between the sheets, and to seal the two sheets together to form a heat or sound barrier (i.e. a sealed unit). Such spacer bars have also been provided with perforations containing desiccant material, which absorb moisture in the trapped air to prevent condensation forming in the space between the sheets. Air can also be replaced with an inert gas such as argon to further improve insulation.

The method steps associated with the manufacture and installation of such panel structures, for example cutting, handling, edge treating, carrying, fixing and installation, in addition to the long term performance of such structures, provide many difficulties. In particular, as a result of the physical attributes of typical panel structures, such as fragility and weight, numerous problems arise. These problems can create deficiencies in, for example, quality, strength, durability and air/water-tightness, and minimising such deficiencies results in additional manufacturing/installation complexity and cost.

Furthermore, panels structures (and their component sheets) used in civil construction may be subjected to sudden impact forces of considerable magnitude or unwanted attempts to remove the sheet material from the supporting framework.

It is, therefore, desirable to realise a supporting frame assembly for sheet material that provides for reduced installation/manufacturing complexity and cost. Furthermore, it is also desirable for such frame assembly to provide significantly improved levels of strength and resistance against impact forces (for example ballistic events and/or bomb blasts) and/or unwanted attempts to remove the sheet material.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a frame assembly as claimed in claim 1.~~comprising: first and second glass panels substantially parallel to each other; an intermediate ballistic panel positioned between the first and second glass panels and comprising a polymeric material; a spacer element positioned between the first and second glass panels and adapted to receive the intermediate ballistic panel, wherein a first portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface of the first glass panel and wherein a second portion of the spacer element is positioned between the intermediate ballistic panel and an inner~~

~~surface the second glass panel, wherein the spacer element comprises a recess adapted to receive~~

~~the intermediate ballistic panel therein, and wherein the recess is larger than the intermediate ballistic panel in at least one dimension by a tolerance value to accommodate thermal expansion of the intermediate ballistic panel.~~

Thus, the invention provides a frame assembly for plural panels that provides high impact resistance. Such a frame assembly may provide sufficient compressive and shear strength to withstand loads induced by: (i) blast pressure waves resulting from the detonation or ignition of explosive or flammable mixtures in proximity to the panels; (ii) wind pressures acting on the panels of sheet material; (iii) small and large projectiles (e.g. bullets, flying debris during extreme weather conditions) impacting the panels; and (iv) unwanted attempts to remove the sheet material (i.e. break-in attempts). Such benefits may also be enabled at reduced installation/manufacturing complexity and cost, when compared to conventional frame assemblies.

Embodiments may be compatible with existing production methods for insulating glazing units, so that the device: (i) can be cut and joined using conventional processing equipment and joining methods (corner cleats etc.); (ii) can be fixed to glazing materials using existing materials (butyl tapes and adhesives, silicone adhesives and sealants, polysulphide adhesives and sealants etc.); and/or (iii) can be effectively sealed with existing sealant systems (primarily polysulphide or silicone formulations).

Also, proposed embodiments may have adequate thermal performance and may not form a significant “cold bridge” between panels of sheet materials.

Embodiments may enable multiple (two, three or more) panels to be connected but at the same time cope with the problem of mismatch of thermal expansion coefficient between panels formed from different materials, which can induce distortion and high stresses in the panels and their connections when the system is subject to temperature variations. The proposed assembly may also allow the thickness of the panels to be varied independently such that the thermal and mechanical properties of the assembly can be tailored to meet specific design requirements.

Unlike a conventional spacer bar (which merely separates the panels within a frame but has no other function), proposed embodiments may employ a structural spacer element that provides the additional function of withstanding high compressive pressure. By withstanding compressive forces (i.e. providing crush resistance), the

Although the above discussion might suggest that the frame assembly is made up of section lengths fitted around the sides of a panel, with corner pieces potentially completing the inner frame, the inner frame sections could have mitred ends if so desired, as with the outer frames. Furthermore, the inner frame sections could extend around a corner of the panels so that in one embodiment the inner frame is made up of four L-shaped inner frame sections (that may be thought of as corner pieces). Thus, if a corner piece extends along a significant length of the panels, then functionally it may be considered as an “inner frame section” within the terms of the invention as defined herein.

According to yet another aspect of the invention, there is provided a spacer element ~~for a frame assembly comprising first and second glass panels substantially parallel to each other and further comprising an intermediate ballistic panel positioned between the first and second glass panels and comprising a polymeric material, the spacer element being adapted to be positioned between the first and second glass panels and adapted to receive the intermediate ballistic panel, wherein a first portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface of the first glass panel and wherein a second portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface the second glass panel, and wherein the spacer element comprises a recess adapted to receive the intermediate ballistic panel therein, the recess being larger than the intermediate ballistic panel in at least one dimension by a tolerance value to accommodate thermal expansion of the intermediate ballistic panel~~according to claim 18.

Also, the spacer element may comprise a hollow polymeric extruded element.

Further, the spacer element may comprise first and second passages extending longitudinally therethrough and separated by a dividing element. The dividing element may, for example, be substantially planar and preferably lies in a plane extending through the first and second glass panels.

In an embodiment, the tolerance value may be greater than or equal to 5 mm.

In some embodiments, the outer cross-sectional shape of the spacer element may be substantially U-shaped.

According to another aspect of the invention, there is provided a method of constructing a frame assembly ~~having plural parallel panels, the method comprising: arranging first and second glass panels substantially parallel to each other; positioning an intermediate ballistic panel between the first and second glass panels, the intermediate ballistic panel comprising a polymeric material; receiving the intermediate ballistic panel in a recess of a spacer element, the recess being larger than the intermediate ballistic panel in at least one dimension by a tolerance value to accommodate thermal expansion of the intermediate ballistic panel; and positioning a spacer element between the first and second glass panels such that a first portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface of the first glass panel and such that a second portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface the second glass panel, wherein the outer surface of the second glass panel is opposite the inner surface of the second glass panel~~according to claim 24.

BRIEF DESCRIPTION OF THE DRAWINGS

Examples of the invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 illustrates a cross-sectional view of a frame assembly according to an embodiment, wherein the left-hand side of the diagram is the external/outside facing side;

Figure 2 illustrates the embodiment of Figure 1 received by an outer frame section;

Figures 3A-3D show various modifications to the spacer employed in the embodiments of Figures 1 and 2;

Figure 4 depicts another modification to the spacer element of Figures 1 and 2; and

Figure 5 illustrates a cross-sectional view of a frame assembly according to another embodiment, wherein the left-hand side of the diagram is the external/outside facing side.

CLAIMS

1. A frame assembly (2) comprising:

first (4) and second (6) glass panels substantially parallel to each other;

an intermediate ballistic panel (8) positioned between the first and second glass panels and comprising a polymeric material; and

a spacer element (10) positioned between the first and second glass panels and adapted to receive the intermediate ballistic panel, wherein a first portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface of the first glass panel and wherein a second portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface the second glass panel,

wherein the spacer element comprises a recess (12) adapted to receive the intermediate ballistic panel therein, and

wherein the recess is larger than the intermediate ballistic panel in at least one dimension by a tolerance value to accommodate thermal expansion of the intermediate ballistic panel

and wherein the recess comprises a plurality of projections (50) adapted to contact a surface of an intermediate ballistic panel received within the recess, wherein the projections project inwardly towards each other from the inner surfaces of the recess in a direction that is angled with respect to an inner surface of the recess so that the projections (50) may flex by a small amount and thus urge against opposing sides of the intermediate ballistic panel (8) to be received within the recess (12).

~~2. The frame assembly of claim 1, wherein the spacer element comprises a hollow polymeric extruded element.~~

~~3. The frame assembly of claim 2, wherein the spacer element comprises first and second passages extending longitudinally therethrough and separated by a dividing element.~~

~~4. The frame assembly of claim 3, wherein the dividing element is substantially planar and preferably lies in a plane extending through the first and second glass panels.~~

~~5. The frame assembly of any preceding claim, wherein the tolerance value is greater than or equal to 3 mm.~~

~~6. The frame assembly of any preceding claim, wherein the outer cross-sectional shape of the spacer element is substantially U-shaped.~~

~~7. The frame assembly of any preceding claim, wherein the spacer element is fitted to at least one of the first and second glass panels using double-side tape.~~

~~8~~2. The frame assembly (2) as claimed in~~of any preceding~~ claim 1, further comprising:

an intermediate glass panel positioned between the intermediate ballistic panel and the first glass panel and being substantially parallel to the first glass panel; and

a second spacer element positioned between the first glass panel and the intermediate glass panel.

~~9. The frame assembly of claim 8, wherein the second spacer element comprises a hollow polymeric extruded element, and optionally wherein the second spacer element comprises first and second passages extending longitudinally therethrough and separated by a dividing element.~~

~~10. The frame assembly of claim 8 or 9, wherein the second spacer element is fitted to at least one of the first glass panel and the intermediate glass panel using double-side tape.~~

~~11~~3. The frame assembly (2) ~~of any preceding~~as claimed in claim 1, further comprising:

a first inner frame section fitted to an outer surface of the first glass panel, wherein the outer surface of the first glass panel is opposite the inner surface of the first glass panel; and

a second, separate inner frame section fitted to an outer surface of the second glass panel, wherein the outer surface of the second glass panel is opposite the inner surface of the second glass panel.

~~12. The frame assembly of claim 11, wherein the first and second inner frame sections are fitted to the first and second glass panels, respectively, using double-side tape.~~

~~13~~4. The frame assembly (2) ~~of~~as claimed in claim ~~11 or 12~~3, further comprising:

an outer frame section for receiving the panels with the first and second inner frame sections fitted thereto, the outer frame section comprising a first projection,

wherein the first inner frame section defines a space adapted to receive the first projection of the outer frame section, whereby the space of the first inner frame section cooperates with the received first projection to restrict movement of the first inner frame section relative to the outer frame section.

~~14~~5. The frame assembly (2) ~~of any of~~as claimed in claim~~s 11 3 to 13~~4, wherein the cross-sectional shape of the first inner frame section is substantially S-shaped or Z-shaped.

~~15~~6. The frame assembly (2) ~~of~~as claimed in claim ~~13 4 or 14~~5, wherein the space of first inner frame section and the first projection of the outer frame section are adapted to have complementary or interlocking geometries.

~~16~~7. The frame assembly (2) ~~of any of~~as claimed in claim~~s 13 4 to 15~~6, wherein the outer frame section has a mouth portion into which the panels with the first and second inner frame sections fitted thereto is adapted to be received, and wherein

the panels with the first and second inner frame sections fitted thereto are wider than the mouth portion.

~~17~~8. The frame assembly (2) ~~of any preceding~~as claimed in claim 1, wherein the frame assembly is a window or door frame assembly and the panels are at least semi-transparent.

~~18. A spacer element (10) for a frame assembly comprising first and second glass panels substantially parallel to each other and further comprising an intermediate ballistic panel positioned between the first and second glass panels and comprising a polymeric material,~~

~~the spacer element being adapted to be positioned between the first and second glass panels and adapted to receive the intermediate ballistic panel, wherein a first portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface of the first glass panel and wherein a second portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface the second glass panel,~~

~~and wherein the spacer element comprises a recess (12) adapted to receive the intermediate ballistic panel therein, the recess being larger than the intermediate ballistic panel in at least one dimension by a tolerance value to accommodate thermal expansion of the intermediate ballistic panel.~~

~~19. The spacer element of claim 18~~9, ~~wherein the spacer element comprises a hollow polymeric extruded element.~~

~~20. The spacer element (10) of claim 19, wherein the spacer element comprises first and second passages extending longitudinally therethrough and separated by a dividing element.~~

~~21. The spacer element (10) of claim 2010, wherein the dividing element is substantially planar and preferably lies in a plane extending through the first and second glass panels.~~

~~22. The spacer element (10) of any of claims 18 to 21, wherein the tolerance value is greater than or equal to 3 mm.~~

~~23. The spacer element (10) of any of claims 18 to 22, wherein the outer cross-sectional shape of the spacer element is substantially U-shaped.~~

~~24. The spacer element of any of claims 18 to 23, wherein the recess comprises one or more projections adapted to contact a surface of an intermediate ballistic panel received within the recess.~~

~~25~~9. A method of constructing a frame assembly having plural parallel panels, the method comprising:

arranging first and second glass panels substantially parallel to each other;

positioning an intermediate ballistic panel between the first and second glass panels, the intermediate ballistic panel comprising a polymeric material;

receiving the intermediate ballistic panel in a recess of a spacer element, the recess being larger than the intermediate ballistic panel in at least one dimension by a tolerance value to accommodate thermal expansion of the intermediate ballistic panel, and wherein the recess comprises a plurality of projections (50) adapted to contact a surface of an intermediate ballistic panel received within the recess, wherein the projections project inwardly towards each other from the inner surfaces of the recess in a direction that is angled with respect to an inner surface of the recess so that the projections (50) may flex by a small amount and thus urge against opposing sides of the intermediate ballistic panel (8) to be received within the recess (12); and

positioning a spacer element between the first and second glass panels such that a first portion of the spacer element is positioned between the intermediate ballistic panel and an inner surface of the first glass panel and such that a second portion of the

spacer element is positioned between the intermediate ballistic panel and an inner surface the second glass panel.