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(54) Benævnelse: **FOTOVOLTAIKMODUL OG FOTOVOLTAIKSYSTEM**

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WO-A1-03/017376
US-A1- 2005 040 374
US-A1- 2006 185 714
US-A1- 2007 227 579
US-A1- 2008 264 472
US-B1- 7 235 736

Description

Documents US 7,196,262 B2 and US 7,394,016 B2 describe a photovoltaic module and a photovoltaic system, respectively.

WO 03/017376 A1 discloses a thermophotovoltaic device in which a radiation emitter arranged at the centre of a tube emits electromagnetic radiation which is converted into electricity by a photovoltaic element which is attached, at a certain distance, to a glass tube made from heat-resistant quartz glass.

US 2008/0264472 A1 discloses a photovoltaic device inside which volume compensation is possible.

US 7,235,736 B1 describes a solar cell and a monolithic integration of a cylindrical solar cell.

US 2006/0185714 A1 discloses a flexible solar cell and a method for producing said solar cell.

One object to be achieved is to provide a photovoltaic module which has increased efficiency, Another object to be achieved is to provide a photovoltaic system which has increased efficiency and reduced maintenance costs.

A photovoltaic module is provided. The photovoltaic module is provided in particular for the direct conversion of the energy contained in sunlight into electrical energy.

According to at least one embodiment of the photovoltaic module, the latter comprises at least one tube. The tube has a main direction of extent and a curved inner face facing the inner space of the tube. The tube can moreover have a curved outer face facing away from the inner face. The tube has, for example, a cylindrical, in particular circular cylindrical form and encompasses the inner space. The tube is thus designed, at least in places, in the manner of a hollow cylinder or a hollow circular cylinder. The outer face of the tube can form an outer face of the photovoltaic module. The photovoltaic module can then have the cylindrical structure of the tube.

The tube preferably has, at least in places, the form of a hollow cylinder. The main direction of extent then corresponds to the height of the hollow cylinder. In a cross-section perpendicularly to the main direction of extent, the tube then has the form of a circular ring. The inner circle of the circular ring hereby forms the inner face of the tube.

Terms such as “cylindrical” and/or “hollow cylinder” should hereby and below not be interpreted in a strictly geometrical sense. Instead, a cylindrical tube or a tube in the form of a hollow cylinder can also have an only approximately circular cross-section perpendicularly to the main direction of extent. For example, the tube has an elliptical cross-section perpendicularly to the main direction of extent, wherein the numerical eccentricity of the ellipse is no more than 0.8.

The tube has a translucent design. “Translucent” means hereby and below that at least 90%, preferably at least 94%, of the light striking the translucent material is transmitted through the material. For example, the tube is formed with a glass or a plastic or consists of a glass or a plastic. For example, the tube is formed with soda lime silica glass or consists of soda lime silica glass. Soda lime silica glass is notable for its low price.

The breaking strength of the glass used can be increased by rapid cooling and/or another special in-line process. This makes it possible in particular to use the tube in unfavourable environmental conditions. Reflection from the outer face of the tube can additionally be reduced in order to improve the transmission properties of the material of the tube. For this purpose, an antireflection coating can be applied to the outer face of the tube.

According to at least one embodiment of the photovoltaic module,

the latter moreover comprises a mechanically flexible photovoltaic component. The photovoltaic component comprises a solar cell arrangement applied to a carrier film. A solar cell arrangement can hereby and below consist of one or more solar cells, in particular connected in series. The solar cell arrangement comprises at least one active layer in which free charge carriers can be generated when sunlight shines on it.

The photovoltaic component has a mechanically flexible design. In particular, the solar cell arrangement and the carrier film have a mechanically flexible design. "Mechanically flexible" hereby and below means that the photovoltaic component can be bent, rolled up and/or curved non-destructively. In particular, the photovoltaic component can be rolled up and/or bent – even several times – without affecting its electrical and/or optical properties.

According to at least one embodiment of the photovoltaic module, the photovoltaic component is arranged in the inner space of the tube. The photovoltaic component can in particular be arranged completely in the inner space. The photovoltaic component at least perpendicularly to the main direction of extent is then completely encompassed by the material of the tube. The photovoltaic module preferably directly adjoins the tube. Alternatively, air or another gas can be arranged between the photovoltaic component and the tube.

According to at least one embodiment of the photovoltaic module, the solar cell arrangement has a curvature. The curvature of the solar cell arrangement at least in places follows the curved course of the inner face of the tube. In other words, in a cross-section perpendicularly to the main direction of extent the solar cell arrangement and the inner face have a similar curvature in the mathematical sense. For example, the inner face of the tube has, in a cross-section perpendicularly to the main direction of extent, the form of an ellipse or a circle. In this case, the solar cell arrangement has at least in places the form of an ellipse or a circle. It is moreover possible that the whole photovoltaic component follows the curved course of the inner face.

According to at least one embodiment of the photovoltaic module, the solar cell arrangement covers the inner face at least partially. In other words, in a view of the tube from the inner space in a direction perpendicular to the main direction of extent, the inner face is covered at least partially by the solar cell arrangement. The covered inner face of the tube then forms a light passage surface of the photovoltaic module.

According to at least one embodiment of the photovoltaic module, the latter comprises a cylindrical translucent tube, encompassing an inner space, with a main direction of extent and a curved inner face facing the inner space, and a mechanically flexible photovoltaic component with a solar cell arrangement applied to a carrier film. The photovoltaic component is arranged in the inner space. The solar cell arrangement has a curvature, wherein the curvature at least in places follows the curved course of the inner face of the tube. The solar cell arrangement covers the inner face at least partially, wherein the covered inner face forms a light passage surface of the photovoltaic module.

The combination of a flexible photovoltaic component with a translucent tube enables in particular the use of a cost-efficient manufacturing process in conjunction with high efficiency. The efficiency of the photovoltaic module is hereby and below the electrical energy generated per surface area covered. The curved, for example cylindrical structure of the photovoltaic module has many advantages compared with conventional flat photovoltaic modules with respect to the efficiency and lifetime of the photovoltaic module. The cross-sectional surface area of the photovoltaic module is, for example, reduced, as a result of which higher weather resistance of the photovoltaic module can be obtained when under load from wind and/or snow. A self-cleaning effect moreover results from a curved outer face. In addition, owing to the cylindrical structure, the weight of the photovoltaic module is reduced compared with flat photovoltaic modules, as a result of which use is possible on buildings with roofs with a low static load bearing capacity.

Moreover, the natural air circulation inside the tube lowers the operating temperature of the photovoltaic module. For this purpose, the tube can, for example, be open at least in places at the ends. Owing to the curved, for example cylindrical structure, in general water or passive cooling of the photovoltaic modules can be implemented more easily than in the case of flat photovoltaic modules. Low operating temperatures ensure a high energy yield and improved functional reliability. Owing to the curved design of the photovoltaic component, sunlight with a low angle of incidence, for example when the sun is low, can additionally be used. It is consequently possible to dispense with a so-called tracking apparatus for orienting the module depending on the position of the sun in the photovoltaic module and, as a result, with a complex mechanical and/or electronic system. Even when used in desert regions, passive cooling is also additionally possible in the case of a photovoltaic module described here. This increases the efficiency of the photovoltaic module and at the same time reduces the maintenance cost.

By virtue of the increased breaking strength of the tube, the outer face of the tube is additionally more resistant to surface damage and/or more scratch-resistant to grains of sand, for example. As a result, the optical properties of the tube can be maintained even over extended use in relatively unfavourable environmental conditions.

According to at least one embodiment of the photovoltaic module, the photovoltaic component has at least one encapsulation film. The at least one encapsulation film covers the solar cell arrangement of the photovoltaic component on at least one outer face. The at least one encapsulation film completely covers, for example, a base surface, facing away from the inner face of the tube, of the photovoltaic component. The encapsulation film can hereby be in direct contact with the base surface at least in places. The at least one encapsulation film preferably has a translucent design. The at least one encapsulation film can moreover likewise have a mechanically flexible design.

According to at least one embodiment of the photovoltaic module, the photovoltaic component has at least two encapsulation films connected together by a material-formed bond. The solar cell arrangement is arranged completely between the at least two encapsulation films. The solar cell arrangement preferably directly adjoins the encapsulation films in places. Each encapsulation film preferably has a mechanically flexible design. A "material-formed bond" is hereby and below a bond in which the bonding partners are sometimes held together by atomic and/or molecular forces. A material-formed bond is, for example, an adhesive bond and/or a fused bond. A material-formed bond can in particular not be loosened non-destructively. In other words, the bonding partners can be separated only with the use of a loosening means or by destroying them.

The photovoltaic component can have, for example, up to three encapsulation films, wherein the solar cell arrangement is arranged between at least two of the encapsulation films. All the encapsulation films of the photovoltaic component can in particular be connected together by a material-formed bond.

The encapsulation films can serve in particular for the mechanical and/or chemical protection of the solar cell arrangement from environmental influences. The encapsulation films can, for example, protect the solar cell arrangement from moisture. The encapsulation films can in particular be designed to be resistant to UV light. This means that it is impossible, or almost impossible, for the encapsulation films to change their optical and/or mechanical properties under UV radiation even over a long period of time.

According to at least one embodiment of the photovoltaic module,

the solar cell arrangement in a cross-section perpendicularly to the main direction of extent within the limits of the manufacturing tolerances at least in places is in the form of an arc of a circle. "Within the limits of the manufacturing tolerances" hereby and below means that the solar cell arrangement does not have the form of an arc of a circle in a strictly mathematically geometrical sense and instead deviations which can be caused by the manufacturing can exist. For example, the solar cell arrangement can have the form of an elliptic arc, wherein the associated ellipse can have a numerical eccentricity of up to 0.8. The curvature of the photovoltaic component can moreover not be uniform.

According to at least one embodiment of the photovoltaic module, at least one of the encapsulation films is a thermoplastic film. All of the encapsulation films are preferably thermoplastic films. The thermoplastic film can be formed from a plastic. A silicone-based plastic is, for example, suitable as the material for the encapsulation film. A thermoplastic film changes its mechanical properties under the application of heat. The thermoplastic film can, for example, be laminated onto the solar cell arrangement. The material-formed bond of the encapsulation films can moreover be generated by lamination. It is additionally or alternatively possible that at least one encapsulation film is formed with a copolymer such as, for example, ethylene vinyl acetate.

The use of a thermoplastic film in particular has the advantage that it has a high degree of electrical insulation, is non-corrosive and is highly flexible even under unfavourable environmental conditions. The mechanical flexibility is hereby ensured both at low and high temperatures. The use of a thermoplastic film moreover enables the photovoltaic module to be recycled at the end of its lifecycle. A photovoltaic module which can be disposed of in an environmentally friendly and cost-effective manner can consequently be provided.

According to at least one embodiment of the photovoltaic module,

at least 30% and at most 100% of the inner face of the tube is covered by the solar cell arrangement. Preferably at least 40% and at most 70% of the inner face of the tube is covered by the solar cell arrangement. It is moreover possible that the at least one encapsulation film covers at least 20%, preferably at least 30%, and at most 100%, preferably at most 80% of the inner face of the tube. For example, only a part, facing the sun, of the inner face of the tube is provided with the solar cell arrangement in order to save costs. It is hereby possible that the at least one encapsulation film likewise does not cover the whole inner face and instead is arranged only on the inner face covered by the solar cell arrangement. It is moreover possible that at least 30% and up to 100% of the inner face of the tube forms the light passage surface. For example, one half of the shell of the cylindrical tube is covered by the solar cell arrangement, whilst the other half of the shell is free of the solar cell arrangement. The shell of the tube can be the outer face of the tube. It is hereby possible that the covered half of the cylinder faces the sun after the photovoltaic module has been mounted, i.e. forms a top side of the photovoltaic module.

According to at least one embodiment of the photovoltaic module, the light passage surface is a singly coherent surface. In other words, the solar cell arrangement covers a continuous surface which has no recesses. For example, when flat, the light passage surface has the form of a rectangle, in particular a rounded one.

According to at least one embodiment of the photovoltaic module, the photovoltaic component perpendicularly to the main direction of extent is completely encompassed by the tube. It is hereby possible that the tube is open at its ends in the main direction of extent and/or the inner space is freely accessible at the ends. Perpendicularly to the main direction of extent, the tube has a continuous one-piece design and completely encompasses the photovoltaic component. As a result, the photovoltaic component can be protected from environmental influences.

According to at least one embodiment of the photovoltaic module, the solar cell arrangement is applied to the carrier film using a printing process. For example, the solar cell arrangement can be applied to the carrier film using an inkjet printing process. The carrier film can be a thin steel film or a thin plastic film. The carrier film is in particular formed mechanically flexibly.

The solar cell arrangement can, for example, be applied to the carrier film in a so-called roll-to-roll process. In such a process, the carrier film is first supplied, rolled up into a roll. The carrier film is then unrolled from the roll and the solar cell arrangement is printed onto the carrier film. After the printing step, the carrier film including the solar cell arrangement applied to the carrier film is rolled up again. Such a roll-to-roll process enables in particular rapid and cost-effective manufacture of the solar cell arrangement. However, other manufacturing processes are also conceivable, by means of which a mechanically flexible solar cell arrangement can be provided.

According to at least one embodiment of the photovoltaic module, the solar cell arrangement is a CIGS solar cell arrangement or an organic solar cell arrangement. A CIGS solar cell arrangement (CIGS: copper indium gallium selenide) comprises copper, indium, gallium and diselenium. An organic solar cell arrangement is formed with organic layers. Such solar cell arrangements have the advantage that they can be applied to a carrier film in a printing process, which is particularly cost-effective. The solar cell arrangement can moreover contain further layers in addition to the abovementioned materials, such as, for example, an electrically conductive layer which can be formed, for example, with a transparent conductive oxide. Moreover, the solar cell arrangement can contain additional layers for contacting and/or for electrical insulation.

According to at least one embodiment of the photovoltaic module, the solar cell arrangement has a thickness of at most 5 µm, preferably at most 2.5 µm. The thickness of the solar cell arrangement is hereby the dimension of the solar cell arrangement perpendicularly to a main plane of extent of the carrier film. The carrier film and/or the solar cell arrangement each have a significantly greater dimension in the main plane of extent of the carrier film than perpendicularly to the main plane of extent. The solar cell arrangement is thus a thin-layer solar cell. Such a thin-layer solar cell can in particular be formed mechanically flexibly and be applied to a carrier film using a printing process.

According to at least one embodiment of the photovoltaic module, the photovoltaic component moreover has a light-emitting component. The component is formed mechanically flexibly. The light-emitting component can, for example, be a mechanically flexible organic light-emitting diode. The light-emitting component can moreover be a plurality of inorganic or organic light-emitting diodes which are arranged on a mechanically flexible carrier.

The light-emitting component covers at least in places free regions of the inner face which are uncovered by the solar cell arrangement. Half of the shell of the cylindrical tube is, for example, covered by the solar cell arrangement. The second half of the shell can then be covered by the light-emitting component. The idea is hereby pursued in particular that part of the photovoltaic module can be used to generate electrical energy from sunlight, whilst the remainder of the photovoltaic module can be used to generate light. A corresponding module is therefore a hybrid module.

The light-emitting component is electrically isolated from the solar cell arrangement. The curvature of the light-emitting component moreover substantially follows the curved course of the inner face of the tube. The light-emitting component has, for example, an arched configuration and has the form of an arc of a circle in a cross-section perpendicularly to the main direction of extent within the limits of the manufacturing tolerances. The free regions of the inner face which are covered by the component can then form a light-emitting surface for the light generated by the light-emitting component.

According to at least one embodiment of the photovoltaic module, it has a mechanically flexibly formed light-emitting component, wherein the light-emitting component covers at least in places the free regions of the inner face which are not covered by the solar cell arrangement, the light-emitting component is electrically isolated from the solar cell arrangement, and the curvature of the light-emitting component substantially follows the curved course of the inner face.

According to at least one embodiment of the photovoltaic module, a storage battery is arranged in the inner space on a base surface of the photovoltaic component remote from the inner face. The storage battery is, for example, completely encompassed by the photovoltaic component and/or by the tube. The storage battery is hereby connected in an electrically conductive manner to the photovoltaic component. The storage battery can, for example, be a lithium-ion storage battery.

According to at least one embodiment of the photovoltaic module, the storage battery is set up to store electrical energy generated by the solar cell arrangement. For example, for this purpose the storage battery is connected in an electrically conductive manner to the solar cell arrangement. The storage battery is moreover set up to emit the stored electrical energy to the light-emitting component after a time delay. For this purpose, the storage battery can likewise be connected in an electrically conductive manner to the light-emitting component. For example, when the sun is shining during the day, the electrical energy generated by the solar cell arrangement can thus be stored and then be emitted again at night to the light-emitting component in order to generate light.

According to at least one embodiment of the photovoltaic module, a cylindrical metal tube is arranged in the inner space on the base surface of the photovoltaic component. The metal tube is preferably formed with a metal or consists of a metal. For example, the metal tube can contain copper or consist of copper. In particular, the metal tube has the form of a hollow cylinder. The metal tube preferably extends completely in the main direction of extent of the tube.

According to at least one embodiment of the photovoltaic module, the metal tube at least in places is in direct contact with the photovoltaic component. The metal tube is in particular connected to the photovoltaic component in a thermally conductive manner. The metal tube encompasses an air-filled or water-filled cooling space. The metal tube can thus be a cooling tube which dissipates the waste heat generated by the photovoltaic component to the environment. This cooling is effected, for example, by air circulation or water circulation inside the metal tube. Natural convection can be employed for this purpose and/or a pump or a ventilator used.

A photovoltaic system is moreover provided. The photovoltaic system is preferably provided for installation outdoors, for example on the roof of a house or on agricultural land. The photovoltaic system comprises a multiplicity of photovoltaic modules described here. This means that all the features which are disclosed for the photovoltaic module are also disclosed for the photovoltaic system, and vice versa.

According to at least one embodiment of the photovoltaic system, it comprises a multiplicity of photovoltaic modules. The photovoltaic modules are preferably not in direct physical contact with one another. In other words, a continuous open space is arranged in each case between the photovoltaic modules. The dimension of the open space, i.e. the gap between the photovoltaic modules, can hereby be selected depending on the desired field of use. The photovoltaic modules can be connected electrically to one another. The photovoltaic modules can hereby be connected in series and/or in parallel.

According to at least one embodiment of the photovoltaic system, it moreover comprises a multiplicity of holders and at least two fastening tubes. The holders can be mechanical components which are provided for fastening the photovoltaic modules to the two fastening tubes. The fastening tubes can have fastening elements which serve, for example, to fasten the holders to the fastening tubes.

According to at least one embodiment of the photovoltaic system, each photovoltaic module is connected mechanically to at least one holder. The mechanical connection is effected, for example, by means of a plug-in connection, a screw connection, an adhesive connection and/or a clamping connection.

According to at least one embodiment of the photovoltaic system, each holder is mechanically limitedly detachably fastened to at least one fastening tube. "Mechanically limitedly detachably fastened" means hereby and below that the fastening to the holders to the fastening tube can be loosened non-destructively. In particular, the fastening tube is not destroyed when the connection is loosened. For example, the fastening of the holder to the fastening tube is effected using a plug-in connection, a screw connection and/or a clamping connection. The mechanically limitedly detachable fastening makes it possible to replace individual photovoltaic modules of the photovoltaic system simply and at reduced cost. As a result, replacing the whole photovoltaic system can be avoided in the event of a defective photovoltaic module.

According to at least one embodiment of the photovoltaic system, it comprises a multiplicity of photovoltaic modules, a multiplicity of holders and at least two fastening tubes, wherein each photovoltaic module is mechanically connected to at least one holder, and each holder is fastened mechanically limitedly detachably to at least one fastening tube.

In the case of the photovoltaic system, the idea is in particular pursued of providing a low-maintenance system for generating electricity. The use of cylindrical photovoltaic modules with a greater outer surface area compared with flat modules enables in particular better use of the surface to covered. A surface to be covered can, for example, be a roof or agricultural land.

The use of the photovoltaic system in conjunction with agricultural land is in particular possible owing to the presence of open spaces between the photovoltaic modules and to the consequently shadow-free design. As a result, the agricultural land below the photovoltaic systems can also be cultivated because in particular rainwater and/or sunlight can pass through the open spaces. Rainwater can thus, for example, serve for irrigation. The respective spatial dimension of the photovoltaic modules and the gap between the photovoltaic modules can hereby be selected depending on the field of application.

Moreover, owing to the mechanically limitedly detachable fastening of the holder to the fastening tube, it is possible to considerably reduce the maintenance cost of the photovoltaic system. Thus, individual photovoltaic modules can be replaced without there being any need to change the whole system. The individual photovoltaic modules in the photovoltaic system can thus be replaced simply in a “plug and play” fashion.

According to at least one embodiment of the photovoltaic system, the main directions of extent of the multiplicity of photovoltaic modules within the limits of the manufacturing tolerances run parallel to each other. In other words, the photovoltaic system comprises a multiplicity of cylindrical photovoltaic modules which are arranged parallel to one another. Open spaces can then be arranged between the photovoltaic modules.

The photovoltaic module described here and the photovoltaic system described here are explained in detail below with the aid of exemplary embodiments and the associated drawings.

Figure 1 shows an exemplary embodiment of a photovoltaic module described here with the aid of a schematic view in section.

Figure 2 shows an exemplary embodiment of a photovoltaic module described here with the aid of a schematic perspective view.

Figure 3 shows an exemplary embodiment of a photovoltaic module described here with the aid of a schematic view in section.

Figures 4, 5, 6 and 7 show exemplary embodiments of a photovoltaic system described here with the aid of schematic views. Elements which are identical, similar or have the same function are provided with the same reference numerals in the drawings. The drawings and the proportions of the elements shown in the drawings should not be considered as being drawn to scale. Instead, individual elements can be depicted as exaggeratedly large for the sake of improved visibility and/or better understanding.

An exemplary embodiment of a photovoltaic module 10 described here is explained in detail according to the schematic view in section in Figure 1. The cross-section shown hereby runs perpendicularly to a main direction of extent Z of the photovoltaic module 10. The main direction of extent Z thus runs into the plane of the drawing.

The photovoltaic module 10 comprises a translucent tube 1 with the form of a circular ring in cross-section in the present case. The tube 1 encompasses a circular inner space 4 and has an inner face 1a facing the inner space 4 and an outer face 1f facing away from the inner face 1a. Part of the inner face 1a forms a light passage surface 1b. Geometrical terms such as "circular" are hereby and below to be understood within the limits of the manufacturing tolerances. For example, the inner space 4 can also have an elliptical structure.

The photovoltaic module 10 moreover has a photovoltaic component 2. In the present case, the photovoltaic component 2 comprises at least two encapsulation films 231, 232 connected together by a material-formed bond. The encapsulation films 231, 232 at least in places are in direct contact with each other and in these places are connected together by a material-formed bond.

The photovoltaic component 2 moreover comprises a solar cell arrangement 21 and a carrier film 22 to which the solar cell arrangement 21 is applied. The solar cell arrangement 21 can, for example, be a CIGS solar cell arrangement or an organic solar cell arrangement. The carrier film 22 can be formed, for example, with a metal or a plastic. The solar cell arrangement 21 and the carrier film 22 are arranged completely between the at least two encapsulation films 231, 232. The two encapsulation films 231, 232 directly adjoin each other in the region in which there is no solar cell arrangement 21 present.

In the exemplary embodiment shown in Figure 1, the two encapsulation films 231, 232 completely cover the inner face 1a. It is alternatively possible – in contrast to what is shown in Figure 1 – that the inner face 1a is free of the encapsulation films 231, 232 in places. For example, the encapsulation films 231, 232 then only cover the solar cell arrangement 21 and edge regions around the solar cell arrangement 21 which are required for the material-formed bond of the encapsulation films 231, 232.

The photovoltaic component 2 is arranged in the inner space 4. The solar cell arrangement 21 of the photovoltaic component 2 hereby has a curvature. In the present case, the solar cell arrangement 21 has the form of an arc of a circle and the curvature of the associated circle. The curvature of the arc of a circle of the solar cell arrangement 21 hereby follows the curvature of the inner face 1a of the tube. The carrier film 22 and the encapsulation films 231, 232 likewise have a curvature which follows the curvature of the inner face 1a at least in places.

The inner face 1a forms the light passage surface 1b in the region in which the solar cell arrangement 21 covers the inner face 1a of the tube 1. That part of the photovoltaic module 10 having the light passage surface 1b forms a top side 101 of the photovoltaic module 10, whilst the part with no light passage surface forms the underside 102.

A metal tube 3 which encompasses a cooling space 31 is moreover arranged in the inner space 4. A base surface 2c of the photovoltaic component 2 facing away from the inner face 1a hereby faces towards the metal tube 3. The metal tube 3 is hereby in direct contact with the photovoltaic component 2. For this purpose, in the present case the metal tube 3 is arranged eccentrically. In other words, the metal tube 3 is arranged such that it is not centred with respect to the tube 1. The metal tube 3 is encompassed completely by the photovoltaic component 2 and the tube 1. The metal tube serves, for example, to cool the photovoltaic component 2. For this purpose, the cooling space 31 of the metal tube 3 can be filled with water and/or air.

A further exemplary embodiment of a photovoltaic module 10 described here is explained in detail according to the schematic perspective view in Figure 2. The photovoltaic module 10 hereby corresponds to the photovoltaic module 10 in Figure 1.

The tube 1 has an elongated design and extends in the main direction of extent Z. Perpendicularly to the main direction of extent Z, the tube 1 has the cross-section shown in Figure 1. The solar cell arrangement 21 of the photovoltaic component 2 extends in the main direction of extent Z. The solar cell arrangement 21 hereby forms a continuous surface in a view of the top side 101. The light passage surface 1b then has a singly coherent design. In a view of the top side 101, the solar cell arrangement 21 has, for example, the form of a rounded rectangle.

A further exemplary embodiment of a photovoltaic module 10 described here is explained in detail according to the schematic view in section in Figure 3. The photovoltaic module 10 shown here differs from that in Figure 1 by the presence of a light-emitting component 71, 72 and a storage battery 8.

The light-emitting component 71, 72 covers free regions 1c of the inner face 1a which are not covered by the solar cell arrangement 21 at least in places. For example, the solar cell arrangement 21 is, as shown here, arranged on the top side 101 of the photovoltaic module 10, whilst the light-emitting component 71, 72 is arranged on the underside 102. The light-emitting component 71, 72 hereby comprises light-emitting layers 71 and a carrier layer 72. The light-emitting layers 71 are formed, for example, with organic layers. It is moreover possible that the light-emitting layers 71 contain inorganic layers. It is hereby possible that the light-emitting layer 71 is not formed continuously and instead is divided into individual segments in order to ensure flexibility of the light-emitting component 71, 72.

The storage battery 8 is moreover arranged in the inner space 4 of the tube 1. The storage battery 8 is connected to the photovoltaic component 2 in an electrically conductive manner. Electrical connections 81 to the solar cell arrangement 21 and to the light-emitting component 71, 72 are, for example, provided.

An exemplary embodiment of a photovoltaic system described here is explained in detail according to the schematic view in Figure 4. The photovoltaic system has a multiplicity of photovoltaic modules 10. The main directions of extent Z of the photovoltaic modules 10 run parallel to one another within the limits of the manufacturing tolerances. An open space 101 is arranged in each case between the photovoltaic modules 10. Rainwater can, for example, pass through this open space 101 in the case of operation outdoors. The photovoltaic modules 10 are attached to two fastening tubes 63 by means of holders 61. In the present case, the fastening tubes 63 run vertically with respect to the main directions of extent Z of the photovoltaic modules 10.

A further exemplary embodiment of a photovoltaic system described here is explained in detail according to the schematic view in Figure 5. An enlargement of a portion of the photovoltaic system shown in Figure 4 is shown hereby.

The holders 63 each have a screw hole 62 through which a screw 64 (not shown here) can be guided. The holder can be connected mechanically limitedly detachably to the fastening tube 63 by means of a screw 64. The photovoltaic system moreover has a contact 66, freely accessible from outside, which serves for electrically contacting the photovoltaic modules 10.

The holders 61 are connected mechanically to the photovoltaic modules 10. In the present case, two holders 61 are in each case associated with a photovoltaic module 10. It is moreover possible – in contrast to what is shown in the drawings – that just one or more than two holders 61 are associated with each photovoltaic module 10. The holders 61 are connected to the associated photovoltaic module 10 via a plug-in connection, a screw connection and/or a clamping connection. The connection and holding can be effected, for example, in a similar manner to a fluorescent tube.

An exemplary embodiment of a photovoltaic system described here is explained in detail according to the schematic view in Figure 6. The photovoltaic system shown corresponds to that in Figures 4 and 5, wherein a cross-section through a photovoltaic module 10 and a fastening tube 63 in the main direction of extent 10 is shown. The holder 61 has recesses 611 in the region of the fastening tube 63 in order to enable a flush fit of the holder 61 with the fastening tube 63.

The photovoltaic module 10 is connected mechanically limitedly detachably to the fastening tube 63 via a screw 64 which is guided through the screw hole 62. For the mechanically limitedly detachable connection, the fastening tube 63 has a fastening element 65 inside it into which the screw engages. The screw 64 is moreover connected in an electrically conductive manner to a contact element 67 which is in turn connected in an electrically conductive manner to the solar cell arrangement 21 which is arranged on the top side 101, facing away from the fastening tube 63, of the photovoltaic module 10. The fastening element 65 thus serves both for the mechanical connection of the holder 62 to the fastening tube 63 and the electrical contacting of the solar cell arrangement 21 of the photovoltaic module 10.

By virtue of the mechanically limitedly detachable connection of the holder 61 to the fastening tube 63, it is in particular possible to replace individual photovoltaic modules 10 at low cost. As a result, a low-maintenance photovoltaic system can be provided.

A further exemplary embodiment of a photovoltaic system described here is explained in detail according to the schematic view in Figure 7. The photovoltaic system shown corresponds to that in Figures 4 to 6, wherein a cross-section through a fastening tube 63 and the holders 61 perpendicularly to the main direction of extent Z is shown. The screws 64 engage into the fastening elements 65. They are in turn connected in an electrically conductive manner to the contact 66. The fastening elements 65 extend at least partially along the fastening tube 63. In the present case, two screws 64 are in each case connected to a fastening element 65.

The invention is not limited by the description with the aid of the exemplary embodiments to said exemplary embodiments. Instead, the invention comprises any new feature and any combination of features, including in particular any combination of features in the patent claims, even if this feature or this combination are not themselves explicitly provided in the patent claims or exemplary embodiments.

This application claims priority for German application DE 10 2014 225 631.3, to the disclosed content of which reference is made hereby.

List of reference numerals:

Z	main axis of extent
10	photovoltaic module
101	top side
102	underside
103	open space
1	tube
1a	inner face
1b	light passage surface
1c	light-emitting surface
1f	outer face
2	photovoltaic component
21	solar cell arrangement
22	carrier film
231, 232	encapsulation films
2c	base surface
3	metal tube
31	cooling space
4	inner space
61	holder
611	recess
62	screw hole
63	fastening tube
64	screw
65	fastening element
66	contact
67	contact element
71	light-emitting layers
72	carrier layer
8	storage battery
81	electrical connection

Patentkrav

1. Fotovoltaikmodul (10) omfattende
- et lysgennemtrængeligt rør (1) omsluttende et indvendigt rum (4) med en hovedudstrækningsretning (Z) og en krummet indvendig flade (1a), som vender mod det indvendige rum, og
- en mekanisk fleksibel fotovoltaikkomponent (2) med en på en bærefolie (22) påført solcelleanordning (21) idet
- fotovoltaikkomponenten (2) er placeret i det indvendige rum (4),
- solcelleanordningen (21) har en krumning, idet krumningen i det mindste nogle steder følger det krummede forløb på den indvendige flade (1a) af røret (1), og
- solcelleanordningen (21) i det mindste delvist overdækker den indvendige flade (1a), idet den overdækkede indvendige flade (1a) danner en lysgennemtrængningsflade (1b) i fotovoltaikmodulet (10),
kendetegnet ved, at
fotovoltaikkomponenten (2) har i det mindste to uadskilleligt med hinanden forbundne indkapslingsfolier (231, 232),
idet
- solcelleanordningen (21) er placeret fuldstændigt mellem indkapslingsfolierne (231, 232),
- indkapslingsfolierne (231, 232) er termoplastiske folier, og
- indkapslingsfolierne (231, 232) i det mindste nogle steder står i direkte kontakt med hinanden.

2. Fotovoltaikmodul (10) ifølge et af de foregående krav, idet i det mindste en indkapslingsfolie (231, 232) dækker solcelleanordningen (21) på en udvendig flade.

3. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor solcelleanordningen (21) i et tværsnit lodret på hovedudstrækningsretningen (Z) inden for rammerne af fremstillingstolerancerne i det mindste nogle steder har form som en cirkelbue.

4. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor

i det mindste 30 % og op til 100 % af den indvendige flade (1a) på røret (1) er overdækket af solcelleanordningen (21).

5. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor lysgennemtrægningsfladen (1b) er en simpelt sammenhængende flade.

6. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor fotovoltaikkomponenten (2) lodret på hovedudstrækningsretningen (Z) er omsluttet fuldstændigt af røret (1).

7. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor solcelleanordningen (21) påføres på bærefolien (22) under anvendelse af en trykproces.

8. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor solcelleanordningen (21) er en CIGS-solcelleanordning eller en organisk solcelleanordning.

9. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor solcelleanrodningen (21) har en tykkelse på højst 5 um, fortrinsvis højst 2,5 um.

10. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor fotovoltaikkomponenten har en mekanisk fleksibelt formet lysemitterende komponent (71, 72), idet
- den lysemitterende komponent (71, 72) på solcelleanordningen (21) i det mindste nogle steder overdækker udækkede frie områder (1c) på den indvendige flade (1a),
- den lysemitterende komponent (71, 72) er elektrisk isoleret fra solcelleanordningen (21), og
- krumningen på den lysemitterende komponent (71, 72) i det væsentlige følger det krummede forløb på den indvendige flade (1a).

11. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor der i det indvendige rum (4) på en bundflade (2c), som vender væk fra den indvendige flade (1a), på fotovoltaikkomponenten (2) er placeret en akkumulator (8), idet akkumulatoren (8) er

elektrisk ledende er forbundet med fotovoltaikkomponentn (2).

12. Fotovoltaikmodul (10) ifølge det foregående krav, hvor akkumulatoren (8) er indrettet til at lagre en ved hjælp af solcelleanordningen (21) frembragt elektrisk energi og tidsforskudt at afgive den til den lysemitterende komponent (71, 72).

13. Fotovoltaikmodul (10) ifølge et af de foregående krav, hvor der i det indvendige rum (4) på bundfladen (2c) er placeret et cylinderformet metalrør (3), idet metalrøret (3) fortrinsvis
- i det mindste nogle steder står i direkte kontakt med fotovoltaikkomponenten (2), og
- omslutter et luft- eller vandfyldt kølerum (31).

14. Fotovoltaiksystem omfattende
- et stort antal fotovoltaikmoduler (10) ifølge et af de foregående krav,
- et stort antal holdere (61) og
- i det mindste to fastgøringsrør (63), idet
- hvert fotovoltaikmodul (10) er forbundet mekanisk med i det mindste en holder (61), og
- hver holder (61) er fastgjort mekanisk betinget løsbart til i det mindste et fastgøringsrør (63).

15. Fotovoltaiksystem ifølge det foregående krav, hvor hovedudstrækningsretningerne (Z) for det store antal fotovoltaikmoduler (10) forløber parallelt med hinanden inden for rammerne af fremstillingstolerancerne.

Fig. 1

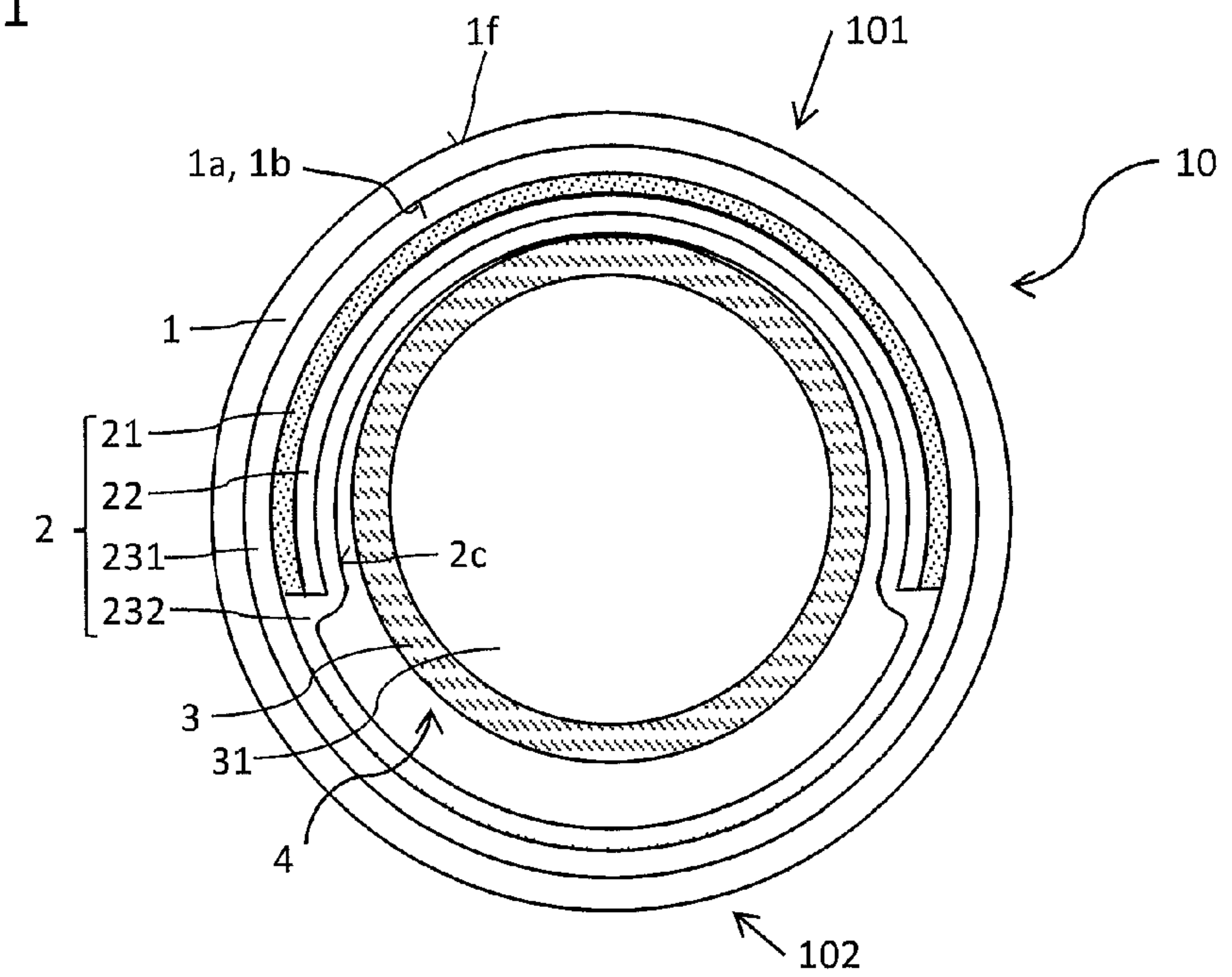

1f
101
1a, 1b
10
1
21
22
2
231
2c
232
3
31
4
102

Fig. 2

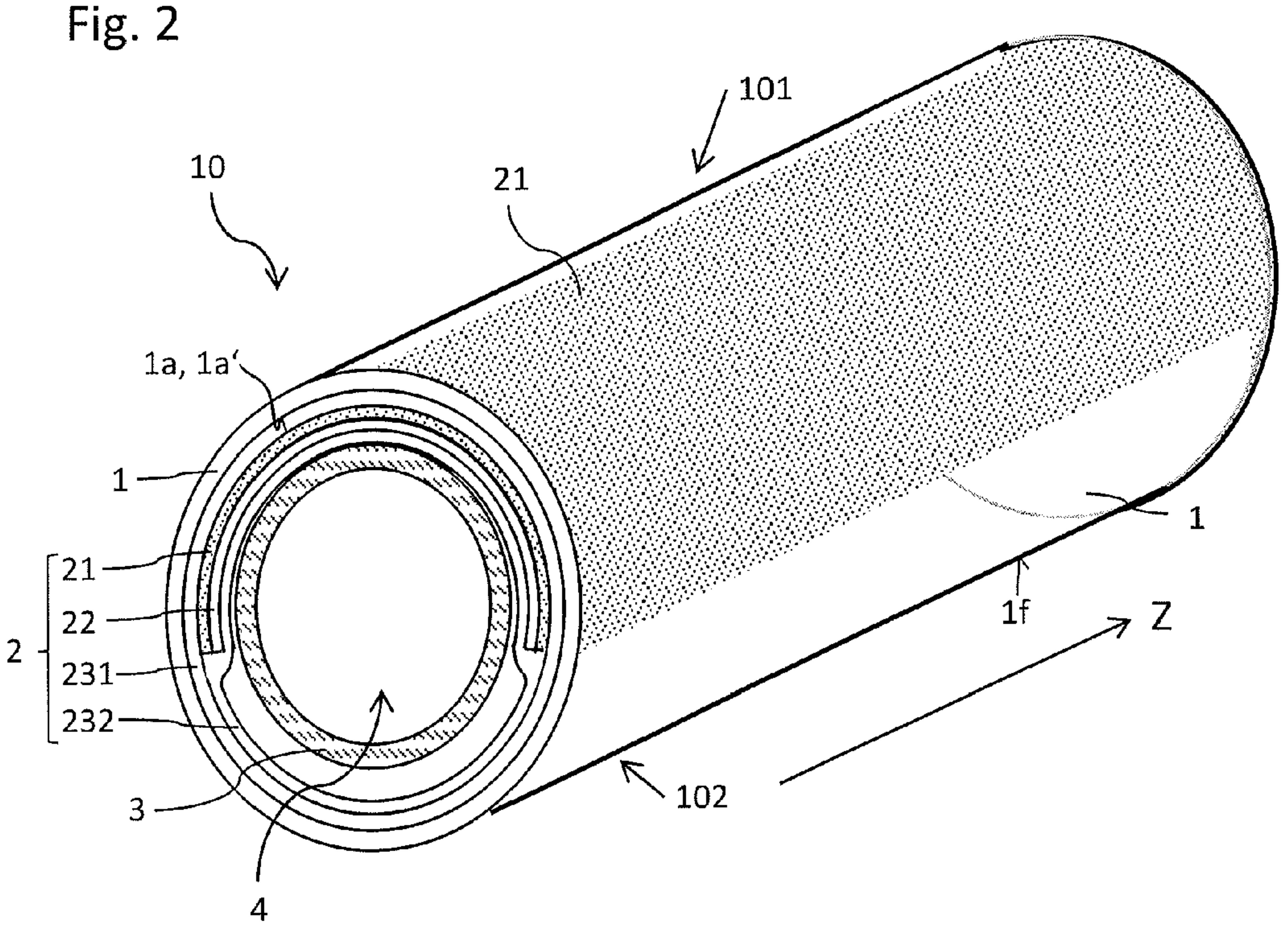

101
10
21
1a, 1a'
1
1
21
22
2
231
232
1f
Z
3
102
4

Fig. 3

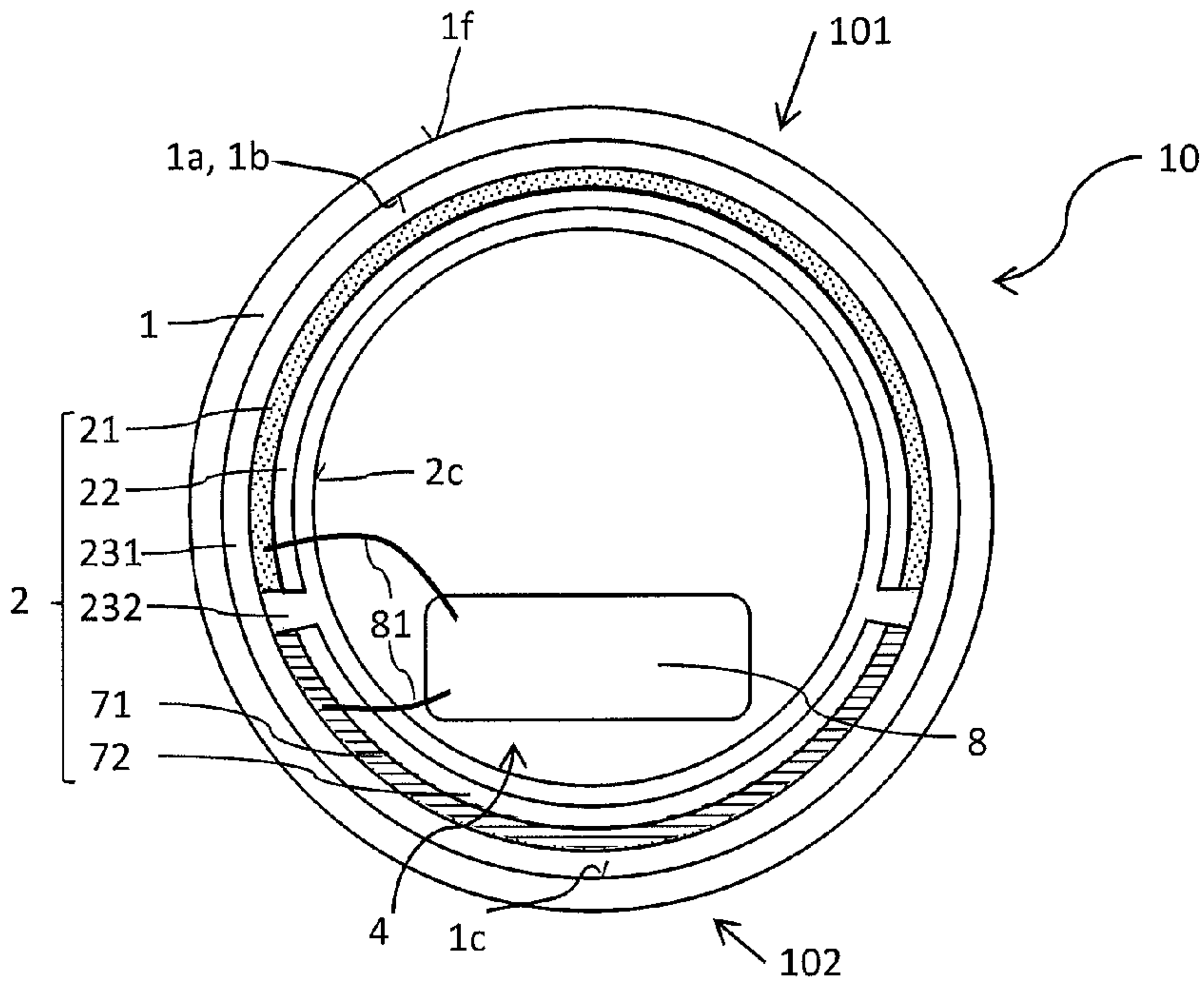
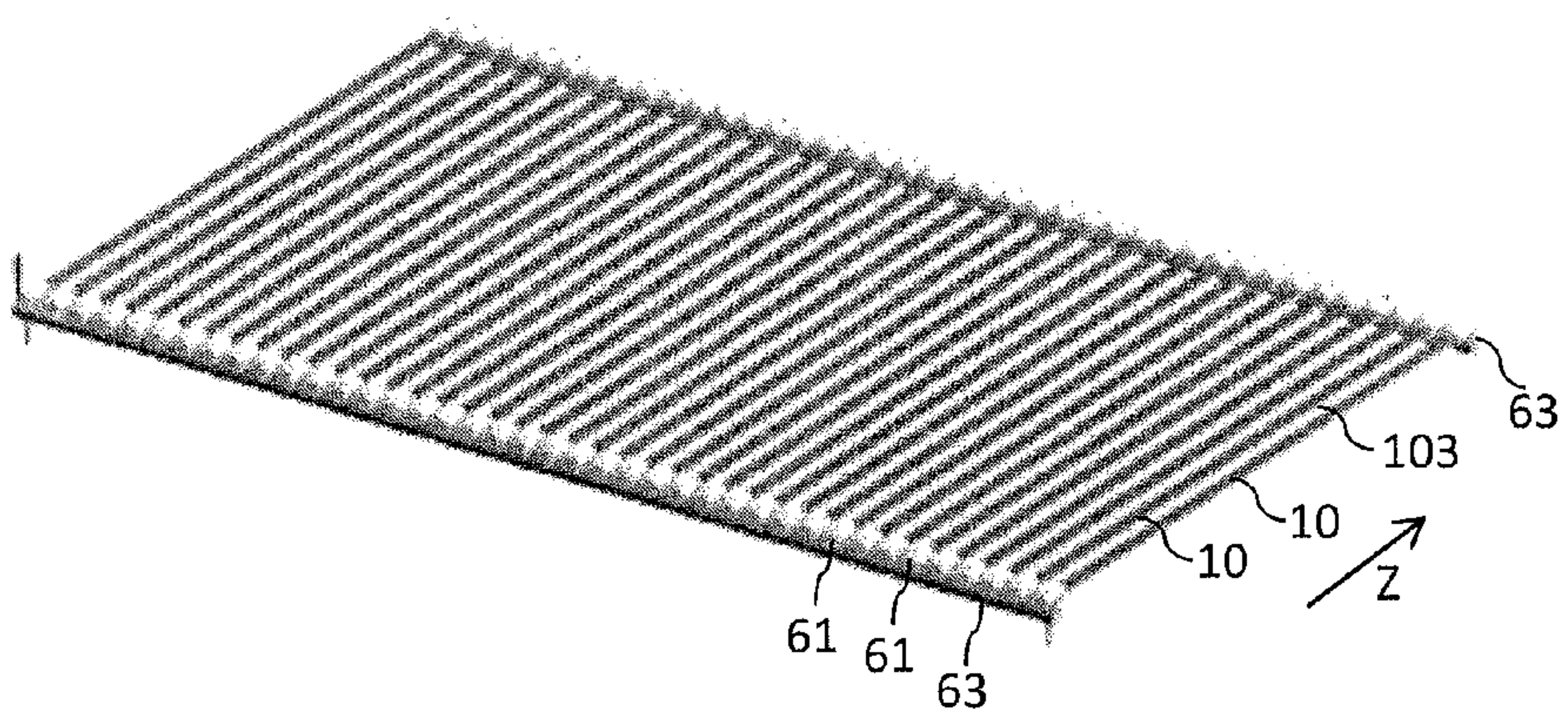

1f
101
1a, 1b
10
1
21
22
2c
231
2
232
81
71
8
72
4
1c
102

Fig. 4


63
103
10
10
Z
61
61
63

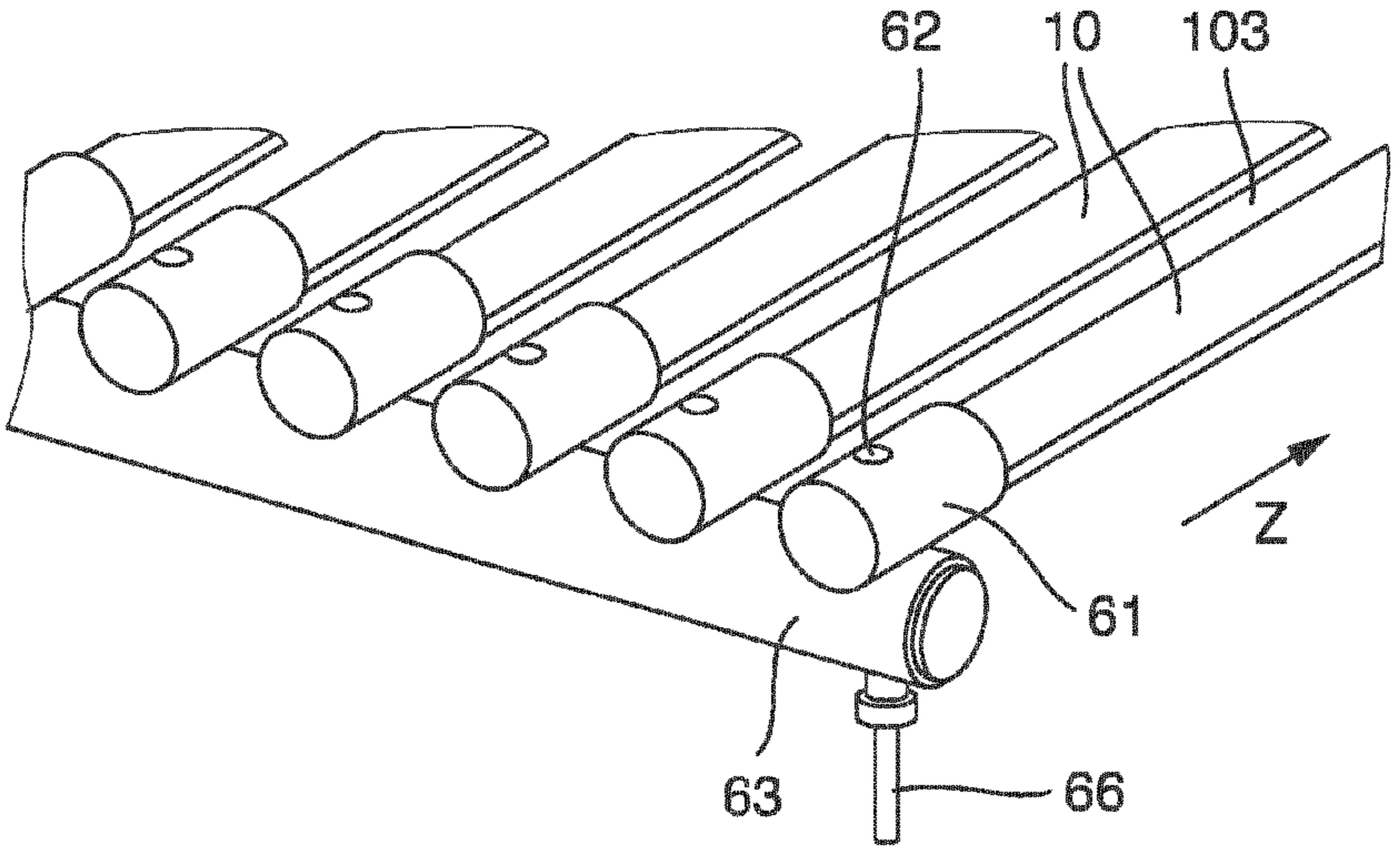


Fig. 5

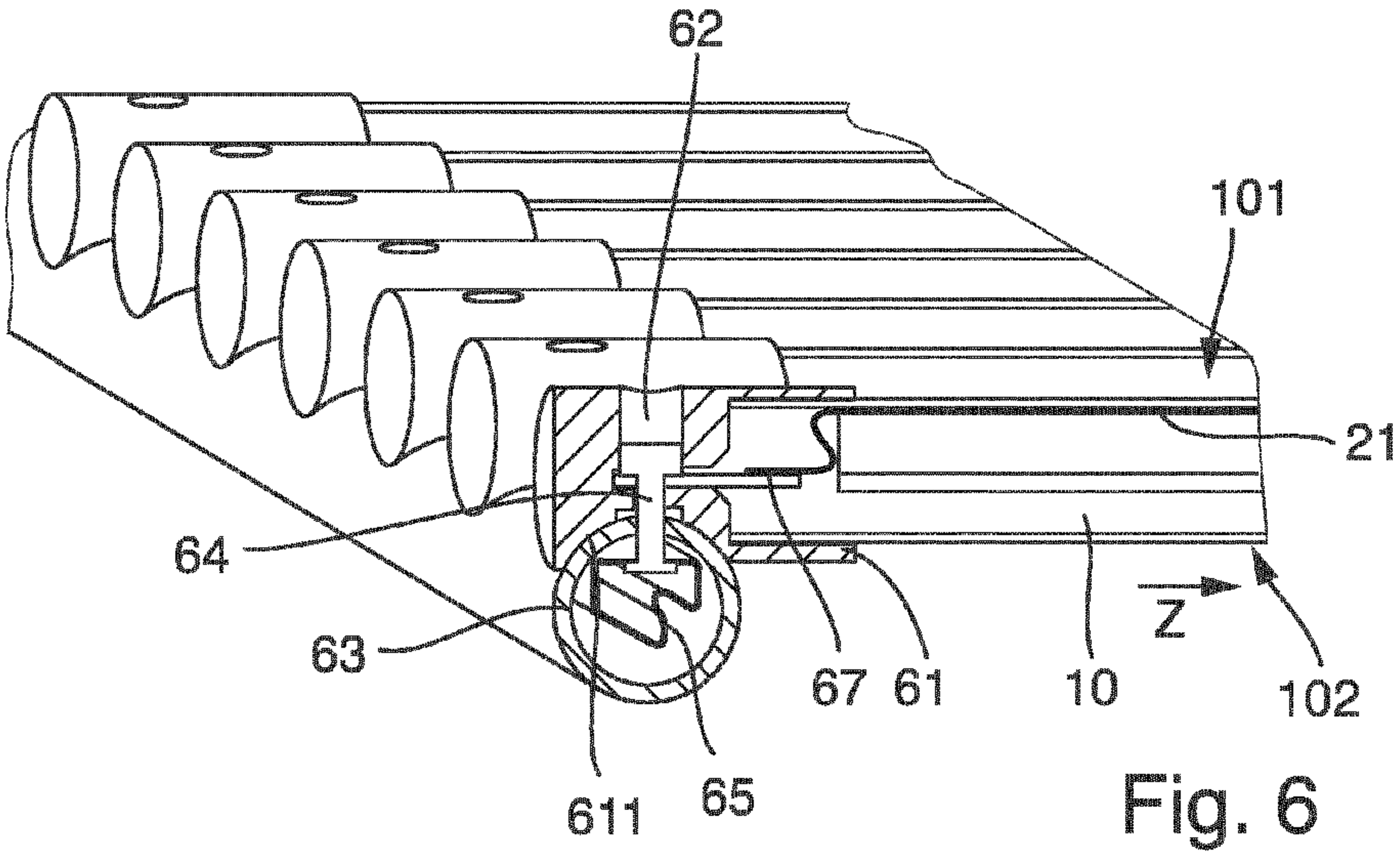


Fig. 6

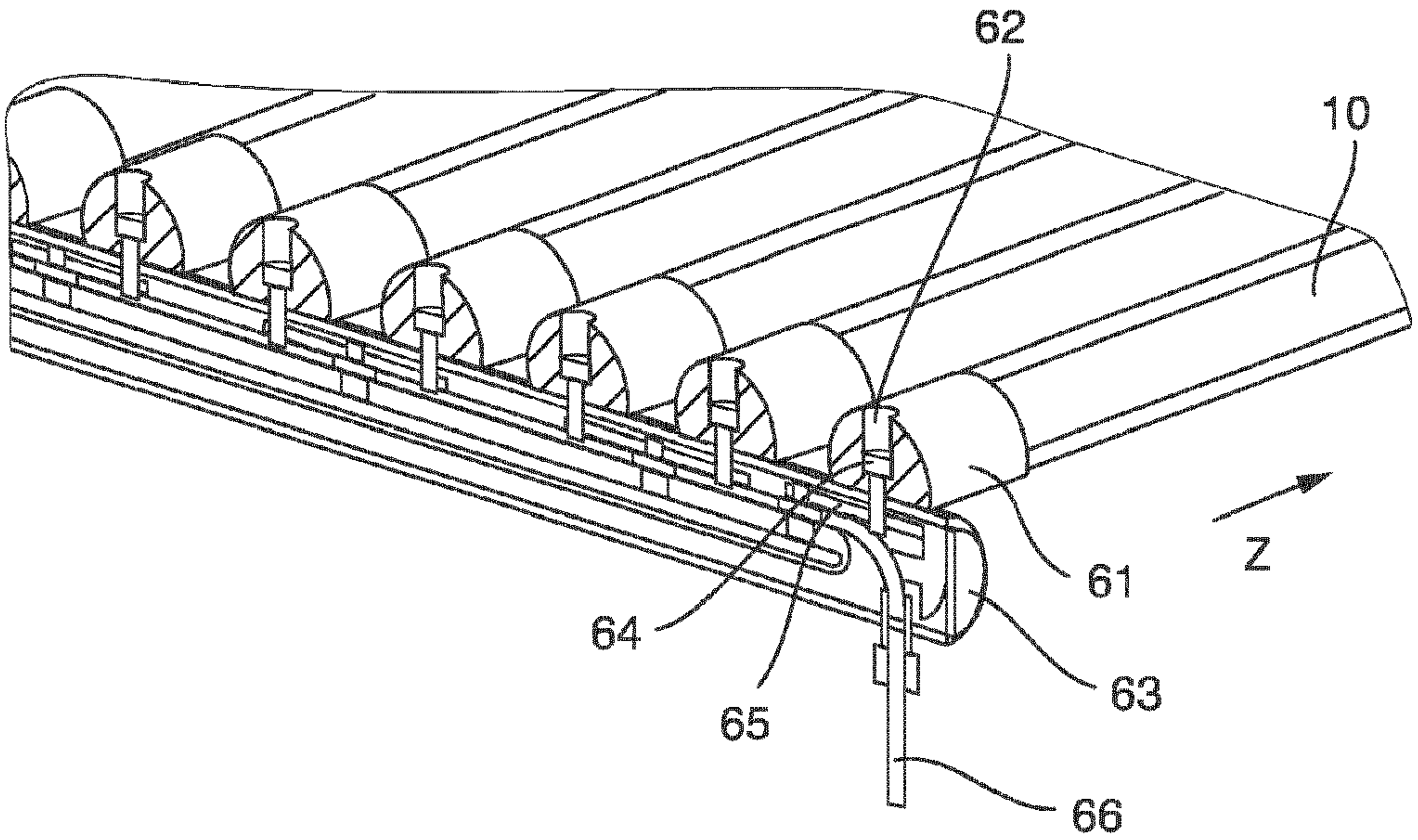


Fig. 7