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(54) Benævnelse: **Vakuumisoleringsglas-byggeelement samt fremgangsmåde og indretning til dets fremstilling**

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The invention relates to a vacuum insulated glass building element, wherein this term is to be understood to mean not only a vacuum insulated glass panel but also any other building element which consists of a combination of vacuum insulated glass with, for example, a solar module. The invention also relates to a method for the manufacture of such a vacuum insulated glass building element.

The invention therefore relates to arrangements in which at least two glass panes or other flat glass structures are connected to each other, with or without the inclusion of a further flat body, so as to form a thin evacuated intermediate space.

Vacuum insulated glass is known per se. It differs from conventional insulated glass in that the panel intermediate space is evacuated, whereas in the case of normal insulated glass it is filled with a noble gas. In the case of vacuum insulated glass, the panel intermediate space is also much thinner than in the case of normal insulated glass, namely is only about 0.7 mm or less, since in the case of vacuum insulated glass there is no convection at all between the individual panes on account of the vacuum. The two individual panes are supported on each other by way of supports distributed in a grid-like pattern over the glass surface, so that the external air pressure cannot press the panes together, and they are connected to each other at their edges by a vacuum-tight edge sealing bond.

According to the known prior art, vacuum insulated glass panels are manufactured in that spacers are placed in the intended grid arrangement on a first individual glass pane and are fixed by gluing, and then the second individual glass pane is laid thereon. The glass pane laid thereon has in the region of its edge a bore with an evacuation nipple sealed therein, namely fixed by glass solder or glued, to which a suction hose of a vacuum pump can be connected. The two glass panes are then laser-welded along their edges using glass solder under atmospheric conditions. To this end, the top glass pane is dimensioned a few millimetres smaller than the bottom pane so that the edge of the top pane is in each case set back somewhat relative to the edge of the bottom pane. In this way, the laser welding of the two panes using glass solder can then take place by means of a laser beam directed onto the arrangement from above.

After the laser welding of the panes, the panel intermediate space is evacuated via the suction nipple. The evacuation takes place over approximately two hours or longer, during which time the glass composite is kept at a temperature of approximately 400°C to approximately 450°C. Only in this way is it possible for volatile substances, primarily water, which are adhering to the glass surfaces to be removed from the intermediate space and for a vacuum of sufficient quality to be established.

This long period of evacuation at high temperature not only means an expensive manufacturing process for the vacuum insulated glass but also leads to a considerable impairment of product quality. Usually, the pane which is located on the inside when used as a window pane is vapour-coated with a reflecting coating on the surface facing toward the panel intermediate space, in order to reflect heat radiation, thereby improving the heat protection function. However, because of the high temperatures used during the evacuation over a long period, the use of high-quality coatings having a low degree of emission (soft coatings) is ruled out. As a result, conventional vacuum glazing units of two-pane construction can only achieve heat insulation values comparable to those of good conventional insulated glazing units.

Furthermore, the high temperature of approximately 450°C that is used for approximately two hours during the evacuation leads to the de-tempering of single-pane safety glass, as a result of which the latter largely loses its safety glass property.

It is known from EP 0 771 313 to perform the laser welding of the two individual panes of a vacuum insulated glass panel, which are separated by an intermediate space and are kept at a distance from each other by means of spacers, in a vacuum chamber so that a subsequent evacuation of the panel intermediate space is no longer necessary. However, said document recommends heating the whole individual glass panes to or slightly above their annealing temperature during the welding of their edges within the vacuum chamber, in order to avoid stress cracks. Here, too, therefore, there is again the problem that no effective coatings for achieving a low degree of emission can be used, and a de-tempering of single-pane safety glass takes place.

However, regardless of whether the welding of the edges of the two individual panes takes place in an atmospheric chamber with subsequent evacuation of the panel intermediate space or in a vacuum chamber, in the case of vacuum insulated glass according to the prior art there is always the considerable problem that the rigid glass edge sealing bond produced by the welding of the individual panes will not withstand the loads occurring during use. This is because the two individual panes separated from each other by the vacuum intermediate space assume different temperatures during use since the pane facing toward the room is warm and the pane facing toward the outside air is cooler, wherein the use of a coating to reduce heat emission considerably further increases the temperature difference. The temperature differences thereby produced between the two individual panes lead to considerable mechanical stresses. This means that it is necessary to limit conventional vacuum insulated glass to maximum formats that are not too large. Such vacuum insulated glass panels thus permit only a certain modest window size. Moreover, no reliable information is yet available concerning the long-term behaviour of such vacuum insulated glass panels under the mechanical stresses occurring during use.

EP 0 421 239 A2 discloses a vacuum insulated glass building element according to the preamble of claim 1, in which metal foil elements having an L-shaped angular profile are attached to the edges of two glass panes supported on one another via spacer elements and are in each case connected to the glass panes in a vacuum-tight manner, and wherein the legs of the L-shaped metal foil angular profiles of the two glass panes, which legs face each other and in each case run at right angles to the plane of the pane, are butted with their ends against each other and are welded.

The object of the invention is therefore to provide vacuum insulated glass building elements which on the one hand achieve much better heat insulation values than good double-pane insulated glass, but which on the other hand require only a manufacturing outlay that is at least not significantly higher than the manufacturing outlay for a good double-pane insulated glass, and which can withstand the mechanical stresses occurring during use due to temperature differences between the two individual panes much better than conventional vacuum insulated glass, and thus promise a reliable long lifespan.

This object is achieved according to the invention by the vacuum insulated glass building element specified in claim 1.

Advantageous embodiments and further developments of the invention form the subject matter of the dependent claims.

A particularly advantageous method for the manufacture of vacuum insulated glass building elements according to the invention forms the subject matter of the method claims.

In the arrangement according to the invention, therefore, the two individual panes are each connected at their edges to a metal foil strip, and the metal foil strips of the two individual panes are welded to each other. A permanently vacuum-tight connection between the two individual panes is thus established, said connection nevertheless not being rigid but rather allowing relative heat movements of the two individual panes with respect to each other. Said movements are absorbed, in a largely stress-free manner, by the metal foil strips which are welded to each other. Since a vacuum-tight, non-rigid edge sealing bond of the vacuum insulated glass building element is thus created, which during use remains substantially free of mechanical stresses even in the event of considerable temperature differences between the two individual panes, the long-term durability of the edge sealing bond can also be deemed to be unproblematic, without any fear of cracks forming due to the effects of heat on the panes during long-term use, which might lead to a loss of vacuum.

The main advantages of the arrangement according to the invention are thus not only a predictable long-term durability of vacuum insulated glass building elements according to the invention but also the fact that there is no limitation to relatively small formats, as is the case with the rigid edge sealing bond of conventional vacuum insulated glass panels due to the glass welding of the two individual panes.

The connection of the glass pane edges to the metal foil strips may take place either by melt welding using glass solder or by “cold” welding using ultrasound. Here, preference is given to ultrasound welding since it causes no thermal stresses. Moreover, the process in the case of ultrasound welding is simpler than in the case of melt welding using glass solder.

A further considerable advantage of the vacuum insulated glass building element according to the invention is therefore that, when ultrasound welding is used, no thermal stressing and impairment of the glass panes takes place. If one of the glass panes consists of safety glass, no de-tempering takes place due to the effect of heat, and the safety glass structure remains unchanged. Furthermore, high-quality low-emission coatings can be used, which are not adversely affected by the production of the edge sealing bond and thus enable very high heat insulation values of the vacuum insulated glass building element.

The production of the edge sealing bond is relatively simple in method terms. The ultrasound welding (or also the melt welding using glass solder) of the glass pane edges to the metal foil strips can take place under atmospheric conditions. The subsequent welding of those areas of the metal foil strips which protrude beyond the glass pane edges when said strips are connected to the glass pane edges can take place in a vacuum chamber by laser welding, so that no subsequent evacuation of the panel intermediate space is necessary. Thereafter, once again outside the vacuum chamber, the welded protruding areas of the metal foil strips can be bent to one or to the other side of the building element, and the edge sealing bond is complete.

The metal foil strips are preferably attached to the mutually facing sides of the glass panes. Prior to the welding of the metal foil strips in the vacuum chamber, a getter material is advantageously applied to one of the metal foil strips on an area thereof facing toward the panel interior with respect to the welding seam to be produced, which getter material serves to absorb any remaining moisture molecules in the panel intermediate space.

An exemplary embodiment of a vacuum insulated glass building element according to the invention as well as a method will be described in greater detail below with reference to the accompanying drawings. In the drawings:

Fig. 1 shows in cross-section an edge area of a vacuum insulated glass building element according to the invention,

Fig. 2 shows the two individual glass panes of the building element with metal foil strips attached thereto, prior to assembly,

Fig. 3 shows the assembled individual glass panes after the welding of the protruding areas of the metal foil strips,

Fig. 4 shows a schematic cross-section through the edge area of a vacuum insulated glass building element according to the invention, configured as a solar module,

Fig. 5 shows a variation of the arrangement shown in Fig. 1,

Fig. 6 shows a schematic diagram which illustrates the sequence of the method for manufacturing vacuum insulated glass building elements according to the invention,

Fig. 7 schematically shows the cleaning stage of the method in a first vacuum chamber, and

Fig. 8 schematically shows the laser welding stage of the method in a second vacuum chamber.

Fig. 1 shows, in cross-section, the edge area of a vacuum insulated glass building element in the form of a vacuum insulated glass panel with a finished edge sealing bond. The arrangement consists of a top pane 1 (outer pane) and a bottom pane 2 (inner pane), which are separated from each other by a panel intermediate space 3. A vacuum prevails in the panel intermediate space 3. The two panes 1 and 2 are kept at the intended distance from each other by spacers 4 which are fixed in a grid-like arrangement on the bottom pane 4, for example by gluing, and on which the top pane 1 is supported. The spacers may be small glass cylinders, as shown, but they may also be configured as spheres and they may also be made of metal.

The top pane 1 and the bottom pane 2 may each have a thickness of 4 mm, and the panel intermediate space may have a thickness preferably in the range from 0.7 mm to 1 mm.

A metal foil strip 5 is attached in a vacuum-tight manner at the edge of each of the two panes 1, 2. The metal foil strips 5 are preferably attached to the sides of the two panes 1, 2 that face each other or face the panel intermediate space 3.

The connection of the metal foil strips 5 to the respective pane may take place either by welding using glass solder or preferably by ultrasound welding. The ultrasound welding takes place with the interposition of a thin aluminium foil strip 6 between the respective metal foil strip 5 and the glass surface, wherein the aluminium intimately bonds to the glass surface and also to the metal foil strip 5 made of a different metal, preferably stainless steel. The areas of the metal foil strips 5, attached to the two panes, which protrude beyond the glass pane edges are pressed together and welded to each other preferably by laser welding. A getter material 8 is arranged inward of the welding seam 7 between the metal foil strips 5, that is to say still within the panel intermediate space, which getter material has been applied to the lower metal foil strip prior to the welding of the metal foil strips 5. The welded protruding area of the metal foil strips 5 is bent onto the edge surface of the bottom pane 2. The getter material need not be arranged between the panes as shown (where there is usually also no space in the case of a thin panel intermediate space), but rather it may be located in the bent-over area of the welded metal foil strips.

Figs. 2 and 3 show, for explanatory purposes, preliminary stages of the finished edge sealing bond of the vacuum insulated glass building element shown in Fig. 1.

Fig. 2 shows the two panes, top pane 1 and bottom pane 2, which are still individual panes, with the metal foil strip 5 welded to the edge in each case. Furthermore, the spacers 4 are already in place on the bottom pane 2.

Fig. 3 shows the assembled arrangement of top pane 1 and bottom pane 2 with the metal foil strips 5 welded thereto, wherein the areas of the metal foil strips 5 protruding beyond the pane edges are welded to each other by the welding seam 7. By bending the welded protruding area of the metal foil strips 5 onto the edge surface of the bottom pane 2, this then creates the finished edge sealing bond as shown in Fig. 1.

Fig. 4 shows an arrangement, as shown in Fig. 1, but wherein the bottom pane 2 is combined with an additional module (or is configured as such), here with a photovoltaic module 10. Here, the photovoltaic module 10 forms a compound arrangement with the bottom pane 2. If, as in the exemplary embodiment shown in Fig. 4, the additional module is made entirely or partially of glass material, the metal foil strips, as shown in Fig. 4, and as also in the basic embodiment shown in Fig. 1, may be attached to the sides of the top pane 1 and the bottom pane 2 or the additional module connected thereto which face toward the panel intermediate space 3. If, on the other hand, the additional module is not suitable for a vacuum-tight attachment of the respective metal foil strip 5, the arrangement shown in Fig. 5 and described below may be chosen. Usually, however, one pane, here the bottom pane, will itself form the additional module by way of an integrated particular function.

Fig. 5 shows a variation of the formation of the vacuum-tight edge sealing bond of the arrangement shown in Fig. 1. It differs from the embodiment shown in Fig. 1 in that the metal foil strips 5 are not attached to the mutually facing sides of the individual glass panes 1 and 2, but rather to the outer sides thereof. This embodiment shown in Fig. 5 is possible and is equally as good as the embodiment of Fig. 1 in terms of the quality of the vacuum-tight edge sealing bond, but it means that the two outer surfaces of the finished vacuum insulated glass building element are not completely smooth right up to the edge but rather have a small raised area due to the metal foil strip 5 attached there. This could be disruptive in some use scenarios, and therefore this second embodiment shown in Fig. 5 appears to be less preferred.

The preferred material for the edge foil strips 5 in all embodiments is stainless steel.

As can be seen from Figs. 1 to 3, the outer gap between the individual panes 1 and 2 and the metal foil strips 5 attached thereto can be sealed by a filler material 9 in the area between the respective individual pane outer edge and the area of connection or welding to the glass pane surface. Said filler material has two functions. It ensures the long-term vacuum-tightness by protecting the weld between the metal foil strips and the glass from external influences and reduces mechanical stresses. In addition, it protects the pane edges against considerable mechanical stress during the bending-over of the welded metal foil strips.

Fig. 6 shows, in the form of a schematic block diagram, the sequence of a preferred method for the manufacture of vacuum insulated glass building elements according to the invention as described above.

In a first method step A, the two individual glass panes are prepared under atmospheric conditions. This includes the connection of the individual panes to the metal foil strips and the attachment of the spacers to the bottom pane as well as optionally the application of the getter material.

The second method step B is the cleaning of the two individual panes, in particular the removal of water molecules from the pane surfaces. Special coatings of the panes bind water molecules which are difficult to remove therefrom. In the prior art, relatively long heating to high temperatures is required for this purpose, but this is undesirable since high temperatures, particularly over a relatively long period of time, destroy high-quality coatings for reducing the degree of emission (so-called low-E layers) and also destroy the glass structure, for example in the case of safety glass, as has already been explained above. In the method according to the invention, therefore, this cleaning step takes place without using heat, by ion sputtering (bombarding the glass pane surface with an ion cloud), wherein the ions absorb the moisture and carry it away, or by plasma cleaning, also known as plasma etching. This method step takes place in a first vacuum chamber under constant suction in order to remove any moisture released from the pane surfaces. It is very important here that in each case both sides of each individual pane are cleaned of moisture, that is to say including in each case that side which does not delimit the evacuated panel intermediate space. This is necessary because any moisture input into the high vacuum chamber in which the laser welding of the metal foil strips takes place must be carefully avoided since otherwise the high vacuum is adversely affected.

Fig. 7 schematically shows the cleaning stage according to method step B in the first vacuum chamber by ion sputtering or vacuum etching on both sides of the pane, wherein the ion sputtering or the vacuum etching takes place in each case in lines over the pane width while the glass pane is moved on transport means 11 through said first vacuum chamber 12.

The third method step C is the laser welding of the metal foil strips in a second vacuum chamber 13, which is shown schematically in Fig. 8 in a sectional view. Here, firstly the bottom pane 2 is introduced into the vacuum chamber 13 and then the top pane is introduced and is placed onto the bottom pane. The vacuum chamber 13 has on its top side, along all four edge areas, a line-like window 14 which, of course, is interrupted by bridge areas of supporting material as necessary for the integrity of the top wall of the vacuum chamber 13. A laser gun 15 is arranged outside, namely above, the vacuum chamber 13 and is movable along the window 14 in order to direct a laser beam through the window 14 onto the metal foil strips to be welded. The pane arrangement is arranged within the vacuum chamber 13 in such a way as to be movable on a suitable carriage in the plane of the pane since, because of the design-based interruptions of the window 14, a certain mobility of the pane arrangement is necessary in addition to the mobility of the laser gun.

This arrangement offers significant advantages. Since the laser gun 15 is arranged outside the vacuum chamber 13 and is movable along the window 14, there is no need for any mirror or any other optical elements or mechanisms within the vacuum chamber, so that the latter can be designed with the smallest possible volume. The necessary length and width thereof depends on the dimensions of the largest pane arrangements to be welded therein, and the height of the vacuum chamber is determined only by the thickness of the pane arrangement and the height required for the carriage carrying it. However, due to the mobility of the laser gun 15, there is also no need for complicated laser-optical equipment, in particular mirror mechanisms, outside the vacuum chamber, as would otherwise be necessary, and this simplifies the device.

In the last method step D, once the pane arrangement with the laser-welded metal foil strips has been removed from the second vacuum chamber 13, the final aftertreatment of the edge areas takes place, namely by introducing the filler material 9, bending over the laser-welded protruding areas of the metal foil strips and, if desired, applying a protective cover to the finished edge sealing bond.

Patentkrav

1. Vakuumisoleringsglas-byggeelement, med en første rude (1) og en anden rude (2), som er støttet på hinanden med afstandsholderelementer (4) og danner et tyndt evakueret mellemrum (3) mellem dem og er lukket af med en vakuumtæt kantforbindelse ved deres kanter
hvor kantforbindelsen er lavet af metalfoliestrimler (5), hvor de første af metalfoliestrimlerne (5) er forbundet til kanterne af den første rude (1) på en vakuumtæt måde, og de andre af metalfoliestrimlerne (5) er forbundet til kanterne af den anden rude (2) på en vakuumtæt måde, og hvor de første og anden metalfoliestrimler er svejset sammen,
kendetegnet ved at kantområderne af de første og anden metalfoliestrimler (5) som rager frem ud over kanterne af den respektive rude (1, 2) er trykt sammen og svejset sammen med lasersvejsning, og ved at de fremragende områder af metalfoliestrimler som er svejset sammen med lasersvejsning efter at være trykt sammen er bøjet til en eller den anden side af byggeelementet.

2. Vakuumisoleringsglas-byggeelementet ifølge krav 1, hvor metalfoliestrimlerne (5) er forbundet til den respektive rude (1, 2) med ultralydssvejsning, hvor en tynd aluminiumfoliestrimmel (6) er indskudt mellem den respektive metalfoliestrimmel (5) og den respektive rude (1, 2), hvor metalfoliestrimlen er forbundet, med ultralydssvejsningen, henholdsvis til glasfladen på en side og til metalfoliestrimlen (5) på den anden side, på en vakuumtæt måde.

3. Vakuumisoleringsglas-byggeelementet ifølge krav 1, hvor metalfoliestrimlerne (5) er forbundet til den respektive rude (1, 2) med svejsning via sammensmeltet glas.

4. Vakuumisoleringsglas-byggeelementet ifølge et hvilket som helst af kravene 1 til 3, hvor et getter-materiale (8) er påført til mindst en af metalfoliestrimlerne (5), hvor getter-materialet er anbragt på siden af svejsesømmen (7) mellem metalfoliestrimlerne som vender mod det evakuerede mellemrum (3) mellem de to ruder (1, 2).

5. Vakuumisoleringsglas-byggeelementet ifølge et hvilket som helst af kravene 1 til 4, hvor metalfoliestrimlerne (5) er henholdsvis forbundet til de to ruder (1, 2) på siderne deraf som vender mod hinanden.

6. Vakuumisoleringsglas-byggeelementet ifølge et hvilket som helst af kravene 1 til 5, hvor metalfoliestrimlerne (5) består af rustfrit stål.

7. Vakuumisoleringsglas-byggeelementet ifølge et hvilket som helst af kravene 1 til 6, hvor spalterne vendende mod den omgivende luft mellem metalfoliestrimlen (5) og de respektive glasflader ud over den respektive metalfoliestrimmel- /glasflade-svejseområder er tætnet med hjælp af et fyldmateriale (9).

8. Vakuumisoleringsglas-byggeelementet ifølge et hvilket som helst af kravene 1 til 7, hvor den første eller den anden rude er kombineret med et yderligere element, som er et solarmodul, et fotovoltaisk modul eller et andet element, eller er konfigureret som sådan et element.

9. Fremgangsmåde til fremstillingen af et vakuumisoleringsglas-byggeelementet ifølge et hvilket som helst af kravene 1 til 8, hvor de klargjorte ruder (1, 2) sammen med metalfoliestrimlerne (5) anbragt derpå introduceres i et vakuumkammer og stables deri på hinanden, og hvor svejsningen af de fremragende områder af metalfoliestrimlerne som er blevet trykt sammen udføres inden i vakuumkammeret (13) ved hjælp af en laserstråle frembragt udenfor vakuumkammeret og bevæges i alt væsentligt langs metalfoliestrimlerne, hvor laserstrålen introduceres ind i vakuumkammeret (13) igennem lineært forløbende vinduer (14), og hvor de fremragende områder af metalfoliestrimlerne som er blevet svejset sammen efterfølgende bøjes til en eller til den anden side af byggeelementet.

10. Fremgangsmåden ifølge krav 9, hvor, før deres introduktion ind i vakuumkammeret (13) i hvilket metalfoliestrimlerne (5) svejses sammen, rengøres de to ruder (1, 2) i et andet vakuumkammer (12) på begge sider med ionforstøvning eller plasmaætsning for at fjerne enhver fugt.

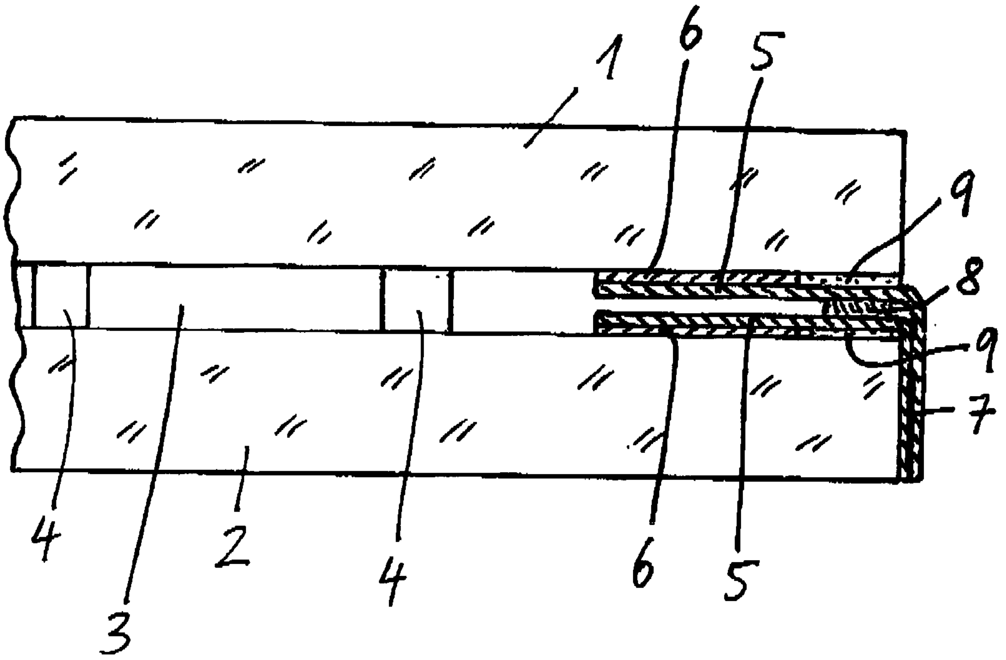

Fig. 1

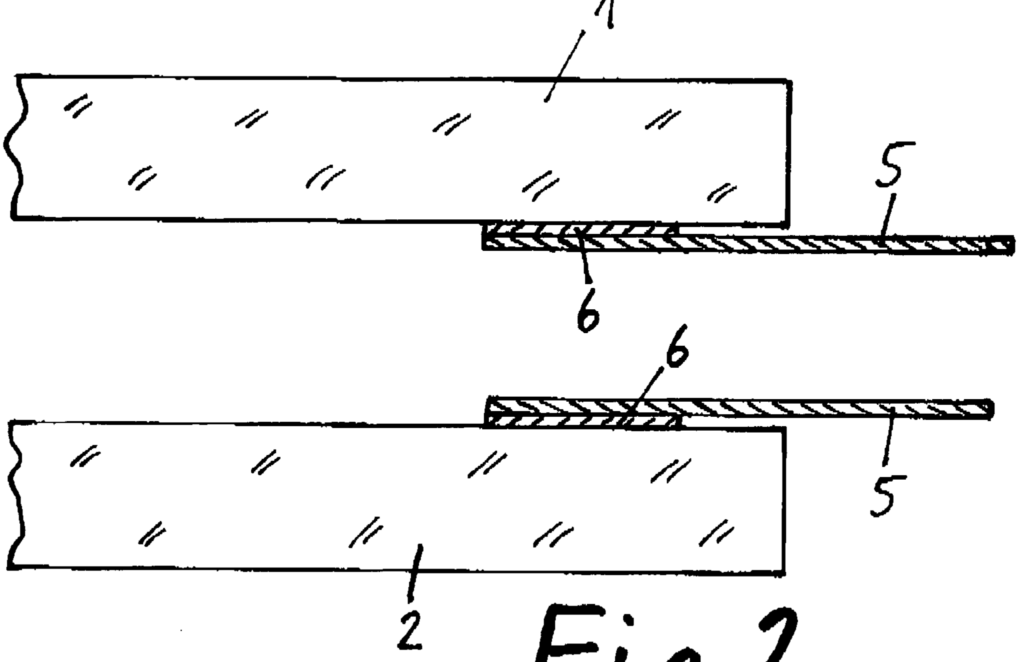

Fig. 2

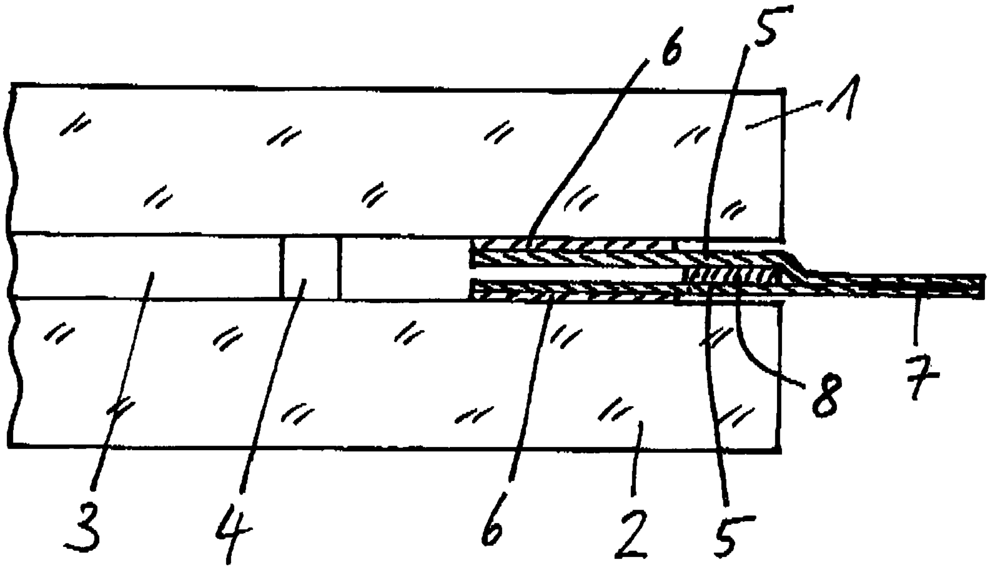

Fig. 3

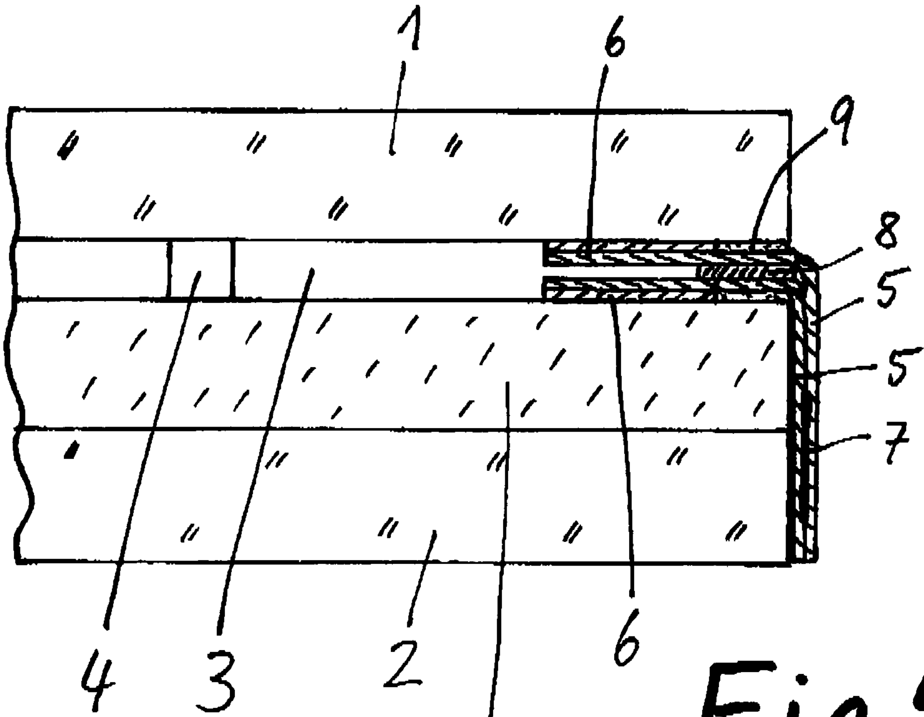

Fig. 4

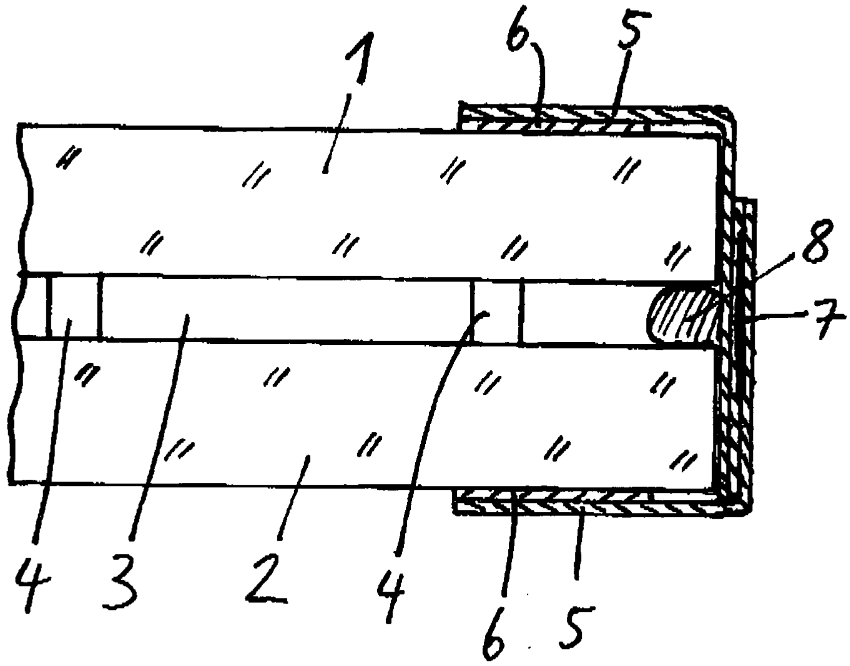

Fig. 5

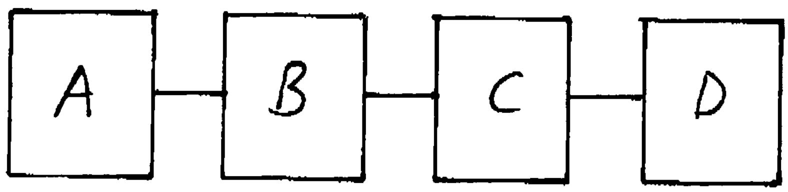

Fig. 6

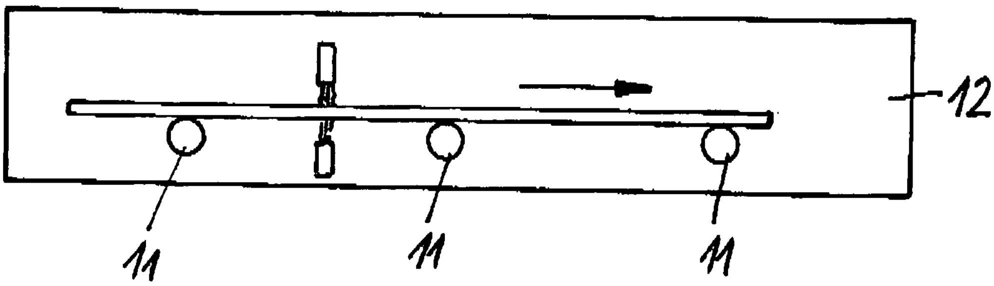

Fig. 7

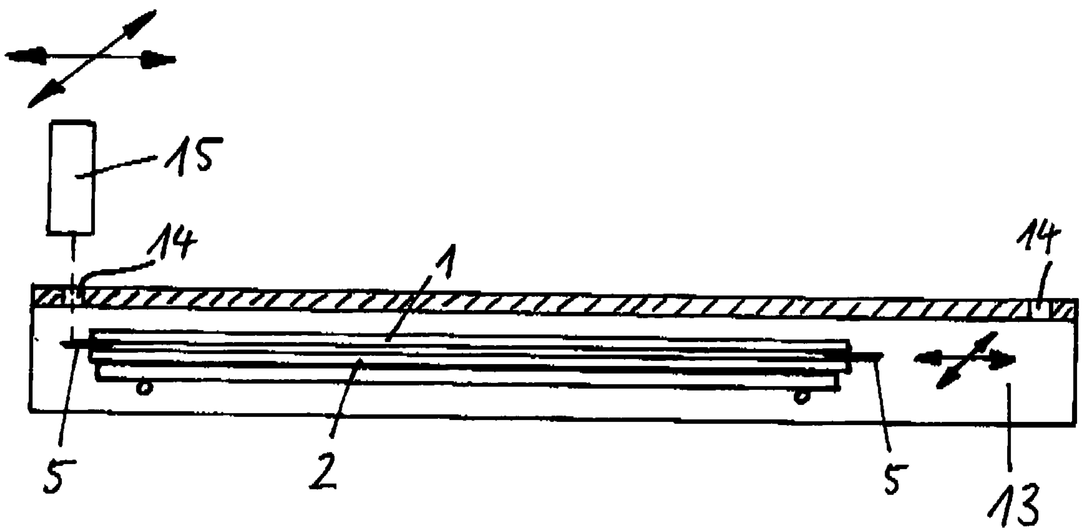

Fig. 8