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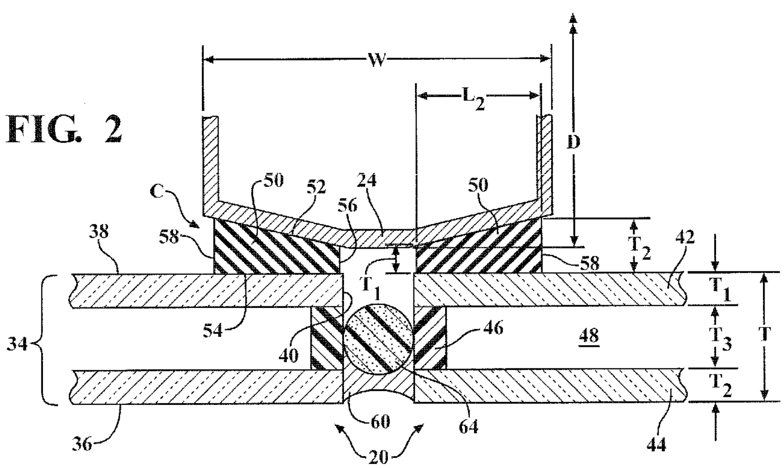
(54) **Title**: ASSEMBLIES FOR A STRUCTURE

FIG. 2



(57) **Abstract**: An assembly for a structure comprises a support and a panel. The panel may be a glass panel. The assembly further comprises a structural adhesive, which couples the panel to the support. The structural adhesive may comprise a silicone. The structural adhesive has a first coupling surface facing the support and a second coupling surface spaced from the first coupling surface and facing the interior surface of the panel. The structural adhesive has a substantially right-trapezoidal cross- section, which is oriented in a certain direction relative to the panel and the support. The first coupling surface is sloped relative to the second coupling surface of the structural adhesive thereby reducing stress in the assembly due to environmental load subjected on the structure, such as wind load. Other supports and assemblies are also provided. The assembly may be used to form curtain walls, window walls, skylights, etc.

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ASSEMBLIES FOR A STRUCTURE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application Serial No. 61/436,521, filed on January 26, 2011, which is incorporated herewith in its entirety.

FIELD OF THE INVENTION

[0002] The present invention generally relates to an assembly for a structure subject to environmental load which causes stress in the assembly, and more specifically to an assembly comprising a support, a panel, and a structural adhesive having a specific cross-sectional shape which is disposed between the support and panel.

DESCRIPTION OF THE RELATED ART

[0002A] Each document, reference, patent application or patent cited in this text is expressly incorporated herein in their entirety by reference, which means that it should be read and considered by the reader as part of this text. That the document, reference, patent application or patent cited in this text is not repeated in this text is merely for reasons of conciseness.

[0002B] Discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

[0003] A curtain wall (or glazing system) is an outer covering of a building comprising a plurality of an assembly (or unit). Each of the assemblies of the curtain wall has a panel or an “infill” disposed within and/or on an inner support made up of various frame-members including vertical mullions, a head, and a sill. When glass panels are used in the curtain wall, an advantage is that light can enter the building.

[0004] Conventional curtain walls are typically designed to resist air and water infiltration, sway induced by wind and seismic forces acting on the building, and dead load weight forces of the curtain wall. The curtain wall transfers horizontal wind loads that are incident upon it to the building through connections at floors or columns of

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the building. Such wind loads can be extremely high based on the design, height, and location of the building.

[0005] A two-sided glazing system is typically one in which the glass panel is conventionally glazed at opposite sides, i.e., mechanically retained with gaskets, but utilizes structural silicone to bond the glass panel to the perimeter framing on the remaining two sides (typically the mullions). The mechanically retained edges generally support the dead load of the glass panel. The live load of the glass panel is carried on the two edges with structural silicone. Dead load is generally considered the load due to mass of the components of the glazing system, while live load is considered the weight imposed by use and occupancy of the building, e.g. snow and wind. Two-sided glazing systems are not to be confused with butt-joint glazing which does not provide a structural bond to the inner support. Butt-joint glazing provides a weather seal only on two edges of the glass panel.

[0006] A four-sided glazing system is typically one in which structural silicone is used to bond the glass panel to perimeter framing on all sides. As such, the structural silicone acts as a continuous flexible anchor between the glass panel and the frame-members. Dead loads are supported either mechanically by a horizontal fin and/or by the structural silicone alone, depending on design of the glazing system. Four-sided glazing systems are sealed continuously around the glass panel perimeter, blocking air and water from entering the interior of the building. Typically, in either glazing system, the structural silicone has a substantially rectangular cross-section due to the shape of the glass panel and shape of the frame-members behind the glass panel.

[0007] "Structural bite" or "bite" is the minimum width or contact surface of the structural silicone on both the glass panel and the support. Typically, the building design wind load, glass panel dimensions, impact loads, dead load, and thermal dilation stresses must be considered in determination of the bite dimension. A typical bite to thickness ratio for a rectangular cross-section of structural adhesive is 1:1 to 3:1, with minimum bites of 6 mm and minimum thicknesses of 6 mm. As such, the bite is typically larger than the thickness of the structural silicone. Thickness is considered the distance from the glass panel to the frame-member, i.e., the shortest side of the rectangular cross-section. Proper thickness facilitates installation of the

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structural silicone and allows reduced adhesive stress from differential thermal movement between the glass panel and the frame-member.

[0008] The bite requirement is directly proportional to the wind load on the building and the dimensions of the glass panel. Two of the controlling variables which affect the bite requirement are the maximum short span dimension of the glass panel and the design wind load that the glazing system must be designed to accommodate. Typically, the higher the wind load and the larger the short span dimension of the glass panel is, the greater the amount of bite required.

[0009] Unfortunately, in some building designs as well as in some building locations, high wind loads prohibit the use of assemblies having structural silicone due to the size of the bite required to maintain adhesion between the glass panel and the frame-members. This problem is compounded by requiring larger frame-members to accommodate the larger bite of the structural silicone. Increasing the size of the bite, and therefore, the size of the frame-members, not only reduces the amount of light that can pass through the curtain wall, but also detracts from the aesthetic quality of the curtain wall. For example, in a building design having 5 ft (~1.5 m) wide glass panels, with 200 lb/ft^2 (PSF; ~9.6 kPa) wind loads acting on the building, e.g. in Florida, a rectangular cross-section of structural silicone would require a bite of at least 2 in (~5 cm) and a thickness of at least 1/4 in (~0.5 cm). This 2 in bite of structural silicone requires an even greater sized frame-member behind it, both of which detract from the lighting and aesthetic qualities of the curtain wall.

[0010] In addition, based on the high wind loads, the structural silicone has high internal stresses due to the glass panel bowing in and out relative to the framework as wind hits and deflects off of the curtain wall. Over time, these internal stresses can cause fatigue and/or failure of the structural adhesive, which is especially problematic in four-sided glazing systems where no other means typically retain the glass panels. In addition, in the event that the glass panel breaks, such as during a hurricane, the remaining glass pieces will bow in and out many more times and to a higher degree during the hurricane. This greatly decreases the time before failure of the structural silicone such that the glass pieces will break free from the structural silicone potentially causing further damage to persons or property.

[0011] As such, there remains an opportunity to provide assemblies having improved properties, such as reduced stress when subject to environmental load. There also remains an opportunity to provide assemblies with improved lighting and aesthetics.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0011A] According to a first principal aspect, there is provided an assembly for a structure subject to an environmental load which causes stress in said assembly, said assembly comprising:

i) a support;

ii) a panel having an exterior surface and an interior surface spaced from said exterior surface with a surrounding edge between said exterior and interior surfaces, wherein said interior surface of said panel faces and is coupled to said support, with a cavity defined between said interior surface of said panel and said support; and

iii) a structural adhesive disposed in said cavity for coupling said panel to said support, said structural adhesive having

a first coupling surface facing said support,

a second coupling surface spaced from said first coupling surface and facing said interior surface of said panel,

an outer peripheral surface between said first and second coupling surfaces and disposed adjacent said surrounding edge of said panel, and

an inner peripheral surface between said first and second coupling surfaces and spaced from said outer peripheral surface inwardly along said panel relative to said outer peripheral surface,

wherein said first and second coupling surfaces and said outer and inner peripheral surfaces define a substantially right-trapezoidal cross-section, and

wherein said outer peripheral surface has a first thickness (which may be referenced in at least one embodiment, for example, as T1) extending away from said interior surface of said panel toward said support, and said inner peripheral surface has a second thickness (which may be referenced in at least one embodiment, for example, as T2) also extending away from the interior surface of said panel toward said support, with the second thickness (for example, T2) of said inner peripheral surface being greater than the first thickness (for example, T1) of said outer peripheral surface such that said first coupling surface is sloped relative to said second coupling surface, thereby reducing stress in said assembly due to the environmental load subjected on the structure.

[0011B] In one embodiment, said structure abuts along at least a majority of said first coupling surface of said structural adhesive and said interior surface of said panel abuts along at least a majority of said second coupling surface of said structural adhesive.

[0011C] In another embodiment, said exterior surface of said panel is free of said support.

[0011D] In a further embodiment, said support has an inner wall and an outer wall spaced from said inner wall with a coupling edge extending between said inner and outer walls such that an obtuse angle is defined between said coupling edge and said inner wall and an acute angle is defined between said coupling edge and said outer wall with said coupling edge abutting said first coupling surface of said structural adhesive.

[0011E] In another embodiment, said support is an extruded frame-member selected from the group of a jamb, a head, a sill, or a combination thereof.

[0011F] In a further embodiment, said support has a width of from about 2 to about 15 centimeters.

[0011G] In another embodiment, said support is further defined as a first support and a second support spaced from said first support with said panel extending between and over each of said first and second supports.

[0011H] According to a second principal aspect, there is provided an assembly for a structure subject to an environmental load which causes stress in said assembly, said assembly comprising:

i) a first support and a second support spaced from said first support;

ii) a panel having an exterior surface and an interior surface spaced from said exterior surface with a surrounding edge between said exterior and interior surfaces, said panel extending between and over each of said first and second supports, wherein said interior surface of said panel faces and is coupled to each of said first and second supports, with a cavity defined between said interior surface of said panel and said first support and a cavity defined between said interior surface of said panel and said second support; and

iii) a structural adhesive disposed in each of said cavities for coupling said panel to said first and second supports, said structural adhesive having

a first coupling surface facing each of said first and second supports,

a second coupling surface spaced from said first coupling surface and facing said interior surface of said panel,

an outer peripheral surface between said first and second coupling surfaces and disposed adjacent said surrounding edge of said panel, and

an inner peripheral surface between said first and second coupling surfaces and spaced from said outer peripheral surface inwardly along said panel relative to said outer peripheral surface,

wherein said first and second coupling surfaces and said outer and inner peripheral surfaces define a substantially right-trapezoidal cross-section, and

wherein said outer peripheral surface has a first thickness (which may be referenced in at least one embodiment, for example, as T1) extending away from said interior surface of said panel toward each of said first and second supports, and said inner peripheral surface has a second thickness (which may be referenced in at least one embodiment, for example, as T2) also extending away from the interior surface of said panel toward each of said first and second supports, with the second thickness (for example, T2) of said inner peripheral surface being greater than the first thickness (for example, T1) of said outer peripheral surface such that said first coupling surface is sloped relative to said second coupling surface, thereby reducing stress in said assembly due to the environmental load subjected on the structure.

[0011I] In one embodiment, said exterior surface of said panel is free of said first and second supports.

[0011J] In a further embodiment, the assembly further comprises a third support extending between said first and second supports and a forth support extending between said first and second supports and spaced from said third support, with a quadrilateral configuration defined by said first, second, third, and fourth supports.

[0011K] In another embodiment, said panel also extends between and over each of said third and fourth supports, said interior surface of said panel facing and also coupled to each of said third and fourth supports, with a cavity defined between said interior surface of said panel and said third support and a cavity defined between said interior surface of said panel and said fourth support.

[0011L] In a further embodiment, said structural adhesive is also disposed in each of said cavities for also coupling said panel to said third and fourth supports.

[0011M] In another embodiment, said exterior surface of said panel is free of said first, second, third, and fourth supports.

[0011N] In a further embodiment, each of said first, second, third, and fourth supports abut along at least a majority of said first coupling surface of said structural adhesive and said interior surface of said panel abuts along at least a majority of said second coupling surface of said structural adhesive.

[0011O] In another embodiment, said first, second, third, and fourth supports define a rectangular configuration.

[0011P] In a further embodiment, each of said first and second supports abut along at least a majority of said first coupling surface of said structural adhesive and said interior surface of said panel abuts along at least a majority of said second coupling surface of said structural adhesive.

[0011Q] In another embodiment, passing at least one of the following two building code requirements:

1) Florida State building code according to protocols TAS-201, TAS-202, and TAS-203; or

2) Miami-Dade County building code according to protocols PA-201, PA-202, and PA-203.

[0011R] In another embodiment, said first coupling surface and said outer peripheral surface of said structural adhesive define an obtuse angle of said substantially right-trapezoidal cross-section, said second coupling surface and said outer peripheral surface of said structural adhesive define a right angle of said substantially right-trapezoidal cross-section, said first coupling surface and said inner peripheral surface of said structural adhesive define an acute angle of said substantially right-trapezoidal cross-section, and said second coupling surface and said inner peripheral surface of said structural adhesive define another right angle of said substantially right-trapezoidal cross-section.

[0011S] In a further embodiment, said second coupling surface of said structural adhesive has a second length (which may be referenced in at least one embodiment, for example, as L2) of no greater than about 5 centimeters and said first coupling surface of said structural adhesive has a length (which may be referenced in at least one embodiment, for example, as L1) greater than the second length (for example, L2).

[0011T] In another embodiment, the first thickness of said outer peripheral surface of said structural adhesive is at least about 0.6 centimeters and the second thickness of said inner peripheral surface of said structural adhesive is greater than the first thickness of said outer peripheral surface.

[0011U] In a further embodiment, each of said first and second supports have a width of from about 1.25 to about 15 centimeters.

[0011V] In another embodiment, said panel is a glass panel.

[0011W] In a further embodiment, said glass panel has a width of from about 0.25 to about 4.75 meters, and a height of from about 0.25 to about 6 meters.

[0011X] In another embodiment, said structural adhesive comprises a silicone.

[0011Y] In a further embodiment, said first and second supports are further defined as a first and second jamb or as a head and a sill.

[0011Z] In another embodiment, said first support is a first jamb, said second support is a second jamb, said third support is a head, and said fourth support is a sill.

[0011AA] According to a third principal aspect, there is provided an assembly for a structure subject to an environmental load which causes stress in said assembly, said assembly comprising:

i) a support;

ii) a panel having an exterior surface and an interior surface spaced from said exterior surface with a surrounding edge between said exterior and interior surfaces, wherein said interior surface of said panel faces and is coupled to said support, with a cavity defined between said interior surface of said panel and said support; and

iii) a structural adhesive disposed in said cavity for coupling said panel to said support, said structural adhesive having

a first coupling surface facing said support and having a first portion and a second portion adjacent said first portion with an obtuse angle defined between said first and second portions,

a second coupling surface spaced from said first coupling surface and facing said interior surface of said panel,

an outer peripheral surface between said first and second coupling surfaces and disposed adjacent said surrounding edge of said panel and said second portion of said first coupling surface, and

an inner peripheral surface between said first and second coupling surfaces and spaced from said outer peripheral surface inwardly along said panel relative to said outer peripheral surface and adjacent said first portion of said first coupling surface,

wherein said first and second coupling surfaces and said outer and inner peripheral surfaces define a substantially concave-polygonal cross-section, and

wherein said structural adhesive has a first thickness (which may be referenced in at least one embodiment, for example, as T1) extending away from said interior surface of said panel toward said support between said first and second portions of said first coupling surface, said inner peripheral surface has a second thickness (which may be referenced in at least one embodiment, for example, as T2) also extending away from said interior surface of said panel toward said support, and said outer peripheral surface has a third thickness (which may be referenced in at least one embodiment, for example, as T3) yet also extending away from said interior surface of said panel toward said support, with the first thickness (for example, T1) of said structural adhesive being less than both of the second thickness (for example, T2) and the third thickness (for example, T3) of said inner and outer peripheral surfaces such that said first coupling surface is concave relative to said second coupling surface, thereby reducing stress in said assembly due to the environmental load subjected on the structure.

[0011AB] In one embodiment, said first portion of said first coupling surface and said inner peripheral surface of said structural adhesive define an acute angle of said substantially concave-polygonal cross-section, said second portion of said first coupling surface and said outer peripheral surface of said structural adhesive define another acute angle of said substantially concave-polygonal cross-section, said second coupling surface and said inner peripheral surface of said structural adhesive define a right angle of said substantially concave-polygonal cross-section, and said second coupling surface and said outer peripheral surface of said structural adhesive define another right angle of said substantially concave-polygonal cross-section.

[0011AC] In another embodiment, the second thickness (for example, T2) of said inner peripheral surface and the third thickness (for example, T3) of said outer peripheral surface are substantially equal.

[0011AD] According to a fourth principal aspect, there is provided a support for an assembly having a panel, the panel having an exterior surface and an interior surface spaced from the exterior surface with a surrounding edge between the exterior and interior surfaces, the assembly for a structure subject to an environmental load which causes stress in the assembly, said support comprising:

an inner wall;

an outer wall spaced from said inner wall; and

a coupling edge extending between said inner and outer wall for coupling to the interior surface of the panel adjacent the surrounding edge such that a cavity is defined between the interior surface of the panel and said support;

wherein an obtuse angle is defined between said coupling edge and said inner wall and an acute angle is defined between said coupling edge and said outer wall.

[0011AE] According to a fifth principal aspect, there is provided a support for an assembly having a panel, the panel having an exterior surface and an interior surface spaced from the exterior surface with a surrounding edge between the exterior and interior surfaces, the assembly for a structure subject to an environmental load which causes stress in the assembly, said support comprising:

an inner wall;

an outer wall spaced from said inner wall; and

a coupling edge extending between said inner and outer wall and having a first portion and a second portion adjacent said first portion with the coupling edge for coupling to the interior surface of the panel adjacent the surrounding edge such that a cavity is defined between the interior surface of the panel and said support;

wherein an obtuse angle is defined between said first and second portions of said coupling edge, another obtuse angle is defined between said first portion of said coupling edge and said inner wall, and yet another obtuse angle is defined between said second portion of said coupling edge and said outer wall.

[0011AF] According to a sixth principal aspect, there is provided an assembly for a structure subject to an environmental load which causes stress in said assembly, said assembly comprising any embodiment of a support according to an aspect as described herein.

[0011AG] According to a seventh principal aspect, there is provided a window wall comprising any embodiment of an assembly according to an aspect as described herein.

[0011AH] According to an eighth principal aspect, there is provided a curtain wall comprising a plurality of one or more embodiments of an assembly according to an aspect as described herein.

[0011AI] In one embodiment, said plurality of said assembly are arranged in a side-by-side configuration such that said curtain wall presents a substantially smooth and continuous exterior surface of the structure.

[0012] The subject invention provides an assembly for a structure. The structure may be subject to an environmental load, which causes stress in the assembly. The assembly comprises a support and a panel. The panel has an exterior surface and an interior surface spaced from the exterior surface. A surrounding edge is between the exterior and interior surfaces. The interior surface of the panel faces and is coupled to the support. A cavity is defined between the interior surface of the panel and the support. The assembly further comprises a structural adhesive disposed in the cavity for coupling the panel to the support. The structural adhesive has a first coupling surface facing the support. The structural adhesive also has a second coupling surface spaced from the first coupling surface and facing the interior surface of the panel. An outer peripheral surface is between the coupling surfaces of the structural adhesive. The outer peripheral surface of the structural adhesive is disposed adjacent the surrounding edge of the panel. An inner peripheral surface of the structural adhesive is between the coupling surfaces. The inner peripheral surface is spaced from the outer peripheral surface inwardly along the panel relative to the outer peripheral surface. The coupling surfaces and the peripheral surfaces define a substantially right-trapezoidal cross-section of the structural adhesive. The outer peripheral surface has a first thickness (which may be referenced in one embodiment, for example, as T1) extending away from the interior surface of the panel toward the support. The inner peripheral surface has a second thickness (which may be referenced in one embodiment, for example, as T2) also extending away from the interior surface of the panel toward the support. The second thickness (for example, T2) of the inner peripheral surface is greater than the first thickness (for example, T1) of the outer peripheral surface. The first coupling surface is sloped relative to the second coupling surface of the structural adhesive thereby reducing stress in the assembly due to the environmental load subjected on the structure. Other supports and assemblies are also provided.

[0013] The assemblies have reduced stress relative to conventional assemblies when the structure is subject to environmental load. The assemblies also have improved lighting and aesthetics, and can be used in various locations and building designs, while providing various benefits such as an air seal, water seal, and/or thermal barrier for the structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present invention may be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0015] Figure 1 is a perspective view of a structure including a plurality of an embodiment of the assembly in a side-by-side configuration forming a curtain wall of a structure;

[0016] Figure 2 is a transverse cross-sectional view of a portion of a curtain wall having two assemblies sharing a support;

[0017] Figure 3 is a transverse cross-sectional view of a portion of another curtain wall having another embodiment of two assemblies with each of the assemblies having a support mechanically connected to a supplemental support;

[0018] Figure 4 is similar to Figure 3 with another embodiment of the assemblies having supports slidably connected to a supplemental support;

[0019] Figure 5 is a perspective cutaway view of a curtain wall having another embodiment of two assemblies each having a sill and a mullion in a four-sided glazing system;

[0020] Figure 6 is a perspective cutaway view of a curtain wall having another embodiment of two assemblies each having a sill and a mullion in a two-sided glazing system;

[0021] Figure 7 is a transverse cross-sectional view of a related art structural adhesive having a substantially rectangular cross-section disposed between a panel and a support in phantom illustrating internal stress of the structural adhesive in pounds per square inch (psi) while under load according to finite element analysis (FEA), with a peak stress of about 59 psi (~407 kPa);

[0022] Figure 8 is a transverse cross-sectional view of an embodiment of invention structural adhesive having a substantially right-trapezoidal cross-section disposed between a panel and a support in phantom illustrating internal stress of the structural adhesive in psi while under load according to FEA, with a peak stress of about 39 psi (~269 kPa);

[0023] Figures 9 through 15 are transverse cross-sectional views of different embodiments of invention structural adhesives having substantially right-trapezoidal cross-sections with varying thicknesses, lengths, and angles;

[0024] Figure 16 is an exploded transverse cross-sectional view of another embodiment of the assembly with the structural adhesive having a substantially concave-polygonal cross-section;

[0025] Figure 17 is an exploded transverse cross-sectional view of a support with the panel and structure adhesive in phantom; and

[0026] Figure 18 is an exploded transverse cross-sectional view of another embodiment of the support with the panel and structure adhesive in phantom.

DETAILED DESCRIPTION

[0027] With reference to the Figures, wherein like numerals indicate corresponding parts throughout the several views, an assembly (or unit) is generally shown at **20**. Referring to Figure 1, a plurality of the assembly **20** is shown coupled to a structure **22**. The assemblies **20** are arranged in a side-by-side configuration. The assemblies **20** can be in line with one another, as shown, or offset with respect to one another (not shown). The assemblies **20** are typically modular such that they are substantial duplicates of one another. However, the structure **22** may include assemblies **20** that are different then each other, such as assemblies **20** of different size, shape, and/or configuration. For example, as shown in Figure 1, the assemblies **20** on one side of the structure **22** are smaller than the assemblies **20** on another side of the structure **22**.

[0028] The configuration of assemblies **20** shown in Figure 1 can be referred to in the art as a curtain wall, more specifically as a four-sided curtain wall or as a four-sided glazing system. In this configuration, the curtain wall presents a substantially smooth and continuous exterior surface of the structure **22**. The assembly **20** can also be implemented as a two-sided curtain wall or as a two-sided glazing system, which typically has a less smooth appearance relative to a four-sided glazing system. Examples of other types of applications suitable for the assembly **20** include stick systems, unitized systems, window wall applications, and skylights (not shown). Further examples include spandrel applications, e.g. non vision applications, including glass, ceramic, stone, composite, or metal spandrel applications. Glazing is another term commonly used for glass. Reference to “two-sided” and “four-sided” is not in reference to the structure **22**, but rather, is in reference to the configuration of the assembly **20**.

[0029] Curtain walls can be used for various structures **22**, such as for commercial buildings, industrial buildings, residential buildings, etc. These buildings can be low-rise, mid-rise, or high-rise. Curtain walls can provide various benefits to the structures **22**, including providing light, view, climate control, weather protection, and aesthetics. Curtain walls typically do not carry roof or floor loads, and are generally hung from the columns or face or top of floor slabs of the structure **22**. As such, curtain walls are typically considered in the art to be non-structural and/or non-load bearing.

[0030] Curtain walls can represent an entire skin (or exterior façade) of the structure **22**, or just a portion thereof. In contrast, window walls are generally oriented in a different location with respect to the structure **22**, such that the exterior façade of the structure **22** also includes faces of floor slabs and/or columns. For example, a window wall will typically extend from the top of one floor to the underside of a floor below, and/or in long horizontal strips around the structure **22**. As such, the window wall will generally be set back into the structure **22**, e.g. between floors, rather than being set out as a continuous outer skin of the structure 22**.** As such, the assemblies **20** may actually span less than one storey, one storey, or more than one storey of the structure **22**. While the assembly **20** is described as being useful for forming curtain walls and window walls of structures **22**, the assembly **20** is not limited to any particular application.

[0031] Referring to Figures 2 through 6, two assemblies **20** are generally shown in a curtain wall configuration, with a right-side portion of one assembly **20** and a left-side portion of another assembly **20**. The left and right sides of the assemblies **20** are generally mirror images of each other, which is described in greater detail below. The same is generally true for the upper and lower sides of the assemblies **20**. However, in certain applications, one or more of the sides of the assemblies **20** may be different than the others, based on what the assembly **20** is intended for or on location of the assembly **20** within or on the structure **22**. This is generally the case with two-sided systems, where the upper and lower sides of the assemblies **20**, i.e., a head and a sill, are different than the left and right sides of the assemblies **20**, i.e., left and right mullions. An example of a lower right and lower left corner of two assemblies **20** in a two-sided glazing system is depicted in Figure 6. In contrast, in four-sided systems, all four sides of the assemblies **20** are generally the same. An example of a lower right and lower left corner of two assemblies **20** in a four-sided glazing system is depicted in Figure 5.

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[0032] The assembly **20** comprises a support **24**. The support **24** can be of various sizes, shapes, and configurations. As shown in Figures 2 through 6, various configurations of supports **24** are shown. The support **24** can be a preexisting part of the structure **22**, e.g. a beam, or more typically, part of the assembly **20** which attaches to the structure **22**, such as by attaching the support **24** to the top or face of a floor slab of the structure **22**. Depending on application, the assembly **20** can be fabricated in a production facility and erected at the jobsite, which is generally the case with four-sided glazing systems, and/or fabricated directly on the jobsite, which is generally the case with two-sided glazing systems (although two-sided glazing systems can also be fabricated offsite and erected onsite). The assembly **20** is not limited to any particular type of manufacturing process.

[0033] The support **24** is typically a frame-member **24**. As such, the support **24** may be a jamb **24**, which is generally a vertical frame-member **24** of the assembly **20**. The support **24** may also be a head **24** or a sill **24**, which is generally a horizontal frame-member **24** of the assembly **20**. Such frame-members **24** can also be referred to in the art as mullions, transoms, or rails. Depending on configuration of the assembly **20**, the support **24** can also be angled relative to the structure **22**, e.g. in a skylight or roofing application. The support **24** can comprise a unitary frame-member **24** forming an entire periphery of the assembly **20**, or be a plurality of two or more joined frame-members **24** around the entire periphery of the assembly **20** or a portion thereof.

[0034] The assembly **20** can be of various shapes as introduced above, typically in a quadrilateral shape, and more typically in a rectangular shape. For example, as shown in Figure 1, each of the assemblies **20** include four supports **24** (in phantom), with some of the assemblies **20** in a rectangular configuration and some of the assemblies **20** in a square configuration.

[0035] In one embodiment, the support **24** is further defined as a first support **24a** and a second support **24b** spaced from the first support **24a**. The support **24** is yet further defined as a third support **24c** extending between the first and second supports **24a,24b** and a forth support **24d** extending between the first and second supports **24a,24b** and spaced from the third support **24c**. A quadrilateral configuration is defined by the first, second, third, and fourth supports **24a,24b,24c,24d**. As introduced above, the support(s) **24** can be frame-members **24**. For example, the first support **24a** can be a right jamb **24a**, the second support **24b** can be a left jamb **24b**, the third support **24c** can be a head **24c**, and the fourth support **24d** can be a sill **24d** of the assembly **20**.

[0036] The support **24** can be of various lengths (or heights), widths **W** and depths **D**. It is useful to minimize the width **W** of the support **24** to increase lighting of the assembly **20**. As width **W** of the support **24** is increased, light passage through the assembly **20** generally decreases. Minimizing width **W** of the support **24** can also be aesthetically pleasing. The support **24** typically has a width **W** of from about 1/2 to about 6, about 7/8 to about 3, or about 15/16 to about 2, inches (in); alternatively from about 1.25 to about 15, about 2 to about 8, or about 2.5 to about 5, cm. Strength of the support **24**, and therefore, the assembly **20**, is generally controlled by the depth **D** of the support **24** rather than by the width **W** of the support **24**. As such, depth **D** of the support **24** can be tailored based on application of the assembly **20**.

[0037] As introduced above, the support **24** can be of various configurations and shapes, depending on application of the assembly **20**. For example, as shown in Figure 2, the support **24** has a C-shaped cross-section and retains two separate assemblies **20** in a side-by-side configuration. As shown in Figure 3, two supports **24** are shown mechanically fastened to a supplemental support **26**. The support **24** has an inner wall **28** and an outer wall **30** spaced from the inner wall **28** with a coupling edge **32** extending between the walls **28,30**. An obtuse angle **A1** is defined between the coupling edge **32** and the inner wall **28** and an acute angle **A2** is defined between the coupling edge **32** and the outer wall **30**. The walls **28,30** can be of various thicknesses, such as about 1/8 in (~0.3 cm) or greater. Figure 17 shows a support **24** similar to the support **24** of Figure 3. The walls **28,30** may be of substantial thickness such that the support **24** is not hollow as shown in the Figures. **A1,A2** of the support **24** may vary in degree, provided they are substantially still within the range of degrees by name, e.g. **A1** is between 90° and 180° and **A2** is less than 90°.

[0038] Figure 4 shows a similar situation as shown in Figure 3, but with differently shaped supports **24** and supplemental support **26**. In this configuration, the assemblies **20** can be slid into place on the supplemental support **26**. The supports **24**, and if present, the supplemental support **26**, can be of various sizes, shapes, and configurations depending on the desired structure **22**, and such configurations are nearly limitless.

[0039] Figures 16 and 18 shows another type of support **24** for another embodiment. The support **24** is similar to the other supports **24**, such as the support **24** of Figure 3, but has a different shaped coupling edge **32**. Specifically, the coupling edge **32** extends between the walls **28,30** and has a first portion and a second portion adjacent the first portion. The first portion is adjacent the inner wall **28** and the second portion is adjacent the outer wall **30**. The first and second portions are generally complimentarily shaped relative to a structural adhesive **50** (or vice-versa). As shown, the coupling edge **32** is generally convex in shape or pointed. In another embodiment (not shown), the coupling edge **32** further has a third portion between the first and second portions. The third portion can be substantially parallel relative to the interior surface **38** of the panel **34** or slightly sloped. For example, the coupling edge **32** of the support **34** can have a partial isosceles cross-section defined by the first, second and third portions. If present, the third portion is also generally complimentarily shaped relative to the structural adhesive **50** (or vice-versa). The coupling edge **32** is adjacent the surrounding edge **40** of the panel **34** such that the cavity **C** is defined between the interior surface **38** of the panel **34** and the support **24**. The coupling edge **32** of the support **24** may be defined by two or more separate supports **24**, provided the coupling edges **32** define the shapes as described herein, i.e., the coupling edges **32** are sloped and/or convex. The structural adhesive **50** is described further below.

[0040] Referring further to Figures 16 and 18, an obtuse angle **A3** is defined between the first and second portions of the coupling edge **32**, another obtuse angle **A1** is defined between the first portion of the coupling edge **32** and the inner wall **28**, and yet another obtuse angle **A2** is defined between the second portion of the coupling edge **32** and the outer wall **30**. **A1,A2,A3** of the support **24** may vary in degree, provided they are substantially still within the range of degrees by name, e.g. **A1** is between 90° and 180°. Lengths of the first and second portions of the coupling edge **32**, and third portion if present, can be the same or vary. In one embodiment, the first and second portions have substantially the same length, such that **A1,A2** are substantially the same.

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[0041] The support **24** can be formed from various materials, typically from a rigid material such as a metal, polymer, or composite. Typically, the support **24** is formed from a metal or a metal alloy, such as aluminum or steel. Aluminum offers an advantage of being able to be easily extruded into nearly any shape required for design and aesthetic purposes of the support **24**. As such, the supports **24** can be extruded aluminum frame-members **24** of various sizes and shapes.

[0042] Optionally, the support **24** may be primed or painted with a coating composition for corrosion protection and/or increased adhesion. An example of such a coating composition is Alodine®, which is commercially available from various chemical suppliers. If utilized, Alodine® is useful for increasing adhesion strength between the support **24** and the structural adhesive **50**.

[0043] The assembly **20** further comprises a panel **34**, which can also be referred to in the art as an infill **34** or lite **34**. The panel **34** has an exterior surface **36** and an interior surface **38** spaced from the exterior surface **36**. A surrounding edge **40** is between the surfaces **36,38**. The interior surface **38** of the panel **34** faces and is coupled to the support **24**, with a cavity **C** defined between the interior surface **38** of the panel **34** and the support **24**. The cavity **C** has a substantially right-trapezoidal cross-section.

[0044] The panel **34** typically extends between and over the supports **24**. In certain embodiments, such as in a four-sided glazing system, the exterior surface **36** of the panel **34** is free of the supports **24**. Such embodiments are generally shown in Figures 1 through 5. In other embodiments, such as in a two-sided glazing system, the exterior surface **36** of the panel is retained by at least one of the supports **24**, typically by two of the supports **24**, such as by the head **24c** and the sill **24d** of the assembly **20**. Such an embodiment is generally shown in Figure 6. The support **24** is typically close to the surrounding edge **40** of the panel **34** to increase lighting and aesthetics of the assembly **20**; however, the support **24** may also be set back from the surrounding edge **40**. Typically, the coupling edge **32** of the support **24** is sloped relative to interior surface **38** of the panel **34**. The interior surface **38** of the panel **34** generally faces inward of the structure **22**, such as into a room or stairwell.

[0045] The panel **34** may be formed from various materials, such as glass, stone, metal, plastic, etc. The panel **34** may also include functional elements, such as louvers, windows, vents, etc. Typically, as like shown in the Figures, the panel **34** is formed from glass such that the panel **34** is a glass panel **34** or glazing **34**. The panel **34** can be single-pane or double-pane. As shown in Figures 2 through 6, the panel **34** includes an inner pane **42** and an outer pane **44**. The panes **42,44** are bonded to opposite sides of a seal **46**. The seal **46** can be formed from various materials, and may include one or more pieces, such as a first sealant and a second sealant. Suitable materials for the seal **46** include, but are not limited to, polyisobutylene and silicone. An air gap **48** is defined within the panel **34** for insulation purposes.

[0046] The panes **42,44** are typically formed from tempered glass to prevent breakage of the panel **34**; however, other types of glass can also be used. The panel **34** can also be laminated glass **34** or composite **34**, such as panes **42,44** of tempered glass with an inner layer sandwiched between the panes **42,44**. The inner layer can formed from a polymeric material, such as ionoplast resin. Such composites **34** can also be referred to in the art as safety glass **34**.

[0047] The panel **34** can be of various sizes and shapes. Typically, the panel **34** is quadrilateral in shape, more typically, rectangular in shape. However, the panel **34** can be in other shapes, such as a trapezoid, a circle, or a triangle. The panel **34** typically has a width **W** of from about 1 foot to about 15 feet (ft), about 3 to about 10, or about 4 to about 7, ft; alternatively from about 0.25 to about 4.75, about 1 to about 3, or about 1.2 to about 2, m. The panel **34** typically has a height **H** of from about 1 to about 20, about 5 to about 15, or about 5 to about 7, ft; alternatively from about 0.25 to about 6, about 1.5 to about 4.75, or about 1.5 to about 2, m. As described above, the assembly **20** may span a portion of a storey, a storey, or more than one storey of the structure **22**.

[0048] Typically the panel **34** is planar with a substantially uniform thickness **T**. The panel **34** typically has a thickness **T** of from about 1/8 to about 8, about 1/4 to about 4, or about 3/8 to about 1, in; alternatively from about 0.3 to about 20, about 0.6 to about 10, or about 1 to about 2.5, cm. As described above, the panel **34** may be single pane **42** or double pane glass **42,44** (if not more), or other materials as described above, e.g. metal. As such, **T** above may refer to a single pane **42**, a combination of panes **42,44**, or **T** of an insulating spandrel panel **34**. Each of the panes **42,44** may be the same **T** as each other, or different than each other. If the panel **34** is a composite **34**, such as the three layered composite **34** described above, two or more of the layers may have the

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same **T**, or the layers may each be of different **T**. In a specific embodiment, the panes **42,44** each have a thickness **T1,T2** of about 3/16 in (~0.5 cm), and the air gap **48** (or inner layer of polymeric material) has a thickness **T3** of about 1/10 in (~0.25 cm). **T1,T2,T3** can each also be larger or smaller in size.

[0049] The assembly **20** further comprises the structural adhesive **50** (hereinafter adhesive **50**), as introduced above. The adhesive **50** is disposed in the cavity **C** for coupling the panel **34** to the support **24**. As best shown in Figure 2, the adhesive **50** is typically shaped complementary to the cavity **C**. The adhesive **50** can also be referred to in the art as an adhesive bead **50** or an adhesive joint **50**. However, the adhesive **50** is different than a conventional gasket or wedge, which do not adhere the panel **34** to the support **24**. Typically, gaskets and wedges merely mechanically engage the panel **34** and the support **24**, whereas the adhesive **50** adheres the panel **34** to the support **24**.

[0050] The adhesive **50** has a first coupling surface **52** facing the support **24**. The adhesive **50** also has a second coupling surface **54** spaced from the first coupling surface **52** and facing the interior surface **38** of the panel **34**. An outer peripheral surface **56** is between the coupling surfaces **52,54**. The outer peripheral surface **56** is disposed adjacent the surrounding edge **40** of the panel **34**. An inner peripheral surface **58** is between the coupling surfaces **52,54** and spaced from the outer peripheral surface **56** inwardly along the panel **34** relative to the outer peripheral surface **40**.

[0051] The coupling surfaces **52,54** and the peripheral surfaces **56,58** define a substantially right-trapezoidal cross-section. The outer peripheral surface **56** has a thickness **T1** extending away from the interior surface **38** of the panel **34** toward the support **24**. The inner peripheral surface **58** has a thickness **T2** also extending away from the interior surface **38** of the panel **34** toward the support **24**. **T2** of the inner peripheral surface **58** is greater than **T1** of the outer peripheral surface **56**. As such, the first coupling surface **52** is sloped relative to the second coupling surface **54**.

[0052] **T1** of the outer peripheral surface **56** of the adhesive **50** is typically of from about 1/4 to about 1, about 1/4 to about 3/4, or about 1/4 to about 1/2, in; alternatively from about 0.6 to about 2.5, about 0.6 to about 2, or about 0.6 to about 1.3, cm. **T2** of the inner peripheral surface **58** of the adhesive **50** is greater than **T1** of the outer peripheral surface **56**. **T2** of the inner peripheral surface **58** of the adhesive **50** is typically of from about 5/16 to about 2, about 1/2 to about 1, or about 1/2 to about 3/4, in; alternatively from about 0.8 to about 5, about 1.3 to about 2.5, or about 1.3 to about 2, cm.

[0053] The second coupling surface **54** of the adhesive **50** has a length **L2**. The first coupling surface **52** of the adhesive **50** has a length **L1** greater than **L2** of the second coupling surface **54**. Typically, **L2** of the second coupling surface **54** of the adhesive **50** is no greater than about 2, about 1/2 to about 2, about 3/4 to about 2, or about 15/16 to about 1, in; alternatively no greater than about 5, from about 1.3 to about 5, about 2 to about 5, or about 2.3 to about 2.5, cm. **L1** of the first coupling surface **52** of the adhesive **50** can be determined by **T1,T2** and the Pythagorean Theorem. The adhesive **50** can have various combinations **T1,T2** and **L1,L2** as exemplified in Figures 9 through 15, provided that the substantially right-trapezoidal cross-section of the adhesive **50** is maintained.

[0054] **L2** of the second coupling surface **54** of the adhesive **50** can also be referred to in the art as “bite” **L2** or as “structural bite” **L2**. On a related note, “glass bite” may refer to the amount of glass panel **32** obstructed by the support **24** and the adhesive **50**. As described above, it is often useful to increase the amount of light able to pass through the assembly **20**, such that the bites are minimized to the extent possible while still maintaining structural integrity of the assembly **20**. For example, once in place, e.g. in a curtain wall, the assembly **20** must withstand certain environment loads, e.g. wind loads, which are described below.

[0055] One or more of the surfaces **52,54,56,58** of the adhesive **50** may have some irregularities such that the surface **52,54,56,58** is not completely planar as shown in the Figures. For example, one of the peripheral surfaces **56,58** may be slightly concave or convex due to placement, and/or expansion or contraction of the adhesive **50**. In addition, one of coupling surfaces **52,54** may be concave or convex depending on the shape of the support **24** and/or the panel **34**, typically, the shape of the support **24**. The coupling edge **32** of the support **24** is generally complimentary to the first coupling surface **52**. For example, the support **24** may be formed to include a substantially planar, concave, or convex coupling edge **32**, which will define the shape of the cavity **C**, and therefore, the shape of the adhesive **50**. As shown in the Figures, the coupling edge **32** is typically substantially planar; however, changes in the shape of the coupling edge **32** of the support **24** may also occur, and such changes may even further reduce stress in the adhesive **50**, as described below. As described above, extrusion can be used to form the support **24**. As such, the support **24** may be formed via extrusion through a die having a planar, concave, and/or convex portion defining the coupling edge **32** of the resulting support **24**.

[0056] As best shown in Figures 2 through 4 and 9 through 15, the first coupling surface **52** and the outer peripheral surface **56** of the adhesive **50** define an obtuse angle **A1** of the substantially right-trapezoidal cross-section. The second coupling surface **54** and the outer peripheral surface **56** of the adhesive **50** define a right angle **A2** of the substantially right-trapezoidal cross-section. The first coupling surface **52** and the inner peripheral surface **58** of the adhesive **50** define an acute angle **A3** of the substantially right-trapezoidal cross-section. The second coupling surface **54** and the inner peripheral surface **58** of the adhesive **50** define another right angle **A4** of the substantially right-trapezoidal cross-section.

[0057] A right-trapezoid is a trapezoid having two right angles. **A1,A2,A3,A4** may vary in degree, provided they are substantially still within the range of degrees by name, e.g. **A1** is between 90° and 180° and **A3** is less than 90°. **A2,A4** may not be exact. Said another way, **A2,A4** be slightly higher or lower than 90°, e.g. 90 ± 5 or fewer degrees.

[0058] Figures 16 and 18 illustrate another embodiment of the adhesive **50**. The adhesive **50** is similar to the structural adhesives of the other Figures, but has a different cross-section. As best shown in Figure 16, the first coupling surface **52** faces the support **24** and has a first portion and a second portion adjacent the first portion. An obtuse angle **A5** is defined between the first and second portions. The outer peripheral surface **58** is disposed adjacent the surrounding edge **40** of the panel **34** and the second portion of the first coupling surface **52**. The inner peripheral surface **56** is spaced from the outer peripheral surface **58** inwardly along the panel **34** relative to the outer peripheral surface **58** and adjacent the first portion of the first coupling surface **52**. The coupling surfaces **52,54** and the peripheral surfaces **56,58** define a substantially concave-polygonal cross-section. The cross-section may also be referred to as a partial-bowtie cross-section. The adhesive **50** has a thickness **T1** extending away from the interior surface **38** of the panel **34** toward the support **24** between the first and second portions of the first coupling surface **52**. **T1** is adjacent **A5**. The inner peripheral surface **56** has a thickness **T2** also extending away from the interior surface **38** of the panel **34** toward the support **24**. The outer peripheral surface **58** has a thickness **T3** yet also extending away from the interior surface **38** of the panel **24** toward the support **24**. **T1** of the adhesive **50** is less than both of **T2,T3** of the peripheral surfaces **56,58** such that the first coupling surface **52** is concave relative to the second coupling surface **54**.

[0059] As best shown in Figure 16, the first portion of the first coupling surface **52** and the inner peripheral surface **56** of the adhesive **50** define an acute angle **A1** of the substantially concave-polygonal cross-section. The second portion of the first coupling surface **52** and the outer peripheral surface **58** of the adhesive **50** define another acute angle **A2** of the substantially concave-polygonal cross-section. The second coupling surface **54** and the inner peripheral surface **56** of the adhesive **50** define a right angle **A3** of the substantially concave-polygonal cross-section. The second coupling surface **54** and the outer peripheral surface **58** of the adhesive **50** define another right angle **A4** of the substantially concave-polygonal cross-section.

[0060] Referring further to Figure 16, **T2** of the inner peripheral surface **56** and **T3** of the outer peripheral surface **58** are substantially equal. In other embodiments, **T2,T3** may be different, such as **T3** being smaller than **T2**, or vice-versa. As also shown in Figure 16, the second coupling surface **54** has a first portion and a second portion, each having a length **L2a,L2b**, respectively. **L2a,L2b** may be the same as or different than each other. The first coupling surface **52** also has a length **L1**, with the first portion having a length **L1a** and the second portion having a length **L2b**. **L1a,L1b** may be the same as or different than each other. As shown, the first coupling surface **52** is generally concave in shape. In another embodiment (not shown), the first coupling surface **52** further has a third portion between the first and second portions. The third portion can be substantially parallel relative to the second coupling surface **54** or slightly sloped. For example, the first coupling surface **52** of the adhesive **50** can have a partial isosceles cross-section defined by the first, second and third portions. If present, the third portion is also generally complimentarily shaped relative to the support **24** (or vice-versa). **A1,A2,A3,A4,A5** of the adhesive **50** may vary in degree, provided they are substantially still within the range of degrees by name, e.g.

A5 is between 90° and 180°. In one embodiment, the first and second portions have substantially the same **L1a,L2b**, such that **A1,A2** are substantially the same.

[0061] As best shown in Figures 2 through 4, the structure **24** typically abuts along at least a majority of the first coupling surface **52** of the adhesive **50**. The interior surface **38** of the panel **34** typically abuts along at least a majority of the second coupling surface **54** of the adhesive **50**. The coupling edge **32** of the support **24** typically abuts the first coupling surface **52** of the adhesive **50**. Increasing contact between the adhesive **50** and the panel **34** and the support **24** generally increases adhesion strength between the support **24** and the panel **34** of the assembly **20**.

[0062] The adhesive **50** can comprise various adhesives. Typically, the adhesive **50** comprises a silicone, which can be formed from a one- or two-part system. As such, the adhesive **50** can also be referred to in the art as structural silicone. Suitable adhesive systems are commercially available from Dow Corning Corporation of Midland, MI, such as Dow Corning® 983 – Silicone Glazing and Curtainwall Adhesive/Sealant or – Silicone Structural Sealant. Further examples include Dow Corning® 995 – Silicone Structural Sealant, Dow Corning® 993 – Structural Sealant, and Dow Corning® 895 – Structural Glazing Sealant. Such adhesives are typically different than other adhesives or sealants, which can be used as weather stripping **60** between or within the assemblies **20**. Such sealant systems are also commercially available from Dow Corning Corp., such as Dow Corning® 795 – Silicone Building Sealant and/or Dow Corning® 791 – Weatherproofing Sealant.

[0063] While not necessarily shown in the Figures, the assembly **20** can have additional components. For example, the assembly **20** may further include weather stripping **60**, gaskets **62**, backing tapes, setting blocks, backing rods **64**, and spacers. Backing tapes or gaskets **62** are often used to back the cavity **C** during application of the adhesive **50**. The adhesive **50** may be applied into the cavity **C** via conventional caulking techniques. Backing rods **64** are often used to back voids when applying weather stripping **60**. While gaskets **62** are shown in Figures 5 and 6, one or more of the gaskets can be absent or replaced by a backing tape. In addition, while not generally shown in the Figures, backing tape or a similar component may be disposed on the cavity **C** on one or both peripheral surfaces **56,58** of the adhesive **50**.

[0064] Referring now to Figure 7, a conventional structural silicone having a substantially rectangular cross-section is shown. Such structural silicones are often present in conventional assemblies due to the configuration of such assemblies, which often include many right angles with respect to supports and panels. For example, many supports are parallel to the panels such that rectangular cavities are defined between the panel and the supports of the assembly. In some building designs, as well as in some building locations, environmental loads prohibit the use of such assemblies having this type of structural silicone or other structural silicones due to the size of the bite required to maintain adhesion between the glass panel and the support. This problem is compounded by requiring larger supports to accommodate the larger bite of the structural silicone. Increasing the size of the bite, and therefore, the size of the supports, not only reduces the amount of light that can pass through the assembly, but also detracts from the aesthetic quality of the assembly. For example, in a building design having 5 ft (~1.5 m) wide glass panels, with 200 PSF (~9.6 kPa) wind loads acting on the building, e.g. in Florida, a rectangular cross-section of structural silicone would require a bite of at least 2 in (~5 cm) and a thickness of at least 1/4 in (~0.6 cm). This 2 in bite of structural silicone requires an even greater sized support behind it, both of which detract from the lighting and aesthetic qualities of the curtain wall including the conventional assemblies.

[0065] In addition, based on the high wind loads, the structural silicone having the rectangular cross-section has high internal stresses due to the glass panel bowing in and out relative to the support as wind hits and deflects off of the glass panel. These stresses are indicated by the various cross-hatches shown in Figure 7, with a peak stress of about 59 psi (~407 kPa). The stresses are determined according to FEA using ANSYS to model the structural silicone as a hyperelastic material. The panel is 5 ft by 7 1/4 ft (~1.5 m by 2.2 m). The structural silicone has a 2 in (~5 cm) bite and a 20 psi (~138 kPa) design. The 20 psi design is generally considered the allowable design stress value or industry standard.

[0066] Under a 200 PSF (~9.6 kPa) wind load, the panel rotates (or bows) inwardly and outwardly relative to the support. The structural silicone acts as a pivot point such that the structural silicone is pinched and stretched between the panel and the support. Stress on the perimeter of the panel under wind load will behave in a trapezoidal

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manner according to the theory of plate behavior under uniform loading. Other sizes of structural silicone having rectangular cross-sections were also calculated, with a 1.33 in (~3.4 cm) bite, (30 psi/~207 kPa design) having a peak stress of about 47 psi (~324 kPa), and a 15/16 in (~1 cm) bite, (44 psi/~303 kPa design) having a peak stress of about 50 psi (~345 kPa).

[0067] Over time, these internal stresses can cause fatigue and/or failure of the structural silicone, e.g. cohesive and/or adhesive failure. As can be seen in Figure 7, the stresses are not uniform, but sporadic throughout cross-section of structural silicone. In the event that the glass panel breaks, such as during a hurricane, the remaining glass pieces will bow in and out many more times and to a higher degree during the hurricane. This greatly decreases the time before failure of the structural silicone such that the glass pieces will break free from the structural silicone potentially causing further damage to persons or property.

[0068] In Figure 8, one embodiment of the adhesive **50** is shown. The adhesive **50** has a bite L2 of 15/16 in (~1 cm), a thickness T1 of 1/4 in (~0.6 cm), and a thickness **T2** of 1/2 in (~1.3 cm). The adhesive **50** was calculated in the same manner as described above for the structural silicone of Figure 7. Surprisingly, the peak stress of the adhesive **50** was about 39 psi (~269 kPa) relative to the structural silicone shown in Figure 7 having a peak stress of about 59 psi, which is a ~33% reduction. The peak stress of the adhesive **50** is also well below the other samples calculated which have rectangular cross-sections, including the one having an equivalent bite of 15/16 in but having a peak stress of about 50 psi (or ~28% higher).

[0069] Without being bound of limited by any particular theory, it is believed that the substantially right-trapezoidal cross-section of the adhesive **50** provides for reduced stress in the assembly **20** relative to conventional assemblies having structural silicones of rectangular cross-sections. In addition, it is also believed that the orientation of the substantially right-trapezoidal cross-section of the adhesive **50** provides for reduced stress in the assembly **20** relative to conventional assemblies. For example, it is believed that **T1** being less than **T2** of the adhesive **50** provides for reduced stress relative to the opposite scenario where **T2** would be less than **T1**. It is believed that this orientation and specific cross-section is important because it is

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thought that the adhesive **50** can act as a hinge between the panel **34** and the support **24** when the panel **34** is subject to wind load.

[0070] It is believed that the substantially concave-polygonal cross-section of the other embodiment of the adhesive **50** with also have similar benefits as the substantially right-trapezoidal cross-section embodiment. For example, it is believed that this orientation and specific cross-section is important because it is thought that the adhesive **50** can act as a double hinge between the panel **34** and the support **24** when the panel **34** is subject to wind load.

[0071] Based on these findings and further hypotheses, the adhesive **50** thereby reduces stress in the assembly **20** due to the environmental load subjected on the structure **22**. Typically, the environmental load of most concern to the structure **22**, on a daily basis, is wind load as described above. For example, the assemblies **20** may be subject to maximum negative wind loads of about 200 PSF (~9.6 kPa), which will attempt to pull out the panel **34** from the structure **22**, and positive wind loads of about 130 PSF (~6.2 kPa), which will attempt to push the panel **34** into the structure **22**. However, other environmental loads may also come into play, such as seismic load, snow load, thermal load, and/or blast load. It is also believed that the assembly **20** will also have reduced stress when subject to these other types of environmental loads. Environmental loads are not equivalent to dead load, which is the generally load imparted by the components of the assembly **20**.

[0072] The assembly **20** is generally configured to pass building codes. Typically, the assembly **20** passes at least one of the following two building code requirements: 1) Florida State building code according to protocols TAS-201, TAS-202, and TAS-203; or 2) Miami-Dade County building code according to protocols PA-201, PA-202, and PA-203. Miami-Dade County building codes are generally considered to be more stringent than Florida State building codes. The assembly **20** can be configured to pass other building codes in other locations as well, such as those required in Broward County, Florida.

[0073] Certain locations of structures **22** have strict building code requirements. For example, locations such as Florida tend to have hurricanes, which include high velocity winds, and therefore, high wind loads which affect structures **22**. With such high winds comes the chance of blown debris (or projectiles) impacting the structure

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22. As such, TAS-201 relates to procedures for conducting impact testing. TAS-202 relates to procedures for conducting uniform static air pressure testing. TAS-203 relates to procedures for conducting cyclic wind pressure loading testing.

[0074] PA-201, 202, and 203 are similar to the Florida State TAS protocols, but are for Miami-Dade County, Florida. Miami-Dade County building code generally requires that every exterior opening, residential or commercial, be provided with protection against wind-borne debris caused by hurricanes. Such protection includes impact-resistant products. There are two types of impact resistant products: large-missile resistant and small-missile resistant. To test for large-missiles, a product, e.g. the assembly **20**, is exposed to various impacts with a piece of lumber weighing approximately 9 lbs, measuring 2 by 4 in by 9 ft (~5 by 10 cm by 2.7 m) in size, traveling at a speed of 50 ft/sec (~55 km/h). Next, the product is subjected to hurricane loading of 9,000 wind cycles, positive and negative (or +/- 4,500 cycles). To test for small-missile resistance, a product has been exposed to various impacts with 10 ball bearings traveling at a speed of 80 ft/sec (~88 km/h). The product is then subjected to wind loads for 9,000 cycles. Typically, the assemblies **20** are at least large missile compliant, which is generally more stringent a standard relative to small missile compliance.

[0075] The following examples, illustrating the assemblies of the present invention, are intended to illustrate and not to limit the invention.

EXAMPLES

[0076] First and second invention assemblies are made to test various physical properties. Each of the assemblies includes a panel structurally glazed to a support, specifically to an anodized aluminum frame, and are configured as four-sided glazing systems. The structural adhesive comprises silicone and has a 15/16 inch (~0.8 cm) bite, and more specifically has the same dimensions and orientation as described above with description of Figure 8.

[0077] The structural adhesive is commercially available from Dow Corning and exceeds the minimum requirements of ETAG 002 – "Guideline for European Technical Approval for Structural Sealant Glazing Systems (SSGS)", and ASTM C1184 – "Standard Specification for Structural Silicone Sealants". The structural adhesive has properties measured according to ASTM C1135 – "Standard Test

Method for Determining Tensile Adhesion Properties of Structural Sealants". These properties are measured in triplicate and are detailed in Table I below.

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Table I

Example No.		1	2	3	Mean	Std. Dev.
Length	in	2	2	2	**2**	0
Thickness	in	0.5	0.5	0.5	**0.5**	0
Peak Stress	psi	157.1	161.2	142.4	**153.5**	9.9
%Strain At Peak	%	116.608	131.171	110.246	**119.342**	10.727
Stress @ 10% Strain	psi	36.896	34.483	37.952	**36.444**	1.778
Stress @ 25% Strain	psi	64.756	60.979	64.778	**63.504**	2.187
Stress @ 50% Strain	psi	98.417	93.019	97.822	**96.419**	2.96
Stress @ 100% Strain	psi	147.152	141.289	141.919	**143.453**	3.219
Elongation at Peak	in	0.583	0.656	0.551	**0.597**	0.054
Peak Load	lbf	157.056	161.197	142.397	**153.55**	9.878

[0078] Each of the panels includes interior and exterior panes of clear tempered glass. Each of the panes is 60 in by 75 in (~152.4 cm by ~190.5 cm), and have an average thickness of 3/16 in (~0.48 cm). An interlayer is sandwiched between the panes. The interlayer has an average thickness of about 0.090 in (~0.23 cm). In the first assembly, the interlayer comprises polyvinyl butyral (PVB). In the second assembly, the interlayer comprises Dupont™ SentryGlas® Plus (SGP).

[0079] Each assembly is tested for air infiltration, water infiltration and structural performance according to the following ASTM Standards: ASTM E330 – "Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference"; and ASTM E331 – "Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference".

[0080] Air infiltration for each assembly is measured at both 1.57 and 6.24 PSF (~75 and ~300 Pa). No measureable air infiltration is detected in either assembly. Water infiltration for each assembly is tested for 15 minutes at 6.24 PSF (~300 Pa). No appreciable water infiltration is detected. Structural performance for each assembly is tested at ±150 PSF, ±200 PSF and ±300 PSF (~7.2 kPa, ~9.6 kPa, and ~14.4 kPa). No failure of the panel, structural adhesive, or support is detected in either assembly. Each assembly passes industry standards for performance with regards to air infiltration, water infiltration and structural integrity.

[0081] A third invention assembly is made, which is the same as the second assembly but includes panes of clear heat strengthened glass. Each of the panes has an average thickness of 1/4 in (~0.635 cm). The assembly is tested according to ASTM E330 and ASTM E331 as described above. The assembly is also tested according to ASTM E1886 –"Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials". No failure of the panel, structural adhesive, or support is detected in the assembly. The assembly passes industry standards for performance with regards to air infiltration, water infiltration, structural integrity, and impact performance. Figure 8 illustrates properties of the structural adhesive as described above.

[0082] One or more of the values described above may vary by ±5%, ±10%, ±15%, ±20%, ±25%, etc. so long as the variance remains within the scope of the disclosure. Unexpected results may be obtained from each member of a Markush group independent from all other members. Each member may be relied upon individually and or in combination and provides adequate support for specific embodiments within the scope of the appended claims. The subject matter of all combinations of independent and dependent claims, both singly and multiply dependent, is herein expressly contemplated. The disclosure is illustrative including words of description rather than of limitation. Many modifications and variations of the present disclosure are possible in light of the above teachings, and the disclosure may be practiced otherwise than as specifically described herein.

[0083] Throughout the specification and the claims that follow, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0084] Furthermore, throughout the specification and the claims that follow, unless the context requires otherwise, the word "include" or variations such as "includes" or "including", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0085] The words used in the specification are words of description rather than limitation, and it is to be understood that various changes may be made without departing from the spirit and scope of the invention. Those skilled in the art will readily appreciate that a wide variety of modifications, variations, alterations, and

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combinations can be made with respect to the above described embodiments without departing from the spirit and scope of the invention, and that such modifications, variations, alterations, and combinations are to be viewed as falling within the ambit of the inventive concept.

The claims defining the invention are as follows:

1. An assembly for a structure subject to an environmental load which causes stress in said assembly, said assembly comprising:

i) a support;

ii) a panel having an exterior surface and an interior surface spaced from said exterior surface with a surrounding edge between said exterior and interior surfaces, wherein said interior surface of said panel faces and is coupled to said support, with a cavity defined between said interior surface of said panel and said support; and

iii) a structural adhesive disposed in said cavity for coupling said panel to said support, said structural adhesive having

a first coupling surface facing said support,

a second coupling surface spaced from said first coupling surface and facing said interior surface of said panel,

an outer peripheral surface between said first and second coupling surfaces and disposed adjacent said surrounding edge of said panel, and

an inner peripheral surface between said first and second coupling surfaces and spaced from said outer peripheral surface inwardly along said panel relative to said outer peripheral surface,

wherein said first and second coupling surfaces and said outer and inner peripheral surfaces define a substantially right-trapezoidal cross-section, and

wherein said outer peripheral surface has a first thickness extending away from said interior surface of said panel toward said support, and said inner peripheral surface has a second thickness also extending away from the interior surface of said panel toward said support, with the second thickness of said inner peripheral surface being greater than the first thickness of said outer peripheral surface such that said first coupling surface is sloped relative to said second coupling surface, thereby reducing stress in said assembly due to the environmental load subjected on the structure.

2. The assembly as set forth in claim 1, wherein said structure abuts along at least a majority of said first coupling surface of said structural adhesive and said interior surface of said panel abuts along at least a majority of said second coupling surface of said structural adhesive.

3. The assembly as set forth in claim 1, wherein said exterior surface of said panel is free of said support.

4. The assembly as set forth in claim 1, wherein said support has an inner wall and an outer wall spaced from said inner wall with a coupling edge extending between said inner and outer walls such that an obtuse angle is defined between said coupling edge and said inner wall and an acute angle is defined between said coupling edge and said outer wall with said coupling edge abutting said first coupling surface of said structural adhesive.

5. The assembly as set forth in claim 1 or claim 4, wherein said support is an extruded frame-member selected from the group of a jamb, a head, a sill, or a combination thereof.

6. The assembly as set forth in claim 1, wherein said support is further defined as a first support and a second support spaced from said first support with said panel extending between and over each of said first and second supports.

7. An assembly for a structure subject to an environmental load which causes stress in said assembly, said assembly comprising:

i) a first support and a second support spaced from said first support;

ii) a panel having an exterior surface and an interior surface spaced from said exterior surface with a surrounding edge between said exterior and interior surfaces, said panel extending between and over each of said first and second supports, wherein said interior surface of said panel faces and is coupled to each of said first and second supports, with a cavity defined between said interior surface of said panel and said first support and a

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cavity defined between said interior surface of said panel and said second support; and

iii) a structural adhesive disposed in each of said cavities for coupling said panel to said first and second supports, said structural adhesive having

a first coupling surface facing each of said first and second supports,

a second coupling surface spaced from said first coupling surface and facing said interior surface of said panel,

an outer peripheral surface between said first and second coupling surfaces and disposed adjacent said surrounding edge of said panel, and

an inner peripheral surface between said first and second coupling surfaces and spaced from said outer peripheral surface inwardly along said panel relative to said outer peripheral surface,

wherein said first and second coupling surfaces and said outer and inner peripheral surfaces define a substantially right-trapezoidal cross-section, and

wherein said outer peripheral surface has a first thickness extending away from said interior surface of said panel toward each of said first and second supports, and said inner peripheral surface has a second thickness also extending away from the interior surface of said panel toward each of said first and second supports, with the second thickness of said inner peripheral surface being greater than the first thickness of said outer peripheral surface such that said first coupling surface is sloped relative to said second coupling surface, thereby reducing stress in said assembly due to the environmental load subjected on the structure.

8. The assembly as set forth in claim 6 or claim 7, further comprising a third support extending between said first and second supports and a forth support extending between said first and second supports and spaced from said third support, with a quadrilateral configuration defined by said first, second, third, and fourth supports.

9. The assembly as set forth in claim 8, wherein said panel also extends between and over each of said third and fourth supports, said interior surface of said panel facing and also coupled to each of said third and fourth supports, with a cavity defined between said interior surface of said panel and said third support and a cavity defined between said interior surface of said panel and said fourth support.

10. The assembly as set forth in claim 9, wherein said structural adhesive is also disposed in each of said cavities for also coupling said panel to said third and fourth supports.

11. The assembly as set forth in claim 8, 9 or claim 10, wherein each of said first, second, third, and fourth supports abut along at least a majority of said first coupling surface of said structural adhesive and said interior surface of said panel abuts along at least a majority of said second coupling surface of said structural adhesive.

12. The assembly as set forth in claim 6 or claim 7, wherein each of said first and second supports abut along at least a majority of said first coupling surface of said structural adhesive and said interior surface of said panel abuts along at least a majority of said second coupling surface of said structural adhesive.

13. The assembly as set forth in claim 1 or claim 7, wherein said first coupling surface and said outer peripheral surface of said structural adhesive define an obtuse angle of said substantially right-trapezoidal cross-section, said second coupling surface and said outer peripheral surface of said structural adhesive define a right angle of said substantially right-trapezoidal cross-section, said first coupling surface and said inner peripheral surface of said structural adhesive define an acute angle of said substantially right-trapezoidal cross-section, and said second coupling surface and said inner peripheral surface of said structural adhesive define another right angle of said substantially right-trapezoidal cross-section.

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14. The assembly as set forth in claims 1, 7, or claim 13, wherein the first thickness of said outer peripheral surface of said structural adhesive is at least about 0.6 centimeters and the second thickness of said inner peripheral surface of said structural adhesive is greater than the first thickness of said outer peripheral surface.

15. The assembly as set forth in any one of the preceding claims, wherein said structural adhesive comprises a silicone.

16. The assembly as set forth in claims 6, 7 or claim 12, wherein said first and second supports are further defined as a first and second jamb or as a head and a sill.

17. The assembly as set forth in claims 8, 9 or claim 10, wherein said first support is a first jamb, said second support is a second jamb, said third support is a head, and said fourth support is a sill.

18. An assembly for a structure subject to an environmental load which causes stress in said assembly, said assembly comprising:

i) a support;

ii) a panel having an exterior surface and an interior surface spaced from said exterior surface with a surrounding edge between said exterior and interior surfaces, wherein said interior surface of said panel faces and is coupled to said support, with a cavity defined between said interior surface of said panel and said support; and

iii) a structural adhesive disposed in said cavity for coupling said panel to said support, said structural adhesive having

a first coupling surface facing said support and having a first portion and a second portion adjacent said first portion with an obtuse angle defined between said first and second portions, a second coupling surface spaced from said first coupling surface and facing said interior surface of said panel,

an outer peripheral surface between said first and second coupling surfaces and disposed adjacent said surrounding edge of said panel and said second portion of said first coupling surface, and

an inner peripheral surface between said first and second coupling surfaces and spaced from said outer peripheral surface inwardly along said panel relative to said outer peripheral surface and adjacent said first portion of said first coupling surface,

wherein said first and second coupling surfaces and said outer and inner peripheral surfaces define a substantially concave-polygonal cross-section, and

wherein said structural adhesive has a first thickness extending away from said interior surface of said panel toward said support between said first and second portions of said first coupling surface, said inner peripheral surface has a second thickness also extending away from said interior surface of said panel toward said support, and said outer peripheral surface has a third thickness yet also extending away from said interior surface of said panel toward said support, with the first thickness of said structural adhesive being less than both of the second thickness and the third thickness of said inner and outer peripheral surfaces such that said first coupling surface is concave relative to said second coupling surface, thereby reducing stress in said assembly due to the environmental load subjected on the structure.

19. The assembly as set forth in claim 18, wherein said first portion of said first coupling surface and said inner peripheral surface of said structural adhesive define an acute angle of said substantially concave-polygonal cross-section, said second portion of said first coupling surface and said outer peripheral surface of said structural adhesive define another acute angle of said substantially concave-polygonal cross-section, said second coupling surface and said inner peripheral surface of said structural adhesive define a right

angle of said substantially concave-polygonal cross-section, and said second coupling surface and said outer peripheral surface of said structural adhesive define another right angle of said substantially concave-polygonal cross-section.

20. A window wall comprising said assembly as set forth in any one of the preceding claims.

21. A curtain wall comprising a plurality of said assembly as set forth in any one of the preceding claims.

22. The curtain wall as set forth in claim 21, wherein said plurality of said assembly are arranged in a side-by-side configuration such that said curtain wall presents a substantially smooth and continuous exterior surface of the structure.

FIG. 1

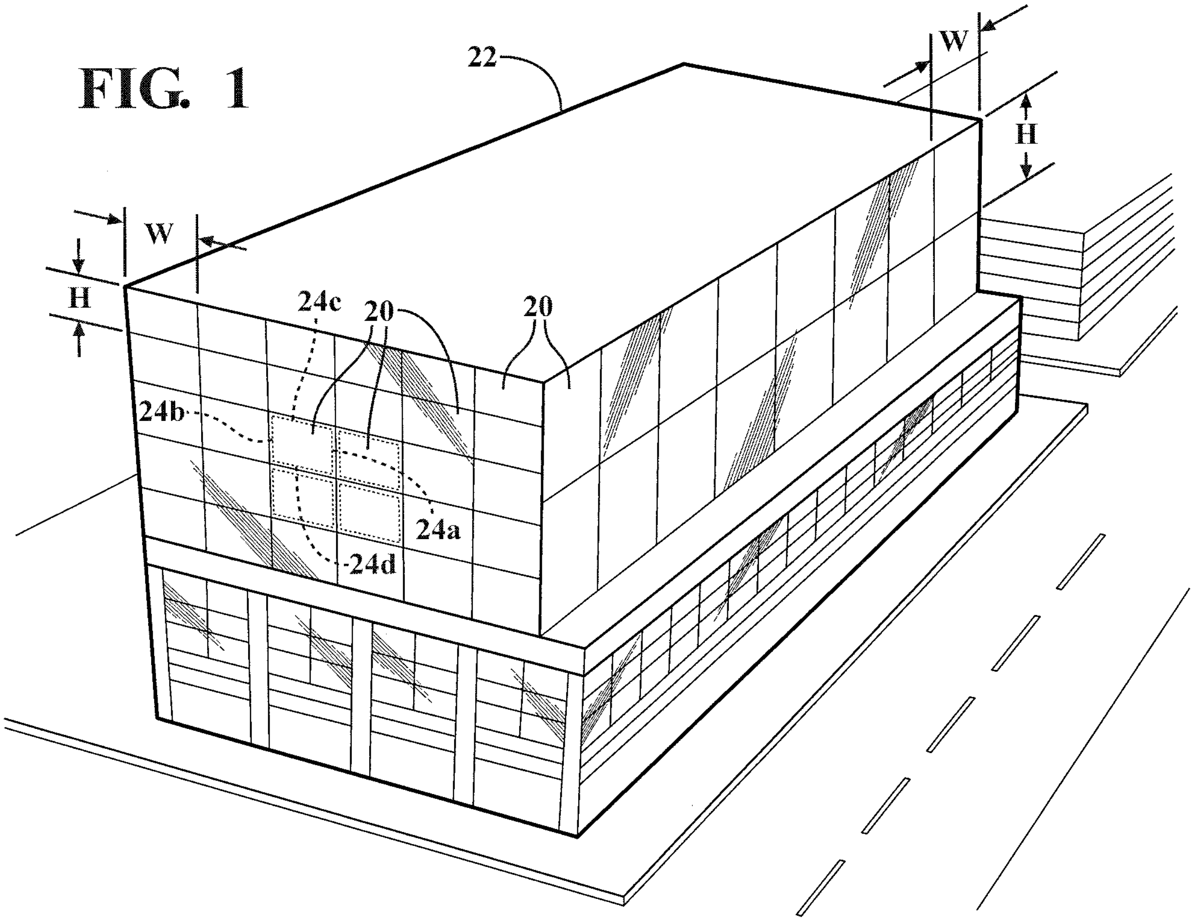
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FIG. 2

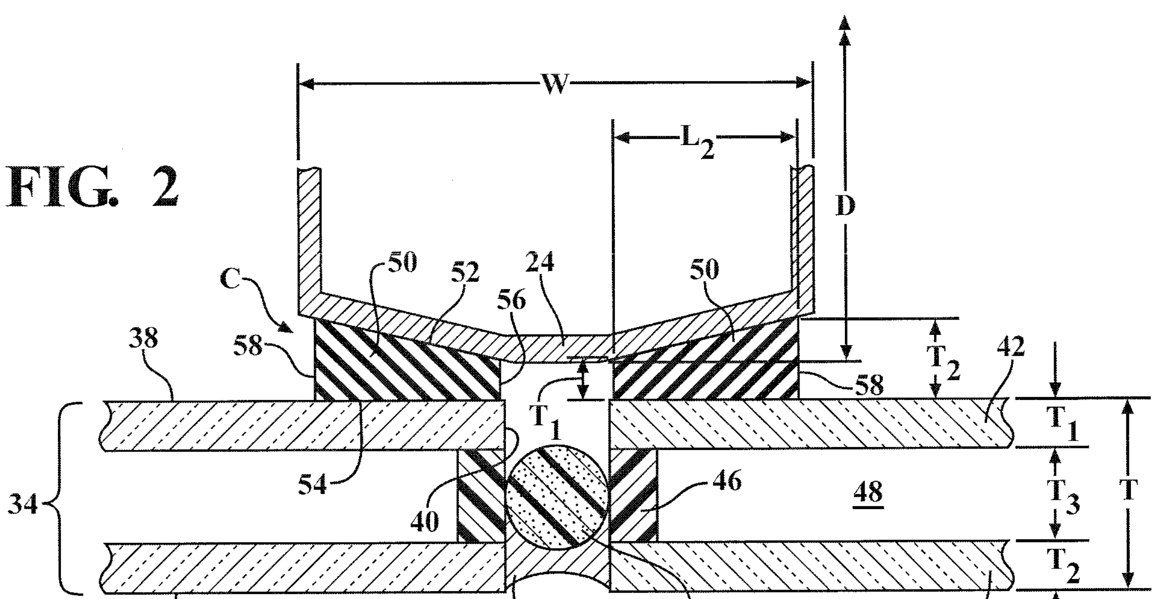
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FIG. 3

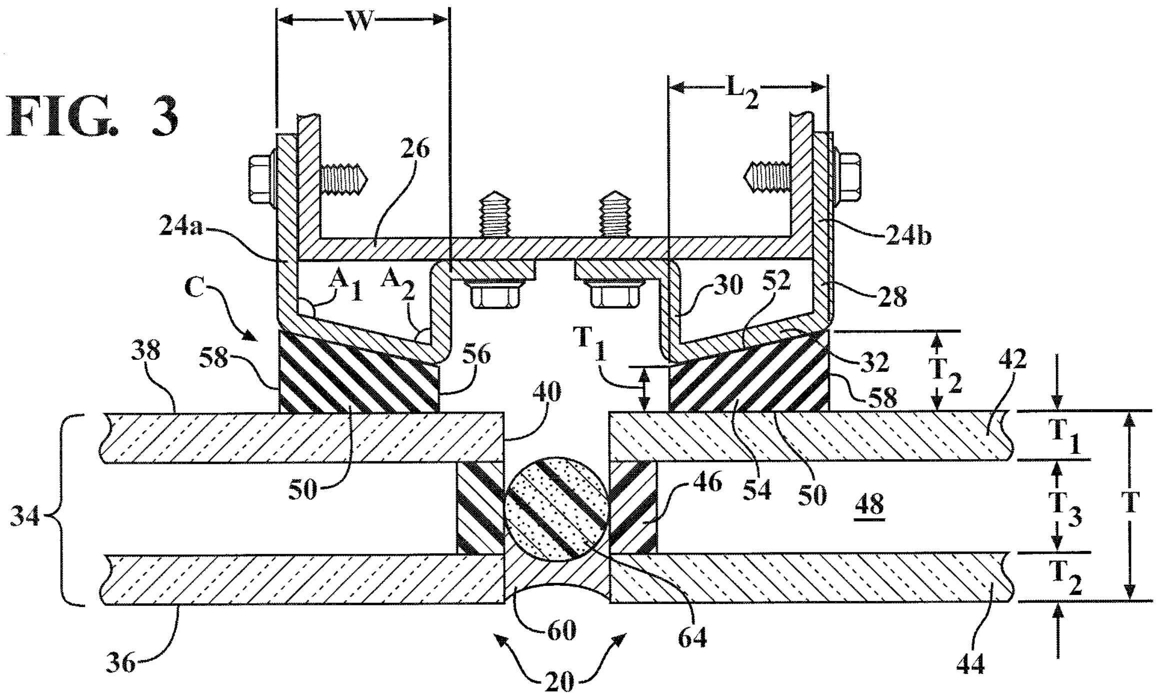
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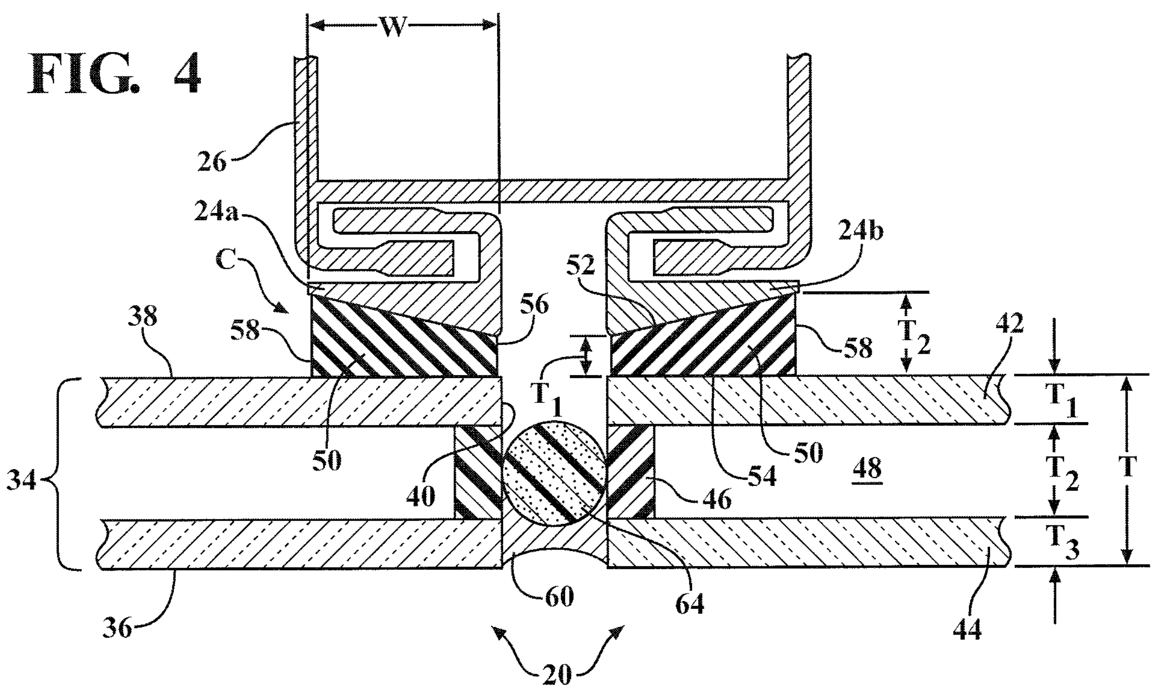
FIG. 4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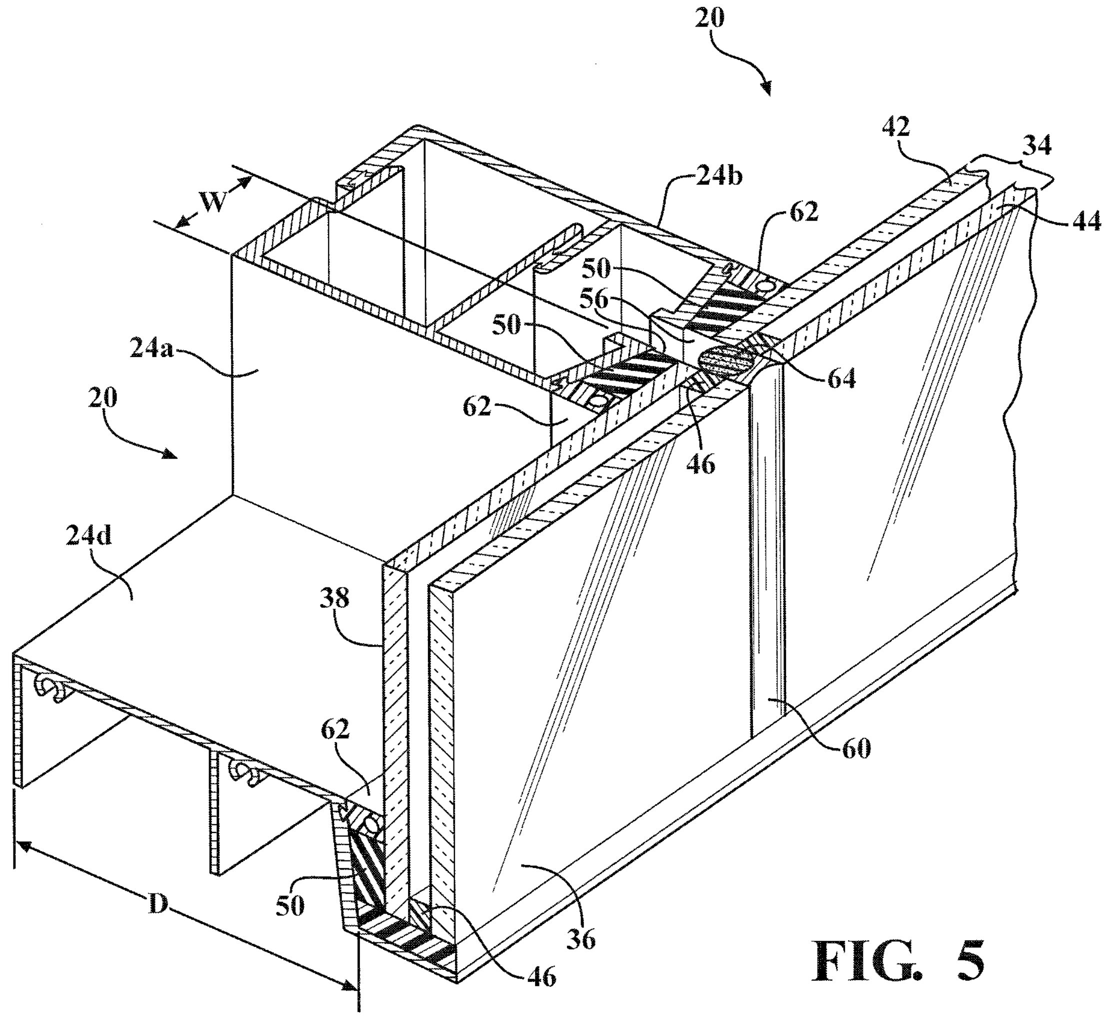

FIG. 5

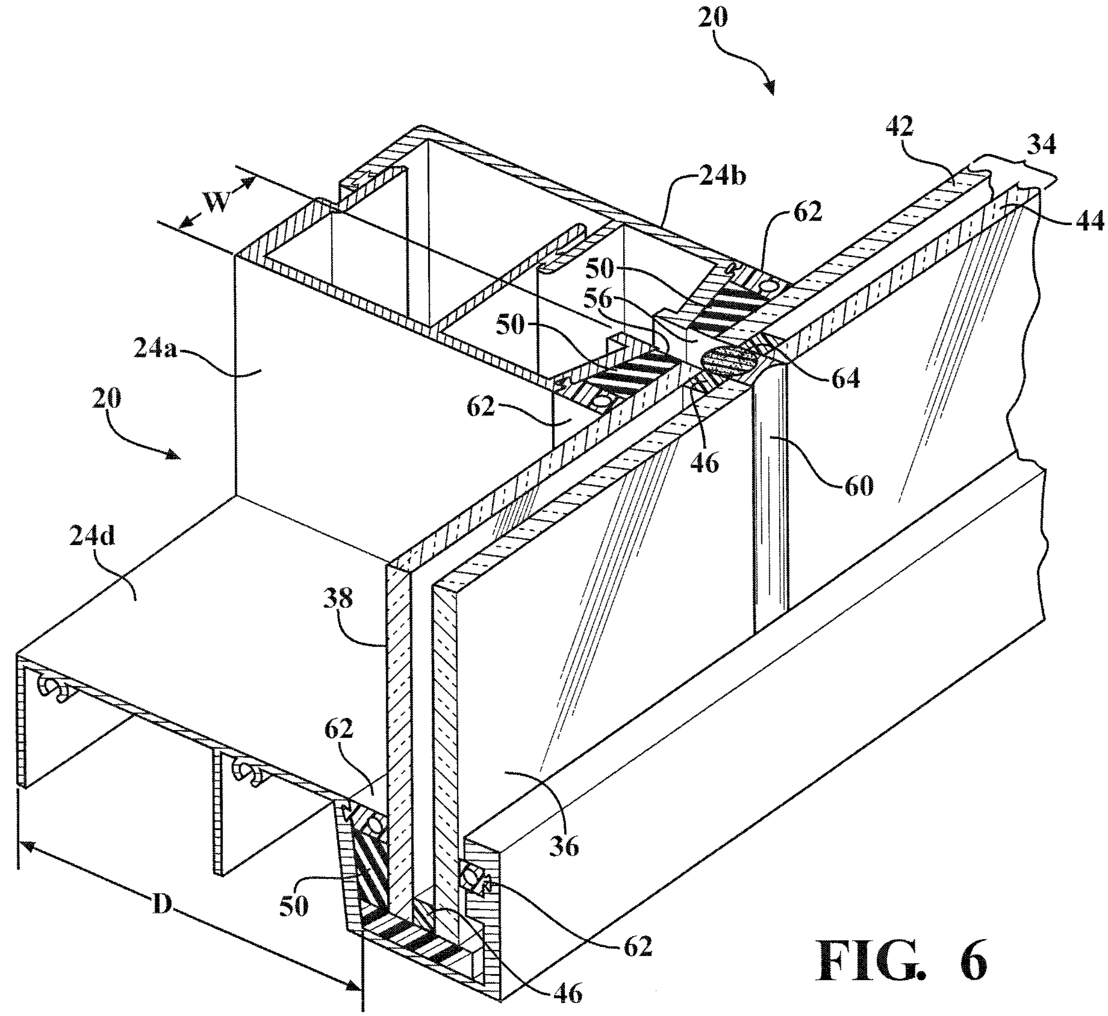

FIG. 6

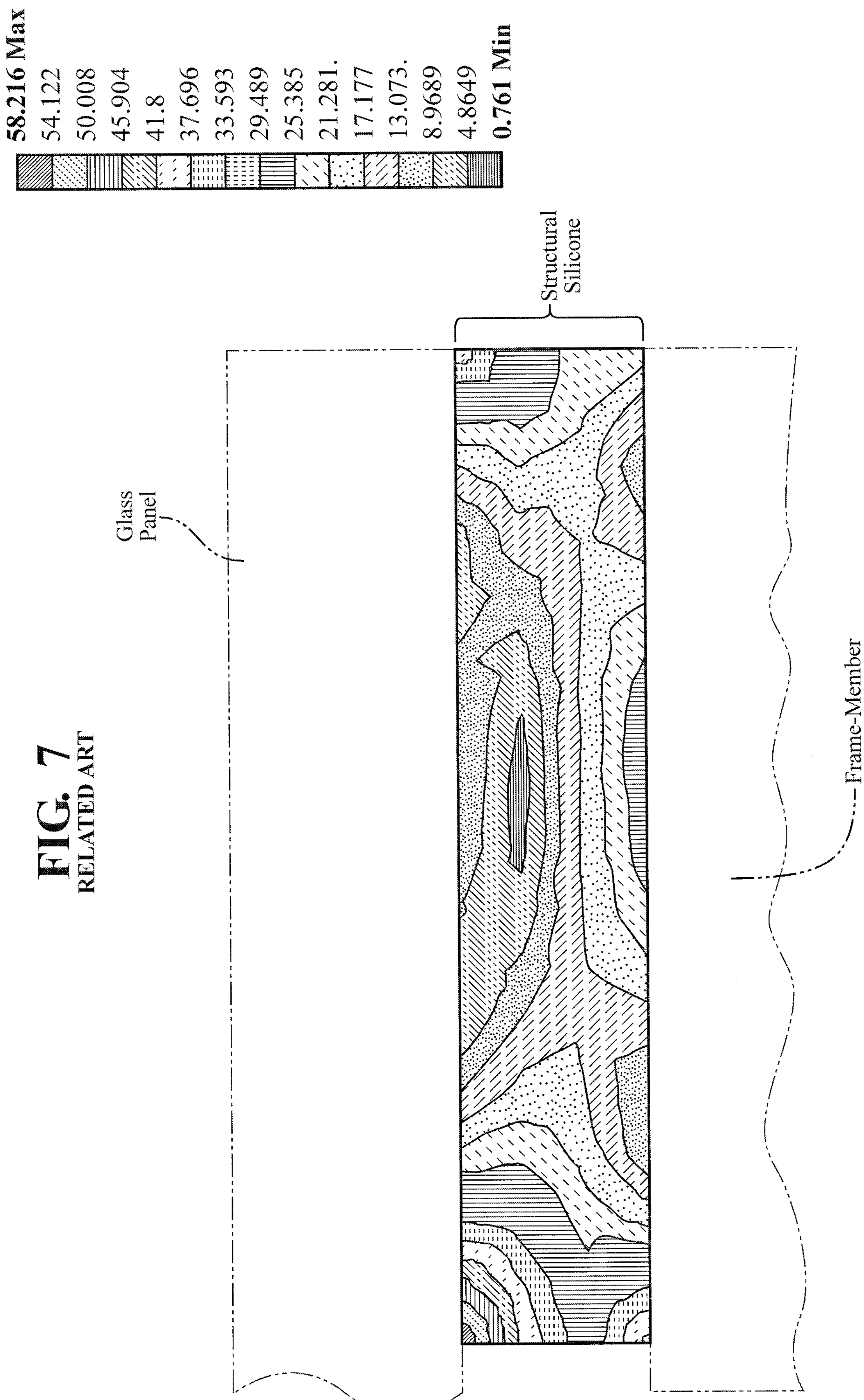

FIG. 7
RELATED ART

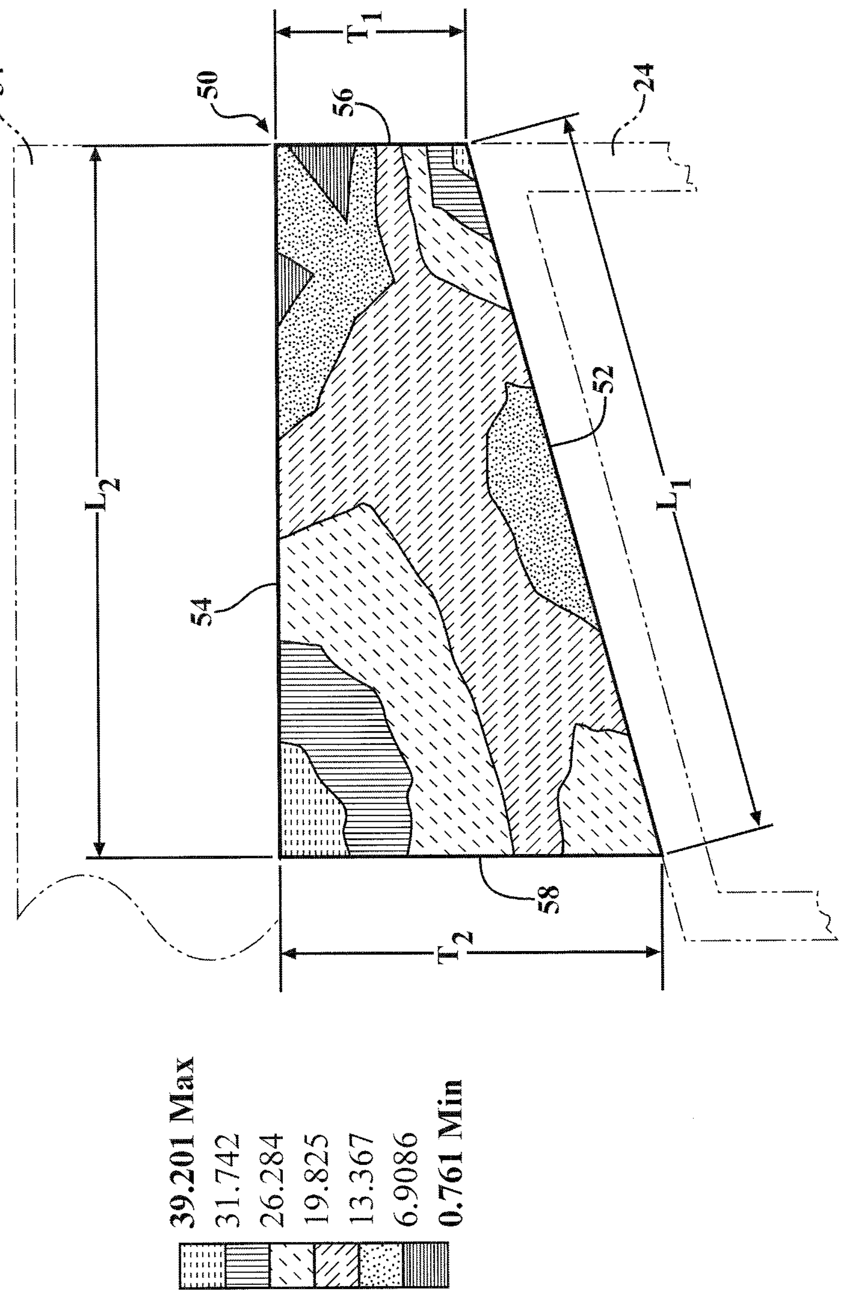
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FIG. 8

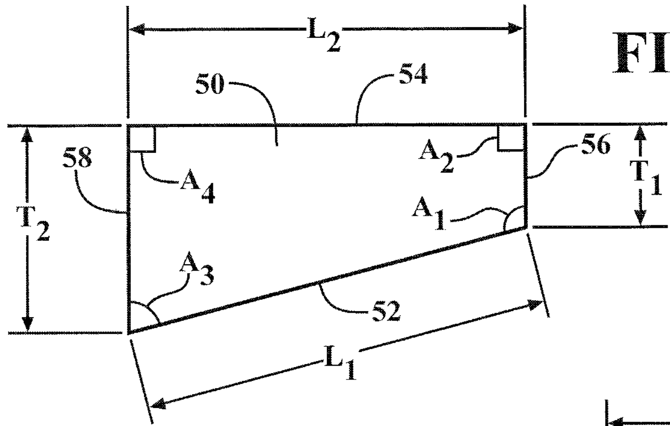
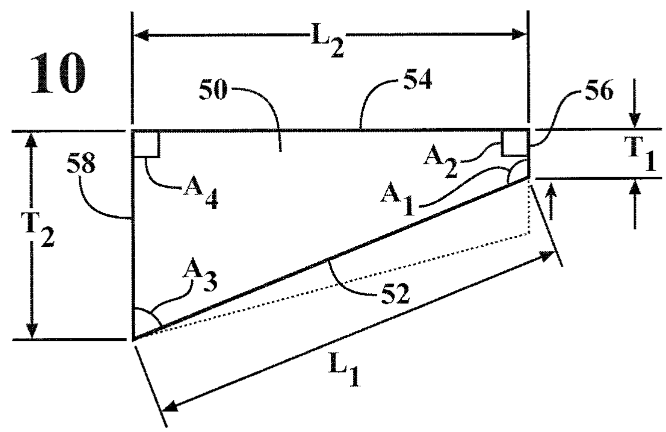


FIG. 9

FIG. 10



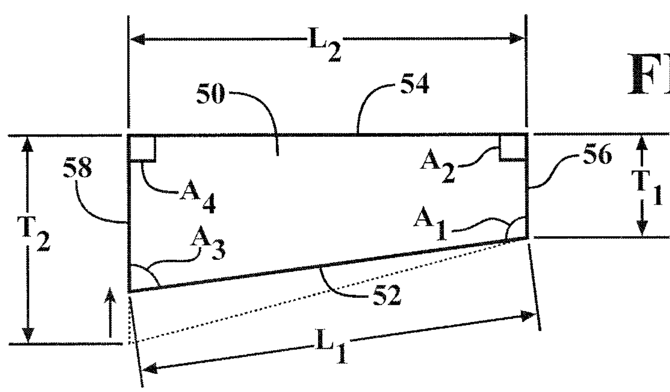
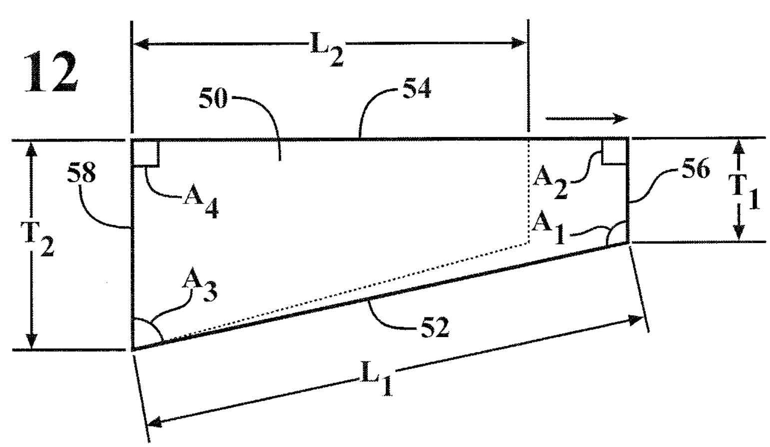


FIG. 11

FIG. 12



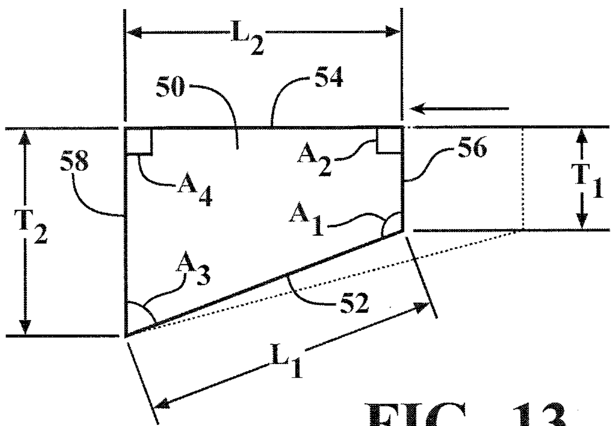


FIG. 13

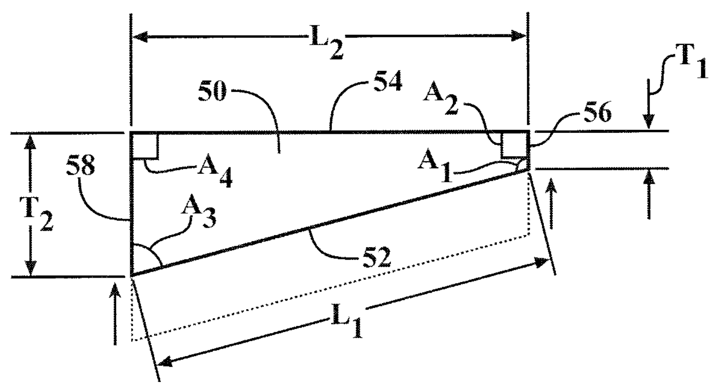


FIG. 14

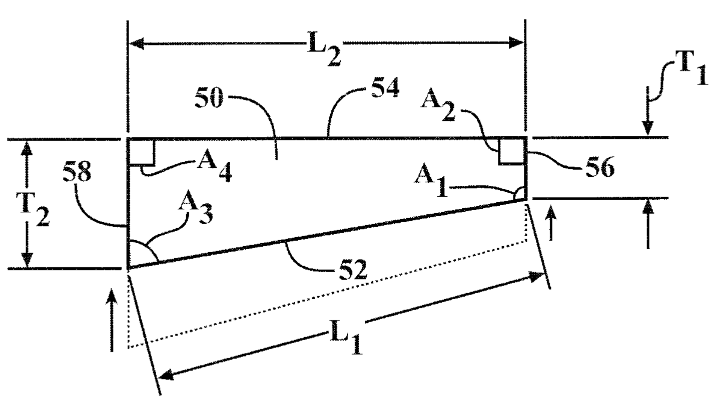
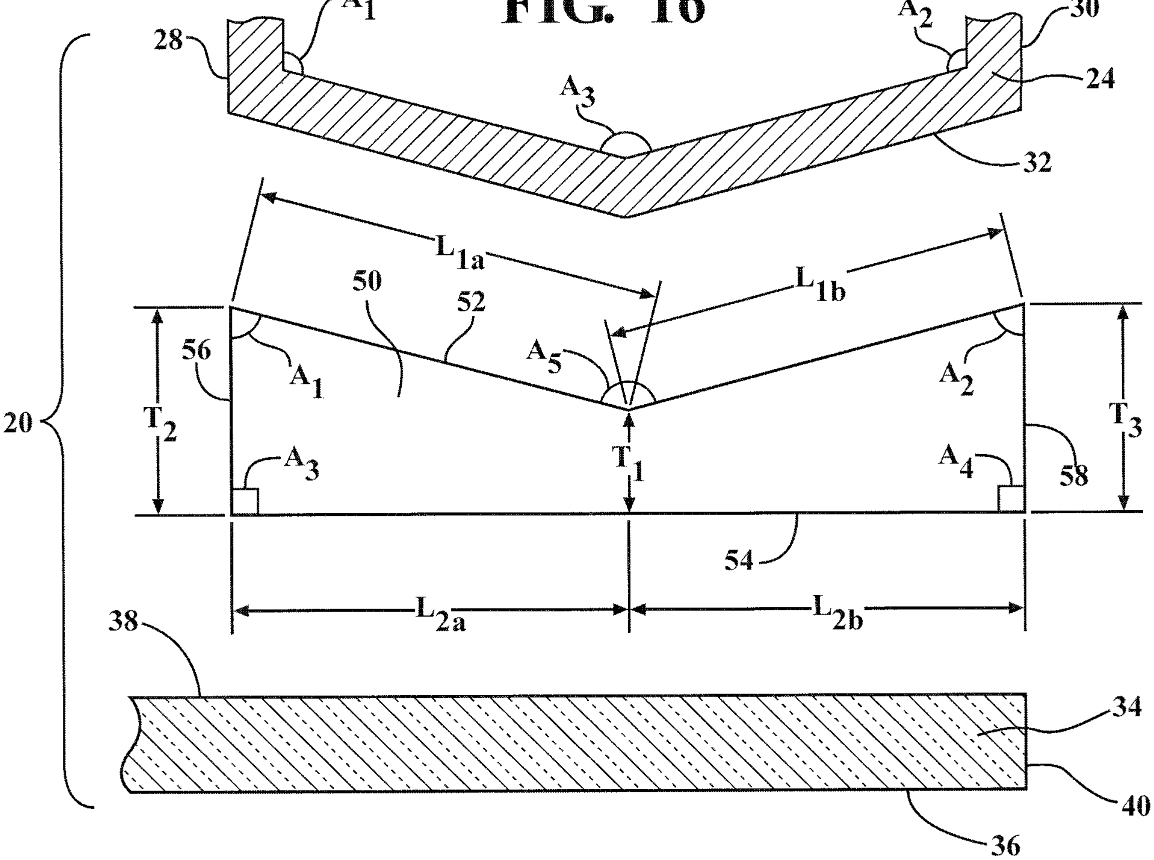


FIG. 15

FIG. 16



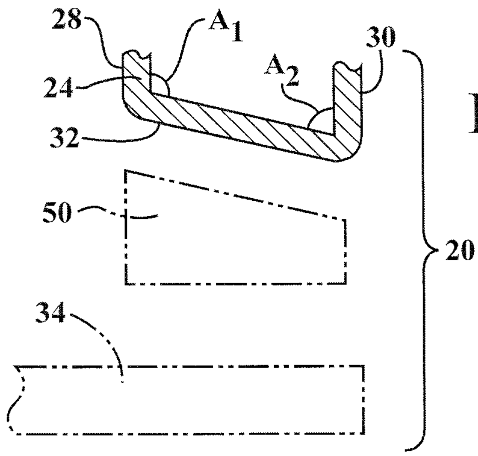


FIG. 17

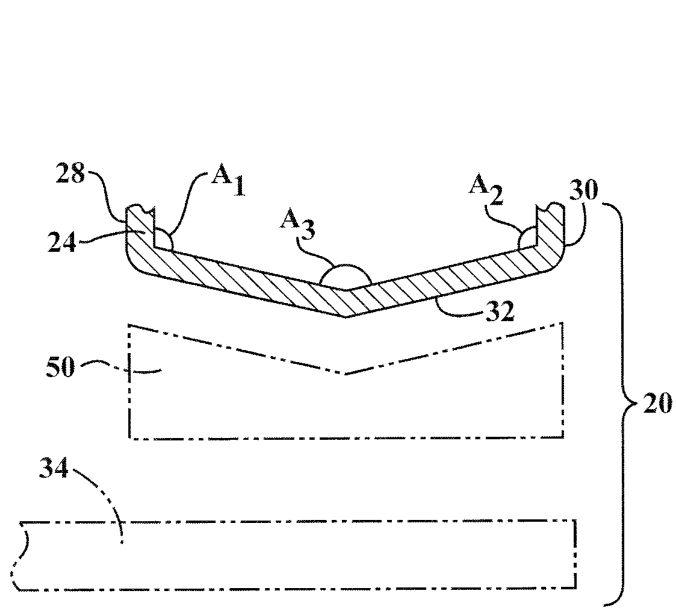


FIG. 18