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Yeadon

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(54) **CONCEALED SPRINKLER COVER**

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(52) **U.S. Cl.**
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(58) **Field of Classification Search**
CPC A62C 37/09; A62C 37/10; A62C 37/11;
A62C 37/12; A62C 37/14; A62C 37/16;
A62C 37/20
See application file for complete search history.

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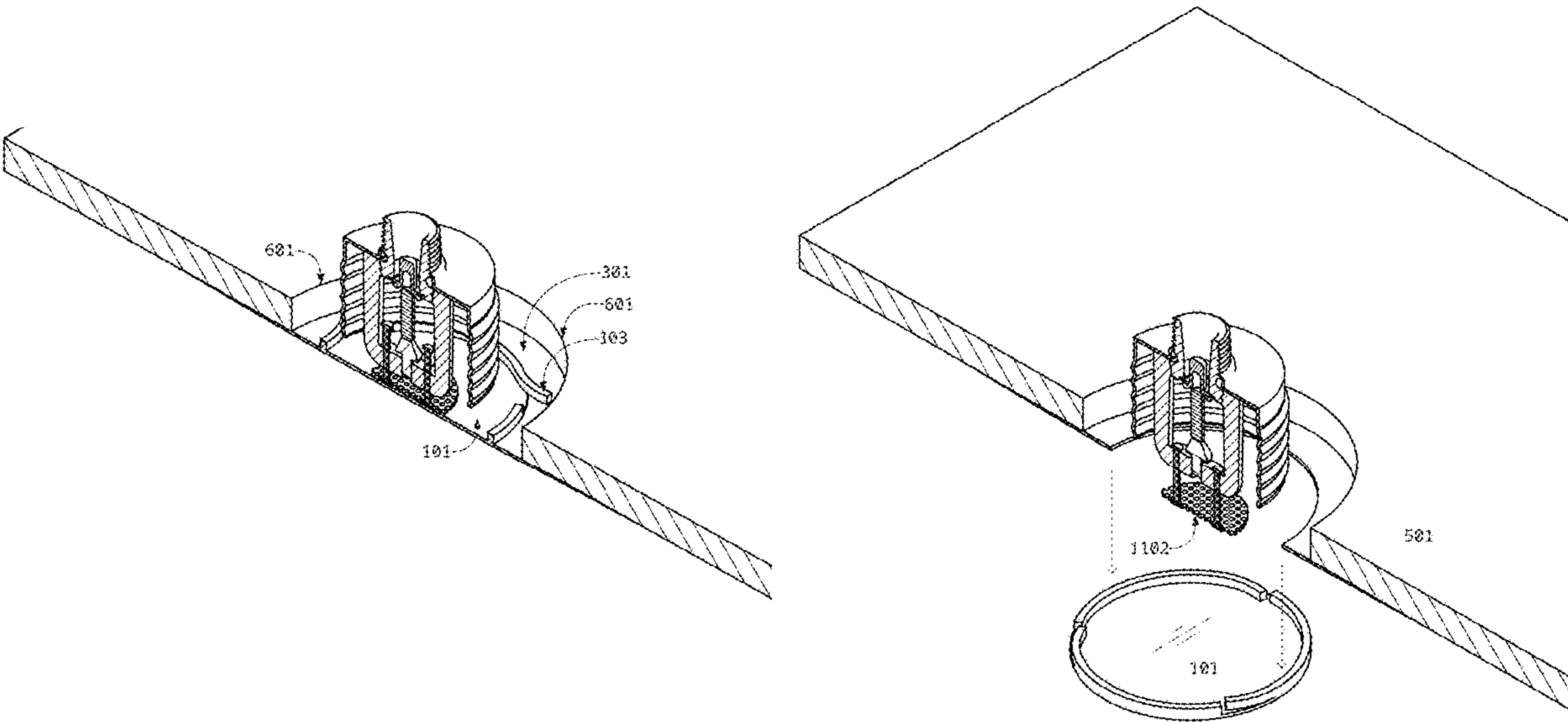
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(57) **ABSTRACT**

A sprinkler cover apparatus conceals sprinkler heads using temperature-responsive materials that release the cover when exposed to a set temperature, allowing unobstructed water flow. The apparatus is an imperceptible component of the ceiling or wall. Embodiments include single- and multi-piece designs, mounted to the ceiling or sprinkler head housing. Some embodiments do not contact the sprinkler head directly. Actuation is achieved via materials like shape-memory polymers (SMPs), shape-memory alloys (SMAs), liquid crystalline polymers, melting substances (e.g., wax, solder), or bimetals. These materials change shape or phase at specific temperatures, enabling automatic cover release.

17 Claims, 18 Drawing Sheets



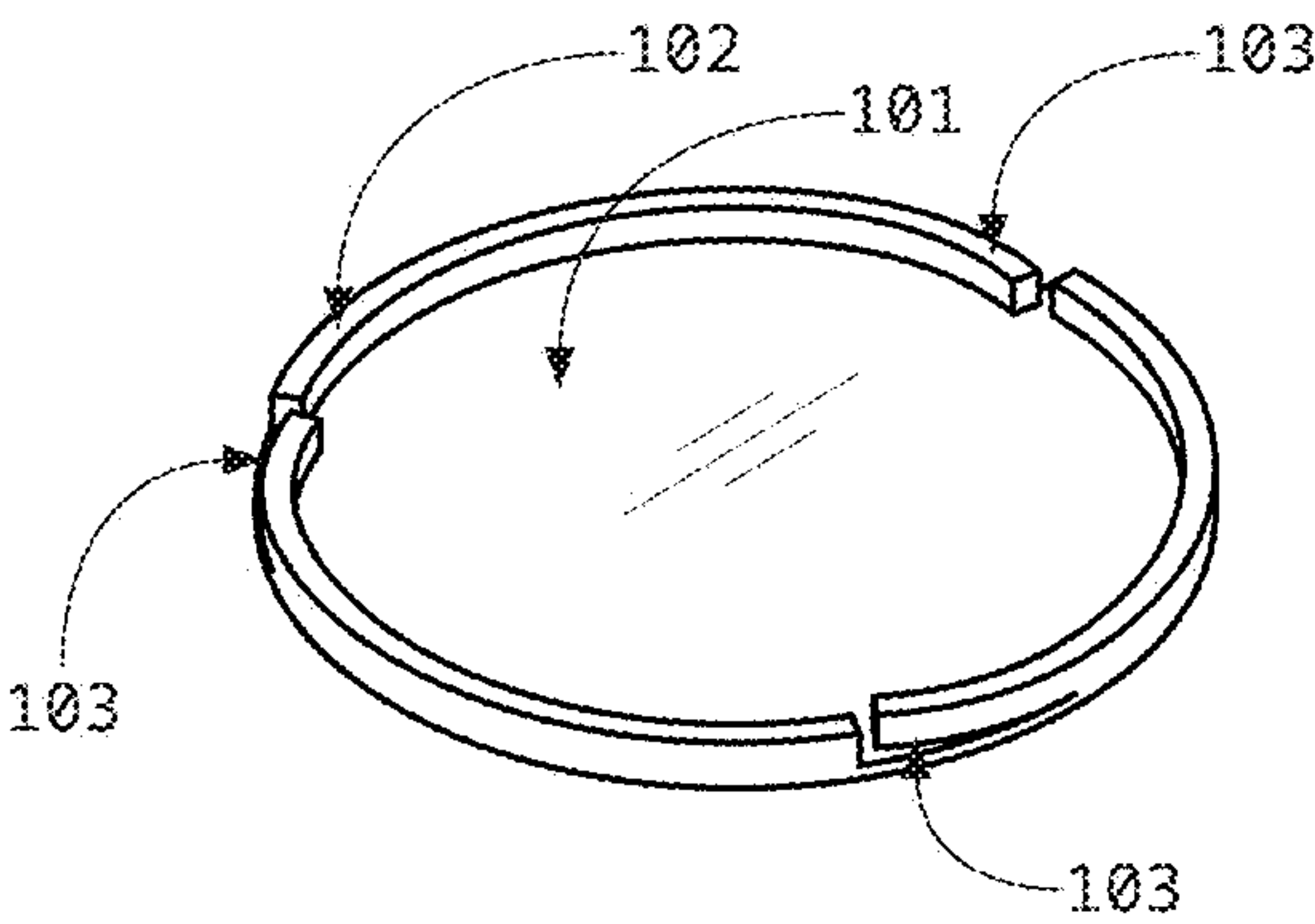


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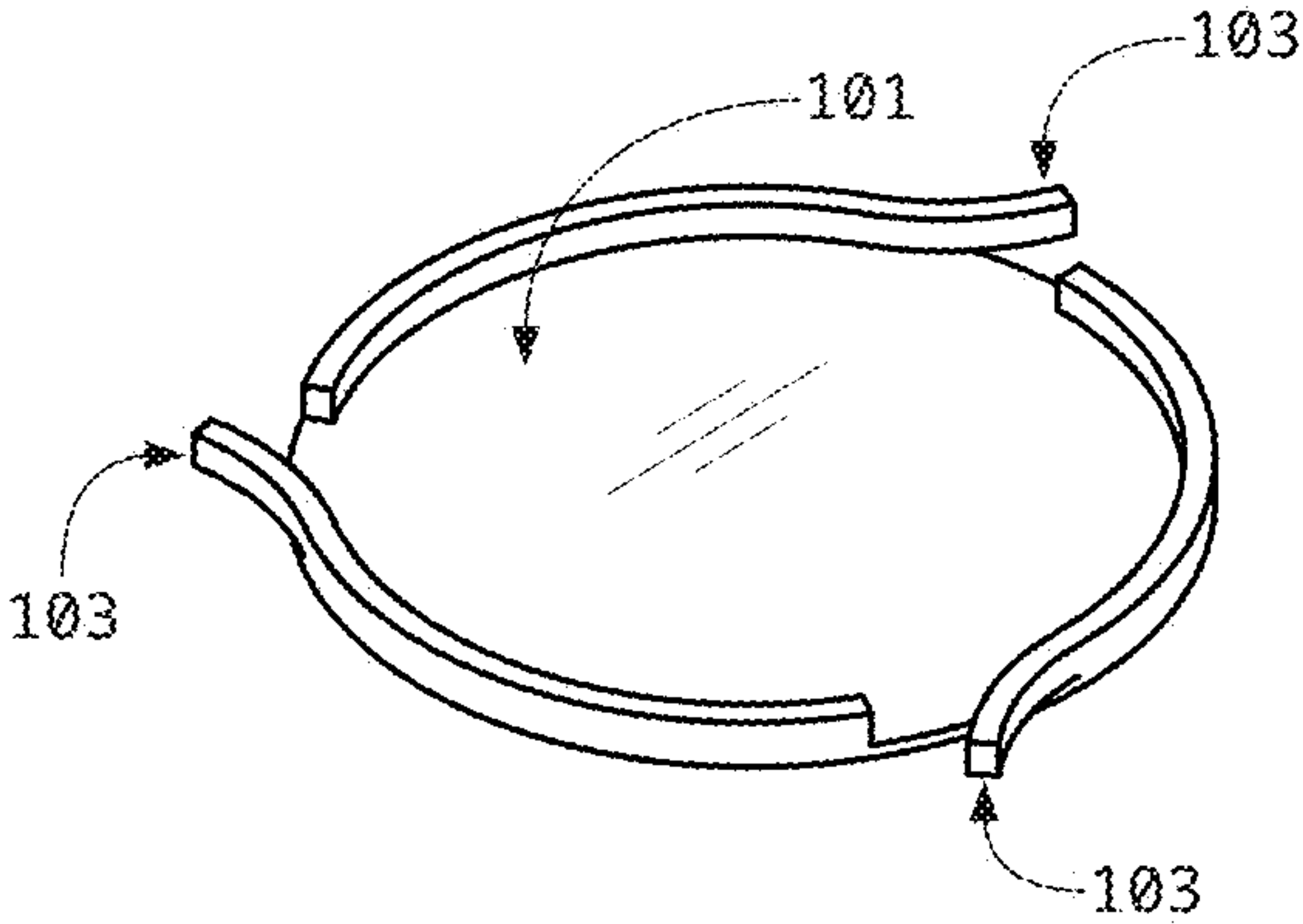


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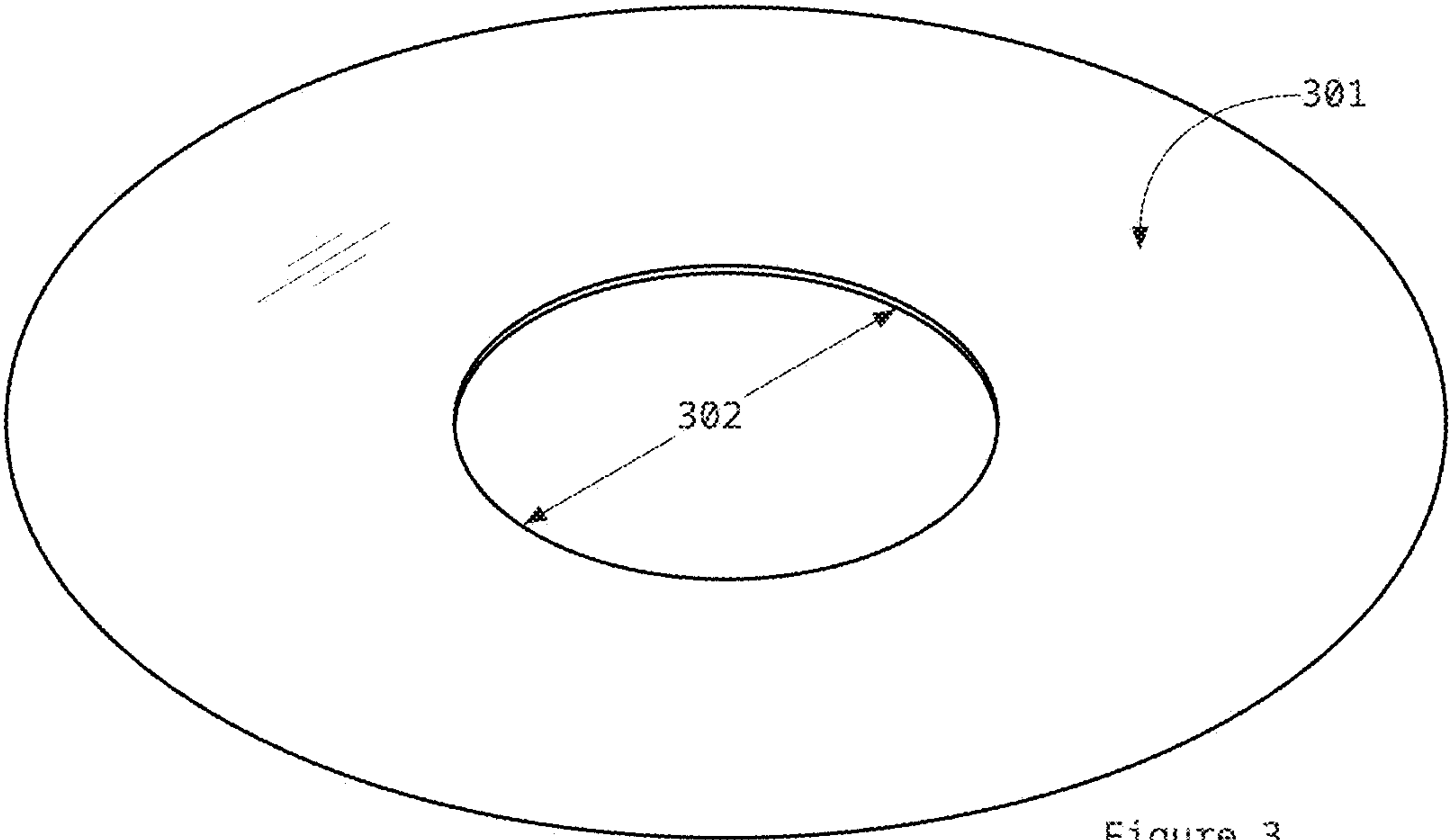


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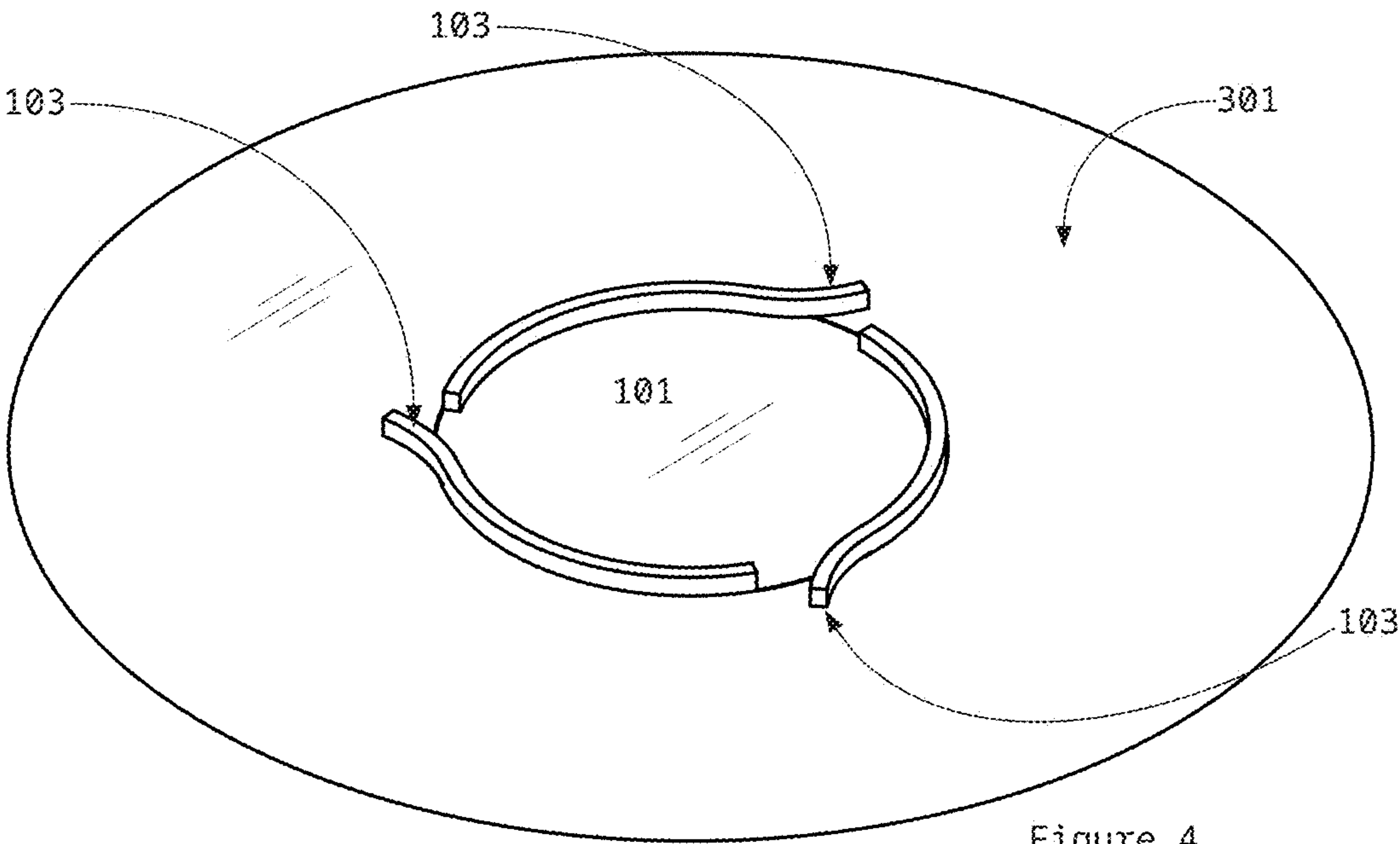


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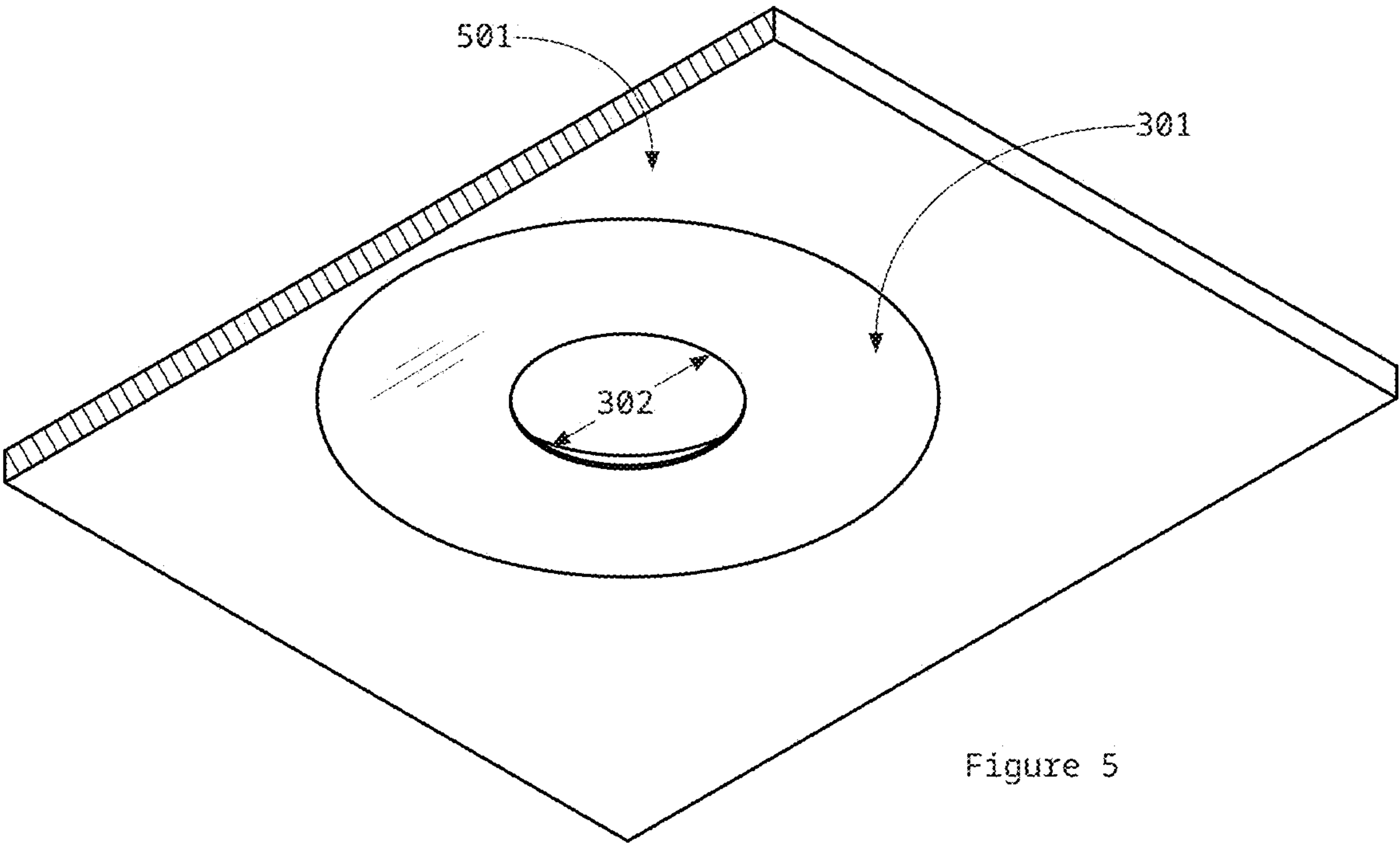


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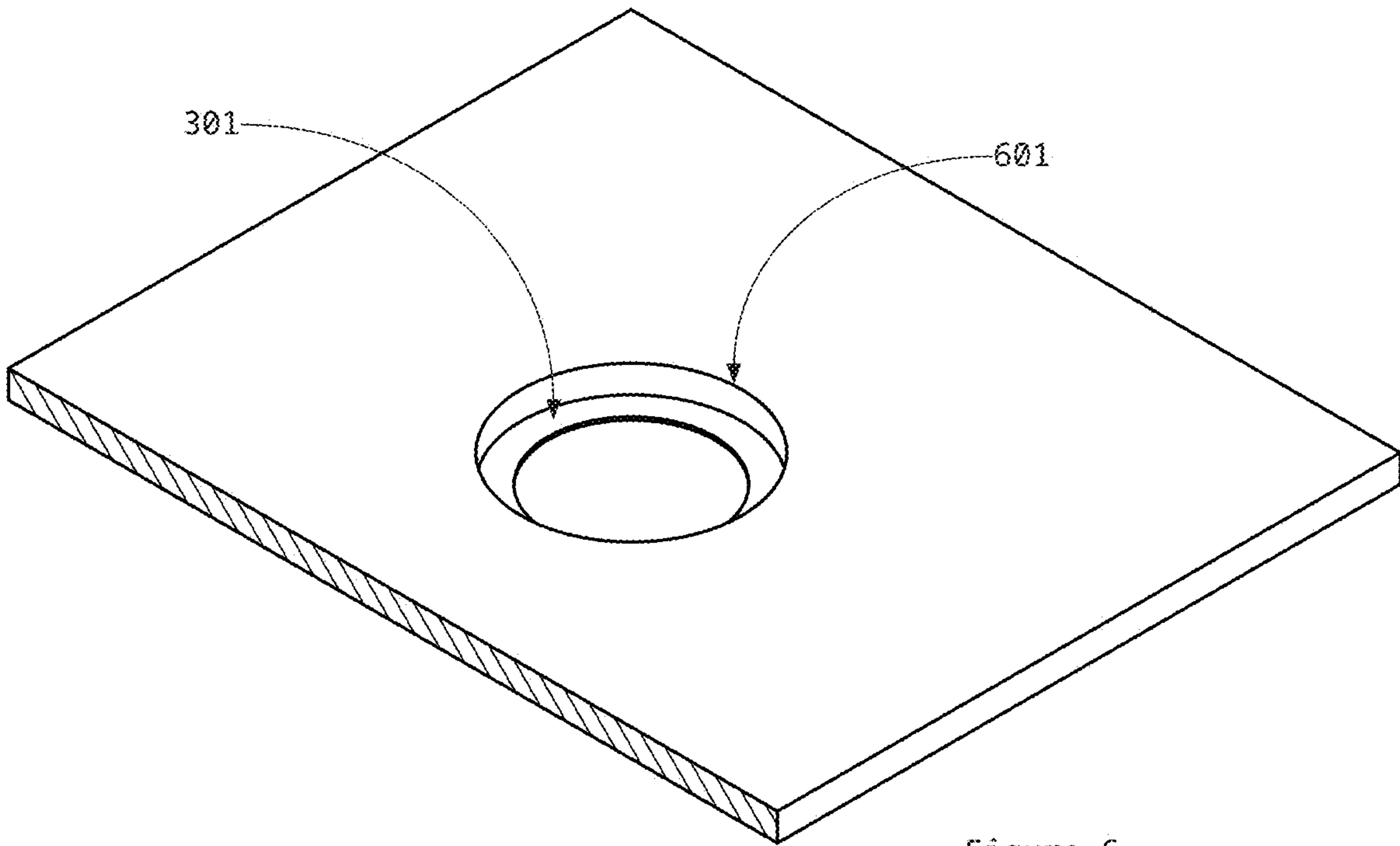


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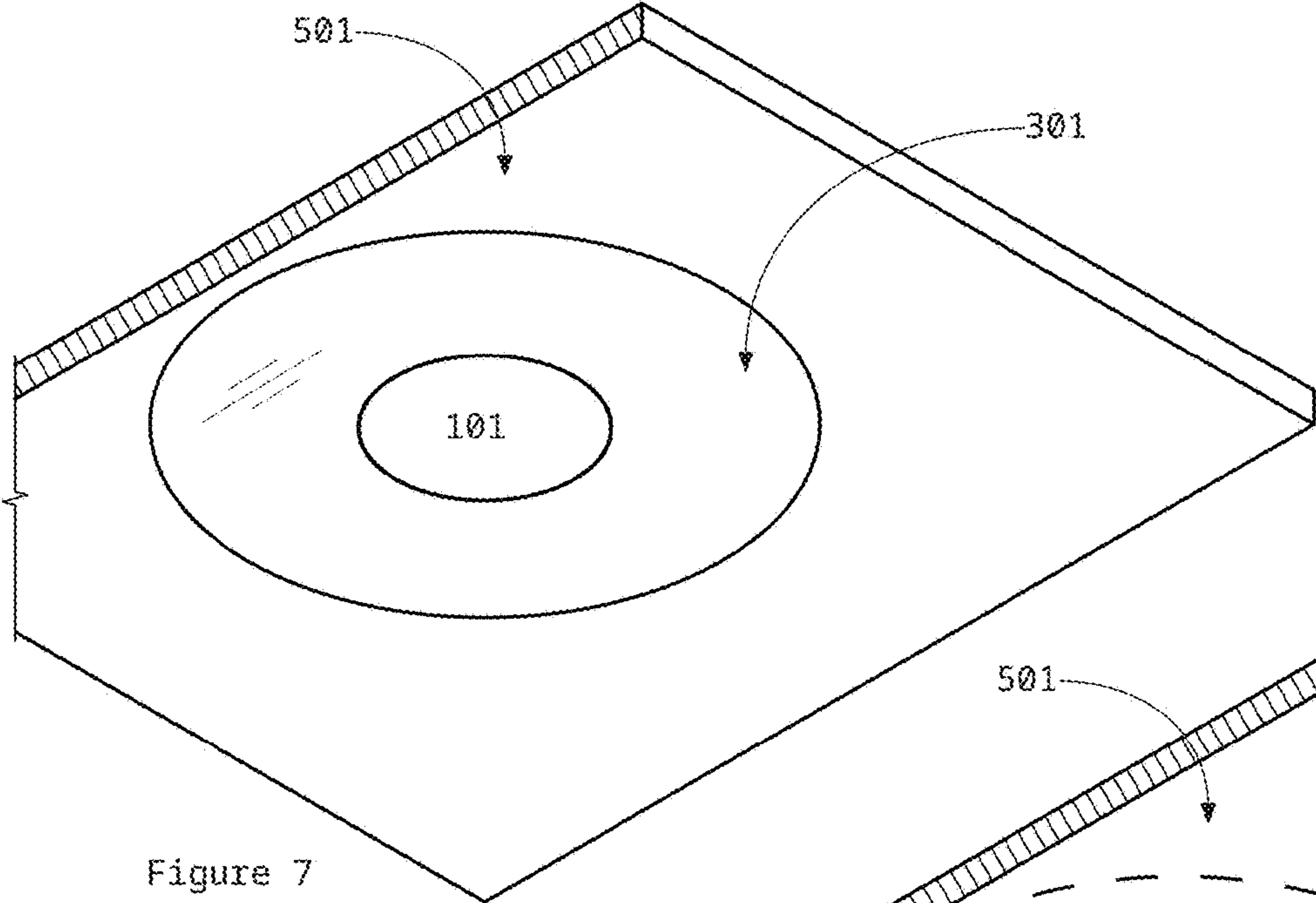


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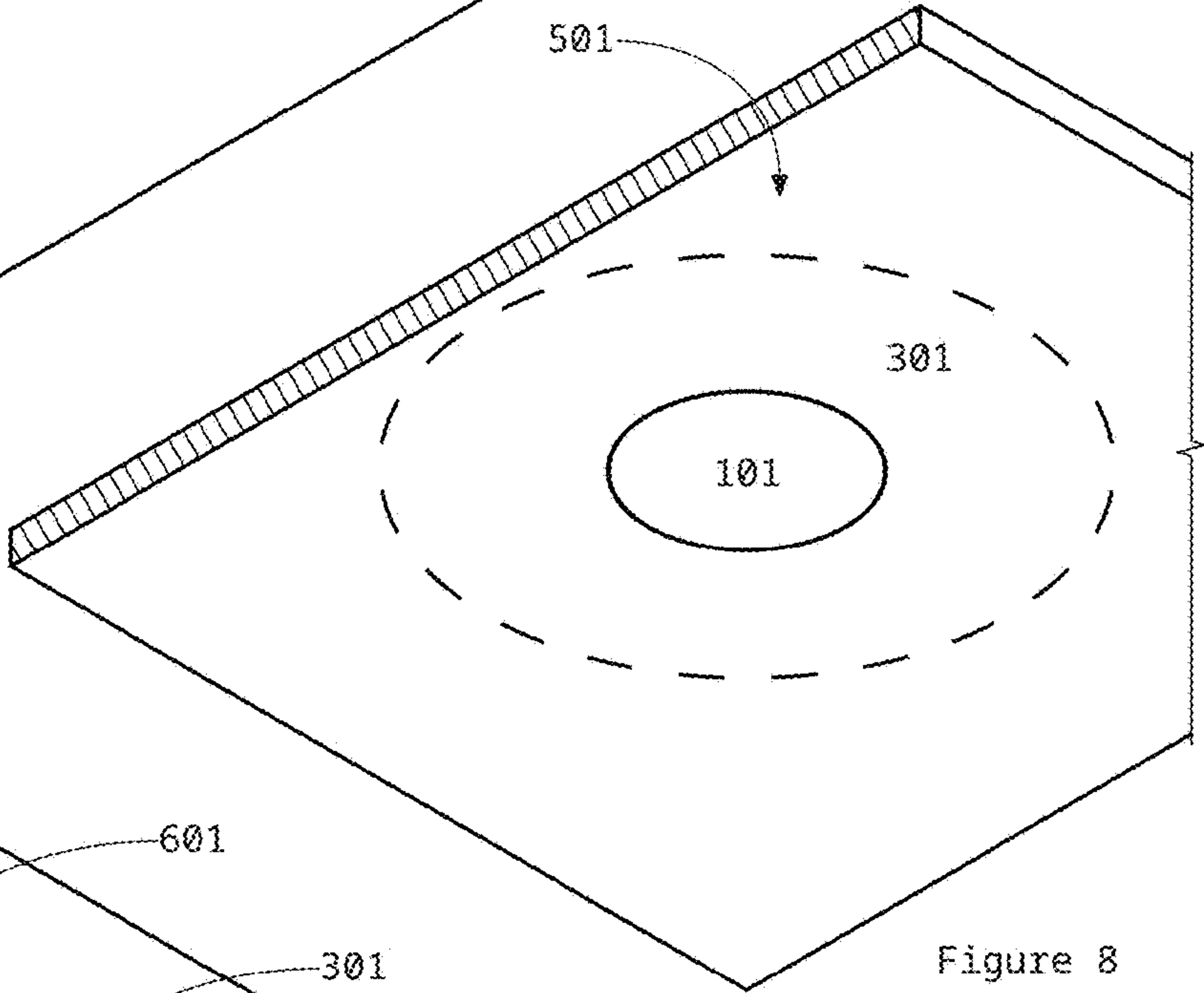


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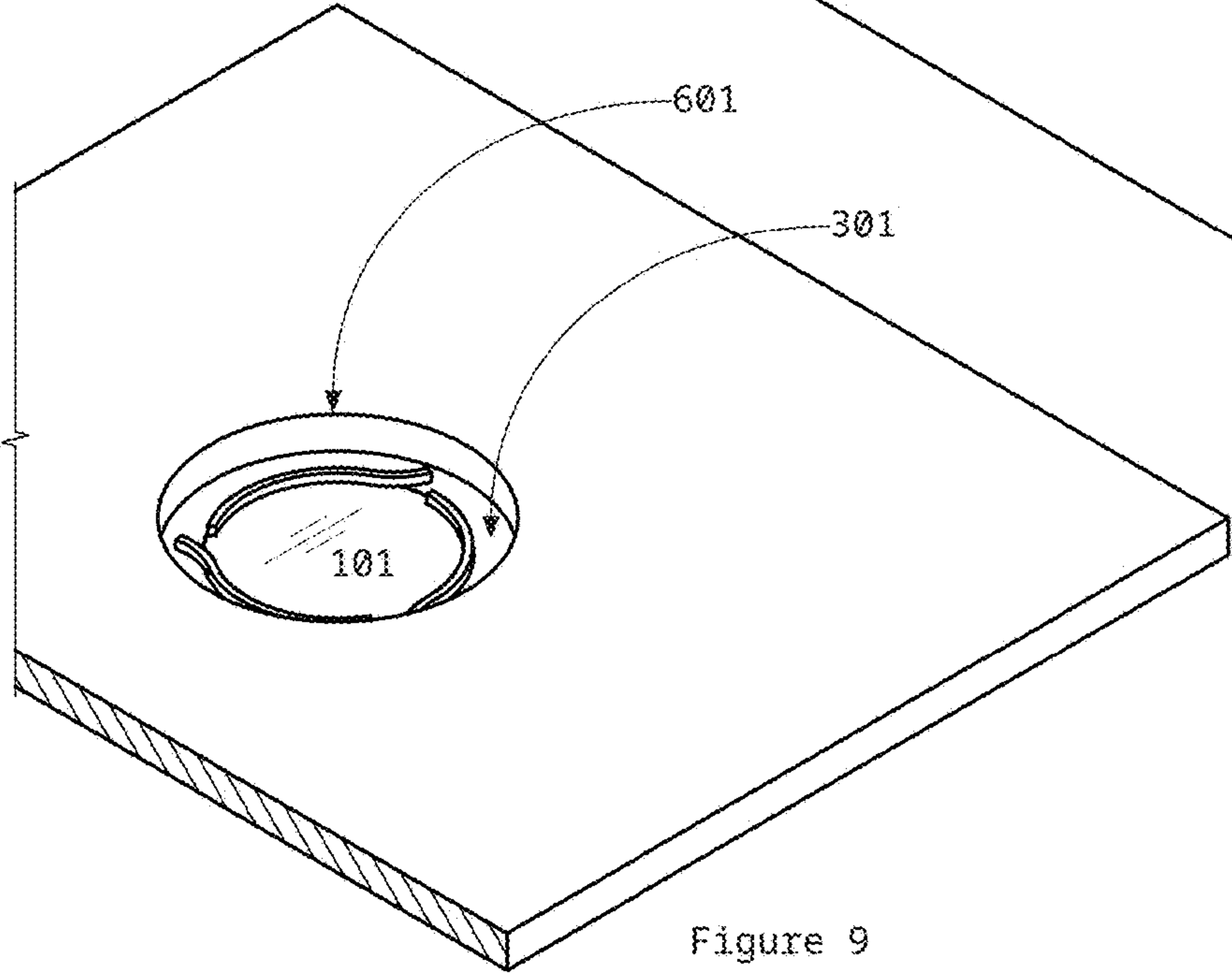
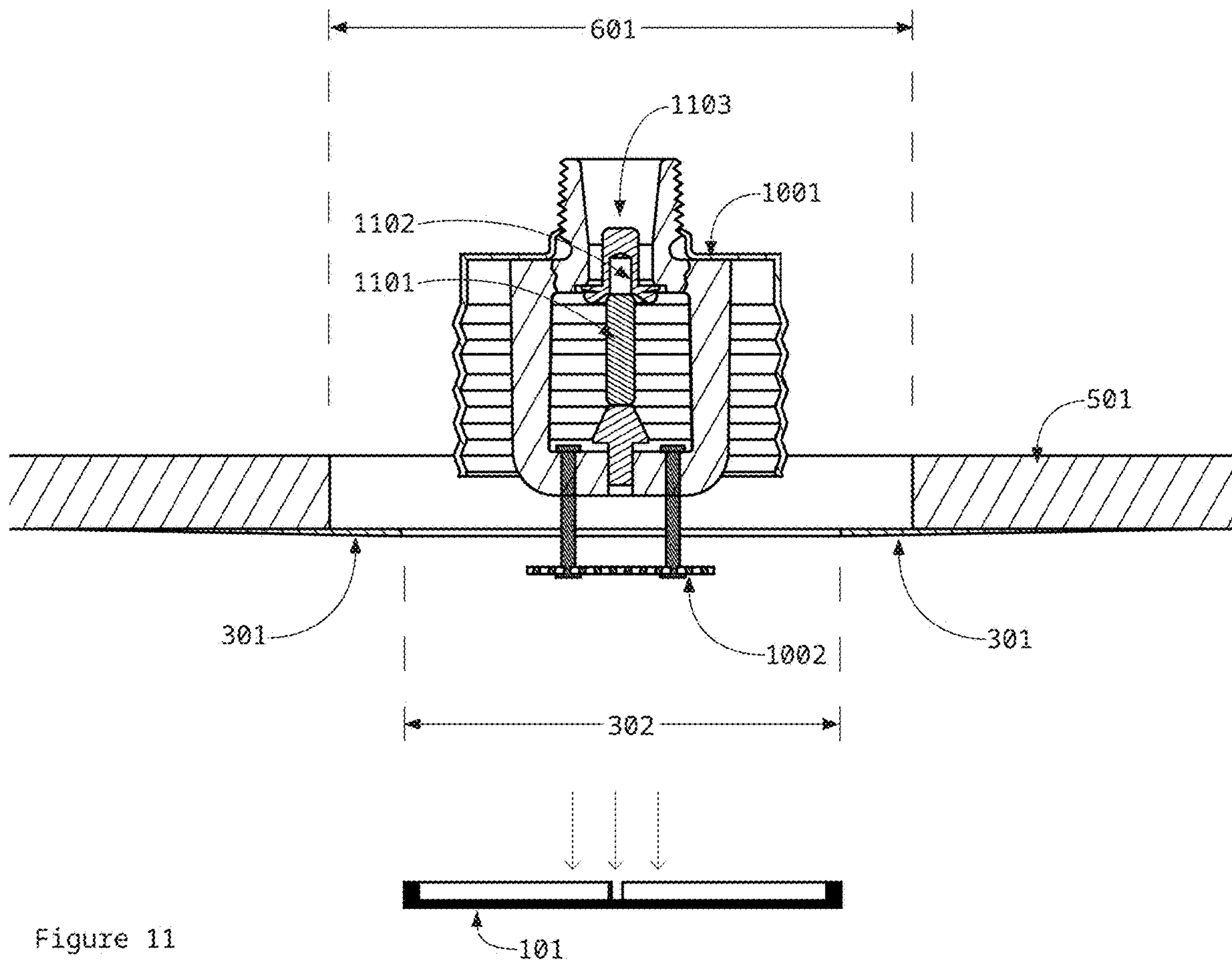
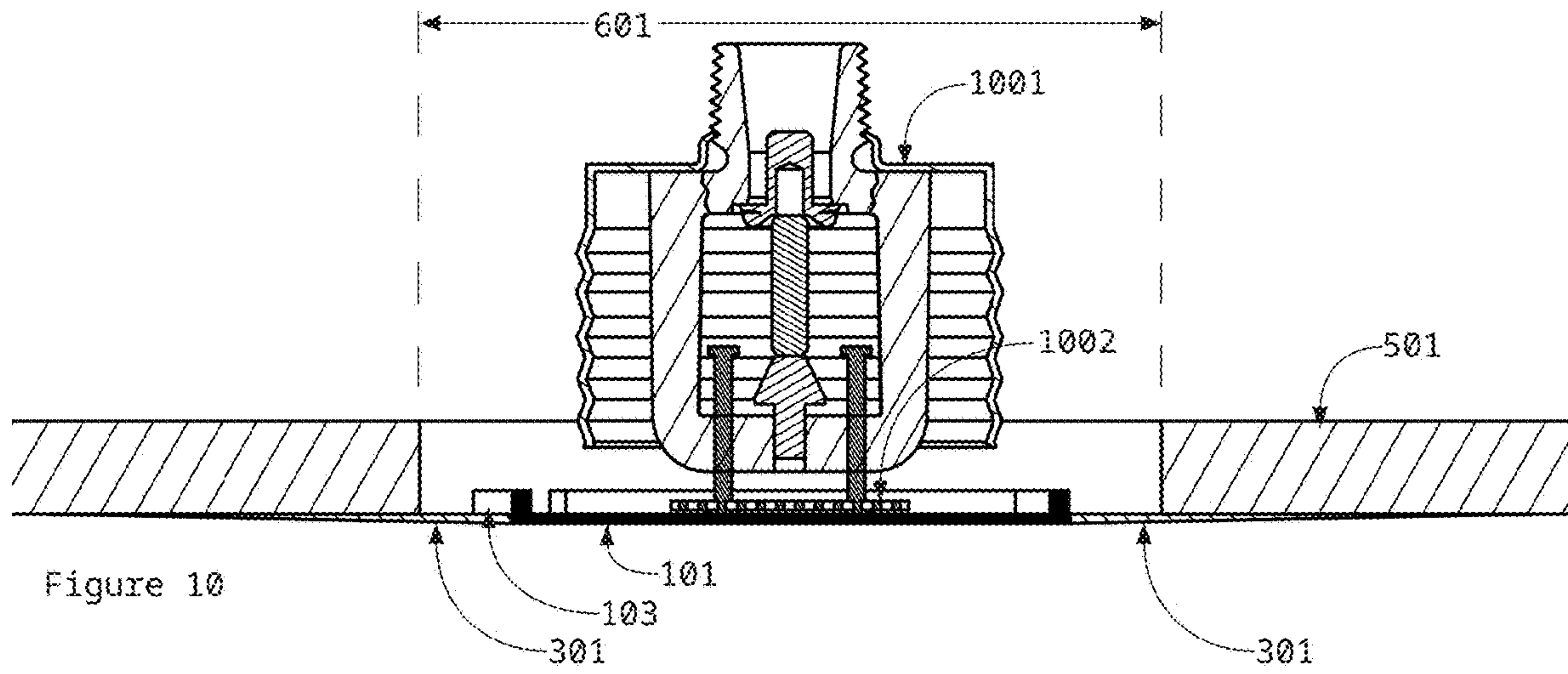
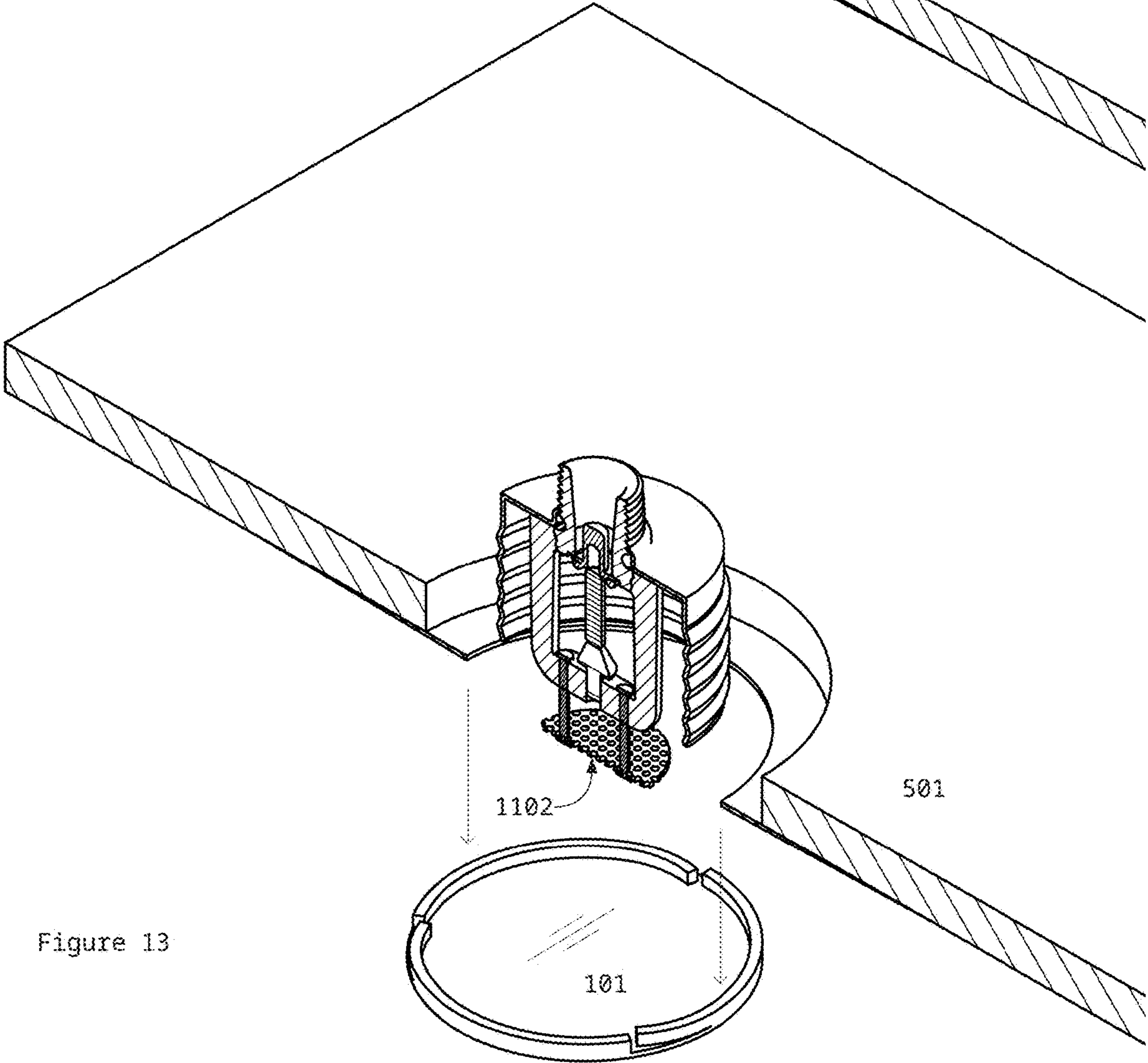
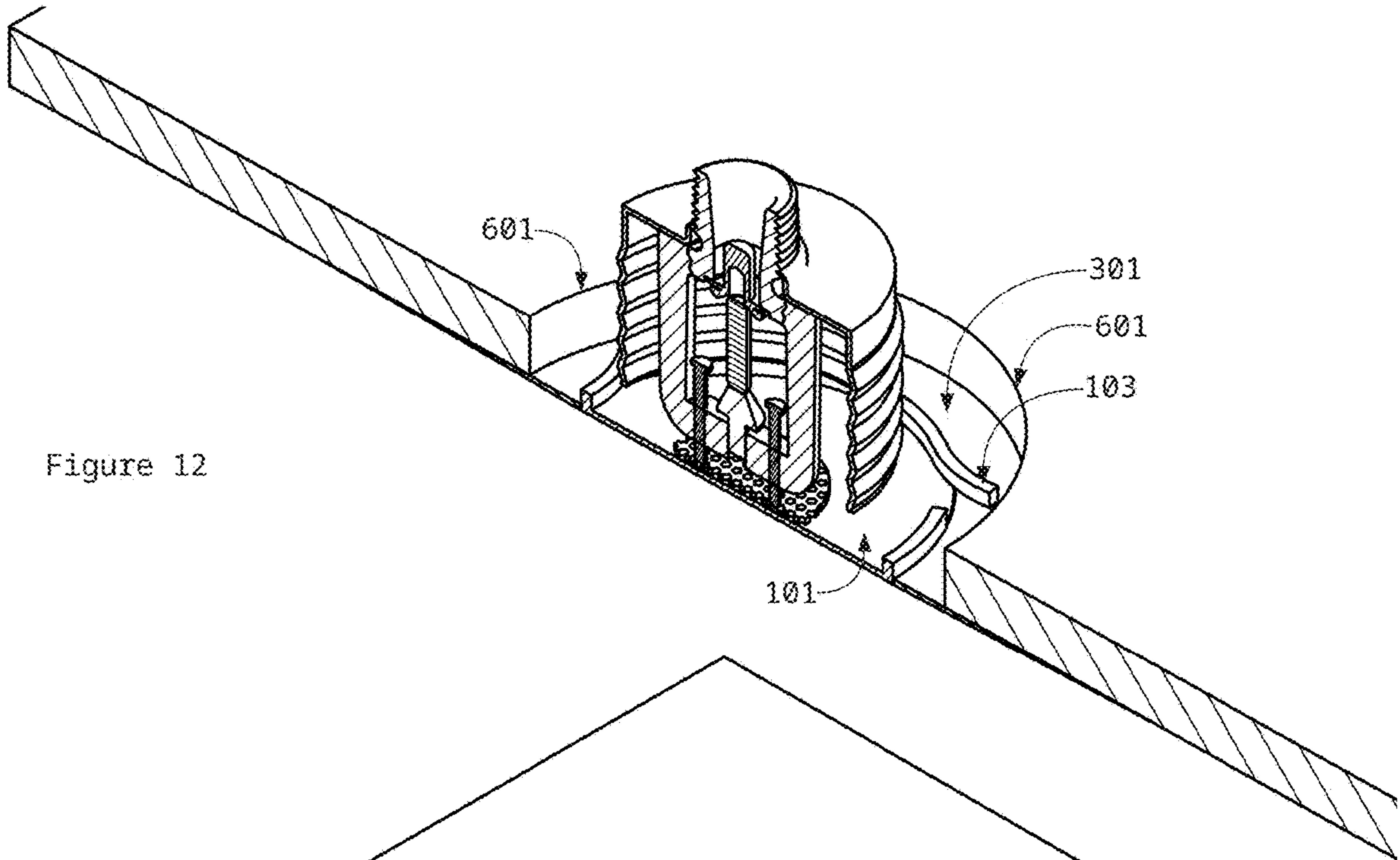
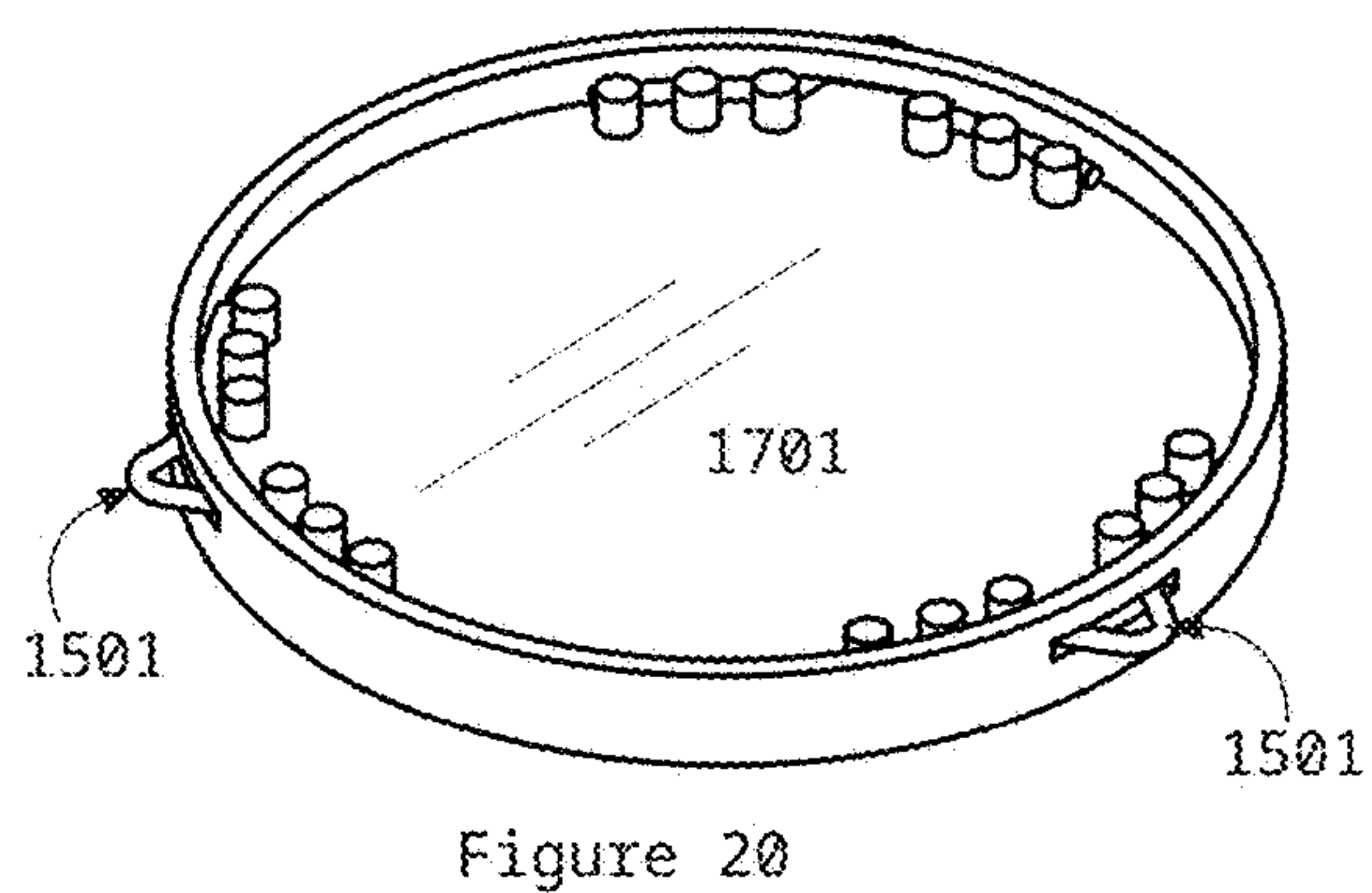
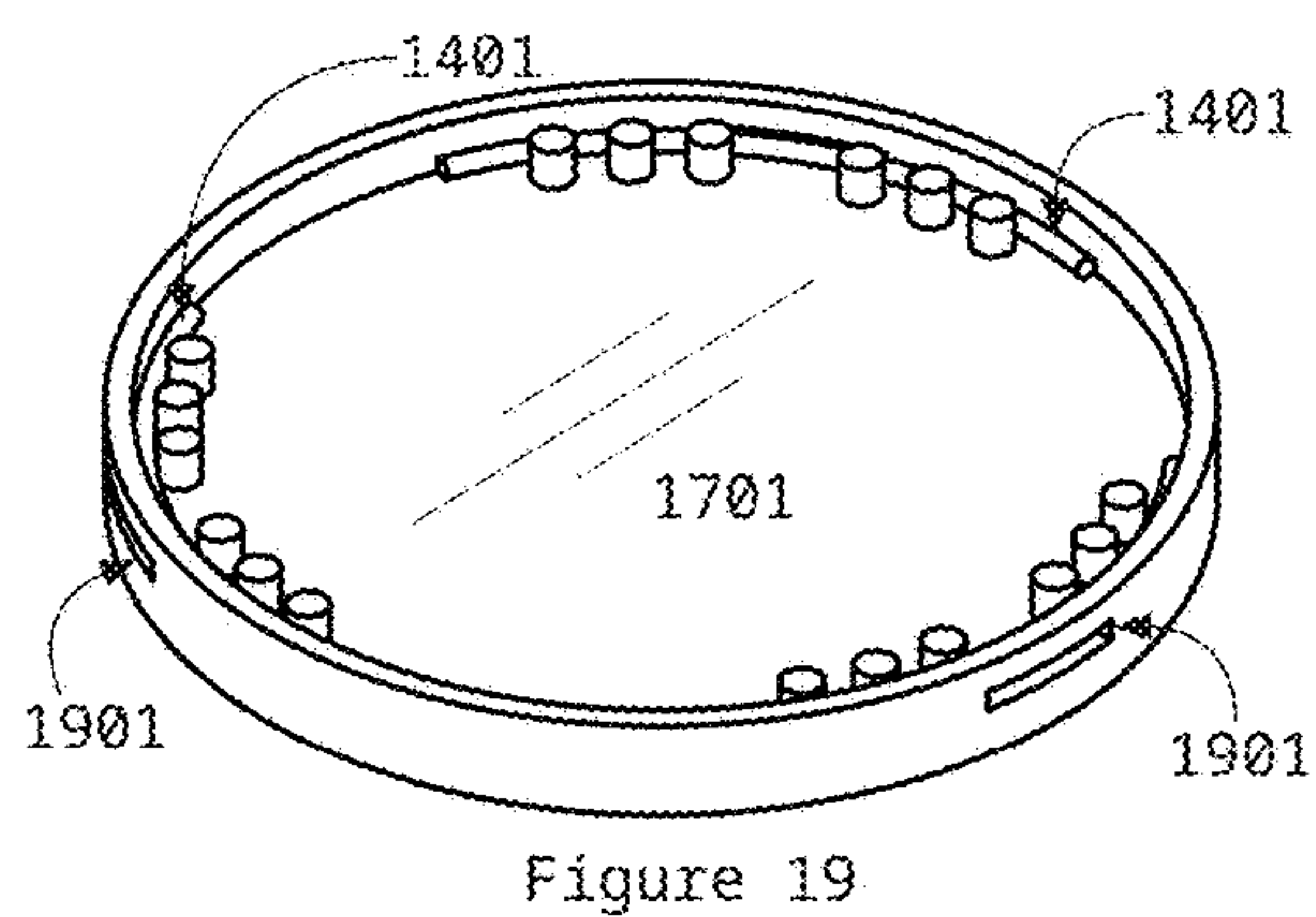
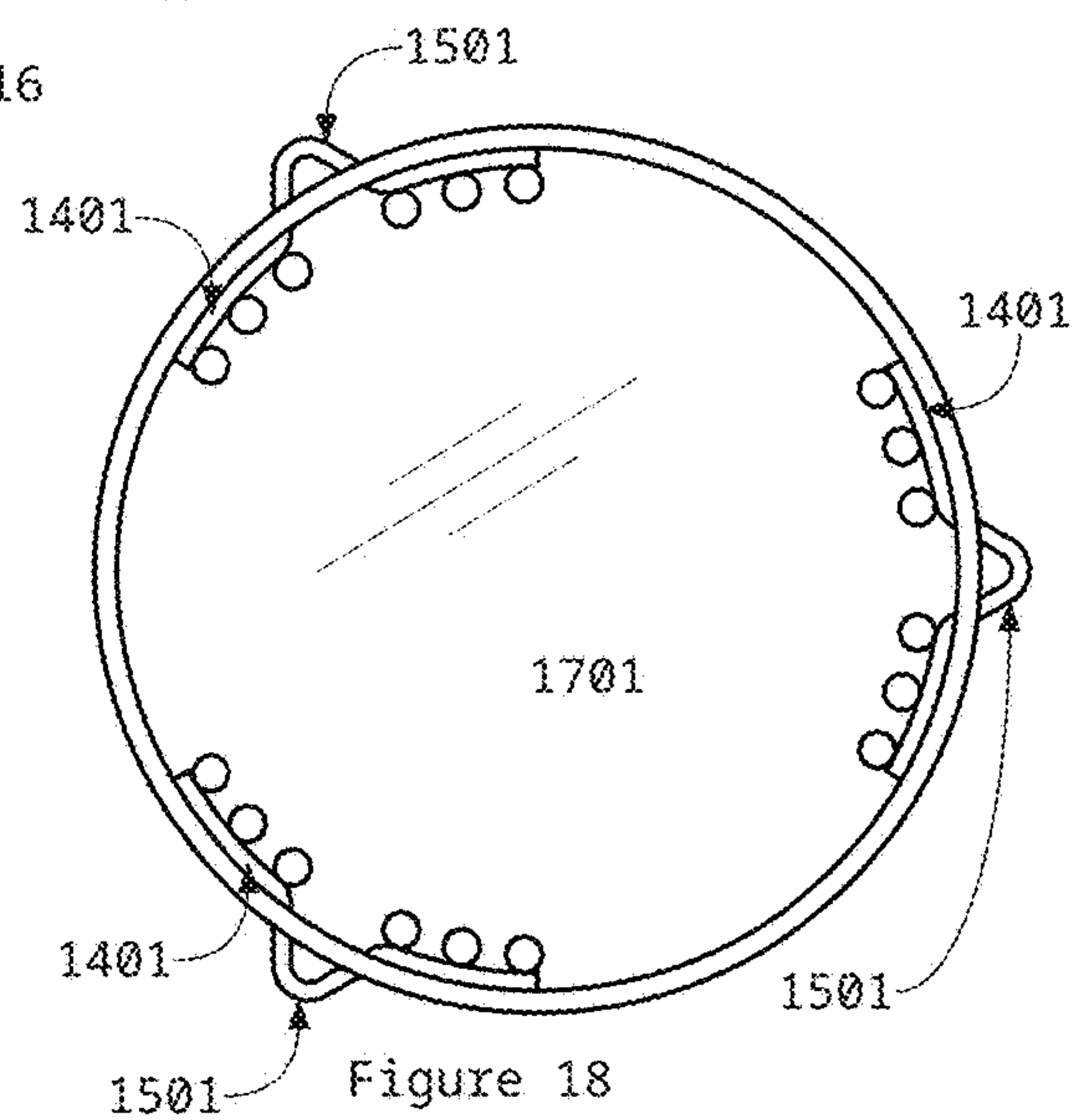
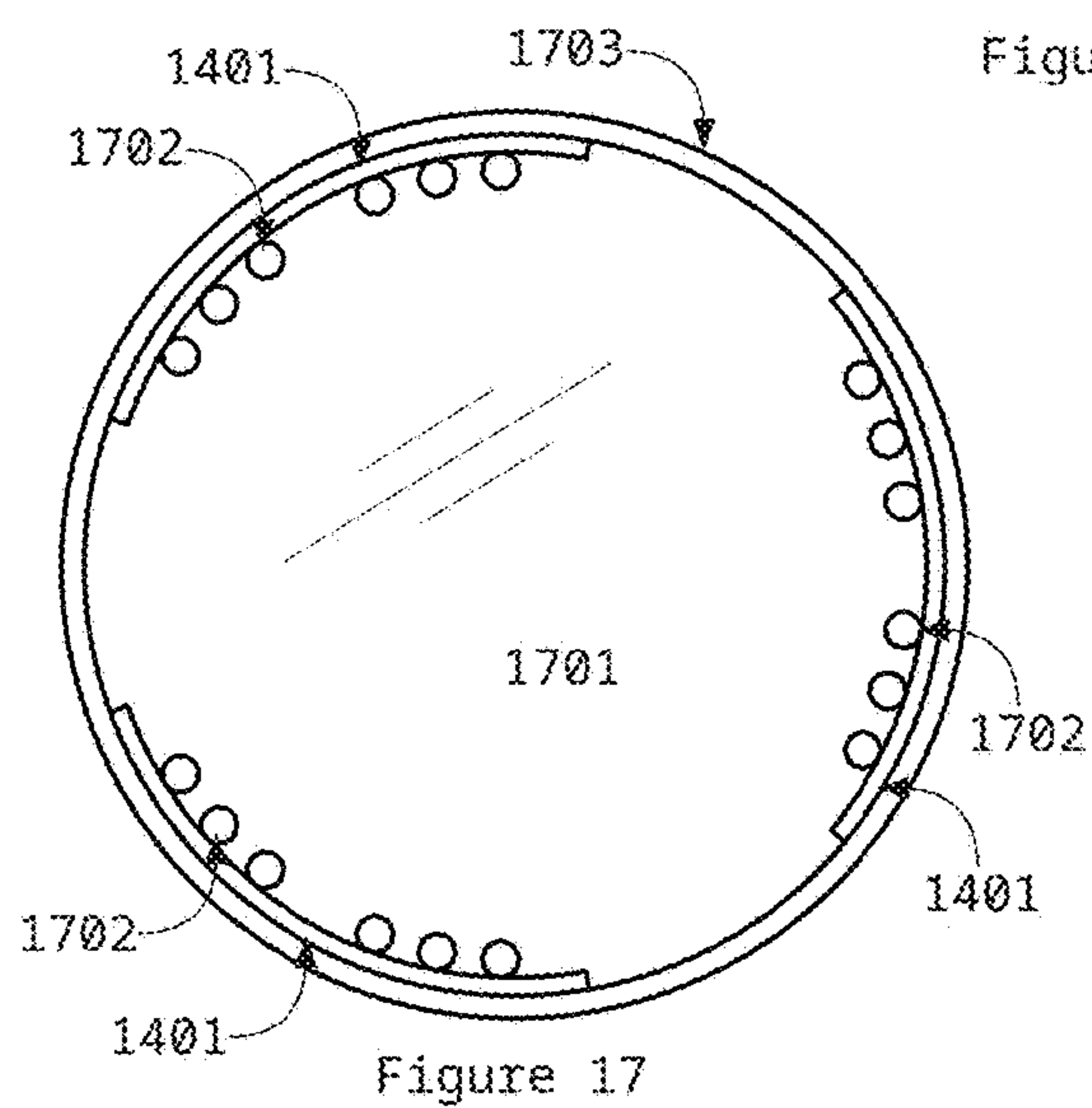
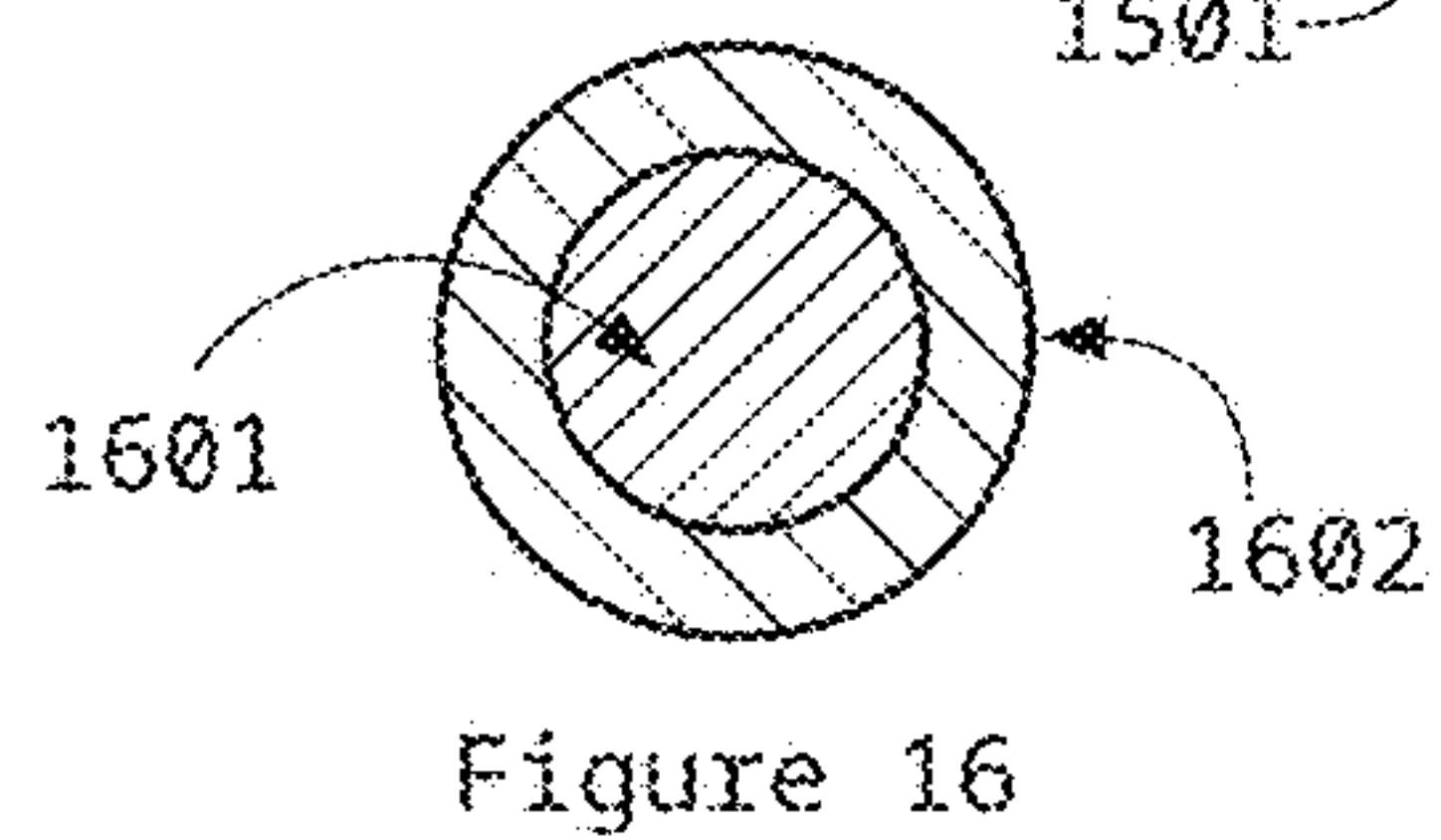
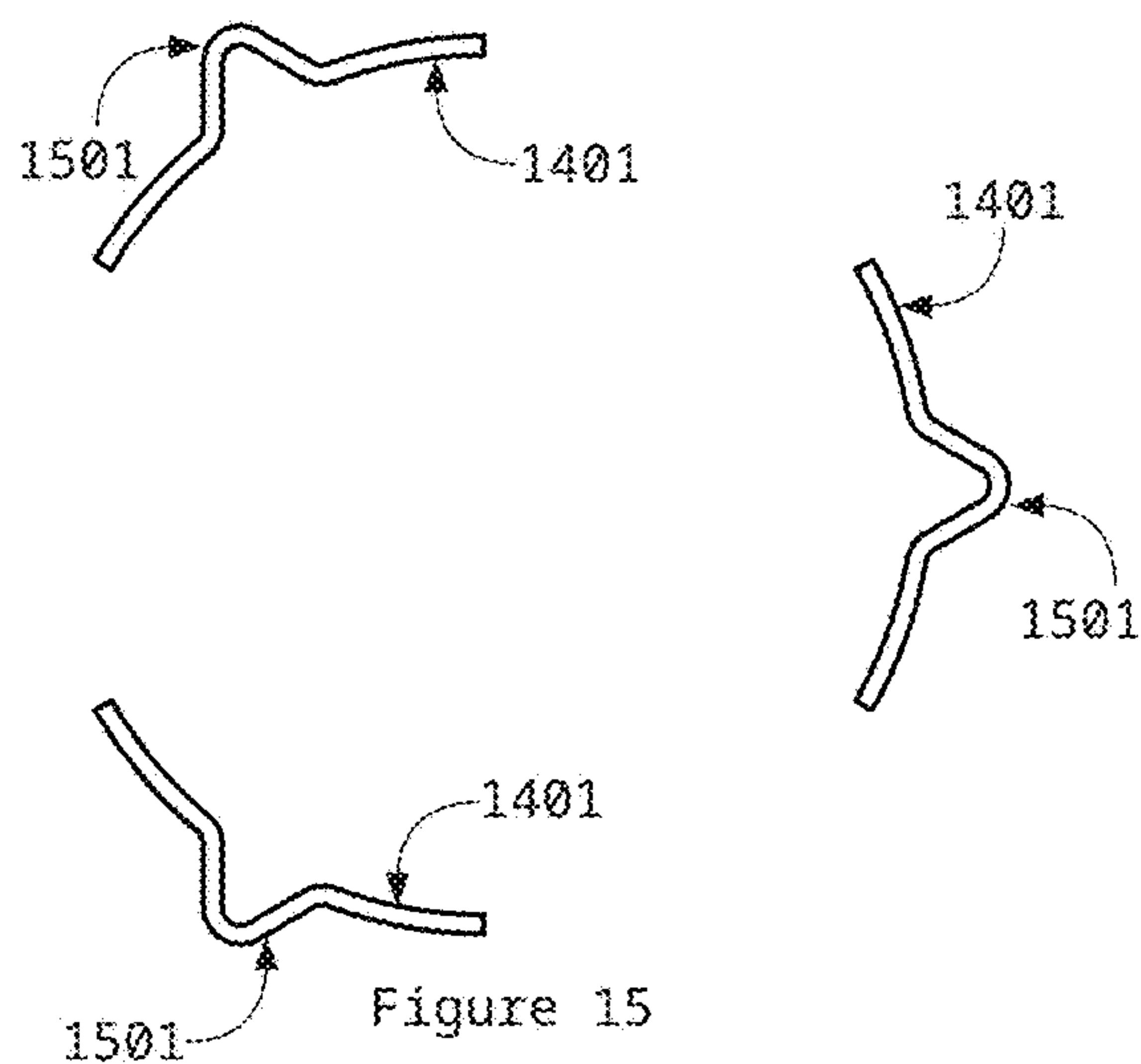
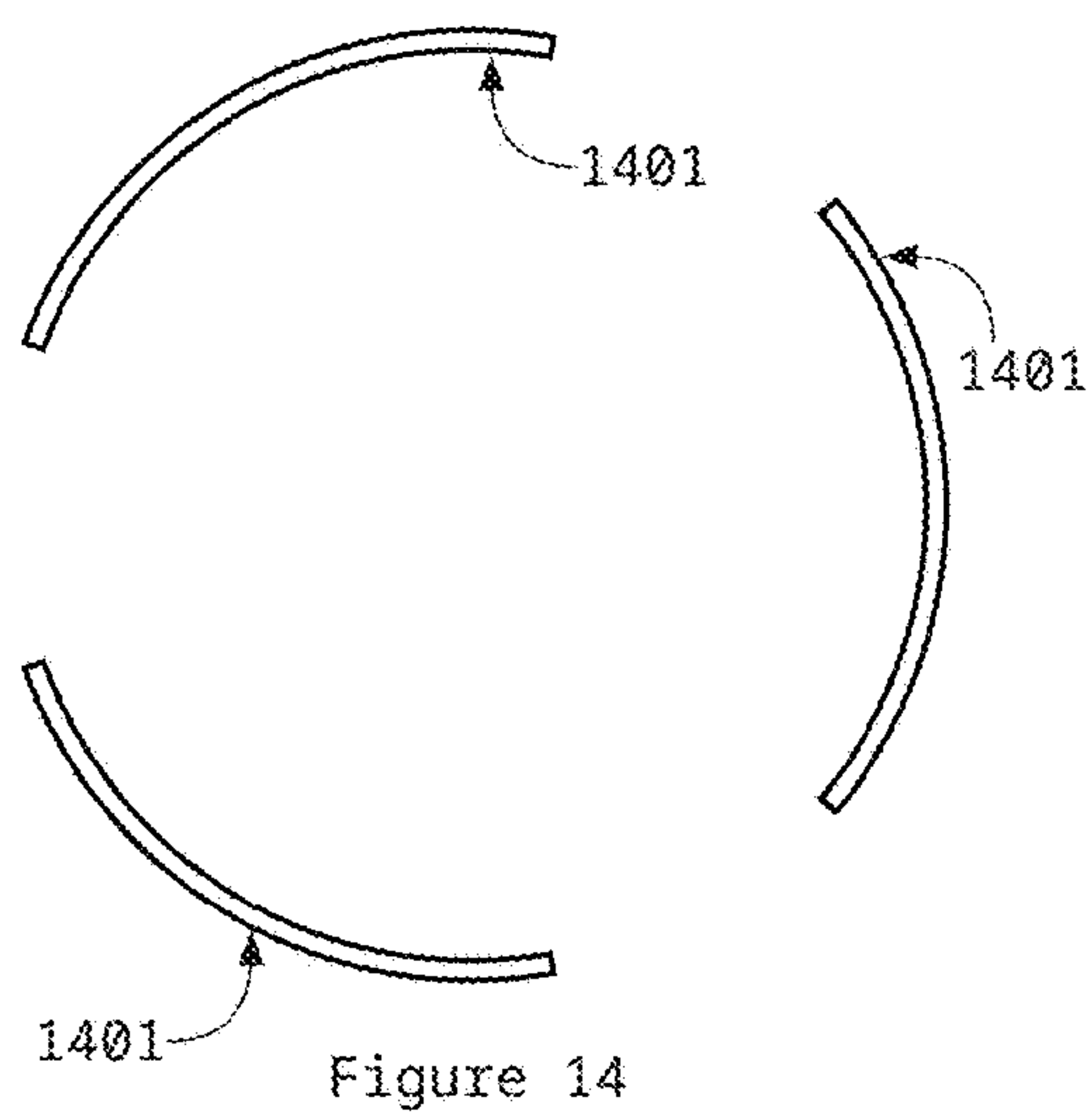


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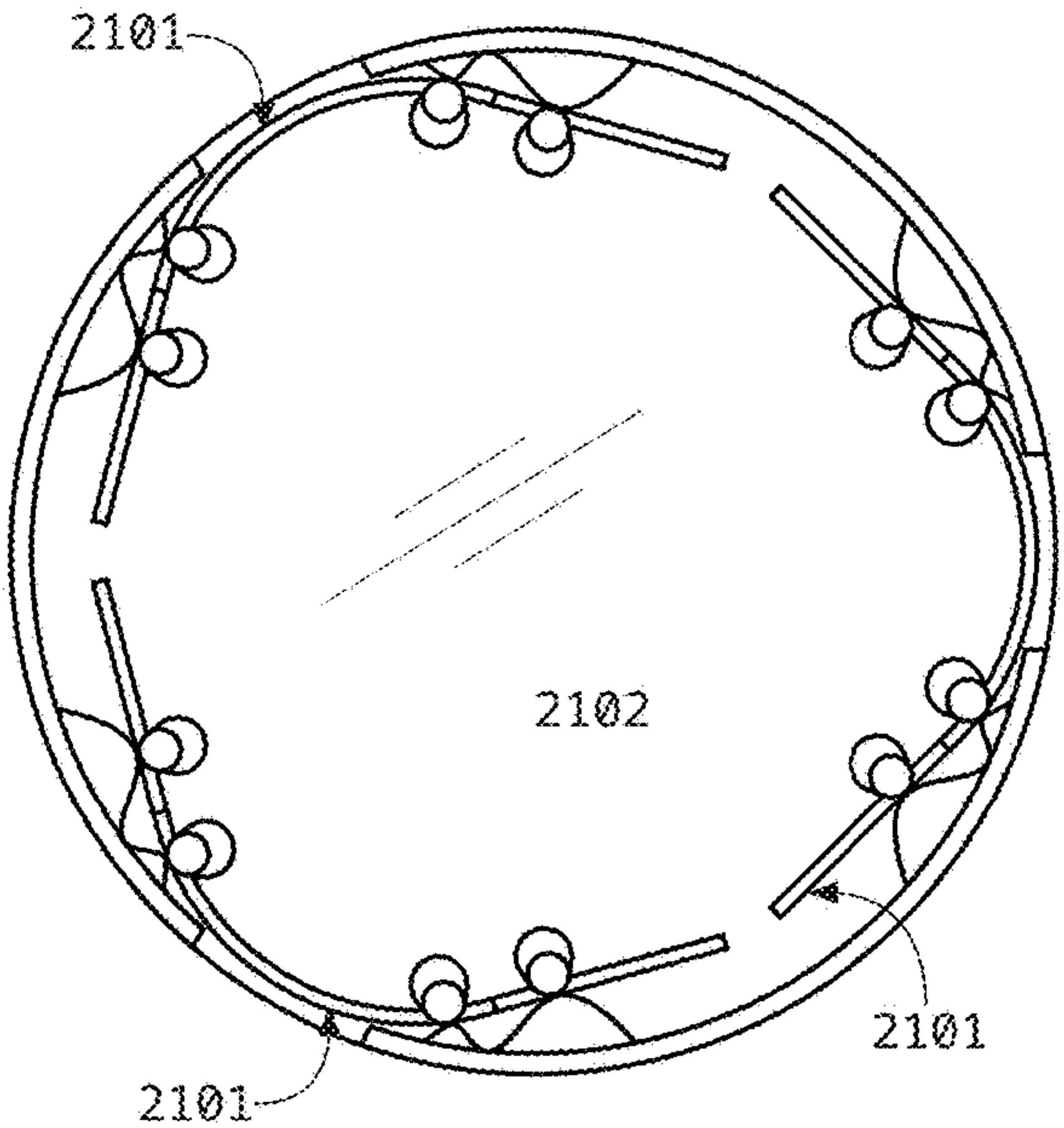


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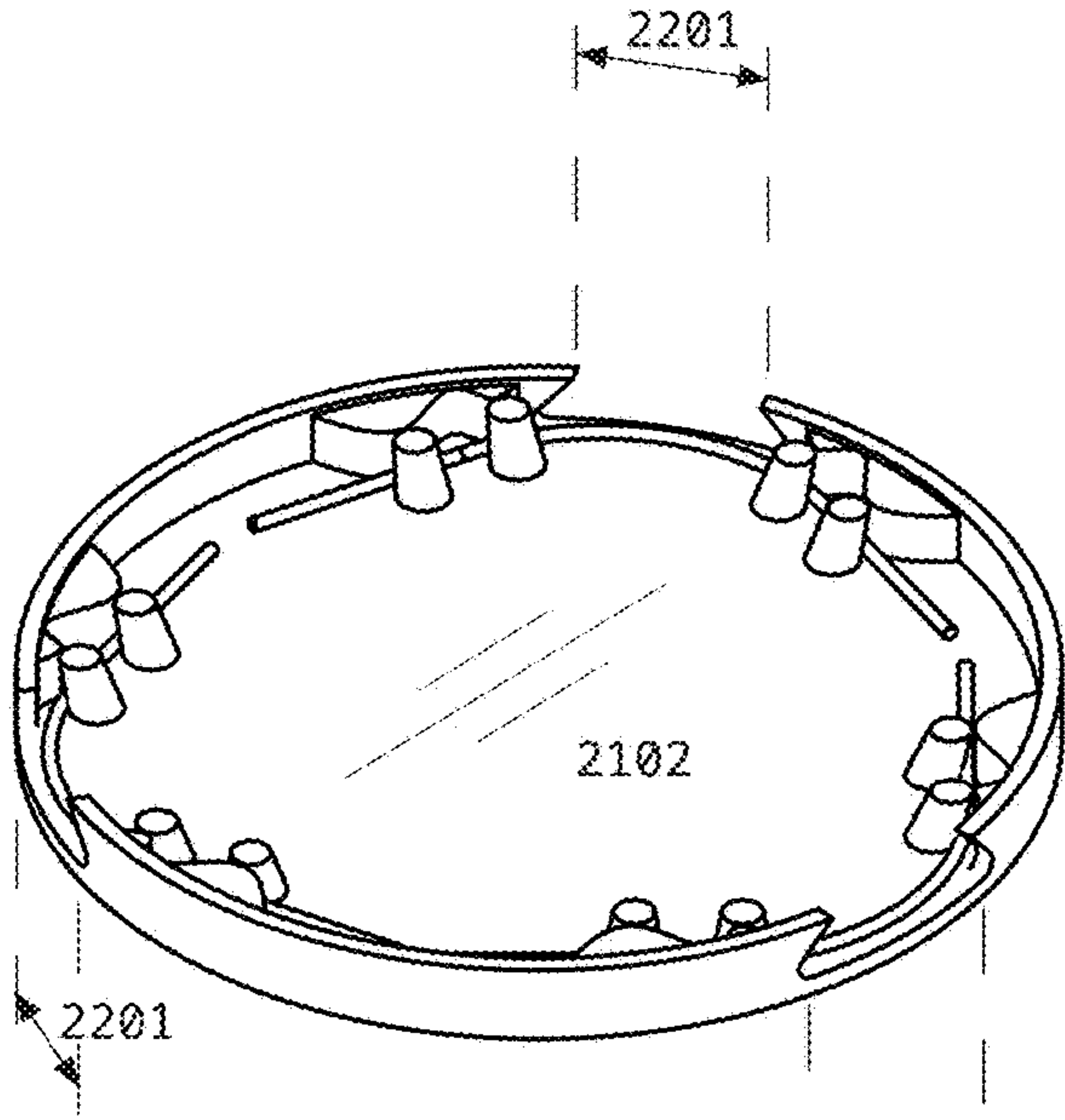


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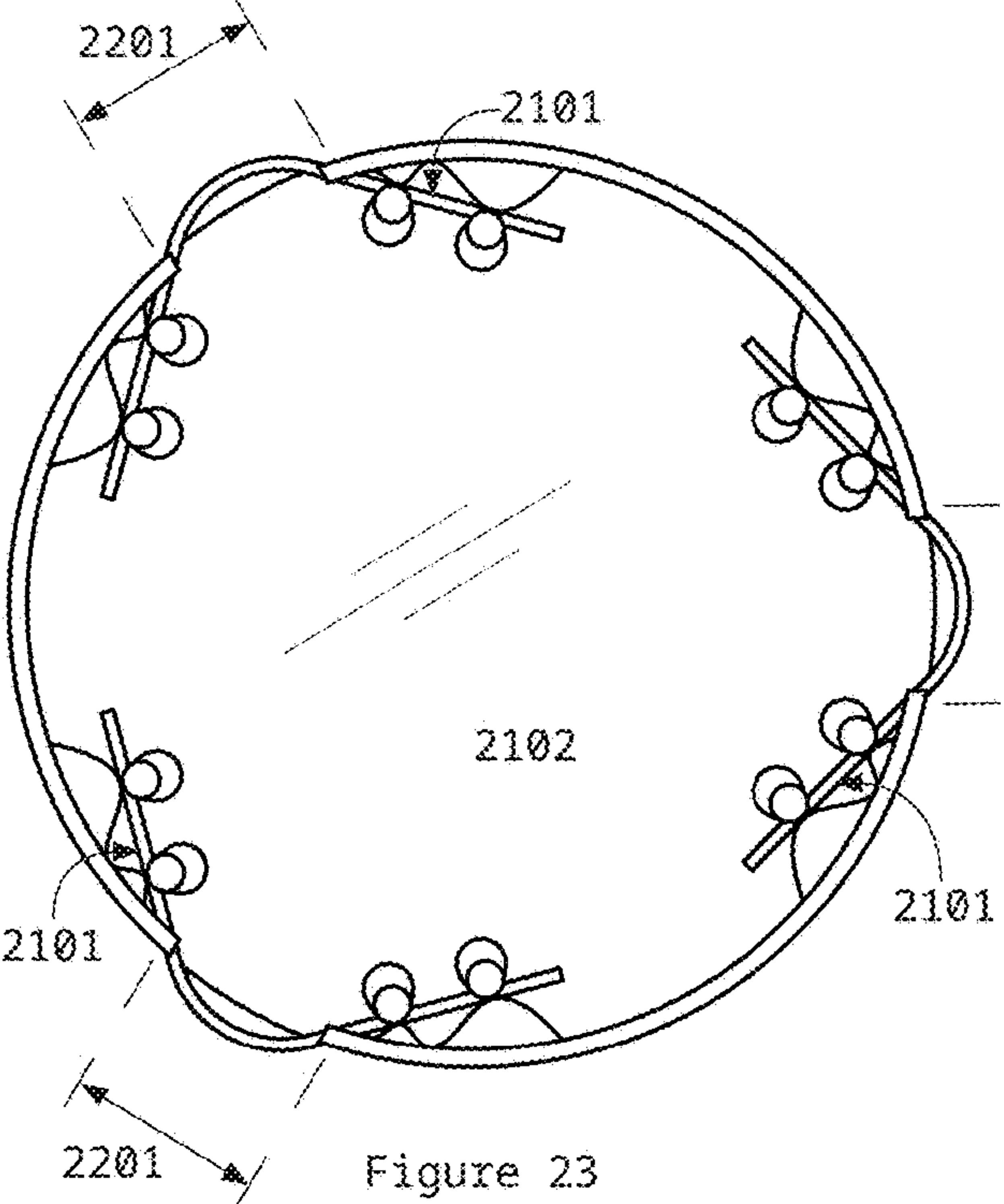


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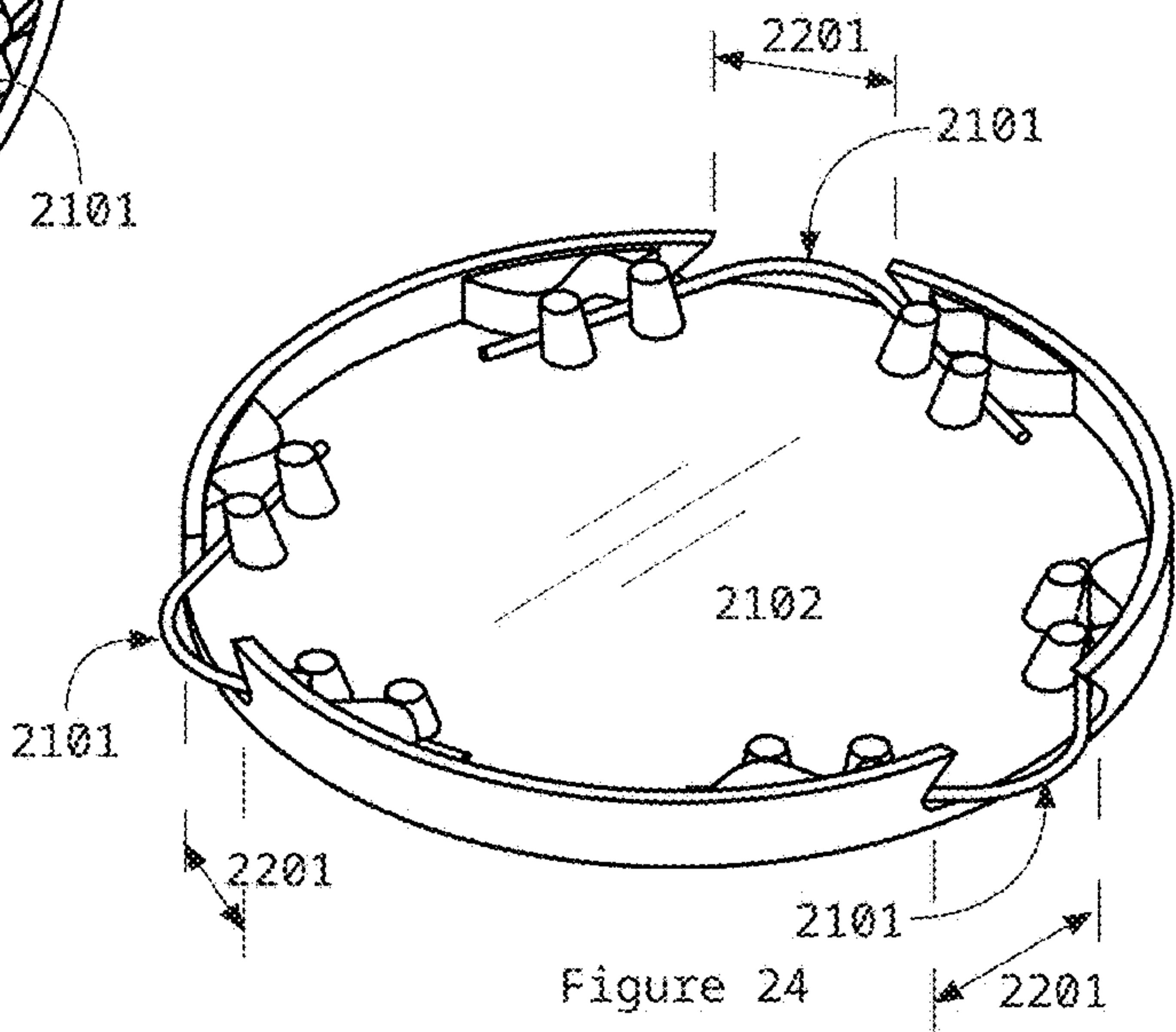


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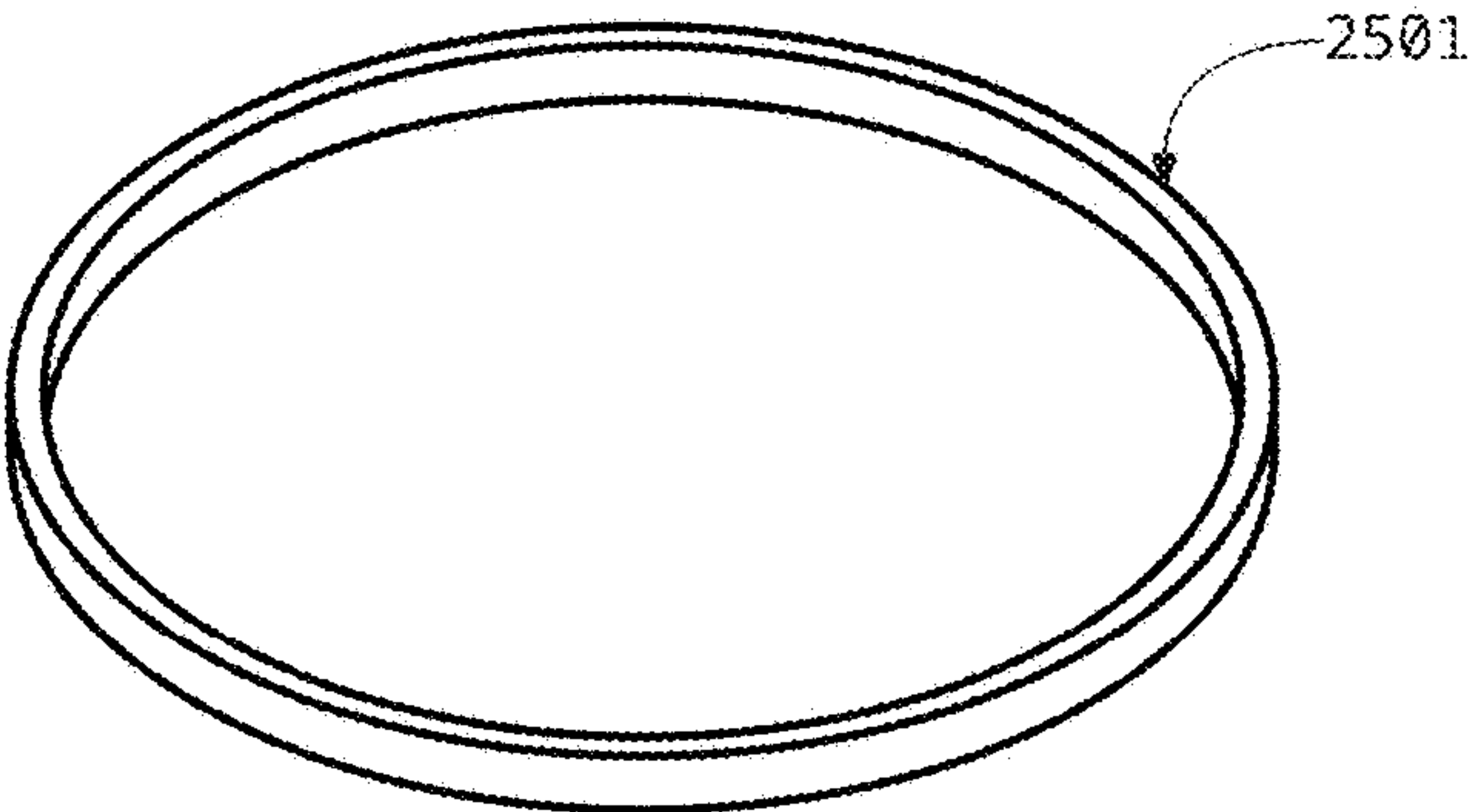


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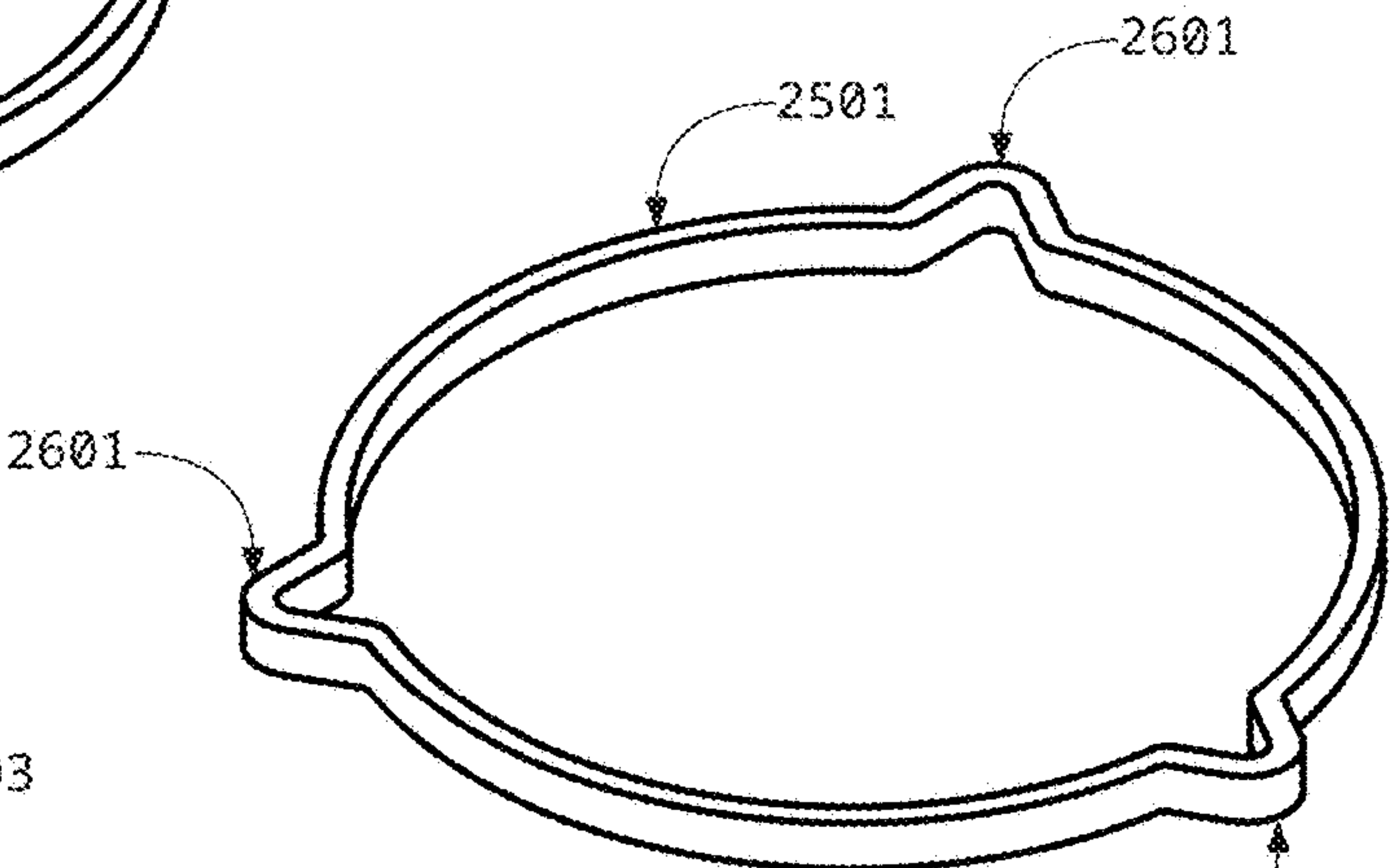


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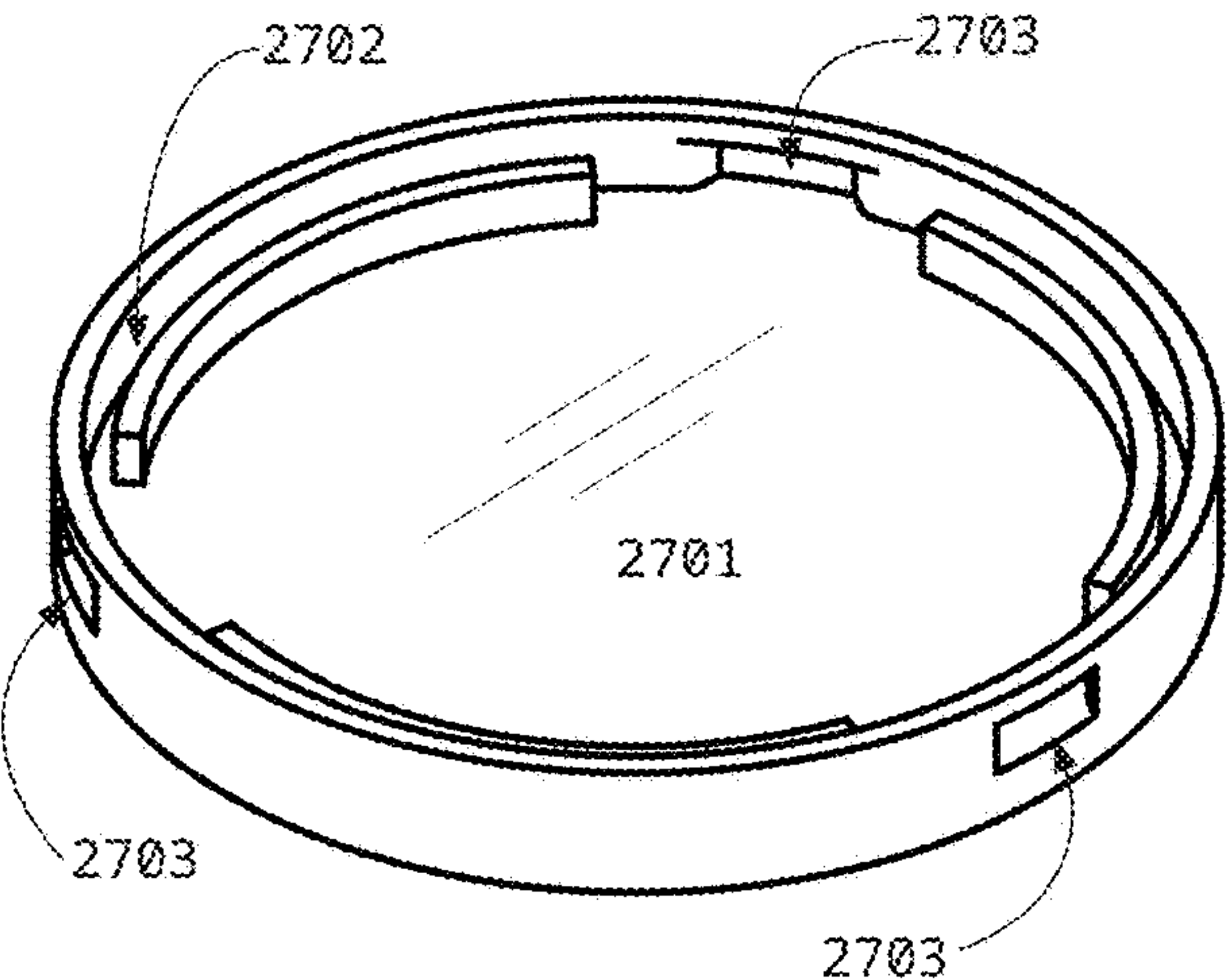


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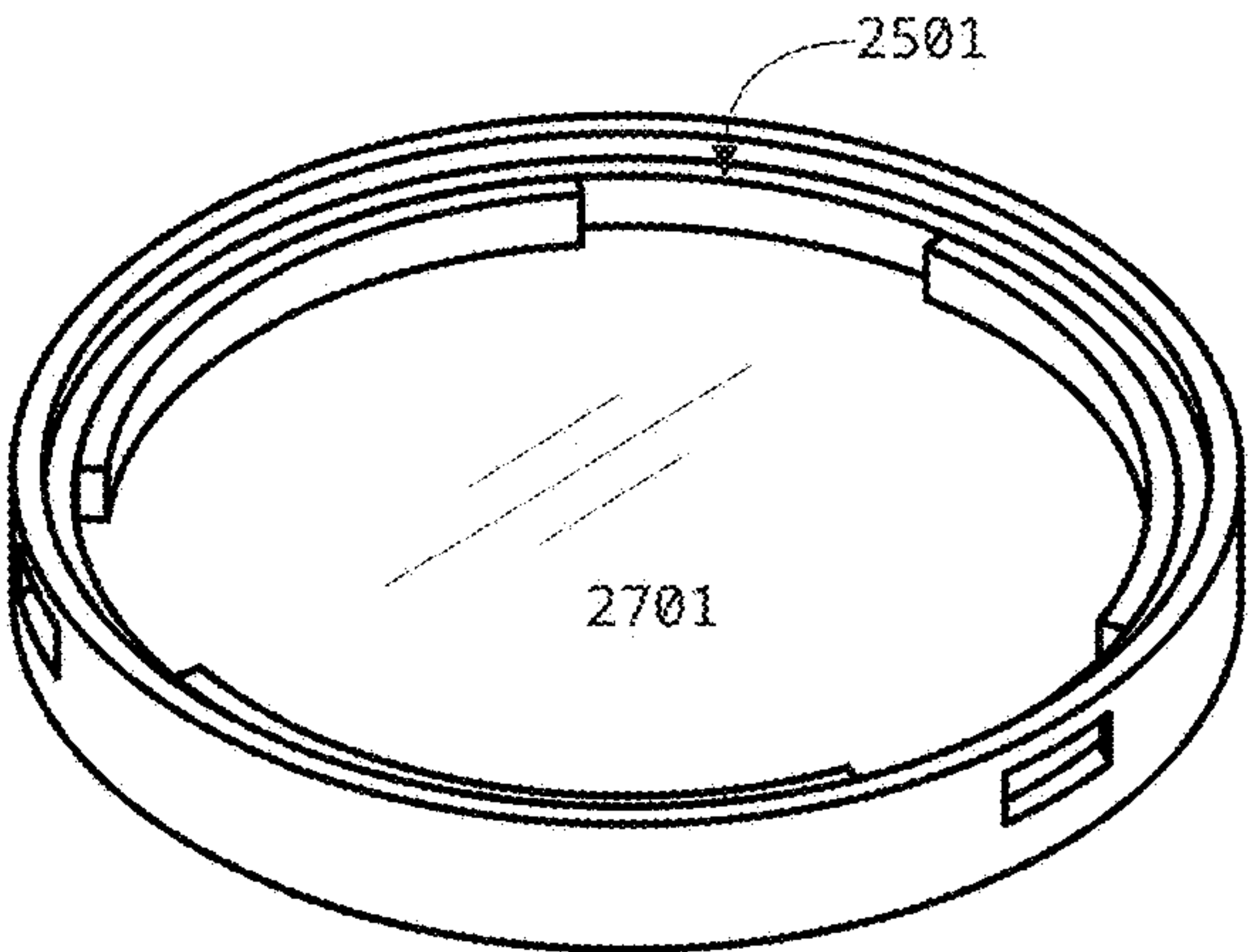


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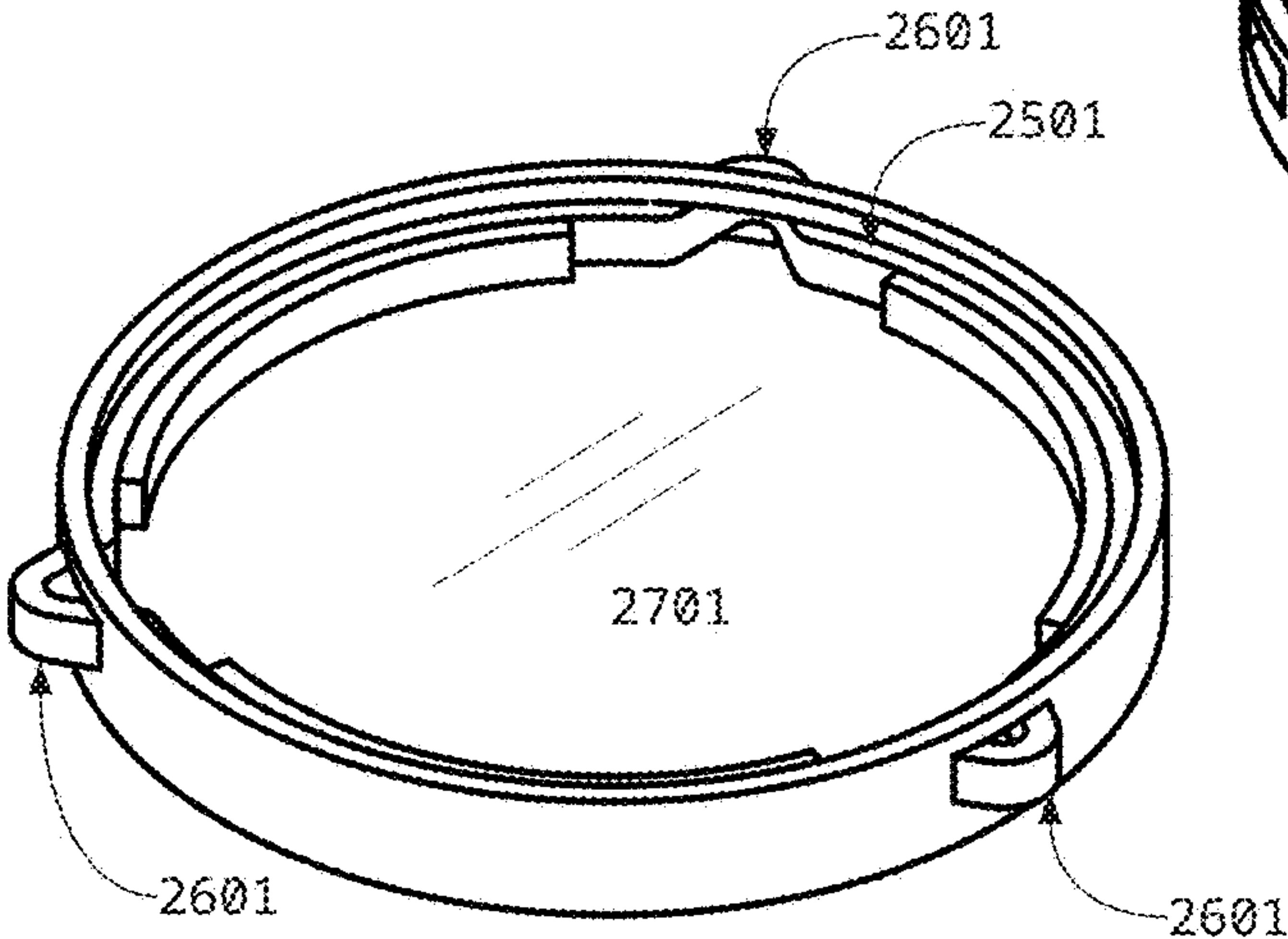


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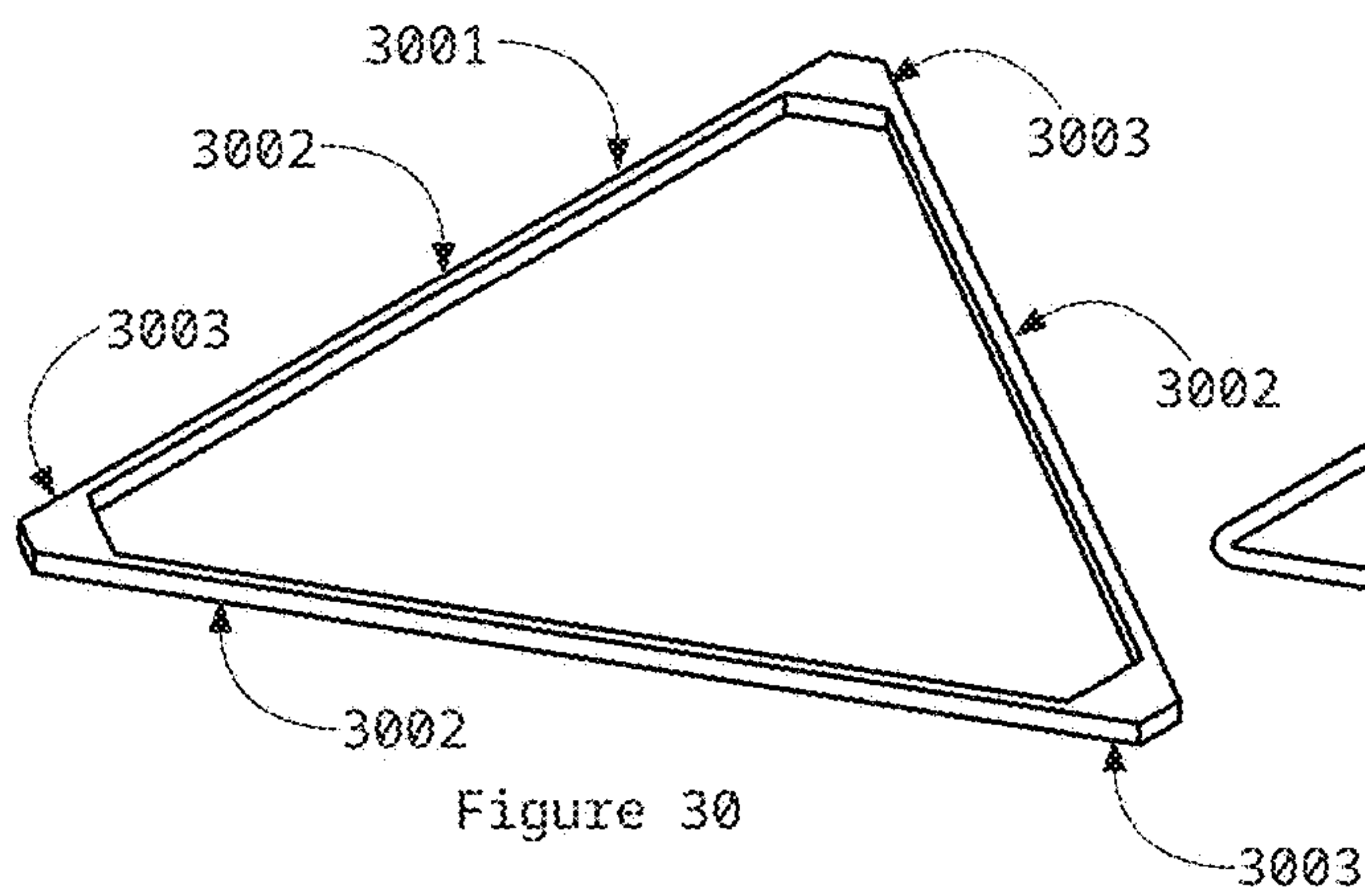


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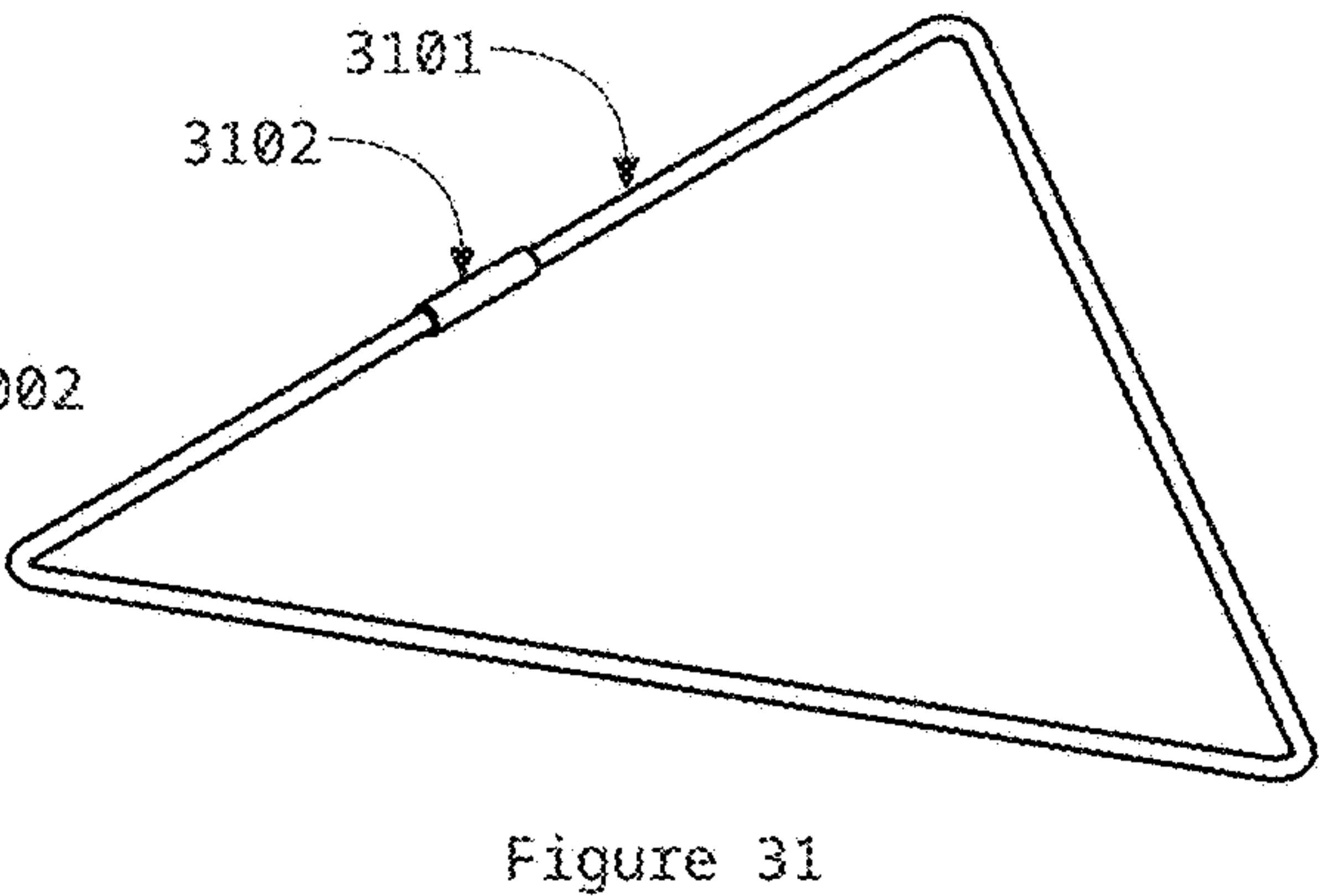


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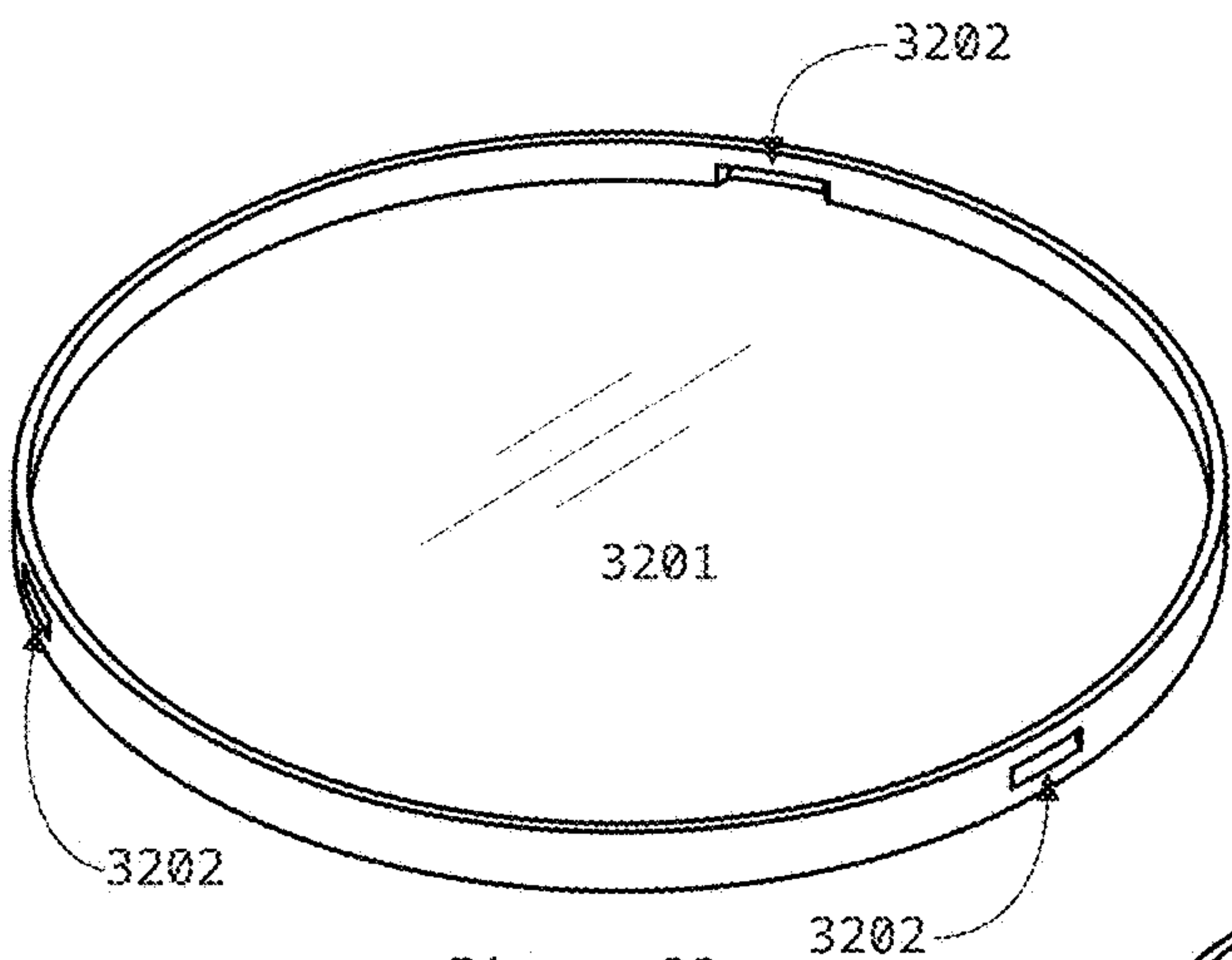


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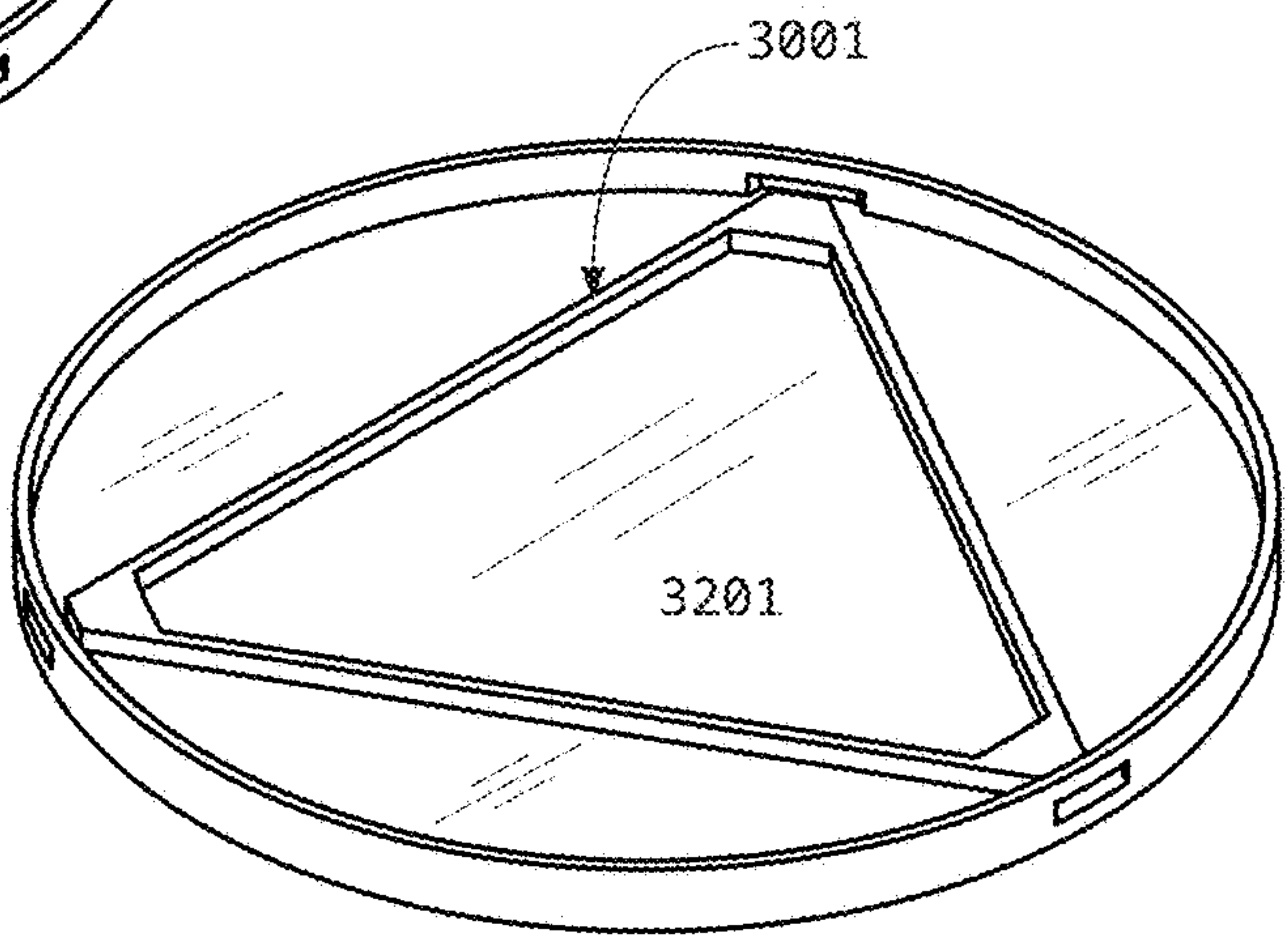


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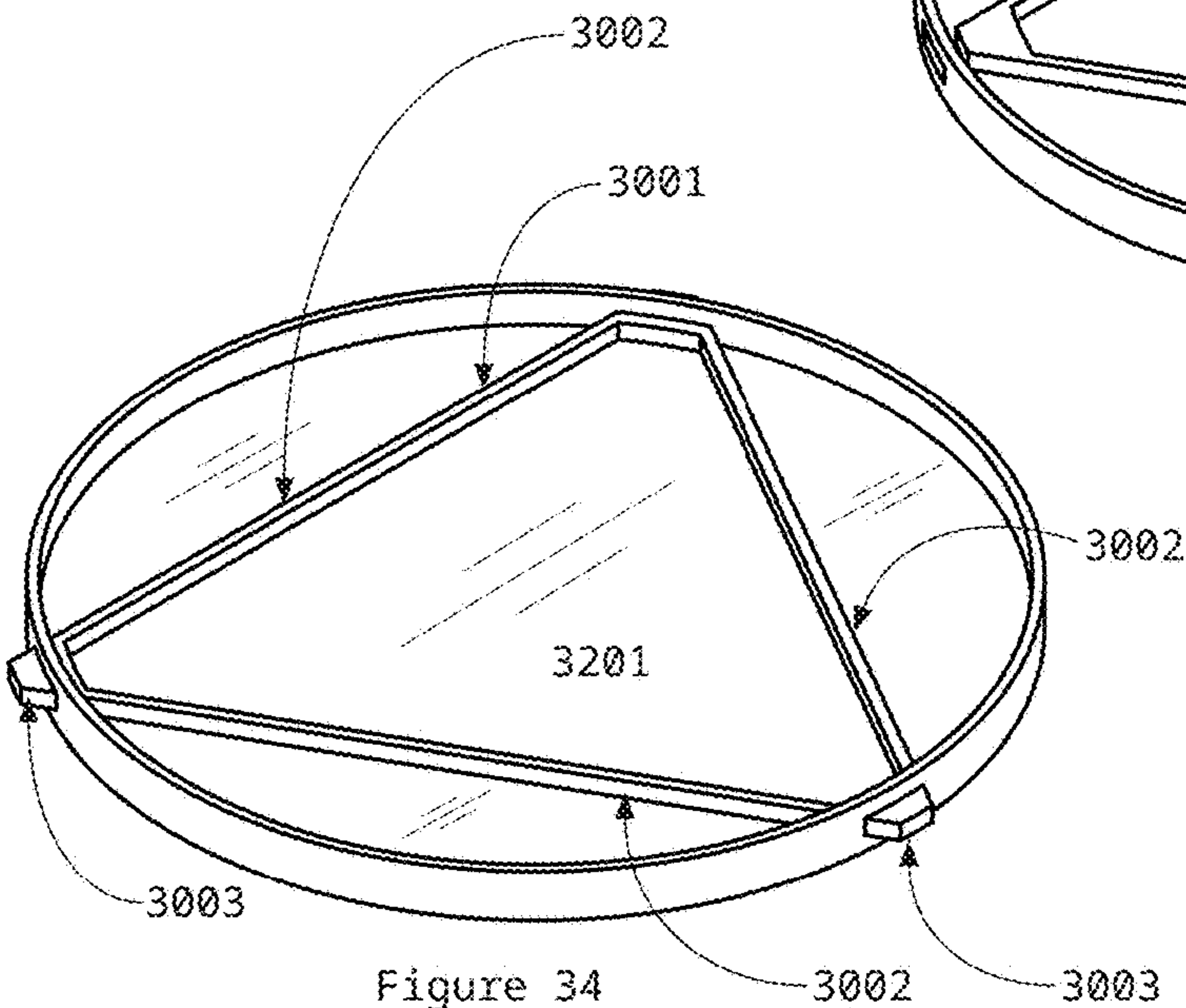


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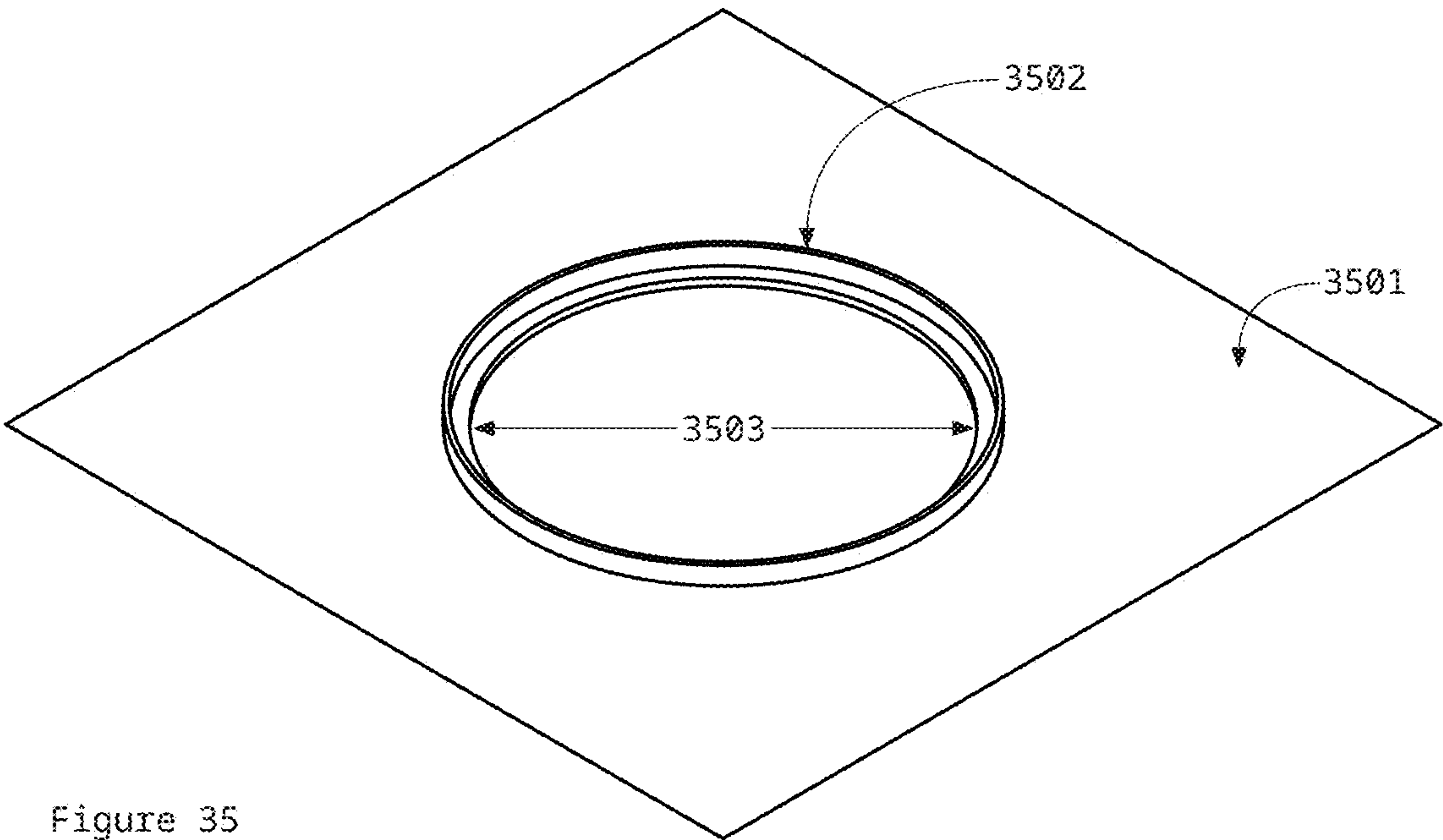


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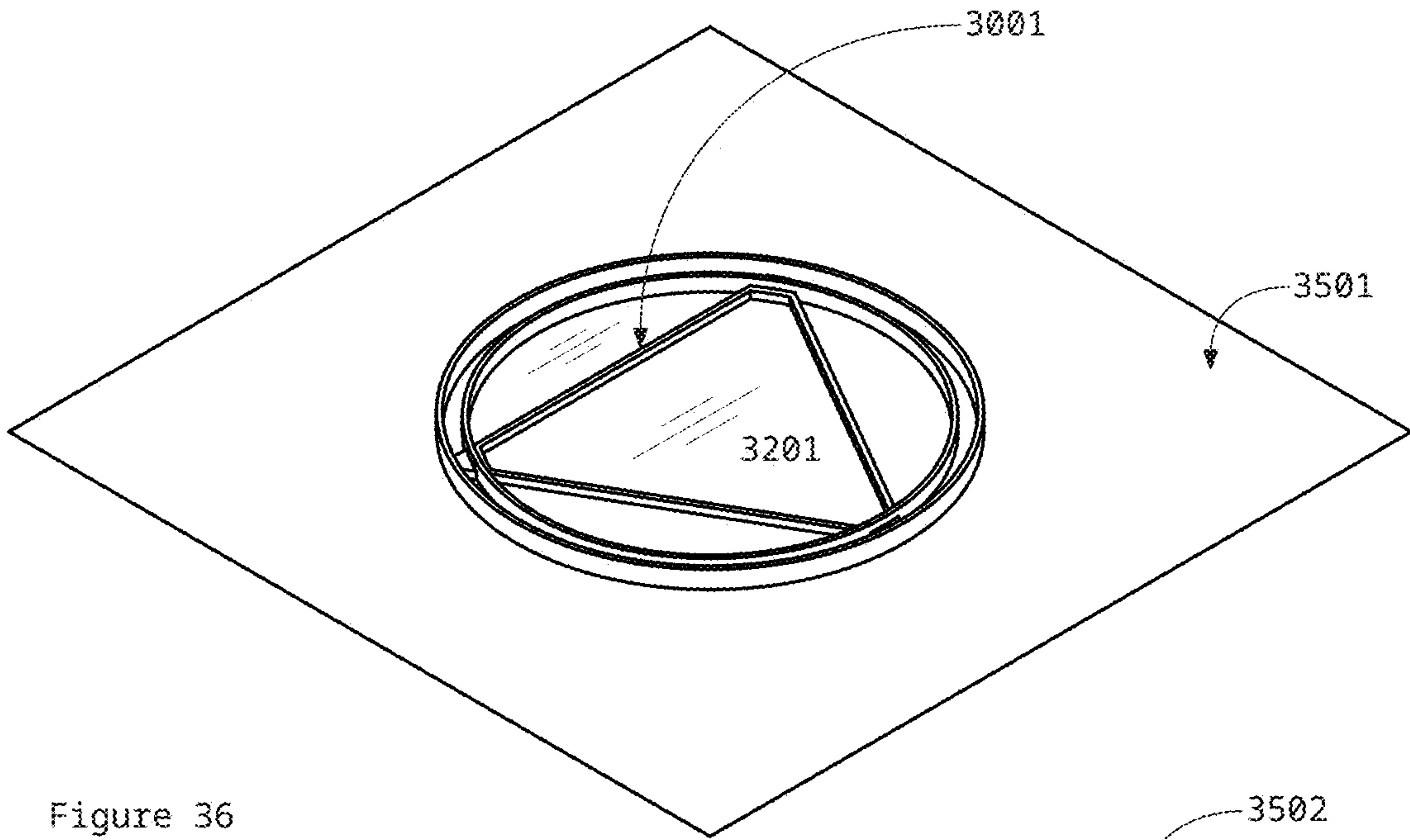


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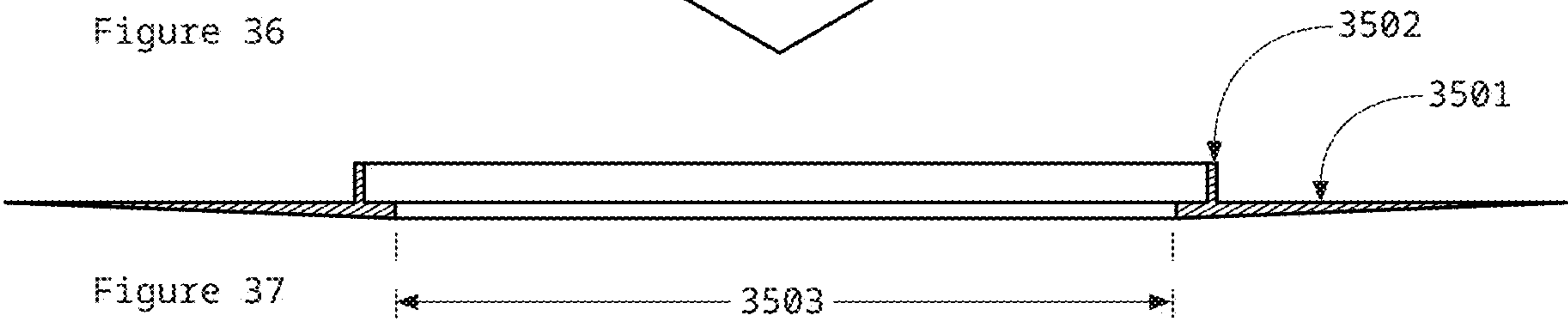


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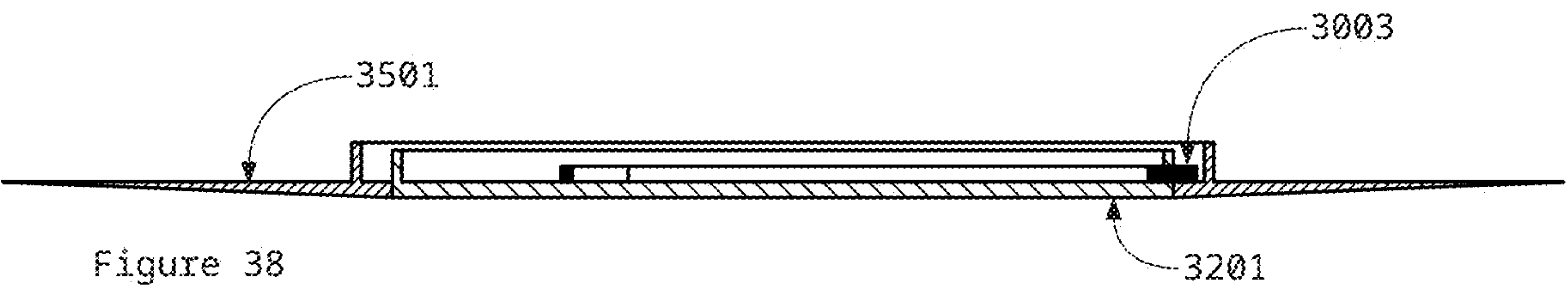


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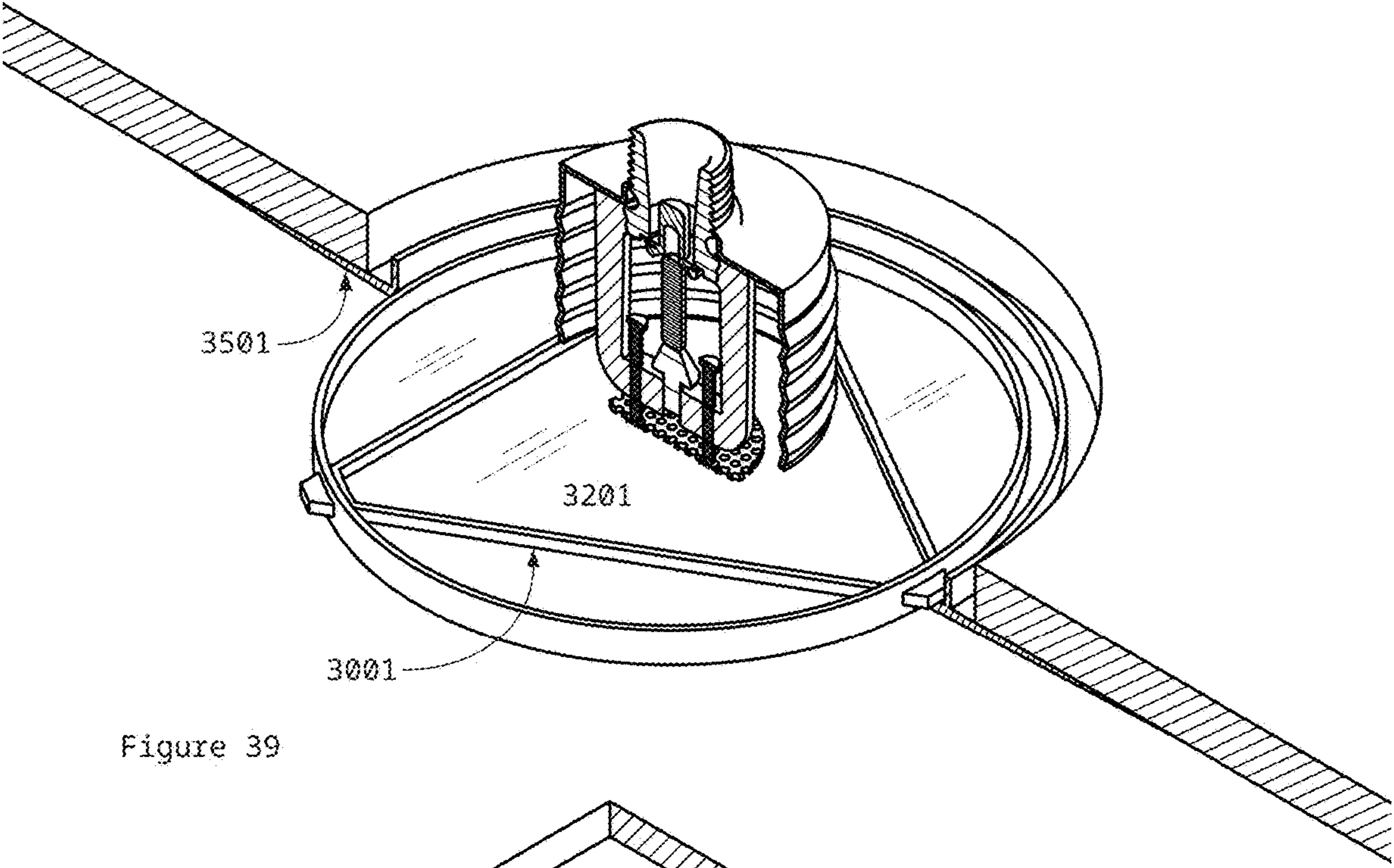


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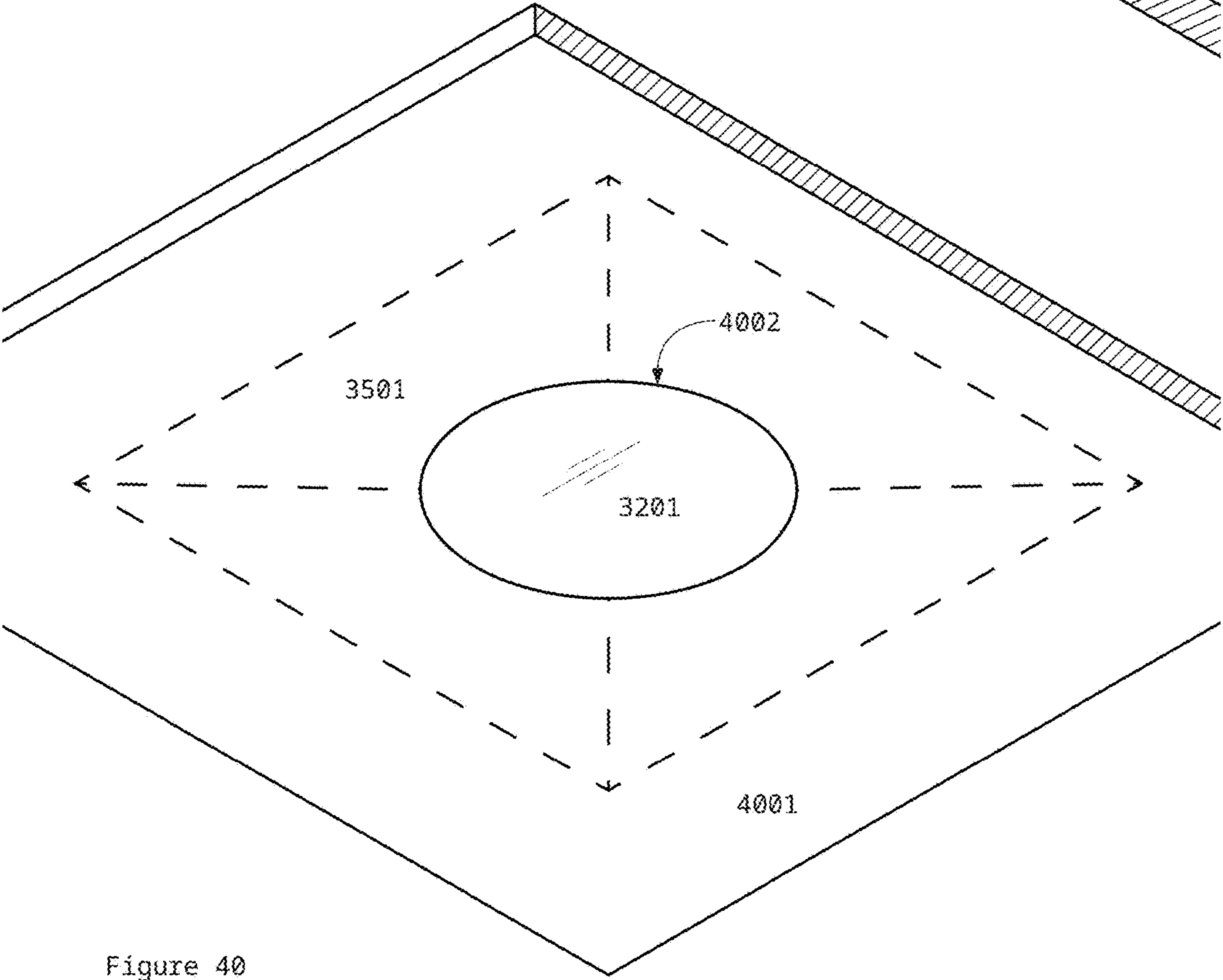


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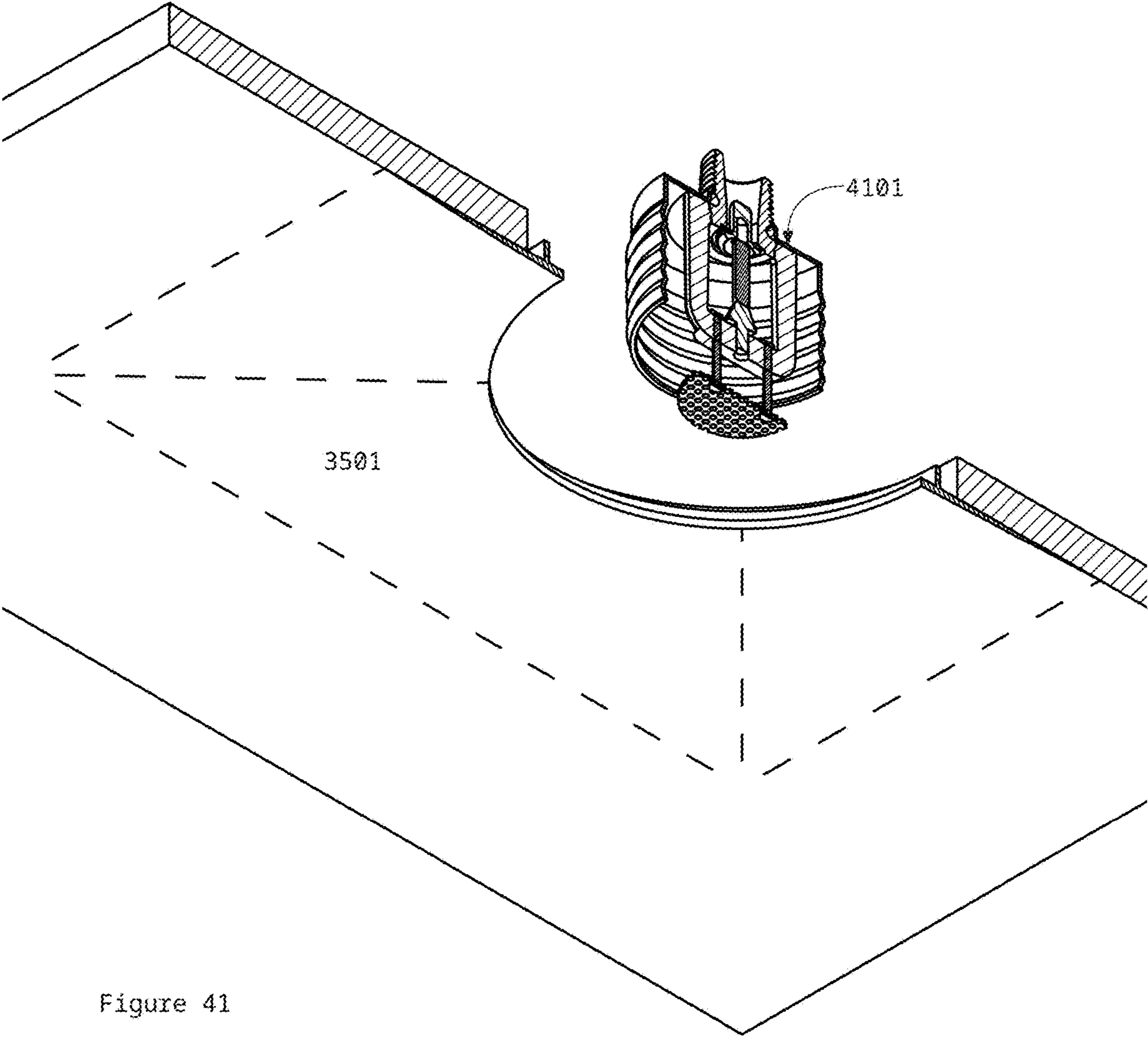


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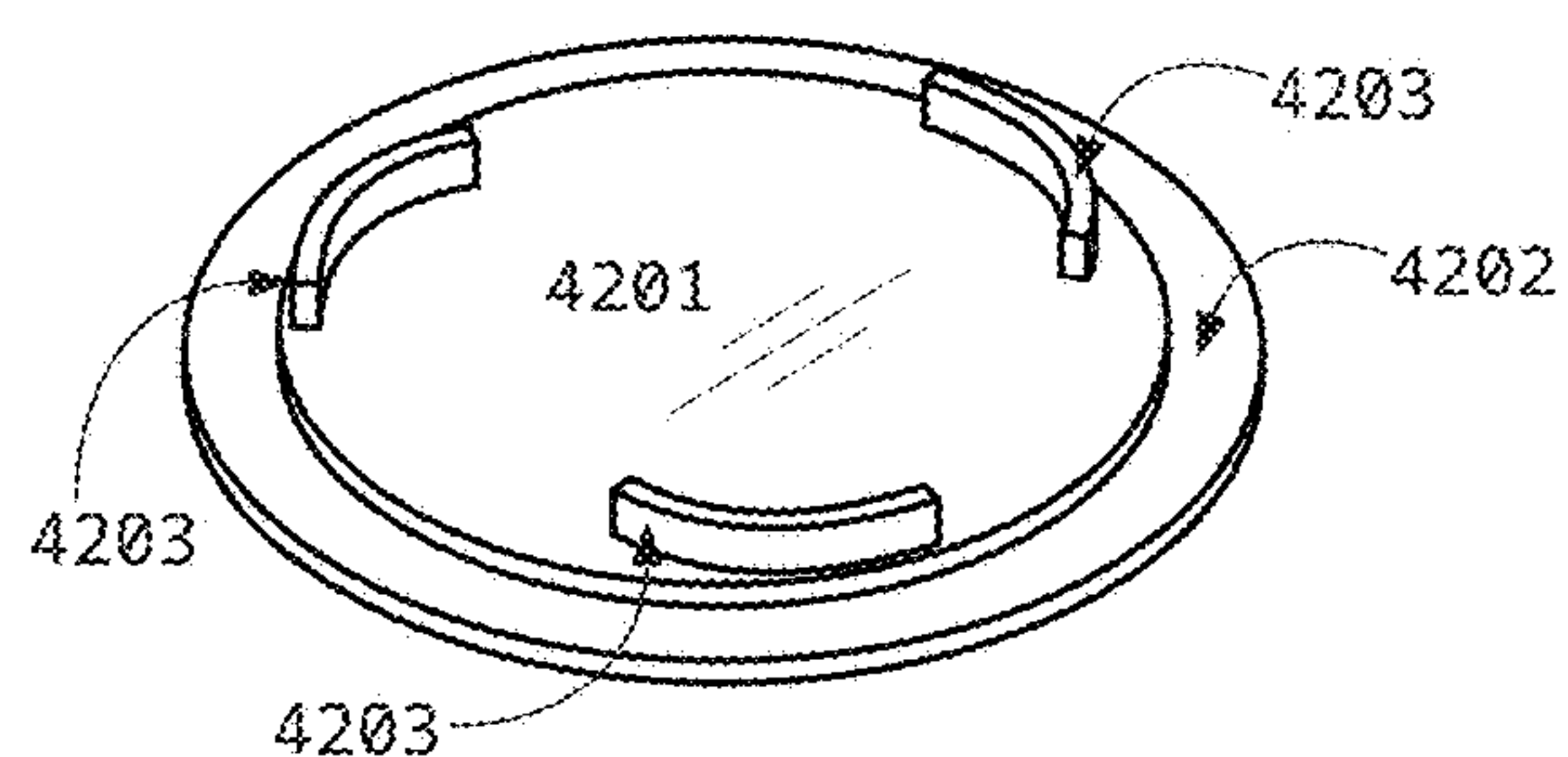


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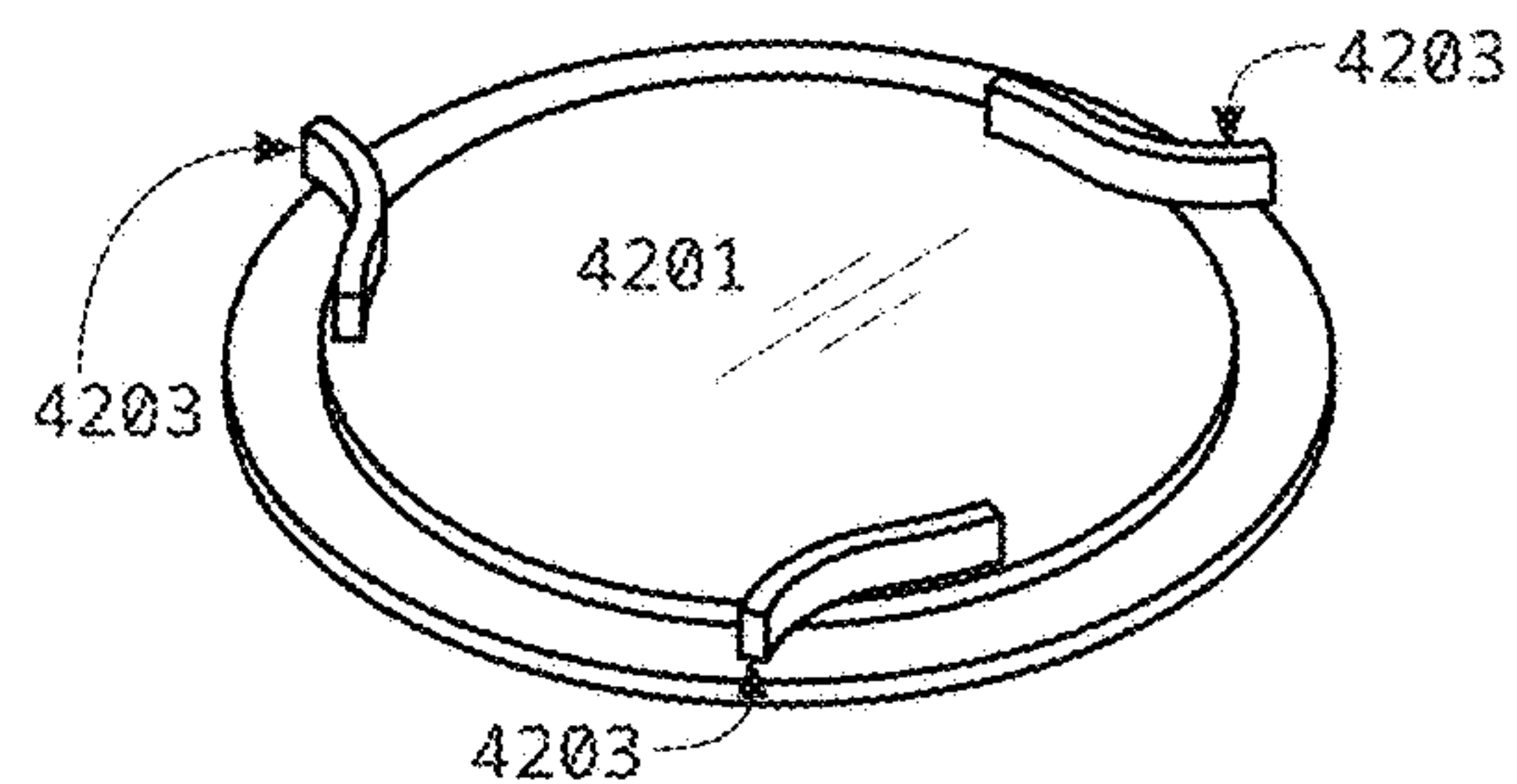


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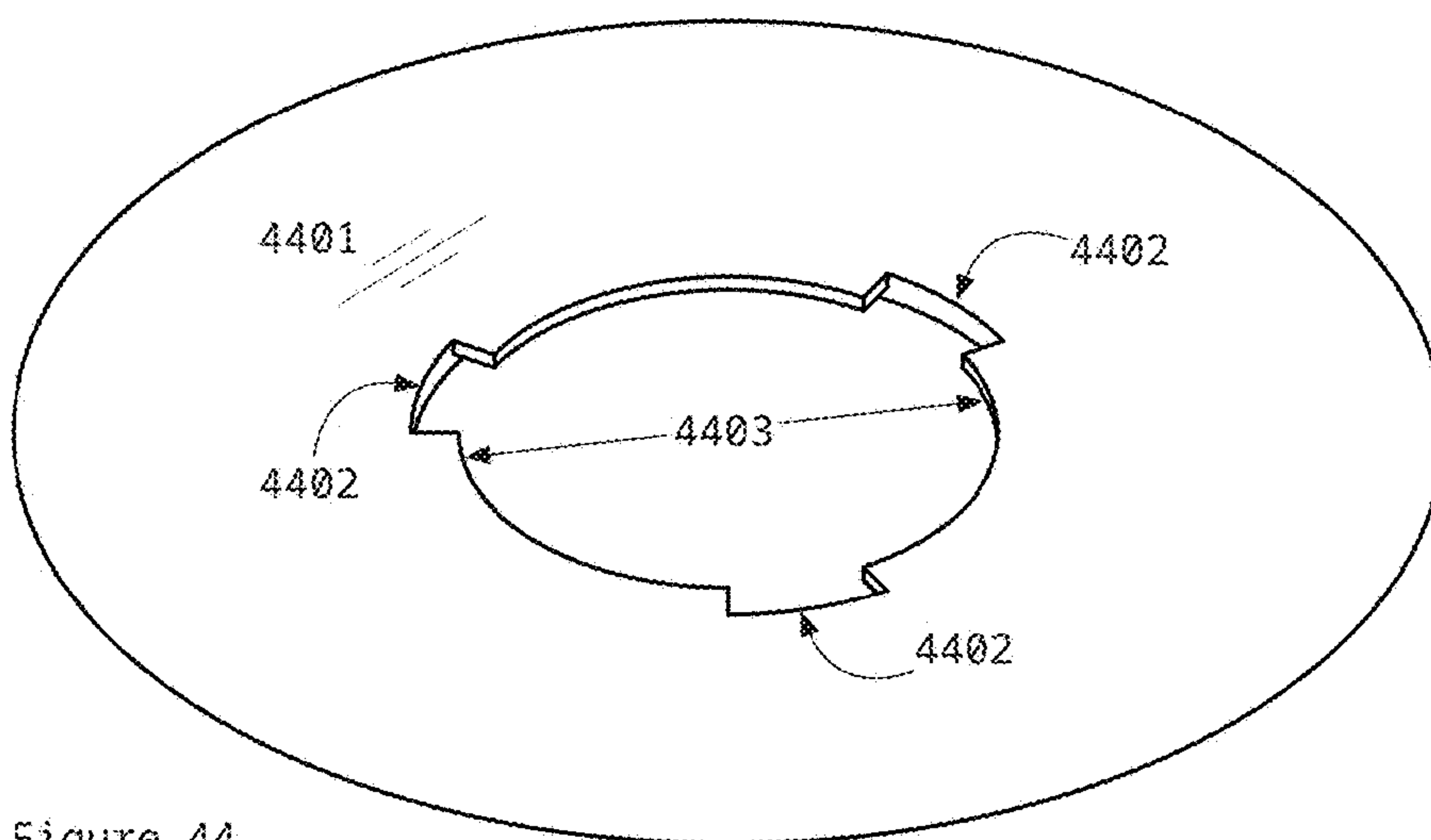


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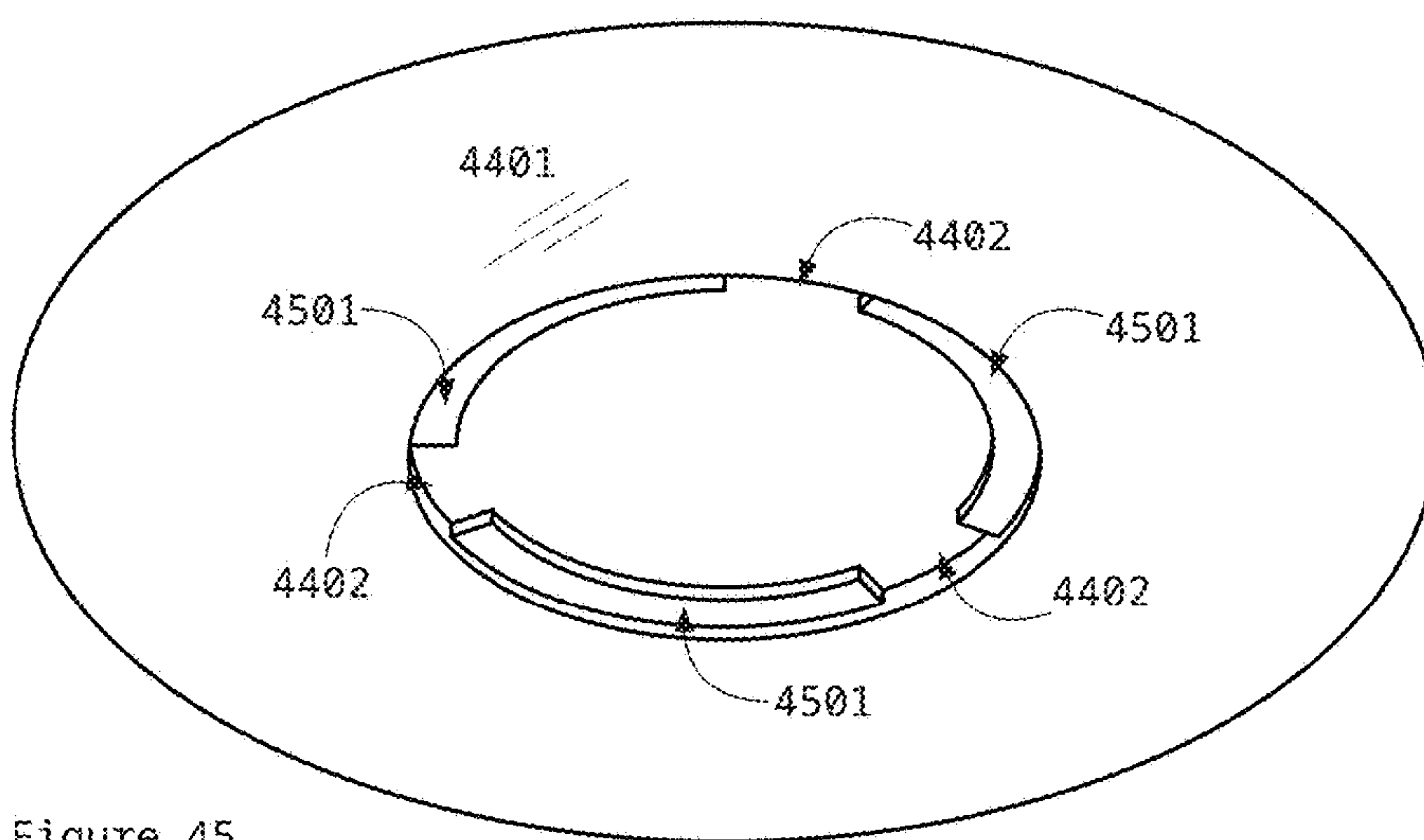


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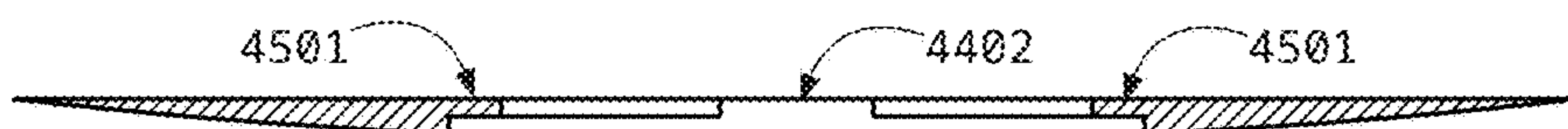


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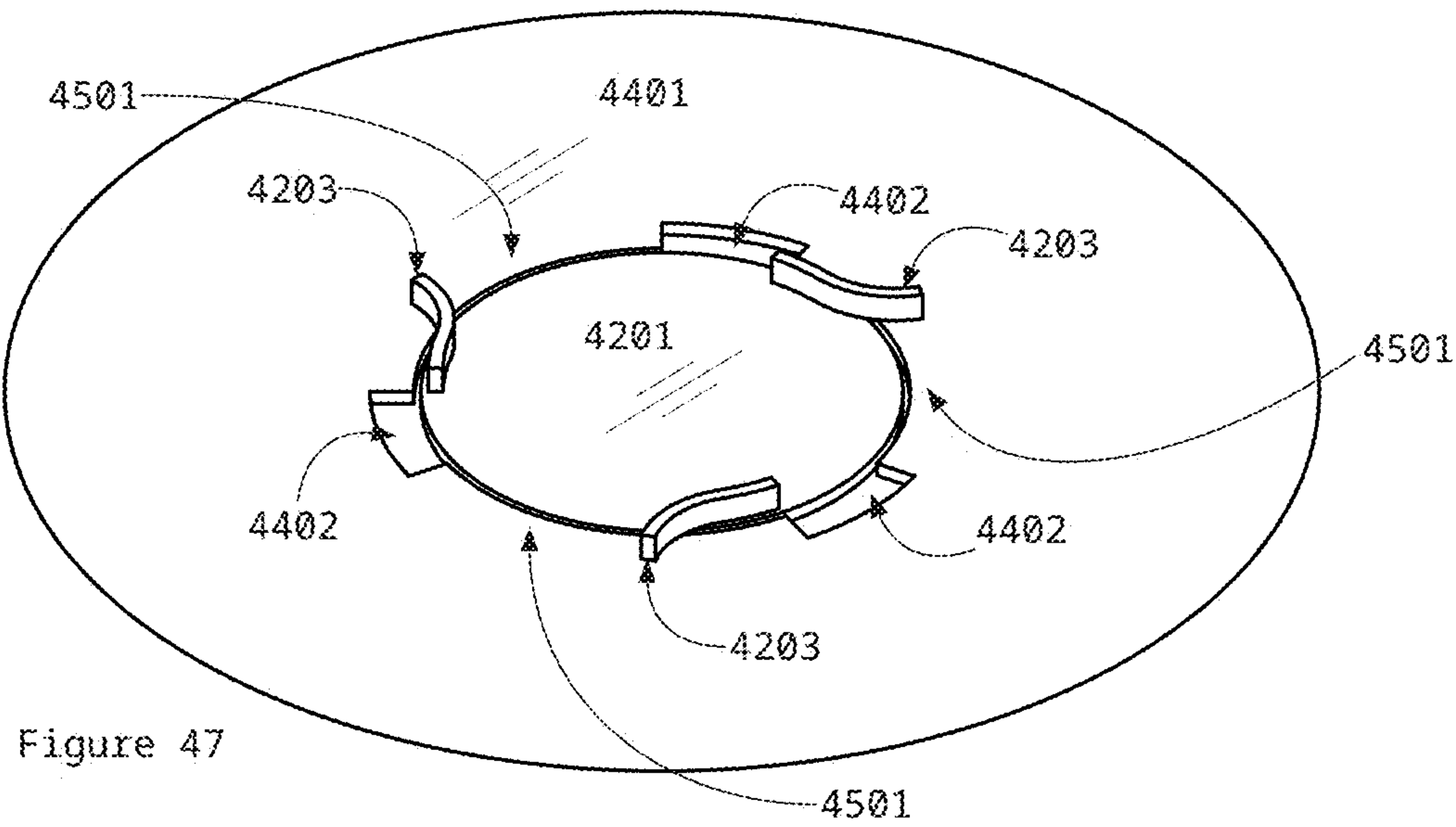


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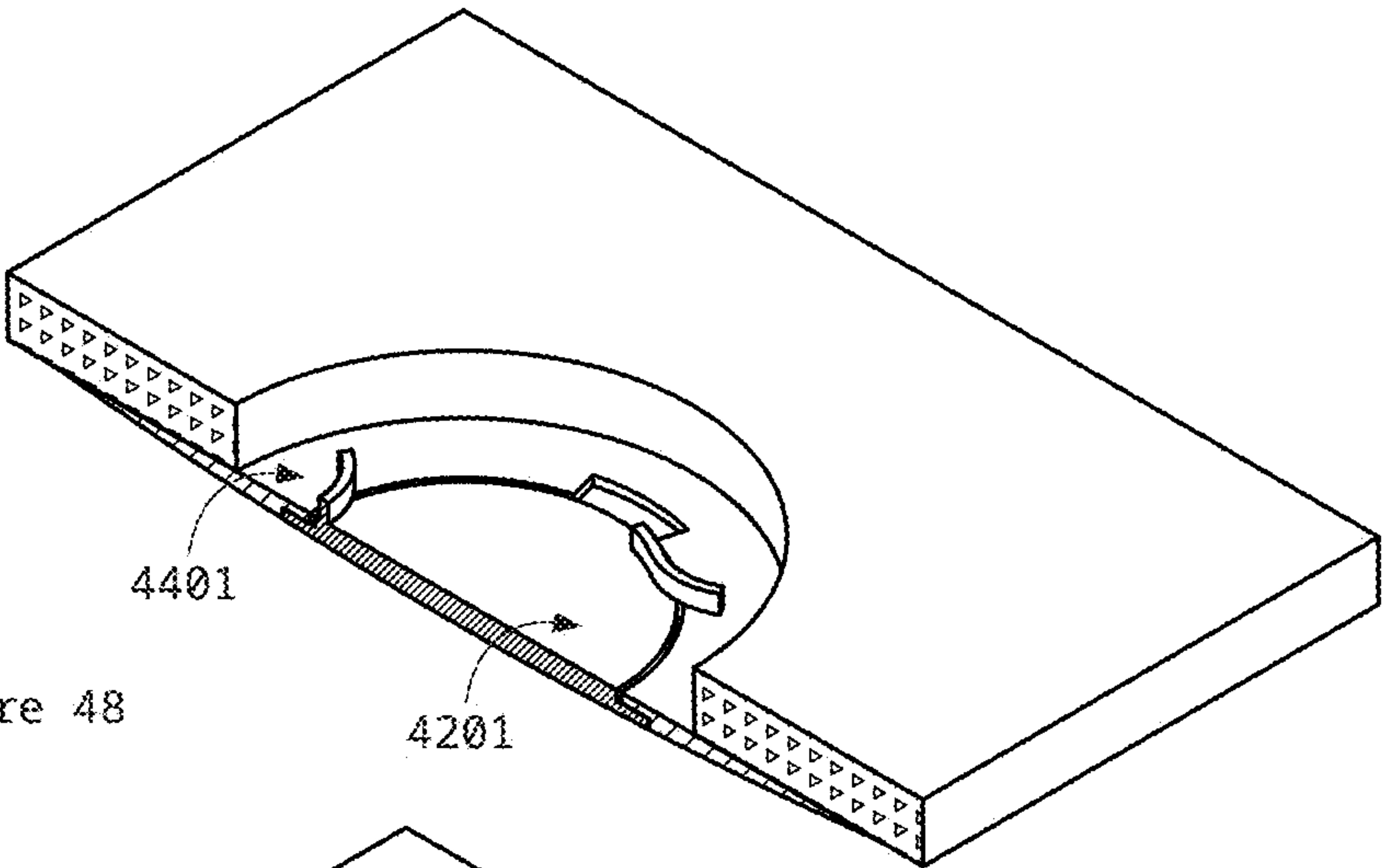


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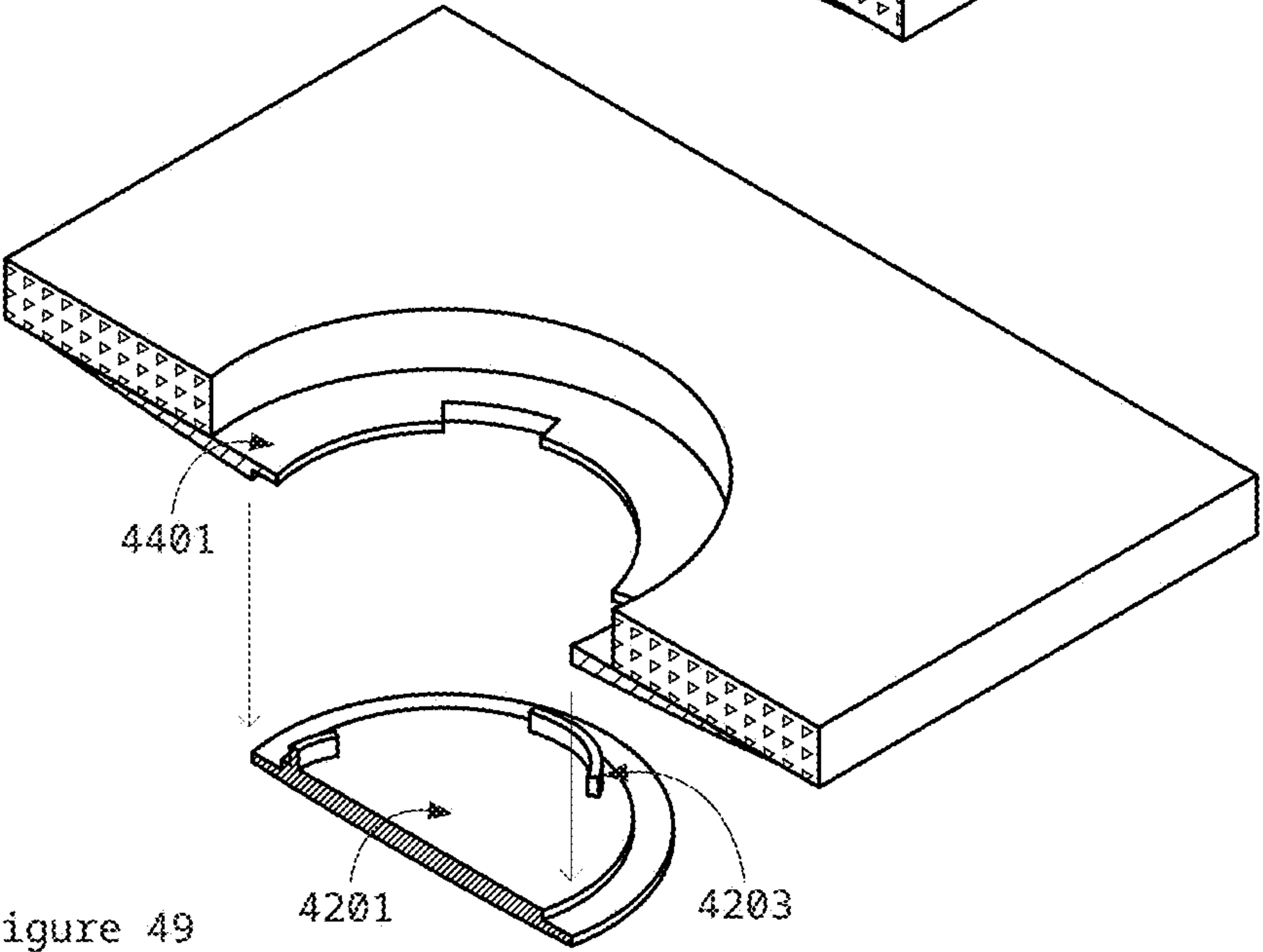


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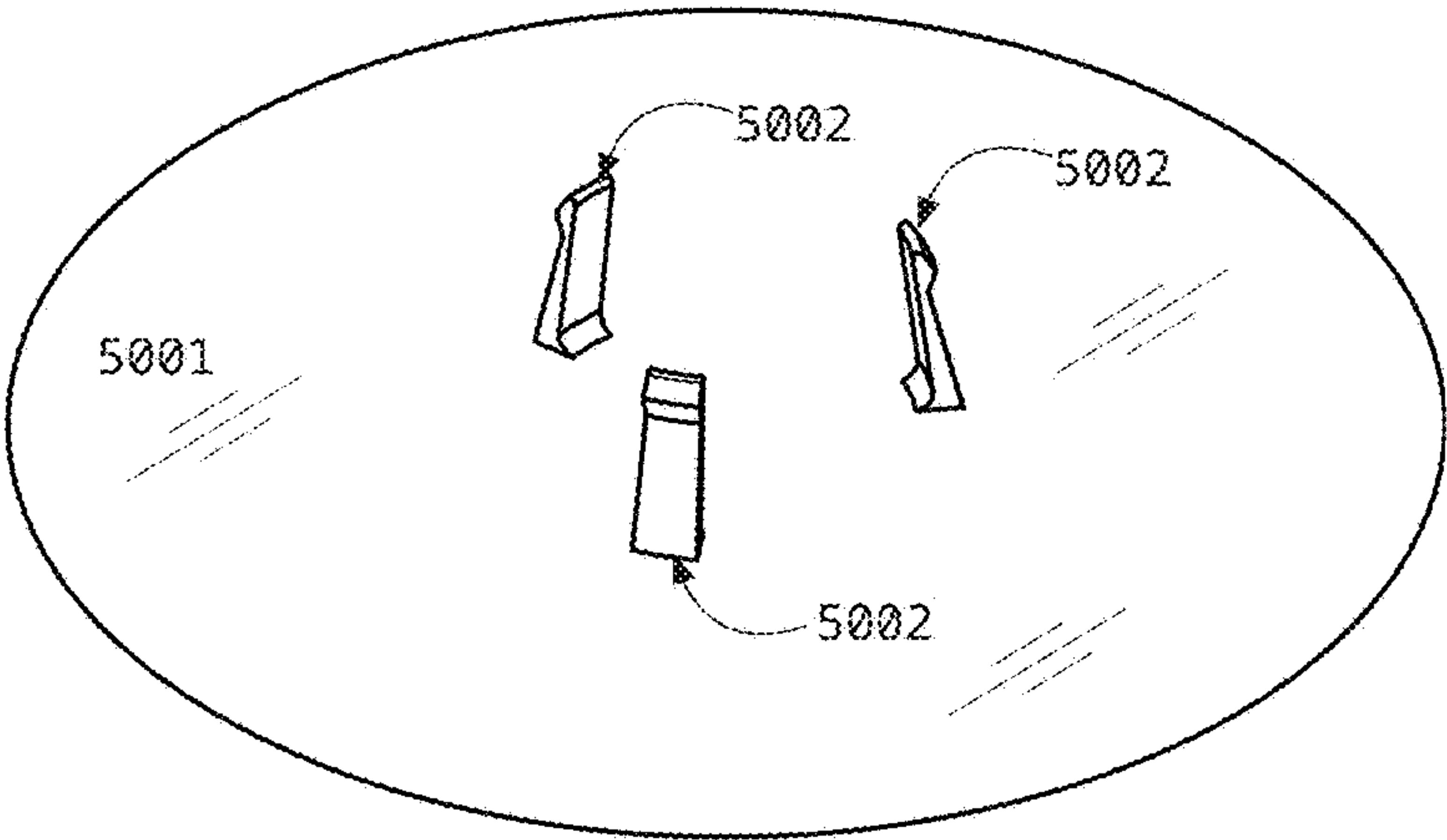


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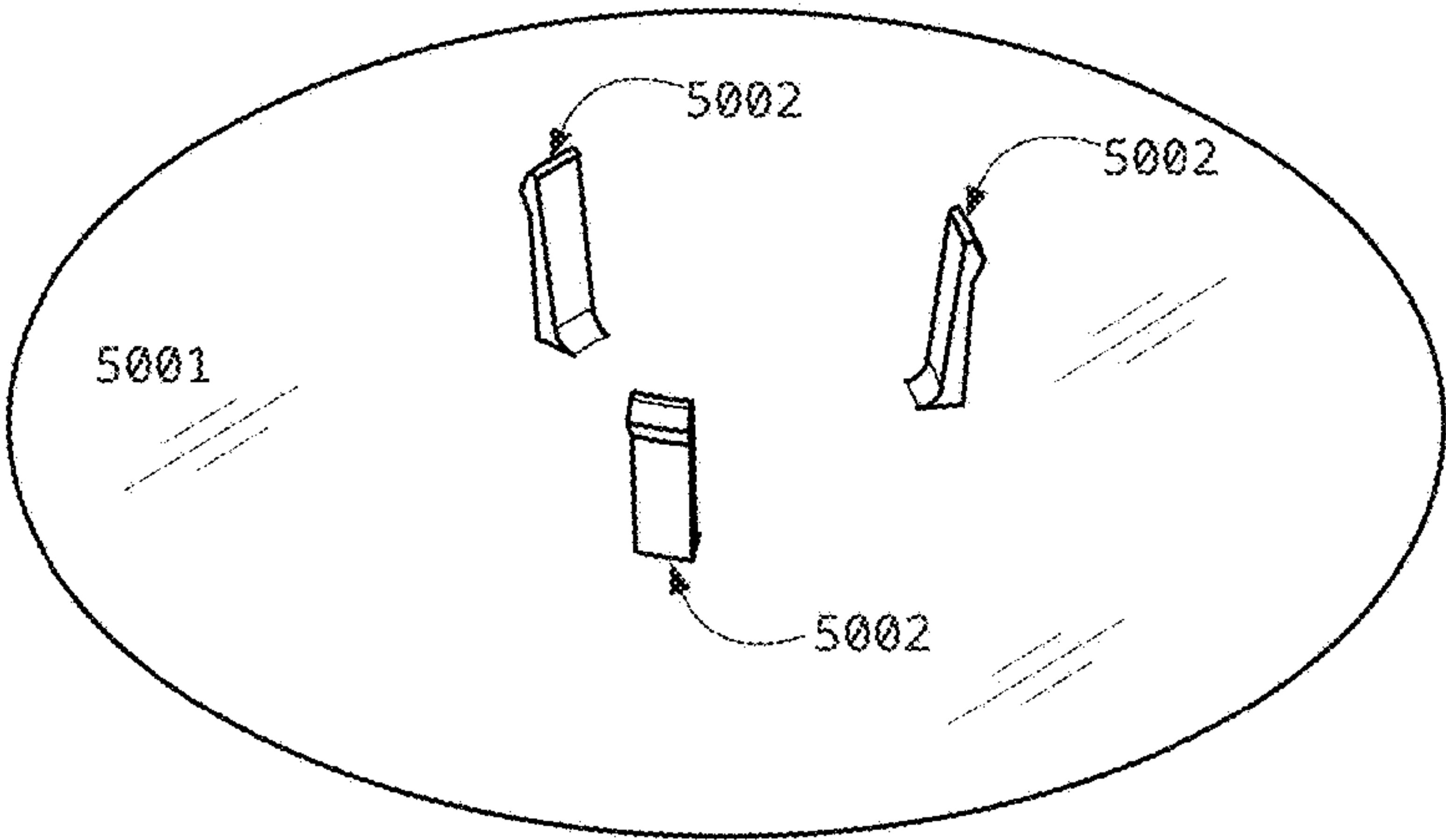


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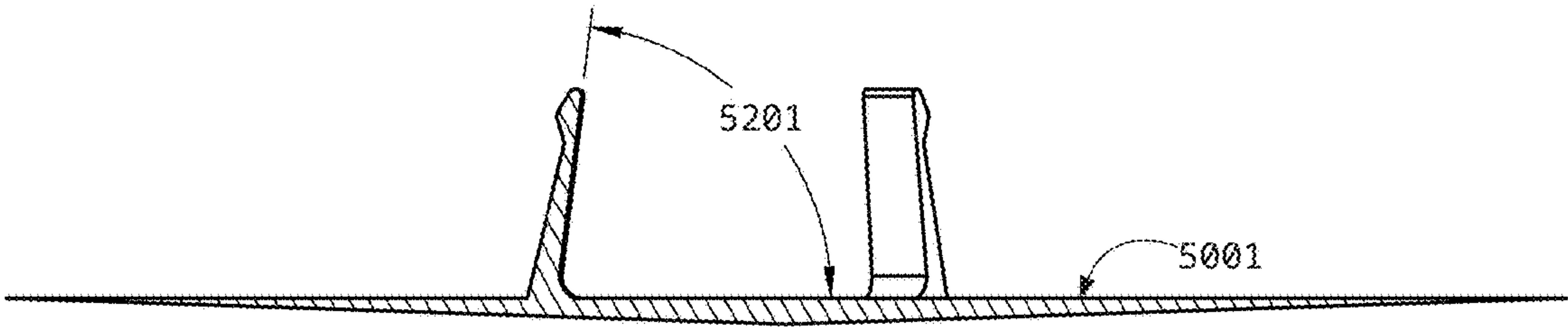


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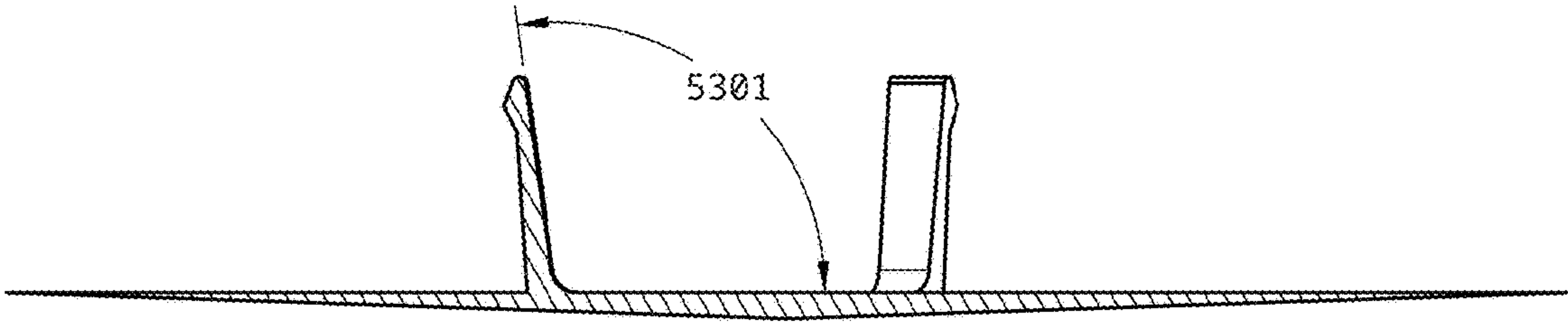


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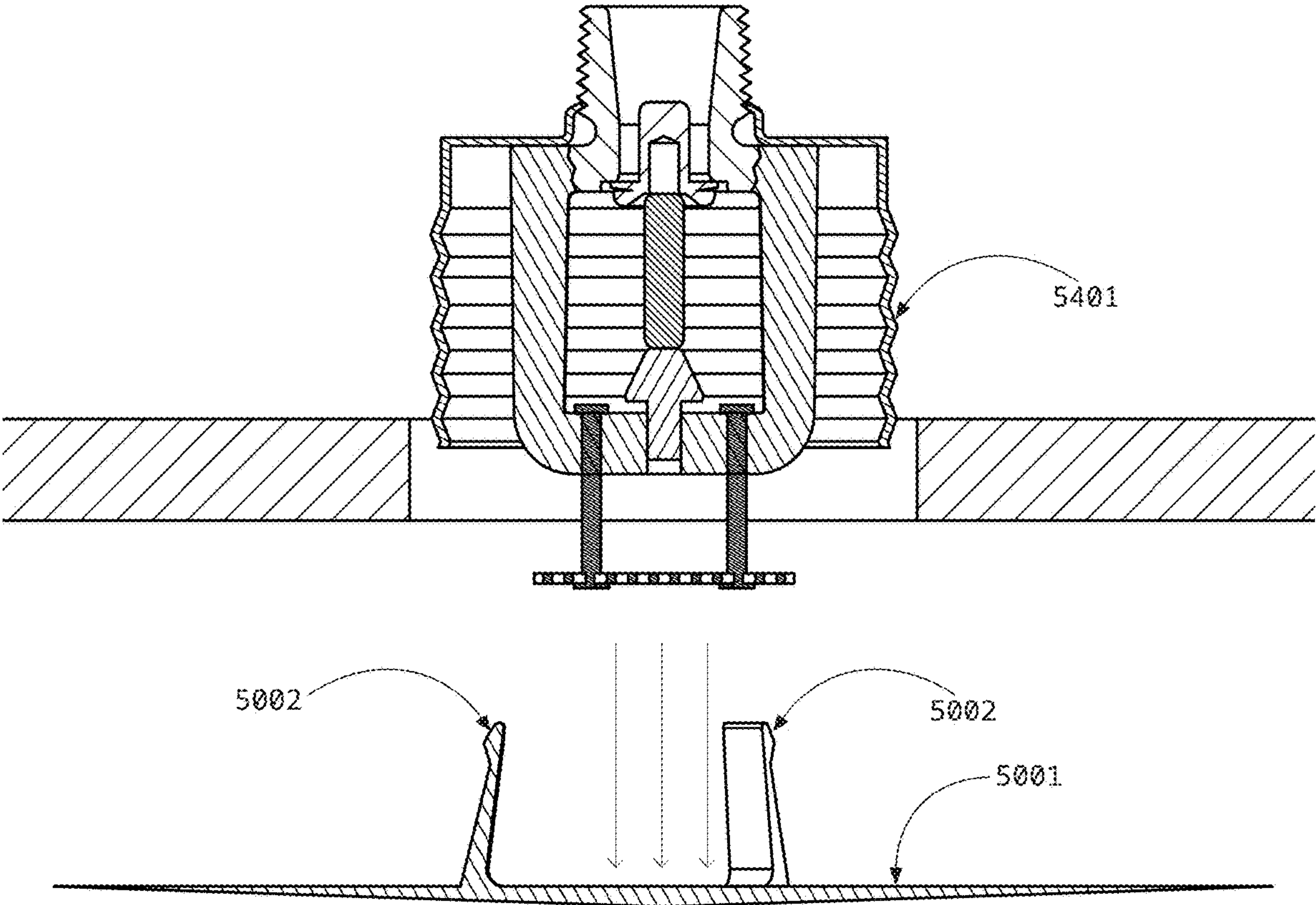
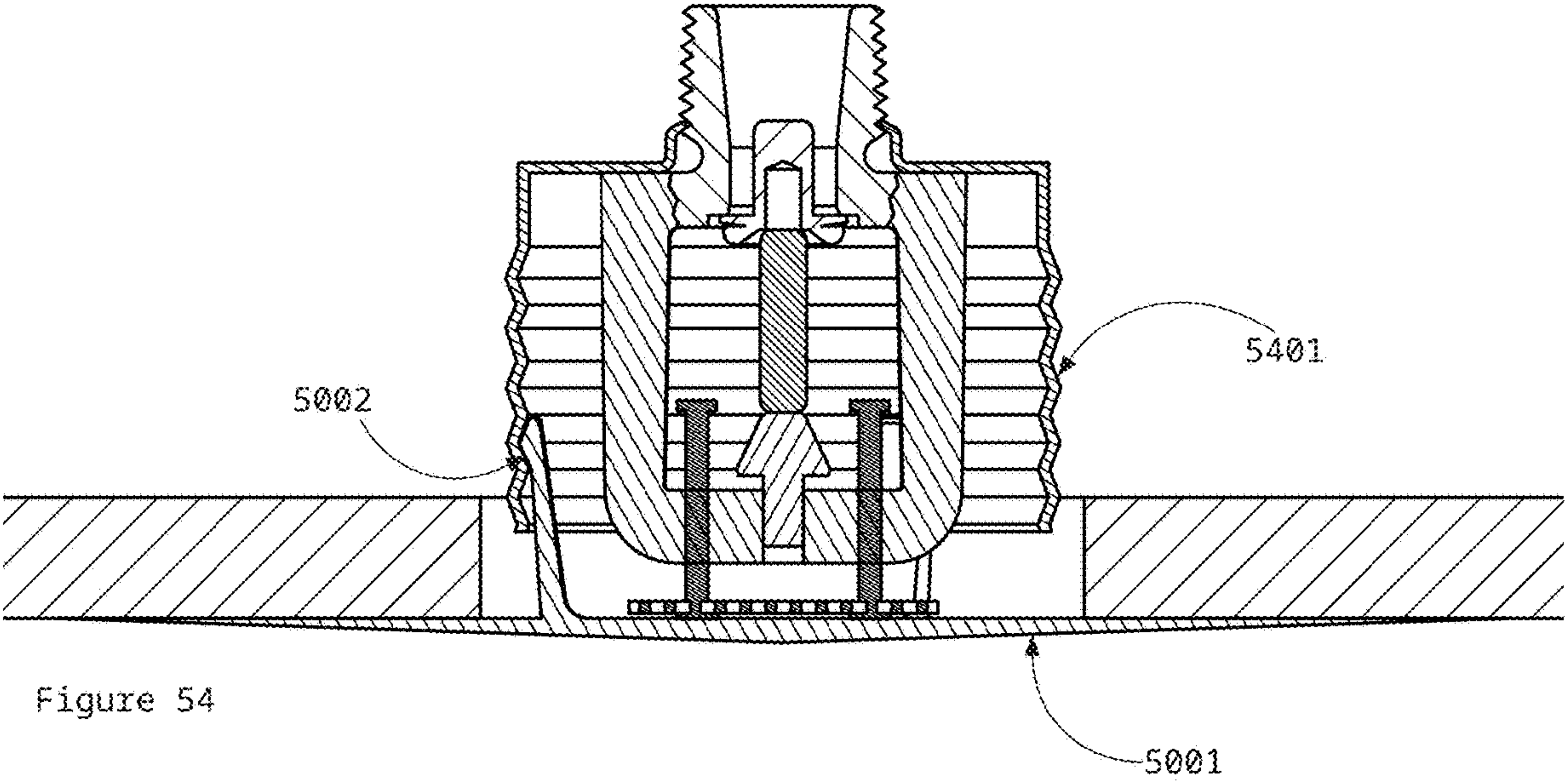


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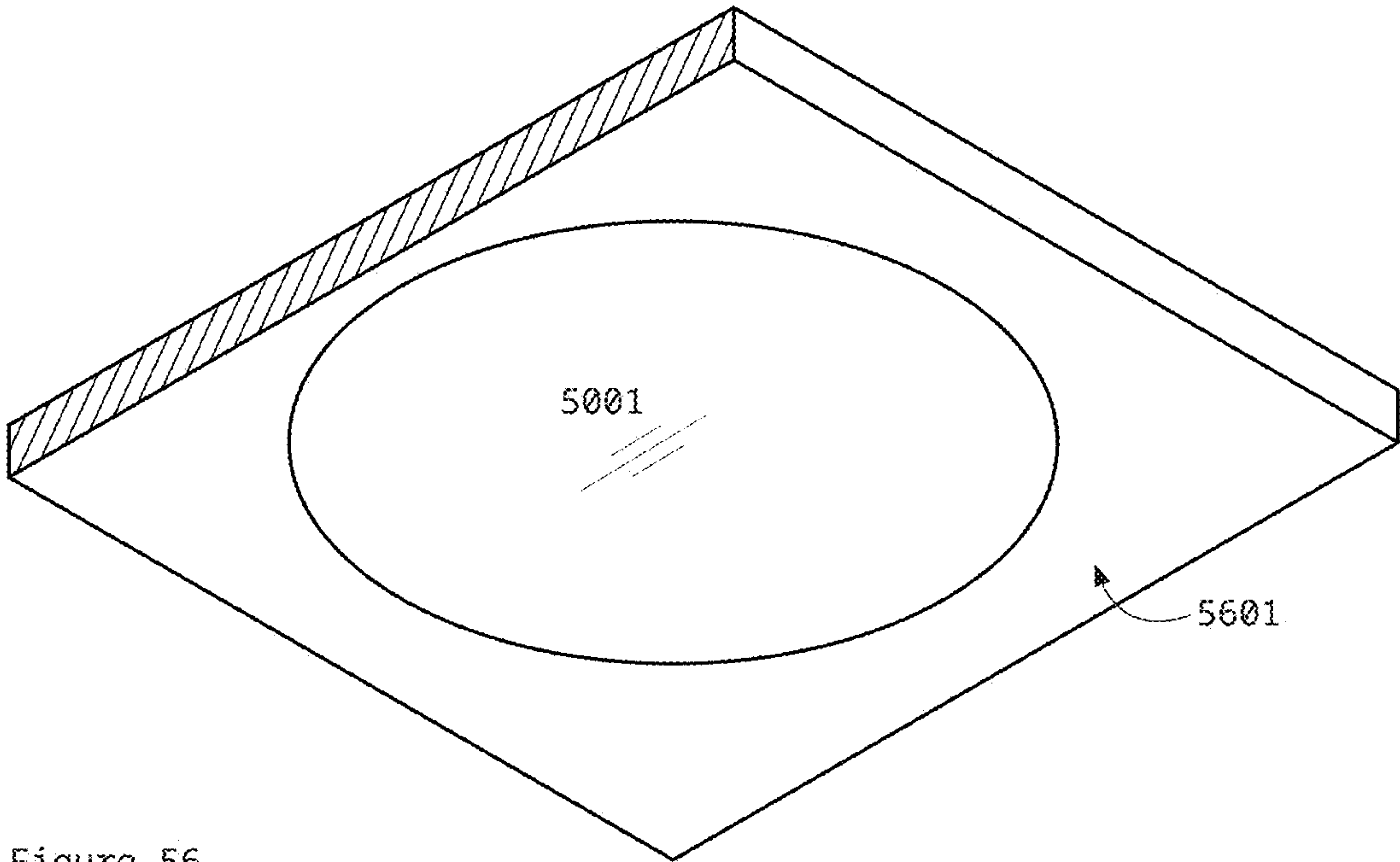


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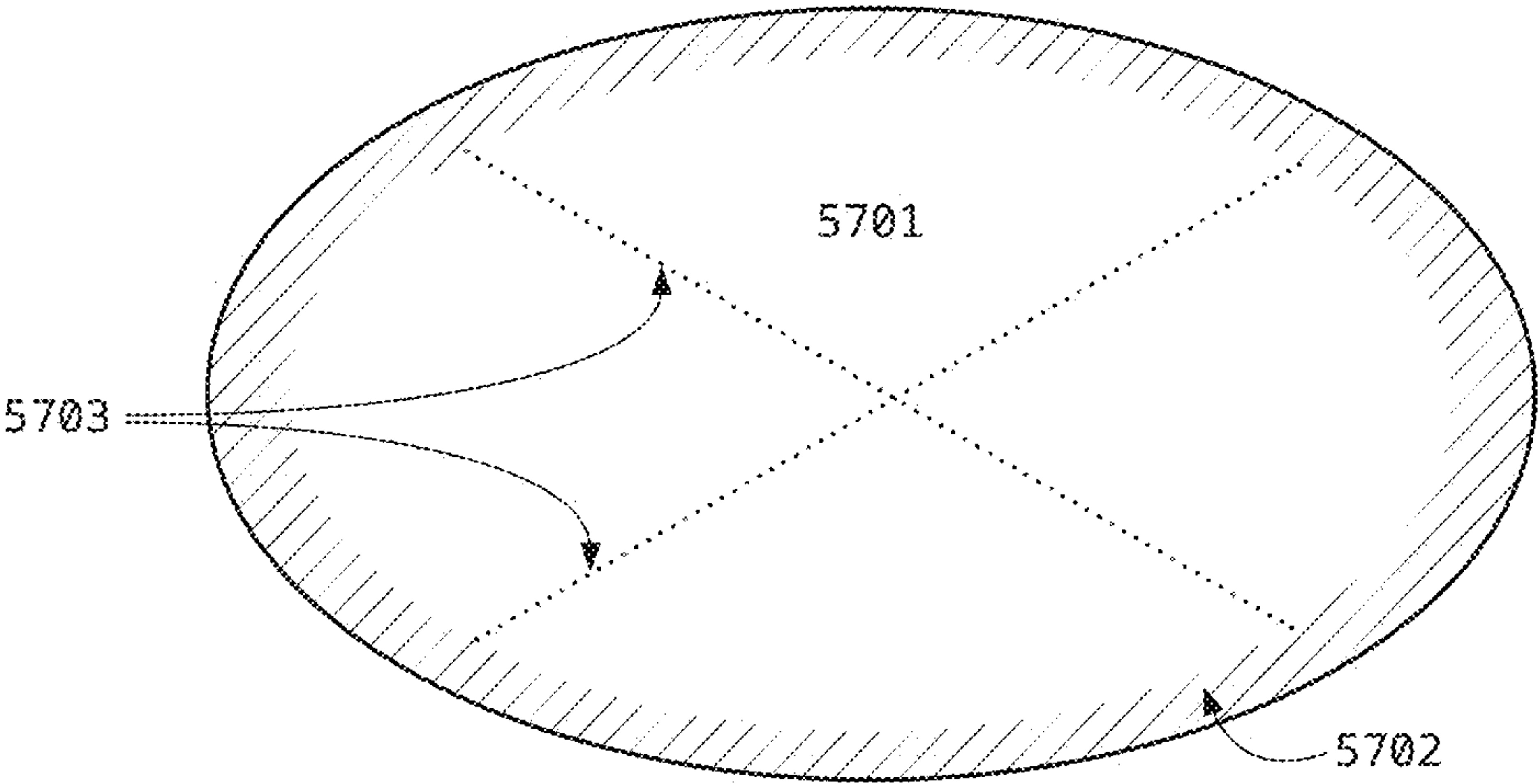


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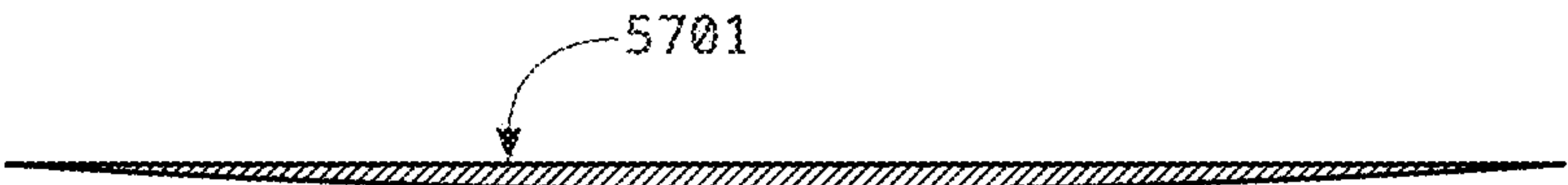


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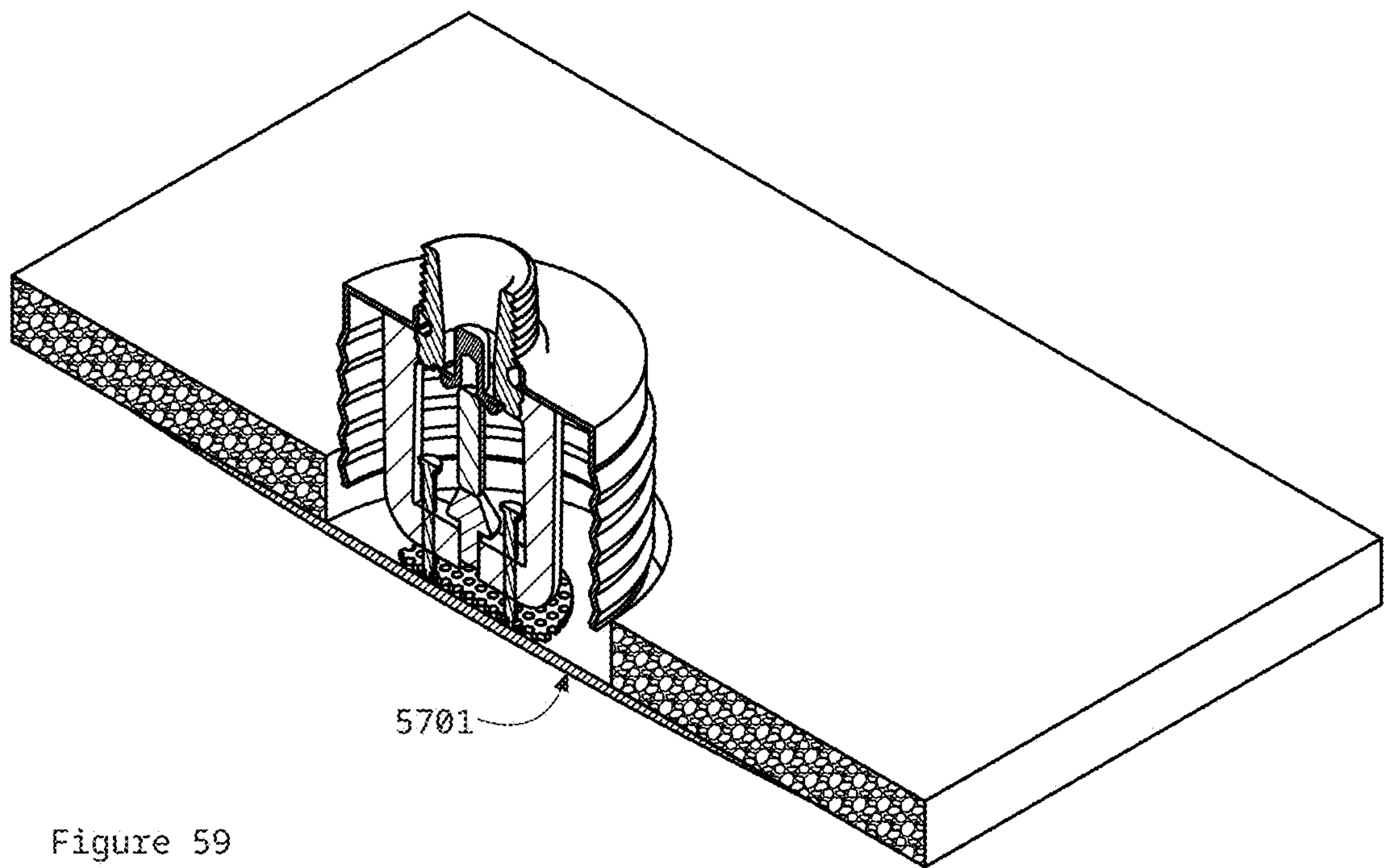


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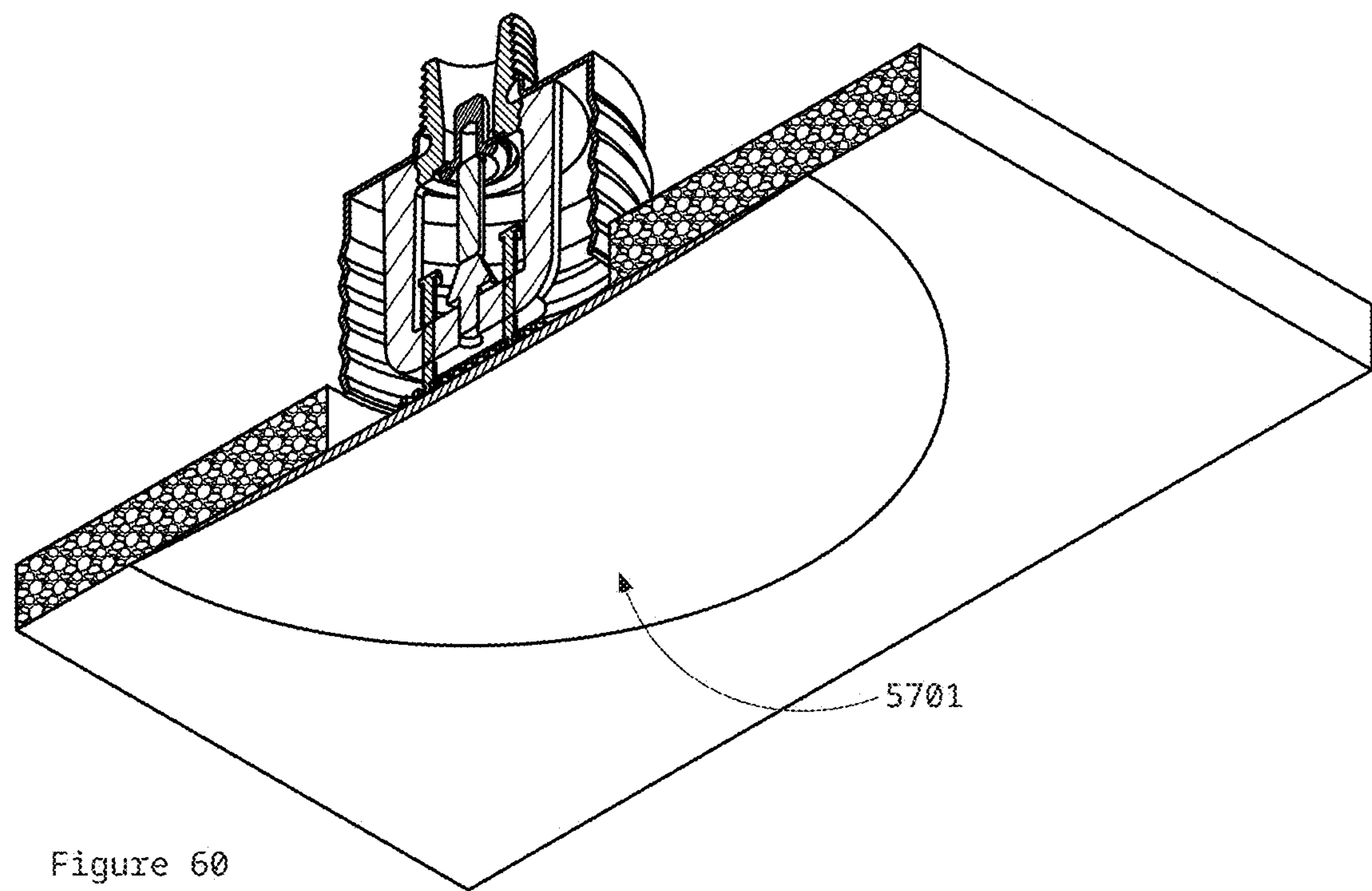


Figure 60

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CONCEALED SPRINKLER COVER

FIELD

The present disclosure generally relates to fire sprinkler covers, and more specifically to an apparatus and process utilizing temperature-responsive materials for removing a discrete sprinkler cover.

BACKGROUND

Sprinkler systems provide a means of extinguishing fires, but the systems are not always attractive or desired by designers. Sprinkler head covers were created to address aesthetics, but they are still visible and an undesirable distraction from the architecture.

Furthermore, the installation of these covers requires precisely positioning a hole in the ceiling, directly in line with the sprinkler head. These covers are generally soldered into the sprinkler head housing, creating a fixed connection, inhibiting safety inspections. The solder has a limited range of available melting temperatures. The solder also creates a physical bond between the cover and the sprinkler head housing, that generally requires an additional force to push the cover away from the ceiling.

A new sprinkler head cover is needed, that is easy to install, readily removed for inspection, detaches from the ceiling at a desired temperature, and is imperceptible.

SUMMARY

The sprinkler cover apparatus is designed to conceal a sprinkler head from view and is made from temperature-responsive materials. When exposed to a specified temperature, the cover detaches, allowing water to flow from the sprinkler unobstructed.

The apparatus comes in multiple embodiments. A two-piece version is comprised of a collar and a removable cover. The collar is affixed to the ceiling and features an aperture through which the sprinkler head discharges water, while the cover conceals the sprinkler during normal conditions. A single-piece version is mounted to a sprinkler head housing or directly to the ceiling. Designs also address aesthetic integration with the ceiling.

In some embodiments, covers and collars can be designed for different sized apertures. In some embodiments, the system is independent of the sprinkler itself, meaning the cover and collar do not physically contact the sprinkler head.

In some embodiments, the apparatus is comprised of actuators that facilitate the opening of the aperture. These actuators can be part of the cover, the collar, or separate from both. Actuators are comprised of temperature-responsive materials, which change shape or phase when heated. These materials can shift between a deformed and original shape, based on reaching a transformation temperature.

In some embodiments, shape-memory materials (e.g., shape-memory polymers and shape-memory alloys) are deformed, and then revert to their original shape when heated to a set temperature. The transformation temperature varies by embodiment, ranging from as low as 0° C. to as high as 100° C., but can exceed those limits if required by the circumstances.

Shape-memory polymers (SMPs) include polyurethanes, PLA, EVA, and others. SMPs can respond to multiple stimuli-heat, light, electricity, and more- and can stretch significantly (up to 800%). Additives such as carbon nano-tubes or metal powders can enhance SMP performance by

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improving thermal or electrical conductivity. This tailoring supports additional functionality depending on the use case.

Shape-memory alloys (SMAs), such as nickel-titanium or copper-based alloys, operate via solid-state phase transitions between martensite (deformable) and austenite (original) states. These materials are more costly and provide less strain but offer high force and environmental resistance. SMAs are typically found in wire or spring form, with customizable transformation temperatures. In some embodiments, electrical input may aid faster transformation by providing resistance heating, reducing actuation time to under one second.

Liquid crystalline polymers and elastomers (LCPs/LCEs) are shape-memory materials with reversible transformation between two solid states. In some embodiments, temperature-responsive materials are designed to melt, such as solder or wax, which then causes the cover to release. In some embodiments, these melting materials are encased in higher melting point tubes to create actuators that reset shape as the material melts. Bimetals offer another solution, converting temperature changes into mechanical movement due to differing expansion rates of bonded metals. They provide simple, controlled displacement for actuation.

The figures illustrate various embodiments. Covers with temperature-responsive actuators may insert into a collar, connect directly with a sprinkler head housing, or attach directly to the ceiling. When the cover reaches transformation temperature, it falls away, enabling the sprinkler to operate.

BRIEF DESCRIPTION OF THE DRAWINGS

Particular descriptions of the principles briefly described above are rendered by specific embodiments illustrated in the drawings. These drawings depict only exemplary embodiments of the disclosure and are not limiting of its scope. The principles and advantages herein are described and explained with additional specificity and detail by the accompanying drawings in which:

FIG. 1 shows a top perspective view of one embodiment of a sprinkler cover in its original shape.

FIG. 2 shows a top perspective view of one embodiment of a sprinkler cover in its deformed shape.

FIG. 3 shows a top perspective view of one embodiment of a sprinkler collar.

FIG. 4 shows a top perspective view of one embodiment of a sprinkler cover in its deformed shape installed in a collar.

FIG. 5 shows a bottom perspective view of one embodiment of a sprinkler collar installed below an opening.

FIG. 6 shows a top perspective view of one embodiment of a sprinkler collar installed below an opening.

FIG. 7 shows a bottom perspective view of one embodiment of a sprinkler cover and collar installed below an opening.

FIG. 8 shows a bottom perspective view of one embodiment of a sprinkler cover and collar installed below an opening, with paint over the sprinkler collar.

FIG. 9 shows a top perspective view of one embodiment of a sprinkler cover and collar installed below an opening.

FIG. 10 shows a side section cut of one embodiment of a sprinkler cover and collar installed below an opening.

FIG. 11 shows a side section cut of one embodiment of a sprinkler collar installed below an opening, where the cover has fallen away.

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FIG. 12 shows a top perspective section cut view of one embodiment of a sprinkler cover and collar installed below an opening.

FIG. 13 shows a top perspective section cut view of one embodiment of a sprinkler collar installed below an opening, where the cover has fallen away.

FIG. 14 shows a top view of one embodiment of three actuators in their original shape for a sprinkler cover.

FIG. 15 shows a top view of one embodiment of three actuators in their deformed shape for a sprinkler cover.

FIG. 16 shows a section cut of one embodiment of an actuator.

FIG. 17 shows a top view of one embodiment of three actuators in their original shape installed in a sprinkler cover.

FIG. 18 shows a top view of one embodiment of three actuators in their deformed shape installed in a sprinkler cover.

FIG. 19 shows a top perspective view of one embodiment of three actuators in their original shape installed in a sprinkler cover.

FIG. 20 shows a top perspective view of one embodiment of three actuators in their deformed shape installed in a sprinkler cover.

FIG. 21 shows a top view of one embodiment of three actuators in their original shape installed in a sprinkler cover.

FIG. 22 shows a top perspective view of one embodiment of three actuators in their original shape installed in a sprinkler cover.

FIG. 23 shows a top view of one embodiment of three actuators in their deformed shape installed in a sprinkler cover.

FIG. 24 shows a top perspective view of one embodiment of three actuators in their deformed shape installed in a sprinkler cover.

FIG. 25 shows a top perspective view of one embodiment of a ring actuator in its original shape.

FIG. 26 shows a top perspective view of one embodiment of a ring actuator in its deformed shape.

FIG. 27 shows a top perspective view of one embodiment of a sprinkler cover configured to hold a ring actuator.

FIG. 28 shows a top perspective view of one embodiment of a sprinkler cover and a ring actuator its original shape.

FIG. 29 shows a top perspective view of one embodiment of a sprinkler cover and a ring actuator its deformed shape.

FIG. 30 shows a top view of one embodiment of a triangle actuator comprised of shape memory polymer.

FIG. 31 shows a top view of one embodiment of a triangle actuator comprised of shape memory alloy.

FIG. 32 shows a top perspective view of one embodiment of a sprinkler cover configured to hold a triangle actuator.

FIG. 33 shows a top perspective view of one embodiment of a sprinkler cover and a triangle actuator its original shape.

FIG. 34 shows a top perspective view of one embodiment of a sprinkler cover and a triangle actuator its deformed shape.

FIG. 35 shows a top perspective view of one embodiment of a sprinkler collar with a structural ring flange around the sprinkler opening.

FIG. 36 shows a top perspective view of one embodiment of a sprinkler cover with a triangle actuator installed in a collar with a structural ring flange around the sprinkler opening.

FIG. 37 shows a section cut view of one embodiment of a sprinkler collar with a structural ring flange around the sprinkler opening.

FIG. 38 shows a section cut view of one embodiment of a sprinkler cover and a triangle actuator its deformed shape.

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FIG. 39 shows a top perspective section cut view of one embodiment of a sprinkler cover with a triangle actuator and collar installed below an opening.

FIG. 40 shows a bottom perspective view of one embodiment of a sprinkler cover with a triangle actuator and collar installed below an opening.

FIG. 41 shows a bottom perspective section cut view of one embodiment of a sprinkler collar with a structural ring flange installed below an opening.

FIG. 42 shows a top perspective view of one embodiment of a sprinkler cover with cover flange in its original shape.

FIG. 43 shows a top perspective view of one embodiment of a sprinkler cover with cover flange in its deformed shape.

FIG. 44 shows a top perspective view of one embodiment of a sprinkler collar with notches.

FIG. 45 shows a bottom perspective view of one embodiment of a sprinkler collar with notches.

FIG. 46 shows a section cut view of one embodiment of a sprinkler collar with notches.

FIG. 47 shows a top perspective view of one embodiment of a sprinkler cover with cover flange in its deformed shape installed in a collar with notches.

FIG. 48 shows a top perspective section cut view of one embodiment of a sprinkler cover with cover flange in its deformed shape installed in a collar with notches.

FIG. 49 shows a top perspective section cut view of one embodiment of a sprinkler collar with notches installed below an opening, where a sprinkler cover with cover flange has fallen away.

FIG. 50 shows a top perspective view of one embodiment of an insertable sprinkler cover in its original shape.

FIG. 51 shows a top perspective view of one embodiment of an insertable sprinkler cover in its deformed shape.

FIG. 52 shows a section cut view of one embodiment of an insertable sprinkler cover in its original shape.

FIG. 53 shows a section cut view of one embodiment of an insertable sprinkler cover in its deformed shape.

FIG. 54 shows a section cut view of one embodiment of an insertable sprinkler cover installed in an opening.

FIG. 55 shows a section cut view of one embodiment of an insertable sprinkler cover having fallen away from an opening.

FIG. 56 shows a bottom perspective view of one embodiment of an insertable sprinkler cover installed in an opening.

FIG. 57 shows a bottom perspective view of one embodiment of a sheet sprinkler cover in its deformed shape.

FIG. 58 shows a side section cut of one embodiment of a sheet sprinkler cover in its deformed shape.

FIG. 59 shows a top perspective section cut view of one embodiment of a sheet sprinkler cover installed below an opening.

FIG. 60 shows a bottom perspective section cut view of one embodiment of a sheet sprinkler cover installed below an opening.

DETAILED DESCRIPTION

The description set forth below in connection with the appended drawings is intended to be a description of various illustrative embodiments of the disclosed subject matter. Specific features and functionalities are described in connection with each illustrative embodiment; however, it will be apparent to those skilled in the art that the disclosed embodiments may be practiced without each of those specific features and functionalities.

Reference throughout the specification to “one embodiment” or “an embodiment” means that a particular feature,

structure, or characteristic described in connection with an embodiment is included in at least one embodiment of the subject matter disclosed. Thus, the appearance of the phrases “in one embodiment” or “in an embodiment” in various places throughout the specification is not necessarily referring to the same embodiment. Further, the particular features, structures or characteristics may be combined in any suitable manner in one or more embodiments. Further, it is intended that embodiments of the disclosed subject matter cover modifications and variations thereof.

It must be noted that, as used in the specification and the appended claims, the singular forms “a,” “an,” and “the” include plural referents unless the context expressly dictates otherwise. That is, unless expressly specified otherwise, as used herein the words “a,” “an,” “the,” and the like carry the meaning of “one or more.” Additionally, it is to be understood that terms such as “left,” “right,” “top,” “bottom,” “front,” “rear,” “side,” “height,” “length,” “width,” “upper,” “lower,” “interior,” “exterior,” “inner,” “outer,” and the like that may be used herein merely describe points of reference and do not necessarily limit embodiments of the present disclosure to any particular orientation or configuration. Furthermore, terms such as “first,” “second,” “third,” etc., merely identify one of a number of portions, components, steps, operations, functions, and/or points of reference as disclosed herein, and likewise do not necessarily limit embodiments of the present disclosure to any particular configuration or orientation.

Furthermore, the terms “approximately,” “about,” “proximate,” “minor variation,” and similar terms generally refer to ranges that include the identified value within a margin of 20%, 10% or preferably 5% in certain embodiments, and any values therebetween.

All of the functionalities described in connection with one embodiment are intended to be applicable to the additional embodiments described below except where expressly stated or where the feature or function is incompatible with the additional embodiments. For example, where a given feature or function is expressly described in connection with one embodiment but not expressly mentioned in connection with an alternative embodiment, it should be understood that the inventors intend that that feature or function may be deployed, utilized or implemented in connection with the alternative embodiment unless the feature or function is incompatible with the alternative embodiment.

A sprinkler cover apparatus hides a sprinkler head from view. The sprinkler cover apparatus is comprised of temperature-responsive materials. When the materials reach a certain temperature (e.g., as the result of a fire), the cover falls away, permitting the sprinkler head to emit water without obstruction. In some embodiments, the sprinkler cover apparatus is comprised of one piece applied directly to the ceiling. In other embodiments, the sprinkler cover apparatus is comprised of two pieces, a cover and a collar. The collar is applied to the ceiling, and provides an aperture through which the sprinkler head emits water. A cover is placed within the aperture to hide the sprinkler head from view during normal conditions.

Covers and collars may be configured to span any sized opening and allow any sized aperture for the emission of water. In one embodiment, the apparatus is independent of the sprinkler system. The cover and collar have no direct contact with the sprinkler head.

In one embodiment, an actuator moves, causing the sprinkler cover to open the aperture. In one embodiment, the actuator is a component of the cover. In another embodiment, the actuator is a component of the collar. In other

embodiments, the actuator is independent of the cover and collar. In one embodiment, the actuator is comprised of temperature-responsive material.

In one embodiment, a temperature-responsive material is configured to form at least two shapes, an original shape, and a deformed shape. Both the original shape and the deformed shape may be fixed to desired geometries. The material has a specified transformation temperature, which is selected as an inherent property. Transformation temperatures may also be referred to as transition temperatures, as they cause the transition between phases as well as shape. In some embodiments, the transformation temperature is referred to as an activation temperature. The material reverts from its deformed shape to its original shape at or above the transformation temperature. Example temperature-responsive materials include shape-memory polymers, shape-memory alloys, liquid crystalline polymers, alloys, bi-metals, and waxes.

In one embodiment, while the material is below the transformation temperature, the material is mechanically manipulated, and deformed, to create its deformed shape. The material is then heated to the transformation temperature, causing the material to revert to its original shape. This process of deformation to the deformed shape and transformation back to the original shape may occur multiple times over the life of the material.

In one embodiment, the transformation temperature is specified at 40° C. In another embodiment, the transformation temperature is specified at 50° C. In another embodiment, the transformation temperature is specified at 57° C. In another embodiment, the transformation temperature is specified at 74° C. The transformation temperature may be specified as low as 0° C., or as high as 100° C.

In alternative embodiments, the temperature-responsive material may also respond to an electrical stimulus. An electrical charge may invoke a transformation from the deformed shape back to the original shape.

In one embodiment, the temperature-responsive material is a shape-memory polymer (SMP). Example SMPs include polyurethanes (PU), polytetrafluoroethylene (PTFE), polylactide (PLA), ethylene-vinyl acetate (EVA), and polyester blends such as poly (ϵ -caprolactone) and poly (butylene terephthalate). SMPs can undergo transformations from a deformed shape to an original shape through a variety of external stimuli. These include changes in temperature, as well as light, electricity, magnetic field, and pH.

SMPs may possess a wide range of physical characteristics. They may be soft or hard, elastic or rigid, thermoplastic or thermoset. SMP's may deform by stretching up to 800% from their original shape. They are generally low in cost, making them suitable for large scale manufacturing.

SMPs may include a variety of additives, providing them with additional properties. In one embodiment, the temperature-responsive material is further comprised of carbon nanotubes, short carbon fibers, carbon black, or metallic nanoparticles and powders, which can increase their thermal and electrical conductivity.

In one embodiment, the temperature-responsive material is a shape-memory alloy (SMA). Example SMAs include copper-zinc-aluminum alloys, copper-aluminum-nickel alloys, and nickel-titanium alloys. SMAs can also be created by alloying zinc, copper, gold, iron, and other elements.

SMAs have at least two solid phases, a martensite phase and an austenite phase. The martensite phase is invoked at temperatures below the transformation temperature and permits deformation from an original shape to a deformed shape through mechanical stress. The austenite phase is

invoked upon the application of heat at or above a transformation temperature and causes the SMA to return to the original shape.

SMA may have a wide range of transformation temperatures. Example commercial SMA wires have transformation temperatures of -32°C ., -20°C ., 0°C ., 15°C ., 30°C ., 40°C ., 45°C ., 50°C ., 60°C ., 70°C ., 80°C ., and 90°C . The transformation temperature can be tailored.

SMA can provide large displacements and forces, and offer good resistance to oxidation, corrosion, and other forms of degradation. In one embodiment, an electrical charge may stimulate the transformation from the deformed shape to the original shape. In some embodiments, the electrical charge provides heat through resistance, as supplemental heat to reach the transformation temperature.

SMA are generally denser and more expensive than SMPs. Commercial embodiments are typically in the form of wires, plates, and springs. A custom shape would be more expensive. SMA provide a relatively lower strain, allowing the material to deform only up to 10%. In some embodiments, the temperature-responsive material is configured in a long formation, like a wire or ribbon, to utilize the change in length. Additionally, SMA are electrically conductive, and the administration of an electrical charge would lower the time from the deformed shape to the original shape to less than one second.

In one embodiment, the temperature-responsive material is a Liquid crystalline polymer (LCP) or liquid crystalline elastomer (LCE). LCP/LCEs are shape-memory polymers with additional functionality. Instead of an original shape and a deformed shape, these materials may have at least two kinetically trapped states, which they can transform between solely through a temperature change, or other external stimulus. The transformation can be reversed through a temperature change in the opposite direction. At a lower temperature, the LCP/LCE has one shape, akin to the deformed shape of an SMP/SMA. At a higher temperature, the LCP/LCE has another shape, akin to the original shape of an SMP/SMA. No deformation through external mechanical force is required. In some embodiments, this reversible property is advantageous, as it may allow a cover to be easily installed, removed, and replaced, to accommodate inspections or repairs to a sprinkler head.

LCPs and LCEs generally have elastic properties and may undergo a significant strain of 50% between states. The transformation temperature, between two states can range from 0°C . to 100°C . In addition to temperature, the external stimulus prompting a state change could be light, an electrical charge, or magnetic field. Additional materials may be combined with the LCP/LCE to create a composite with additional functionalities, to adjust heat conduction, electrical conduction, stiffness, and strain.

In one embodiment, the temperature-responsive material is a material that changes from a solid to a liquid at the transformation temperature. In one embodiment, the material melts away from the apparatus. In these embodiments, the material is comprised of a metal or alloy with a particular melting point. An example is solder. Another example is wax.

In another embodiment, the material is encased in another material with a higher melting point. In one embodiment, the temperature-responsive material is contained in a tube. For example, an actuator is formed by encasing solder in a flexible straight plastic tube and cooled below the melting point. The actuator is then bent to create a deformed shape. When the interior solder is melted at a transformation temperature, the tube reverts to its original straight shape.

In another embodiment, the temperature-responsive material is a bimetal. Bimetals are comprised of at least two layers of two metals with different coefficients of thermal expansion. Upon heating, one metal expands more than the other, causing the bimetal to change shape. This converts the temperature change into a controlled mechanical displacement.

FIG. 1 shows a top perspective view of one embodiment of a sprinkler cover **101** in its original shape. The cover is a circle, with a flange **102** surrounding the perimeter of the cover. Three actuators **103** are cut into the flange and are curved slightly inward towards the center of the cover. In alternative embodiments, there are one or more actuators. In one embodiment, the entire cover is comprised of temperature-responsive material. In another embodiment, just the actuators are comprised of temperature-responsive material. In one embodiment, the temperature-responsive material is an SMP.

FIG. 2 shows a top perspective view of one embodiment of the sprinkler cover **101** in its deformed shape. The actuators **103** are curved slightly outwards.

FIG. 3 shows a top perspective view of one embodiment of a sprinkler collar **301**. The sprinkler cover is a thin sheet of material with an aperture **302** for holding the cover. The collar **301** will be applied to a ceiling, or other surface. In one embodiment, the collar **301** is comprised of a rigid lightweight material.

FIG. 4 shows a top perspective view of one embodiment of a sprinkler cover **101** in its deformed shape installed in a collar **301**. The actuators **103** are slightly bent outward to hold the cover **101** in place within the aperture **302** of the collar **301**. Some embodiments are designed for easy removal and replacement, to facilitate inspection of a sprinkler head. Embodiments with three actuators may be inserted into, and removed from, the aperture **302** while in their deformed shape. Other embodiments may require the cover is in its original shape for installation and removal. Through the application of heat, or another stimulus, the cover can be transformed into its deformed shape after insertion, or transformed into its original shape before removal.

FIG. 5 shows a bottom perspective view of one embodiment of the sprinkler collar **301** installed below an opening in a ceiling. The thin sheet of the collar **301** provides a nearly uniform surface with the ceiling **501**. In one embodiment, the ceiling is comprised of gypsum. In an alternative embodiment, the ceiling is comprised of metal panels. In another embodiment, the ceiling is comprised of acoustic tiles. In another embodiment, the ceiling is comprised of wood tiles. Other ceiling materials capable of supporting a sprinkler cover are envisioned. The aperture **302** allows a sprinkler head to emit water into the room below the ceiling **501**.

FIG. 6 shows a top perspective view of the sprinkler collar **301** installed below an opening **601**. The sprinkler collar **301** may be sized to span an opening **601** of any size or shape. This feature aids installation, eliminating the need to cut or drill a precisely located hole to align with a sprinkler head. Instead, a larger hole may be cut to span the location of a sprinkler head.

FIG. 7 shows a bottom perspective view of one embodiment of the sprinkler cover **101** and collar **301** installed below an opening. The cover **101** and the collar **301** create a smooth surface with the surrounding ceiling **501**. FIG. 8 shows a bottom perspective of the sprinkler cover **101** and collar **301** installed below an opening. In this embodiment, the collar **301** is painted to match the surface of the ceiling

501. In some embodiments, the cover **101** is also painted to match the surface of the ceiling **501**. The cover **101** is painted before insertion into the aperture **302**, leaving a thin gap between the cover **101** and the aperture **302** of the collar **301**.

FIG. **9** shows a top perspective view of one embodiment of a sprinkler cover **101** and collar **301** installed below an opening **601**. The actuators **103** are bent out in the deformed shape, holding the cover **101** in place.

FIG. **10** shows a side section cut of one embodiment of a sprinkler cover **101** and collar **301** installed below a standard sprinkler head **1001** and ceiling opening **601**. In this embodiment, the thinness of the collar **301** is a key feature, intending to create an invisible covering to an observer below the ceiling **501**. The sprinkler cover **101** is in the deformed shape. In this view, one bent actuator **103** is visible in the side section cut, holding the cover **101** in place. A deflector **1002** extends from the sprinkler head **1001** down and rests against the top of the cover **101**.

FIG. **11** shows a side section cut of one embodiment of a sprinkler collar **301** installed below an opening **601**, where the cover **101** has fallen away. When the temperature rises to specified degree, the actuators **103** move, uncovering the aperture and allowing the sprinkler head **1001** to emit water. In this embodiment, the actuators **103** of the cover **101** have reverted to their original shape, as shown in FIG. **1**. This allows the cover **101** to fall from the aperture **302**, away from the collar **301**, exposing the sprinkler head **1001**. The three actuators in these embodiments provide three points of temperature sensitivity. When just one actuator responds, reverting to the original shape, the cover will fall away from the opening. Alternative embodiments are further comprised of a spring, which will help push the cover **101** away from the collar **301**. Alternative embodiments may include a weighted cover **101** to facilitate falling away.

In one embodiment, the cover **101** is further comprised of a material, such as metal, to facilitate heat conduction to the actuators. Alternative embodiments of the cover **101** are further comprised of air vents to permit heat convection into the aperture **302**. If dust or air flow control is a concern, as in a lab or health environment, the apparatus is further comprised of a seal between the cover **101** and collar **301**.

This embodiment of a standard sprinkler head **1001** operates with a temperature-responsive material **1101** inside a glass bulb, holding a valve **1102** in the closed position. When a certain temperature is reached, the temperature-responsive material **1101** expands, breaking the glass and opening the valve **1102**, releasing water through spout **1103**. The deflector plate **1002** drops as the cover **101** falls away, the water leaving the spout **1103** hits the deflector plate **1002**, where it is dispersed laterally below the surface of the ceiling **501**. In some embodiments, the cover actuator responds to a temperature below the activation temperature of the temperature-responsive material holding the valve **1102** closed, ensuring that the cover **101** exposes the aperture **302** before the sprinkler head is activated and emits water.

FIG. **12** shows a top perspective section cut view of one embodiment of a sprinkler cover **101** and collar **301** installed below a ceiling opening **601**. The actuators **103** are bent outwards in the deformed shape, holding the cover **101** in place. FIG. **13** shows cover **101** falling away when a transformation temperature is reached, allowing the sprinkler deflector plate **1002** to fall below the surface of the ceiling **501**.

FIG. **14** shows a top view of one embodiment of three arced-wire actuators **1401** in their original shape for a

sprinkler cover. In this embodiment, the actuators **1401** are comprised of temperature-responsive SMA. An alternative embodiment is comprised of SMP. FIG. **15** shows a top view of the three arced-wire actuators **1401** in their deformed shape. Each actuator **1401** has been bent to include a protrusion **1501**, which will hold the cover in place to the collar.

FIG. **16** shows a section cut of an alternative embodiment of an actuator. This actuator is comprised of a metal or metal alloy **1601** within an enclosed flexible tube **1602**. In this embodiment, the metal or metal alloy is the temperature-responsive material, with a specific melting point. In the original shape, the flexible tube **1602** is relatively straight, similar to the arced-wire actuators **1401** in FIG. **14**. The tubes **1602** are filled with the metal or metal alloy **1601** and then bent into a deformed shape similar to FIG. **15**. When the temperature reaches the melting point of the metal or metal alloy **1601** melts, permitting the flexible tube **1602** to revert to its original shape.

FIG. **17** shows a top view of one embodiment of three arced-wire actuators **1401** in their original shape installed in a sprinkler cover **1701**. The actuators **1401** lie within a channel along the perimeter of the cover **1701**, between a series of pins **1702** and a surrounding flange **1703**. FIG. **18** shows the three actuators **1401** in their deformed shape installed in the sprinkler cover **1701**. The protrusions **1501** of each actuator **1401** extend through the perimeter of the cover **1701**. FIG. **19** shows a top perspective view of the three actuators **1401** in their original shape installed in the sprinkler cover **1701**. In this embodiment, slots **1901** will permit the protrusions **1501** to extend laterally from the cover **1701**. FIG. **20** shows the three actuators in their deformed shape, with the protrusions **1501** extending from the cover **1701**. In one embodiment, the cover **1701** is manufactured with the actuators **1401** in their original shape and then deformed prior to installation. In an alternative embodiment, the cover **1701** is manufactured with the actuators in their deformed shape.

FIG. **21** shows a top view of one embodiment of three actuators **2101** in their original shape installed in a sprinkler cover **2102**. This embodiment is similar to that shown in FIGS. **14-20**, with arced-wire actuators. One embodiment is comprised of SMA. An alternative embodiment is comprised of SMP.

In this embodiment, the actuators are configured to minimize friction between the actuators and the cover. Furthermore, the deformation creating protrusions outside of the cover is less pronounced, facilitating the transformation between the deformed shape and the original shape. FIG. **22** shows a top perspective view of this embodiment. In this embodiment, openings **2201** around the perimeter will permit the actuators to extend from the cover **2102** when in their deformed shape.

FIG. **23** and FIG. **24** show a top view, and top perspective view of one embodiment of three actuators **2101** in their deformed shape installed in a sprinkler cover **2102**. The actuators **2101** extend from the openings **2201**.

FIG. **25** shows a top perspective view of one embodiment of a ring actuator **2501** in its original shape. The ring actuator **2501** is comprised of shape memory material. In one embodiment, the ring actuator **2501** is comprised of SMP. An alternative embodiment is comprised of LCP/LCE. FIG. **26** shows a top perspective view of the ring actuator **2501** in its deformed shape, with one or more protrusions **2601**.

FIG. **27** shows a top perspective view of one embodiment of a sprinkler cover **2701** configured to hold a ring actuator.

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The cover **2701** is configured with a channel **2702** around the perimeter of the cover, to hold the ring actuator **2501**. In this embodiment, one or more slots **2703** allow the protrusions to extend from the perimeter of the cover **2701**. FIG. **28** shows the sprinkler cover **2701** with the ring actuator **2501** installed in its original shape. FIG. **29** shows the ring actuator **2501** in its deformed shape, with the protrusions **2601** extending through the slots of the cover **2701**.

FIG. **30** shows a top view of one embodiment of a triangle actuator **3001** comprised of SMP. An alternative embodiment is comprised of LCP/LCE. The triangular actuator **3001** is comprised of edges **3002** and tongues **3003** at the vertices. Other polygon-shaped actuators are envisioned. FIG. **31** shows an alternative embodiment of a triangle actuator **3101** comprised of SMA. The triangle actuator **3101** may be a single piece around the three edges, with the ends connected by solder or a sleeve **3102** of metal or plastic.

FIG. **32** shows a top perspective view of one embodiment of a sprinkler cover **3201** configured to hold a triangle actuator. The cover **3201** is configured with three openings, or slots **3202**, to allow the vertices of the triangle actuator to extend from the perimeter of the cover **3201**. FIG. **33** shows the sprinkler cover **3201** with the triangle actuator **3001** installed in its original shape. FIG. **34** shows the triangle actuator **3001** in its deformed shape, with the tongues **3003** extending through the slots of the cover **3201**. In the deformed shape, the edges **3002** of the triangle actuator **3001** are stretched. In the original shape, the edges **3002** retract, pulling the tongues **3003** back.

FIG. **35** shows a top perspective view of one embodiment of a sprinkler collar **3501** with a structural ring flange **3502** around the aperture **3503**. This embodiment shows a collar **3501** with a square shape. Other shaped collars are envisioned. This embodiment also has a circular aperture **3503**. Other shaped apertures are envisioned. A ring flange **3502** provides additional stability to the collar **3501** when spanning a sprinkler head opening. FIG. **36** shows a top perspective view of a sprinkler cover **3201** with a triangle actuator **3001** installed in the collar **3501**. The triangle actuator **3001** is in its deformed shape, allowing the tongues to hold it within the aperture of the collar **3501**.

FIG. **37** shows a section cut view of one embodiment of the sprinkler collar **3501** with a structural ring flange **3502** around the aperture **3503**. FIG. **38** shows the section cut view with the sprinkler cover **3201** inserted in the aperture of the collar **3501** with the triangle actuator in its deformed shape. The tongues **3003** extend beyond the perimeter of the cover **3201**, holding it in place.

FIG. **39** shows a top perspective section cut view of one embodiment of a sprinkler cover **3201** with a triangle actuator **3001** installed below an opening. The triangle actuator **3001** is in its deformed shape, holding it in place within the aperture of the collar **3501**. FIG. **40** shows a bottom perspective view of the sprinkler cover **3201** installed within a square-shaped collar **3501**. The collar **3501** is treated to match the surface of the ceiling **4001**, making it virtually invisible to a viewer below. Only a slight seam **4002** is visible upon close inspection. FIG. **41** shows a bottom perspective section cut view of the square-shaped sprinkler collar **3501** after a cover has fallen away, permitting the sprinkler head **4101** to emit water down into the room below.

FIG. **42** shows a top perspective view of one embodiment of a sprinkler cover **4201** with a cover flange **4202**. In some situations, a pressure differential between the top and bottom sides of the ceiling may cause a cover to become dislodged

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from the collar. One embodiment solves this problem by including a cover flange **4202**, which will secure the flange from an upward force. Alternative embodiments of the apparatus include an air vent in the collar or cover.

FIG. **42** shows the sprinkler cover **4201** with three actuators **4203** in their original shape, curved inward towards the center of the cover **4201**. FIG. **43** shows a top perspective view of the sprinkler cover **4201** in its deformed shape, with the actuators **4203** bent slightly outward. In one embodiment, the sprinkler cover **4201** is comprised of SMP. In an alternative embodiment, the sprinkler cover **4201** is comprised of a non-responsive material, but the actuators **4203** are comprised of temperature-responsive material. In one embodiment, the actuators **4203** are comprised of LCP/LCE. An alternative embodiment, the actuators **4203** are comprised of SMA.

FIG. **44** shows a top perspective view of one embodiment of a sprinkler collar **4401** with three notches **4402**. Embodiments with one, two, four, or more notches are envisioned. The notches **4402** allow access for the sprinkler cover **4201** to be inserted into the aperture of the collar **4401** while the cover **4201** is in its deformed shape, the actuators **4203** passing through the notches **4402**.

FIG. **45** shows a bottom perspective view of the sprinkler collar **4401** with notches **4402**. Three collar flanges **4501** are shown between the notches. Embodiments with one or more collar flanges are envisioned. The collar flanges **4501** are configured to interface with the cover flange **4202**, to hold the cover **4201** in place. FIG. **46** shows a section cut view of the sprinkler collar **4401**, demonstrating the collar flanges **4501** and one of three notches **4402**.

FIG. **47** shows a top perspective view of one embodiment of a sprinkler cover **4201** in its deformed shape installed in a collar **4401** with notches **4402**. The cover **4201** has been installed within the aperture of the collar **4401**. The notches **4402** permitted the actuators **4203** to pass through. The cover **4201** is then rotated so the actuators **4203** rest on the top side of the collar flanges **4501**, securing it in place, and preventing movement due to pressure differentials between the air above and below the ceiling.

FIG. **48** shows a top perspective section cut view of one embodiment of a sprinkler cover **4201** with cover flange in its deformed shape installed in a collar **4401** with notches. This view demonstrates how the actuators **4203** have room to rotate within the sprinkler opening after installation.

FIG. **49** shows a top perspective section cut view of one embodiment of a sprinkler collar **4201** with notches installed below an opening, where a sprinkler cover **4201** has fallen away. The temperature rose to a certain level, causing the actuators **4203** to revert to their original shape, bending towards the center of the cover **4201**. When the actuators **4203** no longer extend outside the aperture of the collar **4401**, the cover **4201** falls under the force of gravity.

In some embodiments, a single sprinkler cover is used, without the need to attach to a collar. FIG. **50** shows a top perspective view of one embodiment of an insertable sprinkler cover **5001** in its original shape. This embodiment is a flat surface with mounting tabs **5002** extending roughly perpendicular from the surface. In its original shape, the mounting tabs **5002** of the insertable sprinkler cover angled slightly inward. FIG. **51** shows the insertable sprinkler cover **5001** in its deformed shape, with the mounting tabs **5002** angled slightly outward. Embodiments with one or more mounting tabs are envisioned. In one embodiment, the mounting tabs **5002** are the actuators. In one embodiment, the insertable sprinkler cover **5001** is comprised of SMP. In

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an alternative embodiment, the insertable sprinkler cover **5001** is comprised of LCP/LCE.

FIGS. **52** and **53** show section cut views of one embodiment of an insertable sprinkler cover **5001**. FIG. **52** shows its original shape. The angle **5201** is slightly acute. FIG. **53** shows its deformed shape. The angle **5301** is slightly obtuse. FIG. **54** shows a section cut view of the insertable sprinkler cover **5001** installed in a standard housing **5401** for a sprinkler head. The mounting tabs **5002** securely grip the interior of the sprinkler support cup **5401** when the insertable sprinkler cover **5001** is in its deformed shape. In one embodiment, the insertable sprinkler cover **5001** is screwed into place. In another embodiment, the insertable sprinkler cover **5001** is pushed into the threaded support cup. As the temperature rises to the specified transformation temperature of the cover's material, the insertable sprinkler cover **5001** reverts to its original shape, the mounting tabs **5002** moving back to their acute angled positions **5201**. FIG. **55** shows the insertable sprinkler cover in its original shape. The mounting tabs have angled inward, releasing them from the interior of the sprinkler support cup housing **5401**, causing the insertable sprinkler cover **5001** to fall away from the ceiling.

In some embodiments, the entire insertable sprinkler cover **5001** is comprised of temperature-responsive material. In other embodiments, only the mounting tabs **5002** are comprised of temperature-responsive material. In another embodiment, only an area of deformation connecting the mounting tabs **5002** to the flat surface is comprised of temperature-responsive material.

FIG. **56** shows a bottom perspective view of one embodiment of an insertable sprinkler cover **5001** installed in an opening. The bottom of the insertable sprinkler cover **5001** creates a smooth surface with the ceiling **5601**. This embodiment has a round shape, but other shapes are envisioned.

FIG. **57** shows a top perspective view of one embodiment of a sheet sprinkler cover **5701** in its deformed shape. This embodiment is sheet of material at least partially comprised of temperature-responsive material. In one embodiment, the sheet sprinkler cover **5701** is comprised of SMP. In an alternative embodiment, the sheet sprinkler cover **5701** is comprised of LCP/LCE.

In some embodiments the sheet sprinkler cover **5701** has an adhesive area **5702** for easy attachment to a surface around a ceiling opening. In some embodiments, the center area of the sheet sprinkler cover is not covered with adhesive.

In one embodiment, the sheet sprinkler cover **5701** is comprised of perforations **5703**. In some embodiments the sheet sprinkler cover is circular. Other shaped embodiments are envisioned.

FIG. **58** shows a side section cut of one embodiment of a sheet sprinkler cover **5701** in its deformed shape. The sheet sprinkler cover **5701** is flat in its deformed shape. When it is heated, it reverts to its original shape, pulling free of the adhesive. In one embodiment, the sheet sprinkler cover **5701** tears along the perforations, creating an opening for water. In another embodiment, the original shape is a hemisphere and falls away from the opening.

FIG. **59** shows a top perspective section cut view of one embodiment of a sheet sprinkler cover **5701** installed below an opening. FIG. **60** shows a bottom perspective section cut view of the sheet sprinkler cover **5701**.

CONCLUSION

While there have been shown and described illustrative examples of a concealed sprinkler cover, it is to be under-

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stood that various other adaptations and modifications may be made within the spirit and scope of the embodiments herein. Thus, while the foregoing description has been directed to specific embodiments, it will be apparent that other variations and modifications may be made to the described embodiments, with the attainment of some or all their advantages. Accordingly, this description is to be taken only by way of example and not to otherwise limit the scope of the embodiments herein.

What is claimed is:

1. An apparatus for concealing and uncovering an opening in a ceiling, comprising:

a collar with an aperture the same size or smaller than the opening in the ceiling,

a cover configured to fit within the aperture of the collar, and

at least one actuator at least partially comprised of a shape memory polymer, wherein

the at least one actuator is a component of the cover,

the collar is configured to be installed below the opening in the ceiling with the aperture of the collar located within the opening in the ceiling,

the shape memory polymer responds to a temperature at or above a specified transformation temperature,

the at least one actuator has an original shape,

the at least one actuator is configured to be transformed from the original shape into a deformed shape,

the at least one actuator is configured to transform from the deformed shape to the original shape at or above the transformation temperature, and

the at least one actuator is configured to displace the cover, at least partially exposing the opening in the ceiling.

2. The apparatus of claim 1, wherein the cover is comprised of a plurality of actuators.

3. The apparatus of claim 2, wherein the plurality of actuators are positioned around the cover, permitting the cover to be installed to at least partially conceal the opening in the ceiling while the plurality of actuators are in the deformed shape.

4. The apparatus of claim 1, wherein a sprinkler head is positioned inside the opening in the ceiling.

5. The apparatus of claim 1, wherein the at least one actuator extends from the cover when the at least one actuator is in the deformed shape.

6. The apparatus of claim 1, wherein the collar is comprised of at least one edge and tapers to the at least one edge.

7. The apparatus of claim 1, wherein the cover is configured to be substantially flat, and forms a flush surface with the collar.

8. The apparatus of claim 1, wherein the cover is at least partially comprised of thermally conductive material.

9. The apparatus of claim 1, wherein the collar is treated to make it indistinguishable from the ceiling.

10. The apparatus of claim 1, wherein the transformation temperature is between 40° C. and 74° C.

11. An apparatus for concealing and uncovering an opening in a surface of a ceiling, comprising:

a collar with an aperture the same size or smaller than the opening and configured to be installed below the opening with the aperture of the collar located within the opening,

a cover configured to fit within the aperture of the collar, and

at least one actuator at least partially comprised of a shape memory polymer, wherein

the at least one actuator is a component of the cover,

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the shape memory polymer responds to a temperature at or above a specified transformation temperature, and at or above the specified transformation temperature, the at least one actuator is configured to displace the cover, at least partially exposing the opening.

12. The apparatus of claim **11**, wherein the at least one actuator has an original shape and a deformed shape, and the at least one actuator is configured to transform from the deformed shape to the original shape at or above the transformation temperature.

13. The apparatus of claim **11**, wherein the collar is configured to be installed below the opening in the surface of the ceiling by affixing the collar to the surface of the ceiling.

14. An apparatus for concealing and uncovering an opening in a surface, comprising:

a collar and a cover, wherein

the collar is an independent component from the surface,

the collar is comprised of an aperture the same size or smaller than the opening in the surface, and

the collar is configured to be installed below the opening in the surface with the aperture of the collar located within the opening in the surface,

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the cover is an independent component from both the surface and the collar,

the cover is configured to fit within the aperture of the collar,

the cover is comprised of at least one actuator at least partially comprised of a shape memory polymer,

the shape memory polymer responds to a temperature at or above a specified transformation temperature, and

at or above the specified transformation temperature, the at least one actuator is configured to displace the cover, at least partially exposing the opening in the surface.

15. The apparatus of claim **14**, wherein the surface is a surface of a ceiling.

16. The apparatus of claim **14**, wherein the at least one actuator has an original shape and a deformed shape, and the at least one actuator is configured to transform from the deformed shape to the original shape at or above the transformation temperature.

17. The apparatus of claim **14**, wherein the collar is configured to be installed below the opening in the surface by affixing the collar to the surface.

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