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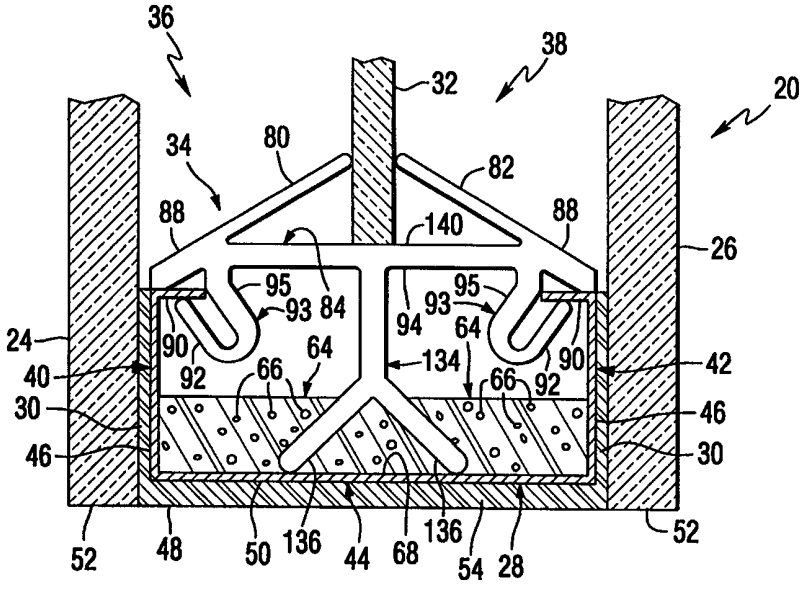

(57) Abstract

In one embodiment a plurality of spaced sheet retaining members (34) is maintained on the legs (40, 42) of the spacer frame (28) between the glass sheets (24, 26). In another embodiment an inner sheet (32) has an edge mounted in an edge receiving member mounted between the legs (40, 42) of the U–shaped side of the spacer frame (28). The remaining edges of the inner sheet (32) are within the interior of the closed spacer frame (28) and spaced from the spacer frame (28) by one or more retaining members (34). In one embodiment, the sheet retaining members (34) each have a pair of flexible fingers (80, 82). A sheet (32) mounted between the fingers (80, 82) is maintained spaced from the outer sheets (24, 26). In another embodiment, the sheet retaining members each have a groove for receiving an edge of a sheet. A first part has a vertical stop and a platform. An elongated securing member is detachably secured on the horizontal platform spaced from the vertical stop to form the groove.

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MULTI-SHEET GLAZING UNIT AND METHOD OF MAKING SAME

FIELD OF THE INVENTION

This invention relates to multi-sheet glazing units and, in particular, to multi-sheet glazing units having a pair of outer glass sheets secured to a spacer frame and one or more glass sheet(s) within the spacer frame between the outer sheets, and optionally to controlling gas movement around top and bottom edges of the inner sheet(s) and to methods of making the units.

BACKGROUND OF THE INVENTION

U.S. Patent No. 5,531,047 (hereinafter "USPN '047"); U.S. Patent No. 5,644,894 (hereinafter "USPN '894") and U.S. Patent No. 5,553,440 (hereinafter "USPN '440") disclose multi-sheet glazing units having one or more inner glass sheets spaced from and between a pair of outer glass sheets. In general, the spacer frame is positioned around the inner sheets, and the outer glass sheets are secured to a spacer frame having a U-shaped cross section by a moisture impervious adhesive.

In USPN '047, a layer of a pliable material having one or more groove(s) for receiving edge portions of the inner glass sheet(s) is mounted on the base of the spacer frame between the outer legs. The spacer stock is wrapped around the inner sheet(s) while positioning the edge portions of the inner sheet(s) in the groove(s) of the pliable material. A limitation of the above method is disturbing the pliable material as the spacer frame is wrapped around the inner sheet(s) making the unit unsightly.

In USPN '894, the spacer stock wrapped around the inner sheet(s) has raised portions formed in the base of the spacer frame to hold the inner sheet in position. A limitation of the above method is the extra processing step to provide spaced rows of raised portions in the base of the spacer frame.

In USPN '440, the spacer stock wrapped around the inner sheet(s) has a sheet retaining member mounted between the upright legs of the spacer frame to receive edge portions of the inner sheet(s). A limitation of the above method is the assembly time and precision required to wrap the spacer stock around the inner sheet(s) while positioning the edge of the inner sheet(s) in the groove(s) of the sheet retaining members.

United States Statutory Invention Regulation No. H975 (hereinafter "Publication H975"), published November 5, 1991, discloses a multi-sheet unit having a pair of outer sheets spaced from one another by and secured to a spacer frame. An example of Publication H975 discloses the construction of a unit by mounting the edge supports on the edge portions of an inner sheet, setting the inner sheet having the edge supports within the closed spacer frame, and securing the edge supports to the frame. The gas flow between the compartments as discussed in Publication H975 is controlled by the spaced distance between the edges of the inner glass sheet and the spacer frame. A limitation of the above method is the time required to mount the edge supports on the edges of an inner sheet and securing the edge supports to the spacer frame.

As can now be appreciated, it would be advantageous to provide multi-sheet glazing units having three or more sheets, and methods of making same that do not have the limitations of the presently available methods and units.

SUMMARY OF THE INVENTION

This invention relates to various embodiments of sheet retaining members. In one embodiment, the sheet retaining member has a flexible finger mounted on each of opposite sides of a support member. The ends of the fingers are spaced from one another to maintain edge portions of the inner sheet(s) therebetween. In another embodiment, the sheet retaining member has a groove to maintain edge portions of the

inner sheet therebetween; the groove is formed by a locking member securable on a horizontal support in combination with a vertical stop.

This invention also relates to various embodiments of a multi-sheet glazing units having three or more sheets; the units are of the type having a closed spacer frame e.g. a spacer frame having a U-shaped cross section formed by opposed legs connected to a base. A sheet is mounted on outer surface of the spacer frame by a moisture-impervious sealant. In one embodiment of the invention, the sheet retaining members having the flexible fingers are mounted on the legs of the spacer frame spaced from the base and between the outer sheets. The fingers maintain a sheet(s) within the spacer frame between the outer sheets. In another embodiment of the invention, sheet retaining members having a groove are mounted on the legs of the spacer frame spaced from the base and between the outer sheets. The groove faces the interior of the spacer frame and have edge portions of the inner sheet(s) therein. In a further embodiment, the inner sheet(s) has(have) edge portions of one side inserted between the pair of outer legs of the spacer frame and the remaining edge portions of the inner sheets within the interior opening of the spacer frame and held in position by sheet retaining members e.g. of the types discussed above. In still a further embodiment, the edge of the inner sheet between the outer legs ("bottom edge of the inner sheet") is mounted in an edge receiving member, e.g. a receiving member having a "⊔" cross section mounted between the outer legs of the spacer frame. The edge portions of the inner sheet between the legs of the spacer frame and the use of the edge receiving member restrict gas flow around the bottom edge of the inner sheet thereby reducing air movement from one compartment to the other compartment. The compartments are provided by the inner sheet between the outer sheets.

Optionally the multiple glazed units may have muntin bars. The muntin bars have ends mounted in any convenient

manner on the sheet retaining members and/or the sheet receiving members.

The invention further relates to methods of making the multi-sheet glazing units. The method includes the steps of providing a closed frame, e.g. a closed frame having a U-shaped cross section, mounting sheet retaining members within the spacer frame, mounting a sheet(s) on the sheet retaining members within the spacer frame e.g. of the type discussed above and securing a sheet to each of the outer surfaces of the spacer frame by a moisture impervious adhesive to provide a compartment between adjacent sheets. In one embodiment the sheet retaining members have flexible fingers. A sheet is moved into the interior of the spacer frame moving the fingers toward the base of the spacer frame, continued movement of the inner sheet engages the other finger and moves the edge of the inner sheet past the end of the fingers in the biased position. As the edge of the inner sheet moves past the biased fingers, the fingers move away from the base of the spacer frame to position the inner sheet between the fingers. In another embodiment the sheet retaining member has a vertical stop and a non-vertical base. Edge portions of the inner sheet are biased against the vertical stop after which a securing member is secured to the base. In a further embodiment of the method, an edge of the inner sheet is mounted in an edge receiving member positioned between the legs of the spacer frame and the remaining edges of the inner sheet are engaged by a sheet retaining member e.g. of the type discussed above.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front elevated view of a multi-sheet glazing unit incorporating features of the invention.

Fig. 2 is the view taken along lines 2-2 of Fig. 1 illustrating one embodiment of a sheet retaining member of the invention.

Fig. 3 is a view similar to the view in Fig. 2 illustrating another embodiment of a sheet retaining member of the invention.

Fig. 4 is a view similar to the view of Fig. 2 illustrating another embodiment of a sheet retaining member of the type illustrated in Fig. 2 having features of the instant invention.

Fig. 5 is a view similar to the view of Fig. 2 illustrating another embodiment of a sheet retaining member of the type illustrated in Fig. 2 having features of the instant invention.

Fig. 6 is an isometric view of a sheet retaining member of the type shown in Fig. 2.

Fig. 7 is a plan view of a strip prior to shaping the strip into a spacer stock having the U-shaped cross sectional configuration.

Figs. 8 and 9 are views similar to the view of Fig. 2 showing selected steps practiced in the fabrication of a multi-sheet glazing unit incorporating features of the invention using the sheet retaining member shown in Fig. 6.

Fig. 10 is an isometric view of another embodiment of a sheet retaining member of the type illustrated in Fig. 2 having features of the invention mounted in a section of a U-shaped spacer frame.

Fig. 11 is a view similar to the view of Fig. 9 showing construction of a multi sheet glazing unit of the instant invention having two inner sheets.

Fig. 12 is a view similar to the view in Fig. 3 illustrating another embodiment of a sheet retaining member of the type illustrated in Fig. 3 having features of the instant invention.

Figs. 13 and 15 are views similar to the view of Fig. 3 showing selected steps practiced in the fabrication of a multi-sheet glazing unit incorporating features of the invention using the sheet retaining member shown in Fig. 3.

Fig. 14 is a view similar to the view in Fig. 3 illustrating another embodiment of a sheet retaining member of the type illustrated in Fig. 3 having features of the instant invention.

Fig. 16 is a view similar to the view of Fig. 14 showing construction of a multi sheet glazing unit of the instant invention having two inner sheets.

Fig. 17 is a front elevated view of a multi-sheet glazing unit having muntin bars, and sheet retaining members and edge receiving members of the invention.

Fig. 18 is the view taken along lines 18-18 of Fig. 17.

Fig. 19 is an isometric view of an edge receiving member incorporating features of the invention.

Fig. 20 is a view similar to the view in Fig. 18 illustrating an embodiment of the edge receiving member of the instant invention for a glazing unit having two inner sheets.

Fig. 21 is a view taken along lines 21-21 of Fig. 17 illustrating one type of a sheet retaining member that may be used with the sheet receiving member of the invention.

Fig. 22 is a view similar to the view of Fig. 21 illustrating another type of a sheet retaining member that may be used with the sheet receiving member of the invention.

Fig. 23 is an isometric view of the sheet retaining member illustrated in cross-section in Fig. 21.

Fig. 24 is an isometric view of the sheet retaining member illustrated in cross-section in Fig. 22.

Fig. 25 is a cross sectional side view illustrating a step of another method of practicing the invention to mount an inner sheet within a closed spacer frame.

Fig. 26 is an isometric view of a section of a spacer frame having cutouts for receiving sheet retaining members or edge receiving members incorporating features of the invention.

DESCRIPTION OF THE INVENTION

The various embodiments of the instant invention will be discussed in the construction of a multi-sheet thermally insulating or glazing units having a low thermal conducting edge determined as disclosed in the European Patent Publication Number 0 475 213 A1 published 18.03.92 Bulletin 92/12. As will be appreciated, the instant invention is not limited thereto and the embodiments of the present invention may be used with any type of multi-sheet glazing unit regardless of its thermal insulating properties. In the following discussion, unless otherwise indicated, like numerals refer to like elements.

Fig. 1 shows a multi-sheet glazing unit 20 incorporating features of the invention, and Figs. 2 and 3 show a cross-sectional view of the various type of multi-sheet units 20 incorporating features of the invention that are used in the practice of the invention. With reference to Figs. 2 and 3, the unit 20 has a pair of outer sheets 24 and 26 secured to a spacer frame 28 by a layer 30 of an adhesive, and an inner or intermediate sheet 32 held in position between the outer sheets 24 and 26 by sheet engaging members shown generally in Fig. 1 by numeral 33; one only shown in Fig. 2 and identified by numeral 34, and one only shown in Fig. 3 and identified by numeral 35 to provide a compartment 36 between the sheets 24 and 32, and a compartment 38 between the sheets 26 and 32. Preferably, but not limiting to the invention, the compartments 36 and 38 are sealed against the egress and/or ingress of air, e.g., gases, moisture and/or dust (hereinafter individually and collectively referred to as "environmental atmosphere") by the adhesive layers 30 discussed in more detail below.

In the following discussion, the sheets are glass sheets; however, as will become apparent, the sheets may be made of any material, e.g., glass, plastic, metal and/or wood, and the selection of the material of the sheets is not limiting to the invention. Further, the sheets may be made of

the same material or the sheets may be made of different materials. Still further, one sheet may be a monolithic sheet, and the other sheet(s) may be laminated sheet(s), e.g., made of one or more monolithic sheets laminated together in any usual manner. One or more of the surfaces of one or more sheets may have an environmental coating to selectively pass predetermined wavelength ranges of light and energy, e.g., glass or plastic transparent sheets may have an opaque coating of the type used in making spandrels or the type of coatings disclosed in U.S. Patent Nos. 4,170,460; 4,239,816; 4,462,884; 4,610,711; 4,692,389; 4,719,127; 4,806,220; 4,853,256; 4,898,789 and 5,356,718, which disclosures are hereby incorporated by reference.

Further, in the practice of the invention, one or more of the glass sheets may be coated and/or uncoated colored sheets, e.g. but not limiting to the invention, colored sheets of the type disclosed in U.S. Patent Nos. 4,873,206; 4,792,536; 5,030,593 and 5,240,886, which disclosures are hereby incorporated by reference. Still further, in the practice of the invention, the surfaces of the sheets may have a photocatalytic cleaning film or water reducing film, e.g., of the type disclosed in U.S. Patent Application Serial No. 08/927,130 filed on September 2, 1997, in the name of James P. Thiel for PHOTOELECTRICALLY-DESICCATING MULTIPLE-GLAZED WINDOW UNITS and U.S. Patent Application Serial No. 08/899,257 filed on July 23, 1997, in the names of Charles B. Greenberg et al., for PHOTOCATALYTICALLY-ACTIVATED SELF-CLEANING ARTICLE AND METHOD OF MAKING SAME, which disclosures are hereby incorporated by reference. The photocatalytic film disclosed in U.S. Patent Application Serial No. 08/899,257 is preferably deposited on the outer surface of one or both sheets 24 and 26; however, the invention contemplates depositing the photocatalytic film on the inner surface of one or both of the sheets 24 and 26 and/or surfaces of the inner sheet 32. The water reducing film disclosed in U.S. Patent Application Serial No. 08/927,130 is preferably deposited on one or more

of the surfaces of the inner sheet(s) 32 or the inner surface of one or more of the outer sheets 24 and 26; however, the invention contemplates depositing the coating on the outer surface of one or both sheets 24 and 26.

The outer glass sheets 24 and 26 preferably have the same peripheral configuration and dimensions; however, as can be appreciated, one outer glass sheet may be larger than the other outer glass sheet. Further, one or more of the sheets 24, 26 and 32 may have different peripheral configurations than the remaining sheet(s).

With continued reference to Figs. 2 and 3, and not limiting to the invention, the spacer frame 28 has a generally U-shaped cross section defined by a pair of spaced outer legs 40 and 42 secured to a base 44. The adhesive layer 30 is preferably a moisture-impervious material e.g. adhesive-sealant of the type used in the art of sealing compartments of insulating units. The layer 30 is provided on outer surface 46 of the legs 40 and 42 of the spacer frame 28 to secure the outer sheets 24 and 26 to the legs 40 and 42, respectively, of the spacer frame 28 to seal the compartments 36 and 38 against movement of environmental atmosphere into and out of the compartments.

It can now be appreciated that the material of the adhesive-sealant layers 30 is not limiting to the invention and preferably has a moisture permeability of less than about 20 grams millimeter (hereinafter "gm mm")/ square meter (hereinafter "M^2") day, and more preferably, less than about 5 gm mm/M^2 day, determined using the procedure of ASTM F 372-73. Materials that may be used in the practice of the invention include, but are not limited to, butyls, silicones, polyurethane adhesives, and butyl hot melts of the type sold by H. B. Fuller, e.g., H. B. Fuller 5140.

It is recommended that the adhesive-sealant layer 30 be thin and long to reduce the diffusion of the insulating gas out of or the environmental atmosphere moving into the compartments of the unit. The invention may be practiced with

the adhesive-sealant layers 30 each having a thickness, i.e., the distance between the glass sheet and the adjacent leg of the spacer frame, of about 0.005 inch (0.013 centimeter, hereinafter "cm") to about 0.125 inch (0.32 cm), preferably about 0.010 inch (0.025 cm) to about 0.020 inch (0.050 cm) and more preferably, about 0.015 inch (0.38 cm), and the layers 30 each having a length, i.e., the distance between the top of the leg of the spacer frame and the base of the spacer frame as viewed in Figs. 2 and 3 of about 0.010 inch (0.025 cm) to about 0.50 inch (1.27 cm), preferably about 0.125 inch (0.32 cm) to about 0.50 inch (1.27 cm) and more preferably about 0.200 inch (0.50 cm).

Preferably, the rate of loss of the insulating gas should be less than about 5% per year and, more preferably, it should be less than about 1% per year determined as described in the above-mentioned European Patent.

A layer 48 of an adhesive, sealant or adhesive-sealant may be provided over outer surface 50 of the base 44 of the spacer frame 28. The layer 48 may be a material similar or dissimilar to the material of the layers 30 and preferred is non-tacky so that the peripheral edges of the multi-sheet unit do not stick to surfaces supporting the edge of the unit. Further, multi-sheet units having the layer 48, preferably have the outer surface 50 of the base 44 recessed inwardly from the peripheral edges 52 of the outer sheets 24 and 26 as viewed in Figs. 2 and 3 to provide a channel 54 to receive the layer 48. The thickness of the layer 48 is not limiting to the invention, and the layer 48 may have a thickness of about 0.031 inch (0.08 cm) to about 0.50 inch (1.27 cm), preferably a thickness of about 0.150 inch (0.38 cm). The layer 48 preferably has similar moisture and gas permeability values as the layers 30. As can now be appreciated and with reference to Figs. 4 and 5, the instant invention contemplates multi-sheet units without the peripheral channel 54 and layer 48 as shown for multi-sheet units 60 and 61 in Figs. 4 and 5 respectively. The outer

surface 50 of the base 44 of the spacer frame 28 for the unit 60 shown in Fig. 4 may be in alignment with the peripheral edges 52 of the outer sheets 24 and 26, or the base of the spacer frame may extend beyond the peripheral edges 52 of the sheets 24 and 26 as shown for the unit 61 in Fig. 5.

The spacer frame may be made of any material, e.g., wood, plastic, metal coated plastic, metal (e.g., stainless steel, galvanized iron or tin coated steel), or aluminum. Although the spacer frame may be made of any material, it is preferred that the spacer frame used in the practice of the instant invention have low thermal conductivity so that the spacer frame 28, the adhesive-sealant layers 30 and the layer 48, if present, collectively define an edge assembly that separates the outer sheets 24 and 26, and has a low thermal conductivity or high RES-value. Further, in the practice of the invention, it is preferred to use a spacer frame made of a material that is moisture and/or gas impervious e.g. but not limited to metal, e.g., stainless steel, halogenated polymeric material, and/or a gas-pervious material covered with an impervious film, e.g., metal or polyvinylidene chloride film.

The above-mentioned European Patent Application (hereinafter "EP Application") discusses in detail the concept of edge assemblies having low thermal conductivity and determination of RES-value; reference may be made thereto for a detailed discussion.

Although the invention is not limited to the cross sectional configuration of the spacer frame, it is preferred in the practice of the invention to use a spacer frame having a U-shaped cross section, e.g., of the type shown in Figs. 2 and 3, to secure a sheet retaining member of the instant invention in position in a manner to be discussed below. In the practice of the invention, the spacer frame may have a generally U-shape cross section as shown for spacer frame 28 of Figs. 2 and 3; a generally rectangular cross section as shown for spacer frame 62 of Fig. 5, or a W-shaped cross-section as shown in U.S. Patent No. 5,377,473. Further, in

the practice of the invention the spacer frame is a closed spacer frame made from a continuous piece of spacer stock as disclosed in U.S. Patent No. 5,177,916 (hereinafter "USPN '916"); however, as will be appreciated, the invention is not limited thereto and may be made from sections of spacer stock, e.g., of the type disclosed in the EP Application and joined together by corner keys or welding ends of spacer sections.

Referring to Figs. 2 and 3, one or more bead(s) 64 of a moisture-pervious material having a desiccant 66 therein is provided on inner surface 68 of the base 44, i.e., the surface of the base between the legs of the spacer frame. The bead(s) 64 may be made of any moisture-pervious material and preferably has(have) a permeability greater than about 2 gm mm/M^2 day as determined by the procedure set out in ASTM F 372-73 are recommended in the practice of the invention. Such materials are disclosed in the U.S. Patent Nos. 5,177,916; 5,531,047 and 5,655,282. The bead 64 having the desiccant may be used in the hollow rectangular spacer 62 shown in Fig. 5 or loose desiccant 66 may be provided in the hollow rectangular spacer as shown in Fig. 5.

As can be appreciated, having a water reducing film of the type disclosed in U.S. Patent Application Serial No. 08/927,130 on selected surfaces of the inner surfaces of outer sheets 24 and 26 and surfaces of inner sheet 32 may be used to reduce the amount of desiccant required or eliminate the need for the desiccant and the beads.

The discussion will now be directed to sheet retaining members incorporating features of the instant invention. As will be appreciated, the invention is not limited to the material of the sheet retaining members of the invention. For example, the sheet retaining members may be made of plastic, rubber, metal, wood, glass and/or reinforced plastic. In the practice of the invention it is preferred that the sheet retaining members be made of plastic because it is thermally non-conductive and economic to form. As can be appreciated by those skilled in the art, the material of the

sheet retaining member should be selected or prepared so that there is no outgassing of the material during use of the unit. In the practice of the invention, the sheet retaining member may extend along each elongated side of the spacer frame or along any selected elongated side(s) of the spacer frame. In the instance where a plurality of sheet retaining members are used along an elongated side of the spacer frame, it is suggested that a sheet retaining member be used at the midpoint of an elongated side of the spacer frame when the elongated side is less than about 2 feet (30 cm), at the quarter points when the elongated side is more than about 2 feet (30 cm) and less than about 4 feet (60 cm), and about every 12 inches (30 cm) when the elongated side is greater than about 4 feet (60 cm).

With reference to Figs. 2 and 6, there is shown one embodiment of a sheet retaining member of the invention. The sheet retaining member 34 has a pair of spaced fingers 80 and 82 mounted to support platform or facilities 84 to engage and/or capture the inner sheet 32 therebetween as shown in Fig. 2. The support platform 84 includes extensions 88 which rest on upper portions of the legs 40 and 42 of the spacer frame as shown in Fig. 2. Although not limiting to the invention, ends 90 of the legs 40 and 42 of the spacer frame 28 are bent toward one another and captured between the extensions 88 and flexible fingers 92 as shown in Fig. 2. Each of the flexible fingers 92 are a finger of U-shaped member 93; the other finger of the U-shaped member 93 is designated by numeral 95 (see Fig. 6). The finger 93 is less flexible i.e. more rigid than the finger 92 and is attached to or part of the bottom surface 94 of the support platform 84. The support member 84 and fingers 92 and 95 are sized and shaped such that moving the sheet retaining member 34 between the ends 90 of the legs 40 and 42 of the spacer frame, bias the fingers 92 toward its respective finger 95. Continued downward motion of the sheet retaining member 34 as viewed in Fig. 2 seats the extensions 88 of the support member 84 on the

ends 90 of the legs 40 and 42 of the spacer frame and the ends 90 of the legs 40 and 42 disengage the fingers 92 allowing the fingers 92 to move under the ends 90 to capture the sheet retaining member on the spacer frame.

The sheet retaining member 34 may be mounted on a spacer frame as discussed above or in any usual manner. For example and with reference to Fig. 5, sheet retaining member 114 has support platform 115 mechanically or adhesively secured at 116 to the inner surface of the rectangular cross-sectional spacer frame 62. Further, as shown in Fig. 4, sheet retaining member 130 has grooves 132 for receiving the ends 90 of the legs of the spacer frame.

In the instance where the sheet retaining member of the instant invention is used with a U-shaped spacer frame, e.g., the spacer frame 28, and the inner sheet 32 has significant weight or more than one inner sheet is used, a support shim may be used e.g. support shims 134 and 138 as shown in Figs. 2 and 4 respectively to prevent the sheet retaining member from dropping between the legs of the spacer frame. The support shims may be made of any structurally stable material and is preferably made of plastic. With reference to Fig. 6, the support shim 134 has an inverted Y shape with legs 136 resting on the base 44 of the spacer frame (see Fig. 2) and the leg 137 connected to or in surface contact with the bottom surface 94 of the support platform 84. When the support shims 134 and 138, and the bead 64 are used, the bead 64 may be provided on each side of the shim or the shim may be pushed into the moisture-pervious matrix of the bead if it is sufficiently soft at room temperature. One type of moisture pervious matrix that is soft at room temperature is PRC 525DM sold by Courtaulds Aerospace. As can be appreciated, the size of the shim is not limiting to the invention and may extend into contact with the legs 40 and 42 of the spacer frame 28.

As can be appreciated, the invention is not limited to the design of a shim to prevent the sheet retaining member

from falling between the legs of the spacer frame. For example, in Fig. 4 the shim 138 has a rectangular shape. Further, the shim and the sheet retaining member may be one piece or discreet pieces.

Further, as can be appreciated by those skilled in the art, increasing the wall thickness of the ends 90 or of the spacer frame 28 provides additional structural stability to support the sheet retaining member. However, increasing the wall thickness of the spacer frame increases thermal conductivity of the spacer frame and increases the weight of the unit. Reducing the weight of the inner sheet by making it thinner and/or from material lighter than glass e.g. plastic may be considered to eliminate the need of the shim.

The invention will be discussed to make a glazing unit similar to the unit 20 shown in Figs. 1 and 2 having a closed spacer frame made from a continuous piece of spacer stock. Each of the outer sheets 24 and 26 are clear glass sheets having a length of about 42 7/8 inches (108.9 centimeter, hereinafter "cm") and a width of about 19 3/4 inches (50.17 cm). The inner sheet 32 is a clear glass sheet having a length of about 42 1/4 inches (107.30 cm) and a width of about 19 1/8 inches (48.57 cm). The outer sheets have a thickness of 0.090 inch (0.229 centimeter), and the inner sheet has a thickness of about 0.070 inch (0.178 cm).

The surface of the glass sheets 24 and 26 designated to be the inner surfaces have a coating of the type sold by PPG Industries under its registered trademark Sungate® 100 coated glass. The designated outer surfaces have a photocatalytic cleaning film of the type disclosed in U.S. Patent Application Serial Nos. 08/899,257 and/or 60/040,566. The surfaces of the inner sheet 32 have a water reducing film of the type disclosed in U.S. Patent Application Serial No. 08/927,130.

A spacer frame 28 having four continuous corners is provided. With reference to Fig. 7, a flat tin coated steel strip 225 having a length of about 126 inches (320 cm), a

width of about 1.25 inches (3.18 cm) and thickness of about 0.010 inch (0.25 mm) is die cut. After die cutting, the strip 225 as shown in Fig. 7 has a tapered and wedged end 226 having a hole 227. Opposite end 228 of the strip 225 has a hole 229. At locations spaced about 1.5 inches (3.8 cm), about 21 1/8 inches (53.65 cm), about 63 7/8 inches (162.24 cm), and about 83 1/2 inches (212.09 cm) from the end 226, material is removed from opposite edge portions 230 of the substrate 225 to provide sets of paired notches 232, 234, 236 and 238 respectively. Crease lines 244 are provided at the notches as shown in Fig. 7. The notched areas form the bent portions 240 as shown in Fig. 4, and the notches provide for the bent portions 240 to be a sufficient distance so as not to overlap. The notched areas also eliminate the extension 90 of the legs 40 and 42 at the corners of the spacer frame and the crease lines 244 provide for ease of bending the spacer stock to provide the closed spacer frame having continuous corners as disclosed in USPN's '047 and '916.

Each of the notches of the set of paired notches 234, 236 and 238 have a length of about 0.536 inch (1.36 cm) at the edge 230 of the substrate, a depth of about 0.170 inch (0.43 cm) as measured from the edge 230 of the substrate toward the center of the substrate. The notches 232 are similar in size as the notches 234, 236 and 238 but the left side of the notch as shown in Fig. 7 is further cut to insert the end 226 into the end 228 after the strip 225 is formed into the spacer stock having a U-shaped cross section. The distance between the points of pairs of notches depends on the width of the base of the spacer frame, i.e., the desired spacing between the outer sheets. The unit has the point of the crease lines spaced about 0.500 inch (1.27 cm) from the edge 230 of the substrate to provide the base with a width of about 0.50 inch (1.27 cm) and ends 88 having an extension of about 0.078 inch (0.18 cm).

The strip 225 is shaped to provide a spacer stock having a U-shaped cross section as shown in Figs. 2-4. Ends

230 of the substrate 225 are bent over to form the ends 88 to provide the spacer frame with structure stability, and to secure the sheet retaining member in position as disclosed above and further discussed below. The layers 30 and 48 of the adhesive-sealant are provided on the outer surfaces 46 of the legs 42 and 44 and outer surface 50 of the base 54 of the spacer frame 28.

A bead 64 of H. B. Fuller HL 5102X-125 butyl hot melt matrix having the desiccant 66 is flowed on the inner surface 68 of the base 44 in any usual manner. Thereafter the spacer stock is bent to form a closed spacer frame. A rivet or screw (not shown) may be used to secure the ends 226 and 228 together to provide the closed frame. One of the outer sheets, e.g., the sheet 24, as shown in Fig. 8 is adhered to the outer surface 46 of a leg of the spacer frame e.g. the leg 40 by the adhesive-sealant layer 30.

Six sheet retaining members 34 of the instant invention made of plastic are provided. With reference to Fig. 6, the support platform 84 of the sheet retaining member 34 has a length (along the length of the spacer) of about 0.5 inch (1.27 cm) and a width of about 0.656 inch (1.7 cm) as measured between the ends of the extension 88. The distance between the fingers 80 and 82 in the unbiased position e.g. the position as shown in Fig. 6 is about 0.070 inch (0.178 cm). The fingers have a thickness of about 0.020 inch (0.508 cm) and the support platform 84 has a thickness of about 0.035 inch (0.076 cm). The legs 136 and 137 of the shim 134 each have a thickness of about 0.035 inch (0.076 cm). The angle subtended by the fingers 80 and 82 in the unbiased position and the upper surfaces of the support platform is about 30°. The horizontal distance from the end of the fingers 80 or 82 to the extension 88 as measured in the unbiased position is about 0.293 inch (0.75 cm). A sheet retaining member 34 is mounted to the spacer frame as previously discussed at the quarter points on the long side of the spacer frame and at the mid point for the short side of the spacer frame.

With reference to Figs. 8 and 9, the inner sheet 32 is moved to the left as viewed in Fig. 8 biasing the finger 82 against the upper surface 140 of support platform 84 as shown in Fig. 8. The sheet 32 is further moved to the left against the finger 80 until the peripheral edge of the inner sheet clears the end of the finger 82 after which the finger 82 moves toward the unbiased position as shown in Fig. 9. The inner sheet 32 is now captured between the fingers 80 and 82 as shown in Fig. 2. Thereafter the designed inner surface of the sheet 26 is adhered to the outer surface 46 of the leg 42 of the spacer frame 28 by the layer 30 of the adhesive-sealant.

The outer glass sheets 24 and 26 are now biased toward one another to flow the adhesive-sealant layer 30 to secure the outer glass sheets to the spacer frame.

As can now be appreciated, the invention is not limited to the number of inner sheets 32 or the number of fingers of the sheet retaining member for engaging the sheet of the invention. For example, as shown in Fig. 10, sheet retaining member 250 has a pair of fingers 252 and 254 on one side of platform member 255 and one finger 256 on the other side. The sheet retaining member 250 has a shim 257 having an "M" shaped cross section and fins 258 to capture the sheet retaining member 250 between the legs of the spacer frame 28. The retaining member 250 is biased downward as viewed in Fig. 10 between the legs of the spacer frame to bend the fins 258. As the fins 258 pass the extensions 90 they unbend to capture the member 250 between the legs 40 and 42 of the spacer frame 28.

With reference to Fig. 11, there is shown the construction of a unit having two inner sheets 32 and 260. As shown in Fig. 11, the sheet 24 is secured to the leg 42 of the spacer frame 28 by the layer 30 of the adhesive-sealant. Sheet retaining members 261 (one only shown in Fig. 11) are secured to the spacer frame in a similar manner as the sheet retaining member 34 was secured to the spacer frame. The

spacing between ends 262 of the fingers is equal to or slightly larger than the thickness of the two inner sheets 32 and 260 and separator 263. The sheet 32 is mounted on the sheet retainer member 261 as previously discussed for mounting the inner sheet 32 on the sheet retaining member 34. The sheet separator 263 is mounted on the upper surface 264 of platform member 266, and thereafter, the sheet 260 is moved to the right as viewed in Fig. 11 to move the finger 82 against the upper surface 264 of and the marginal edge portions of the sheet 260 against the sheet separator 263. Continued movement of the sheet 260 to the left as viewed in Fig. 11 moves the sheet separator 263 and inner sheet 32 to the left as viewed in Fig. 11 and the inner sheet 32 against the finger 80. After the peripheral edge of the sheet 260 moves past the end 262 of the finger 82, the finger 82 moves to the unbiased position, and the finger 80 moves the sheets 32 and 260, and the sheet separator 263 to the right as viewed in Fig. 11, with the sheets 32 and 260 captured between the fingers 80 and 82 and separated by the sheet separator 263. Thereafter the outer sheet 26 is mounted to the spacer frame as previously discussed.

As can be appreciated, the inner sheets 32 and 260, and the sheet separator 263 may be mounted in the sheet retainer member 261 prior to mounting one of the outer sheets to the spacer frame, and one inner sheet may be mounted from one side of the spacer frame and the other inner sheet from the other side. Further, it is recommended that the sheet separator 263 be captured on the upper surface 264 of the platform 266 for sliding movement in any convenient manner in order that the sheet separator may be moved between the fingers as previously discussed and is prevented from falling from between the inner sheets. One technique is to provide a groove in the platform member 266 and a headed stud mounted to the underside of the sheet separator and captured in the groove for sliding movement.

The discussion will now be directed to another embodiment of a sheet retaining member of the instant invention, more particularly, the sheet retaining member 35 shown in Fig. 3. With reference to Fig. 3, the sheet retaining member 35 has a sheet engaging member 280 and a securing or locking member 282. The sheet engaging member 280 has a support member 284 which is captured between the legs 40 and 42 of the spacer frame 28 as shown in Figs. 3 and 12 e.g. by the flexible fingers 92 of the U-shaped member 93 (see Fig. 12) engaging the extensions 90, or the grooves 132 (see Fig. 3) receiving the extension 90, of the legs 40 and 42 of the spacer frame 28 as previously discussed.

With continued reference to Fig. 3 and with particular reference to Fig. 13, the sheet engaging member 280 of the sheet retaining member 35 has an upper flat surface 292 and vertical stop surface 294 and a sloped surface 296. The locking member 282 has a pair of protrusions 298 that are captured in holes 300 in the flat surface 292 of the sheet engaging member 280. When the locking member 282 is secured to the flat surface 292 by inserting the protrusions 298 into the holes 300, the locking member 282 and the vertical stop surface 294 provide the sheet retaining member 35 with a groove 310 as shown in Fig. 3 for receiving the peripheral and marginal edges of the intermediate sheet 32 to secure the intermediate sheet 32 in position between the outer sheets 24 and 26 as shown in Fig. 3.

As can be appreciated, the locking member 282 may be secured to the flat surface 292 to provide the groove 310 in any usual manner. For example, a locking member may be secured to the flat surface by an adhesive, or application of heat to fuse the pieces together or may be detachably secured using hole and protrusion combinations. With reference to Fig. 12, there is shown sheet retaining member 311 having locking member 312 hinged at one end e.g. end 313 as shown in Fig. 12. The locking member 312 shown in phantom is a position prior to securing the inner sheet 32 in position.

As can be appreciated, the invention is not limited to the material of the sheet retaining member 35 and the sheet retaining member 35 may be made of the same material as the sheet retaining member 34 as previously discussed.

The sheet engaging member 280 of the sheet retaining member 35 may be mounted on the spacer frame as discussed above for spacer frames having a U-shaped cross section or as shown in Fig. 14. In Fig. 14 the sheet retaining member 314 may be mechanically or adhesively secured at 315 to the rectangular cross-sectional spacer frame 62.

The support shims 138 (Figs. 3 and 13), 134 (Fig. 12) and 257 (Fig. 10) may be used as previously discussed to prevent the sheet retaining member 35 from dropping between end legs of a spacer frame having a U-shaped cross section.

The invention will be discussed to make the glazing unit 20 having the sheet retaining member 35 and a closed spacer frame made from a continuous piece of spacer stock as previously discussed. Each of the outer sheets 24 and 26 and the inner sheet 32 have the dimensions previously discussed for making the unit 20 of Fig. 2 and are coated as previously discussed. A spacer frame 28 having four continuous corners and the dimension previously discussed is made.

Six sheet retaining members 35 of the instant invention made of plastic are provided. With reference to Fig. 13, the sheet engaging member 280 of the sheet retaining member 35 has a length (along the length of the spacer) of about 0.5 inch (1.27 cm) and a width of about 0.470 inch (1.9 cm) as measured between the ends of extension 320. The support member 284 has a width of about 0.348 inch (0.088 cm). The grooves 132 have a depth of 0.002 inch (0.005 cm). The upper flat surface 292 has a length of about 0.263 inch (0.67 cm). Sloping surface 296 has a length of about 0.208 inch (0.52 cm). The locking member 282, the protrusion 298 and the holes 300 are sized to lock the locking member 282 in position by inserting protrusions 298 into the holes 300 in the flat portion 292 and to give a balanced configuration. Support

shims 138 made of plastic have a height of about 0.206 inch (0.52 cm), a length of about 0.5 inch (1.27 cm) and a depth of about 0.20 inch (0.51 cm) are positioned between the legs 40 and 42 of the spacer frame. The shim 138 is set in position and the sheet retaining member 35 is mounted to the spacer frame as previously discussed at the quarter points on the long side of the spacer frame and at the mid point for the short side of the spacer frame.

The intermediate sheet 32 is positioned on the flat surface 292 of the sheet engaging members against the vertical stop 294. Thereafter, the locking member 282 is snapped into position by inserting the protrusions 298 into the holes 300 (the protrusions 298 and holes 300 clearly shown in Fig. 13). Thereafter and with reference to Fig. 15, the designated inner surface of the sheet 26 is adhered to the leg 42 of the spacer frame 28 by the layer 30 of adhesive-sealant.

The outer glass sheets 24 and 26 are biased toward one another to flow the adhesive-sealant layer 30 to secure the outer glass sheets to the spacer frame.

As can now be appreciated, the invention is not limited to the number of intermediate sheets 32 or the configuration of the sheet retaining member of the invention.

With reference to Fig. 16, there is shown the construction of a unit having the two inner sheets 32 and 260. As shown in Fig. 16, the spacer frame 28 is mounted to marginal edges of the sheet 24 by the layer 30 of the adhesive-sealant. The sheet retaining member 330 is secured to the spacer frame in a similar manner as the sheet retaining member 35 was secured to the spacer frame. The sheet engaging member 334 has a flat surface 336 instead of the sloped surface 296 (compare Fig. 13 with Fig. 16). The inner sheet 32 is moved against vertical stop 338. A spacer or separator block 340 is mounted or secured e.g. by holes and protrusions or by an adhesive on flat surface 336 against the inner sheet 32. The second inner sheet 260 is moved against the spacer block 340 and locking or securing member 342 is secured in

position on surface 344 in a manner similar to securing the locking or securing member 282 in position. Thereafter, the outer sheet 26 is mounted on the other side of the spacer frame and the outer sheets biased toward one another to provide a multi-sheet glazing unit having four sheets and three compartments.

Another embodiment of the invention for making a multi-sheet glazing unit having four sheets contemplates having a sheet retaining member having a horizontal platform e.g. a flat surface 344 on each side of a raised portion having a vertical surface on each side e.g. similar to the surface vertical stop 338 (Fig. 16). A sheet e.g. sheet 32 is mounted on one of the horizontal platforms against one of the vertical surfaces and secured in position by a securing member as previously discussed. A sheet e.g. sheet 260 is mounted on the other one of the horizontal platforms against the other one of the vertical surfaces and secured in position by a securing member as previously discussed. Thereafter the outer sheets 24 and 26 are secured in position as previously discussed.

The height of the sheet retaining members 34 and 35 extending above the top of the spacer frame, i.e., the top of the legs 40 and 42 as viewed in Figs. 2 and 3 is not limiting to the invention. However, as can be appreciated, the more the sheet retaining member extends above the top of the spacer legs, the more visible is the sheet retaining member. Further, as the distance between the edge of the inner sheet 32 and the sheet 260, if present, and the base of the spacer frame or the bead(s) 64 increases, gas circulation between compartments 36 and 38 increases, moving the insulating gas between the compartments and setting up thermal paths. SIR H975 has a discussion regarding the spaced distance and reference may be made thereto. Although not limiting to the invention, in the practice of the invention, it is preferred that there is minimal space between the edge of the intermediate sheet 32 and the base of the spaced frame or the

bead 64 if present. However, the invention contemplates any distance therebetween, e.g. a distance of 0 to about 1/4 inch (0.64 cm) and preferably about 1/32 inch (0.08 cm).

As can now be appreciated, the gap between the edge of the inner sheet and base of the spacer frame may be decreased by increasing the thickness of the bead. Further, as can be appreciated, any space between the edge of the sheet 32 and base of the spacer frame or bead 64 can be eliminated by providing a sheet retaining member sized to completely cover the top or bottom side of the spacer frame thereby preventing any air circulation between the compartments.

The discussion will now be directed to an embodiment of the invention to prevent air flow around the edges of the inner sheet(s) of the unit. With reference to Figs 17 and 18, bottom edge of unit 380 as viewed in Fig. 17 has a pair of edge receiving members 382, only one shown in Fig. 18 and clearly shown in Fig. 19 incorporating features of the invention. The sheet retaining members 33 as designed in Fig. 17 may be of the type discussed above, e.g. sheet retaining members 34 and 35, although the invention is not limited thereto. The edge receiving members 382 and sheet retaining members maintain the intermediate sheet 32 in position to provide the compartments 36 and 38 between the adjacent sheets 24, 26 and 32. Optionally muntin bars 384 discussed in more detail below are provided between the outer sheets 24 and 26, and as shown in Fig. 18 are mounted in the compartment 36.

The discussion will now be directed to the features of the instant invention to prevent gas currents moving along a vertical path around the top edge and bottom edge of the intermediate sheet 32. In the following discussion unless indicated otherwise the top edge of the intermediate sheet 32 is at the top of the glazing unit, and the bottom edge of the intermediate sheet 30 is at the bottom of the glazing unit, as used. The movement of gas i.e. gas currents around the top and bottom edges respectively of the sheet 32, results from warm gas moving upward and cool gas moving downward. In the

winter, the outer sheet of the glazing unit facing the house interior is heated, heating the gas in the compartment in contact with the heated outer sheet, and the outer sheet of the glazing unit facing the exterior of the house is cooled, cooling the gas in the compartment in contact with the cooled outer sheet. In the summertime, the outer sheet facing the exterior of the house is heated, and the outer sheet facing the interior of the house is cooled e.g. by air conditioning. There is minimal if any sideway movement of gas currents. To interrupt the gas flow or current, the flow around the top and/or bottom edge(s) of the intermediate or inner sheet 32 is(are) blocked or restricted. Gas flow may be restricted by minimizing the space between the bottom edge or top edge of the inner sheet 32 and the bead 64 if present or inner surface 68 of the base 44 if no bead 64 is present by, for example, having one of the edges e.g. the bottom edge of the inner sheet 32 as shown in Fig. 18 in contact with the bead 64 of the moisture pervious material or resting on or closely adjacent to the inner surface 68 of the base 44 of the spacer frame 26.

With reference to Fig. 19, in the practice of the invention, the edge receiving member 382 is mounted between the legs of the spacer frame 28 at the bottom of the unit or at the top of the unit as the unit is used. In the preferred practice of the invention, two or more edge receiving members 382 are mounted between the legs 40 and 42 of the spacer frame 28 as shown in Figs. 17 and 18 at the bottom edge of the unit 380. The edge receiving member 382 as shown in Figs. 18 and 19 has a generally "⌐⌙⌐" cross sectional configuration having a pair of horizontal members 390 that rest on the extensions 90 of the outer legs 40 and 42 of the spacer frame 28 (shown in Fig. 18), downwardly sloping wall members 392 as viewed in Fig. 19 connected to and extending from the horizontal members 390, and a horizontal base 394 interconnecting the sloping wall members 392. The bottom edge of the intermediate sheet 32 sets on the horizontal base 394.

The depth of the edge receiving member 382 i.e. the distance between the horizontal base 394 and the horizontal extensions 90 of the spacer frame 28 is selected such that the bottom surface of the horizontal base 394 as viewed in Fig. 18 rests on or slightly moves into the bead 64 of the moisture pervious material when the horizontal members 390 of the edge receiving members 382 are seated on the extensions 90. In this manner, the bottom edge of the inner sheet 32 when positioned on the horizontal base 394 of the edge receiving member 382 contacts the bead 64 of moisture pervious material with minimal, if any, sinking of the bottom edge of the inner sheet 32 into the bead 64. As can be appreciated, the invention is not limited to the position of the bottom edge of the inner sheet 32 to the bead 64; however, sinking the edge of the inner sheet 32 too far into the bead 64 may make the unit unsightly.

In order to position the inner sheet 32 into the edge receiving member 382 after the spacer frame 28 is formed, the inner sheet 32 is sized to fit within the interior opening of the closed spacer frame. More particularly, the distance between the sides of the inner sheet 32 should be less than the distance between the sides of interior opening of the closed spacer frame 28. The distance between the top edge and bottom edge of the inner sheet 32 is selected to permit setting of the bottom edge or top edge of the inner sheet 32, as the case may be, in the edge receiving member 382 and moving the other edge of inner sheet within the interior opening of the closed spacer frame into contact with a sheet receiving member.

As can be appreciated, the edge receiving member 382 may be a continuous piece extending across the bottom side or top side of the spacer frame or may be a plurality of spaced members as shown in Fig. 17. The invention is not limited to the length of the edge receiving members; however, if a continuous piece is not used at least two edge receiving

members are preferably used to balance the inner sheet between the legs of the spacer frame.

With reference to Fig. 20, the unit 400 has two inner or intermediate sheets 32 and 260 having their bottom edges, in edge receiving member 402. The edge receiving member 402 shown in Fig. 20 is similar to the edge receiving member 382 shown in Fig. 19 except that the edge receiving member 402 has two grooves 408 and 410 formed by the downwardly sloping wall members 404 and intermediate member 406 mounted are formed as part of the horizontal base 407.

With reference to Fig. 18, in the following discussion and not limiting to the invention the bottom edge of the inner sheet 32 is mounted in the edge receiving member 382. The sides and top edge of the inner sheet 32 are held in position by sheet engaging members 33 e.g. sheet engaging members 34 and 35 of the type discussed above (see Figs. 2, 3, 21 and 22). As can be appreciated, instead of mounting the bottom edge of the inner sheet 32 in the edge receiving member, the top edge of the inner sheet may be mounted in an edge receiving member, and the bottom edge of the inner sheet may be held in position by the sheet engaging members.

In the construction of multi-sheet glazing units, when muntin bars 384 are used, it is preferred to provide the muntin bars 384 between the outer sheets 24 and 26. With reference to Figs. 18, 20, 21 and 22 as required, the muntin bars 384 are shown mounted in the edge receiving member(s) 382 (see Fig. 18) and 402 (see Fig. 20) and the sheet retaining members 34 and 35 (see Figs. 21 and 22). The construction of muntin bars is well known to those skilled in the art of fabricating multi-sheet glazing units and is not limiting to the invention, therefore, a detailed discussion of the muntin bars is not deemed necessary and reference may be had to U.S. Patent No. 5,313,761 to Glass Equipment Development Inc. and to U.S. Patent No. 5,099,626 to Allmetal Inc., which disclosure is hereby incorporated by reference for a more detailed discussion of muntin bars.

The muntin bars 384 may be mounted to the edge receiving members 384 (Fig. 19) and 402 (Fig. 20) and the sheet retaining members 34 (Fig. 21) and 35 (Fig. 22) in any convenient manner. For example and with reference to Figs. 19 and 23, the end 408 of the muntin bar 384 is mounted and seated within a hole 410 provided in the extension 88 of the sheet retaining member 34 and the hole 410 provided in horizontal member 390 of the edge receiving member 382 shown in Fig. 18. The hole 410 may extend through the extension 88 and horizontal member 390 to rest on the horizontal extensions 90 of the outer legs 40 and 42 of the spacer frame 28. The hole 410 and end 408 of the muntin bar 384 are sized to have a pressure fit.

As can be appreciated, the muntin bar 384 may be secured to the edge receiving members and the edge retaining members by a muntin clip. For example, and with reference to Fig. 24, a muntin clip 412 has a plurality of downwardly shaped ribs 414 which are mounted in the end 416 of a muntin bar 418. The muntin clip 412 has a base 420 having a periphery greater than the inside diameter of the end 422 of the muntin bar 424 and the hole 426 in the sloping surface 296 of the sheet engaging member 280 of modified sheet retaining member 35 to prevent the muntin clip 412 from sliding into the end 422 of the muntin bar 424 or the hole 426. On the other side of the base 420 are a pair of clips or "L" shaped legs 428 which are insertable into hole 426 in the sloped surface 296. The spacing of the walls of the hole 426 is greater than the spread of the legs 428 to capture the muntin clip 412 on the sheet engaging member 280. The L-shaped legs 428 of the muntin clip 412 are biased toward one another as the legs 428 are moved into the hole 426. The legs 428 move away from one another as the base 420 of the clip is seated on the sloping surface 296 to capture the clip 412 in the hole 426. The arrangement for mounting the muntins to the edge retaining member is preferably the same arrangement to mount the muntins to the edge receiving member.

The invention will be discussed to make a glazing unit similar to the unit 20 having a closed spacer frame made from a continuous piece of spacer stock. Each of the outer sheets 24 and 26 are as previously discussed. The inner sheet 32 is a clear glass sheet having a length of about 42 3/16 inches (106.68 cm) and a width of about 18 1/2 inches (46.99 cm), and the inner sheet has a thickness of about 0.070 inch (0.178 cm). The sheets are coated as previously discussed.

With reference to Fig. 19, two edge receiving members 382 (one only shown in Fig. 19) are provided, each member 382 has a thickness of about 0.031 inch (0.079 cm), a length of about 3/8 inch (0.925 cm) and are made of polyurethane. Each of the horizontal members 390 have a width of 0.079 inch (0.20 cm) and the horizontal base 394 has a width of about 0.076 inch (0.19 cm). The sloping members 392 have a width of 0.118 inch (0.30 cm) and a slope of about 36.5 degrees. One of the horizontal legs e.g. the left horizontal leg 390 as viewed in Fig. 19 has a hole for receiving the L-shaped legs 422 of the muntin clip 412. An edge receiving member 382 is mounted at each of the quarter points on the bottom leg of the spacer frame.

Six sheet retaining members 34 or 35 having holes to receive the muntin clip 412 are mounted to the remaining legs of the spacer frame as previously discussed.

The muntin clips 412 are mounted in the ends 416 of the muntin bars formed in a lattice as shown by dotted lines in Fig. 17 in any usual manner, and the muntin clips are mounted in the holes of the edge receiving members 382 and the holes of the sheet retaining members 34 or 35 to position the muntin bars within the interior opening of the closed spacer frame. The outer sheet 24 is thereafter positioned on the adhesive layer 30 on the outer surface of the outer leg 40 of the spacer frame 26. The bottom edge of the inner sheet 32 is positioned on the horizontal base 394 of the sheet receiving member 382 and pivoted into the interior opening of the closed

spacer frame to move the sides and top edge of the inner sheet 32 into engagement with the sheet retaining member 34 or 35 depending on the retaining member used as previously discussed. Thereafter, the designated inner surface of the outer sheet 24 is adhered to the leg 40 of the spacer frame 26 by the layer 28 of the adhesive-sealant to provide the arrangement shown in Fig. 21 when the sheet retaining member 34 is used or the arrangement shown in Fig. 22 when the sheet retaining member 35 is used.

As can now be appreciated, the invention is not limited to the number of inner sheets. For example, and with reference to Fig. 20, the sheet retaining members shown in Figs. 16 and 11 may be used with the edge receiving member 402 (see Fig. 20) to provide a glazing unit having four sheets. The inner sheet 32 is mounted in the groove 408 of the edge receiving member 402 and pivoted into the interior opening of the closed spacer frame into engagement with a sheet retaining member of either Fig. 11 or 16 as previously discussed. Thereafter, the bottom edge of the inner sheet 260 is positioned in the other groove 410 of the edge receiving member 402 and pivoted into the interior opening of the closed spacer frame into engagement with the sheet retaining member of either Fig. 11 or 16 to secure the inner sheets 32 and 260 within the spacer frame.

In the instance when muntin bars are used, the separator 263 for the sheet retaining member 34 (see Fig. 11) or the separator 340 for the sheet retaining member 35 (see Fig. 16) and the intermediate member 406 of the edge receiving member 402 are provided with holes to receive the muntin clip 412. The sheet retaining members and edge receiving members are mounted within the spacer frame. Thereafter the inner sheet e.g. the inner sheet 32 is secured in position with the spacer frame. The muntin bars are mounted within the spacer frame and the other inner sheet is secured within the spacer frame.

It is recommended that two edge receiving members be used to balance the inner sheets and the number of sheet retaining members should be used at the side of the spacer frame to give the unit a balanced appearance. In the instance where the muntin lattice has only one leg and edge receiving members and sheet retaining members are used at the quarter points, three edge receiving members and three sheet retaining members are recommended to support the muntin lattice and give a balanced appearance.

In the preferred embodiment of the invention, an edge receiving member having features of the invention was used; however, the invention may be practiced without an edge receiving member and prevent gas flow around the top and bottom edges of the inner sheet as used. More particularly, and with reference to Fig. 25, a groove 430 formed by a pair of beads 432 of the moisture impervious material having a desiccant is provided on the bead 44 of the spacer frame 28 as disclosed in U.S. Patent No. 5,531,047. The bottom edge of the inner sheet 30 is positioned in the groove 430 and the inner sheet 32 pivoted into the interior opening of the closed spacer frame to capture the sides and top edge of the inner sheet in the edge retaining members as previously discussed. Further, the sheet retaining member of U.S. Patent No. 5,553,440 and the spacer frame having raised portions on the base as disclosed in U.S. Patent No. 5,644,894 may be used to hold the bottom edge of the inner sheet(s) in position between the outer legs 40 and 42 of the spacer frame 26.

In all the previous examples for constructing units, if the layer 48 of the adhesive-sealant was not provided on the outer surface 50 of the base 44 of the spacer frame 28, the layer 48 of the adhesive-sealant is flowed into the channel 54 formed by the marginal edge portions of the sheets 24 and 26 and the outer surface 50 of the base 44 of the spacer frame 28.

As can be appreciated, the bead 64 having the desiccant 66 may be extruded before, after, or during the

extrusion of the layers 30. Further, the layer 48 may be applied during or after the strip is formed into spacer stock. Still further, as now can be appreciated, the invention is not limited to the sequence of steps to make the unit. For example, and not limiting to the invention, after the spacer frame having the bead 64 is provided, the sheet retaining members 34 are mounted on the closed frame. Thereafter the intermediate sheet 32 is secured in position, the layer 30 and sheets 24 and 26 are mounted on the legs 40 and 42 respectively of the spacer frame.

As can now be appreciated, the invention is not limited to the embodiments of the glazing units or the components used in the fabrication of the units discussed above, and additional embodiments can be made within the scope of the invention. For example, and with reference to Fig. 26 and edge receiving members, the ends 90 of the spacer frame 28 may have cutouts 434 to minimize sideward movement of the sheet retaining members along the elongated side of the spacer frame and for specifying location of the sheet retaining members and edge receiving members. Further, the arrangement to secure the sheet retaining member on the legs of the spacer frame may be interchanged and may be used with the edge receiving member.

The scope of the invention is only limited by the scope of the following claims.

WHAT IS CLAIMED IS:

1. A sheet retaining member comprising:

a support means, and

a pair of flexible fingers, each finger having a first side and an opposite side designated as a second side with the first side of one finger mounted to a side of the support means and the first side of the other finger mounted to the other side of the support means with the fingers extending above upper surface of the support facilities toward one another, the fingers in an unbiased position are spaced from the base and the second side of each finger in a fixed relationship to one another.

2. A sheet retaining member comprising:

a sheet engaging member having a vertical stop and a non-vertical support, and

a member securable on the non-vertical support to cooperate with the vertical stop to form a groove.

3. The sheet retaining member according to claim 1 or 2 wherein the sheet engaging member includes a support portion for securing the sheet engaging member on a spacer frame having a U-shaped cross-section.

4. A multi-sheet glazing unit comprising:

a spacer frame having a base and opposed legs connected to one another to have a generally "U" shape;

a sheet on outer surface of each of the opposed legs;

a sheet retaining member comprising:

support means mounted on the spacer frame spaced from the base and between the sheets, and

a sheet engaging member mounted on the support means between the sheets to provide a sheet retaining member, the sheet retaining member having a pair of flexible fingers, each finger having a first side and an opposite side designated as a second side with the first side of each finger mounted to the sheet engaging member spaced from one another with the fingers extending over the support means with the second side of each finger facing one another, and

a third sheet mounted between the second end of the fingers to secure the third sheet in position between the outer sheets.

5. The glazing unit according to claim 4 wherein the support means has a first surface with the fingers spaced from the first surface and an opposite surface defined as a second surface, the second surface having securing means, the legs of the spacer frame have end portions extending over the base toward one another defined as end portions and the securing means cooperating with the end portions to mount the support means on the outer legs of the spacer frame.

6. The glazing unit according to claim 5 wherein the sheet engaging member has at least three flexible fingers with at least two fingers on one side of the support means and at least one finger on the other side of the support means.

7. The glazing unit of claim 5 further including a fourth sheet between the fingers and spaced from the third sheet by a sheet separator.

8. A multi-sheet glazing unit comprising:

a spacer frame having a base and opposed legs connected to one another to have a generally "U" shape;

a sheet on outer surface of each of the opposed legs;

a sheet retaining member comprising:

support means mounted on the spacer frame spaced from the base and between the sheets;

a sheet engaging member mounted on the support means between the sheets to provide a sheet retaining member, the sheet retaining member having a groove facing the interior of the spacer frame, the groove formed by a wall defined as a first wall lying in a plane defined as a first plane intersecting the base, and

a securing member secured to the sheet retaining member, the securing member having a wall defined as a second wall lying in a plane defined as a second plane transverse to the base and spaced from the first plane, and

a third sheet mounted within the groove of the sheet engaging member to secure the third sheet in position between the outer sheets.

9. The glazing unit of claim 8 wherein the groove formed by the sheet engaging member and securing member has a sheet separator therein to provide two channels with the third sheet in one channel and further including a fourth sheet in the other channel.

10. The glazing unit according to claim 4 or 8 wherein the spacer frame has a generally "U" shaped cross section and the support means is mounted on the outer legs.

11. The glazing unit according to claim 10 further including a shim mounted between the outer legs of the spacer frame and between the sheet engaging member and the base of the spacer frame.

12. The glazing unit according to claim 4 or 8 wherein the sheet retaining member is formed as one piece.

13. The glazing unit according to claim 4 or 8 wherein the spacer frame has a rectangular cross section with the base of the spacer frame away from the inner surface of the spacer frame and the side opposite the base designed as the upper side facing the interior of the spacer frame and the sheet retaining member is mounted on the upper side.

14. The glazing unit according to claim 4 or 8 wherein each elongated side of the spacer frame has at least two sheet retaining members spaced from one another.

15. The glazing unit according to claim 4 or 8 wherein the unit has compartments between the sheets on the legs of the spacer frame and the third sheet and further including a water reducing film on at least one major surface of the sheets on the spacer frame facing at least one of the compartments.

16. The glazing unit according to claim 4 or 8 wherein the outer surface of at least one of the outer sheets includes a photocatalytic film.

17. The glazing unit according to claim 4 or 8 wherein the sheets are glass sheets, the spacer frame is made of metal and selected major surfaces of the sheets have a coating to selectively pass selected ultraviolet wavelengths of the ultraviolet visible and/or infrared.

18. The glazing unit according to claim 10 wherein the support means has opposed recesses, the legs of the spacer frame have end portions extending over the base toward one another and the support means is mounted on the outer legs with ends of the outer legs in the recesses.

19. The glazing unit according to claim 4 or 8 further including means for reducing gas movement around the third sheet.

20. The glazing unit according to claim 19 wherein the means for reducing gas movement includes the sheet retaining member extending along an elongated side of the spacer frame.

21. A multi-sheet glazing unit having a closed ended spacer frame having an interior opening and an outer sheet attached to each side of the spacer frame and an inner sheet between the outer sheets, the improvement comprising:

the spacer frame has at least one side having a pair of outer legs and a base to provide the at least one side with a U shaped cross section;

the inner sheet having peripheral and marginal edge portions inserted between the pair of outer legs and remaining peripheral and marginal edge portions of the inner sheet within the interior opening of the closed spacer frame and spaced from the spacer frame, and

means for engaging selected remaining peripheral and marginal edge portions of the inner sheet mounting the spacer frame to maintain the inner sheet in position in the interior opening of the spacer frame between the outer sheets.

22. The unit of claim 21 wherein the means for engaging the peripheral and marginal edge portions of the

sheet between the outer legs is defined as an edge receiving member and the means for engaging is defined as a sheet engaging member.

23. The unit of claim 22 wherein gas movement around the peripheral and marginal edge portions of the inner sheet between the outer legs of the spacer frame is minimized.

24. The unit of claim 23 wherein the spacer frame has four sides designated as a top side, a bottom side, a first side and a second side, each of the sides has a U-shaped cross section having a pair of outer legs joined to a base to have a U-shaped cross section with the peripheral and marginal edge portions of the inner sheet between the outer legs of the bottom side.

25. The unit of claim 24 wherein the sheet engaging members each include:

a sheet engaging member having an intersection formed by a vertical stop and a non-vertical support, and

a member securable on the non-vertical support spaced from the vertical stop to form a groove wherein peripheral and marginal edge portion of the inner sheet is in the groove.

26. The unit of claim 25 wherein the outer legs of the spacer frame have portion extending toward one another over the base and further including means for securing the sheet engaging member on the portions of the outer legs extending toward one another over the base.

27. The unit of claim 24 wherein the edge receiving member is a groove on the base of the bottom side of the spacer frame between the outer legs for receiving peripheral and marginal edge portions of the inner sheet.

28. The unit of claim 27 wherein the edge receiving member is a pair of beads on the base of the spacer frame spaced from one another to provide a groove to receive peripheral and marginal edges of the inner sheet.

29. The unit of claim 27 wherein the groove of the edge receiving member is formed by a base joined to a pair of sloping wall members, the sloping walls mounted on the outer legs of the bottom side of the spacer frame.

30. The unit of claim 29 wherein the outer legs of the spacer frame have portions extending toward one another over the base and the edge receiving member further includes members defined as horizontal members extending from the sloping walls to mount the edge receiving member between the outer legs with the horizontal members mounted on the portions of the outer legs extending toward one another.

31. The unit of claim 30 further including a muntin bar lattice mounted in one of the compartments by inserting one end of the muntin bar lattice in a hole formed in one of the horizontal members of the edge receiving member.

32. The unit of claim 30 further including a muntin bar lattice mounted in one of the compartments by a muntin clip having one end in an end of the muntin bar lattice and other end secured to a horizontal member of the edge receiving member.

33. The unit of claim 4, 5 or 21 further including a muntin lattice in one of the compartments, the muntin lattice having ends, with an end of the muntin lattice mounted in a hole formed in the support means of the sheet retaining member.

34. The unit of claim 4, 5 or 21 further including a muntin lattice in one of the compartments, the muntin lattice having ends and further including a muntin clip having one end inserted in ends of the muntin bar lattice and the other end detachably secured to support means of the sheet engaging members.

35. The unit of claim 21 wherein the unit has two inner sheets between the outer sheets.

36. The unit of claim 35 further including a muntin lattice between the inner sheets.

37. A method of making a multi-sheet glazing unit comprising the steps of:

providing a spacer frame;

providing a plurality of sheet retaining member, at least one of the sheet retaining members having a pair of flexible fingers, the fingers having a first side and a second side with the first side secured to a platform and the fingers extending over the platform toward one another;

mounting the sheet retaining members on the spacer frame spaced from one another with the fingers facing interior of the spacer frame;

biasing a sheet toward the interior of the space frame against one of the fingers of the at least one sheet member to move the finger toward the platform;

continuing the practice of the biasing step until the sheet has passed the second end of the finger moved toward the platform;

discontinuing the biasing step; and

securing an outer sheet on each side of the spacer frame to provide the multi-sheet glazing unit.

38. The method as set forth in claim 37 further including the step of

after the practice of the biasing step, positioning a sheet separator on the platform;

providing a fourth sheet;

practicing the biasing step, the continuing step and the discontinuing step using the fourth sheet, and

practicing the securing step.

39. A method of making a multi-sheet glazing unit comprising the steps of:

providing a spacer frame;

providing a plurality of sheet retaining member, at least one of the sheet retaining members having a vertical portion and a non-vertical portion to provide an edge stop and a securing member;

mounting the sheet retaining members on the spacer frame spaced from one another with the edge stop facing interior of the spacer frame;

biasing edge portions of a sheet against the stop;

positioning the securing member on the non-vertical portion to form a groove having the edges of the sheet therein; and

securing an outer sheet on each side of the spacer frame to provide the multi-sheet glazing unit.

40. The method as set forth in claim 39 further including the step of

after the practice of the biasing step, positioning a sheet separator on the non-vertical portion against the sheet, biasing another sheet

against the sheet separator and thereafter practicing the positioning step.

41. A method of making a multi-sheet glazing unit comprising the steps of:

providing a closed ended spacer frame having an interior opening and at least one side having a U shaped cross section defined by a base and a pair of outer legs;

positioning on edge of an inner sheet between the legs of the at least one side and moving the inner sheet into the interior opening of the spacer frame;

securing edges of the inner sheet to maintain the inner sheet within the interior opening of the closed frame, and

securing an outer sheet on each side of the spacer frame to provide the multi-sheet glazing unit.

42. The method of claim 37, 38 or 41 further including the step of securing a muntin bar lattice within the interior of the spacer frame.

43. The method of claim 41 further including the step of repeating the positioning and securing edge steps to provide two sheets within the interior of the spacer frame spaced from one another and the outer sheets.

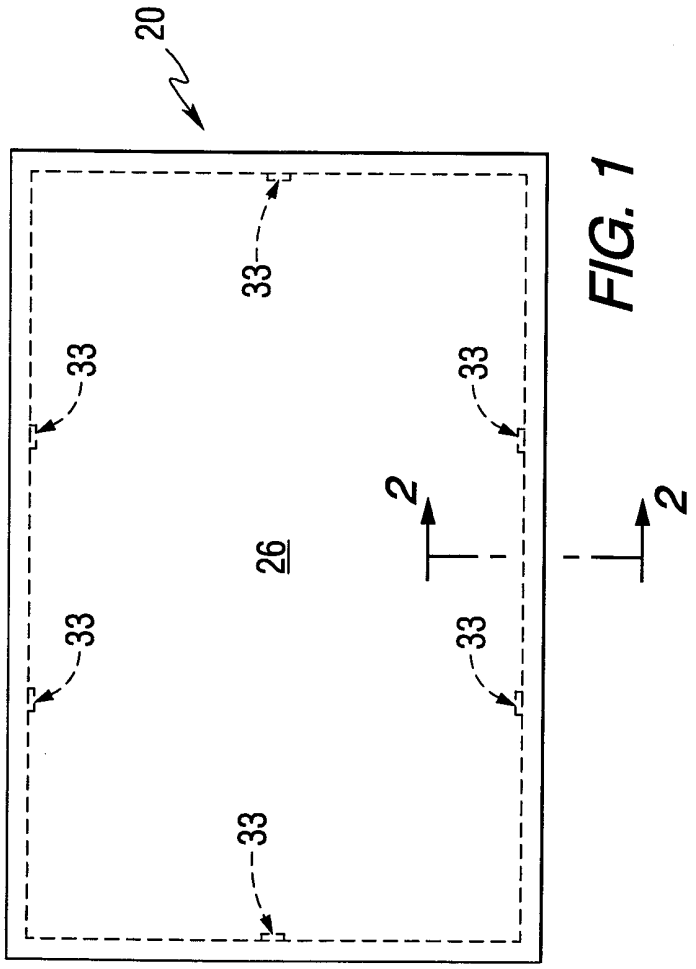
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FIG. 1

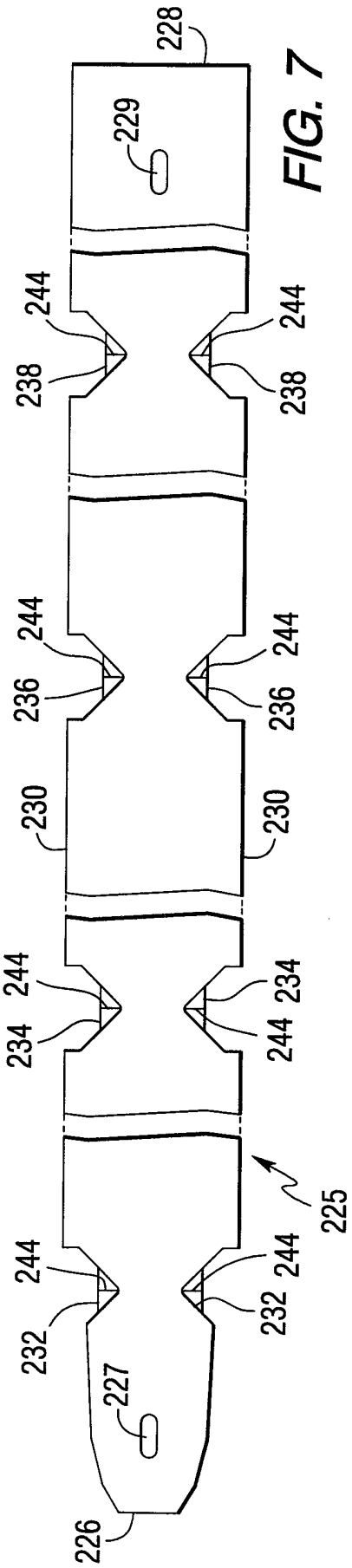
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FIG. 7

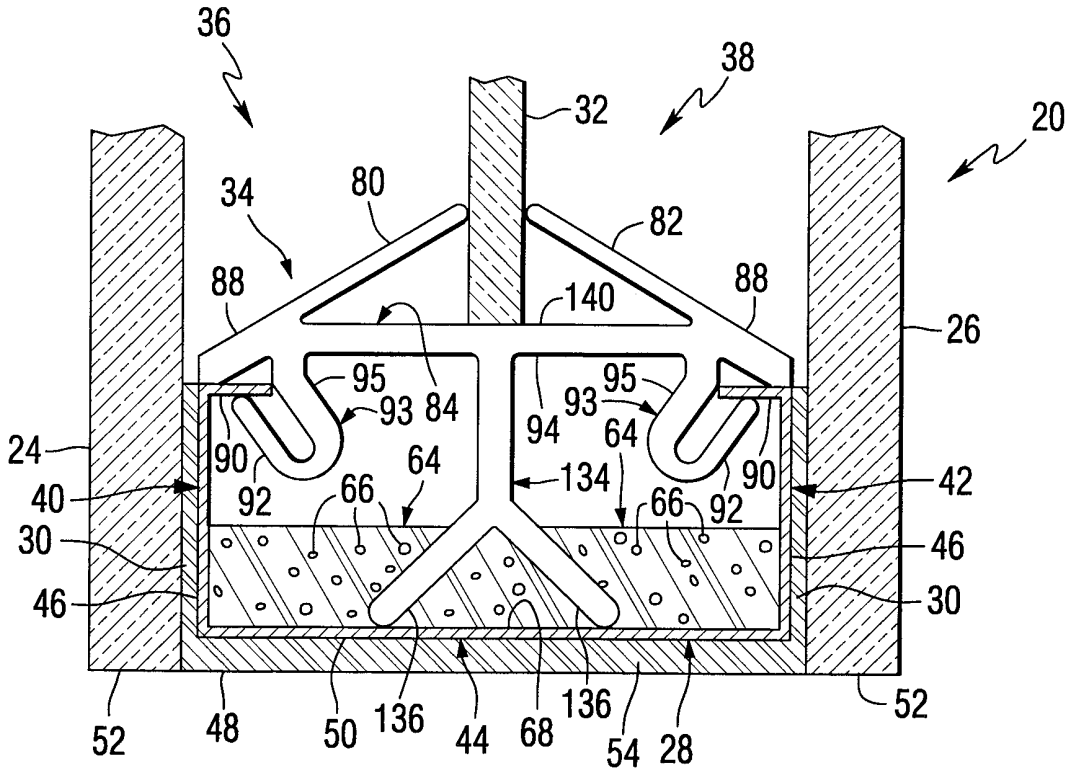
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FIG. 2

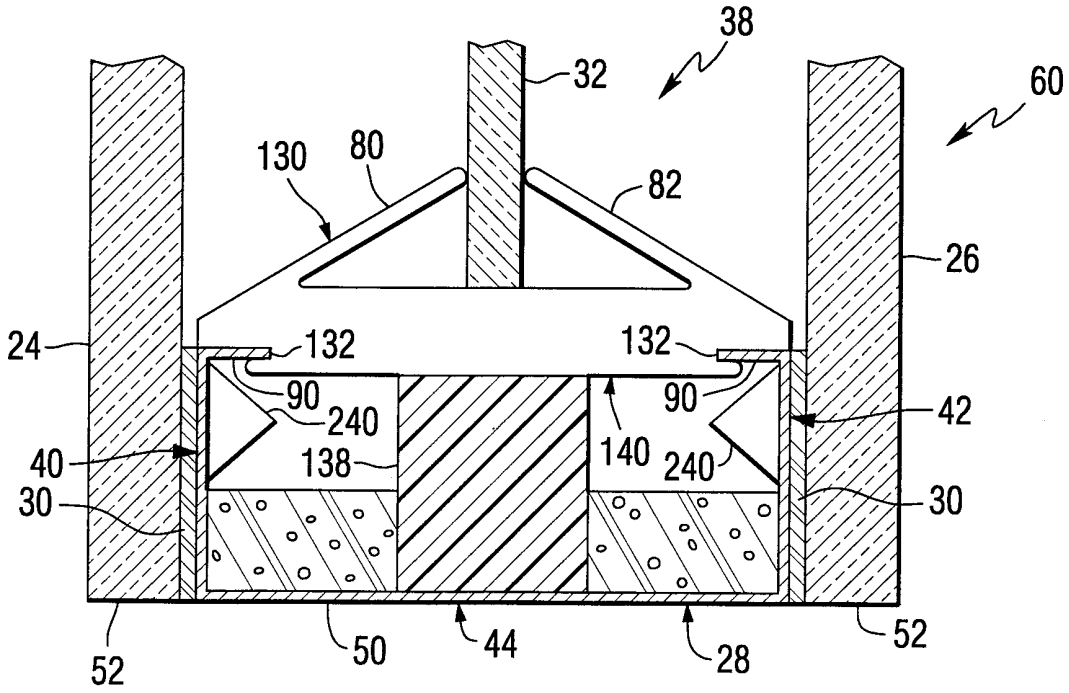
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FIG. 4

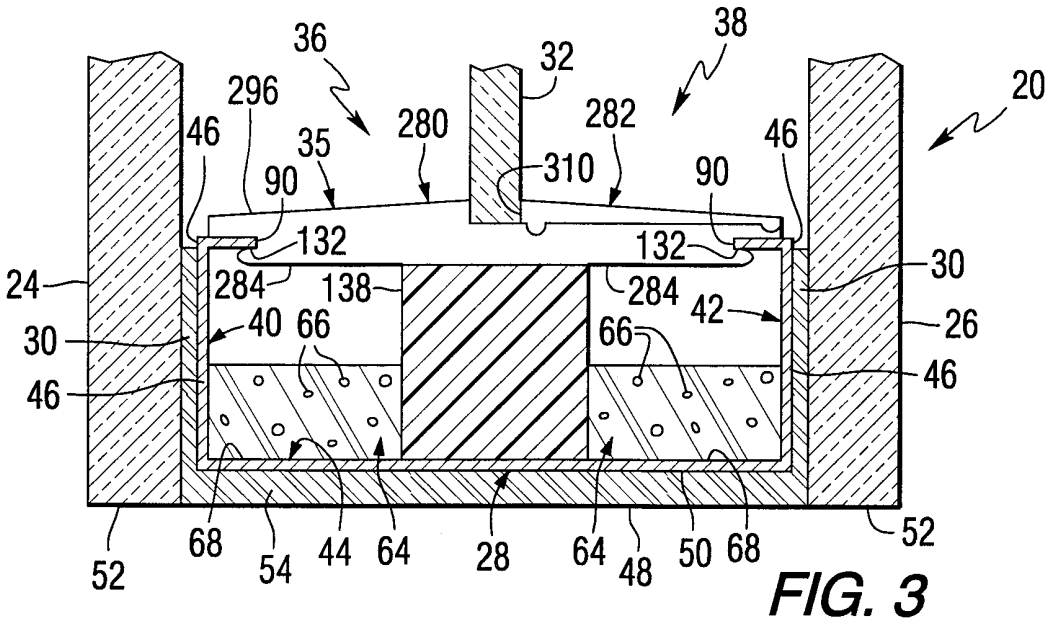

FIG. 3

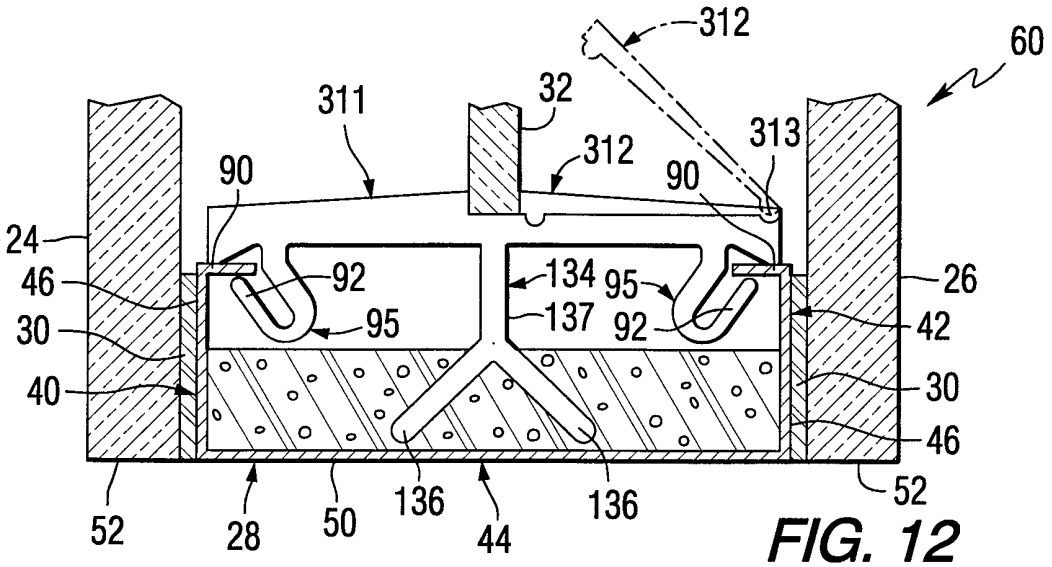

FIG. 12

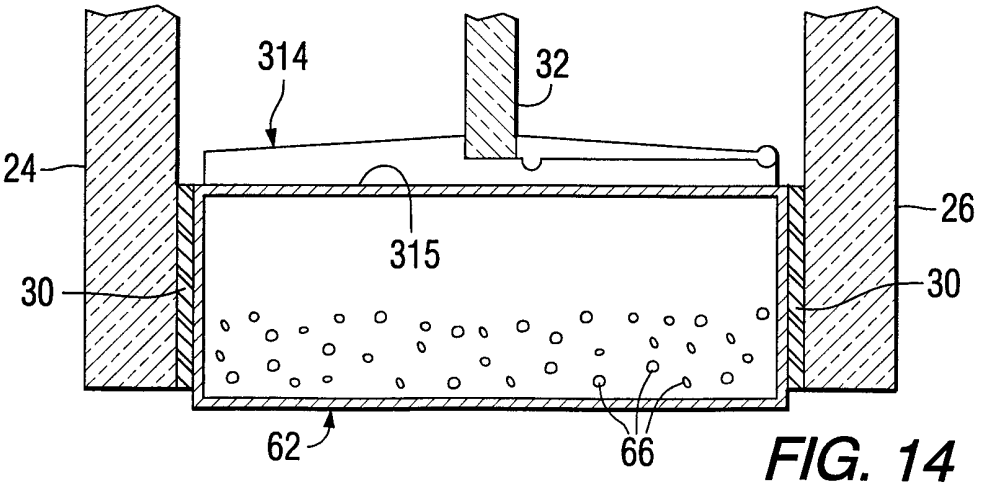

FIG. 14

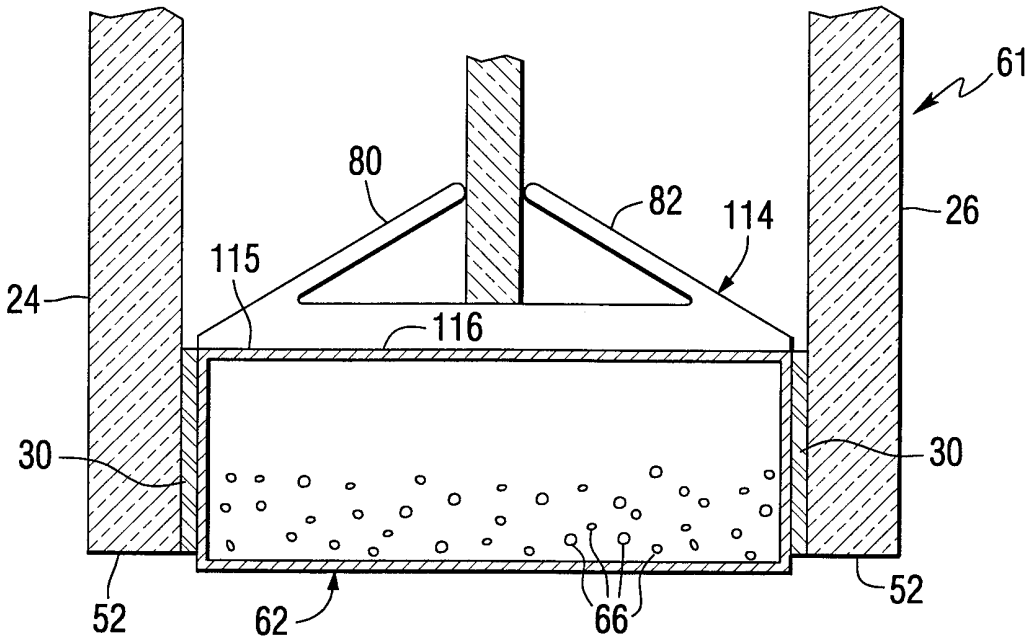
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FIG. 5

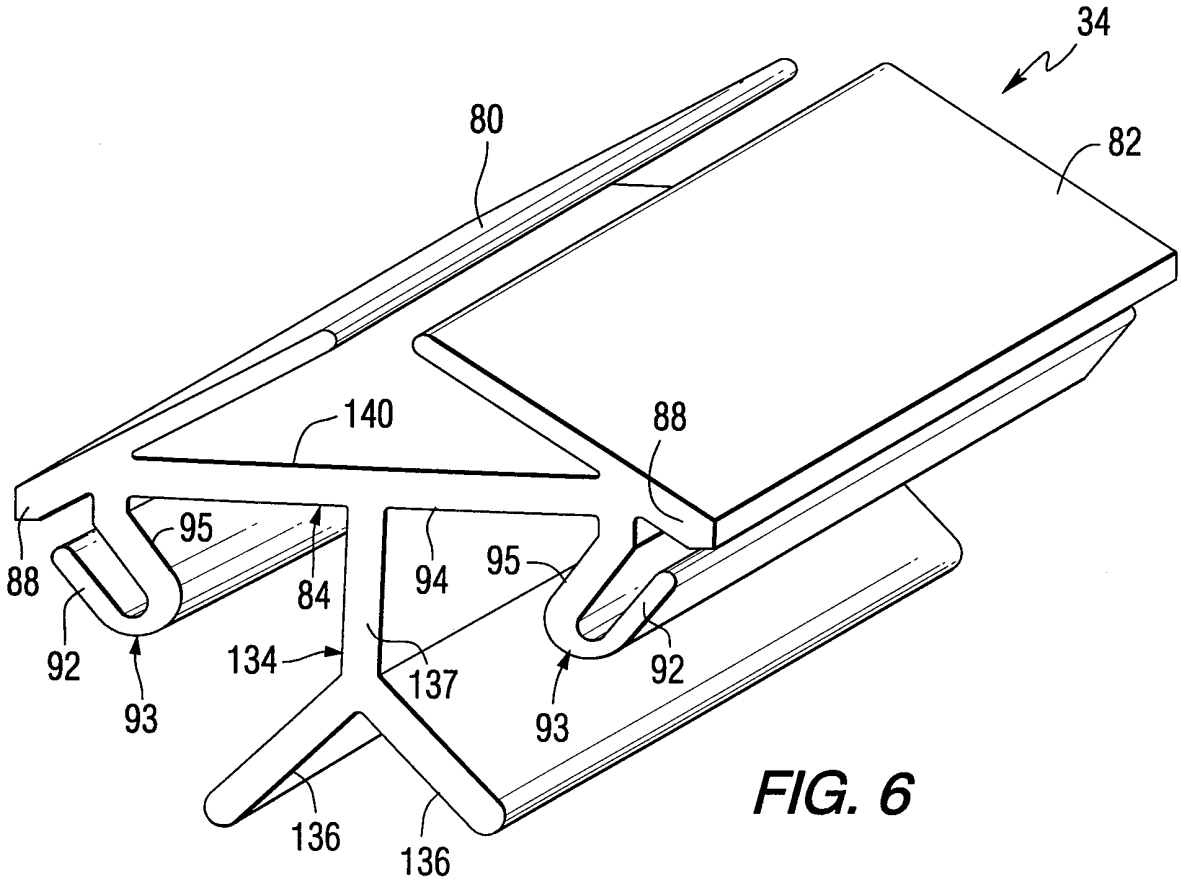
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FIG. 6

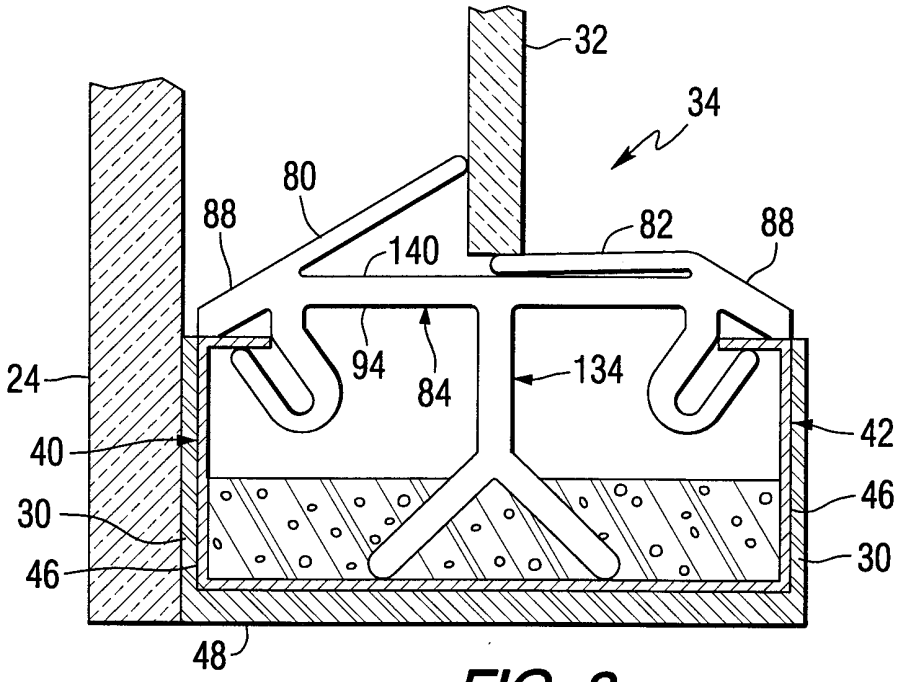
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FIG. 8

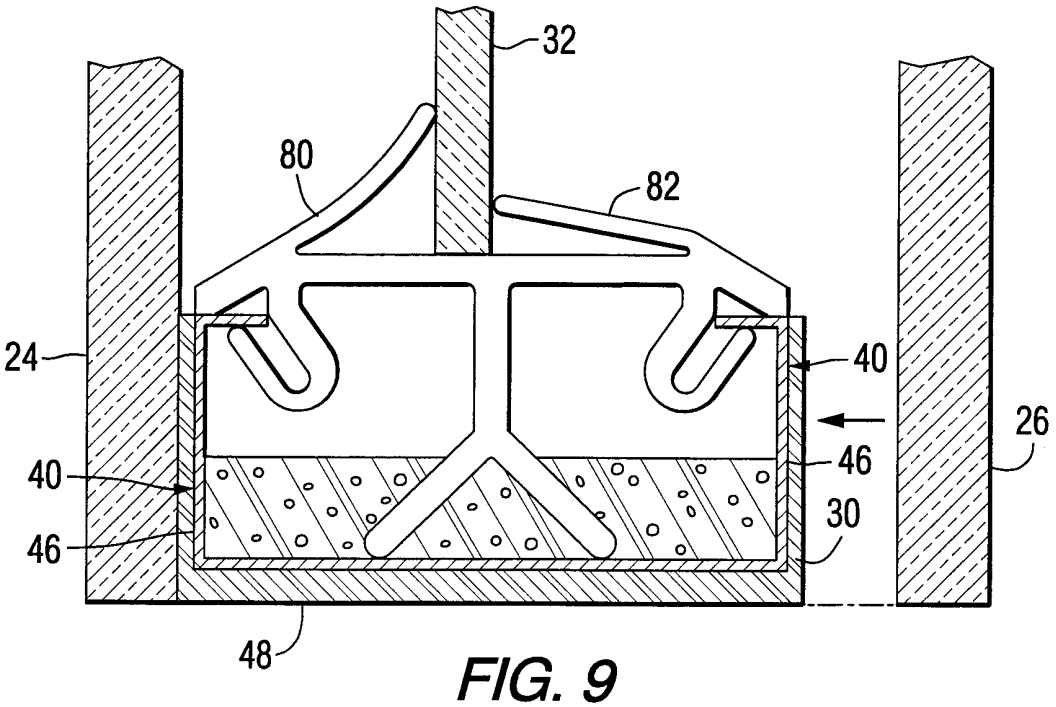
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FIG. 9

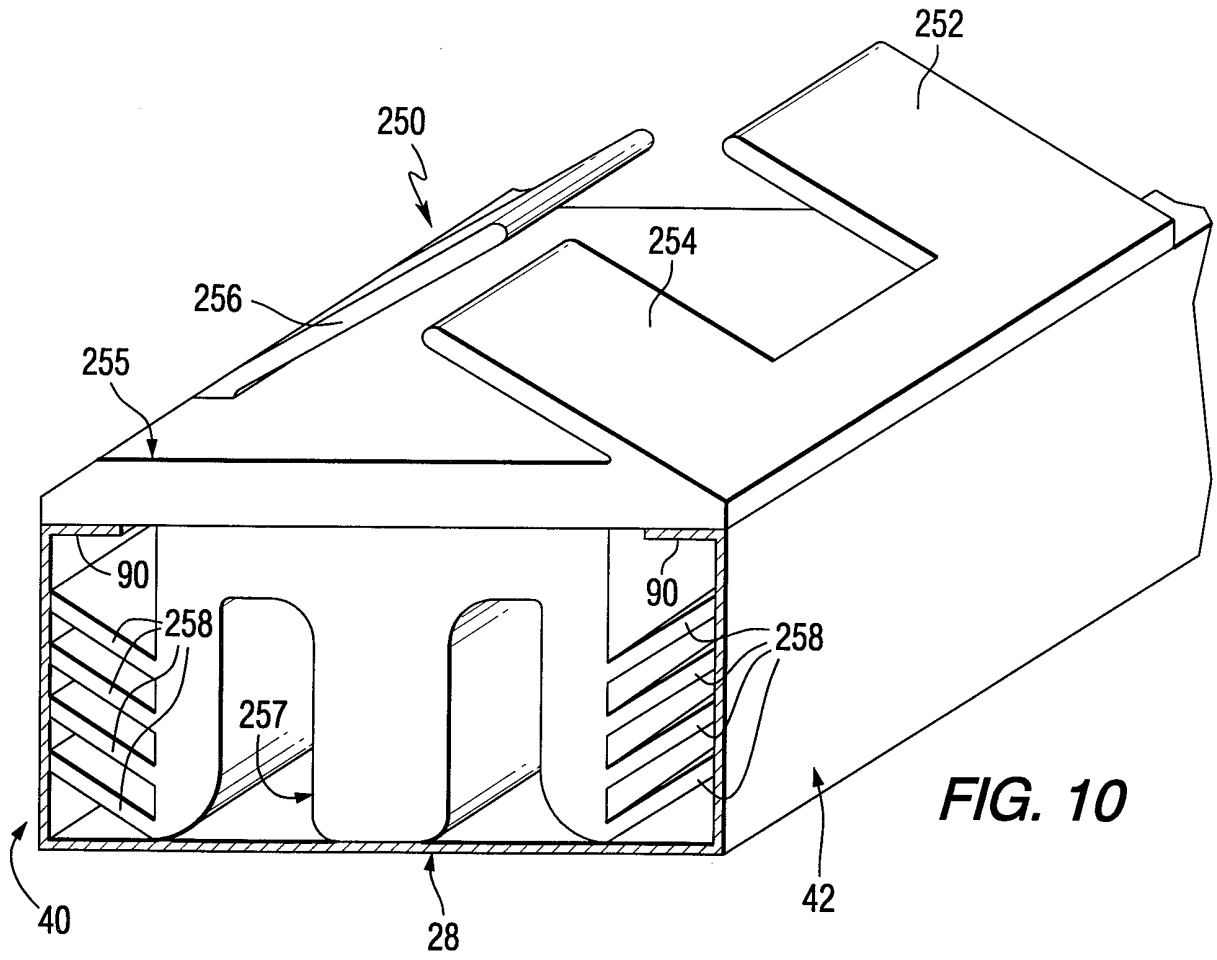
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FIG. 10

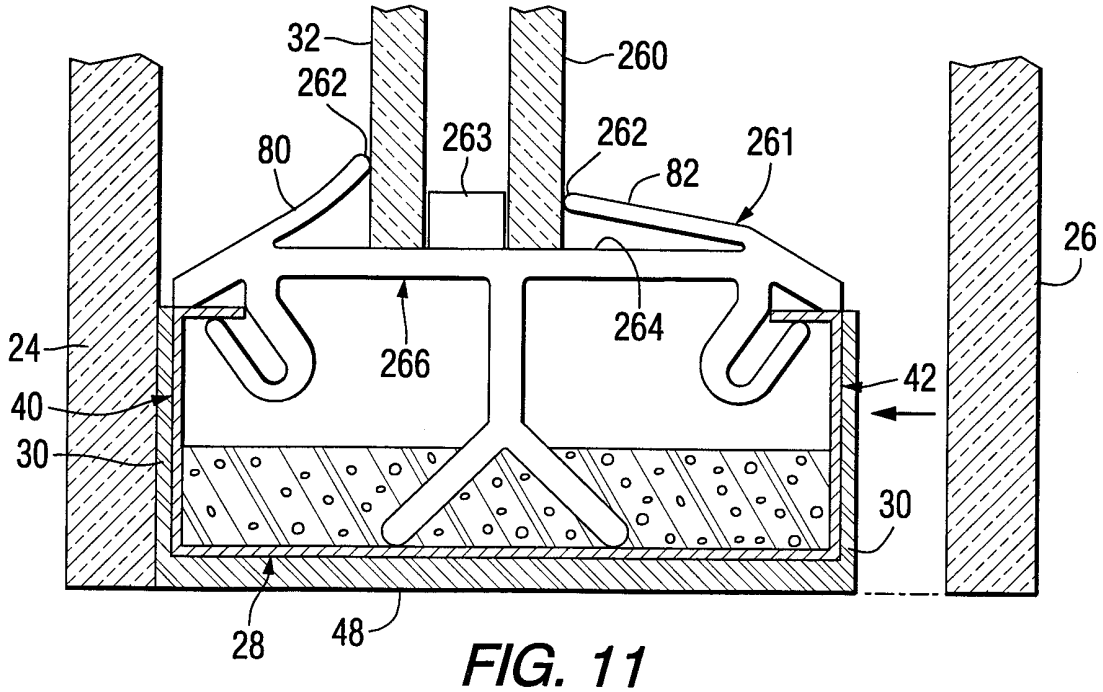
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FIG. 11

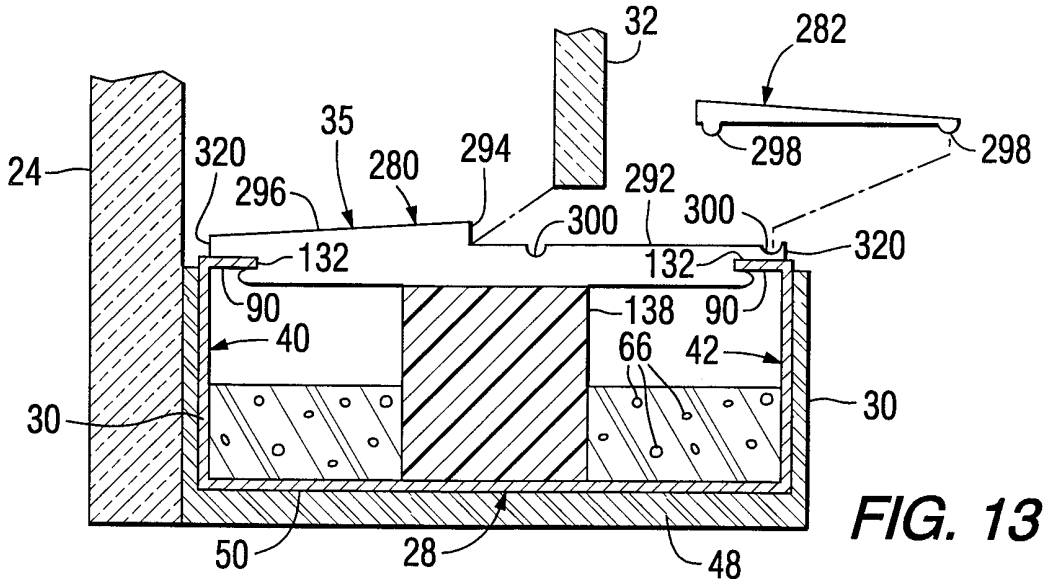

FIG. 13

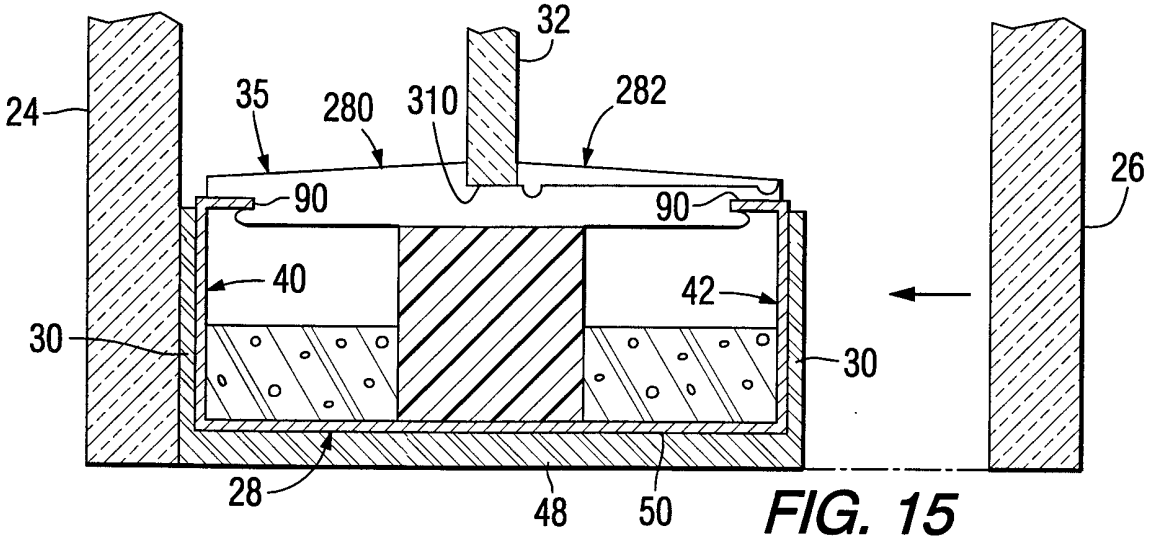

FIG. 15

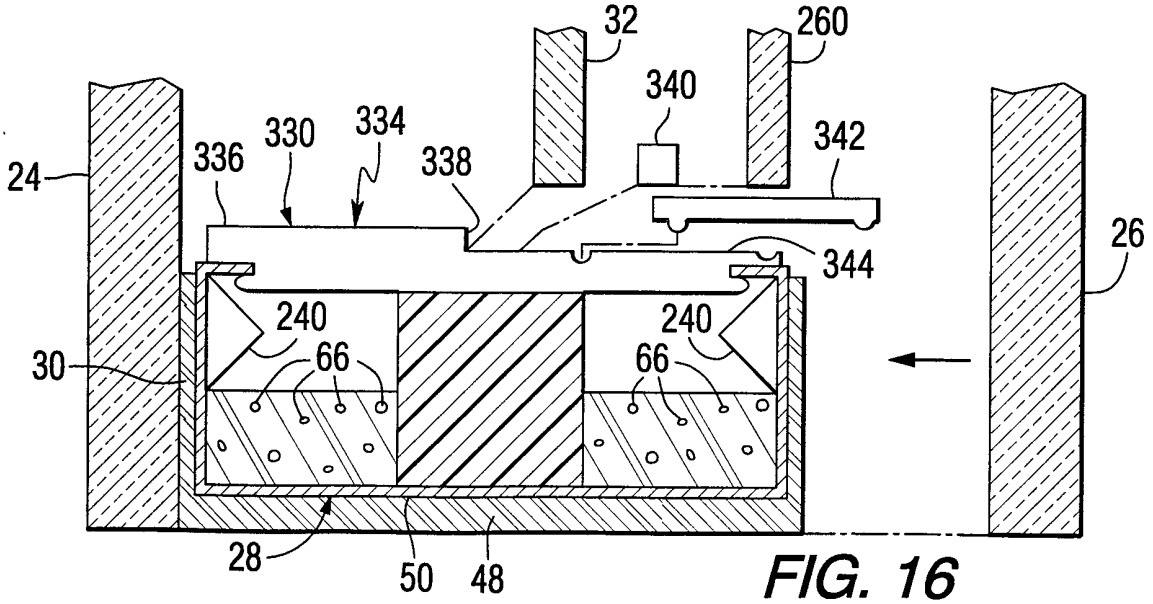

FIG. 16

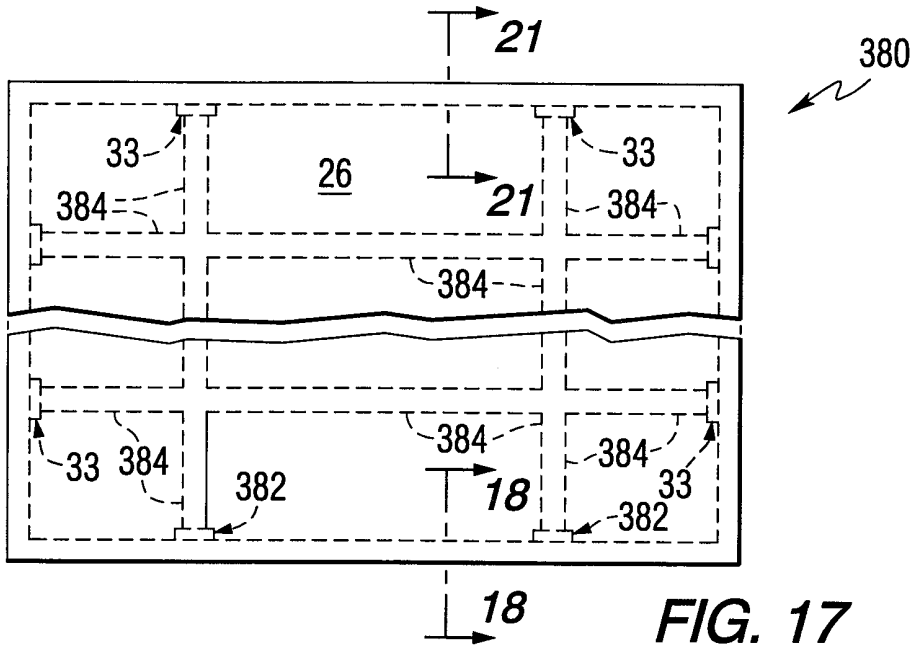

FIG. 17

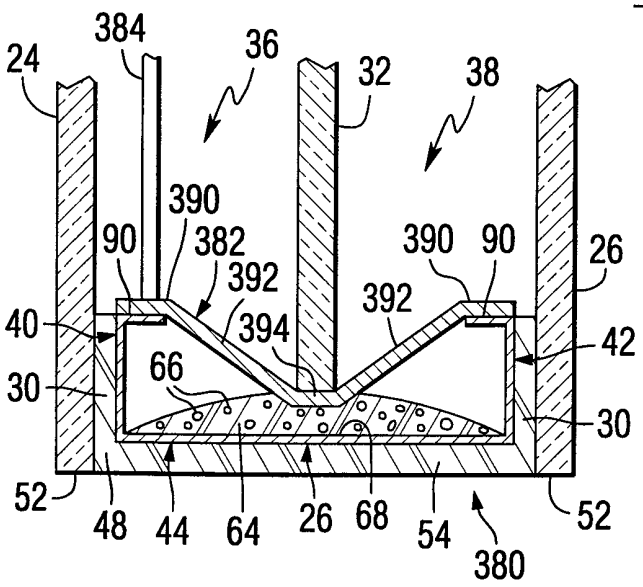

FIG. 18

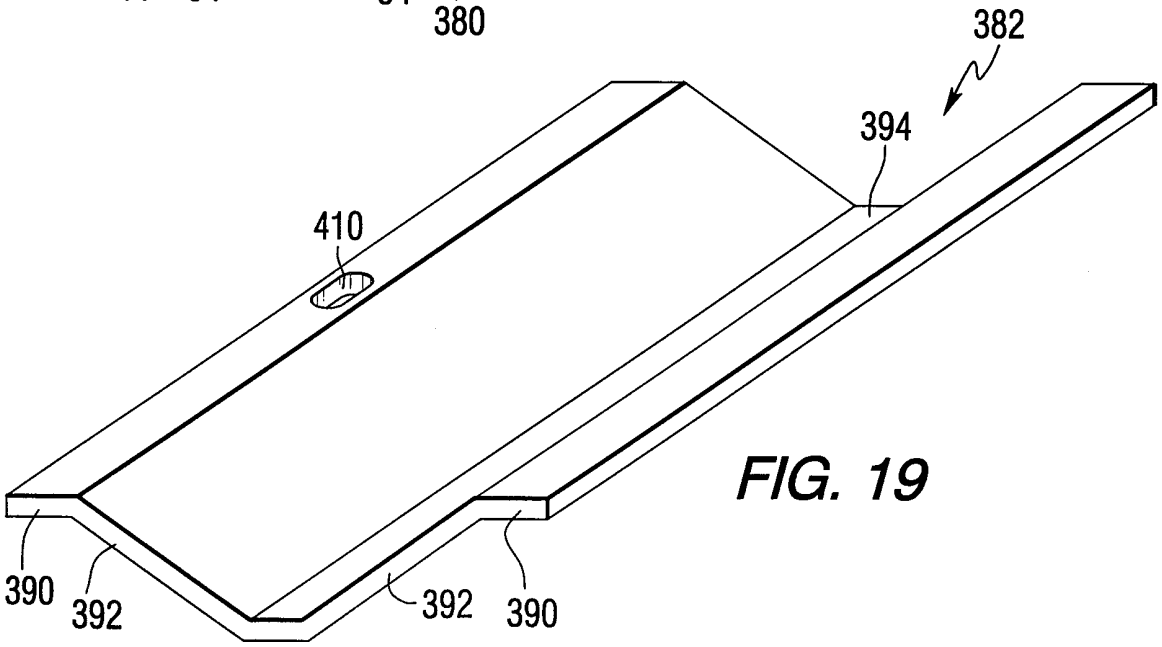

FIG. 19

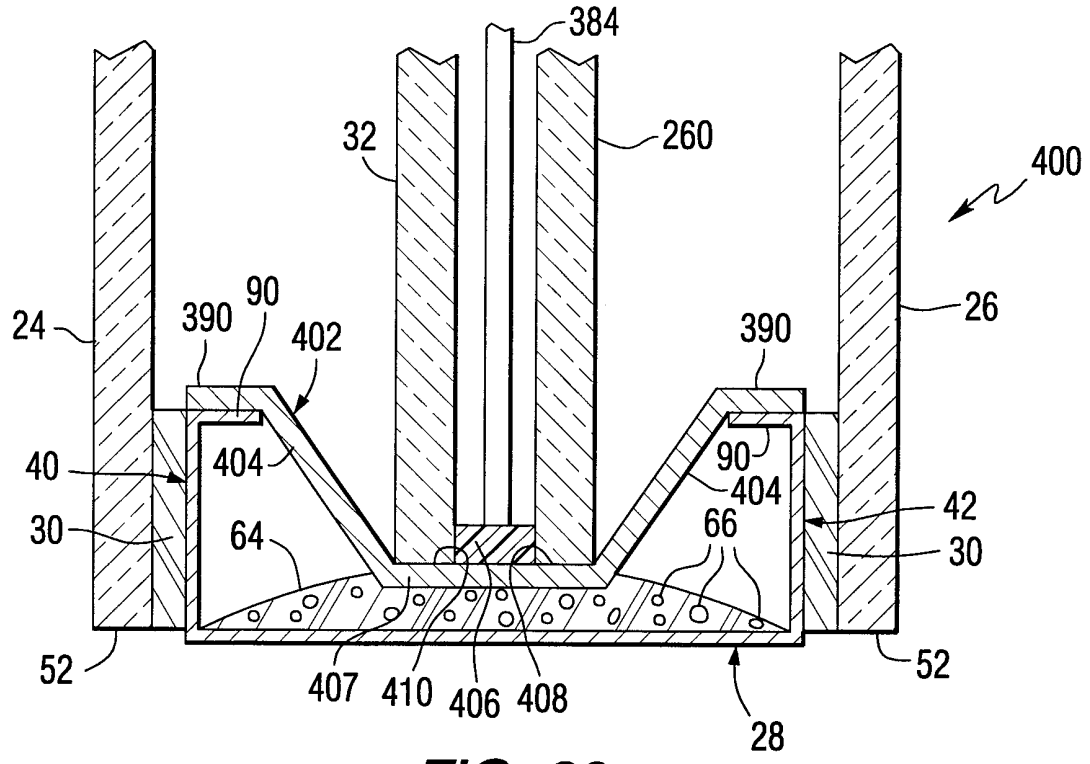
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FIG. 20

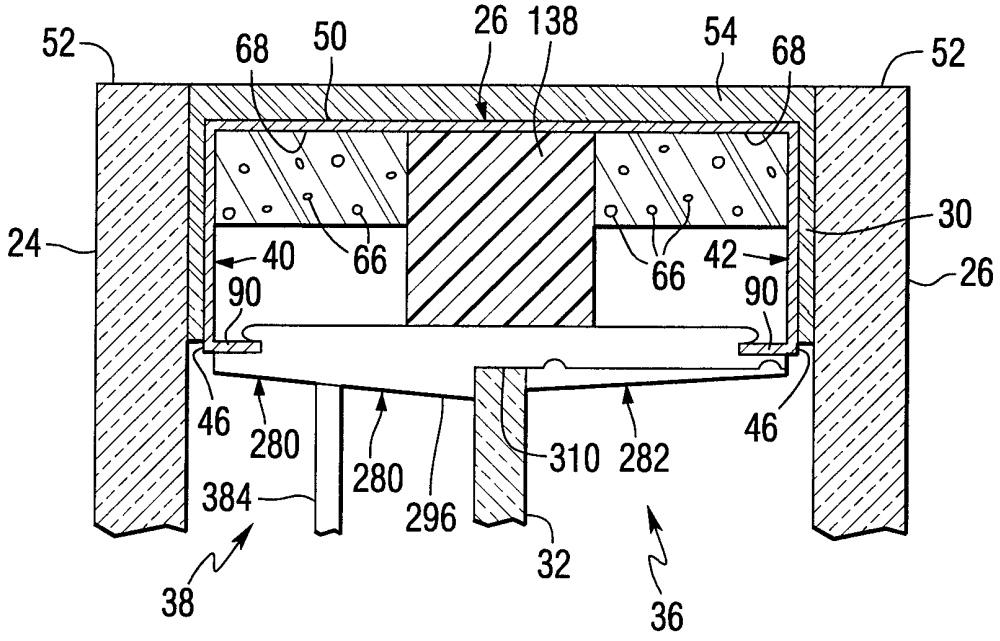
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FIG. 22

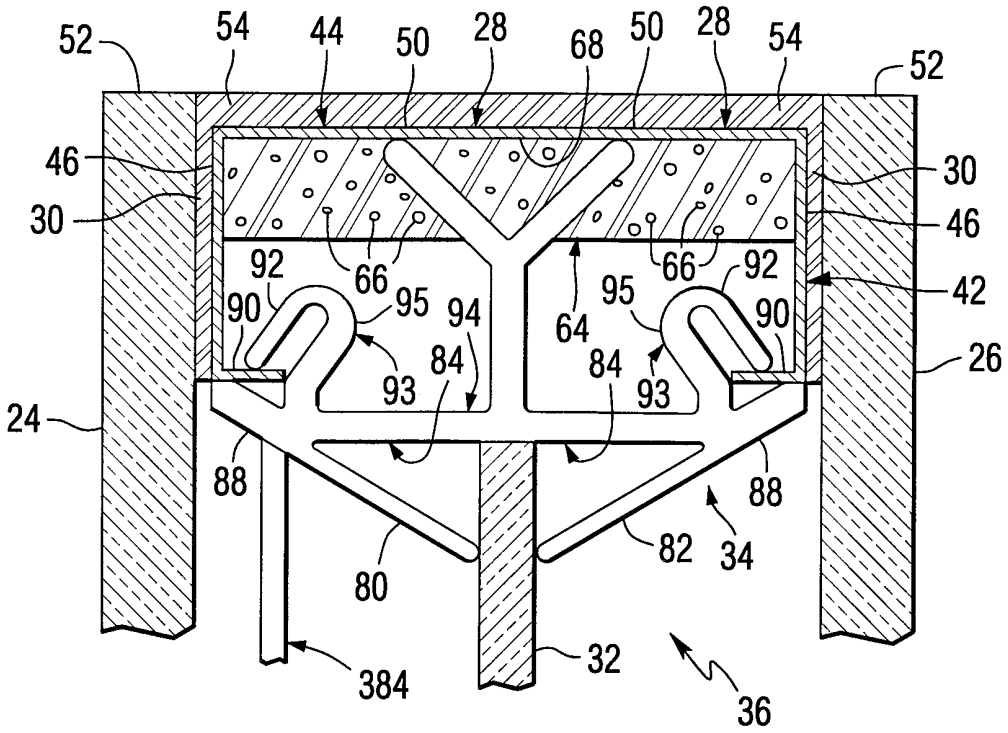

FIG. 21

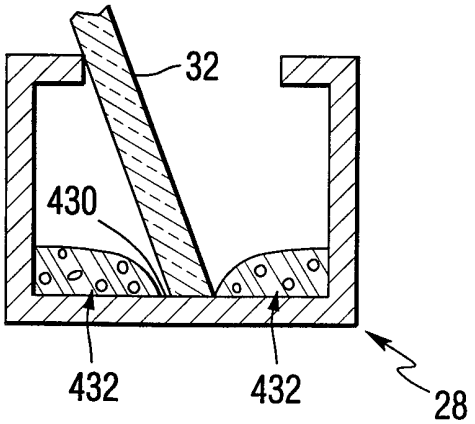

FIG. 25

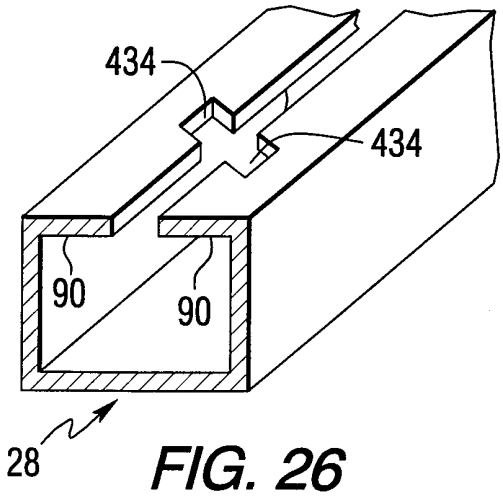

FIG. 26

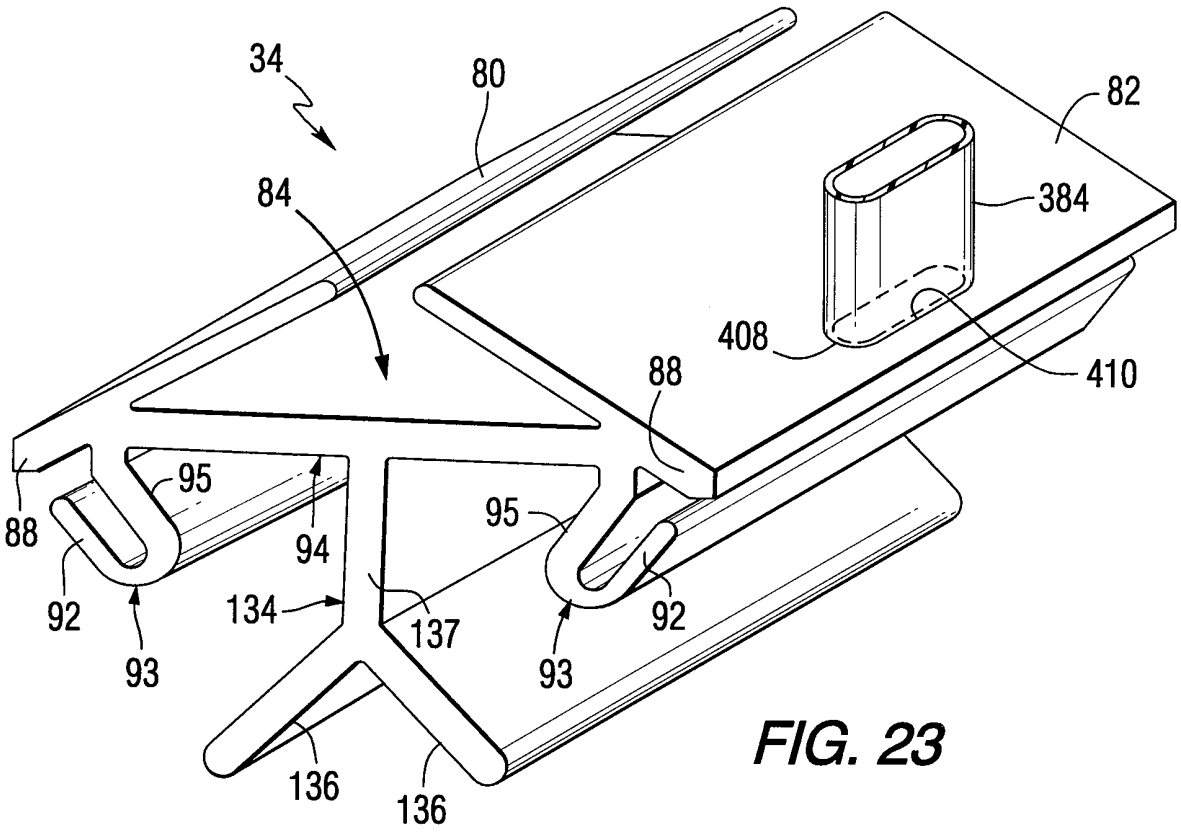
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FIG. 23

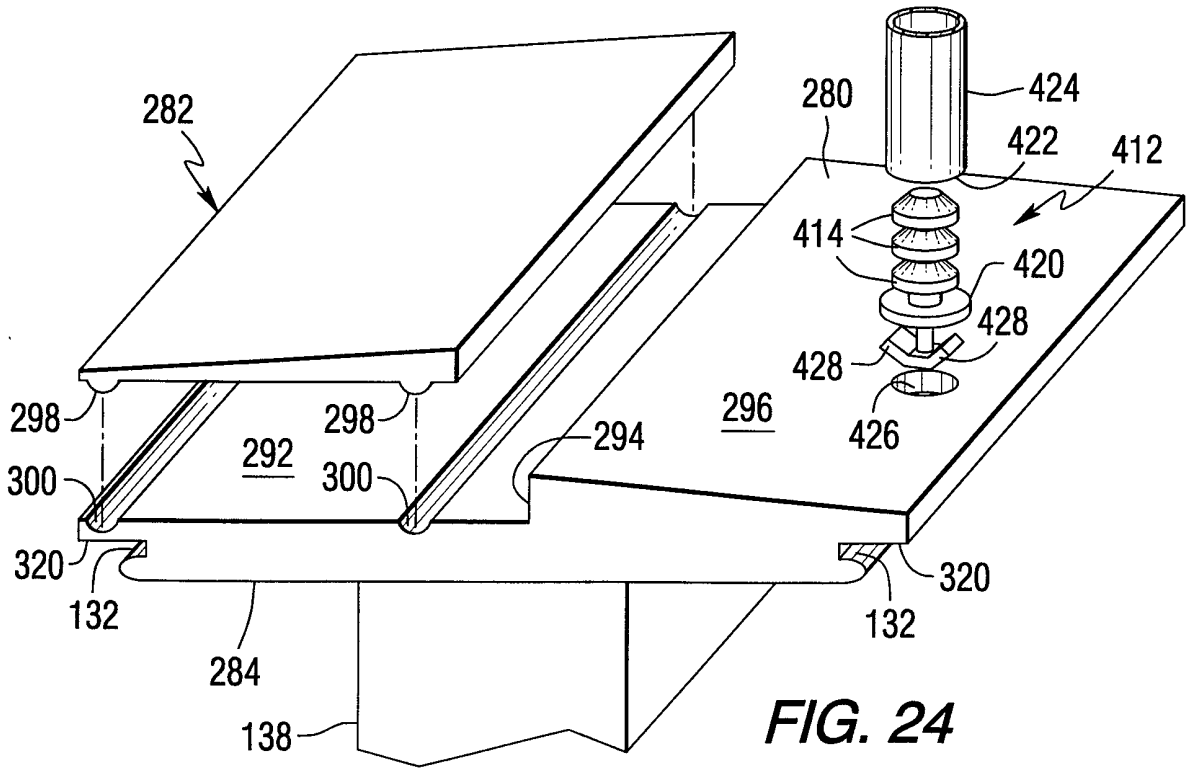
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FIG. 24

INTERNATIONAL SEARCH REPORT

Inter ›nal Application No
PCT/US 99/01959

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E06B3/663

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E06B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 19 08 567 A (H & A SUPPLY COMPANY) 18 September 1969	1,2
Y	see page 8, paragraph 3 - page 9, paragraph 1	3-5, 7-13, 17-20
A	see page 10, paragraph 2 - page 13, paragraph 2 see page 17, paragraph 2 - page 18, paragraph 1 see figures	37,39

X	FR 2 350 436 A (GUTMANN HELLMUT) 2 December 1977	2
A	see page 3, line 13 - line 37 see page 4, line 20 - line 26 see figures	8,17,25

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 May 1999	19/05/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Depoorter, F

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter ›nal Application No
PCT/US 99/01959

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 492 880 A (STEEB DIETER) 30 April 1982	2
A	see claim 1; figures	8,25

Y	DE 42 26 883 A (TROESCH GLAS AG) 4 March 1993	3-5, 7-13, 17-20
A	see column 1, line 54 - column 6, line 60; figure	23,24, 26,35, 37,39,41

A	US 5 553 440 A (BULGER MARK L ET AL) 10 September 1996 cited in the application see column 3, line 25 - column 5, line 41 see column 8, line 35 - column 9, line 13 see figures	8,9,14, 17,24, 27,28

A	CA 1 165 627 A (REPLA LIMITED) 17 April 1984 see page 3, line 26 - page 5, line 30; figures	31,33,42

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