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(54) **SYSTEM OF MULTILAYERED THERMALLY-INSULATING GLAZING UNITS**

MEHRSCHEIBEN-ISOLIERVERGLASUNG SYSTEM

SYSTÈME DE VITRAGE THERMO-ISOLANT A VITRES MULTIPLES

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Description

[0001] The subject matter of this invention covers a system of multilayered thermally-insulating glazing units implemented primarily in the construction industry. In particular, the invention relates to vertical or sloped glazing units as elements of classical joinery for wall openings (operable windows and fixed windows, glazed doors, including patio doors), light glass curtain walls in the operable and fixed versions, glazed facades, steep roof-slope windows and other steep-roof glazing units and structures of the green house type, as well as solar energy generating equipment.

[0002] Up to now, reduction of the undesirable transfer of heat through glazing units has been resolving itself by the introduction of gas with a heat conductivity lower than that of the air into the space between window panes, to the introduction of low-emissivity coatings, as well as to increasing the thickness of the gas layer, which necessitated multiplying the layers inside the chamber of a multiple glass window pane. However, adding subsequent convection-inhibiting partitions results in an increase of the weight of the entire glazing unit, which makes it necessary to mount such a construction of a multiple glass window pane in a robust - therefore weakly-insulating - and material-consuming frame that could hold the increased weight of the glazing unit.

[0003] In order to reduce the weight of an insulated glass unit, while maintaining the number of layers, some manufacturers used polymers as materials for the production of internal layers. Glass units with such a structure can consist of even as many as five layers, where three internal layers can be made of a polymer; of PET in particular. Such solution, however, is not ideal, due to the limited durability of the internal layers, subject to thermal degradation and photo-degradation, deformation, yellowing, etc., and due to their optic parameters that are worse than those of glass, which involves primarily pane hazing. Interference with the sun rays on the surface and inside all the additional elements deteriorates the quality of the view observed through a glazing unit. The system absorbs, reflects and disperses a part of the light falling on such transparent thermal insulation. For this reason, such glazing units cannot be used in places, where it is desirable to get a high level of visible light transfer and perfect optical quality of glazing.

[0004] GB 2 011 985 describes a glazing unit that contains two panes and at least one film partition stretched on a frame between the panes. The internal plastic film partition may be covered with a low-emissivity layer or a layer impervious to ultraviolet radiation. The chamber between glass panes may be hermetically closed and filled with air or another gas or it may be connected to the atmosphere through a filter.

[0005] US 4 563 843 describes a window, where two partitions are arranged between two glass panes which divide the internal air chamber. The partitions are made of 20-100 μm thick polymer film, glass or plastic panels.

The surfaces of the partitions are covered on one or both sides with a low-emissivity layer. Implementation of rigid panes made of glass or plastic results in a considerable weight of the glazing per unit area. Implementation of polymer films with the above-indicated thickness, in turn, involves the risk of photo-degradation and thermal degradation of the polymer and additionally, when the glazing unit is filled with air, the risk of photo-oxidation, affecting the entire thickness of the polymer too. These alterations that penetrate the entire film thickness produce macroscopically observable yellowing and an increase of polymer absorption and diffusivity and its deformations (corrugation, cracking and surface sponginess).

[0006] The use of such polymeric films, e.g. of the Heat-Mirror® type are presented in US 5 156 894, US 5 784 853 and US 5 544 465, and of the Visionwall type - in the description of patent US 7 571 583. Such solutions, however, are not ideal due to the aforementioned limited durability of the internal layers (photo-degradation), poor optical quality and difficulties involved in stretching internal layers during the production process, as well as in the mechanical instability of these layers.

[0007] It was proposed to introduce discontinuous, fibrous or mesh-like structures into the space between glass panes, in order to improve heat-insulation properties and reduce the weight of a glazing unit. WO 2011 068426 reveals transparent partitions in the form of stretched tulle screens made of nanofibres and characterized by a transparent texture, consisting of at least two of the following three layers: (i) a bearing frame made of mechanically resistant, elastic or textured nanofibres, (ii) a layer of conductive nanofibres or nanowires stretched on the frame, and (iii) a covering and thickening tissue made of nanofibres that are 5-25 nanometres in diameter, while the distance between the screens depends on the type of gas.

[0008] There is a need to employ - as the internal layers (partitions) of the thermally-insulating multiple glass window pane - a material that is known (as opposed to those known at the moment, especially those implemented in the above-described solutions) for its resistance to high temperature gradients, resistance to the operation of visible radiation and UV, resistance to aging, by low weight and - which is most important - for its perfect optical characteristics, namely: absolute transparency, low transmittance haze level, low absorption and low reflectivity within the range of visible light. It is preferable for partitions to have as low emissivity and absorption as possible, or as high a coefficient of reflection as possible within the range of thermal radiation, i.e. far infrared radiation.

[0009] This invention is aimed at introducing multi-layered glazing units that combine high heat-transfer resistance with absolute transparency. It is therefore necessary to endow all elements with appropriate optical characteristics, so as to make them practically invisible to the user.

[0010] Glazing units proposed in this invention have the form of a multiple glass window unit, consisting of

two external transparent glass panes and a gas medium, transparent in visible light, between the panes, while transparent internal partitions are placed in the internal space between the above-mentioned panes that is closed with a thermally-insulating hermetic frame, and the partitions are parallel with respect to the external panes.

[0011] The essence of the invented solution consists in the fact that the partitions take the form of a film made of inorganic glass, the film is less than 400 μm thick and it is characterised by a deflection radius that is smaller than 40 cm, while its optical properties are characterised by a total reflectivity coefficient of both partition surfaces that is lower than 7 percent, the visible light absorption below 7 percent and the transmittance haze coefficient below 1.5 percent.

The mechanical and optical parameters of the partitions are measured by methods recognized in the art.

The partitions are made of an ultrathin film, with its thickness within the range from 20 to 300 μm , made of silica glass or boron-lithium glass.

[0012] The partitions are covered with multilayered soft low-emissivity coating that contains at least one nanolayer of silver which is covered with an external anti-reflective layer.

[0013] The antireflective layer may be a nanoporous layer characterised by the gradient of light refraction index and made of silica, another inorganic material or a polymer resistant to photo-degradation. The antireflective layer may be a layer of amorphous, fluorinated polymer that is highly transparent to visible light and transparent to far infrared radiation, also characterised by a very low light refraction index and thus, by a very low reflectivity coefficient. The antireflective layer may be a nanorelief layer of the "moth eye" type, made of an inorganic material or a polymer resistant to photo-degradation.

[0014] The distance between internal partitions depends on the type of gas that fills the multiple glass window unit and fits within the range from 8 millimetres for xenon to 25 millimetres for air.

[0015] Particular partitions are reinforced at their edges with stiffening furniture slats. The multiple glass unit is fitted with an elastic thermally-insulating frame with a hermetic external coating joined with partition stiffening slats by means of grooves and rods inserted into them.

[0016] The frames have thermally-insulating partition separators that keep them at identical distances from each other. The separators may take the form of elastic aerogel-filled sleeves, springy tension rods or porous inserts.

The multiple glass unit may have a system of internal angle braces that endow the entire block of the multiple glass window pane with rigidity and maintain its dimensions in spite of internal pressure changes.

[0017] The multiple glass window pane may be fitted with a hermetically-closed system in order to compensate for gas volume changes. The system takes the form of

compensating bellows. The compensating function may be carried out by means of a semi-opened system that compensates for gas pressure and volume changes by dynamic exchange of atmospheric air. The system contains a filter and a drier. In a centralized version, involving a connection of at least two multiple glass units to a central compensating chamber or to a central semi-opened system that compensates for gas pressure and volume changes by dynamic exchange of atmospheric air, the system contains a filter and a drier.

[0018] The advantages of the invented solution consist of its low weight, a combination of heat-transfer and optical parameters that has been unattainable up to now, exemplified in particular by the heat-transfer coefficient $U < 0.3$, the solar gain $g > 60\%$ and the total reflectivity $< 40\%$ that characterize the double-layered glazing unit. Glazing units characterized by these parameters allow one to realize the assumptions for the passive house, where the surface and location of glazing units are not conditioned by their weight and the heat-transfer coefficient. Up to now, due to the worse U coefficient of glazing units, larger glazing units used in the construction of passive buildings had to consist of very heavy 3- or 4-pane sets, which prevented architects from acting freely and involved the need to give up large-format glazed facades and glazed facades facing North in the Northern hemisphere. Moreover, the invented solution allows one to retain windows with the classical construction, without any need for onerous seasonal changes in the glazing unit structure.

[0019] The inorganic glass film - as opposed to classical glass panes - is characterised by its lower weight, lower absorption and higher elasticity that makes deformations of sheets reversible, and the sheets do not get damaged in the process.

In contrast to the partitions made of polymer films, the inorganic glass film does not undergo aging, wrinkling or yellowing. It is also resistant to extreme temperatures. It does not get destroyed even at temperatures above 300 degrees Celsius and below 50 degrees Celsius below zero still it does not show increased brittleness. It is non-flammable. Compared to polymers, its thermal expansion coefficient is 10 times lower.

[0020] The invented solution is presented as implementation examples illustrated in a set of drawings, where particular figures present:

Fig. 1 - basic elements of a multilayered glass unit,
Fig. 2 - examples of assembling the structure of internal partitions,

Fig. 3 - a cross-section of a multilayered glass unit with an elastic frame of the bellows type, stiffened with angle braces and sleeves connecting stiffening slats of partitions,

Fig. 4 - a cross-section of a multilayered glass unit with an elastic frame of the bellows type, stiffened with angle braces and springy separators connecting stiffening slats of partitions,

Fig. 5 - a cross-section of a multilayered glass unit with elastomeric separators connecting stiffening slats of partitions with compensating bellows,
 Fig. 6 - a comparison of the basic optical characteristics of the hitherto-implemented conventional structures of multi-layered glazing units (A and B) with a glazing unit made according to this invention (C).

[0021] The basic element of glazing units constructed according to this invention is the multiple glass unit 1 presented in Fig. 1. It consists of two external transparent glass panes 2 that enclose a hermetic chamber filled with gas. Inside the hermetic chamber, there are transparent partitions (3), arranged parallel to the external panes 2. The partitions 3 take the form of a film made of inorganic glass. The film is less than 400 μm thick and it is characterised by a deflection radius that is smaller than 40 cm, while its optical properties are characterised by the total reflectivity coefficient of both partition surfaces 3 that is lower than 7 percent, the visible light absorption below 7 percent and the transmission haze coefficient below 1.5 percent.

[0022] Films may be made of inorganic silica glass or boron-lithium glass. It is also possible to make them of glass with other composition, e.g. of oxide glass based on fluorine or phosphorus. Ultra-thin films made of inorganic glass are known for their high elasticity, very low weight and high chemical resistance.

[0023] The internal sides of external panes 2 are covered with low-emissivity coatings 4, preferably with additional anti-reflective properties. The internal partitions 3 are covered on both sides with anti-reflective coatings 5, preferably with additional low-emissivity properties.

[0024] For glazing units to be realized according to this invention, it is crucial to ensure extreme optical properties of the internal partitions 3, especially total transparency achieved as a result of a low degree of transmission haze, as low a level of reflections as is possible and low absorption.

Fig. 2 presents diagrams of selected examples of versions of such partitions made according to this invention.

[0025] A partition 3 made of ultrathin inorganic glass film (20-300 μm thick) is covered on both sides with a double-layered coating that adheres to glass 303. The coating contains at least one nanolayer of silver 301, covered with an external anti-reflective nanoporous layer 302 characterised by a gradient of light refraction index. The external nanoporous layer 302 characterized by a gradient of light refraction index is made of silica, another inorganic material or a polymer resistant to photo-degradation. Such combination of coatings of the type of "a heat mirror covered with a nanoporous layer" results in good thermal properties, without impairing optical properties.

[0026] In another implementation example, a partition 3 made of ultrathin inorganic glass film (20-300 μm thick) is covered on both sides with a double-layered coating

that adheres to glass 303. The coating contains at least one nanolayer of silver 301. The latter layer is covered in room temperature with an external anti-reflective layer of amorphous, highly-transparent fluorinated polymer 304 characterised by a very low light refraction index and thus, by a very low reflectivity coefficient. When in the form of thin layers, the fluorinated polymer is transparent to long-wave infrared radiation. Therefore, such application of the polymer does not hinder the low-emissivity properties of the soft coating deposited on glass.

[0027] In yet another implementation example, a partition 3 made of ultrathin inorganic glass film (20-300 μm thick) is covered on both sides with a double-layered coating that adheres to glass 303. The coating contains at least one nanolayer of silver 301, covered with an external anti-reflective nanorelief layer 305 in the form of a regular network of nanocleats made of a polymer or an inorganic material. Such a combination of coatings of the type of "a heat mirror covered with a moth-eye coating" results in low emissivity, accompanied by considerably reduced reflections and reduced absorption, as in the case of the above-describe coating, which translates into advantageous heat-transfer and optical properties of the partition that have been unattainable up to now in a single structure.

[0028] Both the external panes 2 and the internal partitions 3 are set in thermally-insulating frames 6, known as "warm edge spacer". The frames 6 have an external hermetic coating 7. This coating 7 constitutes an external barrier of the multiple glass unit 1 that isolates the gas filling the pane chamber from the surrounding atmosphere.

[0029] The openings 8 allow gas to flow inside the chamber of the multiple glass unit 1. Depending on the glazing unit construction, it is preferable to use different types of filling. The basic filling is an inert gas such as, for instance, xenon, krypton, argon or a combination of all three. In the case of extremely thick partitions 3, one may use gases that are non-transparent to long-wave infrared radiation (greenhouse gases), such as sulphur hexafluoride, carbon dioxide or a mixture of carbon dioxide and methane, or even dry air purified of aerosols. The distance between internal partitions 3 depends on the type of gas that fills the multiple glass unit and fits within the range from 8 mm for xenon to 25 mm for air.

The external panes 2 and internal partitions 3 may be fitted with hardware i.e. edge stiffening slats 9 that simultaneously stretch elastic film and protect edges against mechanical damage.

[0030] The frame 6 - assembled as an integrated unit, with the width equal to the thickness of the multiple glass unit 1 - has the form of an elastic springy tape and it is fitted with a set of grooves and projections that constitute thermally-insulating separators 10, aimed at protecting internal partitions 3 against stresses and shocks and at insulating the gas filling of the chamber from the surrounding atmosphere.

[0031] In a development of the invention, the stiffening

slats 9 of the external panes 2 and internal partitions 3 are fitted on the outside with a groove 11 adapted to accept a rod 12 fitted into the coating 7 of the frame 6. This allows the set of partitions 3 to be mounted without breaking the continuity of the material used for the coating 7.

[0032] The coating 7 may be made in the form of an elastic laminate sleeve with an elastic thin high-barrier layer of clay materials or a metallic film or in the form of a composite grooved slat.

[0033] Particular elastic partitions 3 may be hermetically bonded to thermally-insulating frames 6 of classical structure or assembled in the form of springy, hermetic sleeves 13, filled with a roll of elastic aerogel sheets.

[0034] Alternatively, the frames 6 that separate particular partitions 3 from each other may be fitted with separators in the form of springy tension rods 14 or porous inserts 15.

[0035] The multiple glass unit 1 fitted with a thermally-insulating frame 6 with coating 7 and partition 3 separators 10 in different forms may be equipped with a set of internal angle braces 16. The set of angle braces 16 stiffens the entire block of the multiple glass window pane 1 and maintains its dimensions, in spite of changes of the internal pressure.

For multilayered units constructed according to this invention, i.e. for units characterized by a higher thickness and volume than standard glazing, it is required to additionally implement a system that compensates for changes in gas pressure and volume inside such glazing units. The system may assume a closed or semi-opened form, for instance, that of hermetic bellows 17 - in the external version.

[0036] A multiple glass unit may alternatively be equipped with a semi-opened system that compensates for changes in gas pressure and volume, based on the dynamic exchange of atmospheric air, and contains a filter and a drier.

[0037] It is also possible to implement a compensating system in a centralized version, involving a combination of at least two multiple glass units to a central compensating chamber or to a central semi-opened system that compensates for gas pressure and volume changes by the dynamic exchange of atmospheric air. The system contains a filter and a drier.

[0038] For comparative purposes, Fig. 6 presents the basic optical characteristics of hitherto used conventional constructions of multilayered glazing units.

[0039] Fig. 6A, in turn, shows the optical characteristics of a traditional multiple glass unit, consisting of several glass panes 102 situated between external panes 2. In such a heavy unit, a ray of visible light reflects many times from the surfaces of successive panes, which leads to a reduction of light ray brightness, while the quality of the observed view considerably deteriorates, due to numerous reflections, and does so in spite of a low scattering level, typical for oxide glass.

[0040] In the case of a multiple glass unit of the "heat

mirror" type with partitions in the form of a set of polymer film sheets 202 presented in Fig. 2B, one faces a similar problem of multiple reflections and absorption occurring on low-emissivity coatings. Moreover, the quality of the observed view is additionally worsened by a relatively high transmittance haze coefficient, typical for the majority of polymers.

[0041] The invented solution presented in Fig. 2C, with partitions 3 made of inorganic glass film, shows decidedly different optical properties and maintains a low weight, in spite of the super-standard thickness of the entire glazing unit and considerably higher number of layers. In the invented glazing unit, the light is reflected and weakened only to a slight degree, while the quality of the view observed through such glazing unit is not degraded, which is due to a low level of transmittance haze.

List of parts

[0042]

1. multiple glass unit
2. external panes
3. internal partitions
- 301 - silver layer
- 302 - nanoporous layer
- 303 - glass
- 304 - layer of amorphous fluorinated polymer
- 305 - nanorelief layer
4. low-emissivity layer
5. anti-reflective layer
6. thermally-insulating frame
7. external layer
8. openings
9. stiffening slats
10. thermally-insulating separator
11. groove
12. rod
13. sleeve with aerogel
14. springy tension rod
15. porous inserts
16. angle braces
17. compensating bellows
- 102 - glass partitions
- 202 - polymer partitions

Claims

1. System of multilayered thermally-insulating glazing units in the form of a multiple glass unit, consisting of two external transparent glass panes and a gas medium that is transparent in visible light between the panes, while transparent internal partitions are placed in the internal space between the above-mentioned panes that is closed with a thermally-insulat-

- ing hermetic frame, and the partitions are parallel with respect to the external panes, **characterised in that** the partitions (3) take the form of a film made of inorganic glass, the film is less than 400 μm thick and it is **characterised by** a deflection radius smaller than 40 cm, measured by a method recognized in the art, while its optical properties are **characterised by** a total reflectivity coefficient of both partition (3) surfaces lower than 7 percent, the visible light absorption below 7 percent and the transmittance haze coefficient below 1.5 percent, all optical properties measured by methods recognized in the art.
2. System of multilayered glazing units as claimed in claim 1, **characterised in that** the partitions (3) are made of an ultrathin film, with its thickness within the range from 20 to 300 μm , made of silica glass or boron-lithium glass.
 3. System of multilayered glazing units as claimed in claim 2, **characterised in that** the partitions (3) are covered with multilayered soft low-emissivity coating that contains at least one nanolayer of silver (301), which is covered with an external anti-reflective nanoporous layer (302) **characterised by** the gradient of light refraction index and made of silica, another inorganic material or a polymer resistant to photo-degradation.
 4. System of multilayered glazing units as claimed in claim 2, **characterised in that** the partitions (3) are covered with a multilayered soft low-emissivity coating that contains at least one nanolayer of silver (301) which is covered with an external anti-reflective layer of amorphous, fluorinated polymer (304) that is highly transparent to visible light and transparent to far infrared radiation, also **characterised by** a very low light refraction index and thus, by a very low reflectivity coefficient.
 5. System of multilayered glazing units as claimed in claim 2, **characterised in that** the partitions (3) are covered with multilayered soft low-emissivity coating that contains at least one nanolayer of silver (301), which is covered with an external anti-reflective nanorelief layer (305) of the "moth eye" type, made of an inorganic material or a polymer resistant to photo-degradation.
 6. System of multilayered glazing units as claimed in claim 2, **characterised in that** the distance between internal partitions (3) depends on the type of gas that fills the multiple glass window unit (1) and fits within the range from 8 millimetres for xenon to 25 millimetres for air.
 7. System of multilayered glazing units as claimed in claim 2, **characterised in that** particular partitions (3) are reinforced at their edges with stiffening furniture slats (9).
 8. System of multilayered glazing units as claimed in claim 1, **characterised in that** the multiple glass unit (1) is fitted with an elastic thermally-insulating frame (6) with a hermetic external coating (7) joined with partition (3) stiffening slats (9) by means of grooves (11) and rods (12) inserted into them.
 9. System of thermally-insulating glazing units as claimed in claim 1, **characterised in that** the frames (6) have thermally-insulating partition (3) separators (10) that keep them at identical distances from each other.
 10. System of thermally-insulating glazing units as claimed in claim 1, **characterised in that** the frames (6) have thermally-insulating partition (3) separators in the form of elastic sleeves (13) filled with aerogel.
 11. System of thermally-insulating glazing units as claimed in claim 1, **characterised in that** the frames (6) are fitted with partition (3) separators in the form of springy tension rods (14) or porous inserts (15).
 12. System of thermally-insulating glazing units as claimed in claim 1, **characterised in that** the multiple glass unit (1) has a system of internal angle braces (16) that endow the entire block of the multiple glass window unit (1) with rigidity and maintain its dimensions in spite of internal pressure changes.
 13. System of multilayered glazing as claimed in claim 1, **characterised in that** the multiple glass unit (1) is fitted with a hermetically-closed system in the form of compensating bellows (17), aimed at compensating for gas volume changes.
 14. System of multilayered glazing units as claimed in claim 1, **characterised in that** the multiple glass unit (1) is equipped with a semi-opened system that compensates for changes in gas pressure and volume, based on the dynamic exchange of atmospheric air, and contains a filter and a drier.
 15. System of multilayered glazing units as claimed in claim 1, **characterised in that** the compensating system is assembled in a centralized version, involving a combination of at least two multiple glass units (1) to a central compensating chamber or to a central semi-opened system that compensates for gas pressure and volume changes by the dynamic exchange of atmospheric air, the system containing a filter and a drier.

Patentansprüche

1. Mehrscheiben-Isolierverglasung System in Form einer Verbundscheibe, bestehend aus zwei externen transparenten Glasscheiben, zwischen denen sich ein im sichtbaren Licht transparentes Gasmedium befindet, wobei im mit einem hermetischen, wärmeisolierenden Rahmen verschlossenen Innenbereich zwischen den genannten Scheiben, parallel zu den externen Scheiben, transparente interne Trennelemente angeordnet sind, **dadurch gekennzeichnet, dass** die Trennelemente (3) die Form einer Folie aus anorganischem Glas mit einer Dicke kleiner 400 μm und einem Biegeradius kleiner 40 cm haben, wobei sich die optischen Eigenschaften durch einen summarischen Reflexionskoeffizienten von beiden Trennelementen (3) kleiner 7 Prozent, Lichtabsorption im sichtbaren Bereich kleiner 7 Prozent und einen Trübungskoeffizienten kleiner 1,5 Prozent charakterisieren. 5
2. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Trennelemente (3) aus einer ultradünnen Folie mit einer Dicke von 20 bis 300 μm aus Quarzglas oder Bor-Lithium-Glas bestehen. 25
3. Mehrscheiben-Isolierverglasung System nach Anspruch 2, **dadurch gekennzeichnet, dass** die Trennelemente (3) mit einer mehrschichtigen weichen Low-E-Beschichtung, enthaltend mindestens eine Nanoschicht Silber (301) mit einer externen nanoporösen Antireflexionsschicht (302) mit einem Gradienten des Lichtbrechungsindex, bestehend aus Siliciumoxid, einem anderen anorganischen Material oder einem gegenüber Photoabbau beständigen Polymer beschichtet sind. 30
4. Mehrscheiben-Isolierverglasung System nach Anspruch 2, **dadurch gekennzeichnet, dass** die Trennelemente (3) mit einer mehrschichtigen weichen Low-E-Beschichtung, enthaltend mindestens eine Nanoschicht Silber (301) mit einer Antireflexionsschicht aus einem amorphen Fluorpolymer (304), das im sichtbaren Licht hochtransparent und im fernen Infrarot in dünnen Schichten transparent ist, mit einem sehr kleinen Lichtbrechungsindex und somit einem sehr kleinen Reflexionskoeffizienten, beschichtet sind. 40
5. Mehrscheiben-Isolierverglasung System nach Anspruch 2, **dadurch gekennzeichnet, dass** die Trennelemente (3) mit einer mehrschichtigen weichen Low-E-Beschichtung, enthaltend mindestens eine Nanoschicht Silber (301) mit einer Nanorelief-Schicht (305) Typ "Mottenaugen" aus einem anorganischen Material oder einem gegenüber Photoabbau beständigen Polymer, beschichtet sind. 45
6. Mehrscheiben-Isolierverglasung System nach Anspruch 2, **dadurch gekennzeichnet, dass** der Abstand zwischen den internen Trennelementen (3) von der Gasart in der Verbundscheibe (1) abhängt und von 8 Millimeter für Xenon bis 25 Millimeter für Luft beträgt. 50
7. Mehrscheiben-Isolierverglasung System nach Anspruch 2, **dadurch gekennzeichnet, dass** die einzelnen Trennelemente (3) an den Kanten mit Versteifungsleisten (9) verstärkt sind. 10
8. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Verbundscheibe (1) mit einem flexiblen wärmedämmenden Rahmen (6) mit einer hermetischen externen Beschichtung (7), verbunden mit den Versteifungsleisten (9) des Trennelements (3) mit Rillen (11), in die die Stäbe (12) hineingeschoben werden, ausgestattet ist. 15
9. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Rahmen (6) wärmedämmende Abstandhalter (10) der Trennelemente (3), die den gleichen Abstand gewährleisten, haben. 20
10. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Rahmen (6) wärmedämmende Abstandhalter der Trennelemente (3) in Form von flexiblen Manschetten (13) mit Aerogel haben. 30
11. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Rahmen (6) wärmedämmende Abstandhalter der Trennelemente (3) in Form von federnden Zugstäben (14) oder porösen Einsätzen (15) haben. 35
12. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Verbundscheibe (1) mit einem System von internen Streben (16), das den ganzen Körper der Verbundscheibe (1) versteift und ihre feste Abmessungen trotz der Änderungen des Innendruckes gewährleistet, ausgestattet ist. 40
13. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Verbundscheibe (1) mit einem hermetisch verschlossenen System in Form eines Kompensationsbalges (17), der die Schwankungen des Gasvolumens kompensiert, ausgestattet ist. 45
14. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Verbundscheibe (1) mit einem halb offenen System zur Kompensation von Änderungen des Gasdruckes 50

und des Gasvolumens auf Basis des Luftaustauschs, enthaltend einen Filter und einen Trockner, ausgestattet ist.

15. Mehrscheiben-Isolierverglasung System nach Anspruch 1, **dadurch gekennzeichnet, dass** das Kompensationssystem eine zentralisierte Version mit der Verbindung von mindestens zwei Verbundscheiben (1) mit einer zentralen Kompensationskammer oder einem zentralen halb offenen System zur Kompensation Änderungen des Gasdruckes und des Gasvolumens, auf Basis des Luftaustauschs, enthaltend einen Filter und einen Trockner, darstellt.

Revendications

1. Système de vitrage thermo-isolant à vitres multiples sous la forme d'une unité de vitrage multiple, constituée de deux carreaux de verre transparents externes, entre lesquels se trouve un milieu gazeux transparent à la lumière visible, alors que dans l'espace interne entre les carreaux susvisés, fermé par un intercalaire thermo-isolant hermétique, sont placés des parois internes transparentes, disposées parallèlement aux carreaux externes, **caractérisé en ce que** les parois (3) prennent la forme d'un film en verre inorganique, le film mesurant moins de 400 μm , et sa plasticité étant **caractérisé par** un rayon de courbure qui est inférieur à 40 cm, alors que ses propriétés optiques sont **caractérisés par** un coefficient de réflectivité totale des surfaces des deux parois (3) qui est inférieur à 7 pour cent, l'absorption de la lumière visible qui est inférieure à 7 pour cent et le coefficient de brume et de transmission qui est inférieur à 1,5 pour cent.
2. Système de vitrage à vitres multiples selon la revendication 1, **caractérisé en ce que** les parois (3) sont réalisées à partir d'un film ultramince, avec une épaisseur de l'ordre de 20 à 300 μm , en verre de silice ou en verre de lithium et de bore.
3. Système de vitrage à vitres multiples selon la revendication 2, **caractérisé en ce que** les parois (3) sont recouvertes d'une pellicule molle multicouche à basse émissivité comprenant au moins une nanocouche d'argent (301), sur laquelle est appliquée une couche antireflet externe à structure nanoporeuse (302) avec un gradient d'indice de réfraction, fabriqué en silice, un autre matériau inorganique ou un polymère résistant à la photodégradation.
4. Système de vitrage à vitres multiples selon la revendication 2, **caractérisé en ce que** les parois (3) sont recouvertes d'une pellicule molle multicouche à basse émissivité comprenant au moins une nanocouche d'argent (301), sur laquelle est appliquée une cou-

che antireflet externe de fluoropolymère amorphe hautement transparent pour la lumière visible (304), transparent dans les couches minces pour l'infrarouge lointain, ayant un très faible indice de réfraction et, par conséquent, un très faible coefficient de réflexion.

5. Système de vitrage à vitres multiples selon la revendication 2, **caractérisé en ce que** les parois (3) sont recouvertes d'une pellicule molle multicouche à basse émissivité comprenant au moins une nanocouche d'argent (301), sur laquelle est appliquée une couche antireflet externe en nanorelief (305) du type « oeil de papillon de nuit », fabriquée en matériau inorganique ou un polymère résistant à la photodégradation.
6. Système de vitrage à vitres multiples selon la revendication 2, **caractérisé en ce que** la distance entre les parois internes (3) dépend du type du gaz remplissant l'unité de vitrage multiple (1) et elle atteint de 8 millimètres pour le xénon jusqu'à 25 millimètres pour l'air.
7. Système de vitrage thermo-isolant à vitres multiples selon la revendication 2, **caractérisé en ce que** les parois internes respectives (3) sont renforcées aux bords avec des barres de rigidité de quincaillerie (9).
8. Système de vitrage à vitres multiples selon la revendication 1 **caractérisé en ce que** l'unité de vitrage multiple (1) est munie d'un intercalaire thermo-isolant souple (6) avec un revêtement extérieur hermétique (7) lié par des barres de rigidité (9) de la paroi (3) au moyen de feuillures (11) et des barres qui y sont glissées (12).
9. Système de vitrage thermo-isolant selon la revendication 1, **caractérisé en ce que** les intercalaires (6) sont munis d'espaceurs thermo-isolant (10) des parois (3) qui les maintient à des distances égales.
10. Système de vitrage thermo-isolant selon la revendication 1, **caractérisé en ce que** les intercalaires (6) sont munis d'espaceurs thermo-isolant des parois (3) sous la forme de manches souples (13) remplies d'aérogel.
11. Système de vitrage thermo-isolant selon la revendication 1, **caractérisé en ce que** les intercalaires (6) sont munis d'espaceurs des parois (3) sous la forme de tiges élastiques (14) ou d'inserts poreux (15).
12. Système de vitrage thermo-isolant selon la revendication 1, **caractérisé en ce que** l'unité de vitrage multiple (1) dispose d'un système d'entretoises internes (16) assurant la rigidité de l'ensemble du vitrage (1) et maintenant ses dimensions en dépit des

changements de la pression interne.

13. Système de vitrage à vitres multiples selon la revendication 1, **caractérisé en ce que** l'unité de vitrage multiple (1) est munie d'un dispositif hermétiquement fermé de compensation de changement de volume de ce gaz sous la forme d'un soufflet de compensation (17). 5
14. Système de vitrage à vitres multiples selon la revendication 1, **caractérisé en ce que** l'unité de vitrage multiple (1) est munie d'un dispositif semi-ouvert de compensation de changement de pression et de volume de gaz basé sur l'échange dynamique de l'air ambiant comprenant un filtre et un dessiccateur. 10 15
15. Système de vitrage à vitres multiples selon la revendication 1, **caractérisé en ce que** le dispositif de compensation constitue une version centralisée, unissant au moins deux unités de vitrage multiples (1) avec une chambre de compensation centrale ou avec un dispositif central semi-ouvert de compensation de changement de pression et de volume de gaz basé sur l'échange dynamique de l'air ambiant comprenant un filtre et un dessiccateur. 20 25

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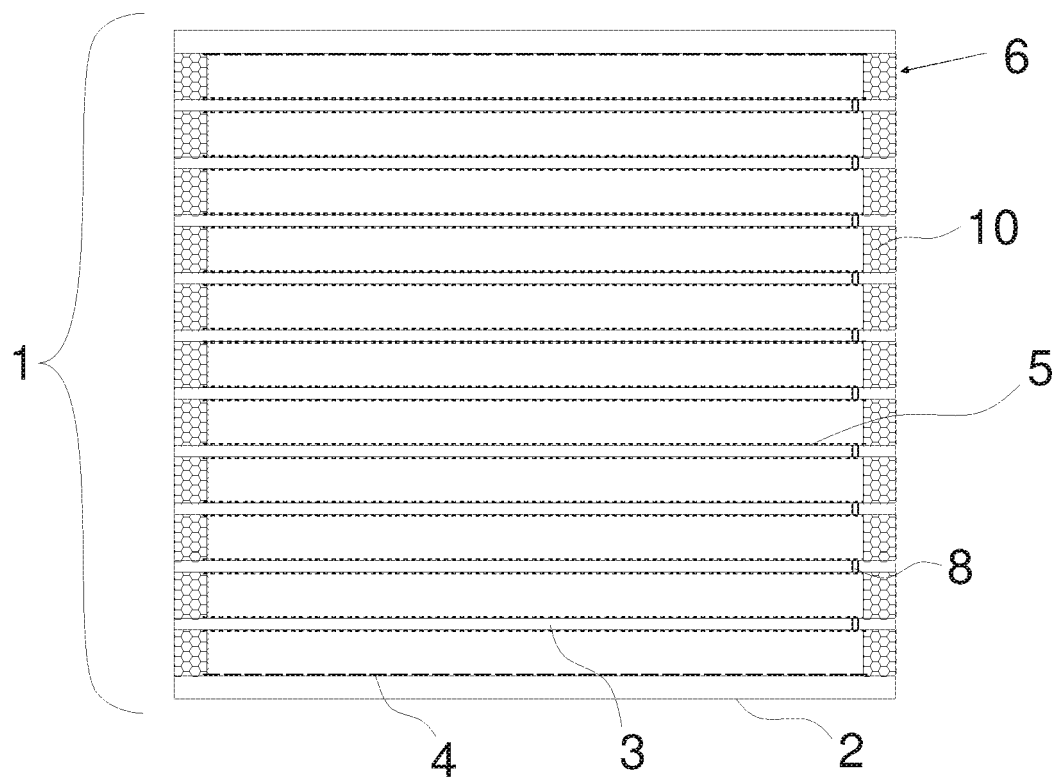


Fig. 1

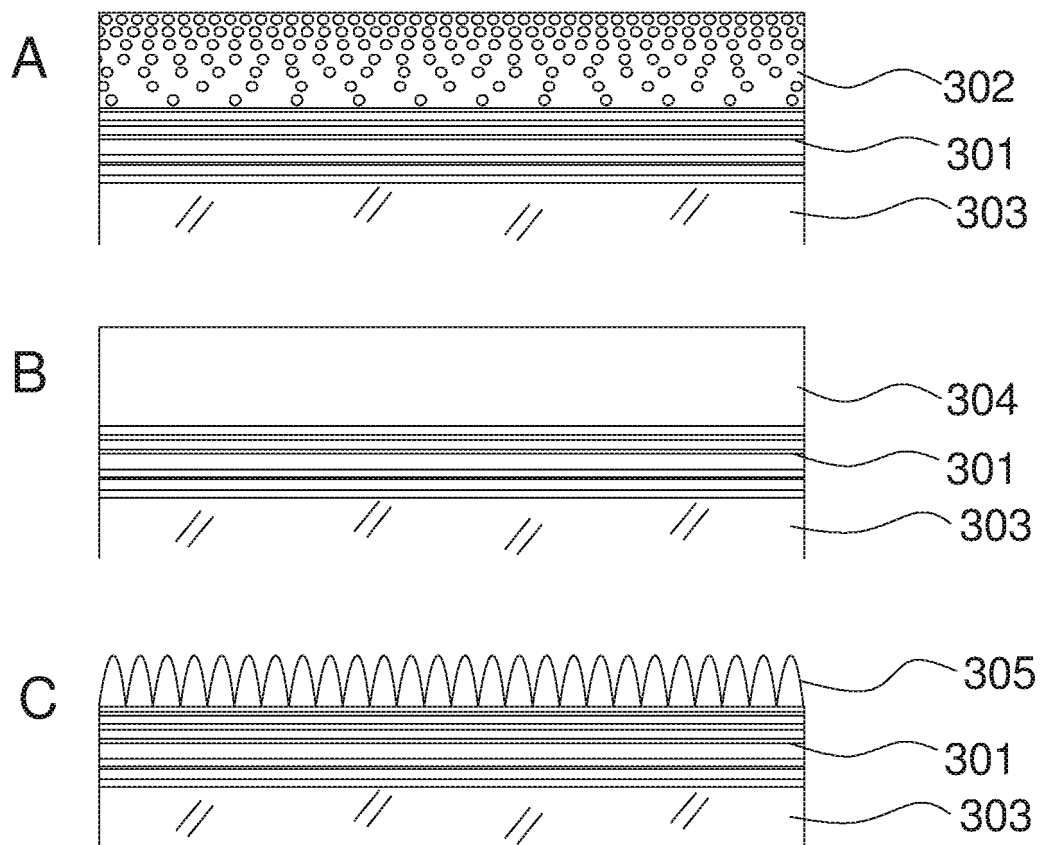


Fig. 2

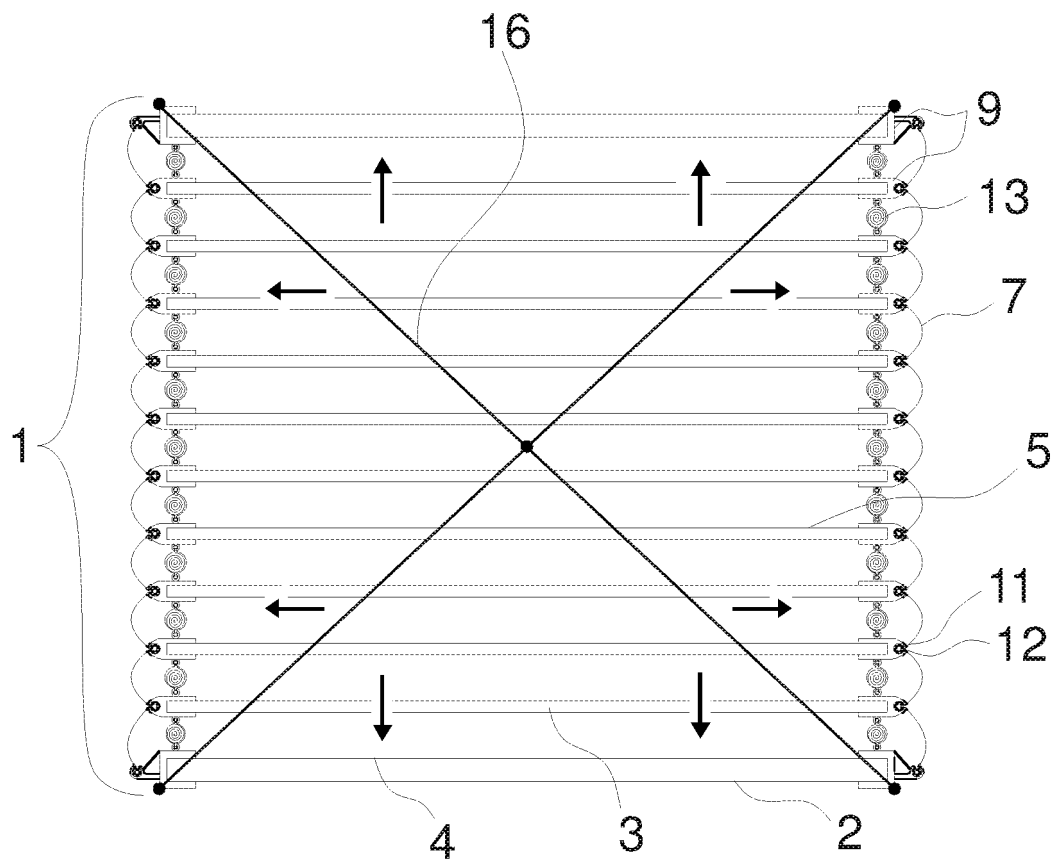


Fig. 3

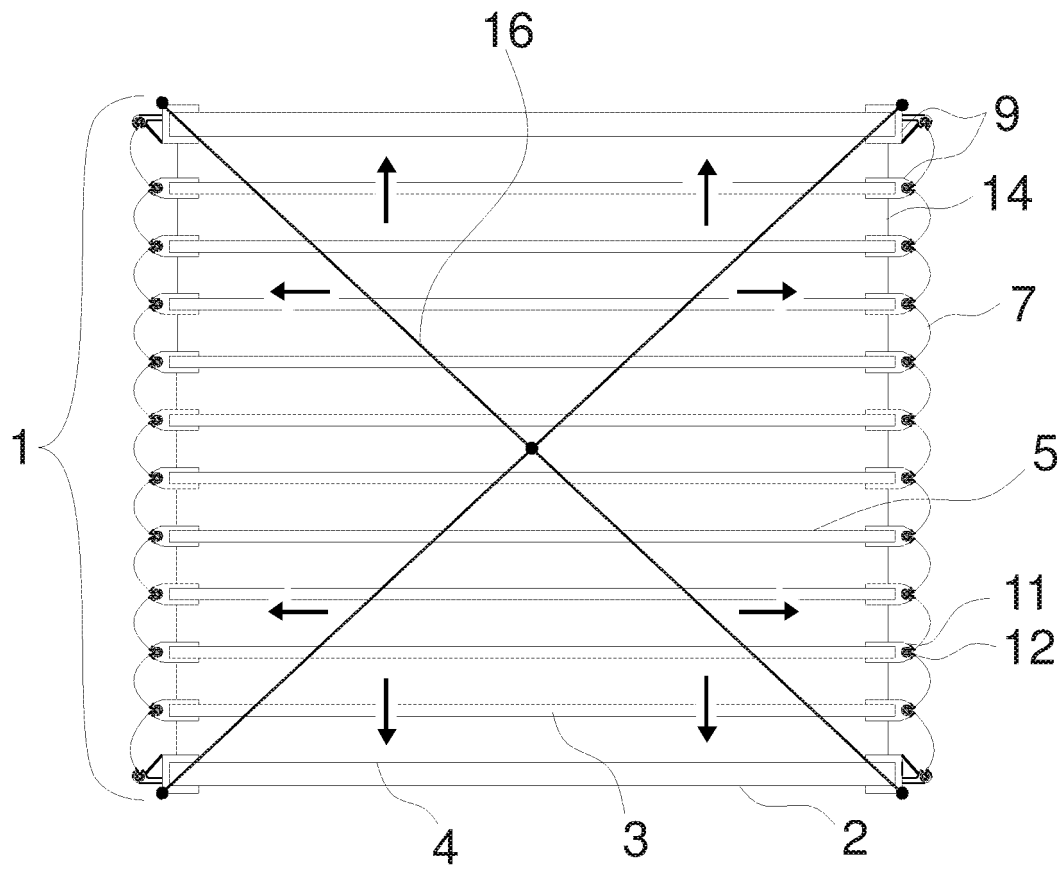


Fig. 4

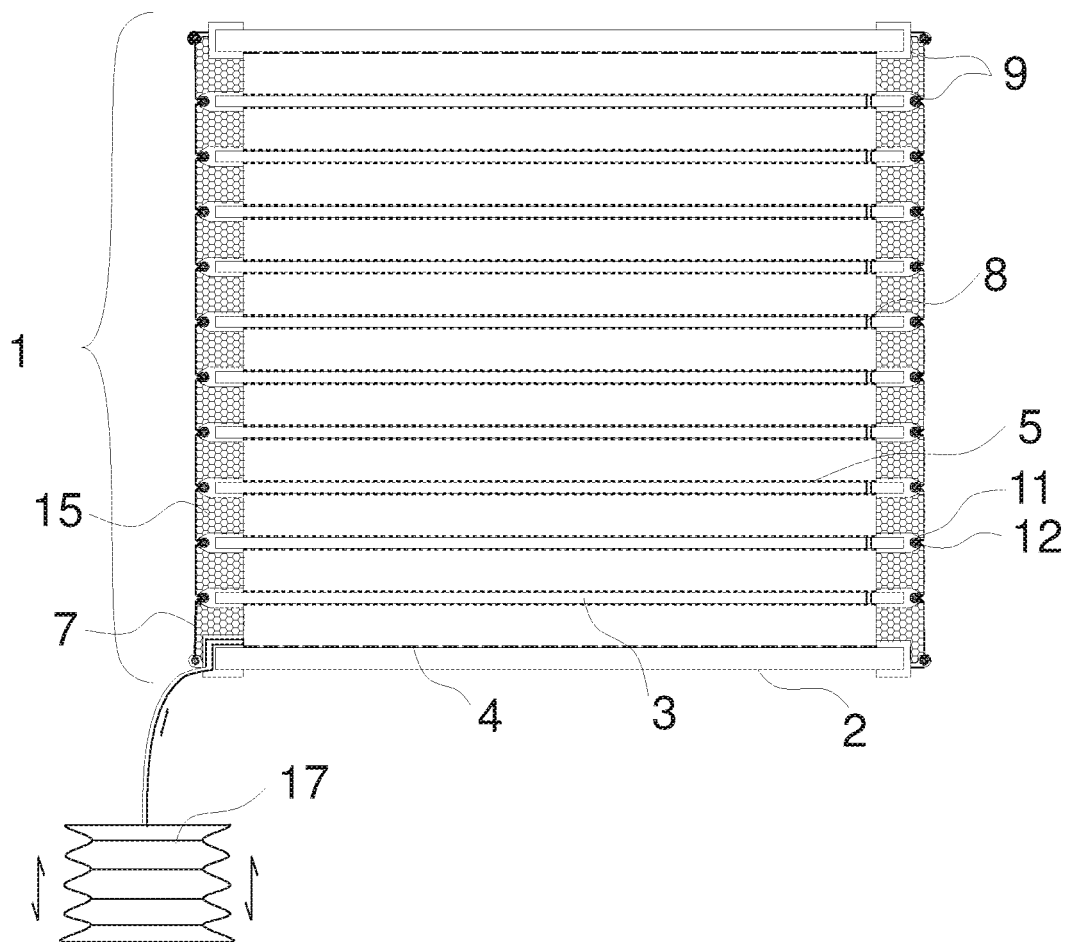


Fig. 5

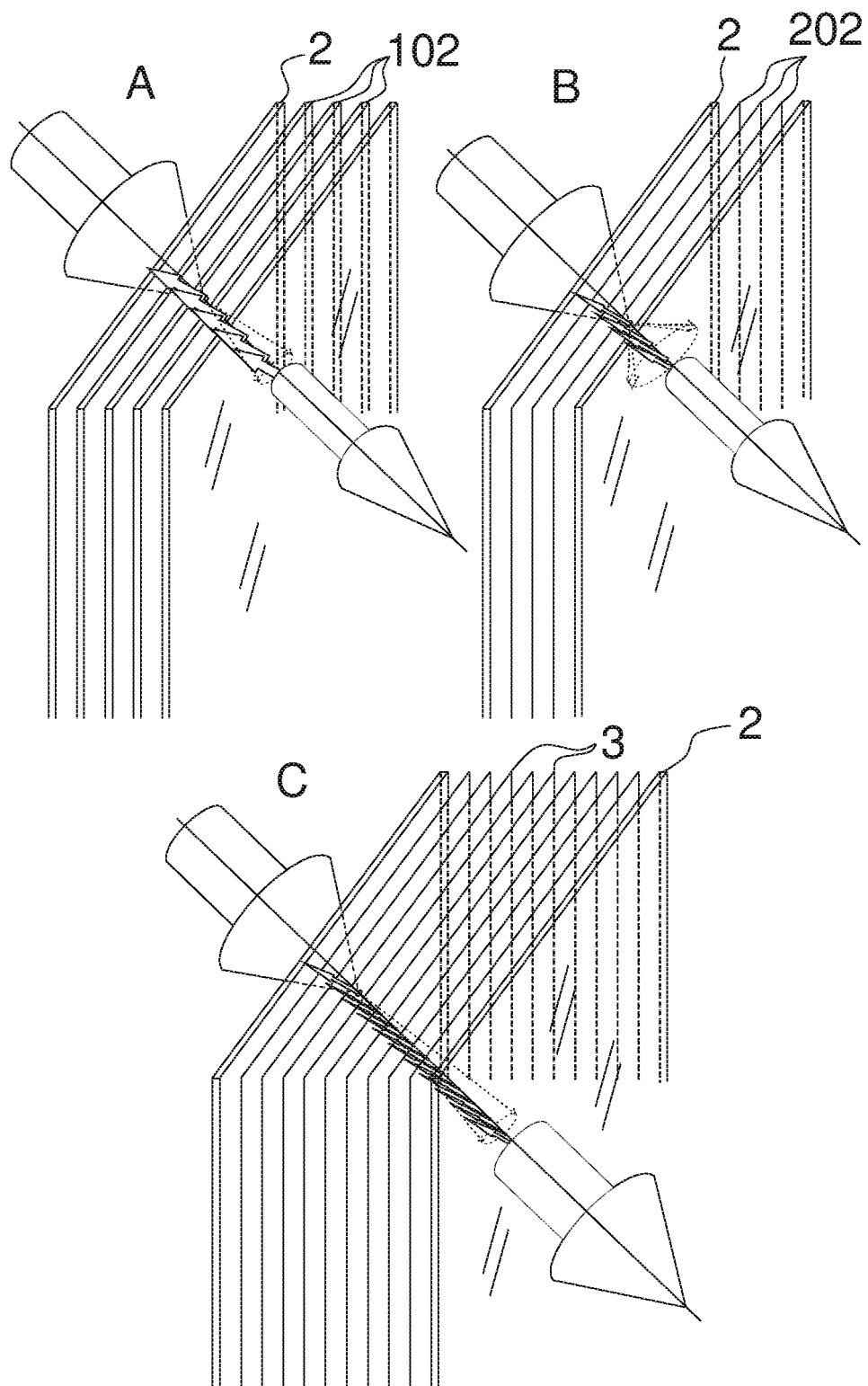


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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