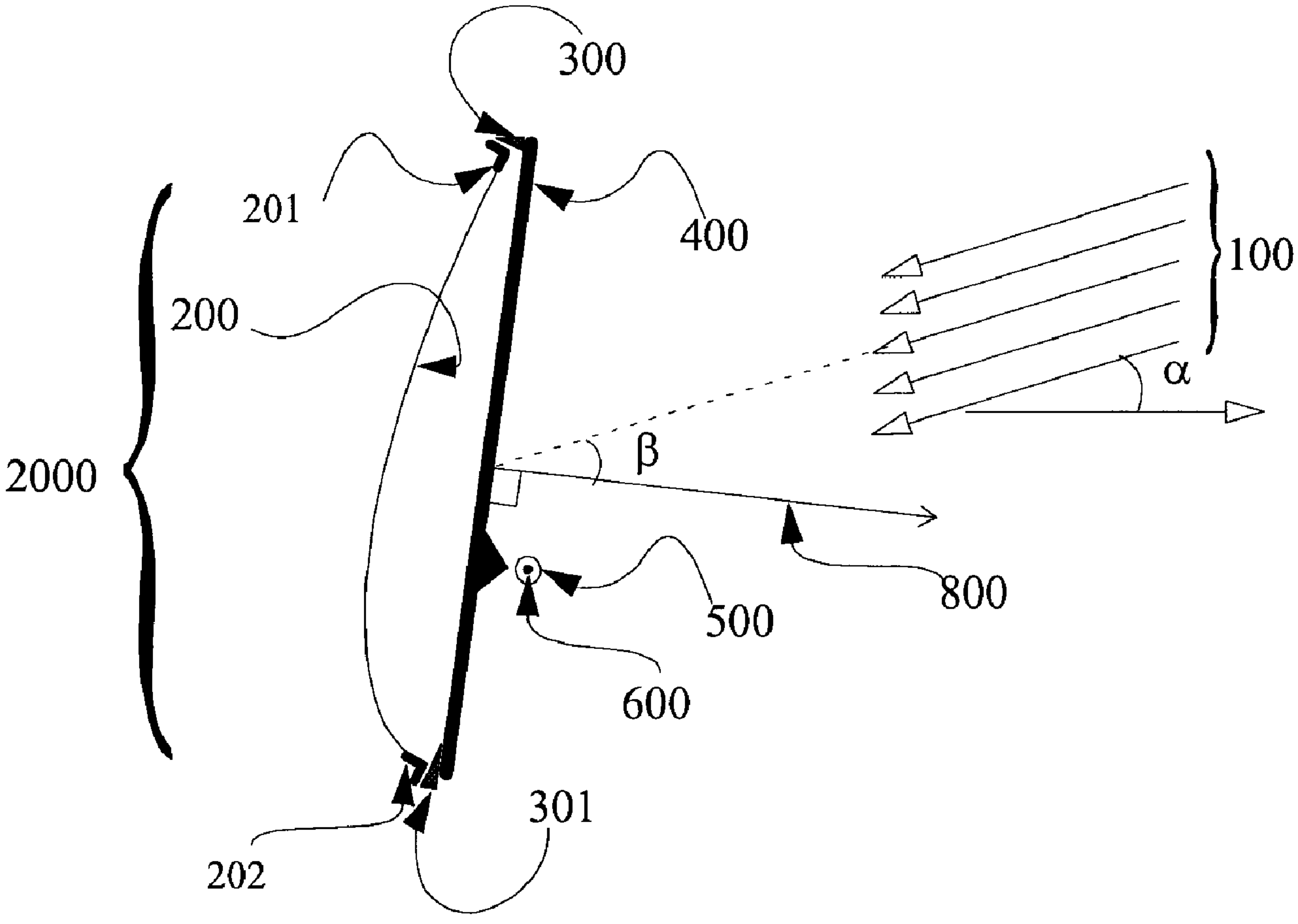
(54) Titre : SYSTEME ASYMETRIQUE DE CAPTEURS SOLAIRES
(54) Title: ASYMMETRIC SOLAR COLLECTOR SYSTEM



(57) Abrégé/Abstract:
An symmetric solar collector system is disclosed which comprises one or more reflectors in the shape of an asymmetrical vertically-biased parabolic trough, which allows for the reflectors to be stacked vertically, and have a zero footprint. The reflectors each

(57) Abrégé(suite)/Abstract(continued):

include a reinforced absorber comprising two or more tubes attached to each other in truss-like fashion, with a sag to length ratio of less than about 1/500. In addition, although the vertically-biased trough shape lessens the amount of surface area available for water or ice to accumulate, the reflector surface is partially coated with a material that is highly absorptive of solar wavelengths, and thus, heats any accumulated water/ice to the point of evaporation.

ABSTRACT

An symmetric solar collector system is disclosed which comprises one or more reflectors in the shape of an asymmetrical vertically-biased parabolic trough, which allows for the reflectors to be stacked vertically, and have a zero footprint. The reflectors each include a reinforced absorber comprising two or more tubes attached to each other in truss-like fashion, with a sag to length ratio of less than about 1/500. In addition, although the vertically-biased trough shape lessens the amount of surface area available for water or ice to accumulate, the reflector surface is partially coated with a material that is highly absorptive of solar wavelengths, and thus, heats any accumulated water/ice to the point of evaporation.

ASYMMETRIC SOLAR COLLECTOR SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to a device and method for collecting solar energy. In particular, the present invention relates to an asymmetric solar collector system with a zero footprint, comprising a means to minimize water-based interference.

BACKGROUND

[0002] The total amount of energy available through solar thermal collection is limited by the size of the available area and the efficiency of the collectors. With moveable mirrors to track the position of the sun, parabolic trough solar collectors maximize the energy collected by using wide mirror apertures, while minimizing the heat loss with small area absorbers. Increasing the amount of energy collected requires increasing the area of the collector installation. Thus, the size of the area available for the collectors limits the total amount of energy collectable for a given location and installation. Maximizing the available area available for solar collectors is therefore paramount to increased energy collection.

[0003] Traditional concentrator designs typically employ symmetric or "horizontally biased" asymmetric mirrors where much of the sunlight is reflected up to an absorber. These systems are often used in horizontal arrays, where the collectors are arranged spatially on a horizontal or near-horizontal surface. In such arrays, the vertical profile of the collectors is low, or the space between collectors large, to minimize the amount of light blocked by adjacent collectors when the sun is low in the sky. The opposite is true for a vertically mounted array of solar collector where the collector's horizontal profile is minimized to reduce the amount of light blocked by vertically adjacent collectors when the sun is high in the sky.

[0004] Additionally, symmetrical or horizontally-biased designs deployed in arrays cover significant horizontal surface area. An example of a trough-like reflector covering a large horizontal surface area is disclosed in WO2007109900A1 (Gerwing et al.). Similarly, WO9857102A1 (Karlsson et al.) disclose an asymmetric parabolic reflector which is horizontally-biased, and thus, requires a large horizontal surface area. These systems have a large "footprint". The horizontal surface areas are not commonly available in urban settings. Tall buildings, such as apartment blocks, have significantly greater ratios of vertical surface area to horizontal area, and thus are limited in their solar energy collection capability by the symmetrical or horizontally biased market options. Such locations are optimal for vertically-biased collectors.

[0005] One factor related to efficient solar energy collection is the method of absorption of solar rays reflected from a parabolic trough. The principle energy gathering components of parabolic trough concentrating solar collectors are a parabolic trough mirror (concentrator mirror) that reflects sunlight into a narrow line at the mirror focus, and an absorber placed along the focal line of the mirror to intercept and absorb the reflected sunlight. The narrow absorber is required to span relatively large distances between supports and must have minimal deflection (sag) due to gravity in order to stay within the focal region of the concentrator mirror. Absorber sag in concentrating solar collectors pulls the absorber away from the focal line to where it fails to intercept all of the concentrated sunlight.

[0006] In traditional designs, it is common for absorbers to be constructed of a single tube or a multiplicity of tubes (as those found in flat plate solar collectors), with thermally conductive fins, or additional structures to cover the focal region of the collector, the configuration of which is uniquely determined by each design. The absorber must intercept the maximum amount of reflected sunlight at, or near, the focus of the reflector. Often these absorbers are found to have either a back plate or structural members that are employed to provide support. Unfortunately, in many cases, extra plates and additional structure lead to higher thermal loss factors due to increased absorber area, and the necessary temperature gradients to transfer energy from the tips of fins to the heat transfer fluid regions. It is recognised that some of these structural elements also mitigate losses by inclusion of insulation or geometric features to reduce the heat loss. Ultimately, these added complexities and necessary design features result in additional costs.

[0007] An absorber, heated by concentrated light, loses energy to its surroundings through black body radiation, forced and natural convection, and conduction. All of these terms scale with the area of the absorber. To maximize efficiency through the absorber area, the ratio of the absorber surface area to the light gathering aperture area of the concentrator is kept to a minimum. Designing to minimize absorber area is difficult, and reducing the size of the absorber usually reduces the structural rigidity of the absorber along its length. Single tube absorbers made from common metals (like steel, copper and aluminium), when supported at distant endpoints, sag significantly, with the absorber falling below the lower edge of the focal line over the absorber length, especially when heated. This draws the absorber out of the focal region of the concentrator mirror. The ratio of absorber length to diameter, for single tube absorbers, with most concentrators makes it impossible for the absorber to span large distances between supports without significant sag.

[0008] While, for example, US 4,156,419; CN20131814; DE19925531; WO199964795; and WO2008090461A2 all disclose absorbers comprising multiple tubes, none address the problem of sagging in a satisfactory manner.

[0009] Another disadvantage of symmetrical or horizontally-biased collector designs is their susceptibility to the accumulation of water phases (e.g. solid and/or liquid, depending on the ambient temperature) and particulate matter. In particular, mirror surfaces with near-horizontal slopes less than 45 degrees from horizontal accumulate different phases of water and debris, which impair the specular reflectivity of the mirror(s), and reduce the light gathering efficiency.

[00010] In some designs, the mirrors employed in parabolic trough and trough-like concentrators are unprotected and subject to outdoor environmental conditions. High reflectivity mirrors, used in concentrating solar radiation collectors, have surface temperatures that do not increase significantly above ambient temperatures. On mirror surfaces having an upward facing component to their slope, water can accumulate as either solid or liquid and may remain on the surface of the mirror for sustained periods. The presence of water reduces the specular reflection of the mirror, lowering the performance of the solar collector. Typical mirrored collector designs employ mirrors that reflect 95% of the incident sunlight radiation, leaving just 5% as heat absorbed by the mirror surface. The low absorptivity that makes the mirror a good reflector, combined with conductive and convective losses, leaves very little residual energy in the mirror to the raise the mirror temperature significantly above the ambient temperature.

[00011] Depending on the season and daily time-dependent location of the sun, the mirror may have a primarily upward facing surface for at least part of its curved surface. Such upwards facing surfaces may then be subject to accumulation of water. This is especially problematic in the winter when the water is often in the solid forms of ice or snow. Once on the surface, the area of the mirror that is covered by water is reflectively impaired and no longer performs as designed, with reduced specular reflectivity. Although US 4,015,585 discloses a solar heating device for melting snow, it is rather complex and expensive, as it requires the use of a plurality of pipes underlying a reflector, and circulating fluid there through.

[00012] There is thus a need for a device and method of solar collection with minimal vertical footprint, employing high-efficiency absorbers and means for minimizing water-phase accumulation.

SUMMARY

[00013] The present invention addresses the aforementioned issues through the use of a vertically-biased solar collector which provides for: zero-footprint; a shallow collector depth; the ability to stack collectors; minimization of component of horizontal mirror surface area; and proximity to a sold vertical surface area to reduce wind-loading leading to mechanical simplicity.

[00014] The invention in its general form will first be described, and then its implementation in terms of preferred embodiments will be detailed hereafter. These embodiments are intended to demonstrate the principle of the invention, and the manner of its implementation. The invention in its broadest and more specific forms will then be further described, and defined, in each of the individual claims which conclude this Specification.

[00015] In one aspect of the present invention, there is provided a novel, vertically-biased design of a solar collector. The cross-section of the mirror is an asymmetric section of a parabola. This asymmetry tilts the aperture vertically relative to designs using a symmetric mirror aperture which is perpendicular to the sun's rays. The mirror is referred to as "vertically-biased" for these reasons.

[00016] In another aspect of the present invention, there is provided a solar collector comprising: a) a reflector assembly for receiving solar radiation; and b) an absorber positioned for receiving solar radiation reflected from the reflector assembly, wherein the reflector assembly comprises a reflector surface having a longitudinal cross-sectional shape of an asymmetric parabola with a vertical bias.

[00017] In a further aspect of the present invention there is provided a device for solar energy collection comprising a plurality of the solar collectors described above mounted on a plurality of rows adjacent to a vertical or near-vertical surface.

[00018] In yet another aspect of the present invention there is provided a solar absorber having a truss-like structure, comprising two or more tubes and a means of joining the tubes, wherein the absorber has a sag to length ratio of about 1/500 or less.

[00019] The present invention comprises a shallow asymmetric parabolic solar collector. By vertically biasing the collector mounted on a vertical surface, the depth of the collector is reduced. The depth is defined as the distance from the vertical surface, upon which the collector is mounted, to the point on the collector furthest from the vertical surface. The vertical bias of the present invention requires less space for mounting nearer the support wall than similar sized symmetrical or horizontally-biased collectors, while still permitting the collector to track the sun year round, preferably for latitudes greater than 23 degrees North or South.

[00020] The present invention provides for a “zero-footprint” design, with no need for a horizontal footing and taking only the wall space at a depth for a single row of collectors when installed as an array. A deployment of a plurality of rows to create an array of collectors requires no horizontal space beyond that of the first row.

[00021] The vertical bias of the collectors provides for a low horizontal profile, and makes the collectors ideal for use in vertical arrays. Collector arrays using the zero-footprint design are suited, for example, in densely populated areas where horizontal real estate is at a premium and vertical real estate is plentiful. The zero-footprint design benefits, for example, apartment block deployments due to the stack-ability, and minimal collector depth.

[00022] A vertically-biased mirror increases the fraction of the year when the entire mirror has little near horizontal slope, and therefore minimizes the build-up of efficiency-impairing water (solid or liquid) and debris on the mirror surface, thus improving overall operational efficiency. Mirror life is prolonged with reduced particle accumulation and longer cycle times between cleaning.

[00023] The solar collector of the present invention is designed to be mounted on a solid vertical or near vertical surface. This takes advantage of the proximity to the solid surface for buffeting from wind loads. The application to wall mounting means that there is no need for wind load protection beyond that inherent in the design. Thus, a design of the present invention is light-weight. Infrastructure supports this light-weight device with no requirement for special reinforcement. The relative low weight of the present invention, translates into lower infrastructure, installation, and material costs.

[00024] The solar collector of the present invention can be integrated into structural or architectural features. Examples of these would be but not limited to building curtain walls, overhangs, steep roofs, fences, and geographic features.

[00025] The truss absorber of the present invention is designed to be positioned along the focal line of the reflected sunlight for a parabolic trough solar collector, the region where the line width of the concentrated sunlight is a minimum. The absorber must be optimized to cover the focal line height at the concentrator focus while being as small as possible to minimize heat loss to the surroundings. Only the smallest amount of design area is apportioned to the absorber height to account for sag. With a simple two-tube absorber design built as a truss, the absorber is greater and more rigid than a single tube absorber. This reduces the absorber sag to a tolerable amount. A simple two-tube absorber can also be easily pre-stressed during fabrication to counter the sag and reducing sag effectively to zero when installed. Two tubes are used in the preferred embodiment of the present invention; however a similar truss structure of alternate embodiments can be made with more than two tubes, if necessary, rigidly joined together to make a truss absorber that therefore meets the design requirement and intercepts all of the reflected sunlight.

[00026] The simple multi-tube truss design of the present invention is also a fin-less design. With fins, heat must be conducted along the fins to the channel containing the heat transfer fluid. The higher temperature at the edge of the fin raises the heat loss of the absorber. The fin-less design results in minimal temperature gradient as the heat is conducted directly through the wall of the tube (about a distance of 1mm). In addition, there are no back plate, nor extra-structural elements, and therefore no additional loss factors.

[00027] Whereby a standard copper tube has a sag to length ratio of about 1/65 (i.e. the sag is about 1/65 of the length of the tube), the absorber truss of the present invention has sag to length ratio of about 1/500 or less. For example, a truss absorber of the present invention spans a collector's design distance of 2.45 m with minimal sag less than 5 mm peak.

[00028] In addition, the truss absorber can, if desired, be employed to support a non-structural features without appreciably increasing the sag. The truss absorber is preferably externally finished with a selective coating with high absorptivity at visible (solar) wavelengths and low emissivity at thermal infrared wavelengths.

[00029] The solar collector of the present invention further comprises a solar energy-absorbing area integrated onto, or adjacent to, the sun facing surface (mirror) of the solar collector appliance. During operation, light is passively absorbed as heat by area(s) with high absorptivity at solar wavelengths, and conducted to the mirror surface of the collector. The solar energy absorbing area provides sufficient heat energy to increase the temperature of the surrounding material to evaporate, sublimate, liquefy or otherwise facilitate removal of water from the mirror surface, clearing the mirror of optical impairments.

[00030] The solar energy absorbing areas, once integrated onto the mirror's surface, covers less than about 5% of the total mirror surface area. This is a considerable improvement when compared to the typical loss of energy transfer due to presence of water which is of the order of 20 to 50% of total mirror surface area. Since water accumulation on vertical surfaces is usually minimal, the absorptive material need only be applied to the relatively small fraction of the vertically-biased mirror that has a low slope. The 5% coverage of the absorbent material over the mirror need only apply to the low slope regions of the mirror.

[00031] The solar energy absorbing areas operate when the solar collector is in operation. Raising surface temperature of the solar collector by a few degrees above ambient temperature is all that is required to begin the evaporation, sublimation, or liquefaction process. While the solar energy absorbing areas are used on vertically-biased mirrors, they are also applicable to existing mirrored systems used to collect solar energy. For example, the solar energy absorbing areas may be extended to glazed systems flat panels or evacuated glass tubes where impairments due to water impact performance of transmitted solar radiation.

[00032] The solar energy absorbing areas may be integrated directly onto a mirror or affixed as an appendage using a stable, thermally conductive product.

[00033] The foregoing summarizes the principal features of the invention and some of its optional aspects. The invention may be further understood by the description of the preferred embodiments which follow.

BRIEF DESCRIPTION OF THE DRAWINGS

[00034] Figures 1 illustrates a side view of a vertically-biased asymmetric parabolic trough concentrating solar collector.

[00035] Figure 2 illustrates a front view of a vertically-biased asymmetric parabolic trough concentrating solar collector, showing the offset of the absorber to the lower region of the collector.

[00036] Figure 3 illustrates a partial isometric view of water accumulation on the lower edge of a solar collector.

[00037] Figure 4 illustrates a side view of a stacked deployment of vertically-biased collectors.

[00038] Figure 5 illustrates a side view of a stacked deployment of vertically-biased collectors during a seasonally high sun angle.

[00039] Figure 6 illustrates an elevation of a truss absorber with periodic joints between adjacent tubes.

[00040] Figure 7 illustrates a close-up view of a joint between two tubes.

[00041] Figure 8 illustrates an elevation of a truss absorber with a continuous joint between adjacent tubes.

[00042] Figure 9 illustrates a close-up view of a continuous joint between two tubes.

[00043] Figure 10 illustrates an end-on cross-sectional view of truss absorber tubes and joint.

[00044] Figure 11 illustrates a close-up view along the length of truss absorber tubes which are each rolled flat at the mid section.

[00045] Figure 12 illustrates cross-section of rectangular area of the tubes at the flattened section.

[00046] Figure 13 illustrates the elevation of two lengths of tubes with mid sections rolled flat configured and joined at an angle offset θ from one another.

[00047] Figure 14 illustrates a cross-section of rectangular area of the tube at the flattened section assembled and joined at an angle offset θ to one another.

[00048] Figure 15 illustrates a cross-sectional view with concentrated sunlight on one side of the truss absorber shown figure 10.

[00049] Figure 16 illustrates a cross-sectional view of a truss absorber supporting a back plate and providing for insulation and exposed absorber area reduction to reduce heat loss.

[00050] Figure 17 illustrates a cross-section of a truss absorber encapsulated in a partially transparent partial back plate apparatus.

[00051] Figure 18 illustrates a cross-sectional view of a truss absorber encapsulated in an apparatus comprised of a clear transparent film or glazing to minimize convective losses.

[00052] Figure 19 illustrates a partial isometric view of water accumulation on the lower edge of a solar collector, with a solar energy absorption area affixed to the mirror.

[00053] Figure 20 illustrates a plurality of passive solar energy absorption areas integrated onto the surface of a solar collector.

DETAILED DESCRIPTION

[00054] Wherever ranges of values are referenced within this specification, sub-ranges therein are intended to be included within the scope of the invention unless otherwise indicated. Where characteristics are attributed to one or another variant of the invention, unless otherwise indicated, such characteristics are intended to apply to all other variants of the invention where such characteristics are appropriate or compatible with such other variants.

[00055] The following is given by way of illustration only and is not to be considered limitative of this invention. Many apparent variations are possible without departing from the spirit and scope thereof.

[00056] A preferred embodiment of the solar collector of the present invention is shown in Figure 1. The solar collector (2000) is vertically-biased, has a zero-footprint, and can be vertically stacked.

[00057] The mirror 200 is constrained to follow a parabolic arc between the upper end block 300 and lower end block 301. The distance between the upper end block 300 and lower end block 301 is precisely defined by the cords 400. The angles between the edges of the mirror 200 and the cords 400 (edge angles) are set by the upper and lower end blocks 300 and 301. The mirror 200 is fixed to the upper end block 300 and lower end block 301 via the upper mirror support 201 and lower mirror support 202. The parabolic shape of the mirror is achieved by matching the distance between the upper and lower end blocks 300 and 301, and the edge angles of the mirror 200 set by the upper and lower end blocks, with the arc length of the mirror.

[00058] The asymmetric parabolic shape in the mirror 200 is achieved by making the edge angle of the mirror 200 at the upper end block 300 different from the edge angle of the mirror 200 at the lower end block 301. In the vertically-biased mirror 200 shown in Figures 1 and 2, the edge angle of the mirror 200 set by the upper end block 300 is smaller than the edge angle of the mirror 200 set by the lower end block 301. This makes the arc length for the portion of the mirror 200 between the vertex of the parabola and the upper end block 300 longer than the arc length for the portion of the mirror 200 between the vertex of the parabola and the lower end block 301. For noon fall and winter sun angles α below 45 degrees, this configuration is vertically-biased in that the cord 400 is closer to vertical than it would be for a symmetrical mirror.

[00059] The angle β between the sunlight 100 and the normal to the cord 800 is a measure of the degree of vertical-bias in the mirror 200. β is 0 degrees in a symmetrical parabolic mirror. When measured in the counter clockwise direction from the normal to the cord 800, vertically-biased mirrors have positive values of β. The mirror 200 in Figure 1 has a β angle that is approximately 30 degrees. In a preferred embodiment, the forward vertical-bias angle β ranges from 5 degrees to 45 degrees, preferably between 15 and 25 degrees; and more preferably between 18 and 22 degrees. The solar collector of the present invention tracks the sun and maintains the angle β during normal light collecting operations.

[00060] The mirror material is that which is typically found in the art. For example, the mirror material may be: highly polished anodized aluminium with a surface protected by a micro coating that prevents oxidation; or aluminium foil over a substrate; or aluminized film over a substrate; a mirrored flexible sheet material (for example, mirrored polycarbonate, mirrored acrylic or mirrored fibreglass); or a mirrored surface or back side reflectively coated material (for example, the mirror may be silver, aluminum or even stainless steel).

[00061] The collector 2000 rotates about the axis of rotation 600 in the preferred embodiment to track the incident sunlight. Axis of rotation 600 could be located differently in alternate embodiments. The absorber 500 is located at the focal line of the parabola. The absorber lies in the focal region and adjacent the axis of rotation in manifestations of this design where the absorber is fixed in place. The front/aperture plane of the collector 2000 is defined by the cord 400, upper mirror support leading edge 201 and the lower mirror support leading edge 202.The solar collector is driven by actuator(s) (not shown) that both move and hold the apparatus in place. The actuators are controlled by a controller designed to track the sun's movement and adjust the collector accordingly.

[00062] Figure 2 illustrates the view looking at the front plane of the collector 2000. The absorber 500, in both Figures 1 and 2, is deployed along the focal region of the mirror 200 to intersect the reflected sunlight. The absorber 500 is shown situated in the lower half of the collector as shown due to the vertically-biased asymmetry of the collector mirror 200.

[00063] Figure 3 illustrates a partial isometric view of the vertically-biased asymmetric parabolic trough concentrating solar collector mirror 200 and depicts the accumulation of water 720 on the lower mirror surfaces near the lower mirror support 202 where, although present, the amount of water accumulation is minimized with the reduction of near horizontal surfaces by the vertical bias of the present invention.

[00064] The vertical stackability of collectors 2000 is shown in Figure 4 with the present invention connected via a support structure 2001 to a vertical structure 3000. Here the deployed angle of the collector is depicted in an operationally seasonal mode with a lower sun angle.

[00065] Figure 5 illustrates the collectors 2000 deployed on vertical structure 3000 depicting a higher sun angle 101 and also depicting minimal shadowing 102 by the collector that is physically higher than the row below, where most of the sunlight 103 passes to the next collectors in subsequently lower rows. Blockage can be reduced with increased vertical spacing between collector 2000 rows, however the high southern (low northern for southern hemisphere) component of the sun elevation occur only in the early morning or late afternoon for latitudes above 40° North (below 40° South) in the spring and summer. The scenario of blockage in this case is not considered a problem since the majority of energy is collected within a few hours of mid day when, in the summer season, the southern (northern) component of the sun elevation is at its lowest daily elevation for a South (North) facing collector, reducing the light blockage during the peak collection period of the day. The slight degradations in efficiency, due to blockage at the extreme early and late periods of the day, therefore, impact only minimally the total daily energy collection.

[00066] Figure 6 illustrates an elevation of a truss absorber with periodic joints between adjacent tubes supported near the end points symbolized by two triangles (199). The truss absorber 500 of figure 6 comprises two or more tubes 510 and a means to rigidly join the tubes 520 (or 550 from figure 8) in such a fashion as to yield a rigid absorber in the direction between the tubes 520 when deployed in a horizontal fashion length-wise and stacked one tube above another tube in a vertical or nearly vertical arrangement as shown.

[00067] A gap 610, of a preferred embodiment of the present invention is shown in Figs. 7 and 10, between tubes 510 or 560 creates separation at the absorber ends to allow for adaptors to be fitted to the tubes to establish mating interconnection with additional absorbers or system plumbing. This gap also permits fixing points to be established between adjacent tubes along the truss' length. These fixing points enable ease of attachment of sensors, back plates, or full encasement coverings. An alternate embodiment may not include the gap 610, securing the tubes to one another without a gap 610.

[00068] Detail 520 and 550 from figures 6 through 9 are any material capable to be employed as a rigid means of attaching tubes and maintain rigidity beyond temperatures of a minimum of 25°C. Non-limiting examples include solder (e.g. melting tin/antimony between the two tubes), brass (e.g. the process of brazing), or a suitable high temperature epoxy. Details 520 and 550 are attached to the tubes by conventional means, for example (but not limited to) welding, soldering, epoxy, or a combination thereof. Details 520 and 550 are not applied within about 0.5% to about 10%, preferably about 1% , from the ends of the tubes 510 to avoid interference with the means of connecting the tubes to other systems.

[00069] Another form of tubes used to form a truss as introduced in figure 6 are shown in figures 11 through 14. Here the tubes 510 have been transformed to become partially flattened tubes 560 giving a tube an approximately elliptical or rectangular profile for most of the tube's functional length. The tubes are not so flattened as to restrict or stop the flow of heat transfer fluid within the tube. These tubes are also not flattened within about 0,5% - 10%, preferably about 1% from the ends of the tubes in order to facilitate means of connecting to other systems. In Figs. 11-14, use of partially-flattened tubes yields an even stronger truss in the direction between the two tubes (vertical).

[00070] Figure 12 shows a cross-sectional view of the truss absorber 410 with the flattened tubes where the elongated widths of both tubes 560 are aligned vertically. This truss 410 configuration yields a stronger truss 410 in the vertical direction than that of truss 500.

[00071] Figures 13 and 14 show an application of the tubes 560 forming truss 415 where the wider width dimension of one tube is aligned vertically and the wider width of the second tube is not aligned vertically but rather at an offset angle θ to the first tube.

[00072] A truss configuration 415 of Figs. 13 and 14 employs two tubes (560) vertically adjacent to each other to provide the strength to resist sagging, while the second more horizontally-biased tube 560 at and offset angle θ to the first tube meets the design requirement to occupy the focal region and absorb the concentrated sunlight. Conversely for a similar horizontally biased arrangement, application of truss absorber 500 or 410 would not benefit from the strength of the truss 415 configuration. Employing truss absorbers 500 or 410 to a horizontal configuration, as this in 415, would result in “sag”.

[00073] Concentrated sunlight 570 (Fig. 15) is reflected to the ‘front’ face of the truss absorber 500 where it is intercepted. Concentrated sunlight is incident upon roughly 50% of the absorber surface. Absorbed energy is efficiently conducted through the tubing walls to the working fluid. Direct sunlight 580 strikes roughly 50% of the absorber 500 area on the ‘back’ face of the truss. The truss absorber in this case can be any of the preferred embodiments of 500, 410 or 415, absorber 500 embodiment is shown for illustration here.

[00074] A non-structural back plate 590 (figure 16) may be added to the design to improve efficiency. The truss absorber 500 in this case is fully capable of supporting the back plate. To help minimize losses, insulation 595 can be added to the design between the truss absorber and the back plate. The back plate 590, while itself continuous end-to-end following the absorber, is attached only periodically along the length of the truss to minimize conduction of heat away from the truss absorber to the back plate. The truss absorber in this case can be any of the preferred embodiments of 500, 410 or 415, absorber 500 embodiment is shown for illustration here.

[00075] An apparatus 620 of Fig. 15 encapsulates the truss for its entire length and is fully supported by the truss absorber 500. This apparatus 620 can be added to the design to reduce convective and radiation losses at both the front, where an optically transparent covering 630 transmits concentrated sunlight to the absorber, and the back, where a plate 640 shields the absorber from forced convection. The apparatus enshrouds the truss design and is attached only periodically along the length of the truss to minimize conduction of heat to the apparatus, away from the absorber. The apparatus 620 can also be insulated 595 on the back side.

[00076] Figure 18 shows optically transparent apparatus 650 encapsulating the truss along the truss’ length. This embodiment permits sunlight, both reflected from the concentrator mirror

570 and directly from the sun 580, to strike the absorber while minimizing convective heat losses. The truss absorber in this case can be any of the preferred embodiments of 500, 410 or 415, absorber 500 embodiment is shown for illustration here.

[00077] Figure 19 shows a partial isometric view of the lower edge of the mirror of a concentrating solar collector's mirror surface 200 with a significant component of upward facing surface area and having depicted herein the accumulation of water 720 on the surface. Passive solar energy absorption area 900 is adjacent to the mirror and affixed to the mirror in a thermally conductive fashion.

[00078] Figure 20 shows a partial isometric view of the concentrating solar collector's mirror surface 700 with a significant component of upward facing surface area and having depicted herein the accumulation of water 720 on the surface. A plurality of passive solar energy absorption areas 730 is integrated onto the surface to distribute the heat over the primarily horizontal region of mirror surface. Heat is conducted away from the absorption areas via the mirror material. The preferred embodiment of the thermally absorption areas 730 are not limited to circular or oval shapes, but could be realized in any pattern, such as a matrix of small dots, linear areas running parallel to the straight edge of the mirror 740, or vertical linear stripes perpendicular to the straight edge of the mirror 740. The surface area of mirror to be integrated with the solar energy absorption area shall not exceed 5% of the total mirror area on the portion of the mirror that is susceptible to accumulation of water. For a vertically-biased mirror this is the lower portion of the mirror, for a symmetrical or horizontally biased mirror this absorbent area is applied to the entire mirror surface.

[00079] A matrix of thermally absorptive ‘dots’ or islands or a strip may be applied via a spraying process directly to the surface requiring heating. Alternatively, a strip of thermally absorptive material may be placed adjacent to and bridged thermally to a surface which will benefit from the heating.

[00080] Examples of the thermally absorptive material include, but are not limited to: black paint; highly-absorptive, low-emissive coating material; anodizing of a thermally absorptive compound; film; etching, or a combination thereof. The thermally absorptive material raises the temperature a few degrees above ambient to start the process of liquefaction, sublimation or evaporation.

CONCLUSION

[00081] The foregoing has constituted a description of specific embodiments showing how the invention may be applied and put into use. These embodiments are only exemplary. The invention in its broadest, and more specific aspects, is further described and defined in the claims which now follow.

[00082] These claims, and the language used therein, are to be understood in terms of the variants of the invention which have been described. They are not to be restricted to such variants, but are to be read as covering the full scope of the invention as is implicit within the invention and the disclosure that has been provided herein.

CLAIMS

1. A solar collector comprising:

    a) a reflector assembly for receiving solar radiation; and

    b) an absorber positioned for receiving solar radiation reflected from said reflector assembly, wherein

    said reflector assembly comprises a reflector surface having a longitudinal cross-sectional shape of an asymmetric parabola with a vertical bias.

2. The solar collector of claim 1, wherein said reflector assembly has a forward vertical bias angle of between 5 and 45 degrees.

3. The solar collector of claim 2, wherein said reflector assembly has a forward vertical bias angle of between 15 and 30 degrees.

4. The solar collector of claim 2, wherein said reflector assembly has a forward vertical bias angle of between 18 and 22 degrees

5. The solar collector of any one of claims 1 to 4, wherein said reflector assembly comprises a reflector surface consisting of polished anodized aluminium protected by an anti-oxidizing micro-coating; an aluminium foil over a substrate; a mirrored flexible sheet material; a mirrored surface; or a back side reflectively-coated material.

6. The solar collector of claim 5, wherein said mirrored flexible sheet material is mirrored polycarbonate, mirrored acrylic or mirrored fibreglass.

7. The solar collector of any one of claims 1 to 6 further comprising a means of rotation about an axis adjacent to said absorber.

8. A device for solar energy collection comprising a plurality of solar collectors of any one of claims 1 to 7 mounted on a plurality of rows adjacent to a vertical or near-vertical surface.

9. The solar collector of any one of claims 1 to 7, wherein said absorber comprises two or more tubes aligned adjacently along an entire length of each said tube; and a means for joining said tubes along their lengths, said joining means being thermally stable and rigid.

10. The solar collector of claim 9, wherein said joining means is discontinuous along said length of said tubes.

11. The solar collector of claim 9 or 10, wherein said absorber has a sag to length ratio of about 1/500 or less.

12. The solar collector of any one of claims 9 to 11, wherein said tubes are preflexed in a direction joining the centres of said tubes.

13. The solar collector of any one of claims 9 to 12, wherein each said tube is partially flattened along part of its length.

14. The solar collector of claim 13, wherein two tubes are used, and are joined longitudinally at an angle.

15. The solar collector of any one of claims 9 to 14, wherein said absorber has a coating having high absorbance for sunlight wavelengths and low emissivity for blackbody wavelengths at ambient temperature.

16. The solar collector of any one of claims 9 to 15, wherein said absorber further comprises glazing, insulation, or a back plate.

17. The solar collector of any one of claims 1 to 16, wherein said reflective assembly comprises a reflective surface partially covered with material that is highly absorptive of solar wavelengths.

18. The solar collector of claim 17, wherein said material has a total area that is less than or equal to about 5% of the total surface area of said reflective surface.

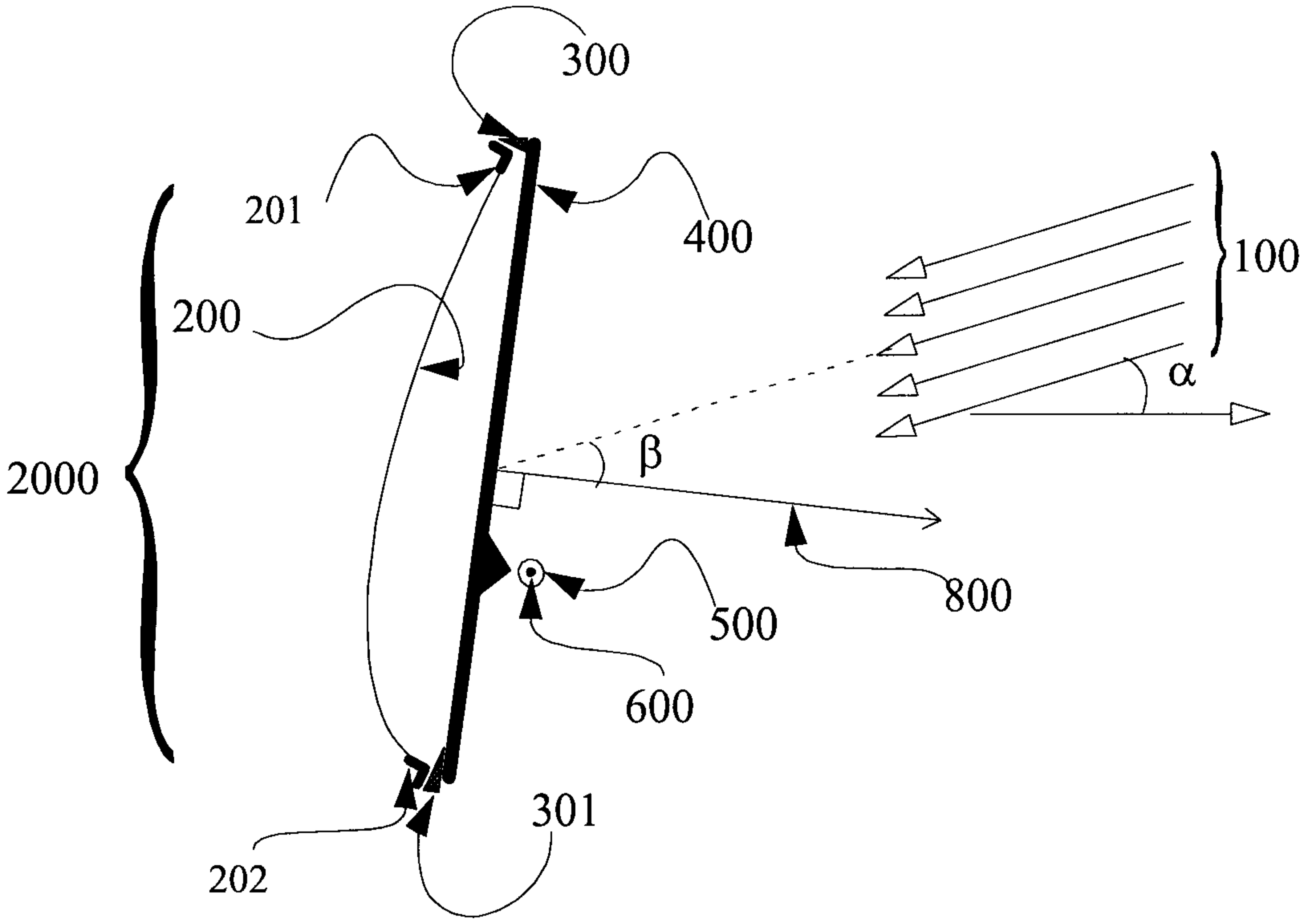
19. The solar collector of claim 17 or 18, wherein said material is used for removal of liquid water or ice from said reflective surface.

20. The solar collector in any one of claims 1 to 19, wherein said reflective assembly comprises a frame partially covered with material that is highly absorptive of solar wavelengths.

21. The solar collector in claim 20, wherein said frame is in thermal contact with said reflective surface.

22. The solar collector of claim 20, wherein said material is used for removal of liquid water or ice from said reflective surface.

23. A solar absorber having a truss-like structure, comprising two or more tubes and a means of joining said tubes, wherein said absorber has a sag to length ratio of about 1/500 or less.



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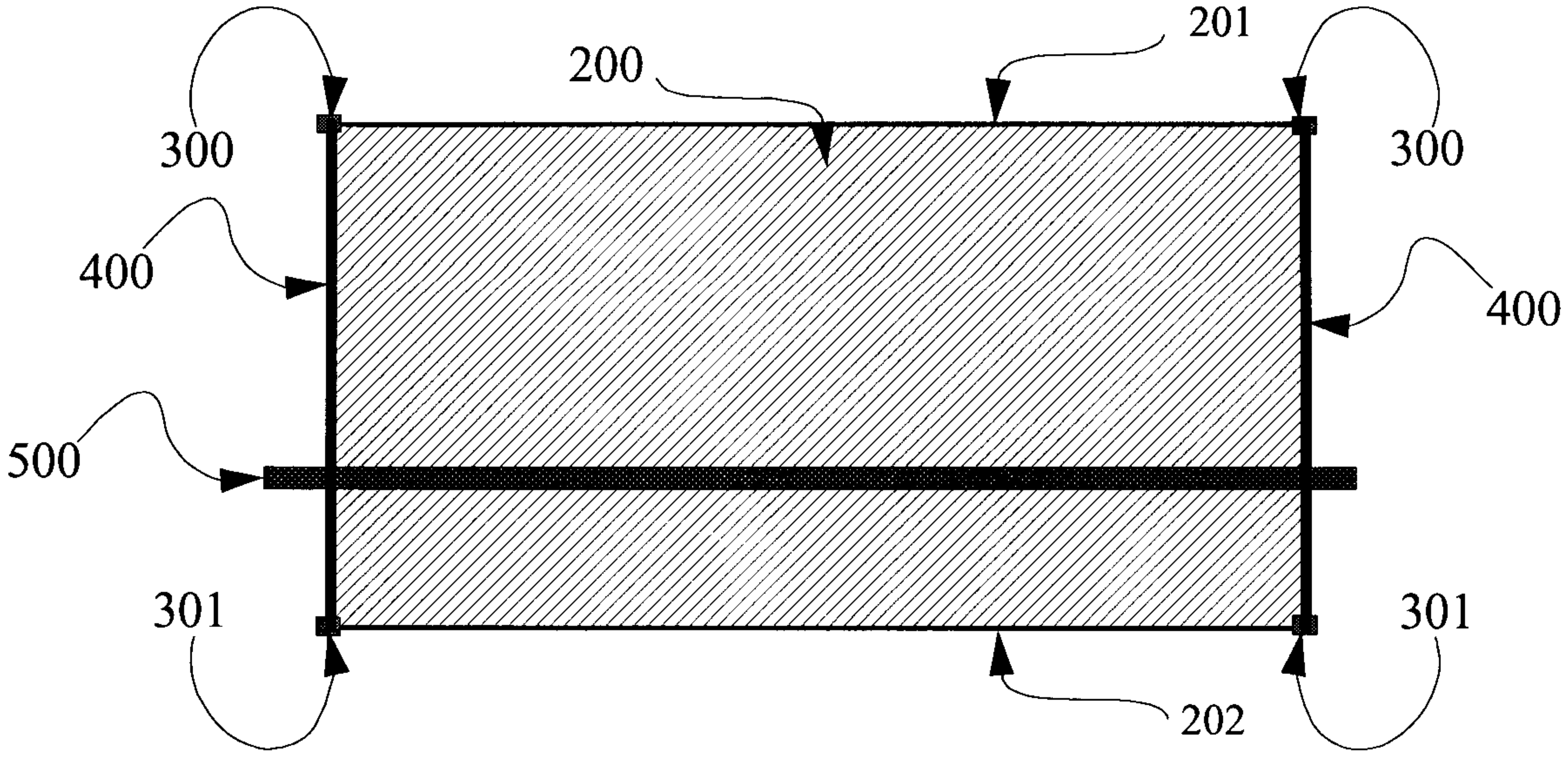

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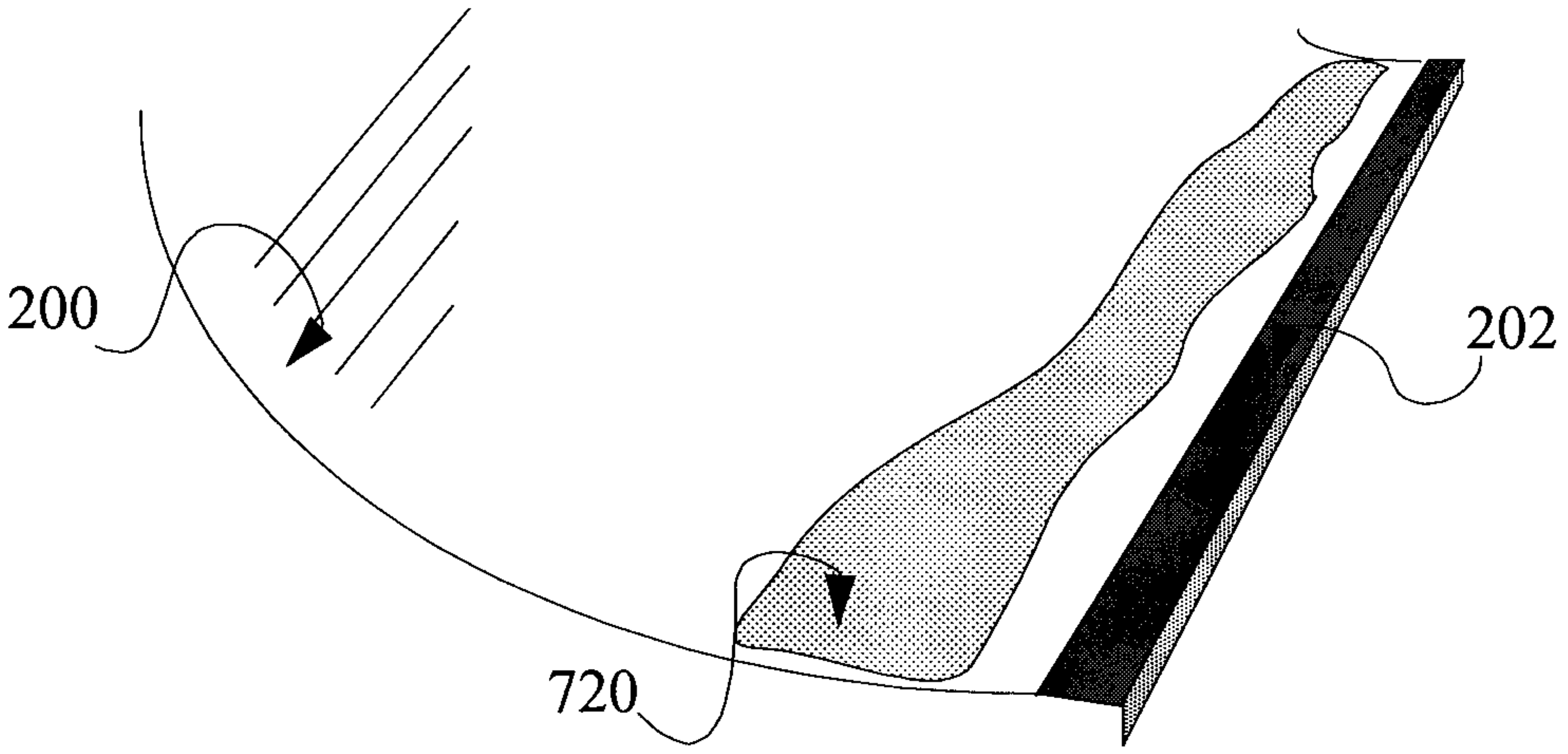

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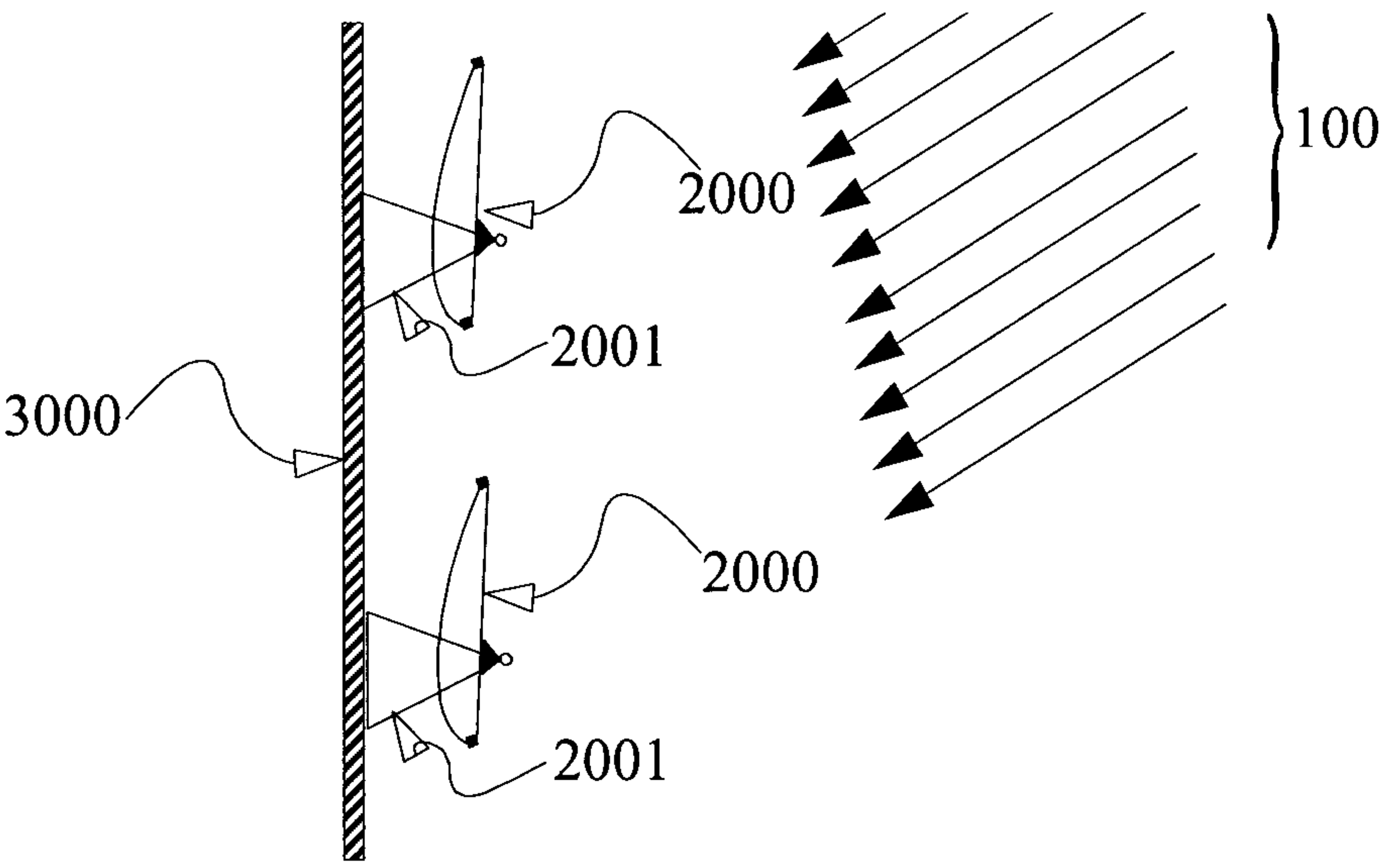

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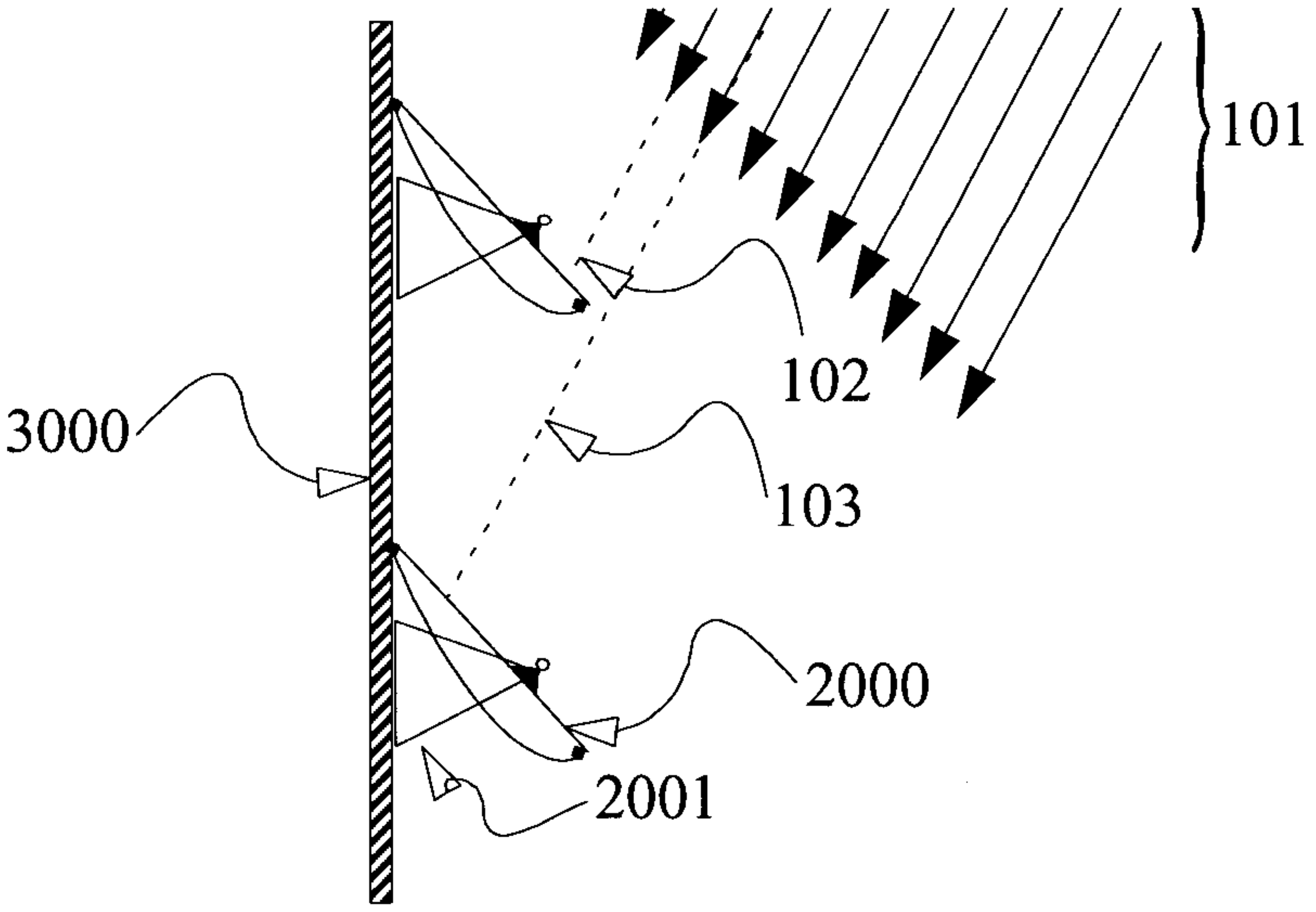

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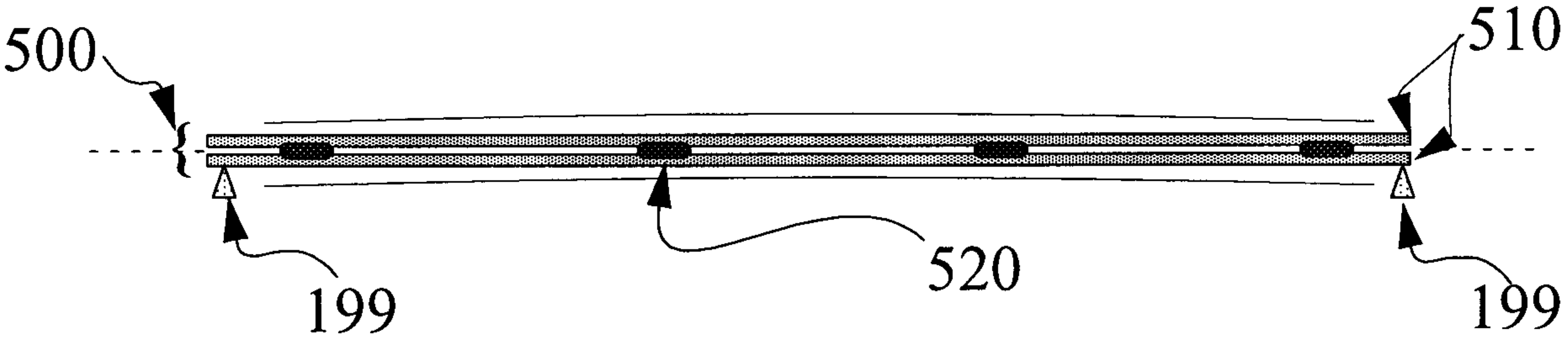

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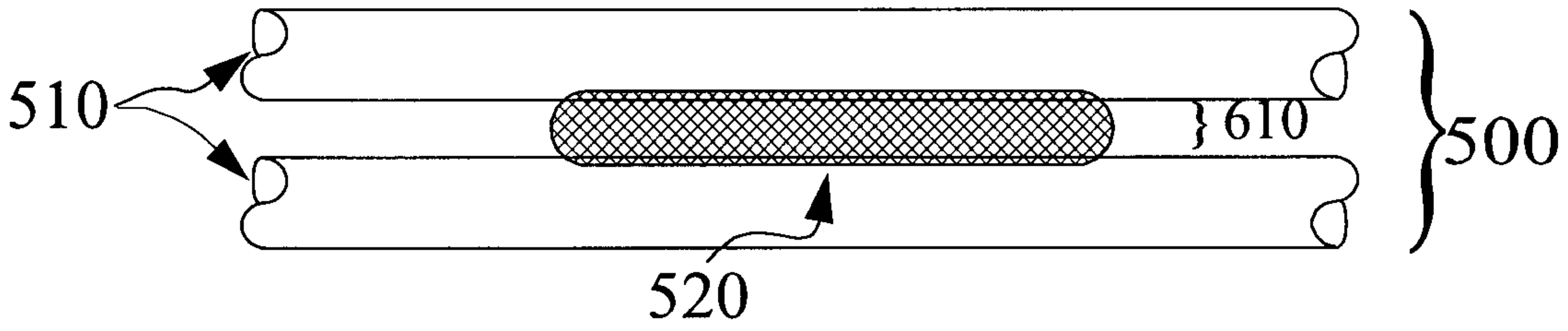

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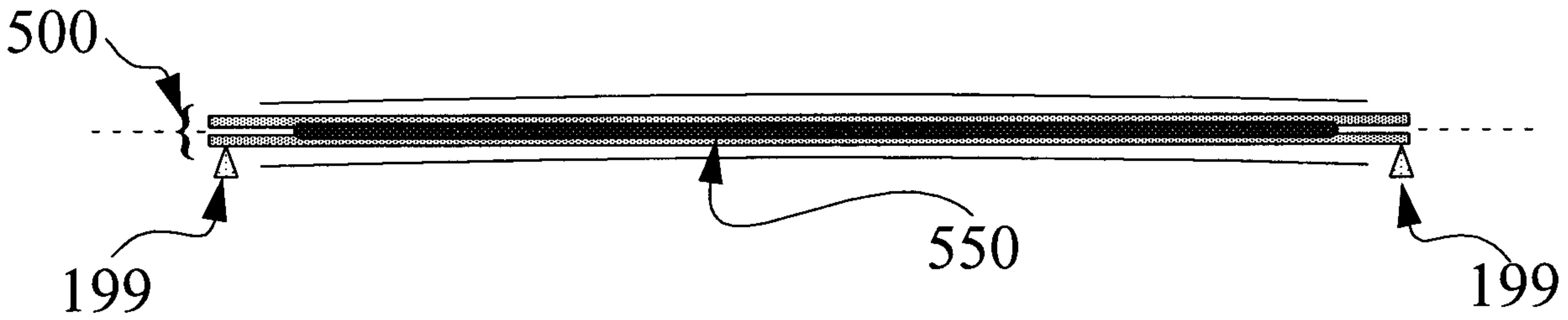

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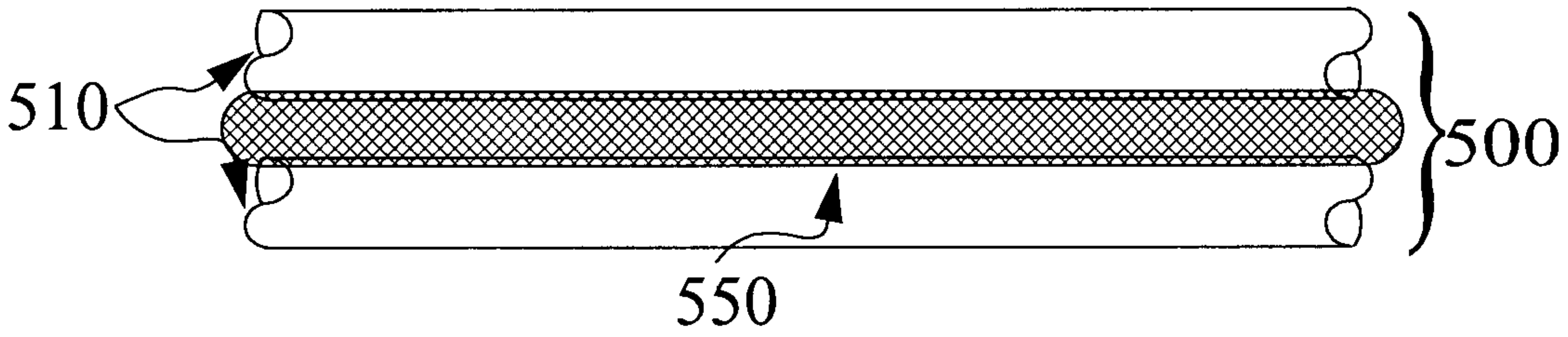

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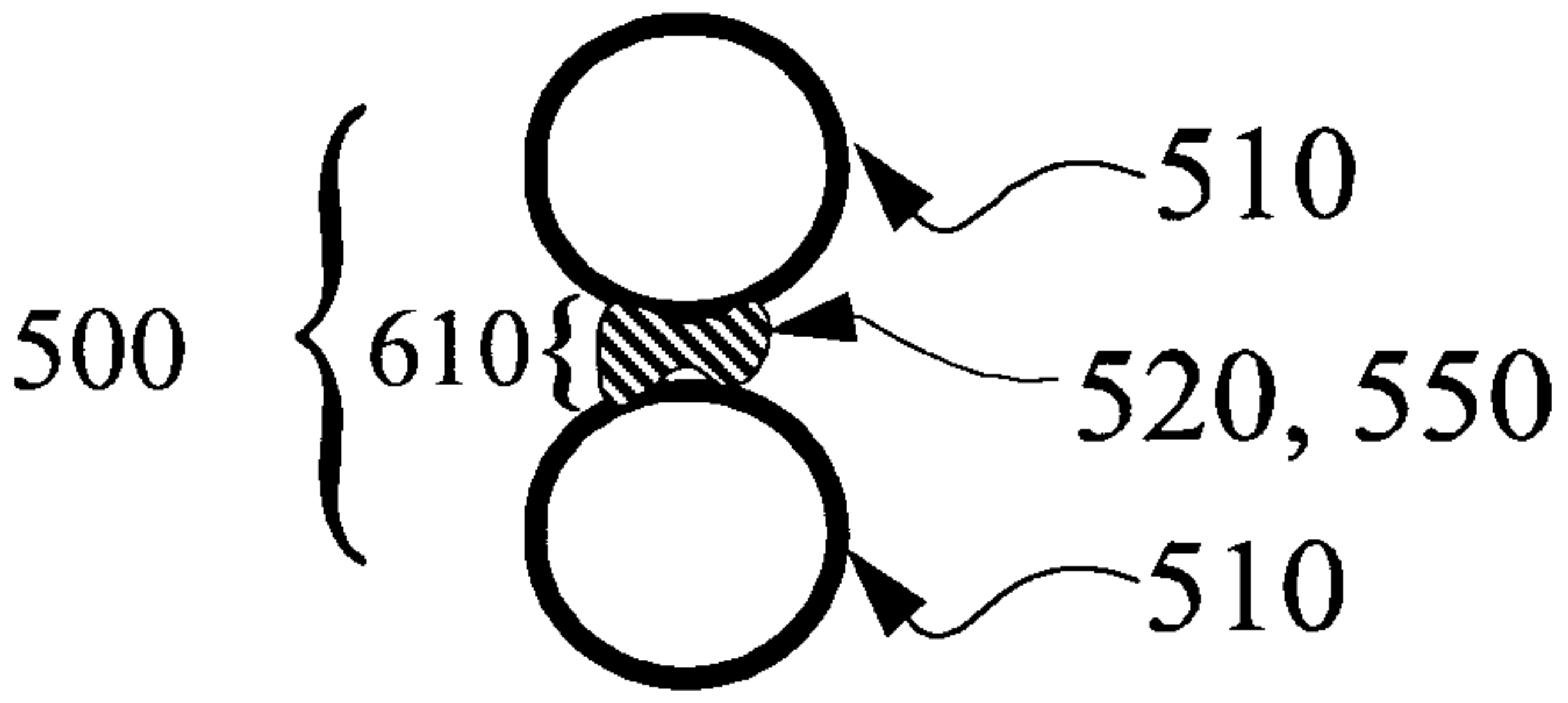

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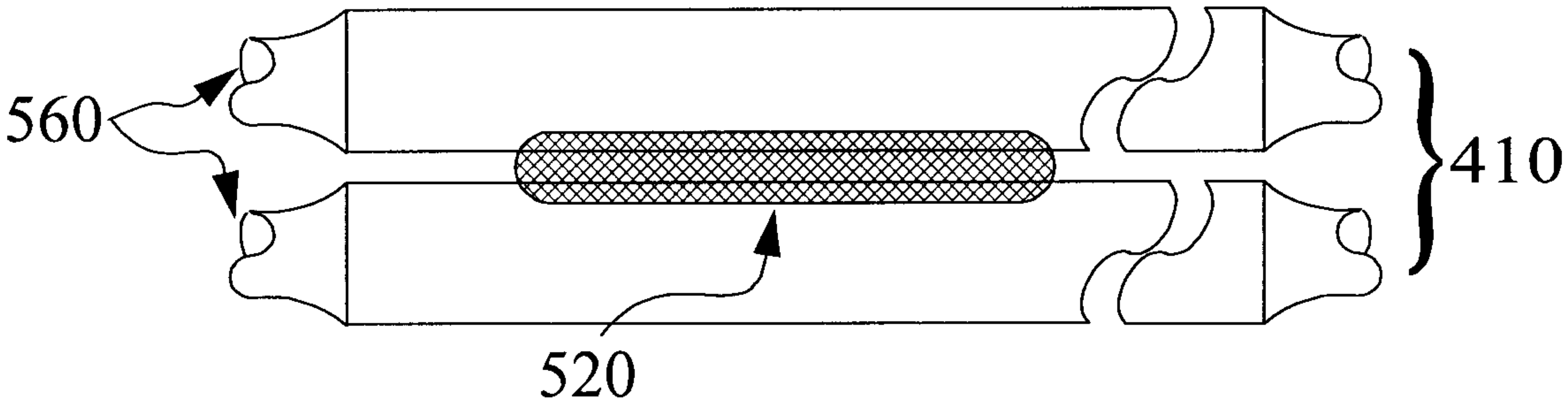

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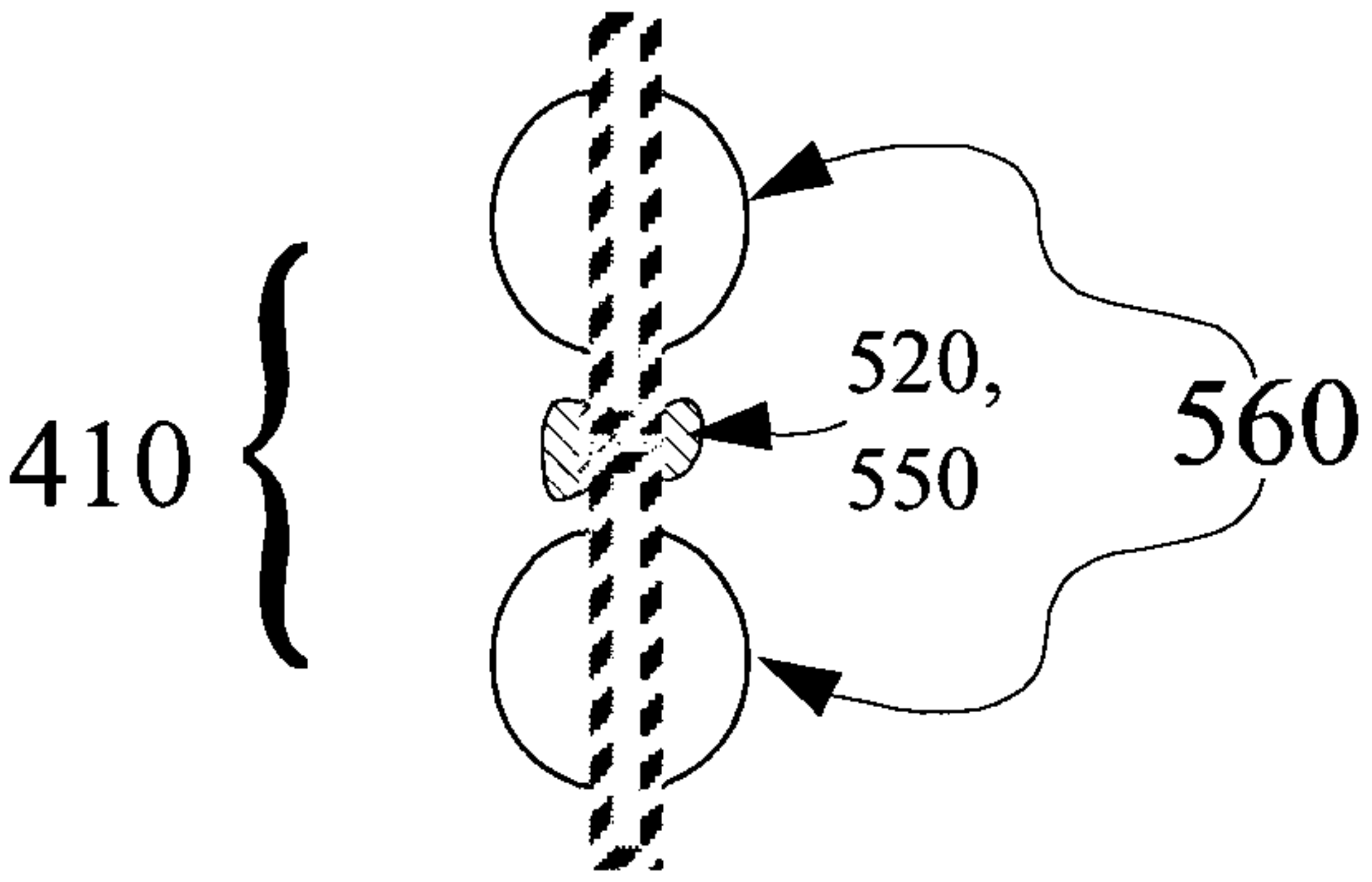

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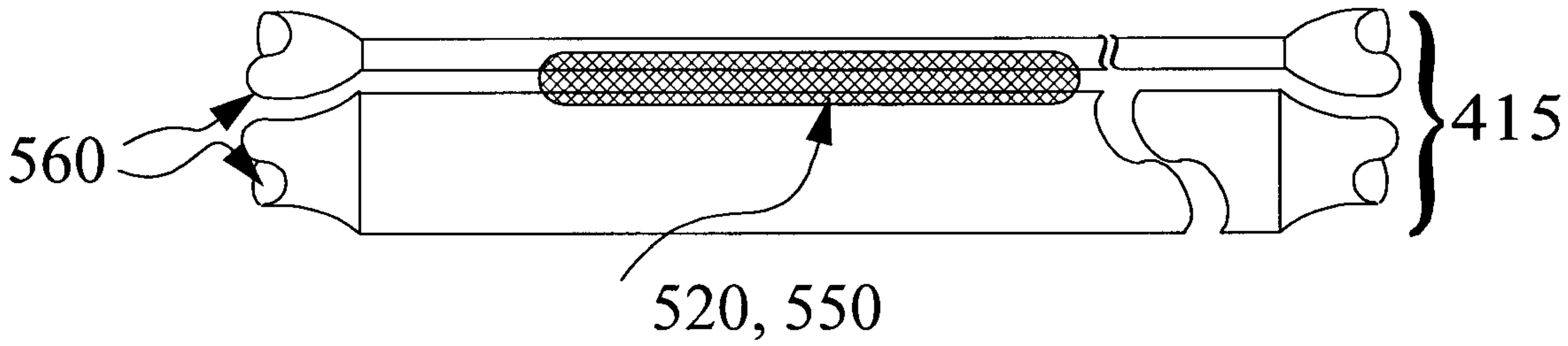

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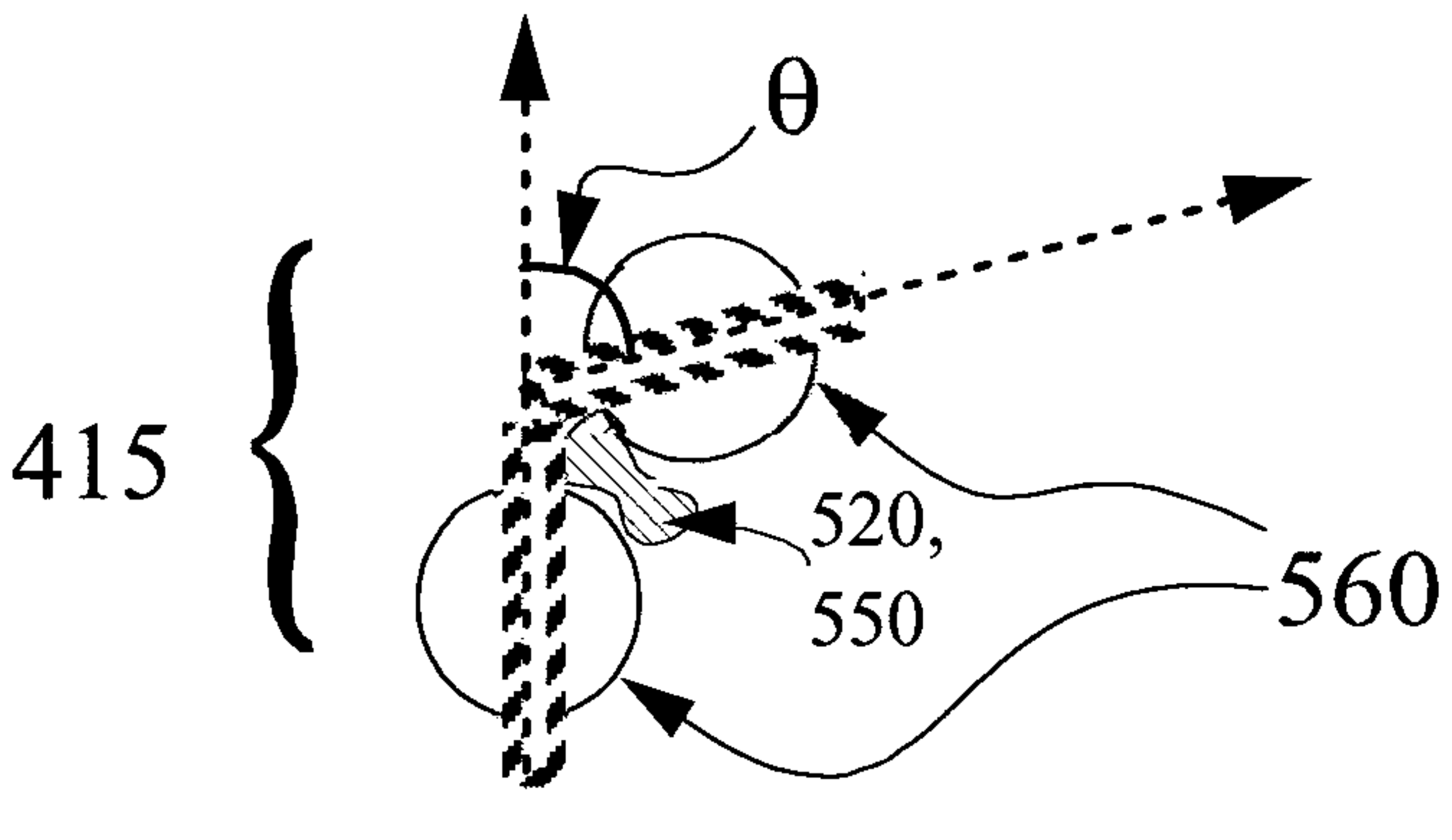

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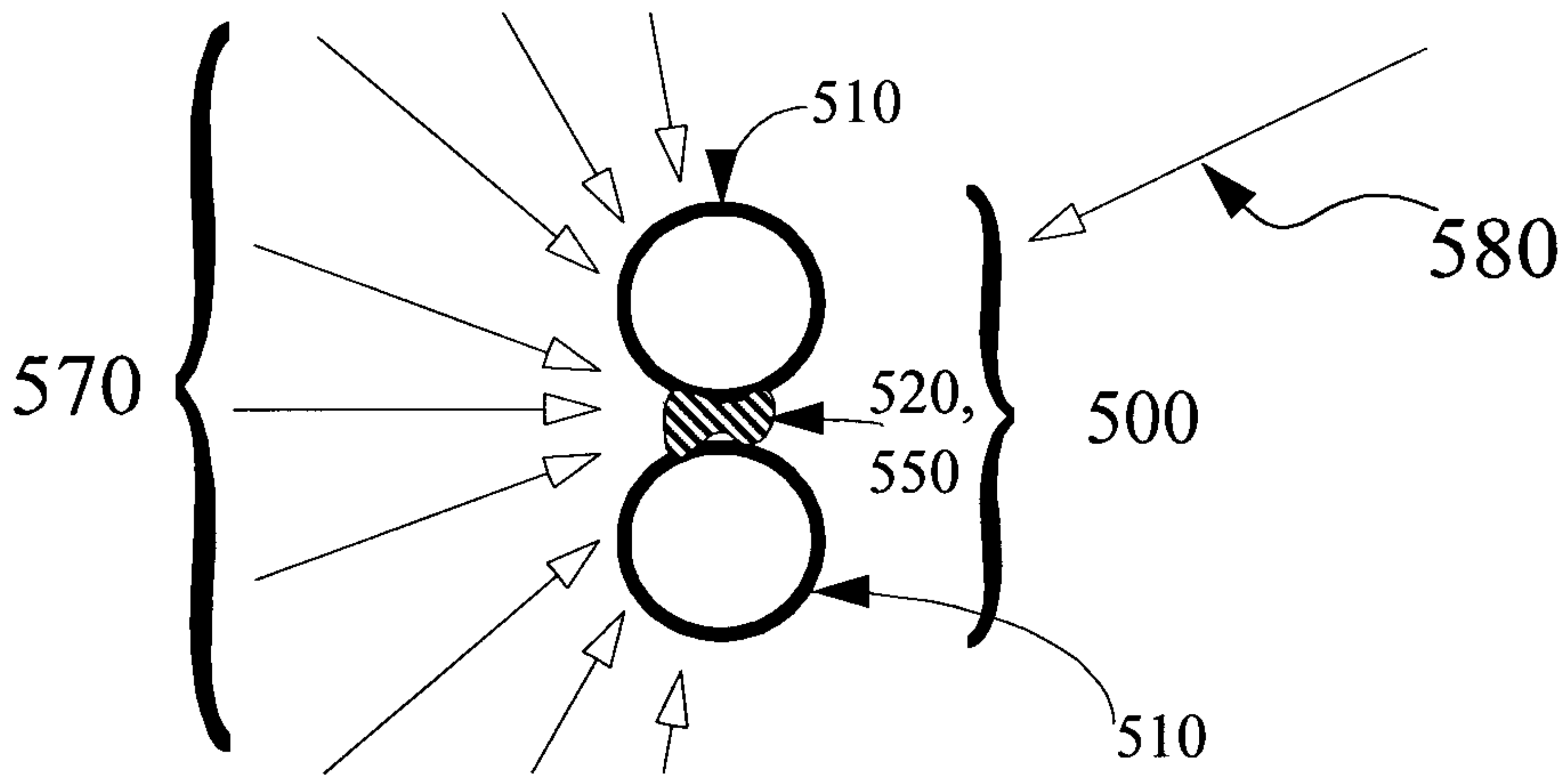

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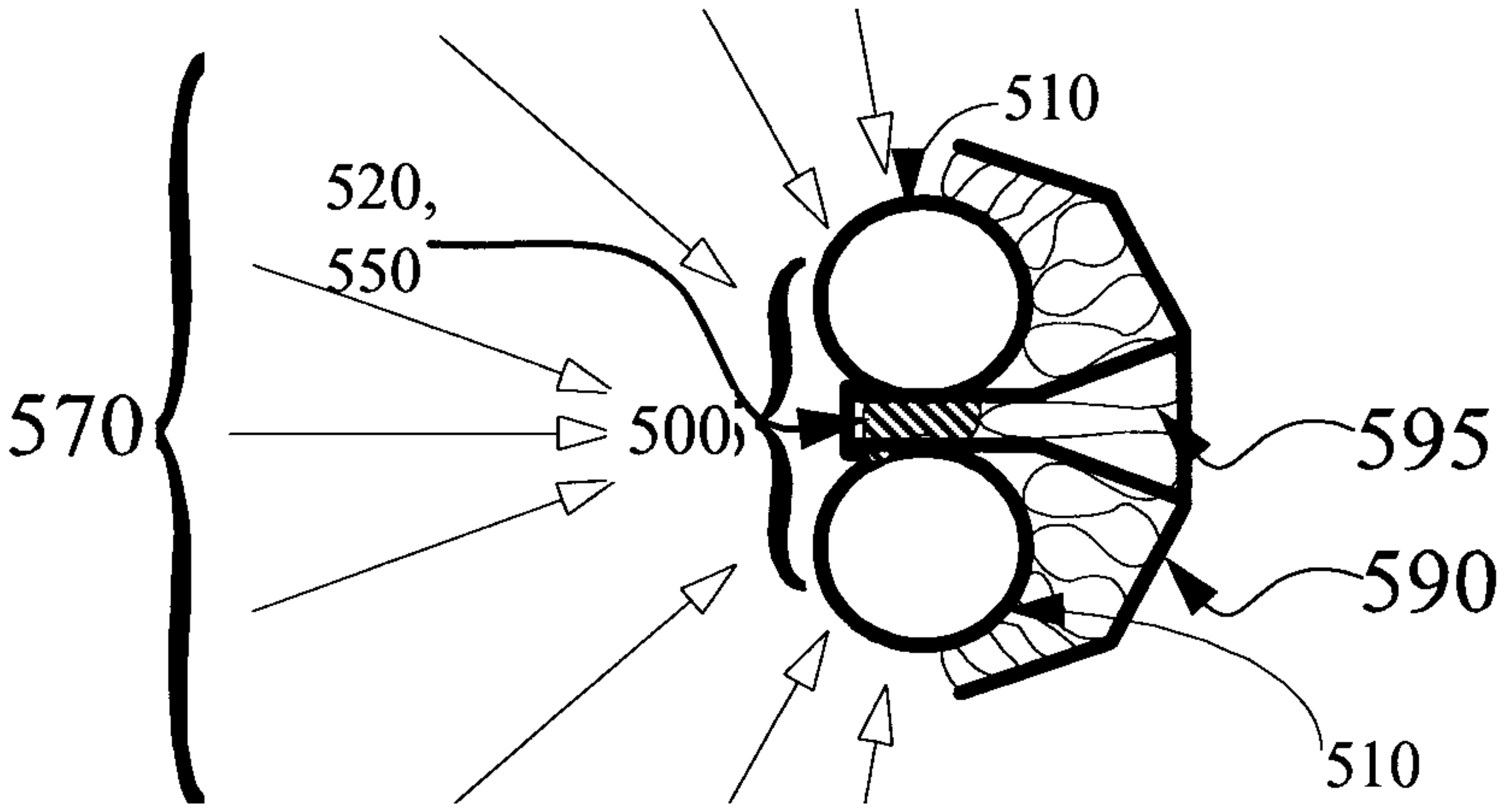

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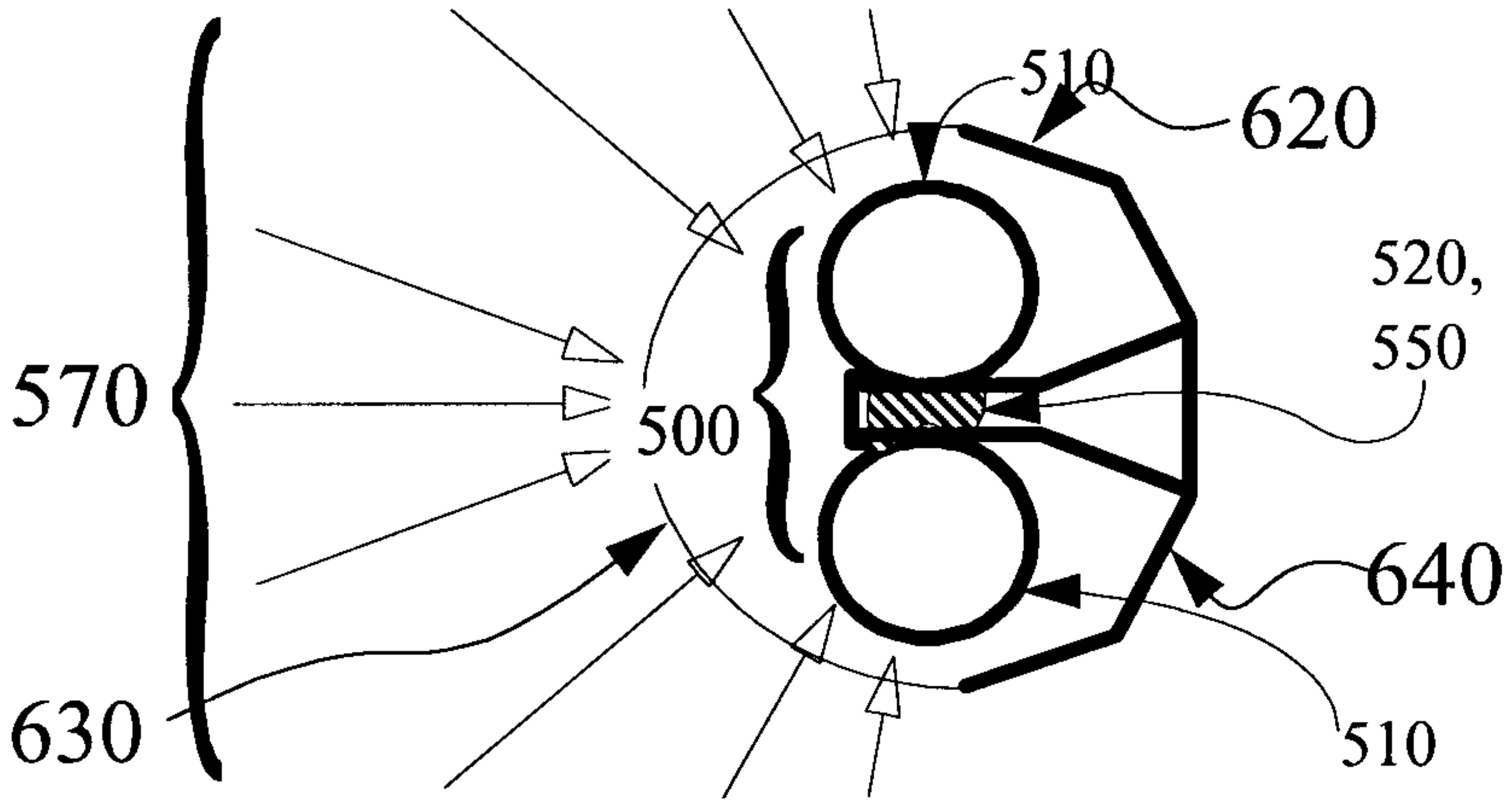

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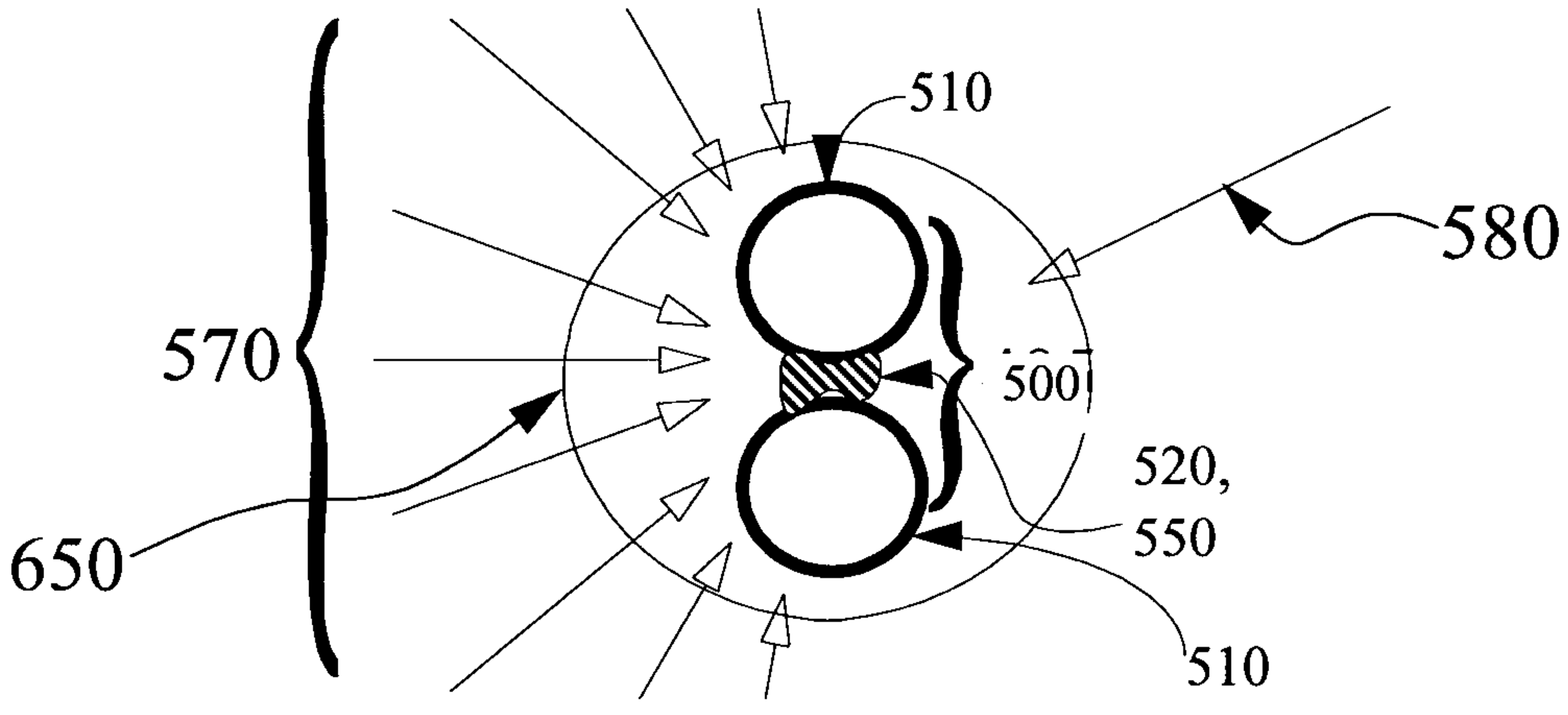

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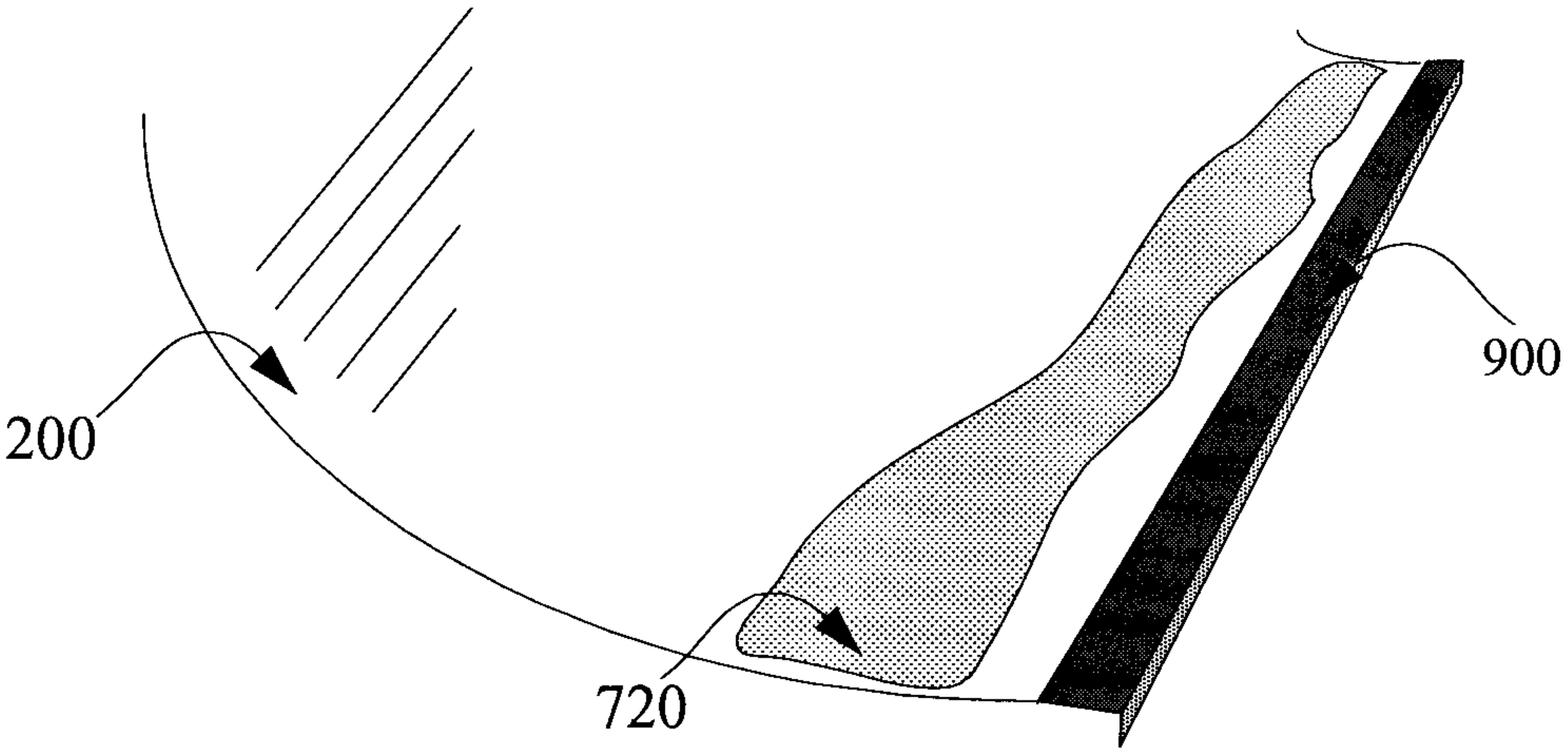

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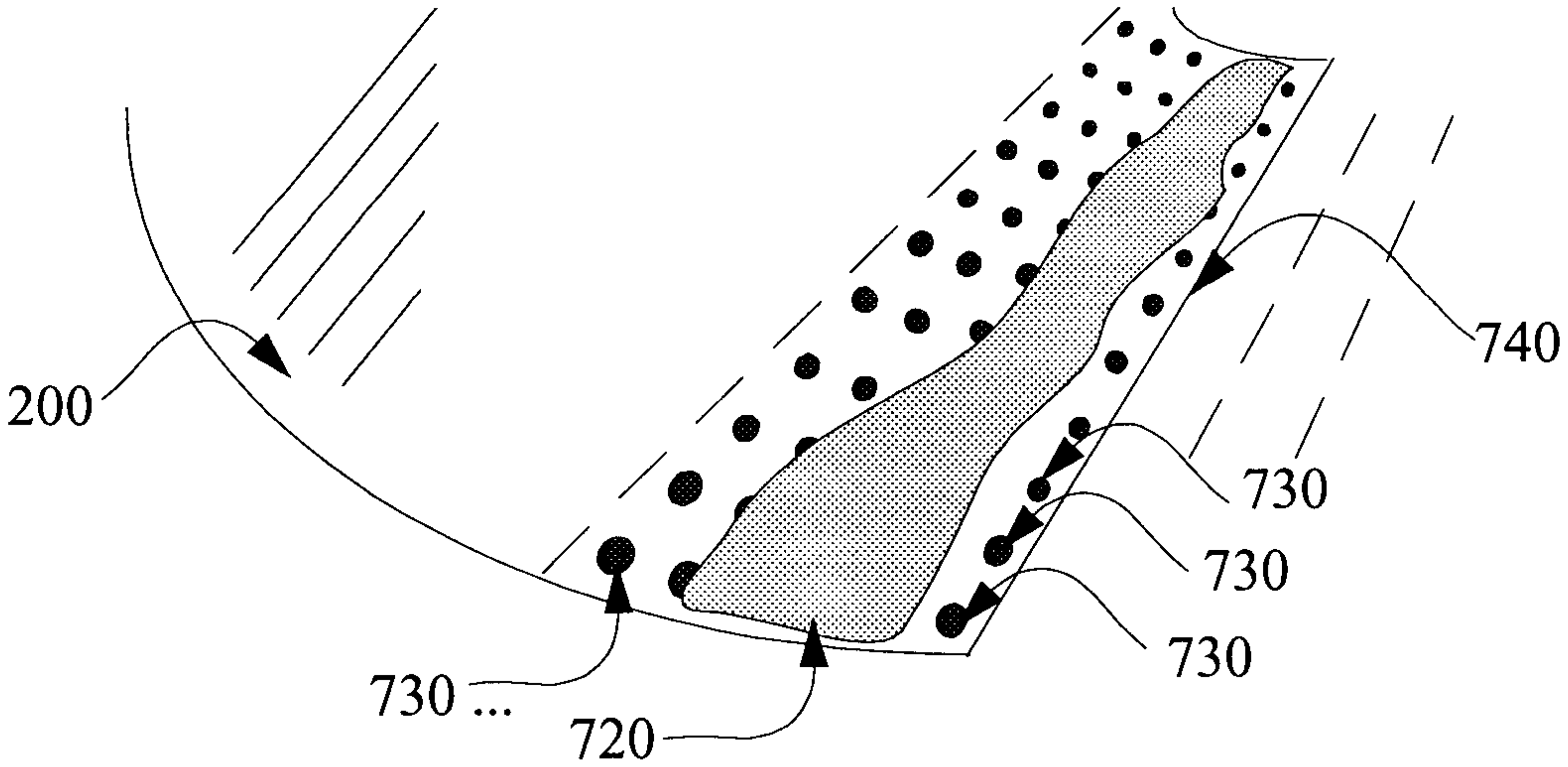

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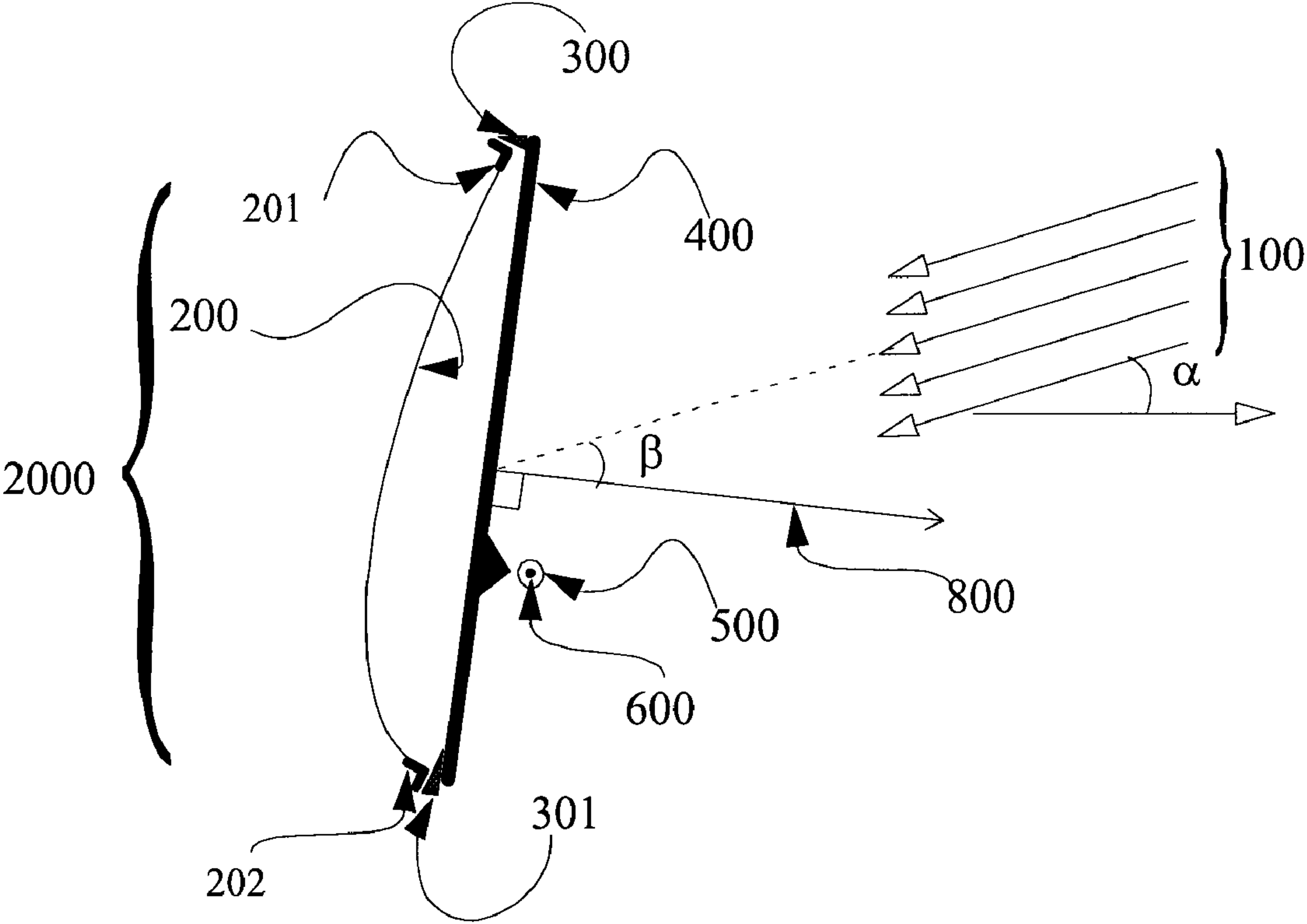
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