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(54) **COMPOSITE FIREPROOF GLASS AND MANUFACTURING METHOD THEREOF**

ZUSAMMENGESETZTES FEUERFESTES GLAS UND HERSTELLUNGSVERFAHREN DAFÜR
VERRE IGNIFUGE COMPOSITE ET SON PROCÉDÉ DE FABRICATION

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Description**Field of the Invention**

5 **[0001]** The invention relates to the field of fireproof glass, and in particular to a compound fireproof glass and a manufacturing method for compound fireproof glass.

Background of the Invention

10 **[0002]** In the prior art, the compound fireproof glass is made from two or more layers of glass chips compounded with water-solubility inorganic sandwich fireproof glue. The compound fireproof glass meets the requirements of both fire integrity and fire insulation. The fireproof principle of the compound fireproof glass is: when the fire broke out, the special transparent chemicals in the middle of the compound insulated fireproof glass absorb a great amount of heat from the flame to foam and expand, and become opaque white at the same time, which efficiently prevents the heat generated
15 by burning from transferring from the heated surface to the unexposed surface, and also prevents thermal radiation of the flame on the heated surface of the glass from conducting to the unexposed surface. In this process, the entire glass remains intact, and forms an effective barrier for blocking diffusion and spread of flame, smoke, and high-temperature toxic gas generated by burning. The function of thermal insulation and anti-heat radiation of the compound fireproof glass enables the escape personnels or rescuers within the unexposed area of the glass to be protected from being hurt
20 by the high-temperature heat and the thermal radiation, when the fire broke out, and also prevents the combustible materials and items within the area, such as wood products and carpet, from being ignited by the high temperature and the thermal radiation within a certain period.

[0003] WO 9309326 A1 discloses a fire-proofing glazing composed of two panes spaced apart by spacers and a fire-proofing foil wound on a shaft in the upper spacer. The fire-proofing foil is secured with its outer longitudinal marginal zone to a plate-like traction weight. The traction weight is fixed in position in the upper spacer by means of a meltable
25 positioning material. In the event of a fire, and once the positioning material has melted, the traction weight filled with a drying agent is pulled downwards by the force of gravity and unwinds the fire-proofing foil, which thus forms between the panes a shield that is inflated when a determined temperature is reached.

[0004] GB 1359941 A discloses a fire-screening system for glazing and other panels with fire-screening means comprising a flowable material or flowable materials held in inoperative position in or in the neighbourhood of the panel, said screening means incorporating or being associated with at least one screen-releasing or activating component which releases or activates the screening means responsive to a rise in temperature indicative of the advent of fire, so that
30 said screening means, on becoming operative, flows into position to provide at least one fire-screening body of material substantially covering the area of said panel.

[0005] DE 10 2008 062333 A1 discloses a spacer for manufacturing fire protection glazing that is utilized in ship outer wall, the spacer having a hollow profile bar made of metal such as steel or aluminum, an outer wall, edges with recesses and an inner wall. The recesses are filled with expanding material with a foaming pressure of 0.03 to 0.3 newton/square millimeter. Density of the expanding material lies in a range between 400 und 700 kg/m³. The expanding material is selected from the group consisting of non expanded vermiculite material, partially dehydrated vermiculite material,
40 expandable graphite or expandable sodium silicate. A hollow space is filled with a drying agent. The document also includes a method for manufacturing a spacer and a method for manufacturing a fire protection glazing.

[0006] EP 0721047 A1 discloses an edge covering of an insulating glass panel. The cover encloses the edges of the fire-resistant panes and also fits between them to hold them apart. It also contains material forming foam on the outbreak of fire. Ribs on the cover bear against the panes to hold them apart, and its melting point allows escape of the foam-forming material from between the panes into the gap between their outer periphery and their mounting. The cover and the foam material can be immediately adjacent, and combined into a single unit. The space between two distance-ribs
45 can be filled with the foam material. A one-piece cover over the latter can be mounted between the rib free ends. Due to the impacts of stability of raw materials and manufacturing process, the compound fireproof glass in the prior art has the following main problems in use:

50 1. In daily use, due to temperature change in four seasons and sunlight irradiation, the phenomenon that the fireproof glue becomes white and emulsified usually occurs, which affects the transparence of the glass. Another typical problem is that fine bubbles appeared in the glue layer of the glass, often develop into big bubbles and affect the transparence of the glass.

55 2. The thickness of the compound insulated fireproof glass in the art is at least tens of millimetres, even up to or more than 100 millimetres. Thus, the compound fireproof glass is very heavy. According to the thickness, the weight per square meter of the common compound fireproof glass in market is 60kg to 90kg, even more. Thus, high load-bearing requirements are imposed upon the fireproof framework and the corresponding building structure for installing

the glass, and also, much adverse effects will be brought to the logistics operations.

3. Due to the complicated and demanding manufacturing process, the relatively long manufacturing cycle and the high cost of logistics resulted from the great dead weight, the compound insulated fireproof glass in the art is very expensive. Taking the European market for example, the price of the compound insulated fireproof glass is about 400-800 euros per square meter.

4. Since the compound insulated fireproof glass itself does not have a central cavity being similar to the hollow glass, the thermal conductivity thereof is higher, close to twice that of the ordinary hollow glass.

5. Thickness tolerance of the compound fireproof glass in the art is very difficult to be controlled because of compound process and raw materials, and is controlled at about $\pm 3\text{mm}$ by the common manufacturers in the market. Therefore, the requirement on frame installation structure is higher, the installation man-hour is wasted, and the installation cost rises.

6. Due to the particularity of structure, transmittance of the compound fireproof glass in the art is only up to 70%-85%, and even that of some domestic products is only 60%.

Summary of the Invention

[0007] The purpose of the invention is to provide a compound fireproof glass, a method for manufacturing a compound fireproof glass, and a curtain, which have good fireproof performance, light weight and high transmittance,.

The invention provides a compound fireproof glass comprising: a first glass substrate; a second glass substrate provided in parallel with the first glass substrate; a connecting portion connected with the first glass substrate and the second glass substrate; a cavity provided between the first glass substrate and the second glass substrate; wherein the compound fireproof glass further comprises: a thermal expansion portion which is an approximately uniformly distributed structure made from a thermal expansion material, and partially fills the cavity, wherein the thermal expansion portion is made from expandable graphite or a product containing expandable graphite, and is directly and fixedly arranged in the cavity, wherein the thermal expansion portion forms an approximately uniform pattern in the cavity, and when heated, the thermal expansion portion can rapidly expand to fill the entire cavity of the compound fireproof glass.

[0008] Further, the first glass substrate is a monolayer or multilayer fireproof glass substrate; the second glass substrate is a monolithic tempered glass substrate, a monolayer or multilayer fireproof glass substrate, a monolayer filmed glass substrate, a coated glass substrate, or a compound glass substrate with at least two layers.

[0009] Further, the compound fireproof glass further comprises a sealing portion provided in the edge of the cavity for sealing the cavity.

[0010] Further, the thermal expansion portion forms a grid-like, dot-like or petal-like pattern.

[0011] The invention further provides a manufacturing method of compound fireproof glass comprising the following steps: a. providing a first glass substrate and a second glass substrate, and forming a cavity between the first glass substrate and the second glass substrate; b. providing a thermal expansion portion in the cavity and making the cavity partially filled with the thermal expansion portion, making the thermal expansion portion from a thermal expansion material with an approximately uniformly distributed structure, wherein the thermal expansion portion is made from expandable graphite or a product containing expandable graphite; and c. connecting the first glass substrate and the second glass substrate as an integral structure, wherein the thermal expansion portion is directly and fixedly arranged in the cavity and forms an approximately uniform pattern in the cavity, and when heated, the thermal expansion portion can rapidly expand to fill the entire cavity of the compound fireproof glass.

[0012] The compound fireproof glass according to the invention has good fireproof performance because the thermal expansion portion, formed by the thermal expansion material and partially filled between the substrates of the double layers glass, can rapidly expand in case of high temperature and form a fire resistance layer. Moreover, as the cavity between the double layers of glass is not completely filled at normal temperature, the compound fireproof glass has lighter weight and good transmittance.

[0013] The invention employs a thermal expansion portion made from expandable graphite or something containing expandable graphite. The expandable graphite has the characteristic of rapid expansion when heated, can rapidly expand by several to tens of times in case of fire, and can rapidly expand to fill the entire cavity of the compound fireproof glass to form a fire resistance layer and prevent the spread of flame and smoke. The expandable graphite has a very small thermal conductivity and has good thermal stability, and can effectively block the transfer of heat. As the expandable graphite has small density, expands rapidly when heated and has a great expansion capacity, the compound fireproof glass just needs a small volume of expandable graphite, compared with other materials, it is more advantageous to reduce the weight of the compound fireproof glass and increase the transmittance of the compound fireproof glass.

Brief Description of the Drawings

[0014] The accompanying drawings constituting a part of the application are used to provide a further understanding

of the invention. The exemplary embodiments and the description thereof are used to explain the invention without unduly limiting the scope of the invention. In the accompanying drawings:

Fig. 1 shows a structural view of the compound fireproof glass according to an arrangement not forming part of the invention;

Fig. 2 shows an A-A structural view of Fig. 1;

Fig. 3 shows a structural view of the compound fireproof glass according to one embodiment of the invention;

Fig. 4 shows a structural view of the compound fireproof glass according to an arrangement not forming part of the invention, in which the thermal expansion portion is in a storage state;

Fig. 5 shows a partial enlarged structural view of part B in Fig. 4;

Fig. 6 shows a partial enlarged structural view of part C in Fig. 5;

Fig. 7 shows a 3D structural view of the accommodating case in the compound fireproof glass according to the arrangement of Fig. 4;

Fig. 8 shows a side structural view of the compound fireproof glass in Fig. 4;

Fig. 9 shows a structural view of the compound fireproof glass according to the arrangement of Fig. 4, in which the thermal expansion portion is in an expanded state;

Fig. 10 shows a partial enlarged structural view of part D in Fig. 9;

Fig. 11 shows a partial enlarged structural view of part E in Fig. 10;

Fig. 12 shows a partial structural view of a driving device of the compound fireproof glass according to the arrangement of Fig. 4; and

Fig. 13 shows a structural side view of the compound fireproof glass in Fig. 9.

Detailed Description of the Embodiments

[0015] The invention will be described hereinafter in detail with reference to the drawings and embodiments. It shall be understood that the embodiments of the application and the features of the embodiments can be combined with each other if there is no conflict.

The invention provides a compound fireproof glass, comprising: a first glass substrate; a second glass substrate provided in parallel with the first glass substrate; a connecting portion connected with the first glass substrate and the second glass substrate; a cavity provided between the first glass substrate and the second glass substrate. The compound fireproof glass further comprises a thermal expansion portion which is an approximately uniformly distributed structure made from a thermal expansion material, and partially fills the cavity, wherein the thermal expansion portion is made from expandable graphite or a product containing expandable graphite, and is directly and fixedly arranged in the cavity, wherein the thermal expansion portion forms an approximately uniform pattern in the cavity, and when heated, the thermal expansion portion can rapidly expand to fill the entire cavity of the compound fireproof glass.

Glass Substrate

[0016] At least one of the first glass substrate and the second glass substrate is a heated surface glass substrate, which should be fire-resistant and should not be deformed or damaged at high temperatures, and could be a monolayer or multilayer (more than two layers) fireproof glass substrate. Generally, one of the two glass substrates is a heated surface glass substrate, and the other is an unexposed surface glass substrate, and according to the requirements, both of the two glass substrates could be heated surface glass substrates. The unexposed surface glass substrate could be selected from a monolithic tempered glass substrate, a monolayer or multilayer fireproof glass substrate, a monolayer filmed glass substrate, a coated glass substrate, or a compound glass substrate with at least two layers.

Connection Portion

[0017] In the invention, the connecting portion connects the first glass substrate with the second glass substrate, and the connecting portion could select any suitable connection member to make the two substrates connected. In one embodiment, the connecting portion is a spacer sandwiched and stuck between edge positions of the two glass substrates, for example, the spacer could be a glass plate or metal framework, and so on, or could be a clip clipping at the outer edge of the two glass substrates. The connecting portion can seal the cavity between the two glass substrates while making the two glass substrates connected. The connecting portion could only have the connection function but the sealing function, in the case, the cavity could be non-hermetic.

Sealing Portion

[0018] The compound fireproof glass could further comprise a sealing portion, which is provided in the edge of the cavity for sealing the cavity. In one embodiment, the connecting portion could also serve as the sealing portion.

Thermal Expansion Portion

[0019] The thermal expansion portion contains a thermal expansion material, preferably volume of which can at least expand 1.5 times than its original volume at 100-200°C, and volume of which, at a temperature of above 200°C, can rapidly expand several, dozen, or even tens or hundreds of times than its original volume with the rise of the temperature.

[0020] The thermal expansion portion has a very small volume before heated, and is in the partial location of the cavity of the double-layer glass, for example, within an area 20mm far away from the edge. After the heated surface glass substrate of the compound fireproof glass contacts with fire and the temperature rises, the volume of thermal expansion portion rapidly expands and fills the entire cavity of the double-layer glass to form a fire resistance layer. As the fire resistance layer formed by the thermal expansion portion has a very small thermal conductivity and is opaque, it can effectively insulate thermal radiation, thermal convection and thermal conduction.

[0021] The thermal expansion material for forming the thermal expansion portion could be hydrated alkali metal silicate, such as sodium silicate, or organic thermal expansion material, such as polyurethane polyfoams, and so on. However, more preferably, the thermal expansion material could be expandable graphite. The expandable graphite has the characteristic of rapid expansion when heated, can rapidly expand by several to tens of times in case of fire, and can rapidly expand to fill the entire cavity of the compound fireproof glass and form a fire resistance layer, to prevent the spread of flame and smoke. Compared with the common glass interlayer materials in the prior art, the expandable graphite has a small density, expands rapidly when heated and has a great expansion volume. Therefore, only a small volume of expandable graphite is needed, compared with other materials, which is more advantageous to reduce the weight of the compound fireproof glass and increase the transmittance of the compound fireproof glass.

[0022] By means of experiments, the inventor of the invention unexpectedly found that the effect of using expandable graphite is superior to that of using hydrated alkali metal silicate or polyurethane polyfoams to a great extent, which will be proved by the experimental results provided in the first arrangement. When used, the expandable graphite can be directly fixed between the two glass substrates. It should be noted that, the thermal expansion portion could also be made from a product containing expandable graphite, for example, expansion strips formed by expandable graphite as the main raw material in combination with fireproof glue.

[0023] In one arrangement not forming part of the invention, the thermal expansion portion is located at the edge and/or in the center of the cavity.

[0024] In an embodiment of the invention, the thermal expansion portion forms a pattern which is substantially uniformly distributed in the cavity, preferably, forms a grid-like pattern in the cavity, or forms the patterns, such as a dot-like, petal-like or snowflake-like, and so on.

[0025] In another arrangement not forming part of the invention, the thermal expansion portion is movably arranged in the cavity. Wherein the thermal expansion portion is curtain-like, and forms a curtain of the thermal expansion material, which is folded and accommodated at the edge and/or in the center of the cavity at normal temperature.

[0026] The compound fireproof glass preferably further comprises a driving device, which changes the curtain of the thermal expansion material from a storage state to an expanded state when the compound fireproof glass contacts with fire.

[0027] The thermal expansion portion in the form of a curtain may be only provided in the upper portion of the cavity. Taking a curtain in the form of shutter for example, a plurality of parallel curtain strips is connected together via a connecting thread. One end of the connecting thread is fixed in the upper portion of the cavity, and the plurality of curtain strips are stacked and accommodated in the upper portion of the cavity through a fixed release member. When the fixed release member is opened, the plurality of curtain strips falls down under the effect of their own gravity, and forms an expanded curtain. The fixed release member, for example, a thin wire or a memory alloy wire, ties the plurality of stacked curtain strips together, and in case of fire, the thin wire or memory alloy wire can automatically release the curtain strips under the effect of temperature variation. Specifically, the fixed point of the thin wire can be broken automatically to release the curtain strips when the temperature rises to a certain temperature, and the memory alloy wire can change from an expanded state to a contracted state under the effect of temperature. The fixed release member may also adopt a buckle structure, for example, the left side and the right side of the upper portion of the cavity are respectively provided with a buckle. Under normal conditions, the buckles block the plurality of stacked curtain strips, and in case of fire, the buckles are disengaged to release the plurality of stacked curtain strips, thus the curtain strips fall down and become expanded. In another example, an accommodating case to be described in detail in the third arrangement can also serve as a fixed release member. Under normal conditions, the curtain strips are folded and accommodated in the accommodating case, and in case of fire, a cover of the accommodating case is automatically opened, and the curtain strips fall

down and are expanded. According to the above description, in the case where the thermal expansion portion is only provided in the upper portion of the cavity, the driving device may not be provided.

[0028] The curtain of the invention contains the thermal expansion material or is made from the thermal expansion material. Besides the form of shutter as described above, the curtain can also be in the form of a full curtain or a hollow curtain. It is required that the curtains with above forms can be foldably provided.

[0029] The driving device of the invention changes the thermal expansion portion from the storage state to the expanded state, when the compound fireproof glass contacts with fire. Unrestricted by the embodiments, the driving device could also adopt other structures or manners besides the embodiments, its power could be provided in the manner of power in the prior art, such as a spring, a rubber band, a gravity structure, and a motor. It is only necessary to provide a trigger mechanism, such as a memory alloy or a sensor, which provides power for the driving device in case of fire so as to change the curtain-like thermal expansion portion from the storage state to the expanded state. In addition, the driving device can also use a temperature sensor, an optical sensor or the like as a drive signal, and a battery as the driving power to drive the movable thermal expansion portion. It is also feasible to provide the power part of the driving device outside the cavity, and only provide a curtain, a necessary traction device, and so on in the cavity.

[0030] The thermal expansion portion can be provided in the left side and/or the right side of the cavity, or in the center of the cavity. When the thermal expansion portion is provided in the center of the cavity, the curtain can expand towards the left and right directions.

[0031] In one arrangement, the driving device comprises: a supporting rod provided in the upper portion of the cavity; rollers for winding traction line provided on the left and right ends, and/or the right end of the cavity, and located below the supporting rod; a traction line annularly wound on the rollers for winding traction line; a plurality of connecting rings, the upper portions of which are slidably provided on the supporting rod, and the lower portions of which are in connection with the upper portion of the thermal expansion portion. The connecting rings are connected with the traction line fixedly. The traction line is connected with a driving member fixedly, and the driving member can pull the traction line, and further drive the curtain-like thermal expansion portion to change from the storage state to the expanded state. In one arrangement, the driving member is a memory alloy wire, comprising a first end and a second end opposite to each other, the first end is connected with the first glass substrate or the second glass substrate fixedly, and the second end is connected with the traction line fixedly. The memory alloy wire is in a straight line at normal temperature and in a spring shape under 80°C to 120°C.

[0032] The invention further provides a manufacturing method for compound fireproof glass, comprising the following steps: a. providing a first glass substrate and a second glass substrate, and forming a cavity between the first glass substrate and the second glass substrate; b. providing a thermal expansion portion in the cavity and making the cavity partially filled with the thermal expansion portion, making the thermal expansion portion from a thermal expansion material with an approximately uniformly distributed structure, wherein the thermal expansion portion 130, 230, 330 is made from expandable graphite or a product containing expandable graphite; and c. connecting the first glass substrate and the second glass substrate as an integral structure. Preferably, the step b comprises: directly and fixedly arranging the thermal expansion portion in the cavity.

[0033] In addition, the invention and all the embodiments thereof are not limited to a compound fireproof glass with two layers of glass, but are applicable to a compound fireproof glass with at least three layers of glass. Moreover, the shape of the invention and all the embodiments thereof are not limited to a rectangle, but could also be a circular, a parallelogram, or a polygon with at least five sides.

[0034] The invention further provides a curtain made from the thermal expansion material. Preferably, the curtain comprises a plurality of curtain strips that are made from the thermal expansion material.

Embodiments

[0035] The left side and the right side in the invention are the directions viewed from the heated side to the unexposed side.

The first arrangement

[0036] As shown in Figs. 1-2, the compound fireproof glass 100 in the first arrangement is a rectangular compound fireproof glass with substantially parallel double layers of glass substrates, which mainly comprises a heated surface glass substrate 110A, an unexposed surface glass substrate 110B, and a connecting portion 120 for connecting the edge portions of the heated surface glass substrate 110A with the edge portions of the unexposed surface glass substrate 110B. The connecting portion 120 may adopt a glass strip, the glass strip is provided on the outside of the edges of the two layers of glass substrates 110A and 110B, and they are integrated by means of sticking with inorganic fireproof glue. The heated surface glass substrate 110A, the unexposed surface glass substrate 110B and the connecting portion 120 define the cavity. The thermal expansion material partially fills the edges of the cavity, and thereby a thermal expansion

portion 130 is formed. As shown in Fig. 1, the thermal expansion portion 130 is a strip-like structure made from the thermal expansion material, and the strip-like structure is located in the left, right upper and lower sides of edges of the compound fireproof glass 100, and is directly fixed between the heated surface glass substrate 110A and the unexposed surface glass substrate 110B.

[0037] Refer to the data in Table 1 and Table 2, it has been demonstrated by experiments that expandable graphite has superior performance. Therefore, in the first arrangement and the following other embodiments and arrangements, only the thermal expansion portion made from expandable graphite is taken as an example to describe the compound fireproof glass of the invention.

[0038] In the first arrangement, the unexposed surface glass substrate 110B of the double-layer glass adopts the conventional tempered glass with the thickness of 6MM or other. The ordinary tempered glass can withstand the thermal shock of temperature variation of over 200°C, and therefore, the unexposed surface glass substrate 110B adopting a monolayer tempered glass will not be broken under thermal shock. Of course, in order to ensure the strength of the unexposed surface glass substrate 110B in case of fire, a monolithic fireproof glass substrate, a monolayer filmed or coated glass substrate, or a double-layer or multilayer compound glass substrate can also be used as the unexposed surface glass substrate 110B. The heated surface glass substrate 110A preferably uses a fireproof glass substrate which may be ordinary monolayer or multilayer fireproof glass sold in the market. The fireproof glass substrate can ensure maintenance of fire integrity of the compound fireproof glass and insulation of naked flame, and toxic and harmful gas from the heated surface in a certain time, in order to ensure that there is sufficient time for the thermal expansion material layer 130 to fill the entire cavity so as to form a fire resistance layer.

[0039] Refer to Table 1 and Table 2, according to eight fireproof experiments on the compound fireproof glass, the thermal expansion portion of which is made from different thermal expansion materials, when the thermal expansion portion is made from expandable graphite, as long as the manufacturing process and product quality meet the requirements, and the experiment lasts for at least 90 minutes under the condition that the temperature of the heated surface is 1000-1100 °C, it can be ensured that the highest temperature rise of the unexposed surface is no more than 180°C and the average temperature rise is no more than 140°C, which can meet or be superior to Chinese national standards or European standards for fireproof glass.

[0040] In the contrast experiments, the glass substrates of the compound fireproof glasses use the same material, the size is 800mm × 1000mm, the distance between the first glass substrate and the second glass substrate is 25mm, all the thermal expansion portions are arranged in the edges of the cavity, and located at the position which is less than 25mm away from the edge of the cavity. The thermal expansion portions are respectively made from sodium silicate, polyurethane polyfoams and expandable graphite. The comprehensive results of the contrast experiments demonstrate that expandable graphite has superior physical properties and fireproof performance to sodium silicate and polyurethane polyfoams.

Table 1: Comparison table of physical properties of compound fireproof glasses with thermal expansion portions made from different materials

Material of thermal expansion portion	Weight per square meter (unit: kg/m ²)	Visible transmittance (unit: %)
sodium silicate	40	78
polyurethane polyfoams	40	76
expandable graphite	35	77

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Table 2: Comparison table of fireproof performance of compound fireproof glasses with thermal expansion portions made from different materials

Experiment number	Material	Filling time (unit: minute) and filling degree (unit: percent)	Time of the unexposed surface being overtemperature (the highest temperature rise exceeds 180°C or the average temperature rise exceeds 140°C) (unit: minute)
1	sodium silicate	25 minutes, percent of filling is 15%	25 minutes
	polyurethane polyfoams	40 minutes, percent of filling is 95%	40 minutes
	expandable graphite	15 minutes, percent of filling is 100%	91 minutes
2	sodium silicate	20 minutes, percent of filling is 18%	20 minutes
	polyurethane polyfoams	19 minutes, percent of filling is 95%	19 minutes
	expandable graphite	19 minutes, percent of filling is 100%	99 minutes
3	sodium silicate	23 minutes, percent of filling is 25%	23 minutes
	polyurethane polyfoams	31 minutes, percent of filling is 99%	31 minutes
	expandable graphite	11 minutes, percent of filling is 100%	101 minutes
4	sodium silicate	15 minutes, percent of filling is 14%	15 minutes
	polyurethane polyfoams	25 minutes, percent of filling is 95%	25 minutes
	expandable graphite	12 minutes, percent of filling is 100%	122 minutes
5	sodium silicate	10 minutes, percent of filling is 9.5%	10 minutes
	polyurethane polyfoams	38 minutes, percent of filling is 95%	38 minutes
	expandable graphite	18 minutes, percent of filling is 100%	98 minutes
6	sodium silicate	27 minutes, percent of filling is 19%	27 minutes
	polyurethane polyfoams	34 minutes, percent of filling is 75%	34 minutes
	expandable graphite	11 minutes, percent of filling is 100%	96 minutes
7	sodium silicate	21 minutes, percent of filling is 17%	21 minutes
	polyurethane polyfoams	35 minutes, percent of filling is 100%	35 minutes
	expandable graphite	10 minutes, percent of filling is 100%	90 minutes

(continued)

Experiment number	Material	Filling time (unit: minute) and filling degree (unit: percent)	Time of the unexposed surface being overtemperature (the highest temperature rise exceeds 180°C or the average temperature rise exceeds 140°C) (unit: minute)
8	sodium silicate	8 minutes, percent of filling is 11 %	8 minutes
	polyurethane polyfoams	45 minutes, percent of filling is 99%	45 minutes
	expandable graphite	14 minutes, percent of filling is 100%	92 minutes

[0041] In the case that sodium silicate or polyurethane polyfoams is used, since their thermal expansion performance is inferior to the thermal expansion performance of expandable graphite, they are only applicable to the case that the size of the compound fireproof glass is small. For the large size glass, as the cavity is relatively large and is not easy to be filled, only expandable graphite can easily meet the expansion requirement.

[0042] Besides the superior fireproof performance, the above compound fireproof glass of the first arrangement further has the following advantages: the weight per square meter of the compound fireproof glass is much less than that of the compound fireproof glass in the prior art. Because the compound fireproof glass is partially filled with the thermal expansion material and only a small part of the compound fireproof glass is filled with the thermal expansion material, and the part not filled with the thermal expansion material has the same transmittance as the ordinary hollow glass, the overall transmittance of the compound fireproof glass is improved. Because the compound fireproof glass employs the same technology as the ordinary hollow glass to control the thickness, the thickness could be effectively controlled. As the compound fireproof glass has the cavity similar to the ordinary hollow glass, the thermal conductivity thereof is smaller. In the case that the thermal expansion material in the compound fireproof glass is expandable graphite, there is little change under the common season alternation and sunlight irradiation, which can effectively overcome the defect of poor weatherability of the current compound fireproof glass.

[0043] The other embodiments of the invention and arrangements will be described in detail as follows, and the similar to the first arrangement will be no longer specifically described.

The second arrangement (embodiment of the invention)

[0044] As shown in Fig. 3, the compound fireproof glass 200 in the embodiment mainly comprises a heated surface glass substrate 210A, an unexposed surface glass substrate 210B, and a connecting portion 220 for connecting the edge portions of the heated surface glass substrate 210A with the edge portions of the unexposed surface glass substrate 210B. The cavity defined by the heated surface glass substrate 210A, the unexposed surface glass substrate 210B and the connecting portion 220 is partially filled with a thermal expansion portion 230. The difference from the thermal expansion portion 130 in the first arrangement is that the thermal expansion portion 230 in the embodiment forms a uniformly distributed pattern between the two layers of glass substrates. Specifically, the pattern in the embodiment is a rectangular grid-like pattern. In the embodiment, the thermal expansion portion 230 forming a uniformly distributed pattern is also formed by directly fixing the thermal expansion material between the heated surface glass substrate 210A and the unexposed surface glass substrate 210B.

[0045] The term "directly fixed/fixing" in the first arrangement or the embodiment means there is no an enclosed layer outside the thermal expansion material, but the thermal expansion portion 130 or 230 is directly sandwiched between the two layers of glass substrates. The reason is that the enclosed layer will affect the expansion speed of the thermal expansion portion 130 or 230, also affect the uniformity of the expansion, even destroy the integrity of the fire resistance layer, and significantly reduce the fireproof performance of the compound fireproof glass.

[0046] Besides the effects of the first arrangement, the advantages of forming the thermal expansion portion 230 by means of the embodiment are that: compared with the first arrangement, the thermal expansion portion 230 can expand more rapidly and uniformly to fill the entire cavity when contacting with fire, which can more effectively achieve the object of fire resistance, and also make the compound fireproof glass 230 aesthetic and decorative.

[0047] Compared with the first arrangement, the embodiment has the effects reflected in the following Table 3.

The third arrangement

[0048] Figs. 4-12 show the compound fireproof glass 300 of the third arrangement of the invention. The compound fireproof glass 300 of the third arrangement mainly comprises a heated surface glass substrate 310A, an unexposed surface glass substrate 310B, and a connecting portion 320 for connecting the edge portions of the heated surface glass substrate 310A with the edge portions of the unexposed surface glass substrate 310B. The difference from the first arrangement and the embodiment, the thermal expansion portion 330 is a curtain in the form of shutter formed by a plurality of curtain strips, the distance between the first glass substrate and the second glass substrate is 25mm, and the thickness of the thermal expansion portion 330 is 0.8mm. When the compound fireproof glass 300 is used in a normal environment, as shown in Figs. 4-8, the thermal expansion portion 330 in the form of curtain is folded and accommodated in the left side and the right side of the cavity formed by the heated surface glass substrate 310A, the unexposed surface glass substrate 310B and the connecting portion 320. When contacting with fire and heating up, the thermal expansion portion 330 in the form of curtain can move from the left and right side to the center, and finally fill the entire cavity. Thus, in the third arrangement, the thermal expansion portion 330 is movably provided in the cavity of the compound fireproof glass.

[0049] Preferably, a driving device 340 could be provided in the cavity, and in case of fire, as shown in Figs. 9-12, the thermal expansion material 330 can be rapidly expanded through the driving device 340 to form a curtain for covering the entire surface of the compound fireproof glass 300. With the rise of temperature, the expanded thermal expansion material 330 rapidly expands to fill the entire cavity to form a complete fire resistance layer.

[0050] With reference to Figs. 4-12, the structure and principle of the third arrangement will be specifically described below.

[0051] Fig. 4 is a structural view of the compound fireproof glass 300 of the third arrangement, in which the thermal expansion portion 330 is in a storage state; Fig. 5 is a partial enlarged structural view of part B in Fig. 4; Fig. 6 is a partial enlarged structural view of part C in Fig. 5; and Fig. 8 is a side structural view of the compound fireproof glass in Fig. 4.

[0052] The driving device 340 mainly comprises a supporting rod 341, a glass fiber traction line 342, a plurality of connecting rings 343, a memory alloy wire 344 and two parallel rollers for winding traction line 345. The upper portion of the connecting ring 343 has a through hole, the plurality of connecting rings 343 can be slidably hung on the supporting rod 341 through the through holes in upper portions thereof, and the lower portions of the connecting rings 343 are substantially uniformly distributed and connected to the upper portion of the curtain of the thermal expansion material 330. The two rollers for winding traction line 345 are provided in the left end and the right end of the cavity respectively and below the supporting rod 341. The glass fiber traction line 342 is annularly wound on the two rollers for winding traction line 345. Thus, in the third arrangement, and the two lower traction portions substantially parallel to each other are formed in the upper portion of the cavity. Of course, the glass fiber traction line 342 can also respectively form front and rear traction portions which are parallel to each other.

[0053] A memory alloy spring is straightened to form the memory alloy wire 344, the right end of which is stuck to the heated surface glass substrate 310A or the unexposed surface glass substrate 310B, and the left end of which is connected to the nearest connecting ring 343 on the left side, therefore which is connected to the glass fiber traction line 342 through the nearest connecting ring 343. The left end of the memory alloy wire 344 could also be directly connected with the glass fiber traction line 342.

[0054] The plurality of connecting rings 343 on the left side of the memory alloy wire 344 are respectively fixed, corresponding to the position that the thermal expansion portion 330 is in the expanded state, on the traction portion on the lower side of the glass fiber traction line 342; while the plurality of connecting rings 343 on the right side of the memory alloy wire 344 are respectively fixed, corresponding to the position that the thermal expansion portion 330 is in the expanded state, on the traction portion on the upper side of the glass fiber traction line 342.

[0055] As shown in Figs. 4-5, when the thermal expansion portion 330 is in a storage state, the memory alloy wire 344 is in an expanded state.

[0056] Fig. 7 is a 3D structural view of the accommodating case of the compound fireproof glass according to the third arrangement. In the third arrangement, both the left side and the right side of the cavity are provided with an accommodating case 350, and the two accommodating cases 350 have the same structure and are arranged to face each other. The main structure of the accommodating case 350 is a case body 351 with a rectangular section, a cover 354 is provided on the inner side of the case body 351 towards the cavity of the compound fireproof glass 300, the cover 354 is pivotally provided, via two or more spring hinges 352, on the side surface of the case body 351 towards the side of the unexposed surface glass substrate, and the cover 354 and the side surface of the case body 351 towards the side of the heated surface glass substrate are connected via a plurality of hot melt adhesive seal points 353. At normal temperature, the thermal expansion portion 330 is folded and accommodated in the accommodating case 350, and in case of fire, the hot melt adhesive seal points 353 are broken by heating, and the cover 354 is automatically opened under the effect of the spring hinges 352, then the thermal expansion portion 330 could be expanded, unimpeded by the cover 354, under the drive of the driving device 340.

[0057] Although the accommodating case 350 is not necessary for the compound fireproof glass 300 in the third arrangement to achieve the fireproof function, the accommodating case 350 will prevent the thermal expansion portion 330 from becoming irregular in the transportation and installation process at normal temperature, affecting the appearance of the compound fireproof glass, and the occurrence of the problems such as aging of the thermal expansion portion 330 due to long-term sunshine.

[0058] Fig. 9 is a structural view of the compound fireproof glass according to the third arrangement, in which the thermal expansion portion 330 is in an expanded state. Fig. 10 is a partial enlarged structural view of part D in Fig. 9; Fig. 11 is a partial enlarged structural view of part E in Fig. 10; Fig. 12 is a partial structural view of the driving device of the compound fireproof glass according to the third arrangement; and Fig. 13 is a side structural view of the compound fireproof glass in Fig. 9.

[0059] When a fire breaks out, the heated surface glass substrate 310A is heated, the hot melt adhesive seal points 353 are broken by heating, and the cover 354 is automatically opened under the effect of the spring hinges 352. The memory alloy wire 344 gradually reaches the deformation temperature of 80-120°C, under the effect of the deformation temperature, the memory alloy wire 344 automatically contracts to a spring shape. The pulling force generated in the contracting process of the memory alloy wire 344 pulls the connecting ring 343 connected with the left end thereof, and the connecting ring 343 pulls the glass fiber traction line 342. On one hand, the traction portion of the lower portion of the glass fiber traction line 342 expands the curtain of the thermal expansion portion 330 on the left side under the force from left to right, and on the other hand, the traction portion of the upper portion of the glass fiber traction line 342 expands the curtain of the thermal expansion portion 330 on the right side under the force from right to left. Therefore, a complete curtain made from the thermal expansion material is rapidly formed on the entire base surface of the compound fireproof glass. As the complete curtain can be formed rapidly on the entire base surface of the glass substrate, in the third arrangement, although the entire cavity is not full of the thermal expansion material, the better fire resistance effects have already been achieved. With the rise of the temperature continually, the complete curtain begins to expand and eventually fills the entire cavity to form a fire resistance layer, thereby achieving more effective fire resistance effect.

[0060] Identical to the first arrangement, the heated surface glass substrate 310A preferably uses a fireproof glass substrate. When a fire occurs, it can be assured that the fireproof glass substrate will not be broken at the beginning of the fire. Shown by the data obtained by eight experiments, for the compound fireproof glass of the third arrangement, with the rise of temperature, the thermal expansion material for forming the complete curtain can rapidly expand to fill the cavity and form the fire resistance layer, which can effectively block heat from transferring to the unexposed surface glass substrate 310B. In the case that the manufacturing process and product quality meet the requirements, it can be assured that, within 90 minutes, the highest temperature rise of the unexposed surface glass substrate 310B is no more than 180°C, and the average temperature rise is no more than 140°C.

[0061] The compound fireproof glass of the third arrangement also has the advantages of the compound fireproof glass of the first arrangement. As the thermal expansion portion 330 is accommodated in the side edges of the cavity at normal temperature, the compound fireproof glass has more advantages in transmittance. At the beginning of the fire, the thermal expansion portion 330 can be rapidly and automatically expanded into the curtain to cover the entire base surface of the glass, and then expands. Compared with the first arrangement, it can more uniformly and rapidly fill the entire cavity. Compared with the embodiment, it has a better fire resistance effect even when it does not fill the entire cavity. Moreover, the fire resistance layer in the third arrangement has higher quality because of very uniform expansion, and therefore it is more advantageous to the achieve fire and smoke resistance functions.

[0062] Table 3 is a comparison table of fireproof performance of the first, second and third arrangements when the thermal expansion portion is made from expandable graphite. In the three arrangements, all the glass substrates have a size of 400mm × 600mm and the same material. However, the thermal expansion portion is arranged in the edges of the cavity according to the first arrangement, in the cavity in a grid-like pattern according to the embodiment, and in the left side and the right side of the cavity in the form of a complete curtain according to the third arrangement. Besides, the driving device is the one shown in Figs. 4-12.

Table 3: Comparison table of fireproof performance of compound fireproof glass in the first, second and third arrangements.

Experiment number	Arrangement	Filling time (unit: minute) and filling degree (unit: percent)	Highest/average temperature rise of the unexposed surface (unit: °C)
1	The first arrangement	10/100%	151/134
	The second arrangement (embodiment)	5/100%	133/126
	The third arrangement	8/100%	105/101

(continued)

Experiment number	Arrangement	Filling time (unit: minute) and filling degree (unit: percent)	Highest/average temperature rise of the unexposed surface (unit: °C)
2	The first arrangement	12/100%	176/140
	The second arrangement (embodiment)	8/100%	135/131
	The third arrangement	8/100%	122/109
3	The first arrangement	15/100%	145/135
	The second arrangement (embodiment)	6/100%	138/128
	The third arrangement	9/100%	130/121
4	The first arrangement	13/100%	179/135
	The second arrangement (embodiment)	11/100%	141/130
	The third arrangement	9/100%	111/100
5	The first arrangement	12/100%	163/128
	The second arrangement (embodiment)	6/100%	132/127
	The third arrangement	9/100%	109/103
6	The first arrangement	14/100%	155/137
	The second arrangement (embodiment)	4/100%	139/129
	The third arrangement	11/100%	146/121
7	The first arrangement	11/100%	167/133
	The second arrangement (embodiment)	7/100%	136/130
	The third arrangement	10/100%	129/110
8	The first arrangement	11/100%	177/139
	The second arrangement (embodiment)	6/100%	139/120
	The third arrangement	8/100%	128/107

[0063] The compound fireproof glass of the invention could adopt the following manufacturing method:

- a. providing a first glass substrate and a second glass substrate, and forming a cavity between the first glass substrate and the second glass substrate;
- b. providing a thermal expansion portion in the cavity and making the cavity partially filled with the thermal expansion portion, making the thermal expansion portion from a thermal expansion material with an approximately uniformly distributed structure; and
- c. connecting the first glass substrate and the second glass substrate as an integral structure.

[0064] One preferred solution is that the step b comprises: directly and fixedly arranging the thermal expansion portion in the cavity.

[0065] Another option is that, in the step b, the thermal expansion portion is movably arranged in the cavity.

[0066] In the step b, it is feasible to fold and accommodate the curtain-like thermal expansion portion in the upper side of the cavity, or the left side and/or the right side of the cavity, or in the center of the cavity.

[0067] More preferably, the step b comprises: arranging the driving device in the edge of the cavity.

[0068] Arranging the driving device in the edge of the cavity specifically comprises: providing a supporting rod 341 in the upper portion of the cavity; providing two rollers for winding traction line 345 parallelly in the left end and the right end of the cavity, respectively, and below the supporting rod 341; winding a traction line 342 annularly onto the two rollers for winding traction line 345; slidably providing the upper portions of a plurality of connecting rings 343 on the supporting rod 341, uniformly and distributedly connecting the lower portions thereof with the upper portion of the thermal expansion portion 330, and fixedly connecting the central portions thereof with the traction line 342 uniformly and distributedly; and fixedly connecting a first end of a memory alloy wire 344 with the glass substrates forming the cavity, and fixedly connecting a second end, which is opposite to the first end, of the memory alloy wire 344 with the traction line 342.

[0069] The step b further comprises the steps of arranging an accommodating case 350 in the corresponding side of the cavity where the thermal expansion portion 330 is folded and accommodated, and folding and accommodating the thermal expansion portion 330 in the accommodating case 350.

[0070] According to the above description, the above arrangements achieve the following technical effects: the compound fireproof glass has superior fireproof performance; the weight per square meter of the compound fireproof glass is much less than that of the compound fireproof glass in the prior art; on the whole, the transmittance of the compound fireproof glass is improved; and the compound fireproof glass employs the same process as the ordinary hollow glass, and the thickness can be well controlled.

[0071] The descriptions above are only preferable arrangements or embodiments of the invention, which are not used to restrict the invention.

Claims

1. A compound fireproof glass comprising:

a first glass substrate (210A);
a second glass substrate (210B) provided in parallel with the first glass substrate (210A);
a connecting portion (220) connected with the first glass substrate (210A) and the second glass substrate (210B);
a cavity provided between the first glass substrate (210A) and the second glass substrate (210B);
wherein the compound fireproof glass further comprises:

a thermal expansion portion (230) which is an approximately uniformly distributed structure made from a thermal expansion material, and partially fills the cavity,

wherein the thermal expansion portion (230) is made from expandable graphite or a product containing expandable graphite, and is directly and fixedly arranged in the cavity,

characterized in that the thermal expansion portion (230) forms an approximately uniform pattern in the cavity, and when heated, the thermal expansion portion (230) can rapidly expand to fill the entire cavity of the compound fireproof glass.

2. The compound fireproof glass according to claim 1, wherein

the first glass substrate (210A) is a monolayer or multilayer fireproof glass substrate;

the second glass substrate (210B) is a monolithic tempered glass substrate, a monolayer or multilayer fireproof glass substrate, a monolayer filmed glass substrate, a coated glass substrate, or a compound glass substrate with at least two layers.

3. The compound fireproof glass according to claim 1, wherein the compound fireproof glass further comprises a sealing portion provided in the edge of the cavity for sealing the cavity.

4. The compound fireproof glass according to any of claims 1 to 3, wherein the thermal expansion portion (230) forms a grid-like, dot-like or petal-like pattern.

5. A manufacturing method of compound fireproof glass comprising the following steps:

a. providing a first glass substrate (210A) and a second glass substrate (210B), and forming a cavity between the first glass substrate (210A) and the second glass substrate (210B);

b. providing a thermal expansion portion (230) in the cavity and making the cavity partially filled with the thermal expansion portion (230), making the thermal expansion portion (230) from a thermal expansion material with an approximately uniformly distributed structure wherein the thermal expansion portion (230) is made from

expandable graphite or a product containing expandable graphite; and

c. connecting the first glass substrate (210A) and the second glass substrate (210B) as an integral structure,

wherein the thermal expansion portion is directly and fixedly arranged in the cavity and forms an approximately uniform pattern in the cavity, and when heated, the thermal expansion portion can rapidly expand to fill the entire cavity of the compound fireproof glass.

Patentansprüche

1. Feuerfestes Verbundglas, umfassend:

ein erstes Glassubstrat (210A);

ein zweites Glassubstrat (210B), das parallel zum ersten Glassubstrat (210A) verläuft;

ein Verbindungsteil (220), das mit dem ersten Glassubstrat (210A) und dem zweiten Glassubstrat (210B) verbunden ist;

einen Hohlraum, der zwischen dem ersten Glassubstrat (210A) und dem zweiten Glassubstrat (210B) vorgesehen ist;

wobei das feuerfeste Verbundglas weiterhin umfasst:

ein Wärmeausdehnungsteil (230), das eine etwa gleichmäßig verteilte Struktur aus einem Wärmeausdehnungsmaterial ist und den Hohlraum teilweise ausfüllt,

wobei das Wärmeausdehnungsteil (230) aus expandierbarem Graphit oder einem expandierbaren Graphit enthaltenden Produkt hergestellt ist und direkt und fest im Hohlraum angeordnet ist, **dadurch gekennzeichnet, dass** das Wärmeausdehnungsteil (230) ein etwa gleichmäßiges Muster im Hohlraum bildet und das Wärmeausdehnungsteil (230) bei Erwärmung sich rasch ausdehnen kann, um den gesamten Hohlraum des feuerfesten Verbundglases auszufüllen.

2. Feuerfestes Verbundglas nach Anspruch 1, wobei

das erste Glassubstrat (210A) ein einschichtiges oder mehrschichtiges feuerfestes Glassubstrat ist;

das zweite Glassubstrat (210B) ein monolithisches Hartglassubstrat, ein einschichtiges oder mehrschichtiges feuerfestes Glassubstrat, ein einschichtiges, mit Folien beschichtetes Glassubstrat, ein beschichtetes Glassubstrat oder ein Verbundglassubstrat mit mindestens zwei Schichten ist.

3. Feuerfestes Verbundglas nach Anspruch 1, wobei das feuerfeste Verbundglas weiterhin ein Abdichtungsteil umfasst, das am Rand des Hohlraums zum Abdichten des Hohlraums vorgesehen ist.

4. Feuerfestes Verbundglas nach einem der Ansprüche 1 bis 3, wobei das Wärmeausdehnungsteil (230) ein gitterartiges, punktförmiges oder blütenblattähnliches Muster bildet.

5. Verfahren zur Herstellung von feuerfestem Verbundglas, das folgende Schritte umfasst:

a. Bereitstellen eines ersten Glassubstrats (210A) und eines zweiten Glassubstrats (210B) und Bildung eines Hohlraums zwischen dem ersten Glassubstrat (210A) und dem zweiten Glassubstrat (210B);

b. Bereitstellen eines Wärmeausdehnungsteils (230) im Hohlraum und teilweises Ausfüllen des Hohlraums mit dem Wärmeausdehnungsteil (230), wobei das Wärmeausdehnungsteil (230) aus einem Wärmeausdehnungsmaterial mit einer etwa gleichmäßig verteilten Struktur hergestellt wird und das Wärmeausdehnungsteil (230) aus expandierbarem Graphit oder einem expandierbaren Graphit enthaltenden Produkt hergestellt ist; und

c. Verbinden des ersten Glassubstrats (210A) und des zweiten Glassubstrats (210B) als integrale Struktur,

wobei das Wärmeausdehnungsteil direkt und fest im Hohlraum angeordnet ist und ein etwa gleichmäßiges Muster im Hohlraum bildet und das Wärmeausdehnungsteil bei Erwärmung sich rasch ausdehnen kann, um den gesamten Hohlraum des feuerfesten Verbundglases auszufüllen.

Revendications

1. Verre ignifuge composite comprenant :

un premier substrat de verre (210A) ;
 un second substrat de verre (210B) prévu parallèlement au premier substrat de verre (210A) ;
 une partie de raccordement (220) raccordée au premier substrat de verre (210A) et au second substrat de verre (210B) ;
 une cavité prévue entre le premier substrat de verre (210A) et le second substrat de verre (210B) ;
 où le verre ignifuge composite comprend en outre :

une partie à dilatation thermique (230) qui est une structure répartie de manière approximativement uniforme fabriquée à partir d'un matériau à dilatation thermique, et qui remplit partiellement la cavité,
 où la partie à dilatation thermique (230) est fabriquée à partir de graphite expansible ou d'un produit contenant du graphite expansible, et est directement et fixement disposée dans la cavité,
caractérisé en ce que la partie à dilatation thermique (230) forme un motif approximativement uniforme dans la cavité, et **en ce que** lorsqu'elle est chauffée, la partie à dilatation thermique (230) peut rapidement se dilater pour remplir la totalité de la cavité du verre ignifuge composite.

2. Le verre ignifuge composite selon la revendication 1, où le premier substrat de verre (210A) est un substrat de verre ignifuge monocouche ou multicouche ;
 le second substrat de verre (210B) est un substrat de verre trempé monolithique, un substrat de verre ignifuge monocouche ou multicouche, un substrat de verre pelliculé monocouche, un substrat de verre à couches, ou un substrat de verre composite de deux couches au moins.

3. Le verre ignifuge composite selon la revendication 1, où le verre ignifuge composite comprend en outre une partie de scellage prévue dans la bordure de la cavité pour sceller la cavité.

4. Le verre ignifuge composite selon l'une quelconque des revendications 1 à 3, où la partie à dilatation thermique (230) dessine un motif en forme de grille, de point ou de pétale.

5. Un procédé de fabrication de verre ignifuge composite comprenant les étapes suivantes :

a. prévoir un premier substrat de verre (210A) et un second substrat de verre (210B), et former une cavité entre le premier substrat de verre (210A) et le second substrat de verre (210B) ;
 b. prévoir une partie à dilatation thermique (230) dans la cavité et remplir partiellement la cavité avec la partie à dilatation thermique (230), fabriquer la partie à dilatation thermique (230) à partir d'un matériau à dilatation thermique avec une structure répartie de manière approximativement uniforme où la partie à dilatation thermique (230) est fabriquée à partir de graphite expansible ou d'un produit contenant du graphite expansible ; et
 c. raccorder le premier substrat de verre (210A) et le second substrat de verre (210B) en une structure intégrale, où la partie à dilatation thermique est directement et fixement disposée dans la cavité et forme un motif approximativement uniforme dans la cavité, et où, lorsqu'elle est chauffée, la partie à dilatation thermique peut rapidement se dilater pour remplir la totalité de la cavité du verre ignifuge composite.

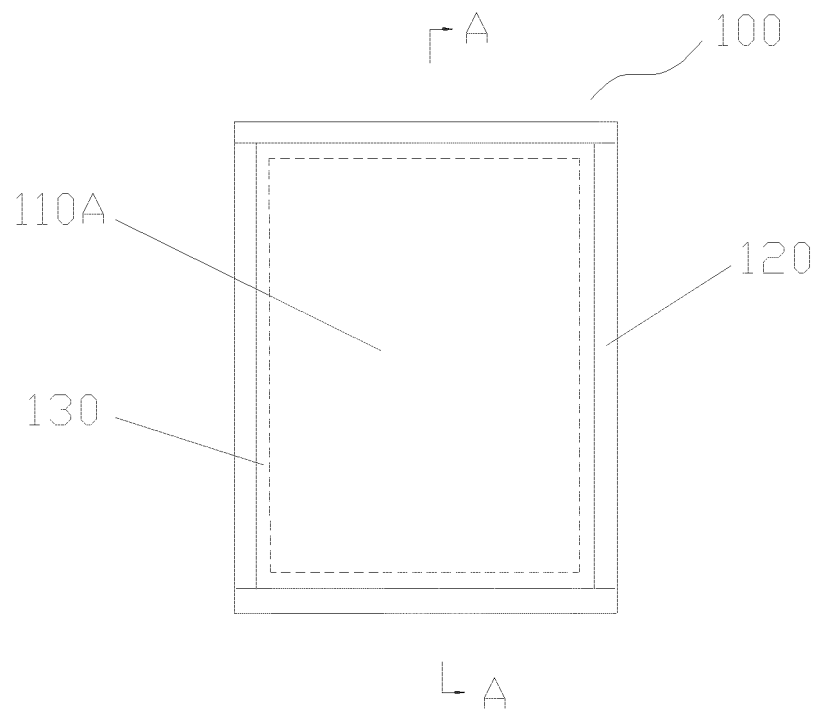


Fig. 1

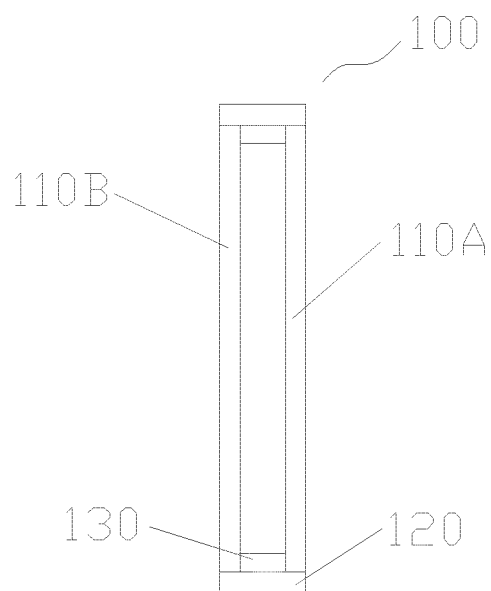


Fig. 2

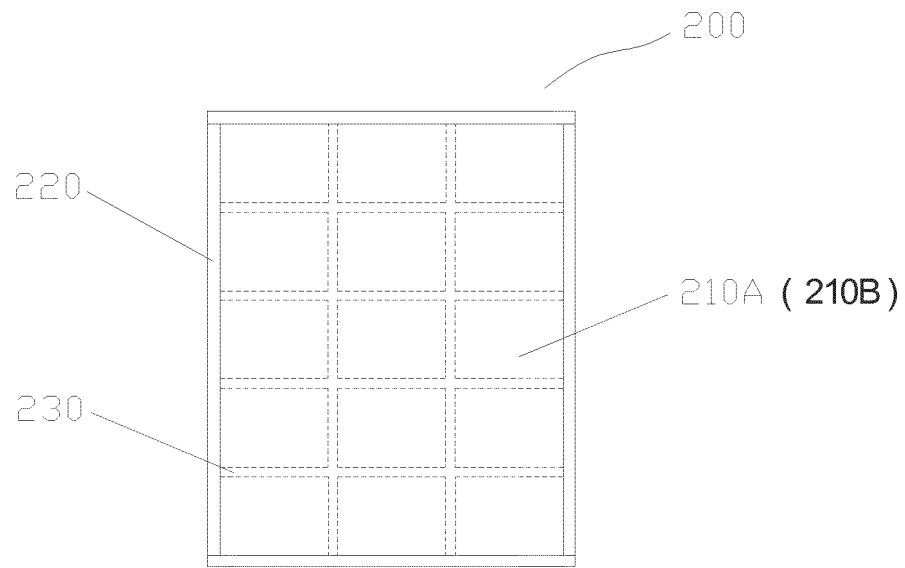


Fig. 3

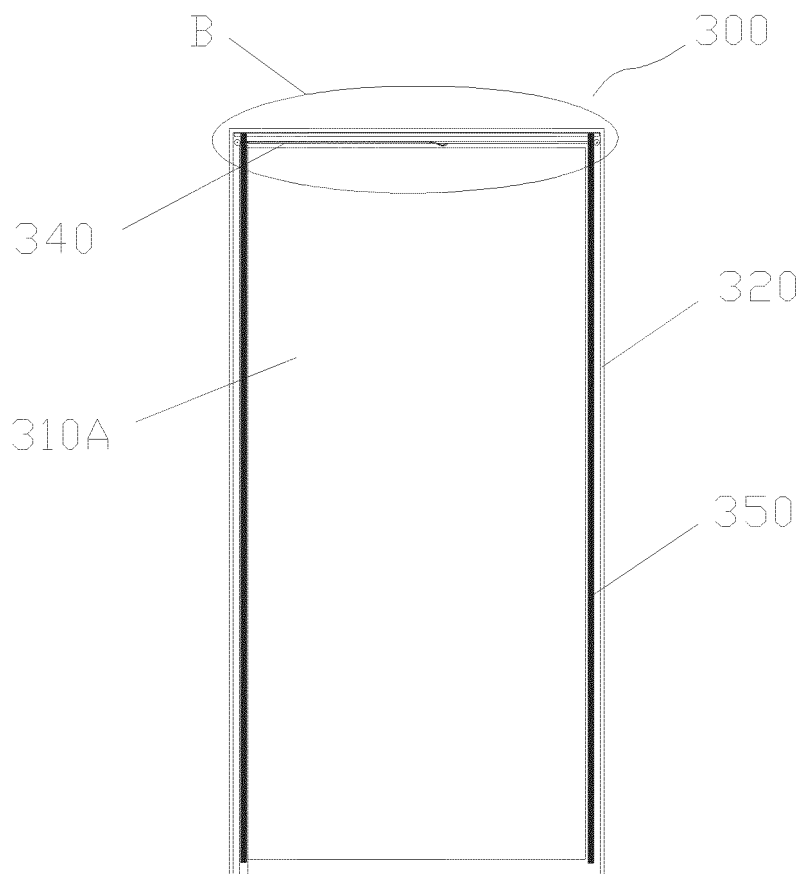


Fig. 4

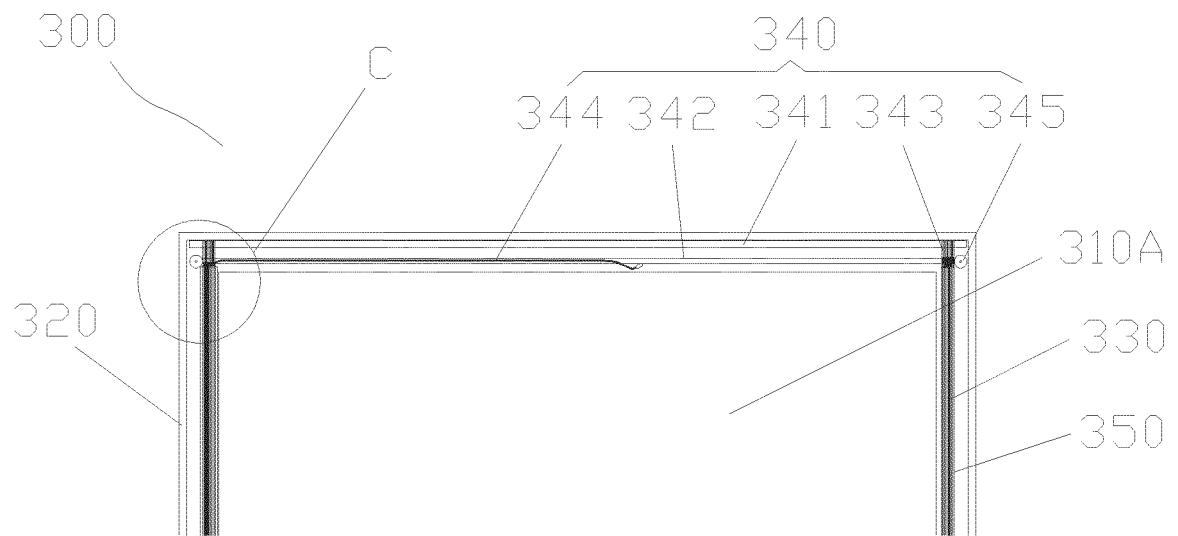


Fig. 5

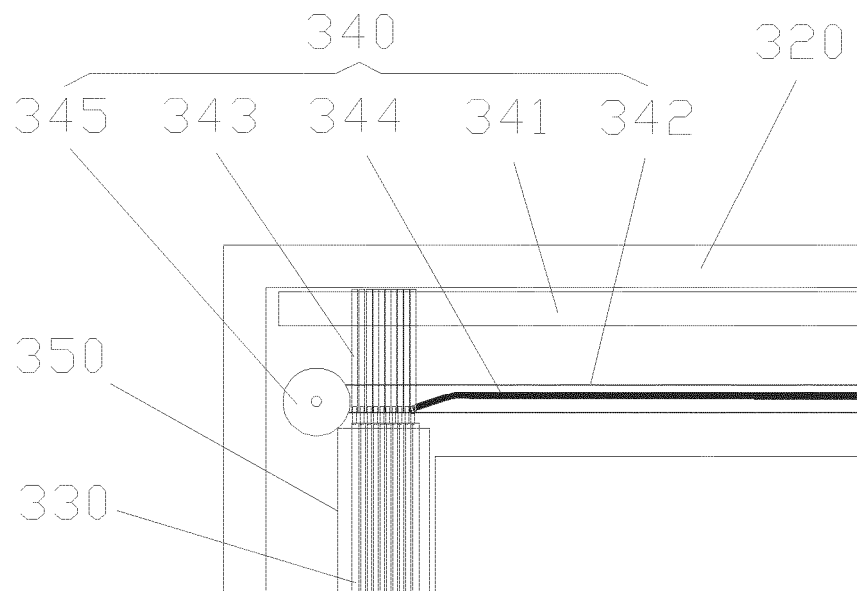


Fig. 6

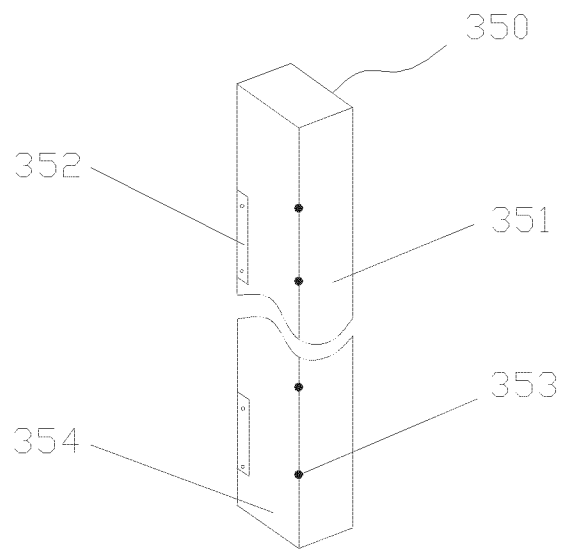


Fig. 7

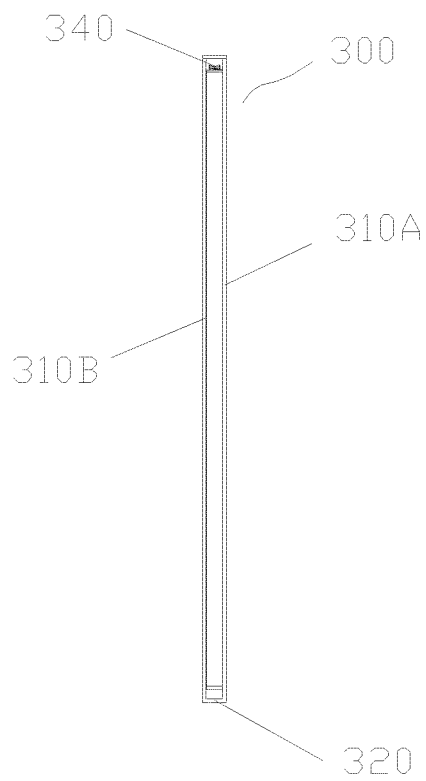


Fig. 8

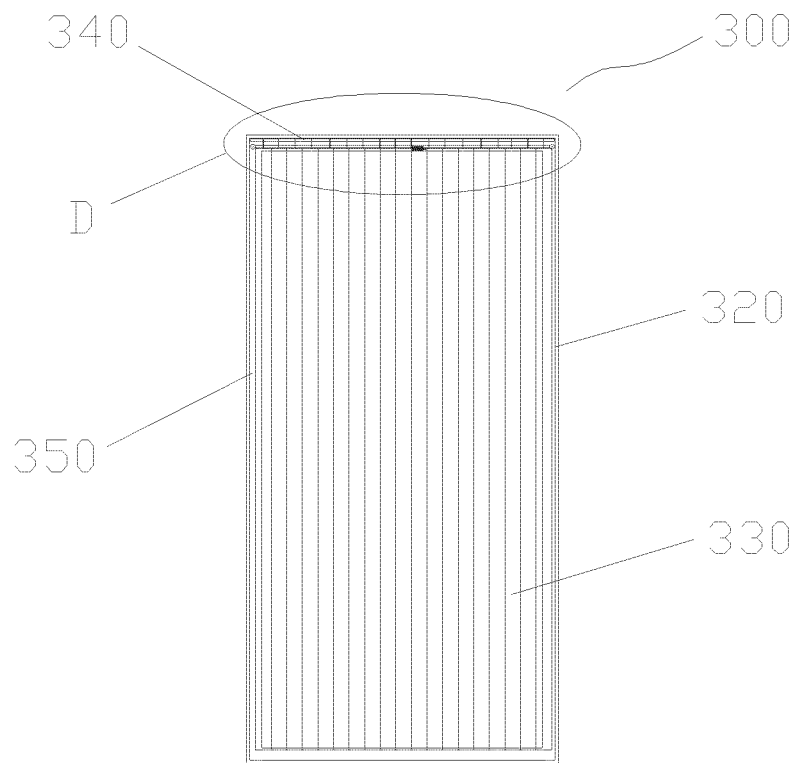


Fig. 9

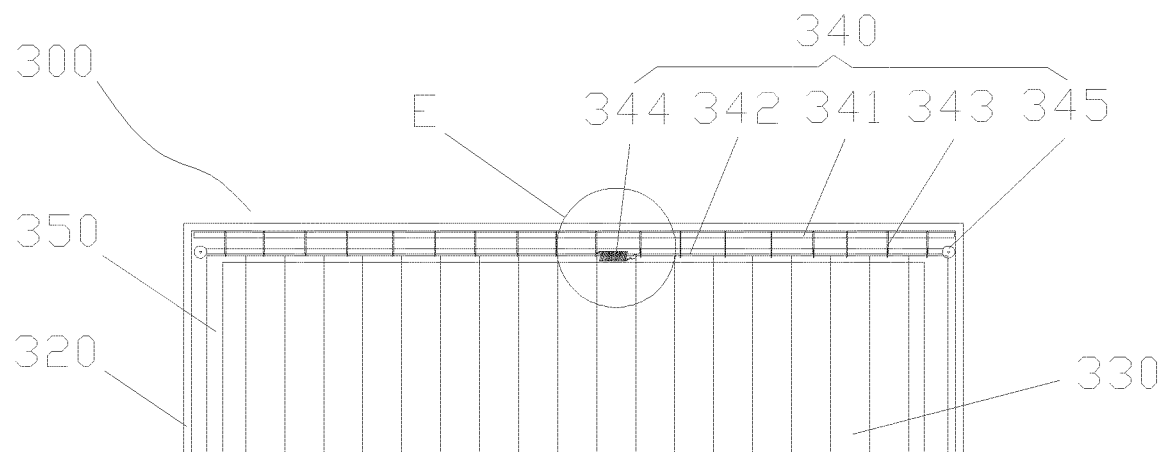


Fig. 10

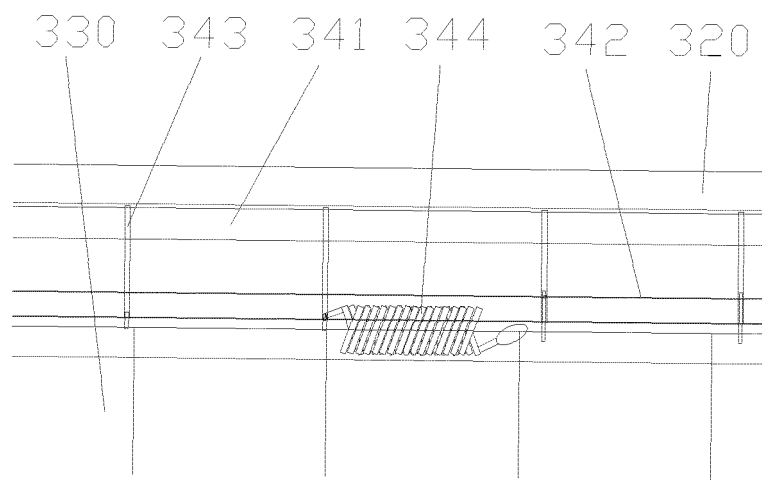


Fig. 11

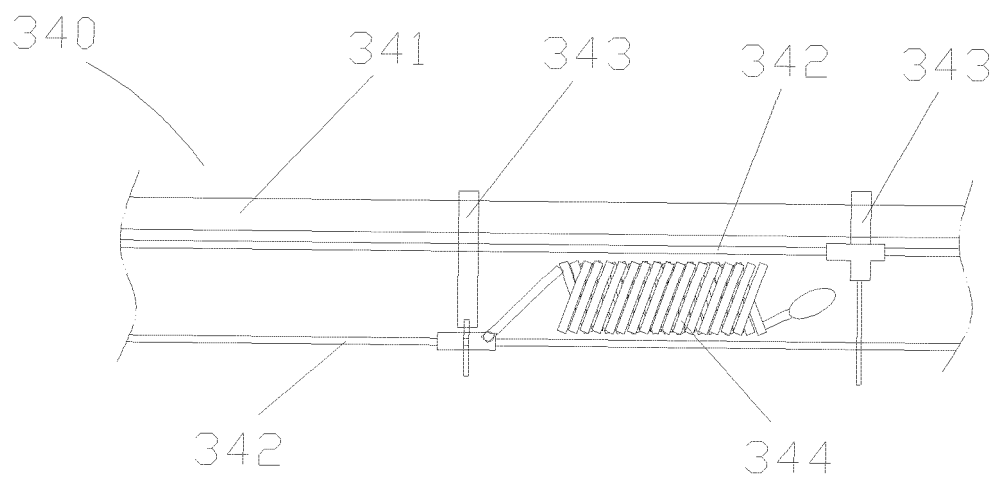


Fig. 12

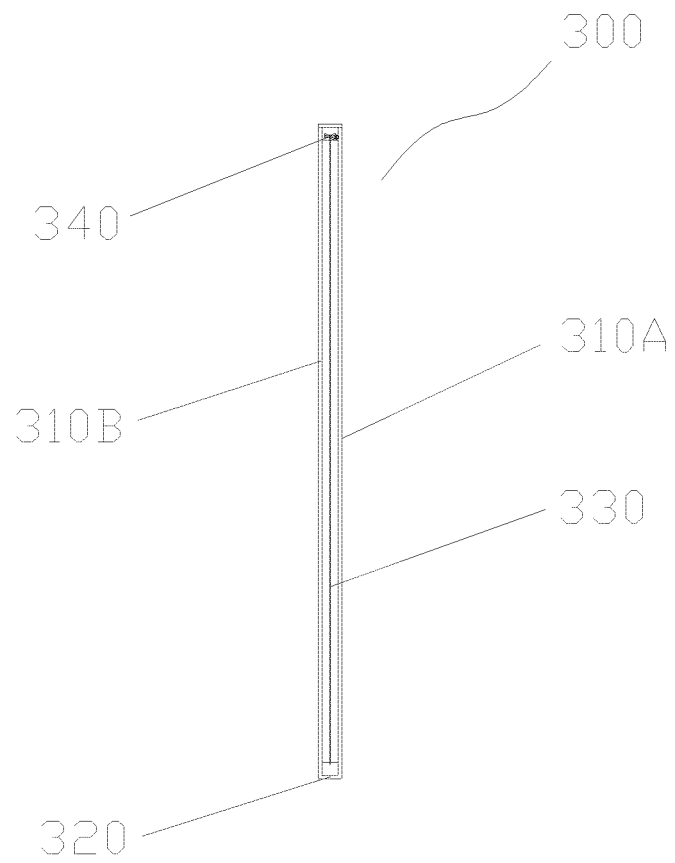


Fig. 13

REFERENCES CITED IN THE DESCRIPTION

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